Appendix E. Other Supporting Information

E.1. Resources Considered but Eliminated from Further Analysis
E.2. Redacted Cultural Inventory Reports
E.3. Biological Assessment
E.4. Utah Natural Heritage Program Online Species Search Report
E.5. Fish and Wildlife Species of Concern
E.6. Forest Service Biological Assessment/Biological Evaluation
E.7. Forest Service Biological Specialist Report
E.8. Flat Canyon Clay Mine Plan
E.9. Unanticipated Archaeological Discoveries Procedures
E.10. Technical Memoranda

Appendix E.1. Resources Considered but Eliminated from Further Analysis

Resource	Rationale
Coastal zone management areas	Coastal zone management areas do not occur in Utah, which is an inland state.
Coral reefs	Coral reefs do not occur in Utah, which is an inland state.
Ecologically critical areas	Ecologically critical areas are not known to occur within the watershed area.
Essential fish habitat	Essential fish habitat does not occur in Utah.
Fire/fuels management (BLM)	The proposed action would have no impact on fire/fuels management as it does not change access to areas where fires may occur and standard stipulations will address basic fire mitigation measures required for operation.
Forest resources	Forest resources such as timber and fuelwood occur in the higher elevations of the watershed area, but would not be impacted by project activities.
Livestock grazing (BLM)	The proposed riprap sites are located within the Gypsum and Salls Meadow allotments. Vegetation would be removed for material extraction, but the areas are relatively small compared to the overall allotments. There would still be sufficient forage for livestock; therefore, there would be little to no impact to livestock grazing. All fences that were cut, removed, or damaged would need to be repaired or replaced following completion of the project.
Paleontology (BLM)	The proposed action is located in Potential Fossil Yield Classification (PFYC) 1-very low because the surface geology is igneous rocks. If any paleontological resources are discovered during the proposed action, work must stop at that location and a qualified BLM representative must evaluate the find.
Parklands	No state, county, or national parklands occur within or near the watershed area.
Rangeland health standards (BLM)	The proposed action is not anticipated to have a significant impact on Rangeland Health Standards. Reseeding disturbed sites and placing riprap in areas to prevent erosion would be beneficial, due to the relatively small scale of the project no further analysis is needed.
Scientific resources	No scientific resources are known to occur within or near the watershed area.
Sensitive animal species (BLM)	Sensitive wildlife species have been observed in the area around the riprap material sites, including bald eagle, burrowing owl, and golden eagle; for full list of observed or possible wildlife species see Wildlife Staff Report. Wildlife clearances are required before project implementation to prevent any negative impacts to any sensitive species that may be present. If den and nest sites of sensitive wildlife are found, spatial buffers will be placed around those sites to protect the wildlife. Additionally, all raptor nests would need to have seasonal buffers enacted as outlined in the Raptor BMP, which is a part of the RFO RMP. (Appendix 10)
Sole source aquifers	The nearest sole source aquifer is over 100 miles away from the watershed area (Environmental Protection Agency [EPA] 2023a).

Resource	Rationale
Wild and scenic rivers	Wild and scenic rivers do not occur in Sevier County (National Wild and Scenic Rivers System 2023). Nationwide Rivers Inventory (NRI) segments do not occur within 40 miles of the watershed area (National Park Service 2023).
Woodland / Forestry (BLM)	The immediate area contains scattered pockets of pinyon and juniper, while the broader landscape includes larger blocks of pinyon-juniper woodlands. These areas provide woodland products such as firewood, fence posts, and pine nut collection sites. The establishment of a riprap site is expected to have minimal impact on these resources due to the limited tree removal within the project area and the abundant availability of woodland resources within a 5-mile radius. While some impacts will occur, they are not anticipated to be significant enough to warrant further analysis.
Vegetation Excluding Designated/Special Status Species (BLM)	The proposed project site is dominated by big sagebrush, black sagebrush, Utah juniper, Squirreltail grass, Indian ricegrass, and sandberg bluegrass. Some of the existing vegetation would be lost during the construction activities. However, the loss of vegetation during the proposed action would be a minor, short term impact. Rehabilitation of the disturbance would be a positive impact, because seeding with desirable perennial species would result in better, future vegetation. Long-term benefits, due to rehabilitation through seeding, far out-weigh any short-term loss of the current vegetative resource on the proposed project area. Therefore, considering all factors, it is determined that the vegetative resource would not be impacted to the degree that further analysis is needed.

Appendix E.2. Redacted Cultural Inventory Reports

COVER PAGE
Must Accompany All Project Reports
Submitted to the Utah SHPO

Utah Division of State History

Report Title: Cultural Resource Survey of NRCS' Sevier Valley Watershed Project Near Richfield, Sevier County, Utah.
UDSH Project Number: U19MQ0243 Org. Project Number: 19-030
Report Date: December 21, 2019 County(ies): Sevier
Report Author(s): Jody Patterson Principal Investigator: Jody Patterson
Record Search Date(s): May 16, 2019 & June 26, 2019 Field Supervisor(s): Jessica Del Bozque
Intensive Acres Surveyed (<15m intervals): 821.2 Recon/Intuitive Acres Surveyed (<15m intervals): 0
USGS 7.5' Series Map Reference(s): Annabella, Aurora, Elsinore, Richfield, Sigurd, White Pine Peak, UT.

Sites Reported	Count	Smithsonian Trinomials
Revisits (no updated site forms)	6	42SV2343, 42SV2500, 42SV2502, 42SV3046, 42SV3389, 42SV3522
Updates (updated site forms attached)	10	42SV665, 42SV693, 42SV1375, 42SV1485, 42SV1821, 42SV1824, 42SV2087, 42SV2344, 42SV3862, 42SV3863
New recordings (site forms attached)	22	42SV3896 – 42SV3917
Total Count of Archaeological Sites in APE	35	42SV693, 42SV1375, 42SV1821, 42SV1824, 42SV2343, 42SV2344, 42SV2500, 42SV2502, 42SV3046, 42SV3389, 42SV3522, 42SV3862, 42SV3863, 42SV3896 – 42SV3917
Historic Structures (structures forms Attached)	0	N/A
Total National Register Eligible Sites	15	42SV693, 42SV1375, 42SV1821, 42SV2343, 42SV2344, 42SV2500, 42SV2502, 42SV3046, 42SV3863, 42SV3899, 42SV3900, 42SV3902, 42SV3908, 42SV3910, 42SV3911

*Please list all site numbers per category. Number strings are acceptable (e.g. "42TO1-13; 42TO15"). Cells should expand to accommodate extensive lists.

Checklist of Required Items for Submittal to SHPO

- ☑ "Born Digital" Report in a PDF/A format
  - ☑ SHPO Cover Sheet
  - ☑ File Name is the UDSH Project Number with no hyphens or landowner suffixes
- ☑ "Born Digital" Site forms in PDF/A format
  - ☑ UASF with embedded maps and photos
  - ☑ File name is Smithsonian Trinomial without leading zeros (e.g. 42TO13 not 42TO00013)
  - ☑ Photo requirements (including size and quality)
- ☑ Archaeological Site Tabular Data
  - ☑ Single spreadsheet for each project
  - ☑ Follows UTSHPO template (info here: https://goo.gl/7SLMqj)
- ☑ GIS data
  - ☑ Zipped polygon shapefile or geodatabase of survey (if different from APE) or other activity area with required field names and variable intensity denoted
  - ☑ Zipped polygon shapefile or geodatabase of site boundaries with a the required field name

CULTURAL RESOURCE SURVEY OF NRCS' SEVIER VALLEY WATERSHED PROJECT NEAR RICHFIELD, SEVIER COUNTY, UTAH

Jody J. Patterson

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CULTURAL RESOURCE SURVEY OF NRCS' SEVIER VALLEY WATERSHED PROJECT NEAR RICHFIELD, SEVIER COUNTY, UTAH

By:

Jody J. Patterson

Prepared For:

Natural Resources Conservation Service
Salt Lake City, Utah

Bureau of Land Management
Richfield, Utah

State of Utah School and Institutional Trust lands Administration
Salt Lake City, Utah

Fishlake National Forest
Richfield, Utah

Prepared Under Contract With:

Jones and DeMille Engineering
Richfield, Utah

Prepared By:

Montgomery Archaeological Consultants, Inc.
Moab, Utah

MOAC Report No. 19-030

December 21, 2019

United States Department of Interior (FLPMA)
Permit No. 19-UT-60122

State of Utah Public Lands Policy
Archaeological Survey Permit No. 167

State of Utah Antiquities Project No. U19MQ0243

U.S. Department of Agriculture Forest Service
Temporary Special – Use Permit No. FIL1905

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ABSTRACT

Between June and August 2019, Montgomery Archaeological Consultants, Inc. (MOAC) conducted a Class III cultural resource survey for the Natural Resources Conservation Service's (NRCS) proposed Sevier Valley Watershed Project, near Richfield, Utah. The project area is located on both sides of the Sevier River Valley between Aurora and Elsinore in Sevier County, Utah. The project area consists of 14 separate parcels covering a total of 821.2 acres. The proposed project area consists of parcels located in [redacted] (Figure 1-7). The parcels occur on public lands administered by the USFS Fishlake National Forest (113.6 acres), BLM (556.7 acres), and SITLA (3.2 acres). An additional 147.7 acres of the project area occurs on private land.

The inventory of NRCS' proposed Sevier Valley Watershed Project resulted in the location of six previously recorded sites (42SV2343, 42SV2500, 42SV2502, 42SV3046, 42SV3389, and 42SV3522), the update or redocumentation of seven previously recorded sites (42SV693, 42SV1375, 42SV1821, 42SV1824, 42SV2087, 42SV3862, and 42SV3863) and the documentation of 22 newly identified sites (42SV3896-42SV3917) (Table 3). Of the 13 previously documented sites, nine have been recommend as eligible for listing on the NRHP based on Criterion A, Criterion D, or Criteria C and D and three previously recorded sites have been determined ineligible for listing on the NRHP. Of the 22 newly documented sites, 6 are recommended as eligible for the NRHP and 17 are recommended as ineligible.

Five sites (42SV1821, 42SV2344, 42SV2500, 42SV2502, and 42SV3863) may potentially be impacted by the proposed undertaking. Based on the inventory results and that two sites will be, and possibly three other sites could be, impacted by the proposed undertaking, a finding of *adverse effect* is recommended for the proposed undertaking pursuant to Section 106.

TABLE OF CONTENTS

ABSTRACT i
INTRODUCTION 1
DESCRIPTION OF PROJECT AREA 4
Environmental Setting 5
Historical Overview 13
SURVEY METHODOLOGY 17
INVENTORY RESULTS 17
Archaeological Sites 17
Isolated Finds of Artifacts 36
NATIONAL REGISTER OF HISTORIC PLACES EVALUATION 38
CONCLUSIONS AND RECOMMENDATIONS 40
REFERENCES CITED 42
APPENDIX A 45

FIGURES

Figure 1. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah. 6
Figure 2. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah. 7
Figure 3. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah. 8
Figure 4. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah. 9
Figure 5. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah. 10
Figure 6. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah. 11
Figure 7. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah. 12

TABLES

Table 1. Table 1. Previous projects within one half-mile of the current project area. 2
Table 2. Previously documented archaeological sites within one half-mile of the current project area. 3
Table 3. Archaeological Sites Associated with NRCS' Sevier Valley Watershed Project. 35
Table 4. Isolated Finds Associated with NRCS' Sevier Valley Watershed Project 36

INTRODUCTION

Between June and August 2019, Montgomery Archaeological Consultants, Inc. (MOAC) conducted a Class III cultural resource survey for the Natural Resources Conservation Service's (NRCS) proposed Sevier Valley Watershed Project, near Richfield, Utah. The project area is located on both sides of the Sevier River Valley between Aurora and Elsinore in Sevier County, Utah. The project area consists of 14 separate parcels covering a total of 821.2 acres. The project area occurs on public lands administered by the U.S. Forest Service (USFS) Fishlake National Forest, the Bureau of Land Management-Richfield Field Office (BLM), State of Utah School and Institutional Trust lands Administration (SITLA) and private property. The inventory was conducted at the request of Ms. Jenna Jorgensen of Jones and DeMille Engineering, Richfield, Utah.

The inventory objective was to locate, document, and evaluate any cultural resources within the project area in order to comply with 36 CFR 800, the National Historic Preservation Act (NHPA) of 1966 (as amended). The inventory was also implemented to attain compliance with a number of federal and state mandates, including the National Environmental Policy Act of 1969, the Archaeological and Historic Preservation Act of 1974, the Archaeological Resources Protection Act of 1979, the American Indian Religious Freedom Act of 1978, and Utah State Antiquities Act of 1973 (amended 1990), and Utah Public Law 9-8-404.

Jessica Del Bozque (Field Supervisor), Tanner Gittins, Michael Bianchini, and Brian Meinhart conducted the survey between June 28 and August 11, 2019 under the direction of Jody Patterson (Principal Investigator). The inventory was completed under the auspices of US Department of the Interior (FLPMA) Permit No. 19-UT-60122 (expires May 2020), State of Utah Public Lands Policy Principal Investigator Permit No. 167, State of Utah Antiquities Permit (Survey) No. U19MQ0243, and U.S. Department of Agriculture Forest Service Temporary Special – Use Permit No. FIL1905 issued to MOAC, Moab, Utah.

Adam Thomas conducted an online file search using Preservation Pro on May 16, 2019. Mr. Chuck Hutcheson, archaeologist for Fishlake National Forest, conducted an additional file search of the Fishlake National Forest database on June 26, 2019. These file searches identified 51 previous projects within one half-mile of the current project area (Table 1) and 47 previously recorded sites occur within the same area (Table 2). Sixteen of the previously documented sites occur within the current project area (42SV665, 42SV693, 42SV1375, 42SV1821, 42SV1824, 42SV2087, 42SA2343, 42SV2344, 42SA2500, 42SA2502, 42SA3046, 42SV3389, 42SV3522, 42SV3862, and 42SV3863). Site 42SV2599 also occurs in the project area. This site consists of a segment of the Piute Canal. SHPO dropped this site number and included the information under site number 42SA2344. Site 42SV1485 was indicated in the search results as located in [redacted], but this location is incorrect. MOAC surveyed the plot at that location to verify no cultural material was present. The correct site location is [redacted]. Per the request of Mr. Arie Leeflang of the Utah Division of State History, an update was completed for 42SV1485 to document that the plot within the current project area is inaccurate. During the inventory it was also observed that the plot for 42SV1375, a rock art site, was misplotted and the rock art described in that form is at the plot for 42SV2187. Site 42SV2187 consists of

rock art and has no site form but is briefly described in report U87AK0773; the descriptions in that report strongly resemble those rock art panels located at the plot for 42SV2187 and pictured in the site form for 42UN1375. MOAC completed an update to re-document the rock art and combine site numbers 42SV1375 and 42SV2187 during the current inventory. No cultural materials were observed at the plot for 42SV1375.

Table 1. Previous projects within one half-mile of the current project area.

State Project Number	Project Title	Consultant
U75WJ0062	UP&L Camp Williams to Sigurd Line	Worldwide Surveys
U76BC0162	Intensive Survey of Three Transmission Line Routes.	BYU
U84BC0178	An Archaeological Inventory of the I-70 Elsinore-South Richfield Segment Sevier County, Utah and Three Proposed Borrow Pit Areas	BYU
U84BC0216	Prop Sigurd-Cameron 138KV Relocation nr Elsinore	BYU
U84BC0220	An Archaeological Survey of Several Borrow Areas Along the North Richfield to Sigurd Segment of Interstate 70 Sevier County, Utah	BYU
U84BC0237	Site 42SV1897 Near Elsinore	BYU
U85BC0401	An Archaeological Inventory of Four Proposed Borrow Pits for I-70 Construction, North Richfield-South Richfield	BYU
U85BC0550	Prop Gravel Borrow Area/Holding Pond N of Richfield	BYU
U85BC0591	3 Borrow Areas between Richfield & Elsinore - Addendum	BYU
U85BC0749	Prop Rip-Rap Pit Near Sigurd and Sigurd-Sevier River Bridge	BYU
U85BC0750	Prop Material Borrow Area Near North Richfield	BYU
U86AK0420	Nielson - Maglebee Borrow Pit	BYU
U86BC0486	UP&L Sigurd to Cedar City	BYU
U87AK0773	CRS of a Borrow Pit for Le Grand Johnson Construction on Reliable Insurance Company Lands	ARCON
U87BC0077	2 Reports-Pipeline Survey/Salina Sisters Burial Site	BYU
U89BL0463	Aurora City Pipeline	BLM
U89BL0533	Aurora Pipeline Gravel Pit	BLM
U94AS0567	CRI and Historical Reconnaissance Survey for Utah Department of Transportation's SR-260 Improvement Project, Sevier County, Utah	Abajo Archaeology
U95WZ0502	Salina Seismic Program	Desert West Research
U98FS0776	Flat Canyon Clay Pit	Forest Service
U03BC1000	UP&L Sigurd to Nevada Powerline	BYU
U04BC0381	UP& L Sigurd to Glen Canyon	BYU
U04MV0106	Sevier County Seismic Lines	Mountain States Archaeology
U04MV0866	Sevier Valley Seismic Lines	Mountain States Archaeology
U04UJ0433	Piute Canal 280 Acres	Utah State University
U04UJ0434	Test Excavation and Analysis of the Panguitch Creek Site 42GA5340	Utah State University
U05FS0122	ATV Play Areas	Forest Service
U05LW1224	Dawson Geo. WGO 2006 Southern	Western Land Services Inc.
U06ST1699	Pioneer 2-D Seismic in Sevier County	SWCA
U06UM0553	Richfield Public Shooting Range	SITLA
U07FS0535	Fishlake N.F. Travel Management Plan Survey	Forest Service

State Project Number	Project Title	Consultant
U07LW1125	Covenant 3-D Seismic	Western Land Services Inc.
U08BL0087	Aurora OHV Play Area	BLM
U08LW0080	Wolverine Data - Frogs 2-D Seismic	Western Land Services Inc.
U09EO0612	Sigurd to Red Butte Transmission Corridor	EPG
U10EO0327	A CRI for the Sigurd to Red Butte Geotechnical Investigations Project No. 2, Beaver, Iron, Millard, Sevier, and Washington Counties, Utah	EPG
U10EO0510	Sigurd to Red Butte Transmission Line	EPG
U11EO0482	Sigurd to Red Butte Geotechnical Investigation Project #3	EPG
U12BL0299	Bull Claim Hill Rip Rap Quarry	BLM
U12BL1119	Bull Hill Claim Quarry Inventory 2012	BLM
U12BL1120	Glenanna Vegetation Treatment Inventory 2012	BLM
U12HO0845	Horizon Energy Well Pads	Bighorn
U13HO0317	Sigurd to Red Butte Variance 30-091a Access Road Near Structure 35, Sevier County	Bighorn
U13HO0462	EC Source Sigurd to Red Butte Access Road/ROW Variance Between Structures 65 and 68	Bighorn
U13HO0509	A CRI for the EC Source ENV-042 Access Road 030-77 For Structure 29 Sigurd to Red Butte Transmission Line Project Near Richfield, Sevier County, Utah	Bighorn
U13HO0557	A CRI for the EC Source Sigurd to Red Butte Transmission Line Variance ENV-051 Fly Yard 65 Near Elsinore, Sevier County, Utah	Bighorn
U13HO0946	A Cultural Resources Inventory for the EC Source Variance ENV-023 ECS030-171 Access Road to Structure 65 Near Elsinore, Sevier County, Utah	Bighorn
U15HO0265	A Cultural Resource Inventory for the Aurora SITLA Inventory Near Aurora, Sevier County, Utah	Bighorn
U16SH0782	Cultural Resources Inventory of an NRCS Emergency Watershed Protection (EWP) Project Near Willow Canyon, Near Richfield, Sevier County, Utah	NRCS
U16SH0783	Cultural Resources Inventory of an NRCS Emergency Watershed Protection (EWP) Project in Flat Canyon Near Elsinore, Sevier County, Utah	NRCS
U16SH0843	Cultural Resources Inventory of an NRCS Emergency Watershed Protection (EWP) Material Source Location on Bull Claim Hill Near Anabella, Sevier County, Utah	NRCS
U18MQ0697	CRI of Richfield City's Richfield Bike Trails Survey, Phase I, Sevier County, Utah	MOAC

Table 2. Previously documented archaeological sites within one half-mile of the current project area.

Site Number	Affiliation	Site Type	NRHP Eligibility	In Current Project
42SV457	Unknown Aboriginal	Rock Art	Undetermined	No
42SV612	Unknown Aboriginal	Rock Art	Undetermined	No
42SV665	Fremont	Artifact Scatter	Undetermined	Yes
42SV691	Unknown Aboriginal	Lithic Procurement	Not Eligible	No
42SV692	Unknown Aboriginal	Lithic Procurement	Not Eligible	No
42SV693	Unknown Aboriginal	Rock Shelter	Eligible	Yes
42SV694	Unknown Aboriginal	Lithic Scatter	Not Eligible	No
42SV695	Unknown Aboriginal	Lithic Procurement	Eligible	No
42SV696	Unknown Aboriginal	Lithic Scatter	Not Eligible	No
42SV697	Fremont(?)	Camp	Not Eligible	No
42SV698	Unknown Aboriginal	Lithic Scatter	Not Eligible	No
42SV699	Unknown Aboriginal	Lithic Scatter	Not Eligible	No
42SV700	Unknown Aboriginal	Lithic Procurement	Not Eligible	No

Site Number	Affiliation	Site Type	NRHP Eligibility	In Current Project
42SV701	Unknown Aboriginal	Lithic Procurement	Not Eligible	No
42SV702	Unknown Aboriginal	Lithic Scatter	Not Eligible	No
42SV1375	Fremont	Rock Art	Eligible	Yes
42SV1619	Unknown Aboriginal	Rock Art	Eligible	No
42SV1821	European/American	Richfield Dump	Eligible	Yes
42SV1823	European/American	Dump	Not Eligible	No
42SV1824	European/American	Dump	Not Eligible	Yes
42SV1832	European/American	Dump	Not Eligible	No
42SV1897	Unknown Aboriginal	Stone Circle, Rock Art	Undetermined	No
42SV2087	European/American	Corral & Dugout	Not Eligible	Yes
42SV2343	European/American	Vermillion Canal	Eligible	Yes
42SV2344	European/American	Sevier Valley/Piute Canal	Eligible	Yes
42SV2500	European/American	Richfield Canal	Eligible	Yes
42SV2502	European/American	D&RG Railroad (Marysvale Branch)	Eligible	Yes
42SV2599	European/American	AKA 42SV2344	Eligible	Yes
42SV2636	Unknown Aboriginal	Lithic Procurement	Eligible	No
42SV2641	European/American	Dump	Not Eligible	No
42SV2642	Unknown Aboriginal	Lithic Scatter	Not Eligible	No
42SV2729	European/American	Venice Canal	Eligible	No
42SV2775	European/American	Domestic Artifact Scatter	Not Eligible	No
42SV2806	European/American	Telephone Line	Not Eligible	No
42SV3041	Multicomponent	Prehistoric/Historic Artifact Scatter	Not Eligible	No
42SV3045	European/American	Dump	Not Eligible	No
42SV3046	Multicomponent	Puebloan ceramic scatter/Historic Dump	Eligible	Yes
42SV3047	Multicomponent	Archaic-Late Prehistoric artifact scatter and rock art/ Historic Dump	Eligible	No
42SV3048	Multicomponent	Lithic Scatter/1 Tin Can	Not Eligible	No
42SV3384	Unknown Aboriginal	Lithic Scatter	Not Eligible	No
42SV3385	Multicomponent	Prehistoric/Historic Artifact Scatter	Not Eligible	No
42SV3389	European/American	Historic artifact scatter/camp	Not Eligible	Yes
42SV3522	European/American	Historic Artifact Scatter	Not Eligible	Yes
42SV3545	Unknown Aboriginal	Lithic Procurement	Eligible	No
42SV3662	European/American	Dump	Eligible	No
42SV3862	European/American	Powerline	Not Eligible	Yes
42SV3863	European/American	CCC Road	Eligible	Yes

DESCRIPTION OF PROJECT AREA

The project area consists of several parcels scattered throughout the Sevier River Valley between Aurora and Elsinore, Utah. The project area consists of 14 separate parcels covering a total of 821.2 acres. The proposed project area consists of parcels located in [redacted] (Figure 1-7). The parcels occur on public lands administered by the USFS Fishlake National Forest (113.6 acres), BLM (556.7 acres), and SITLA (3.2 acres). An additional 147.7 acres of the project area occurs on private land.

The proposed undertaking includes two debris basins, each located at the mouth of Flat or Tank Canyon. Flood channels at the north and south end of the project area would be improved to convey flows from canyons on the west side of the valley to the Sevier River. A series of two water and sediment control basins would be constructed at the mouth of Wood Canyon, and the channel downstream would be improved. The Sevier Valley Canal flood control gate would be upgraded. Riprap for the features would be extracted from public lands on the east side of the valley. The surveyed area contains the project features and associated construction disturbance areas for each component.

Environmental Setting

The study area lies within the Sanpete-Sevier Valleys subsection of the Basin and Range-Colorado Plateau physiographical province (Stokes 1986). The Sevier River valley is a narrow depression filled with sediments and alluvial fans that mask a complex area of subsidence caused by faulting, folding, and the removal of salt from Jurassic formations (Stokes 1986:248). The project area occurs primarily between Aurora and Elsinore, Utah. This portion of the Sevier River Valley is flanked in the west by the Pahvant Range and in the east by the Sevier Plateau. The intermediary elevations of these two ranges extend upwards of 2,500 feet above the valley floor, though the peaks in the Pahvant range approach 10,000 ft. The Sevier River Valley is about seven miles wide, with an average elevation of 5,300 ft. The Sevier River originates about 80 miles south of the project area, in the Pink Cliffs of northern Kane County and flows north through Marysvale Canyon in Piute and Sevier counties, eventually emptying into Sevier Lake in central Millard County. Throughout the project area, the river's original course through its floodplain has been heavily altered and restricted. Several intermittent drainages flow down from the range toward Richfield, the most prominent, Cottonwood Creek. Elevation of land surveyed as part of this project ranges between 5,250 ft and 6,500 ft and lies within the Upper Sonoran life zone. Natural vegetation includes sparse pinyon and juniper, blackbrush, greasewood, rabbitbrush, sagebrush, yucca, saltbush, cheatgrass, prickly pear cactus, snakeweed, various grasses characterized by a pinyon-juniper woodland community with an understory including low sagebrush, ephedra, bunch grasses, and cliffrose. Modern impacts to the area include urbanization, agriculture, camping, target shooting, ATV/recreation trails, roads and highways, dumping, and several transmission lines.

[MAP REDACTED]

Figure 1. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah.

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[MAP REDACTED]

Figure 2. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah.

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[MAP REDACTED]

Figure 3. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah. Previous Inventory indicates projects from last ten years only.

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[MAP REDACTED]

Figure 4. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah. Previous Inventory indicates projects from last ten years only.

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[MAP REDACTED]

Figure 5. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah. Previous Inventory indicates projects from last ten years only.

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[MAP REDACTED]

Figure 6. Survey Area of NRCS' Sevier Watershed Project, Sevier County, Utah.

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[MAP REDACTED]

Figure 7. Survey Area of NRCS' Sevier Watershed Project area, Sevier County, Utah. Previous Inventory indicates projects from last ten years only.

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Historical Overview

Human occupation in the study area spans 10,000-12,000 years and encompasses four prehistoric cultural temporal units: the Paleoindian, Archaic, Formative, and Late Prehistoric (Paiute and Ute). Historic Euroamerican occupation of the area is extensive and begins in the mid-1800s.

The Paleoindian period in the continental United States extends from the end of the Pleistocene (ca. 11,000 YBP) to the early Holocene (7,500 YBP). Environmental conditions during the Pleistocene supported a variety of megafauna including bison, mammoth, camel, and ground sloth. In Utah, three Paleoindian complexes are recognized: Clovis (ca. 11,500-11,000 B.P.), Folsom (ca. 11,000-10,000 B.P.), and Plano (ca. 10,000-7500 B.P.). Despite minor differences in tool kits and tool manufacturing technology, the three complexes share a variety of traits including big game hunting, low population densities, and wide spatial distributions. Diagnostic cultural materials attributed to the Clovis complex have been found in sand dunes along the Sevier River, including a lithic scatter containing a Clovis projectile point (42JB180) (Copeland and Fike 1988). In western Utah, the Hell'n Moriah Clovis site (42MD1067), a single component retooling station, yielded seven Clovis fluted projectile points, flaked tools, and lithic debitage (Davis, Hurst, and Westfall 1994).

The earliest Archaic presence in the study area occurred during the Pleistocene-Holocene boundary (10,000-8000 B.P.). Diagnostic artifacts dated to the interval are found in the eastern Great Basin around 9500 B.P. and include Pinto Series projectile points and Western Stemmed Tradition points. A long period of environmental variability followed the Pleistocene-Holocene transition, with the span between 8000 and 4000 B.P., the Altithermal distinguished by aridity and the loss of broad areas of lakeshore marshes and the drying up of the large Pleistocene lakes. The environment subsequently became wetter, with increased precipitation causing lakeshore flooding. Sometimes called the "Neoglacial", this period is marked by an increase in the number of known sites and a movement from lakeshore to upland environments. Elko Series and Gypsum projectile points are common projectile points from this time period and Rose Spring-Eastgate Series projectile points begin to replace the larger projectile point styles, indicating a switch from use of the atlatl and dart to use of the bow and arrow.

Sometime between A.D. 1 and 400, the Formative stage emerges on the northern Colorado Plateau and in portions of the Great Basin. Maize, ceramics, and the bow and arrow were adopted in different spatiotemporal patterns, indicating that these features did not arrive as a complex from the south (Madsen and Simms 1998:260). Characteristics considered diagnostic of this stage are well-documented on either side of the southern Wasatch Plateau, including permanent architecture, plant domestication, and bow and arrow technologies. Several aceramic Late Archaic/Formative stage sites containing early pit structure architecture have been investigated in central Utah, such as Structure 2 at Icicle Bench (Talbot et al. 1997), and the Late Archaic Pahvant Park pit structure at North Richfield (Talbot and Richens 1993). By A.D. 700, a ceramic tradition is well-represented at hundreds of sites attributed to the Fremont complex in central Utah. Marwitt (1970) defined five Fremont regional variants. Under this scheme, the project area falls within the Sevier Fremont variant (ca. 780 to 1260), characterized by rectangular, square, and circular pit structures with ventilators or crawlway entrances, but without deflectors (Marwitt 1970:140). Dominant ceramic types include Sevier Gray and Snake Valley Gray. In central Utah and elsewhere, significant population growth began sometime around A.D. 900, represented by intensification of architecture, population growth, and expanding frontiers. Janetski et al. (2000) suggests that the

apparently high population of Fremont in the central Sevier Valley probably represented a supra-community equivalent to that of the Parowan Valley; Fremont occupations are known beneath the historic towns of Monroe, Elsinore, Glenwood, Aurora, Salina, and in Lost Creek Canyon. Permanent habitations such as Five Finger Ridge in Clear Creek Canyon are designated as "villages" and contain contemporaneous habitation structures, architectural features associated with communal economic cooperation, and evidence of political integration in the form of communal structures (Janetski et al. 2000).

Following the disappearance of the Fremont from the archaeological record, a largely nomadic hunting and gathering economic strategy resumed. Numic-speaking Southern Paiute and Ute groups were present throughout much of Utah upon the arrival of Europeans. Although the name Paiute was originally applied only to the Southern Paiute, it was extended to additional groups as the exploration of the Great Basin proceeded. Numic occupation in the study area is evidenced by Desert Side-notched projectile points, Southern Paiute Utility Ware ceramics, and distinct perishables. In the vicinity of the study area, several radiocarbon dates have been obtained from Late Prehistoric occupations in Clear Creek Canyon. The North Cedars Cave contained numerous brownware sherds (in mixed deposits), and yielded dates of A.D. 1400s and 1600s (Janetski et al. 2000). Although settlement patterns reflected a mobile society, family groups tended to occupy the same localities within their territory over the course of a year. Often families claimed certain springs as private property (Kelly and Fowler 1986). The major gatherings of the pre-contact period were centered around the pine nut harvest and the spring fish spawning time at such places as Fish Lake (Tom and Holtz 2000:124). Occupying the study area at the time of European American arrival were the Pah Vent (or Pahvant) Utes. According to Steward (1938:227), the traditional territory of the Pah Vent Utes stretched from "the deserts surrounding Sevier Lake west of the Wasatch Mountains nearly to the Nevada border." Known villages were located near the modern communities of Kanosh, Deseret, Black Rock, Holden, Lyndyl, and Scipio. Each of these villages denoted the winter headquarters of a division of the band (Steward 1938:227). There were approximately 500 Pah Vent Utes when the Mormons arrived in the 1860s to build Cove Fort (Van Cott 1997:94).

The earliest recorded visit by Europeans to Utah was the Dominguez-Escalante expedition, which departed from Santa Fe, on July 29, 1776. After traveling north through western Colorado, then turning west near Jensen, Utah, the party reached Utah Valley in late September. Following a three day rest the group headed south and in early October passing the Cove Fort area by approximately 20 miles to the west (Warner 1976). Near Black Rock, Utah a decision was made to return south to Santa Fe rather than continue the trek towards Monterey, California. Although their goal of establishing a new route between Santa Fe and Monterey was not met, the area became better known through the friars' journals. Following this expedition, Spanish traders and trappers continued to enter the region and soon established both a primary and secondary trail system in Utah that became known as the "Old Spanish Trail." In 1826, the American fur trapper and explorer Jedediah S. Smith, accompanied by 15 other trappers, traveled south through Sevier County from Bear Lake, eventually reaching southern California. By September 8, 1826, the party had encountered the Sevier River and proceeded to follow it upstream through the valley. As the canyon continued to narrow further south, the trappers turned west, passed through Clear Creek Canyon, and exited near Cove Creek at the present site of Cove Fort (Brooks 1977).

The Old Spanish Trail was busy with government travelers between 1853 and 1854 at which time Congress appropriated funds to conduct a series of surveys in the West for a possible transcontinental railroad to the Pacific Coast. In 1853, Lt. Edward F. Beale, who was serving in California as Superintendent of Indian Affairs, was delegated to unofficially survey a central route on his return trip to California from Washington D.C. The expedition reached the head of Salina Canyon and the headwaters of Salina Creek in July 1853 where they reported a new wagon road which was being used by Mormon freighters and miners to haul salt rock from the salt mines near Salina to the newly established settlements in Sanpete County (Bishop 1997:62). The expedition turned south at Salina and followed the Sevier River upstream. The expedition's recorder, Gwin H. Heap, wrote that the Sevier Valley "surpasses in beauty and fertility anything we had yet seen." The company left the county following the river to present-day Marysvale and Kingston where they connected with the Old Spanish Trail, eventually reaching California.

Mormon exploration of central and southern Utah in search of new settlements commenced in 1849, when Brigham Young commissioned a fifty-man company led by Parley P. Pratt, a Mormon apostle. Pratt and his men were to maintain a complete record of soil conditions, topography, vegetation, streams, timber, pasture lands, and other natural resources necessary to locate any new forts and settlements (Arrington 1958:86). Proceeding down the Sanpete Valley, the explorers reached the Sevier River by early December 1849 (Newell 1999:41). Pratt reported the occurrence of coal near the present site of Salina and had praise for the rich bottomland of the Sevier River Valley, where Richfield would eventually stand. In July 1863 George W. Bean was called by Mormon apostle George A. Smith, who was presiding over the Utah Valley area, to take a small exploration party go up the Sevier River above Gunnison and look for suitable locations for settlements. After crossing to the west side of the Sevier River, the party found a big spring where Richfield was later settled. There they found fertile soil, good water, and wood in the nearby hills. The party, returning by way of Spring City, met Mormon Apostle Orson Hyde, who informed them that the settlement of Sevier Valley was under his direction. In January 1864, an independent party of ten men under the leadership of Albert Lewis came from Sanpete and arrived in what is now Richfield on the sixth of January. In the winter of 1864 Orson Hyde called additional families to go. Some bought their way out, but others responded to the call to settle. The first settlement was called Big Springs or Warm Springs, after the life-giving spring at the foot of the red hills to the west. The settlement later was called Omni after a prophet in the *Book of Mormon*. The name was changed to Richfield because of the fertile soil. In 1864 Nelson Higgins, a veteran of the Mormon Battalion, was selected as temporary president of the settlement. In February 1865, the first schoolhouse was built; the first teacher in the school was Hans P. Miller. A fort was started in the fall of 1865; each man who owned a city lot was required to build one rod (16.5 feet) of wall.

Sevier County was officially created in early 1865, at which time there were a few small settlements, including Richfield, Glenwood, and Monroe (known at the time as Alma) (Bishop 1997:62). In 1865, another 100 families settled in the county, most immigrating from neighboring Sanpete County. Many of the county's early settlers were Scandinavians, who brought distinctive building styles and cultural practices with them. Expansion throughout central Utah was briefly interrupted as a result of the Black Hawk War, which began in 1865 (Poll 1978). Under Black Hawk's leadership, Ute bands initiated raids against settlers occupying their historical territory principally in Sanpete and Sevier Counties. Though it was labeled a "war" by many, it was actually a series of raids, chases, and skirmishes between the settlers

and their territorial militia and various bands of Utes (Powell 1994:44). In 1865, Black Hawk and his band took ninety head of stock from nearby Salina, killing two settlers working in the canyon. Other attacks followed. For safety, about forty families from nearby Glenwood moved to Richfield. Three settlers, Jens Peter Petersen, his wife Amalia, and Mary Smith were killed by Black Hawk's band between Richfield and Glenwood on March 21, 1867. Brigham Young called for the evacuation of the Sevier River Valley when the Indian depredations persisted and began to increase. The evacuation of the settlement was completed by April 1867. However, at the western end of Sevier County, Cove Fort was constructed and maintained in order to protect communication and transportation interests. Although the conflict dissipated with the signing of the Black Hawk War treaty in 1868, attempts to resettle the Sevier Valley by Mormon pioneers failed until 1870. By July 1872 there were 150 families in the Richfield area. In March 1874 Bishop Williams Seegmiller reported 145 families, 172 men, and a total of 753 persons in Richfield. There were 117 children attending school.

The population of Sevier County steadily increased after 1874 with the establishment of villages such as Annabella (1871) six miles southeast of Richfield, and Sevier Ward (1872), the county's southernmost community. The Sevier Ward, with boundaries extending from the mouth of the Sevier Canyon to south of Joseph, was settled by the heads of nine families living near Clear Creek Canyon. The first community effort by these families was the construction of a 2.5-mile-long irrigation ditch to divert water from Clear Creek to grow such diverse crops as apples, apricots, peaches, pears, grapes, and black walnuts (Bishop 1997:83).

In 1890, the narrow-gauge Denver & Rio Grande Western mainline between Ogden and Denver was being widened. A standard gauge roadbed was built south from Thistle to Ephraim, but laid with a three-foot-gauge track. During the two-year transition from narrow gauge to standard gauge, the Sevier Railway became the repository of most of the narrow-gauge equipment still left in the Utah half of the Rio Grande Western. The Sevier Railway was formed by citizens of Sevier County in May 1891 who purchased the right-of-way to build tracks from the towns of Manti to Marysvale for the use of the D&RGW trains (Newell 1999:196). Track was completed to Salina in 1891 and the rails reached Richfield by June 1896. Beginning in 1907 Sevier County received revenue derived from the national forests to assist with the funding of roads and public schools in the county (Bishop 1997:137). Several years later the Utah State Legislature established the state highway system and state highway department. In subsequent years, Richfield continued to grow with the development of businesses, hotels, restaurants, railroad service, and other amenities.

In 1933, a Civilian Conservation Corps (CCC) camp (F-12) was constructed near Fish Lake, and camp F-25 was built in Richfield (Bishop 1997:177). The CCC employed young men from needy families, and trained them to work on conservation and road construction projects in military style units. The goal of the CCC was to provide work during the depression era as part of the "New Deal" programs, and to repair the nation's roads, watersheds, and campgrounds. Thousands of young men worked for the CCC in Utah between 1933 and 1941. There were originally 48 men working for the CCC in Sevier County, housed in forest camps, given food and shelter, and paid a dollar a day for their labor. In the winter of 1933/34 the CCC workers from the Fish Lake Camp in Sevier County, and the Grover camp in Wayne County, were relocated to the fairgrounds in Richfield. New barracks were later built at the Richfield airport.

SURVEY METHODOLOGY

An intensive pedestrian survey was performed for this project which is considered 100% coverage. Each parcel within the project area was surveyed by the archaeologists walking parallel transects spaced no more than 15 m (49 ft) apart. Ground visibility was generally fair to good. The project area encompasses a total of 821.2 acres, of which 774.5 were inventoried for cultural resources during the current project. The remining 76.7 acres within the project area were previously surveyed within the last 10 years (see Table 1, Figures 3, 4, 5, and 7). Acreage surveyed for the inventory on public lands includes 98.6 acres on USFS, 555 acres on BLM, and 1.9 acres on SITLA land. An additional 119 acres were surveyed on private land.

Cultural resources were recorded as archaeological sites or linear sites. Archaeological sites are defined as spatially definable areas with ten or more artifacts and/or features. Sites were documented by the archaeologists walking transects across the site, spaced no more than 3 m (10 ft) apart and marking the locations of cultural materials with pin flags. This procedure allowed clear definition of site boundaries and artifact concentrations. At the completion of the surface inspection, a handheld Trimble GeoXH GPS unit was employed to point-provenience diagnostic artifacts and other relevant features in reference to the site datum, an aluminum capped rebar stake stamped with the temporary site number. The archaeological sites were plotted on a 7.5' USGS quadrangle map, photographed, and documented with site data entered on a Utah Archaeology Site Form (2018 version) inventory form (Appendix A). The documentation of linear sites (e.g., roads, canals) followed the Utah Professional Archaeological Council guidelines (updated 2008), which state, "linear features encountered within a survey area that extend outside of the inventory should be field recorded to a maximum of 400 meters in each direction outside of the survey area." Linear sites were plotted on a 7.5' USGS quadrangle with site data entered on a Utah Archaeology Site Form (2018 version) inventory form (Appendix A).

INVENTORY RESULTS

The inventory of NRCS' proposed Sevier Valley Watershed Project in the location of six previously recorded sites (42SV2343, 42SV2500, 42SV2502, 42SV3046, 42SV3389, and 42SV3522), the update or redocumentation of seven previously recorded sites (42SV693, 42SV1375, 42SV1821, 42SV1824, 42SV2344, 42SV3862, and 42SV3863) and the documentation of 22 newly identified sites (42SV3896-42SV3917) (Table 3). Three sites (42SV665, 42SV1485, and 42SV2087) shown on PresPro to be in the project area have either been destroyed or were misplotted. Sites 42SV665 and 42SV2087 were not relocated during the survey. Site 42SV1485 was misplotted in the incorrect township. In addition to archaeological sites, seven isolated finds were also documented (IF-A – IF-G) (Table 4).

Archaeological Sites

Smithsonian Site No.: 42SV665
Affiliation: Fremont
Site Type/Name: Artifact Scatter
Land Status: Forest Service

Eligibility: N/A
Description: Site 42SV665 is a roughly [redacted] artifact scatter of Fremont affiliation documented by UDSH-Antiquities in 1976. [redacted] A couple of utility poles related to the power grid [redacted] as well as numerous ATV/dirt bike trails, which may have destroyed the site. The survey area [redacted] and no prehistoric sites were found in that area. There is no site form on record for 42SV665 at the Fishlake National Forest Office or at the Utah Division of State History. Due to a lack of site form, the site could not be pursued outside of the inventory area. Therefore, the site is thought to be either destroyed or the plot on record is incorrect. All information on this form is derived from Preservation Pro.

Smithsonian Site No.: 42SV693
Affiliation: Fremont
Site Type/Name: Rock Shelter/Rock Art
Land Status: BLM
Eligibility: Eligible, C and D
Description: Site 42SV693 was originally recorded in 1976 by the BYU Department of Archaeology and Anthropology. When BYU documented the site in 1976, the [redacted]. MOAC relocated site 42SV693 during the current inventory. [redacted] MOAC completed a full re-record to correct the site plot, update the site description, and add a Part D to describe the rock art. Site 42SV693 [redacted]

Smithsonian Site No.: 42SV1375
Affiliation: Fremont
Site Type/Name: Rock Art
Land Status: Private Property
Eligibility: Eligible, C and D

Description: Site 42SV1375 is a rock art site originally documented in 1979 and assigned site number 42SV1375. In 1987, a cultural resource report of the [redacted] identified a rock art site [redacted] and referred to as 42SV2187. The report provides a vague description and no photos and to date, no form for 42SV2187 has been found. During the current inventory, MOAC examined the SHPO plot and surrounding area for 42SV1375 and no rock art or sites [redacted]. At the SHPO plot for 42SV2187, rock art was located that matched photos from the 42SV1375 site form. These panels also corresponded with the descriptions provided in the 1987 report. MOAC determined that 42SSV1375 and 42SV2187 were the same site, and that the original plot for 42SV1375 was inaccurate. MOAC conducted a full-rerecord to combine the previous documentations under the original number (42SV1375) and to add previously undocumented panels. This redocumentation provides a sketch map, Part-D forms, updated photos, and the correct plot for site 42SV1375. [redacted]

Smithsonian Site No.: 42SV1485
Affiliation: Unknown Prehistoric
Site Type/Name: Habitation and lithic scatter
Land Status: Forest Service
Eligibility: Eligible, D
Description: Site 42SV1485 is a short-term prehistoric habitation site [redacted]. It was documented by the Forest Service in 1989. [redacted]

Smithsonian Site No.: 42SV1821
Affiliation: Historic

Site Type/Name: Domestic Artifact Scatter
Land Status: BLM/Private
Eligibility: Eligible, D
Description: Site 42SV1821 is the Richfield City Dump, which was first documented in 1984 by CRMS/BYU. [redacted]

Smithsonian Site No.: 42SV1824
Affiliation: Historic
Site Type/Name: Domestic Artifact Scatter
Land Status: Forest Service
Eligibility: Not Eligible
Description: Site 42SV1824 is a historic and modern trash scatter. It was first documented by CRMS/BYU in 1984 as a historic dump [redacted]. Environmental Planning Group visited the site location in 2011 and were unable to locate the materials originally described. In 2016, the NRCS revisited the area and found that abundant materials were [redacted] while the original site sketch noted debris [redacted]. However, the NRCS felt that these

materials related to the original site and an update was completed to document the new, larger area. [redacted]

Smithsonian Site No.: 42SV2087
Affiliation: Historic
Site Type/Name: Corral and Dugout
Land Status: Private
Eligibility: Not Eligible
Description: Site 42SV2087 is a corral and dugout camp area documented by CRMS/BYU in 1985 [redacted] This area was examined as well as the area around the site plot derived from Preservation Pro. Site 42SV2087 was not relocated within the current inventory area and could not be identified on aerial or satellite imagery in the project area or nearby. Since the site was previously determined ineligible, the site was not extensively searched for outside of the APE. The site was in poor condition at the time of documentation in 1985 with impacts cited as collapse and vandalism. It is possible in the last 34 years the site has been destroyed by dismantling, colluvial movement, or utility line construction.

Smithsonian Site No.: 42SV2343
Affiliation: Historic
Site Type/Name: Vermillion Canal
Land Status: Private
Eligibility: Eligible, A, C, D
Description: Site 42SV2343 represents the Vermillion Canal, which was built in 1878 and continues in use today. Various portions of the canal have been previous documented by Abajo (U94AS0567), Mountain States Archaeology (U04MC0106), MOAC (U05MQ0241), SWCA (U06ST1699), Western

Land Services (U07LW1225 & U08LW0080), and Bighorn (U12HO0545). In 2008, Western Land Services (documented the portion of the canal that intersects the current project area. The portion of the canal that occurs in the current project area was previously recorded by Western Land Services in 2008 (U07LW1125). MOAC revisited the canal segment within the project area. The segment remains unchanged since its original documentation 11 years ago.

Smithsonian Site No.: 42SV2344
Affiliation: Historic
Site Type/Name: Sevier Valley Canal/ Piute Canal
Land Status: BLM, SITLA, Private
Eligibility: Eligible, A
Description: Site 42SV2344 is the Sevier Valley Canal/Piute Canal. It is the largest canal in Sevier County, extending nearly 53 miles from its diversion from the Sevier River southwest of Joseph to its termination near the Sevier River Bridge Reservoir. [redacted] Historic records indicate the canal company responsible for building the canal was incorporated in 1910 and construction on it began the same year (Whetstone 1990). Various portions of the canal have been previously documented by several companies, with Abajo Archaeology being the first in 1994 (U94AS0567). [redacted]

Smithsonian Site No.: 42SV2500
Affiliation: Historic
Site Type/Name: Richfield Canal
Land Status: Private
Eligibility: Eligible, A & C
Description: Site 42SV2500 is the Richfield Canal constructed by Richfield Canal Company in 1893. [redacted] Baseline first documented the canal in 2000 (U00BS0252) and additional portions of it have been documented by Mountain States Archaeology (U-04MV0196), Western Land Services (U06LW0586 & U07LW1125), Bighorn Archaeology (U06HO1424 & Unknown Proj. No), MOAC (U06MQ1531), UDOT (Unknown Proj. No.), and NRCS

(U16SH0587). The current project area intersects with the canal in two places in [redacted]. Western Land Services documented the portion of the canal in the project area in 2008. The canal at both its intersections with the project area were revisited and found to be unchanged since that time.

Smithsonian Site No.: 42SV2502
Affiliation: Historic
Site Type/Name: D&RGW RR, Marysvale Branch
Land Status: Private
Eligibility: Eligible, A, C, and D
Description: Site 42SV2502 represents the Marysvale Branch of the Denver and Rio Grande Western Railroad. The branch, constructed as a narrow-gauge railroad in 1890 and replaced with a standard gauge track the following year, was in use for 93 years before it was eventually abandoned. The track did not actually extend to Marysvale until 1900. The branch was abandoned after the Thistle landslide occurred in 1983. Various portions of the railroad spur have been documented since soon after its abandonment. These efforts include those by BYU (Unknown Proj. No.), MOAC (U01MQ0130, U02MQ0171, U03MQ0183, U05MQ0241), Earth Touch (U03EP0044), Mountain States Archaeology (U04MV0106), Baseline (U05BS0538), Western Land Services (U06LW0586, U08LW1125, U08LW0080), Bighorn Archaeology (U06HO1424, U12HO0545), SWCA (U06ST1699), Sagebrush Archaeology (U08SJ0697), and NRCS (U16SH0689). The current project area intersects with 42SV2502 [redacted]. Western Land Services recorded this segment of the railroad in 2008 (U07LW1125). As detailed in the 2008 IMACs update, a portion of the railroad crossing through the current project area has been destroyed. MOAC revisited the site and observed that the documented portion of railroad bed through the project area has been graded and is essentially destroyed. MOAC did not observe any related features or artifacts.

Smithsonian Site No.: 42SV3046
Affiliation: Historic/Ancestral Puebloan (?)
Site Type/Name: Trash Scatter/ Prehistoric Ceramic Scatter
Land Status: BLM
Eligibility: Eligible, D
Description: Recorded by Western Land Services as part of a seismic project in 2007 (U07LW1125), site 42SV3046 [redacted] to the dump and likely reflects sporadic dumping for the last 120 years. [redacted] 42SV3046 was revisited during the current survey and found to be well-documented. No notable changes to the site condition or artifact assemblage were noted.

Smithsonian Site No.: 42SV3389
Affiliation: Historic

Site Type/Name: Historic Campsite
Land Status: Forest Service
Eligibility: Not Eligible
Description: Site 42SV3389 was identified by the Environmental Planning Group (EPG) during the [redacted] in 2010 (U10EO510). The site consists of a historic artifact scatter and roadside camp. [redacted] MOAC revisited the site during the current inventory and found the site to be well documented. No new impacts were noted since its original documentation.

Smithsonian Site No.: 42SV3522
Affiliation: Historic
Site Type/Name: Historic Trash Scatter
Land Status: Private
Eligibility: Not Eligible
Description: Site 42SV3522 is a small, but dense, historic artifact scatter first recorded in 2010 by EPG. [redacted] MOAC revisited the site in 2019 and found no evidence of disturbance since its initial documentation.

Smithsonian Site No.: 42SV3862
Affiliation: Historic
Site Type/Name: Powerline
Land Status: Private
Eligibility: Not Eligible
Description: Site 42SV3862 was originally recorded in 2018 by Montgomery Archaeological Consultants. The site is a linear segment of a powerline [redacted]

Smithsonian Site No.: 42SV3863
Affiliation: Historic

Site Type/Name: Civilian Conservation Road
Land Status: SITLA/Private
Eligibility: Eligible, A
Description: Site 42SV3863 is a segment of Fishlake NF Road 40096, also known as Civilian Conservation Road, [redacted] This road, which was originally constructed by the Civilian Conservation Corp stationed in Richfield during the winter of 1933, was a wood haul road that ran 12 miles into the western mountains towards Fillmore, Utah (Bishop 1997: 179). [redacted]

Smithsonian Site No.: 42SV3896
Affiliation: Unknown Prehistoric
Site Type/Name: Task Specific Artifact Scatter
Land Status: BLM
Eligibility: Not Eligible
Description: Site 42SV3896 is a small (963 m^2) task specific site consisting of a small lithic scatter [redacted]

Smithsonian Site No.: 42SV3897
Affiliation: Historic
Site Type/Name: Gravel Pit/Trash Scatter
Land Status: BLM
Eligibility: Not Eligible
Description: Site 42SV3897 is a large ([redacted]) historic site [redacted] The site seems to represent a small gravel pit operation. [redacted]

[redacted]

Smithsonian Site No.: 42SV3898
Affiliation: Historic
Site Type/Name: Telephone Line
Land Status: BLM
Eligibility: Not Eligible
Description: Site 42SV3898 consists of [redacted] cut down telephone poles [redacted]. [redacted] At some point the utility poles were cut down leaving stumps in their place. [redacted]
Specific information regarding this telephone line could not be located in the Utah Centennial County History Series, Utah Digital Newspapers, cadastral plats, or GLO records. However, the telephone line is thought to have been installed in the early 20th century and dismantled by the 1950's. These dates are based on when the Rocky Mountain Bell Telephone Company began installing telephone lines in Sevier County to bring telephone service to its residents, which was July 1901. The telephone line documented is not visible on 1953 or 1958 aerial imagery and is not on the 1961 [redacted] Quadrangle, indicating it was dismantled by this time. [redacted]

Smithsonian Site No.: 42SV3899
Affiliation: Historic
Site Type/Name: Lime Kilns
Land Status: BLM
Eligibility: Eligible, A-D
Description: Site 42SV3899 consists of a large lime kiln feature and associated retaining wall. [redacted] The lime kilns recorded in this area were constructed by Jens Larson Jenson and J.H. Kyhl beginning in 1903. This kiln [redacted] are all part of the lime production activity that took place in the Sevier Valley beginning in the 1880s (Notarianni 1978). Jens Larson Jenson (sometimes spelled Jensen) was born in Dalby, Scona, Sweden on July 14, 1827. Jenson converted to Mormonism and joined the Church of Latter-day Saints in 1855 and served a two-year church mission while living in Sweden (Eagle Scouts Kiosk). Four years later (in 1859) Jenson moved to Utah after joining the Rowley Handcart Company

(Notarianni 1978). After serving jail time for the outlawed practice of polygamy, Jenson arrived in Richfield to settle in the late 1880s. Jenson made a living farming and curing lime, which was an important material used in construction. To cure the limestone, Jenson built a total of seven lime kilns in the [redacted]. The first kilns he created were small structures constructed [redacted], such as this kiln and the one at 42SV3900. These smaller kilns were constructed prior to the construction of the larger more efficient kilns (Notarianni 1978). One such kiln built in 1903 by Kyhl is known as the "Jens Larson Jenson Lime Kiln" and is located two miles north of Richfield, Utah [redacted]. The Jens Larson Jenson Lime Kiln was listed to the National Register of Historic Places in 1978. Jenson produced lime until 1907 when he passed away sometime after losing his eyesight due to years of working in extreme head associated with operating the lime kilns (Notarianni 1978 and Richfield Reaper 1976). After his death, the kilns were operated for at least three years by Jenson's sons and in 1910 the Jens Larson Jenson Lime Kiln was sold to Leonard Ogden. The Jens Larson Jenson Lime Kiln was operated by Ogden for years after and the lime produced during this time was used to construct buildings like the Elsinore Sugar Factory and the Richfield First Ward Chapel (Notarianni 1978). It is unclear if the smaller kilns like 42SV3899 were still used after Jenson's death in 1907. Like the Jens Larson Jenson Lime Kiln, the kiln at 42SV3899 was [redacted]. [redacted] As described in the interpretive kiosk sign at the Jens Larson Jenson Kiln [redacted], these kilns were fitted with a metal grate at the bottom to hold rocks in them as a fire burned below (Eagle Scouts Kiosk). To create the lime, fires would burn underneath the rocks for three days. After this process, the material was hauled to town where it was sold (Eagle Scouts Kiosk). [redacted] This kiln and others represent a skilled process provided by Jenson that contributed to the development of Richfield and the surrounding area.

Smithsonian Site No.: 42SV3900
Affiliation: Historic
Site Type/Name: Lime Kiln
Land Status: BLM
Eligibility: Eligible, A-D
Description: Site 42SV3900 is a historic lime kiln related to lime production in and near Richfield, Utah. It consists of a large kiln feature constructed of local limestone and silt stone materials used to produce lime which was in turn used for construction. [redacted] The lime kilns recorded in this area were constructed by Jens Larson Jenson and J.H. Kyhl beginning in 1903. This kiln and [redacted] are all part of the lime production activity that took place in the Sevier Valley beginning in the 1880s (Notarianni 1978). Jens Larson Jenson (sometimes spelled Jensen) was born in Dalby, Scona, Sweden on July 14, 1827. Jenson converted to Mormonism and joined the Church of Latter-day Saints in 1855 and served a two-year church mission while living in Sweden (Eagle Scouts Kiosk). Four years later (in 1859) Jenson moved to Utah after joining the Rowley Handcart Company (Notarianni 1978). After serving jail time for the outlawed practice of polygamy, Jenson arrived in Richfield to settle in the late 1880s. Jenson made a living farming and curing lime,

which was an important material used in construction. To cure the limestone, Jenson built a total of seven lime kilns [redacted]. The first kilns he created were small structures [redacted] as this kiln and the one at 42SV3899. These smaller kilns were constructed prior to the construction of the larger more efficient kilns (Notarianni 1978). One such kiln built in 1903 by Kyhl is known as the "Jens Larson Jenson Lime Kiln" and is located two miles north of Richfield, Utah [redacted]. The Jens Larson Jenson Lime Kiln was listed to the National Register of Historic Places in 1978. Jenson produced lime until 1907 when he passed away sometime after losing his eyesight due to years of working in extreme head associated with operating the lime kilns (Notarianni 1978 and Richfield Reaper 1976). After his death, the kilns were operated for at least three years by Jenson's sons and in 1910 the Jens Larson Jenson Lime Kiln was sold to Leonard Ogden. The Jens Larson Jenson Lime Kiln was operated by Ogden for years after and the lime produced during this time was used to construct buildings like the Elsinore Sugar Factory and the Richfield First Ward Chapel (Notarianni 1978). It is unclear if the smaller kilns like 42SV3900 were still used after Jenson's death in 1907. Like the Jens Larson Jenson Lime Kiln, the kiln at 42SV3900 [redacted]. As described in the interpretive kiosk sign at the Jens Larson Jenson Kiln [redacted], these kilns were fitted with a metal grate at the bottom to hold rocks in them as a fire burned below (Eagle Scouts Kiosk). To create the lime, fires would burn underneath the rocks for three days. After this process, the material was hauled to town where it was sold (Eagle Scouts Kiosk). The kiln recorded as 42SV3900 is undoubtedly associated with several other constructed kilns [redacted]. This kiln and others represent a skilled process provided by Jenson that contributed to the development of Richfield and the surrounding area.

Smithsonian Site No.: 42SV3901
Affiliation: Historic
Site Type/Name: Domestic Artifact Scatter
Land Status: BLM
Eligibility: Not Eligible
Description: Site 42SV3901 is a small ([redacted]) historic artifact scatter [redacted]

Smithsonian Site No.: 42SV3902
Affiliation: Fremont

Site Type/Name: Long-Term Habitation
Land Status: BLM
Eligibility: Eligible, D
Description: Site 42SV3902 is a small ( ) probable Fremont habitation site [redacted]

Smithsonian Site No.: 42SV3903
Affiliation: Unknown Prehistoric
Site Type/Name: Task Specific Artifact Scatter
Land Status: BLM
Eligibility: Not Eligible
Description: Site 42SV3903 is a small ( ) task specific site of unknown prehistoric affiliation [redacted]

Smithsonian Site No.: 42SV3904
Affiliation: Unknown Prehistoric/Historic
Site Type/Name: Task Specific Artifact Scatter/ Temporary Camp
Land Status: BLM
Eligibility: Not Eligible
Description: Site 42SV3904 is a small ( ) multi-component site [redacted] The prehistoric component is of unknown affiliation [redacted] The historic component consists of a [redacted]

[redacted] An examination of historic aerial imagery shows nothing in the area.

Smithsonian Site No.: 42SV3905
Affiliation: Unknown Prehistoric/Historic
Site Type/Name: Artifact Scatter/Gravel Pit
Land Status: BLM
Eligibility: Not Eligible
Description: Site 42SV3905 is a small ([redacted]) mining operation for gravel[redacted]

Smithsonian Site No.: 42SV3906
Affiliation: Unknown Prehistoric/Historic
Site Type/Name: Artifact Scatter
Land Status: BLM
Eligibility: Not Eligible
Description: Site 42SV3906 is a [redacted] multi-component artifact scatter [redacted] The historic component [redacted] The prehistoric component of the site consists of a small lithic scatter. [redacted]

Smithsonian Site No.: 42SV3907
Affiliation: Unknown Prehistoric
Site Type/Name: Task Specific Artifact Scatter
Land Status: BLM
Eligibility: Not Eligible

Description: Site 42SV3907 is a [redacted] task specific lithic scatter of unknown prehistoric cultural affiliation. [redacted]

Smithsonian Site No.: 42SV3908
Affiliation: Prehistoric/Historic, unknown
Site Type/Name: Rock Ring
Land Status: BLM
Eligibility: Eligible, D
Description: Site 42SV3908 consists of a single rock ring feature. [redacted]

Smithsonian Site No.: 42SV3909
Affiliation: Historic
Site Type/Name: Domestic Artifact Scatter
Land Status: BLM/Private
Eligibility: Not Eligible
Description: Site 42SV3909 is a large [redacted] local roadside dump [redacted]

[redacted]

Smithsonian Site No.: 42SV3910
Affiliation: Historic
Site Type/Name: Dugout
Land Status: Private
Eligibility: Eligible, D
Description: Site 42SV3910 is a previously documented historic dugout [redacted] The site was originally documented as 42SV2188 by Archaeological Research Consultants in 1987, but no site form was completed, and the only description of the site is in the report (U87AK0773); the location plotted in Pres Pro was examined and found to be misplotted. A prehistoric lithic scatter [redacted] was also documented under 42SV2188 in 1987 by Abajo Archaeology. Abajo Archaeology completed a site form that was submitted to the Utah Division of State History. After consulting with the Utah Division of State History, it was determined that the historic dugout site needed a unique site number and was issued 42SV3910. The site is small [redacted] was patented to Hans C. H. Ramlose in 1896 under the Homestead Act of 1862 (12 Stat. 392). Hans C. H. Ramlose was born in Denmark in 1822 and immigrated to Utah with his wife Johannah in 1877 after converting to Mormonism. They had nine children together, eight of which survived his death in 1898. His wife preceded him in death. Hans first moved to Richfield in 1878 and stayed for four years. He relocated for a few years but returned to Richfield in 1888 where he resided until his death. At the time of his death in 1898, Hans Ramlose was considered one of the earliest pioneers of the Richfield area and one of the "hand cart brigade to claim the honor of settling this part of Utah and making a barren desert habitable" (*Salt Lake Herald-Republican* 1898 June 14:6). Posthumously, the results of a land case were printed in the *Salt Lake Herald-Republican* that mentions Ramlose had improved a portion of land embraced by his entry and proved sufficient waterpower to entitle him to patent for his land (1898 September 8). [redacted] It appears after his death, part of the Hans Ramlose estate was left intact with some portions parceled out for inheritance by his surviving children (*Salt Lake Tribune* 1904 June 15). Besides a few newspaper articles and information regarding his gravesite online, no additional sources could be located regarding Hans Ramlose and his life and contributions to Sevier Valley. [redacted]

Smithsonian Site No.: 42SV3911
Affiliation: Unknown Prehistoric
Site Type/Name: Depression and wall
Land Status: BLM
Eligibility: Eligible, D
Description: Site 42SV3911 consists of two features including a rock wall and a rock ring/depression [redacted] The site is presumed to be prehistoric affiliated until further work, such as testing, can be conducted.

Smithsonian Site No.: 42SV3912
Affiliation: Historic
Site Type/Name: Domestic Artifact Scatter
Land Status: Forest Service
Eligibility: Not Eligible
Description: Site 42SV3912 is a medium sized [redacted] historic artifact scatter/dump. [redacted]

Smithsonian Site No.: 42SV3913
Affiliation: Unknown Prehistoric
Site Type/Name: Task Specific Artifact Scatter
Land Status: Forest Service
Eligibility: Not Eligible
Description: Site 42SV3913 is a small [redacted] lithic scatter [redacted]

Smithsonian Site No.: 42SV3914
Affiliation: Historic
Site Type/Name: Domestic Artifact Scatter
Land Status: Forest Service
Eligibility: Not Eligible
Description: Site 42SV3914 is a [redacted] trash dump [redacted]

Smithsonian Site No.: 42SV3915
Affiliation: Historic
Site Type/Name: Domestic Artifact Scatter
Land Status: Forest Service
Eligibility: Not Eligible
Description: Site 42SV3915 is a [redacted] historic artifact scatter with some modern debris. [redacted]

Smithsonian Site No.: 42SV3916
Affiliation: Historic
Site Type/Name: Domestic Artifact Scatter
Land Status: Private
Eligibility: Not Eligible
Description: Site 42SV3916 is a small [redacted] scatter of dense glass and ceramic fragments concentrated around a small concrete pad. [redacted] Although the land is on private property, a GLO record search could not tie the site location to a specific land patent.

Smithsonian Site No.: 42SV3917
Affiliation: Historic
Site Type/Name: Telegraph/Telephone Line

Land Status: Private/SITLA
Eligibility: Not Eligible
Description: Site 42SV3917 is a segment of an old telegraph or telephone line [redacted] These poles and wire are thought to be a telegraph line but could possibly be a telephone line. An intensive search of cadastral plats, historic maps, digital newspaper archives, Utah Centennial County History Series, as well as other Utah publications was pursued and the direct age, affiliation, and function of the line could not be found. A general history of the telegraph and telephone of Richfield and Sevier Valley follows. The first transcontinental telegraph line when into operation in 1861, which passed through Salt Lake City, and was greatly assisted by the Mormons who provided almost 1,000 miles of the line (Arrington 1951). Brigham Young used this experience to establish the Deseret Telegraph Company, with the goal of constructing a north-south territorial line to connect all Mormon settlements. The southern terminus of the line was planned for St. George, traveling through Fillmore in Millard County. The line between Logan and St. George was opened in the beginning of 1867. In 1872, the line was extended from Gunnison to Monroe to serve the Sevier Valley settlements. The efforts of the Deseret Telegraph Company were co-operative in nature and settlements helped provide supplies and labor. Richfield was responsible for supplying 450 of the poles. The Mormon Church sold the company to Western Union in 1900 (Arrington 1951). This site could possibly be a spur off the Sevier Valley line. In 1901, telephone service arrived in Sevier County when the Rocky Mountain Bell Telephone Company extended its lines into the area (Bishop 1997). By 1930, 174 of the county's 653 farms had telephones (Bishop 1997). On a 1917 cadastral plat for [redacted] the "Govt. Telephone Line from Richfield to Rockwood Ranger Station" is shown with a spur extending to the Red View Rangers Cabin (later the Ranger Station) and beyond. This site could also be part of this government line. The primary use dates for the site are general and given as ca. 1872 to ca. 1935, based on the establishment of telegraph lines in Sevier Valley (1872) and the turning point of when clear glass insulators became primarily used over colored glass insulators (1935), [redacted]. It's possible if this site represents a telephone line it was used beyond 1935, it just cannot be determined at this time.

Table 3. Archaeological Sites Associated with NRCS' Sevier Valley Watershed Project.

Smithsonian Site No.	Affiliation	Site Type	Eligibility	Land Status
42SV665 (Not Relocated)	Fremont	Artifact Scatter	N/A	Forest Service
42SV693	Fremont	Rock Shelter/Rock Art	Eligible, C&D	BLM
42SV1375	Fremont	Rock Art	Eligible, C&D	Private
42SV1485 (Misplotted in PA, outside APE).	Unknown Prehistoric	Habitation	Eligible, D	Forest Service
42SV1821	Historic	Domestic Artifact Scatter (Dump)	Eligible, D	BLM/Private
42SV1824	Historic	Domestic Artifact Scatter	Not Eligible	Forest Service
42SV2087 (Not Relocated)	Historic	Dugout & Corral	Not Eligible	Private
42SV2343	Historic	Vermillion Canal	Eligible, A, C, D	Private
42SV2344	Historic	Sevier Valley Canal	Eligible, A	BLM/SITLA/Private
42SV2500	Historic	Richfield Canal	Eligible, A, C	Private
42SV2502	Historic	Historical Railroad	Eligible, A, C, D	Private

42SV3046	Historic	Historic Trash Dump with Prehistoric Component	Eligible, D	BLM
42SV3389	Historic	Historic Campsite, Prehistoric Isolate	Not Eligible	Forest Service
42SV3522	Historic	Historic Artifact Scatter	Not Eligible	Private
42SV3862	Historic	Powerline	Not Eligible	Private
42SV3863	Historic	CCC Road	Eligible, A	SITLA/Private
42SV3896	Unknown Prehistoric	Artifact Scatter	Not Eligible	BLM
42SV3897	Historic	Gravel Pit	Not Eligible	BLM
42SV3898	Historic	Telephone Line	Not Eligible	BLM
42SV3899	Historic	Lime Kilns	Eligible, A-D	BLM
42SV3900	Historic	Lime Kiln	Eligible, A-D	BLM
42SV3901	Historic	Domestic Artifact Scatter	Not Eligible	BLM
42SV3902	Fremont	Habitation	Eligible, D	BLM
42SV3903	Unknown Prehistoric	Artifact Scatter	Not Eligible	BLM
42SV3904	Multicomponent	Artifact Scatter/Temp Camp	Not Eligible	BLM
42SV3905	Multicomponent	Artifact Scatter/Gravel Pit	Not Eligible	BLM
42SV3906	Multicomponent	Artifact Scatter	Not Eligible	BLM
42SV3907	Unknown Prehistoric	Artifact Scatter	Not Eligible	BLM
42SV3908	Unknown Prehistoric	Rock Ring	Eligible, D	BLM
42SV3909	Historic	Artifact Scatter	Not Eligible	BLM
42SV3910	Historic	Dugout	Eligible, D	Private
42SV3911	Unknown Prehistoric	Depression & Rock Wall	Eligible, D	BLM
42SV3912	Historic	Domestic Artifact Scatter	Not Eligible	Forest Service
42SV3913	Unknown Prehistoric	Artifact Scatter	Not Eligible	Forest Service
42SV3914	Historic	Domestic Artifact Scatter	Not Eligible	Forest Service
42SV3915	Historic	Domestic Artifact Scatter	Not Eligible	Forest Service
42SV3916	Historic	Domestic Artifact Scatter	Not Eligible	Private
42SV3917	Historic	Telegraph/Telephone Line	Not Eligible	SITLA/Private

Isolated Finds of Artifacts

Seven IFs were identified during the survey (Table 4). The IFs include two chipped stone tool fragments (IF-D and IF-E), two probable Fremont corn cobs (IF-B and IF-C), a cairn (IF-A), a rock wall (IF-F), and a small artifact cluster consisting a core/chopper, a used flake, and two tertiary flakes (IF-G).

Table 4. Isolated Finds Associated with NRCS' Sevier Valley Watershed Project

Isolated Find	Land Status	Legal Description	Affiliation	Artifact(s) Description	Comments
IF-A	Private	[redacted]	Historic	Cairn	[redacted]
IF-B	BLM	[redacted]	Fremont	Corn Cob	

Isolated Find	Land Status	Legal Description	Affiliation	Artifact(s) Description	Comments
IF-C	BLM	[redacted]	Fremont	Charred Corn Cob	
IF-D	BLM	[redacted]	Unknown Prehistoric	Stage VI Biface Fragment	[redacted]
IF-E	BLM	[redacted]	Unknown Prehistoric	Project Point Fragment	
IF-F	BLM	[redacted]	Historic (?)	Rock Wall	
IF-G	Forest	[redacted]	Unknown Prehistoric	Artifact Cluster	

NATIONAL REGISTER OF HISTORIC PLACES EVALUATION

The National Register Criteria for Evaluation of Significance and procedures for nominating cultural resources to the National Register of Historic Places (NRHP) are outlined in 36 CFR 60.4 as follows:

> The quality of significance in American history, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects of State and local importance that possess integrity of location, design, setting, material, workmanship, feeling, and association, and that they:
>
> a) are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> b) are associated with the lives of persons significant to our past; or
>
> c) embody the distinctive characteristics of a type, period, or method of construction; or that represents 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) have yielded or may be likely to yield information important in prehistory or history.

The inventory of NRCS' proposed Sevier Valley Watershed Project resulted in the location of six previously recorded sites (42SV2343, 42SV2500, 42SV2502, 42SV3046, 42SV3389, and 42SV3522), the update or redocumentation of seven previously recorded sites (42SV693, 42SV1375, 42SV1821, 42SV1824, 42SV2344, 42SV3862, and 42SV3863) and the documentation of 22 newly identified sites (42SV3896-42SV3917). Of the 13 previously documented sites, 9 have been recommend as eligible for listing on the NRHP based on Criterion A (42SV2344 and 42SV3863), Criterion D (42SV1821 and 42SV3046), Criteria C and D (42SV693 and 42SV1375) or Criteria A, C, and D (42SV2343, 42SV2500 and 42SV2503). MOAC relocated these sites and agrees with the original eligibility determinations. Four previously recorded sites have been determined ineligible for listing on the NRHP, these include 42SV1824, 42SV3389, and 42SV3522, 42SV3862. MOAC identified no additional materials, features, artifacts, or information at these sites that would alter the original determinations.

Of the 22 newly documented sites 6 are recommended as eligible for the NRHP and 17 are recommended as ineligible. The six sites recommended as eligible include 42SV3899, 42SV3900, 42SV3902, 42SV3908, 42SV3910, and 42SV3911. Sites 42SV3899 and 42SV3900 represent historic kilns built and operated by Jens Larson Jenson at the beginning of the 20th Century. One Jenson lime kiln, not one of those recorded as part of this project, is already listed on the NRHP. The additional kilns at 42SV3899 and 42SV3900 have similar integrities and fulfill all four eligibility criteria. Sites 42SV3902 represents a Fremont habitation site [redacted]. The site retains integrity of location, design, setting, materials, feeling, and association. Given the likelihood of buried structural remains, it is likely to contribute to our understanding of Formative lifeways in the Sevier River valley and is recommended as eligible based on Criterion D. 42SV3908 and 42SV3911 represent architectural features likely representing prehistoric structures, [redacted]

[redacted]. 42SV3908 consists of circular rock ring [redacted]. It is similar in morphology, size, and construction to Fremont-affiliated structures in the region (e.g., 42SV1897). Although no artifacts were identified, the lichen growth present on the boulders used to construct the feature is considerable and suggests considerable antiquity. Site 42SV3911 consists of a large boulder-lined depression and associated rock wall. The depression has a similar size to numerous several Fremont pit structures excavated at Icicle Bench, Clear Creek, and Five Finger Ridge (Talbot et al. 1997). Both 42SV3908 and 42SV3911 are tentatively recommended as eligible for listing on the NRHP under Criterion D. Though beyond the scope of this project, nature and extent testing at both sites would confirm or refute the assumed function and affiliation of the structures. Finally, site 42SV3910 is a historic dugout on land patented to Hans C.H. Ramlose in 1896. The dugout [redacted]. While [redacted], the site likely contains buried cultural deposits that may help elucidate subsistence and economic strategies of early pioneers in the Sevier River Valley. Therefore, site 42SV3910 is recommended as eligible for listing on the NRHP based on Criterion D.

The 17 sites recommended as ineligible for listing on the NRHP include 6 historic artifact scatters (42SV3901, 42SV3909, 42SV3912, 42SV3914, 42SV3915, and 42SV3916), 2 transmission lines (42SV3898 and 42SV3917), 4 prehistoric artifact scatters (42SV3896, 42SV3903, 42SV3907, and 42SV3913), a gravel pit (42SV3897), and 3 multicomponent sites (42SV3904, 42SV3905, and 42SV3906). The historic artifact scatters are all small single episode dumping events [redacted]. The domestic refuse dumps cannot be tied to events of persons significant to the past nor do they reflect distinctive characteristics pertinent to type, period, or construction. Furthermore, they are unlikely to yield important historic information. Similarly, the prehistoric artifact scatters are small, have low artifact richness and density, lack temporally diagnostic artifacts or features, and little likelihood of having buried cultural remains. The prehistoric artifacts fail to meet any of the eligibility criteria. The two transmission lines, though extensively researched, could not be associated with any significant events or people and lack any temporal distinction. They too are unlikely to yield any data pertinent to the region's history. The gravel pit too fails to meet any of the eligibility criteria.

The three multicomponent sites include a prehistoric and historic artifact scatter (42SV3906), a historic gravel pit spatially associated with a small prehistoric artifact scatter (42SV3905), and a prehistoric artifact scatter associated with a historic tent platform and artifact scatter (42SV3904). Each component at all three sites lacks distinction or association with past events or people. There is no evidence to suggest that they contain information relevant to regional history and prehistory, and lack unique characteristics of type, period, or construction. All three multicomponent sites are recommended as ineligible for listing on the NRHP.

Finally, seven IFs were documented over the course of the fieldwork (IF-A – IF-G). While the two corn cobs (IF-B and C) are interesting and may be an indication of a nearby Fremont habitation or granary, none of the isolates are significant enough to warrant their listing on the NRHP.

CONCLUSIONS AND RECOMMENDATIONS

The inventory of NRCS' proposed Sevier Valley Watershed Project resulted in the location of six previously recorded sites (42SV2343, 42SV2500, 42SV2502, 42SV3046, 42SV3389, and 42SV3522), the update or redocumentation of seven previously recorded sites (42SV693, 42SV1375, 42SV1821, 42SV1824, 42SV2087, 42SV3862, and 42SV3863) and the documentation of 22 newly identified sites (42SV3896-42SV3917) (Table 3). Of the 13 previously documented sites, nine have been recommend as eligible for listing on the NRHP based on Criterion A, Criterion D, Criteria A and C, Criteria A, C, and D, or Criteria C and D and three previously recorded sites have been determined ineligible for listing on the NRHP. Of the 22 newly documented sites, 6 are recommended as eligible for the NRHP and 17 are recommended as ineligible.

Ten of the total 15 sites in the project area recommended or determined as eligible to the NRHP will be avoided by the proposed undertaking. Sites 42SV3899 and 42SV3900, both historic lime kilns, are at least 600 ft from any proposed disturbance. Both sites are also far enough away from the proposed disturbance that the setting and feeling aspects of their integrity will not likely be compromised. Sites 42SV693, 42SV1375, 42SV3046, 42SV3902, 42SV3908, 42SV3910, and 42SV3911 are all located in potential source material and rip rap areas. If work does occur in these areas, the sites will be avoided by at least 100 ft. Site 42SV2343, the Vermillion Canal, is along the north flood channel which the proponent plans to pipe from the Richfield canal to an existing channel that drains into the Sevier River. The proposed pipeline will be bored underneath 42SV2343, thereby avoiding any adverse impact to the Vermillion Canal.

Five sites (42SV1821, 42SV2344, 42SV2500, 42SV2502, and 42SV3863) may potentially be impacted by the proposed undertaking. Site 42SV1821 is a historic Richfield Dump. Proposed work at the location consists of cleaning debris and stabilizing the sides of the existing flood channel. The channel has previously been straightened and partially stabilized [redacted]. New disturbances will be limited to the footprint of the previously disturbed areas. If work is limited to the previous disturbance, there will likely be no adverse effect to the site. Spot monitoring of the construction is recommended.

Site 42SV2344 is the Sevier Valley/Piute Canal. The proposed project includes armoring a portion of the canal at one location and installing a flood control gate and armoring the floor and walls of the canal at a second location. At the head of the lateral canal, the proponent plans to construct an emergency canal overflow structure. Based on SHPO's guidelines pertaining to historic canals, these measures will constitute an adverse effect. Within the lateral canal, which is considered non-contributary, the proponent plans to improve the existing channel and install a rock chute and stilling basin downstream of the emergency canal overflow structure.

Site 42SV2500 is the Richfield Canal. The proposed project includes installing riprap at the confluence of the canal with the lateral of the Sevier Valley/Piute Canal to avoid erosion, the cleaning of approximately 2,000 linear feet of the Richfield Canal, and the installation of an emergency overflow and

pipe inlet structure with a trash rack in the Richfield Canal at the proposed storm water pipe location. Based on SHPO's guidelines pertaining to historic canals, these measures will constitute an adverse effect.

Site 42SV2502 is the Marysvale Branch of the Denver & Rio Grande Western Railroad. The proponent plans to install a storm water pipe within or adjacent to the former railroad alignment. The railroad bed through the project area has been destroyed by grading related to agriculture and the installation of the storm water pipe will not further degrade the integrity of the documented railroad within the project area.

Site 42SV3863 is the historic CCC road. The construction of a water retention dam may adversely affect an original segment of the road and an associated retaining wall. The depth of suitable rock on the hillslope, which is currently unknown, below the road and retaining wall will determine if the segment will be impacted.

Based on the inventory results and that one site will be, and possibly two other sites could be, impacted by the proposed undertaking, a finding of *adverse effect* is recommended for the proposed undertaking pursuant to Section 106.

Based on conversations with the proponent, lead agency, and SHPO, the following measures are suggested to mitigate the proposed project's adverse effect.

1. For potential impacts related to channel clearing and stabilization at 42SV1821, a post construction walk-through to document any impacts that may have accidentally occurred outside the previously disturbed area.
2. Per SHPO's potential recommended mitigation strategies related to historic canals, a "desktop" review of the Sevier Valley/Piute and Richfield canals will be conducted. While the entirety of the canals have been mapped by the Utah Division of Water Rights, the desktop review would use freely available satellite imagery (e.g., Google Earth, and historical aerial photographs to identified and locate historic alignments of the canals and their primary laterals, potential features (head gates, weirs, flumes, etc.), and modern alterations of the canals. Updated Utah Archaeological Site Forms will be produced detailing the results of the desktop analysis of the canals.
3. To mitigate potential adverse effects to 42SV3863, it is recommended that an interpretive sign detailing the significance of the CCC, in general, and the road, in particular, be installed at the nearby parking lot for the recently constructed Richfield mountain bike trails.

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APPENDIX A:

Utah Archaeology Site Forms

On File At:

Utah Division of State History

Salt Lake City, Utah

CULTURAL RESOURCE SURVEY OF THE NRCS' SOUTH FLOOD CHANNEL PROJECT: AN ADDENDUM REPORT TO THE NRCS' SEVIER VALLEY WATERSHED PROJECT NEAR RICHFIELD, SEVIER COUNTY, UTAH

REDACTED

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REDACTED

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Jessica Del Bozque

Prepared For:

Natural Resources Conservation Service
Salt Lake City, Utah

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UDOT Region 4
Richfield, Utah

Prepared Under Contract With:

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MOAC Report No. 23-026

March 4, 2024

State of Utah Public Lands Policy
Archaeological Survey Permit No. 167

State of Utah Antiquities Project (Survey)
Permit No. U23MQ0740

Utah Division of Wildlife Resources
Special Use Permit No. L169SU0167

ABSTRACT

In September 2023, MOAC conducted a cultural resource survey for the Natural Resources Conservation Service's (NRCS) South Flood Channel Project in Sevier County, Utah. This is an addendum report to the *Cultural Resource Survey of NRCS' Sevier Valley Watershed Project Near Richfield, Sevier County, Utah* conducted by MOAC between June 28 and August 11, 2019 (Patterson 2019; SHPO No. U19MQ0243). The South Flood Channel work is an additional component of this overall watershed project. The project occurs between Central Valley, Utah to the south and Richfield Municipal Airport to the north; and Interstate 70 to the west and the Annabella Wildlife Management Area to the east. It is in Township 24 South, Range 3 West, Sections 9, 10, 12, 13, 14, 15, and 16. The survey was conducted at the request of Jenna Jorgensen, Jones and DeMille Engineering, Richfield, Utah. The project occurs on lands managed by the Utah Division of Wildlife Resources (DWR) (81.4 acres), the Utah Department of Transportation (UDOT) (0.8 acres), and on private lands (236.6 acres). The proposed undertaking consists of reconstructing an overshot structure spanning the Sevier Valley Canal facilitating flow into a flood channel and allowing 50 cfs of spillover to enter the canal; constructing a rock chute and stilling basin to dissipate hydraulic energy downstream from the overshot structure; upgrading approximately 8,000 linear feet of existing open flood channel and replacing a 36 in. diameter culvert with a 48 in. diameter culvert; constructing a splitter structure allowing 50 cfs to enter the Richfield Canal and 100 cfs to enter a closed conduit inlet; installing approximately 8,600 linear feet of closed conduit pipe to convey flow from the splitter to an open channel; and installing a pipe outlet and approximately 5,600 linear feet of earthen channel leading to the Sevier River. The Area of Potential Effect (APE) covers 318.8 acres.

The cultural resource survey of the NRCS' South Flood Channel Project in Sevier County, Utah resulted in the identification and update of four previously recorded archaeological sites (42SV2344, 42SV2500, 42SV2502, and 42SV2600), the documentation of four newly identified archaeological sites (42SV4533-42SV4536), and the documentation of one isolated find (IF-A). Four of the cultural resources are recommended as eligible for inclusion in the National Register (42SV2344, 42SV2500, 42SV2502, 42SV2600); all four sites are linear. Of these four sites, the documented segments of two (42SV2502 and 42SV2600) sites within the APE are recommended as non-contributing elements to the eligibilities of the sites. Documented segments of 42SV2344 and 42SV2500 within the APE are considered contributing to their respective site eligibilities. At 42SV2344, the Sevier Canal, proposed work includes reconstructing the overshot structure for the flood channel (Feature A). Feature A has been previously modified which impacted its historic fabric and character and it is considered a non-contributing feature. Therefore, further modification to the feature will not have an adverse effect to site 42SV2344. At 42SV2500, the Richfield Canal, the proponent plans to install conduit pipe under the canal. The pipe will be bored, or an open cut may be used to install the pipe. If an open cut is used, the canal would be restored to pre-construction condition, which will not adversely affect site 42SV2500. The four newly documented sites (42SV4533-42SV4536) and isolated find (IF-A) are recommended as ineligible for NRHP listing. Based on the findings, a determination of *no adverse effect* is recommended for the undertaking pursuant to 36 CFR 800 and Section 106 of the National Historic Preservation Act.

Table of Contents

ABSTRACT i
INTRODUCTION 1
DESCRIPTION OF PROJECT AREA 3
ENVIRONMENTAL SETTING 3
HISTORICAL OVERVIEW 6
SURVEY METHODOLOGY 7
SURVEY RESULTS 7
ARCHAEOLOGICAL SITES 8
ISOLATED FINDS 12
NATIONAL REGISTER OF HISTORIC PLACES EVALUATION 12
CONCLUSIONS AND RECOMMENDATIONS 14
REFERENCES CITED 16

List of Figures

Figure 1. Cultural Resource Survey of the NRCS' South Flood Channel Project in Sevier County, Utah APE Showing Cultural Resources. 4
Figure 2. Project Area Overview facing West. U23MQ0740. 5
Figure 3. Project Area Overview facing Northeast. U23MQ0740. 5

List of Tables

Table 1. Previous Projects within One-Half Mile of the APE. 2
Table 2. Previously Recorded Sites within One-Half Mile of the APE. 3
Table 3. Management Summary Table. 14

INTRODUCTION

In September 2023, MOAC conducted a cultural resource survey for the Natural Resources Conservation Service's (NRCS) South Flood Channel Project in Sevier County, Utah. This is an addendum report to the *Cultural Resource Survey of NRCS' Sevier Valley Watershed Project Near Richfield, Sevier County, Utah* conducted by MOAC between June 28 and August 11, 2019 (Patterson 2019; SHPO No. U19MQ0243). The South Flood Channel work is an additional component of this overall watershed project. The project occurs between Central Valley, Utah to the south and Richfield Municipal Airport to the north; and Interstate 70 to the west and the Annabella Wildlife Management Area to the east. It is in Township 24 South, Range 3 West, Sections 9, 10, 12, 13, 14, 15, and 16. The survey was conducted at the request of Jenna Jorgensen, Jones and DeMille Engineering, Richfield, Utah. The project occurs on lands managed by the Utah Division of Wildlife Resources (DWR) (81.4 acres), the Utah Department of Transportation (UDOT) (0.8 acres), and on private lands (236.6 acres). The proposed undertaking consists of reconstructing an overshot structure spanning the Sevier Valley Canal facilitating flow into a flood channel and allowing 50 cfs of spillover to enter the canal; constructing a rock chute and stilling basin to dissipate hydraulic energy downstream from the overshot structure; upgrading approximately 8,000 linear feet of existing open flood channel and replacing a 36 in. diameter culvert with a 48 in. diameter culvert; constructing a splitter structure allowing 50 cfs to enter the Richfield Canal and 100 cfs to enter a closed conduit inlet; installing approximately 8,600 linear feet of closed conduit pipe to convey flow from the splitter to an open channel; and installing a pipe outlet and approximately 5,600 linear feet of earthen channel leading to the Sevier River. The Area of Potential Effect (APE) covers 318.8 acres.

The survey served to locate, document, and evaluate any cultural resources within the project area to comply with 36 CFR 800, the National Historic Preservation Act (NHPA) of 1966 (as amended). The inventory was also implemented to attain compliance with several federal and state mandates, including the National Environmental Policy Act of 1969, the Archaeological and Historic Preservation Act of 1974, the Archaeological Resources Protection Act of 1979, the American Indian Religious Freedom Act of 1978, Utah State Antiquities Act of 1973 (amended 1990), and Utah Code, Title 9, Chapter 8, Section 404 (9-8-404).

Fieldwork was conducted by Jody J. Patterson (Principal Investigator), Jessica Del Bozque, Brian J. Meinhart, and Sheridan Hatch on September 3 and September 28-30, 2023. The survey was completed under the auspices of State of Utah Public Lands Policy Archaeological Survey Permit No. 167 and State of Utah Antiquities Project (Survey) No. U23MQ0740, issued to MOAC, Moab, Utah and DWR Special Use Permit No. L169SU0167, issued to Jones and DeMille Engineering, Richfield, Utah.

Jody J. Patterson holds an active PLPCO PI permit (No. 167) and is the PI (statewide) for MOAC's BLM UT CRUP Permit 23-UT-60112 (exp. 05/30/2026). All MOAC personnel authorized to work under this PLPCO PI permit are also listed on MOAC's BLM UT CRUP permit. Jody received his BA in Anthropology and Sociology in 1994, a MA in Southwest Studies/Anthropology in 1996 (a multidisciplinary degree in anthropology, history, and political science focusing on greater American Southwest), and a PhD in Anthropology in 2010 and he has over 22 years of experience in Utah. Jessica

Del Bozque has worked as an archaeologist in Utah since 2011 and is listed on MOAC's BLM UT CRUP permit statewide as a field director and PI. She completed a BA in Anthropology in 2010 and is currently working on a MA in Cultural Resource Management (anticipated graduation Spring 2024). Brian Meinhart has nearly three years of experience working as an archaeologist in Utah, starting shortly after completing his MA in Archaeology and Heritage in 2020. Brian is listed as a field director on MOAC's BLM CRUP permit (Great Basin). Sheridan Hatch is a seasonal field technician for MOAC that always works under the supervision of one of the previous listed personnel members. She has a bachelor's degree in Anthropology.

Jody J. Patterson and Brian J. Meinhart conducted Sego file searches on August 30 and September 22, 2023. These consultations identified 20 projects and nine sites that occur within one-half mile of the APE (Tables 1 and 2). Four of these sites occur within the APE (Table 2). In addition to the online file search, the Utah Division of Water Rights database, historic General Land Office (GLO) maps, historic topographic maps, historic aerial photographs, and satellite images were consulted. These reviews identified three historic agriculture related sites (42SV4533, 42SV4534, and 42SV4535) and a historic flood channel (42SV4536) that were documented during the current project. The one-half mile search area of the APE was searched on the HUB on February 20, 2024, which identified two historic structures built in 1935 (Property Records 104802 and 87911). These include the eligible Nebeker Lane Bridge (104802, not listed) and the Sevier River Bridge (87911) that has been demolished. Both are outside the APE.

Table 1. Previous Projects within One-Half Mile of the APE.

Report No.	Project Title	Consultant/ Agency
U84BC0178	An Archaeological Inventory of the I-70 Elsinore-South Richfield Segment, Sevier County, Utah and Three Proposed Borrow Pit Areas	BYU
U84BC0216	Prop Sigurd-Cameron 138KV Relocation near Elsinore	BYU
U85BC0591	3 Borrow Areas between Richfield & Elsinore - Addendum	BYU
U86AK0420	Nielson - Maglebee Borrow Pit	Archaeological Research Consultants
U87BC0077	2 Reports-Pipeline Survey/Salina Sisters Burial Site	BYU
U94BS0611	UDOT Nebeker Lane Bridge Over Sevier River near Anabella	Baseline Data Inc.
U04MV0866	Sevier Valley Seismic Lines	Mountain States Archaeology
U06HO1424	SR-118 Richfield to Monroe Turn Lanes	Bighorn
U06LW0795	Wolverine Gas & Oil Corporation - Henries Hollow	Western Land Services
U07FS0535	Fishlake N.F. Travel Management Plan Survey	US Forest Service
U09EO0612	Siguard to Red Butte Transmission Corridor	Environmental Planning Group
U10EO0510	Sigurd to Red Butte Transmission Line	Environmental Planning Group
U11IG0979	An Archaeological Survey of the Proposed Richfield Airport Improvement Project in Sevier County, Utah	Intersearch
U11UQ0195	Annabella Wildlife Management Area Habitat Project #2106	UDWR
U12SH0540	CRI of the Sevier South Emergency Watershed Protection (EWP) Project, Sevier and Sanpete Counties, Utah	NRCS
U13ST0001	Archaeological Investigations for the Sigurd to Red Butte No. 2-345kV Transmission Project in Beaver, Iron, Millard, Sevier, and Washington Counties, Utah	SWCA

Report No.	Project Title	Consultant/ Agency
U16SH0783	Cultural Resources Inventory of an NRCS Emergency Watershed Protection (EWP) Project in Flat Canyon Near Elsinore, Sevier County, Utah	NRCS
U17SH0205	Cultural Resources Inventory for NRCS Project No. 748D43150GM, Sevier County, Utah	NRCS
U21UX0676	Arcadian Fiber Optic Route Moroni to Joseph	WestLand Resources
U22JH0273	Cultural Resource Inventory of the Richfield City Road Improvement Project, Sevier County, Utah	Boulder Mountain Consulting

Table 2. Previously Recorded Sites within One-Half Mile of the APE.

Site Number	SHPO Number	Site Type	NRHP Eligibility	Within APE
42SV1825	U84BC0178	Historic Artifact Scatter	Not Eligible	No
42SV2115	U84BC0178	Historic Mine	Not Eligible	No
42SV2344	U10EO0510 U13ST0001	Sevier Valley Canal	Eligible	Yes
42SV2500	U06HO1424 U21UX0676	Richfield Canal	Eligible	Yes
42SV2501	U00BS0252	Elsinore Canal – Mill Ditch	Eligible	No
42SV2502	U87BC0077 U06HO1424 U21UX0676	D&RGW RR – Marysvale Branch	Eligible	Yes*
42SV2600	U21UX0676	Elsinore Canal	Eligible	Yes
42SV3459	U11UQ0195	Historic Structure	Not Eligible	No

*Portion through APE obliterated

DESCRIPTION OF PROJECT AREA

The project area occurs between Central Valley, Utah to the south and Richfield Municipal Airport to the north; and Interstate 70 to the west and the Annabella Wildlife Management Area to the east. It is in Township 24 South, Range 3 West, Sections 9, 10, 12, 13, 14, 15, and 16. The project occurs on lands managed by DWR, UDOT, and on private property. The APE covers 318.8 acres.

ENVIRONMENTAL SETTING

The project area lies within the Sanpete-Sevier Valleys section of the Basin and Range – Colorado Plateau physiographic province. The geology of the valley bottoms is quite complex, with subsidence caused by faulting, folding, and salt removal from buried Jurassic formations, but this complicated geology is obscured by the alluvial deposits of the Sevier and San Pitch Rivers, which drain their respective valleys (Stokes 1986). These rich deposits and the availability of water are the primary reason early settlers were drawn to the area and why intensive agriculture is characteristic of the area today.

The valley bottom is flat, and the project area ranges in elevation from 5,265-5,420 ft. (Figure 1). Much of the project area transverses cultivated farmland, including pastureland, corn, alfalfa, and grain. Non-agricultural vegetation includes shadscale, rabbitbrush, grasses, ragweed, willow, and various trees. Modern impacts include roads, residences, agriculture, fence lines, and the airport (Figures 2 and 3).

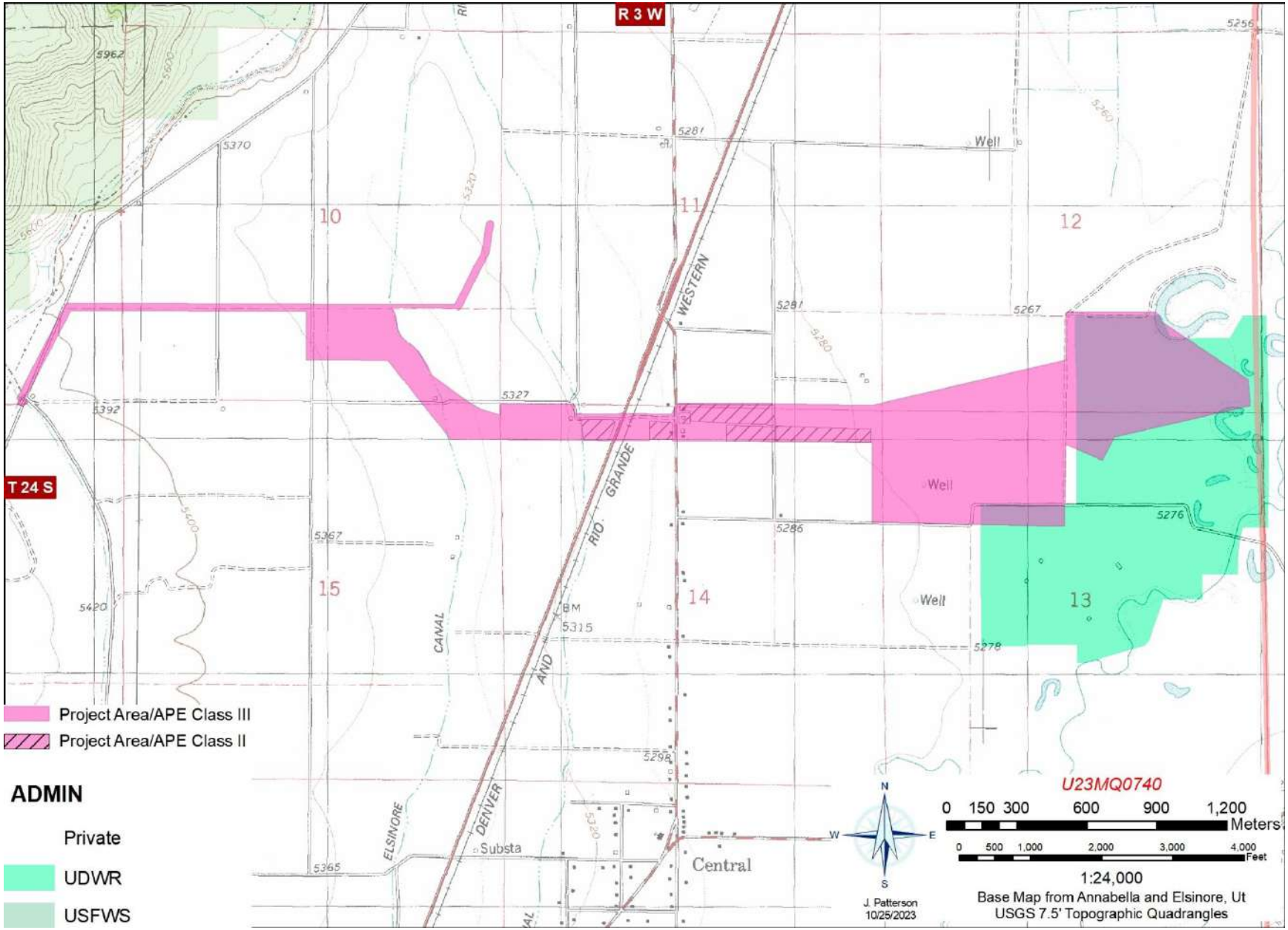


Figure 1. Cultural Resource Survey of the NRCS' South Flood Channel Project in Sevier County, Utah APE.



Figure 2. Project Area Overview facing West. U23MQ0740.



Figure 3. Project Area Overview facing Northeast. U23MQ0740.

HISTORICAL OVERVIEW

Human occupation in the region spans the last 10,000-12,000 years and is represented in prehistory by the Paleoindian, Archaic, Formative, and Late Prehistoric periods. The historic period began with Euroamerican occupation of the area beginning in earnest in the mid-1800s. Archaeological sites identified within the APE date to the historic period.

The earliest recorded visitation by Europeans to Utah was the Dominguez-Escalante expedition, which departed Santa Fe in July 1776 seeking a route to Monterey, California. The group entered Utah near present-day Jensen, entered the Utah Valley in September, and reached the Cove Fort area in October (Warner 1976). The group reached the area of Black Rock, Utah before deciding to discontinue the journey and return to Santa Fe. Though failing to achieve their intended goal, the journals kept by Frs. Dominguez and Escalante provided detailed and valuable information regarding the areas they trekked and the peoples they met. Spanish traders and trappers followed in their footsteps and established a network of trails that became known as the "Old Spanish Trail". The American trapper Jedediah Smith and a group of 15 companions traversed the area in 1826, following the Sevier River up valley and exiting near Cove Fort.

Exploration and settlement of Central Utah occurred shortly thereafter, when the LDS church under Brigham Young commissioned an investigatory party under Parley P. Pratt in 1849, which was to document the nature of the area, including soil conditions, topography, and the potential for natural resource development (Bishop 1997). This party provided a favorable report of the area. Additional exploration in 1863 confirmed the suitability of the area for settlement, and in 1864 the first settlement, named Big Springs or Warm Springs was established at the foot of the hills to west of the Sevier River valley. The name of the settlement was changed to Omni, then again to Richfield due to the high quality of the soil (Bishop 1997). Sevier County was established the following year, in 1865, by which time several settlements were already in place, including Richfield, Glenwood, and Monroe (Alma at the time) (Bishop 1997).

Further settlement in the area was interrupted by the outbreak of the Black Hawk War in 1865 (Poll 1978). Ute bands under Black Hawk clashed with settlers in a series of raids and skirmishes, eventually prompting Brigham Young to call for the evacuation of the Sevier River valley. The conflict ended in 1868 by a treaty, and by the 1870s the valley had been resettled.

Early agricultural development was greatly facilitated by the digging of several canals to distribute irrigation water throughout the valley. Taking their cue from the experience of settlers in the Great Salt Lake Valley, settlers in the Sevier River valley began to plan and construct water infrastructure projects concurrent with settlement (Bishop 1997). Three of these, the Sevier Valley Canal (Surveyed in 1884 and constructed in 1910), the Elsinore Canal (constructed in 1895), and the Richfield Canal (constructed in 1865) transect the APE.

Around the time of Utah statehood in 1896, communities in the valley undertook efforts to expand and modernize, including transportation. The county was initially responsible for raising funds for and directing the construction of roads, but in 1909 the state legislature established a state highway system and

department. Federal and local funds augmented state efforts to build out a modernized road system. The railroad too arrived around this time when the Sevier Railway Company was established in 1891 and built a rail line through the area. The company was purchased by the Denver & Rio Grande Western Railroad in 1908, and this Marysvale Branch ran between Thistle and Marysvale until 1982 when a mudslide impacted the line and forced its abandonment (Bishop 1997; Jennings 1988).

During the Great Depression, the Civilian Conservation Corps (CCC) constructed Camp F-12 near Fish Lake and Camp F-25 in Richfield (Bishop 1997). The CCC provided work for young men during these trying times for conservation and construction projects and employed thousands in Utah between 1933-1941.

The first airport in Richfield was built as a Works Progress Administration (WPA) project in 1936-1937 (Bishop 1997). A new airport was constructed in 1946 with the intent of serving as a commercial and regional hub. Though the airport was built, the expansion of Salt Lake City International Airport and the outpacing of Richfield in population by both Cedar City and St. George has lessened the regional importance of the facility (Bishop 1997). The airport was significantly upgraded in 2015 and serves primarily as a cargo and charter flight facility (Richfield City 2023).

SURVEY METHODOLOGY

MOAC performed both an intensive Class III and Class III (reconnaissance) pedestrian survey for this project as outlined in the Utah SHPO Cultural Resource Compliance Guide (2022 edition). The APE was examined for cultural resources by the archaeologist walking parallel transects spaced no more than 15 m (49 ft.) apart. MOAC conducted Class III survey on 296.2 acres of the project area and reconnaissance survey (Class II) on 22.6 acres of the APE (Figure 1). The acreage covered by Class II survey included private land where permission to access the land was not granted. The Class II survey consisted of an examination of recent and historical photographs, publicly available LiDAR data (both first and ground returns), and other historic maps and documents. In addition to the desktop review of the Class II areas, MOAC archeologists visually inspected the parcels from areas where access and permission had been granted. Ground visibility ranged from poor to excellent, though most of the APE consisted of fallow, overgrown fields, and mature agricultural crops (e.g., corn). The APE covers 318.8 acres and includes lands administered by DWR (81.4 acres), UDOT (0.8 acres), and on private lands (236.6 acres).

Cultural resources were recorded as archaeological sites or as isolated finds. Archaeological sites were documented by the archaeologist walking through and immediately around the site, mapping, describing, and photographing the locations of cultural materials. One site (42SV4535) was inaccessible due to property boundaries and was recorded utilizing visual observation from a distance, photographs, historic aerial photographs, and satellite imagery. Linear sites were recorded consistent with 2008 guidance provided by the Utah Professional Archaeological Council (UPAC). These procedures allowed clear definition of site boundaries, cultural features, and materials. A Geo-Explorer Trimble was employed to map the sites and relevant features. Archaeological sites were plotted on a 7.5' USGS quadrangle, photographed, and documented on Utah Archaeological Site Forms. Isolated finds are described in this report.

SURVEY RESULTS

The cultural resource survey of the NRCS' South Flood Channel Project resulted in the identification and update of four previously recorded archaeological sites (42SV2344, 42SV2500, 42SV2502, and 42SV2600), the documentation of four newly identified archaeological sites (42SV4533-42SV4536), and the documentation of one isolated find (IF-A). One of the previously recorded sites, 42SV2502, is obliterated through the APE; a Part A update was completed for this site documenting its state within the APE. All the sites are located on privately-owned land.

ARCHAEOLOGICAL SITES

Smithsonian Site No.: 42SV2344
Site Type: Agriculture/Subsistence
Affiliation: European-American
Eligibility: Eligible
Description: Site 42SV2344 is the Sevier Valley / Piute Canal. It was first recorded in 1994 by Abajo Archaeology (Montgomery 1994; U94AS0567) and has subsequently been recorded numerous times with additional segments added to the record. For this project MOAC documented a previously unrecorded 1,312-ft segment of the Sevier Canal. It is indirectly connected to a segment recorded by Environmental Planning Group in 2011 (Yentsch 2011; U10EO0510) and revisited by SWCA in 2016 (Hovanes 2016; U13ST0001). Water is diverted into the canal south of the town of Joseph, and the canal runs generally northward to its terminus northwest of Gunnison in neighboring Sanpete County. The canal company was incorporated in 1910 and construction of the canal began that same year (Whetstone 1990). The documented portion may have been surveyed as early as 1884 (Bishop 1997). Two features were observed, including an aqueduct (Feature A) spanning the canal and a headgate (Feature B). The aqueduct is built utilizing the concrete abutments and wing walls of a historic bridge, but the span itself is modern construction. Per historic aerial photographs, a bridge crossed the canal at least as early as 1953 and was in place at least as late as 1981. Per satellite imagery, at some point between 1981 and 1993 a portion of the road south of and utilizing the bridge was partially converted into a section of the flood control channel (site 42SV4536) which historically began immediately north of the bridge. This likely occurred in the mid-1980s (Weingroff 2017). The headgate is a slider-gate metal headgate built into a concrete wall on the eastern bank of the canal that was likely updated/replaced sometime since the 1970s.

Smithsonian Site No.: 42SV2500
Site Type: Agriculture/Subsistence
Affiliation: European-American
Eligibility: Eligible
Description: Site 42SV2500 is the Richfield Canal, which runs northward from an intake on the Sevier River southwest of Elsinore to a terminal junction with the Vermillion Canal in Sigurd. For this project, MOAC documented an 1,896 ft. segment. In this segment, the canal manifests as an earthen ditch, approximately 16 ft. wide. Three features were documented, including a concrete weir with a metal foot bridge and an associated metal headgate set into a cobble wall (Feature A); the remnants of a historic

concrete weir/road crossing at the north end of the more modern structure (Feature B); and a metal headgate set into a cobble wall (Feature C). No artifacts were observed. Numerous segments of the canal have been recorded, including a short section at the southern end of this segment documented in 2021 by WestLand Resources (Allen 2021; U21US0676). The canal was constructed in 1865 and represents an important example of early water infrastructure construction in the valley which enabled early settlements to survive and flourish (Nielson 2000; U00BS0252). It is still utilized in the present day.

Smithsonian Site No.: 42SV2502
Site Type: Transportation/Communication
Affiliation: European-American
Eligibility: Eligible (Updated Segment Non-Contributing to Eligibility)
Description: Site 42SV2502 represents the Denver & Rio Grande Western Railroad – Marysvale Branch which operated between Marysvale and Thistle, Utah from 1890 – 1982, when a mudslide near Thistle impacted operability and the line was abandoned (Jennings 1988). It was first recorded by Brigham Young University in 1987 (Southworth 1987; U87BC077). Multiple segments have been subsequently recorded, including a segment south of but outside of the current APE, recorded by Bighorn Archaeological Consultants in 2006 (Jordan 2006; U06HO1424). MOAC inspected the alignment of the site that passes through the current project area and confirmed that it is no longer extent, as is the alignment a short distance north of the APE. The segment recorded by Bighorn to the south is still visible. This update serves as MOAC's attempt to locate and record any remnants of the site within the APE.

Smithsonian Site No.: 42SV2600
Site Type: Historic Agriculture/Subsistence
Affiliation: European-American
Eligibility: Eligible (Updated Segment Non-Contributing to Eligibility)
Description: Site 42SV2600 is the historic Elsinore Canal, first recorded by Baseline Data, Inc. in 2003 (Nielson 2003; U03BS0073) and updated by WestLand Resources, Inc. in 2021 (Allen 2021; U21UX0676). Baseline inspected a small portion that intersected their APE but described the canal in its entirety including PLSS descriptions, based on a desktop review, which include the intake at the Sevier River southwest of Elsinore Town to the terminus in a field southwest of Richfield Municipal Airport. Segments updated by WestLand are in the far south near the intake but are described as essentially the same as the description provided by Baseline, which described the canal as an earthen ditch, crossing beneath roads via concrete culverts, and diverted into fields and ditches via steel and concrete gates. Based on this description, the concrete lining in the segment updated by MOAC for this project was poured post-2003 and represents a significant modern modification. The integrity of the alignment remains true. Numerous features were recorded, and include the canal ditch(es), which begins as two parallel ditches from a property boundary in the south to a road, at which point one parallel diverts into a field ditch and the other crosses beneath the road via a corrugated pipe culvert and transitions into a single ditch; five wheel-crank slider-gate headgates; two Parshall flumes and a concrete flume; a temporary bridge span constructed of welded sheet metal; a concrete cistern; and two corrugated pipe outlets leading into adjacent fields. In addition, several small, gated portals were observed built into one of the parallel canal ditches for flood irrigating an adjacent field, and several hand-crank slider dams are built into the same parallel to raise the water level for these portals. These appear un-weathered and very recently installed. No artifacts were observed, though some modern

debris, including concrete, lumber, and metal fragments are present. The canal was constructed in 1895 and is still utilized in the present day (Nielson 2003).

Smithsonian Site No.: 42SV4533
Site Type: Agriculture/Subsistence
Affiliation: European-American
Eligibility: Not Eligible
Description: Site 42SV4533 is a 1,087 m^2 corral complex comprised of a small (approximately 63 x 66 ft.), square corral (Feature A), mostly dismantled; a small wooden shack (Feature B) believed to house a water well pump providing water and power to an adjacent heated livestock waterer (Feature C); and a second trough (Feature D) located at the eastern end of a chute leading into the corral. The corral remnants consist of ten standalone juniper posts and segments of relatively intact juniper post, barbed, and mesh wire fencing. Several un-milled wood rails are piled within the corral and may represent dismantled remnants. Remnants of a galvanized steel trough are also located within the corral. A juniper post, barbed, and mesh wire fence chute, approximately 231 ft. long and running east-west is connected to the northeast corner of the corral. The artifact assemblage is relatively small and homogenous and consists of milled lumber fragments, wire nails, galvanized metal fragments, bolts, hinges, tube steel and mesh wire gate remnants, and a horse/tractor-drawn wheeled plow. The footprint of the complex is visible on a 1953 historic aerial photograph, and the heated livestock waterer is labeled as a Marlor Inc. Model ME-2-0; Marlor Inc. was established in 1963 (Harryman 2018). The site therefore predates 1953 and was utilized at least as late as 1963, but the terminal date of the corral's usage is unknown. The pasture in which the site is located is still utilized to graze livestock, but the corral complex is no longer functional.

Smithsonian Site No.: 42SV4534
Site Type: Agriculture/Subsistence
Affiliation: European-American
Eligibility: Not Eligible
Description: Site 42SV4534 represents a small agricultural complex consisting of a small wooden shack (Feature A) and adjacent water trough (Feature B). No artifacts were observed. The shack was wired into a power line, but the connection was cut. An inspection of the interior revealed miscellaneous modern refuse, including a hot water heater tank, but there did not appear to be any historic remnants. Due to the location of the trough immediately next to the shack, it is believed the shack housed a water well pump feeding into the trough. The site is in a disturbed area that once contained numerous additional structures, with some likely visible in a 1953 aerial immediately north of the site, expanded by 1973, including the site, and in apparent use until 2009, with several additional structures appearing in 1993 satellite imagery to the south (gone by 1998). Most of these structures were demolished by 2011 per satellite imagery by road construction. Several debris piles, mostly lumber, are located near the site and are believed to represent the remains of some of these structures that once stood around the site. Given that the overall complex appears to have been expanded between 1953 and 1973 and the extent structures are not conclusively verifiable until 1973, the site is dated from pre-1973 to 2009, at which point most structures had been demolished and continued use of the site was unlikely.

Smithsonian Site No.: 42SV4535
Site Type: Agriculture/Subsistence
Affiliation: European-American
Eligibility: Not Eligible
Description: Site 42SV4535 consists of two historic structures; a granary (Feature A) and an open stable/animal shade (Feature B). Both structures are located on private property and could not be directly inspected due to lack of access. Descriptions are based on visual observations from a distance and photographs, and measurements are estimates taken utilizing satellite imagery. Feature A is a rectangular structure, externally framed with a peaked roof, gables, and overhanging rake and eaves. The roof appears sheathed with dimensional lumber and shingled with wood shingles. An opening near the peak likely framed a ventilation element or may indicate the structure was converted to other uses and may have framed a chimney or other element. A large opening in the south gable provided a port for depositing grain/hay. No doors were observed, but it is likely an access door is located on the east wall, which could not be directly observed. The framing appears to be of balloon framing technique, which was largely phased out of practice by the 1930s. It measures approximately 16 x 12 ft. The height is not known. Feature B is a long, south-facing open animal shade or stable that appears to be constructed of juniper posts supporting a long, peaked roof, with dimensional lumber forming a rear (north) wall. The west wall is gabled and sheathed with dimensional lumber; though not directly observed it is likely the east wall is of similar construction. The roof is sheathed with dimensional lumber and corrugated sheet metal. The structure measures approximately 74 x 23 ft. The height is not known. No artifacts were observed due to inaccessibility. Both structures are deteriorated and appear to be in disuse. It is likely the two structures are contemporaneous and were constructed prior to the 1930s. Their terminal dates are unknown. According to county assessor records, the primary residence on the associated property was built in 1934.

Smithsonian Site No.: 42SV4536
Site Type: Agriculture/Subsistence
Affiliation: European-American
Eligibility: Not Eligible
Description: Site 42SV4536 is a flood channel which begins near the Sevier Valley Canal (42SV2344) and empties into the Richfield Canal (4SV2500). The current runoff channeling features leading to the documented flood channel date to the mid-1980s and later. As such, it is possible site 42SV4536 may have originally served as a lateral ditch between the Sevier Valley Canal and the Richfield Canal as the flood control features feeding into the channel do not appear to be historic. Discussions with a local resident indicate the channel was at one time cement lined, with maintenance activities in the late 1970s damaging the lining. Concrete fragments observed within the channel appear to support this information. Subsequent water flow has significantly eroded the flood channel. Asphalt and concrete fragments and boulders have been placed within the channel to counter this erosion. Historic debris, including building materials, miscellaneous metal, and glass were observed within a berm on the edge of the channel, but these appear to have been recently dug out and piled, and are not in situ. The eastern end of the drainage has been rerouted north to empty into a rerouted portion of the Richfield Canal; these reroutes are due to runway construction at the airport and a recently constructed road. The flood channel (possible former lateral ditch) is visible in 1953 historic aerials and dates to at least that early. The east-west portion of the site is depicted as an earthen dam in 1980 topographic quads but appears to be a channeled feature on historic aerials that

predate 1980; the topographic map symbol likely references the earthen berm on the bank of the channel. No in situ artifacts or additional features were observed.

ISOLATED FINDS

The cultural resource survey of the South Flood Channel resulted in the documentation of one isolated find (IF-A). IF-A is some sort of machinery axel/attachment measuring 4 x 4 ft with a 23 ½ inch opening and a 7 ft long connector to a hitch attachment. IF-A dates to the historic period, likely the mid-20th century, and is of European-American affiliation.

NATIONAL REGISTER OF HISTORIC PLACES EVALUATION

The National Register Criteria for Evaluation of Significance and procedures for nominating cultural resources to the National Register of Historic Places (NRHP) are outlined in 36 CFR 60.4 as follows:

> The quality of significance in American history, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects of State and local importance that possess integrity of location, design, setting, material, workmanship, feeling, and association, and that they:
> a)…are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> b)…are associated with the lives of persons significant to our past; or
>
> c)…embody the distinctive characteristics of a type, period, or method of construction; or that represents 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)…have yielded or may be likely to yield information important in prehistory or history.

The cultural resource survey of the NRCS' South Flood Channel Project resulted in resulted in the identification and update of four previously recorded archaeological sites (42SV2344, 42SV2500, 42SV2502, and 42SV2600), the documentation of four newly identified archaeological sites (42SV4533-42SV4536), and the documentation of one isolated find (IF-A). Four of these archaeological sites have been previously determined eligible for inclusion in the National Register of Historic Places (42SV2344, 42SV2500, 42SV2502, 42SV2600). Site 42SV2344 is the Sevier Valley Canal, which has been previously determined eligible under Criterion A. The newly documented segment maintains integrity aspects of location, design, setting, feeling, and association and is recommended as a contributing element of this historic site under Criterion A. The two associated features include a modern aqueduct deck using historic bridge abutments (Feature A) and a slider-gate metal headgate set into a concrete wall (Feature B). These features have been heavily modified (Feature A) or replaced/updated in the modern era (Features A and B) resulting in minimal integrity and association with the historic period of significance of the overall canal system. Therefore, Features A and B are considered non-contributing elements of this eligible site.

Site 42SV2500, the Richfield Canal, has been previously determined eligible under Criteria A and C. The newly documented segment maintains integrity aspects of location, design, setting, feeling, and association and is recommended as a contributing element of this historic site under Criterion A. The documented segment does not have any structures that are considered contributing under Criterion C. However, two of the structures are considering contributing under Criterion A. These include a metal crank wheel slider gate headgate set into a cobble and concrete or mortar wall (Feature C) and a similar headgate feature associated with a concrete weir (Feature A). These two features are thought to date from the early-mid 20th century and contribute to the feeling of the historic canal system. Feature B is a historic weir and road crossing that has been mostly replaced by a modern structure of the same function. Only 3 ft of the original structure are intact. The feature has lost most of its integrity and is considered a non-contributing feature to the eligible site.

Site 42SV2502 represents the Denver & Rio Grande Western Railroad – Marysvale Branch which operated between Thistle and Marysvale, Utah from 1890 – 1982. The site has been previously determined eligible for inclusion in the National Register under Criterion A. MOAC investigated the alignment of the historic railroad through the current project area and confirmed that it has been destroyed. As remnants of the railroad are no longer extent within the project area, it does not constitute a contributing element to this eligible site.

Site 42SV2600, the Elsinore Canal, has been previously determined eligible under Criterion A. The documented segment maintains aspects of integrity for location, setting, and association. However, modern upgrades to the canal (concrete lining of the historically earthen channel) in the recorded segment have significantly altered the appearance of the site from its historic form. Therefore, it is recommended as a non-contributing segment to the eligibility of the site. The 12 associated features are also considered non-contributing. These include non-original features (flume – Feature F, post-1967; cistern – Feature I, post-2006), basic steel culvert features (Features J and L), an ephemeral sheet metal canal crossing (Feature D), and several features built into the concrete canal lining including metal crank wheel slide-gate headgates (Features A, C, E, H, and K), and metal Parshall flumes (Features B and G); some of these features may be reused historic materials, but the reinstallation into a concrete lining has impacted the overall integrity of these features. In summary, no portion of the documented canal segment or its associated features are recommended as contributing elements to overall site eligibility under Criterion A

Newly documented sites 42SV4533-42SV4536 represent a corral complex (42SV4533), a small agricultural complex (42SV4534), a granary and animal stable (42SV4535), and a flood channel (42SV4536). These sites were found to lack strong associations with events or persons significant to our past (Criteria A and B). The sites do not embody a type, period, or method of construction (Criterion C) nor are they likely to yield additional data important to our past (Criterion D). Therefore, sites 42SV4533-42SV4536 are recommended as ineligible for NRHP listing as they fail to meet the outlined criteria. IF-A is also recommended as ineligible for NRHP listing.

CONCLUSIONS AND RECOMMENDATIONS

The cultural resource survey of the NRCS' South Flood Channel Project in Sevier County, Utah resulted in the identification and update of four previously recorded archaeological sites (42SV2344, 42SV2500, 42SV2502, and 42SV2600), the documentation of four newly identified archaeological sites (42SV4533-42SV4536), and the documentation of one isolated find (IF-A). Four of the cultural resources are recommended as eligible for inclusion in the National Register (42SV2344, 42SV2500, 42SV2502, 42SV2600); all four sites are linear. Of these four sites, the documented segments of two (42SV2502 and 42SV2600) sites within the APE are recommended as non-contributing elements to the eligibilities of the sites. Documented segments of 42SV2344 and 42SV2500 within the APE are considered contributing to their respective site eligibilities. At 42SV2344, the Sevier Canal, proposed work includes reconstructing the overshot structure for the flood channel (Feature A). Feature A has been previously modified which impacted its historic fabric and character and it is considered a non-contributing feature. Therefore, further modification to the feature will not have an adverse effect to site 42SV2344. At 42SV2500, the Richfield Canal, the proponent plans to install conduit pipe under the canal. The pipe will be bored, or an open cut may be used to install the pipe. If an open cut is used, the canal would be restored to pre-construction condition, which will not adversely affect site 42SV2500. The four newly documented sites (42SV4533-42SV4536) and isolated find (IF-A) are recommended as ineligible for NRHP listing. Based on the findings (summarized in Table 3), a determination of *no adverse effect* is recommended for the undertaking pursuant to 36 CFR 800 and Section 106 of the National Historic Preservation Act.

Table 3. Management Summary Table.

Site No.	Site/Feature Type	NRHP Status	Proposed Project Impacts	Recommendation of Effect
42SV2344	Sevier Valley/ Piute Canal – canal segment	Eligible (A) Contributing	The canal channel will not be impacted by the project.	42SV2344
42SV2344	Feature A – modern aqueduct deck/historic bridge abutments	Non-contributing	This is an existing overshoot structure that will be reconstructed	42SV2344
42SV2344	Feature B – metal headgate set in concrete wall	Non-contributing	Outside APE and will not be impacted	42SV2344
42SV2500	Richfield Canal – canal segment	Eligible (A & C) Contributing to Criterion A	The canal is within the flood pipeline corridor and will be crossed at one location by the proposed flood pipeline. This will consist of a conduit pipeline that will be bored, or an open cut may be used to install the pipe. If an open cut is used, the canal will be restored to pre-construction condition	42SV2500
42SV2500	Feature A – metal headgate set in cobble wall with associated concrete weir	Contributing to Criterion A	Outside APE and will not be impacted	42SV2500

Site No.	Site/Feature Type	NRHP Status	Proposed Project Impacts	Recommendation of Effect
42SV2500	Feature B – historic weir/road crossing mostly replaced by modern structure	Non-contributing	Outside APE and will not be impacted	42SV2500
42SV2500	Feature C – metal headgate set in cobble wall	Contributing to Criterion A	Outside APE and will not be impacted	42SV2500
42SV2502	D&RGW RR – Marysvale Branch	Eligible (A) Non-contributing	A destroyed portion of the historic railroad alignment is crossed by the flood pipeline corridor	42SV2502
42SV2600	Elsinore Canal – canal segment	Eligible (A) Non-contributing	The canal is within the flood pipeline corridor and will be crossed by the proposed flood pipeline.	42SV2600
42SV2600	Feature A – headgate	Non-contributing	Outside APE and will not be impacted	42SV2600
42SV2600	Feature B – Parshall flume	Non-contributing	Outside APE and will not be impacted	42SV2600
42SV2600	Feature C – headgate	Non-contributing	Outside APE and will not be impacted	42SV2600
42SV2600	Feature D – makeshift bridge	Non-contributing	Within flood pipeline corridor.	42SV2600
42SV2600	Feature E – headgate	Non-contributing	Within flood pipeline corridor.	42SV2600
42SV2600	Feature F – concrete flume	Non-contributing	Within flood pipeline corridor.	42SV2600
42SV2600	Feature G – Parshall flume	Non-contributing	Within flood pipeline corridor.	42SV2600
42SV2600	Feature I – concrete cistern	Non-contributing	Within flood pipeline corridor.	42SV2600
42SV2600	Feature J – outlet pipe	Non-contributing	Within flood pipeline corridor.	42SV2600
42SV2600	Feature K – headgate	Non-contributing	Within flood pipeline corridor.	42SV2600
42SV2600	Feature L – outlet pipe	Non-contributing	Within flood pipeline corridor.	42SV2600
42SV4533	Corral Complex	Not Eligible	Within open channel/overland flow area.	42SV4533
42SV4534	Agricultural Complex	Not Eligible	Within flood pipeline corridor.	42SV4534
42SV4535	Granary and Stable	Not Eligible	Within flood pipeline corridor.	42SV4535
42SV4536	Flood channel	Not Eligible	Entire documented segment will be upgraded, and a splitter structure will be built within the channel	42SV4536

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Appendix E.3. Biological Assessment

Biological Assessment

Richfield-West Sevier Watershed Plan
Sevier County, Utah

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July 24, 2025

Contents

1. Introduction 1
1.1. Consultation to Date 1
2. Project Description 1
2.1. Project Location 1
2.2. Project Details 1
2.3. Conservation Measures 4
2.4. General Setting 4
3. Species Considered 5
3.1. Species that May Be Present 5
3.2. Critical Habitat 5
3.3. Species Carried Forward 5
4. Project Action Area 6
5. Effects Analysis 6
5.1. Direct and Indirect Effects – Monarch Butterfly and Suckley's cuckoo bumble bee 6
5.2. Interrelated and Interdependent Effects 7
5.3. Cumulative effects 7
6. Conclusion and Determination of Effect 8
7. Literature Cited 8

Appendix A. Map

Appendix B. USFWS IPaC Species Report

1. Introduction

This Biological Assessment (BA) analyzes the potential effects to federally listed species and designated critical habitat from the implementation of the Richfield-West Sevier Watershed Plan Project in Sevier County, Utah. Sevier County, the project sponsor, proposes to construct several improvements within the Richfield-West Sevier Watershed for the purpose of flood prevention.

The Natural Resources Conservation Service (NRCS) is providing technical and financial assistance to the Sponsor for the project, and is the lead federal agency. The project occurs on private lands, within the Fishlake National Forest, within Bureau of Land Management (BLM)-administered land, and within a Utah State Wildlife Management Area; the U.S. Forest Service and BLM are cooperating agencies. Project activities will likely require Section 404 permitting with the U.S. Army Corps of Engineers (USACE). This BA has been prepared for the NRCS to identify the project's potential impacts on federally listed species, including critical habitat for such, and make an effects determination in accordance with the Endangered Species Act (ESA) of 1973 (7 U.S.C. 136, 16 U.S.C. 1531 et seq.), as amended.

1.1. Consultation to Date

- June 3, 2025 – An official species list was acquired from the IPaC system.

2. Project Description

2.1. Project Location

The proposed project is located in western Sevier County. More specifically, the project occurs within the following sections within the Salt Lake Base and Meridian:

T23S, R2W, Sections 12, 13, 14, 16, 17, 18, 20, and 21

T24S, R2W, Sections 4 and 9

T24S, R3W, Sections 9, 10, 13, 14, 15, 16, 17, and 21

2.2. Project Details

The Proposed Action consists of measures at the following locations to address flood damage risk:

1) A debris basin in Flat Canyon
2) Improvement of a south flood channel to the Sevier River
3) Improvement of a north flood channel to the Sevier River
4) Installation of a flood control gate on the Sevier Valley Canal

Rock riprap would be acquired from BLM-administered land on the east side of the Sevier Valley. The locations of these measures are shown on Map 1 in Appendix A.

Flat Canyon Debris Basin

The Flat Canyon debris basin would detain flows from Flat Canyon and reduce the risk of canal breach and flooding throughout the watershed area. The debris basin would be located within the Fishlake National Forest boundaries, with the exception of a staging area on nearby private land.

The debris basin would be constructed at the mouth of Flat Canyon; the earthen dam would be approximately 73 feet high with a longitudinal crest length of 1,150 feet. Per NRCS design criteria, the basin would have a capacity of 827 acre-feet and would drain in 10 days or less following an event large enough to completely fill the basin. The maximum inundation area would be approximately 37 acres in the bottom of Flat Canyon. The basin would provide for sediment accumulation and storage throughout the 100-year design life.

Approximately 540,000 cubic yards of soil material would be excavated from the basin inundation area for construction of the dam embankment, and 64,000 cubic yards of clay core material would be collected from the native clay ridge adjacent to the inundation area for construction of the core. Sand filter materials and rock riprap would be imported from other permitted sites.

Forest Road (FR) 106 in the bottom of Flat Canyon would be rerouted around the south abutment to allow for continued vehicular access into Flat Canyon; the road would be approximately 16 feet wide. There would also be a restricted access road along the dam crest for operation and maintenance purposes. The embankment would be fenced with non-reflective fencing to prevent access on the embankment slopes.

Approximately 109.5 acres would be disturbed by construction, operation, and maintenance of this measure; 84.3 acres would be disturbed permanently and the remaining 25.2 acres would be disturbed by temporary staging or inundation.

Construction access and staging would use existing routes and disturbed areas.

South Flood Channel Improvements

The south flood channel would convey flows from the Flat Canyon debris basin to the Sevier River floodplain, and improvements would mitigate the risk of exceeding the capacities of the canals during the flood events from Flat Canyon. The area crosses private property and UDWR-owned land.

Specific items for channel improvement include:

1. Reconstruct the overshot structure to allow storm flows to be directed into the flood channel while allowing for up to 50 cfs to enter the Sevier Valley Canal.
2. Construct a rock chute and stilling basin to help dissipate energy downstream of the overshot structure.
3. Upgrade approximately 7,900 linear feet of existing open channel, including armoring two bends and inlets and outlets of existing culverts and reshaping the banks. Project activities would stay within a 100-foot-wide corridor along the channel.
4. Construct a splitter structure to allow for up to 50 cfs to enter the Richfield Canal and a closed conduit inlet structure to divert the remaining minimum 100 cfs.
5. Install approximately 8,940 linear feet of 48-inch-diameter HDPE pipe to convey flows from the splitter structure through developed and cultivated areas. Project activities would stay within a 100-foot-wide corridor along the pipeline. A combination of directional drilling and open cutting would be used for pipeline crossings of four roadways, including 860 North, SR-118, Central Valley Main Street, and 200 North. The Richfield and Elsinore canals would be open-cut in accordance with canal company best practices and outside of irrigation season. The pipeline would be buried deep enough to provide protection from normal canal cleaning and other operation and maintenance activities.

6. Install a pipe outlet structure and channel and dike to convey overland flow to the Sevier River. The outlet structure would consist of a concrete headwall with a flap gate to prevent reverse flows. The channel would be 3.3 feet deep with a 15-foot bottom width and side slopes of 3H:1V. The dike would be constructed on the south side of the channel with a 3H:1V side slope and be 4 feet wide at the top. The height of the dike would vary as needed to achieve required freeboard.

Up to 59.3 acres would be temporarily disturbed for construction; 38.8 acres would be disturbed permanently and the remaining 20.4 acres would be disturbed temporarily for installation of the buried pipeline.

North Flood Channel Improvements

The north flood channel would convey flows from the Sevier Valley Canal to the Sevier River to reduce the risk of exceeding the capacities of the canals during the flood events that enter the canal. The north flood channel crosses private land. The existing channel currently conveys flood water from Willow Creek Canyon through an overshot on the Sevier Valley Canal to the Richfield Canal.

Specific items for channel improvement include:

1. Construct an emergency canal overflow structure in the canal bank to allow for up to approximately 200 cfs of floodwater to exit the Sevier Valley Canal into the existing channel; construct a rock chute and stilling basin to dissipate energy downstream of the emergency canal overflow structure.
2. Upgrade approximately 7,100 linear feet of existing open channel between the Sevier Valley Canal and the Richfield Canal. Upgrades would consist of reshaping the canal to a consistent cross section, installing riprap armor at four sharp bends to protect against erosion, and installing riprap armoring at the inlets and outlets of four existing culverts to prevent erosion and potential culvert bypass. Project activities would stay within a 100-foot-wide corridor along the channel.
3. Install riprap bank protection at the confluence with the Richfield Canal to prevent erosion.
4. Construct an emergency overflow and pipe inlet structure with trash rack in the Richfield Canal to allow for up to approximately 100 cfs of floodwater to exit the canal and enter the proposed storm water pipe.
5. Install approximately 6,700 linear feet of pipe to convey flows from the Richfield Canal, under the Vermillion Canal, to an existing channel that drains into the Sevier River. Project activities would stay within a 100-foot-wide corridor along the pipeline. A combination of directional drilling and open cutting would be used for the pipeline crossing of SR-118 and a county gravel road.

Approximately 44.3 acres would be temporarily disturbed for construction; 16.9 acres would be disturbed permanently and the remaining 27.4 acres would be disturbed temporarily for installation of the buried pipeline.

Sevier Valley Canal Flood Control Gate

An upgraded flood control gate would facilitate emergency flood conveyance and minimize the risk of canal breaching. The Sevier Valley Canal flood control gate is located within private property. The proposed gate would replace the existing stop-log structure that is currently used to regulate canal flows. The new control gate would consist of extension of a concrete structure from existing bridge wingwalls and automated control gates. The gates would allow the canal to operate at a range of canal

flows while allowing for emergency flood conveyance in any season. The control gate would facilitate conveyance of flood waters downstream and minimize the risk of canal breaching throughout the watershed area.

Approximately 60 feet of the canal would be disturbed for installation of the concrete gate structure and downstream riprap armoring. Approximately 1.8 acres would be temporarily disturbed for construction; less than 0.1 acre would be permanently disturbed by the new structure and riprap armoring.

Riprap Extraction

Rock riprap would be acquired from BLM-administered land on the east side of the Sevier Valley; suitable rock has been identified near Venice and at Bull Claim Hill. Approximately 9,000 cubic yards of rock would be extracted between the two sites to armor embankments and channels. Rock would be excavated from the exposed surface with a track hoe, and placed in trucks for delivery to the placement sites.

Up to 235.3 acres would be permanently disturbed by material extraction.

2.3. Conservation Measures

The following conservation measures are proposed:

1. Equipment will be washed and inspected prior to entering the project area to remove any soil and debris that may contribute to the spread of noxious weeds.
2. Equipment servicing and refueling areas will be located at least 300 feet away from any stream channels. To ensure that accidental spills do not enter waters, the storage of petroleum-based fuels and the refueling of construction machinery will not occur outside of approved designated staging/batch plant areas. The project will comply with state and federal water quality standards and toxic effluent standards to minimize any potential adverse impacts from discharges to waters of the U.S.
3. A stormwater pollution prevention plan (SWPPP) will be prepared by the construction contractor prior to initiation of ground disturbance for each project measure that disturbs more than 1 acre. The SWPPP will detail the best management practices and site-specific control features to prevent sediment and other pollutants from discharging off the site during construction. BMPs may include silt fence, fiber wattles, and earthen berms.
4. Where practicable, disturbed areas will be seeded with an appropriate seed mix.
5. Where practicable, vegetation will be removed during the fall and winter to avoid impacts during the breeding bird season (March 1 – August 31). If vegetation removal activities occur between March 1 and August 31, clearance surveys for migratory birds within 10 days prior by a qualified biologist will be required. Appropriate spatial and temporal buffers will be applied if nesting birds are located.

2.4. General Setting

The project is located within the High Plateaus of Utah section of the Colorado Plateau physiographic province (Fenneman and Johnson 1946). More specifically, the area is located within Sevier Valley, in central Utah. Topography ranges from the alluvial valley of the Sevier River, upward through moderately steep foothills, and up to steep mountains. Elevation ranges between 5,200 feet above sea level along the river in the valley bottom, up to 10,200 feet on White Pine Peak. The climate is arid, with average total annual precipitation of only 8 inches (Western Regional Climate Center 2023).

3. Species Considered

3.1. Species that May Be Present

An official species list was obtained from the Information for Planning and Consultation (IPaC) system on June 3, 2025 (see Appendix B). The species listed as threatened or endangered that "may be present in the area of the proposed action" are listed in Table 3-1 below.

Table 3-1. Listed species that may be present in the area of the Proposed Action, and rationale for further consideration in this Biological Assessment

Species	Status	Species Likely Occurrence in the Project Area and Consideration in this BA
Yellow-billed cuckoo (*Coccyzus americanus*)	Threatened	Not considered. The nearest critical habitat for this species is located over 90 miles away. Suitable riparian nesting habitat of appropriate patch size and configuration below 8,500 feet in elevation (USFWS 2017) does not occur within the watershed area.
Monarch butterfly (*Danaus plexippus*)	Proposed Threatened	**Considered**. Suitable habitat that provides milkweed (*Asclepias* spp.) and nectar sources (USFWS 2024a) may occur in association with the riparian areas along the canals and Sevier River.
Suckley's cuckoo bumble bee (*Bombus suckleyi*)	Proposed Endangered	**Considered.** Suitable nesting and overwintering habitat and nectar and pollen sources (USFWS 2024b) likely occur within the project area.
Ute ladies'-tresses (ULT; *Spiranthes diluvialis*)	Threatened	Not considered. Habitat characteristics for the species include adequate soil moisture, direct sunlight, and "additional supporting floral resources for pollinators in and around the habitat" (USFWS 2023). Based on field reviews in 2019 and 2023, suitable habitat for Ute ladies'-tresses does not occur within 300 feet of the project area.

The NRCS has determined that there would be no effect to the following species as a result of the Proposed Action: yellow-billed cuckoo and Ute ladies'-tresses.

3.2. Critical Habitat

There is no designated critical habitat within or adjacent to the watershed area.

3.3. Species Carried Forward

Monarch butterfly and Suckley's cuckoo bumble bee were identified as potentially occurring in the vicinity of proposed project activities; therefore, these species are being carried forward in this BA for further analysis.

Monarch butterfly

The monarch butterfly is an insect that is proposed for listing as threatened. The species is found mainly in North America, in separate populations east and west of the Rocky Mountains. Monarchs require milkweed (*Asclepias* spp.), overwintering habitat, and migration habitat. Overwintering for the western population occurs along the Pacific Coast, and migration habitat is typically associated with riparian corridors (USFWS 2024a).

Suckley's cuckoo bumble bee

Suckley's cuckoo bumble bee was proposed for listing as an endangered species in 2024. The bee is an obligate social parasite for other species in the same genus. The species occurs broadly across North America and from elevations between sea level and 10,500 feet. Nest sites are typically holes underground in various habitats and specific overwintering requirements are unknown. They require "a diversity of native floral resources (pollen and nectar) for nutrition." The minimum distance between nest or overwintering sites and suitable foraging resources is unknown (USFWS 2024b).

4. Project Action Area

The Action Area for monarch butterfly and Suckley's cuckoo bumble bee consists of the disturbance limits for all project features (including staging and access), and extends 300 feet beyond the disturbance limits to address potential indirect impacts of dust and vibration; this Action Area encompasses approximately 1,315 acres. A standard buffer of 300 feet is commonly applied for identifying indirect impacts to plants (USFWS 2011). Dust deposition on plants affects growth and vigor and may reduce the attractiveness to pollinators (Lewis et al. 2017, Phillips et al. 2021). Turbulence disturbs pollinators and may inhibit foraging (Phillips et al. 2021).

Landownership within this Action Area includes developed and undeveloped portions of private property, National Forest System lands, BLM-administered lands, and state wildlife management areas (WMAs), and includes sparse residential and municipal development, roadways, irrigated fields and pastures, and portions of the Sevier River.

Ongoing activities within the Action Area include residential, agricultural, and infrastructure development.

5. Effects Analysis

5.1. Direct and Indirect Effects – Monarch Butterfly and Suckley's cuckoo bumble bee

Habitat

Construction activities would remove flowering plants and create fugitive dust and air turbulence that may affect flying insects such as butterflies and bumble bees. The project would result in the temporary loss of less than 450.2 acres of flowering plants that could provide nectar or pollen for these insects, and the permanent loss of flowering plants on 375.4 of those acres. Flowering plants would remain where they occur adjacent to the disturbed areas. Once construction was completed, temporarily disturbed areas would be reseeded with a mix that includes nectar- and pollen-bearing species; suitable butterfly and bumble bee food sources would be expected to be available by the next growing season.

Approximately 1,315 acres within and around the project disturbance limits would be impacted by dust and turbulence. A large portion of the Action Area includes existing local, state, and interstate roadways,

residences, and agricultural fields, which currently result in regular dust emissions and turbulence. Increased turbulence and dust from construction and maintenance of the project measures could deter pollinators from using flowering plants within the Action Area; however, project disturbance would be localized to the individual project measures and would be temporary and short-term; this is estimated to be 3 years based on the time for construction and for vegetation to establish on reseeded areas and reduce dust emissions. Considering the temporary and localized nature of the disturbance associated with construction and maintenance of the project measures, construction and maintenance of the project would not adversely affect foraging habitat for monarch butterfly or Suckley's cuckoo bumble bee in the long term. Operation of the project measures would not be expected to affect foraging habitat for butterflies and bumble bees.

Project activities could also disturb or destroy bumble bee nesting or overwintering sites if they occur in the project area. Up to 534.0 acres would be directly disturbed by project construction or maintenance activities. Similar habitat surrounds the project disturbance limits and would provide suitable dispersal opportunities where nesting and overwintering sites occur. Operation of the project measures could result in localized flooding (inundation) of nesting or overwintering sites that were located within the proposed detention basin. Operation of the other project measures would not be expected to affect nesting or overwintering habitat for bumble bees.

Species

Impacts to insects could include direct mortality and displacement of butterflies and bees within the project area during construction and maintenance activities. Once vegetation was cleared, the insects would avoid the immediate area of project disturbance and feed on available flowering plants outside of the project disturbance limits. Operation of the project measures would not affect foraging butterflies or bees.

Impacts to Suckley's cuckoo bumble bees could include direct mortality and displacement of nesting or overwintering bees within the water-detention area after storm events.

Determination

Due to the localized disturbance area, the availability of alternate flowering plants nearby, and the temporary timeframe of disturbance, implementation of the Proposed Action **would not likely jeopardize the continued existence** of monarch butterfly or Suckley's cuckoo bumble bee.

5.2. Interrelated and Interdependent Effects

The project is not part of a larger action, nor would any other actions be dependent upon this project; therefore, there are no interrelated or interdependent effects of the Proposed Action.

5.3. Cumulative effects

Non-federal activities that are likely to occur in the foreseeable future and that have potential to cause cumulative effects include private property development for residential, agricultural, or municipal purposes.

Future development could lead to mortality or displacement of butterflies and bees into alternate or less suitable habitats. Habitats in the watershed area are already affected by dust and turbulence associated with existing uses. The Proposed Action would have a slight additive adverse effect on flying insects by increasing turbulence and dust during construction and maintenance, but these impacts are not expected to be measurable. Due to the limited potential for impacts from project activities and the

small percentage of habitat impacted, implementation of the Proposed Action would not result in measurable cumulative impacts to monarch butterfly or Suckley's cuckoo bumble bee.

6. Conclusion and Determination of Effect

Considering all the potential effects disclosed above, we determine that the Proposed Action:

- **Would not likely jeopardize the continued existence of the monarch butterfly or Suckley's cuckoo bumble bee.**
- Would have **no effect** on yellow-billed cuckoo or Ute ladies'-tresses.
- Would have **no effect** on designated critical habitat.

7. Literature Cited

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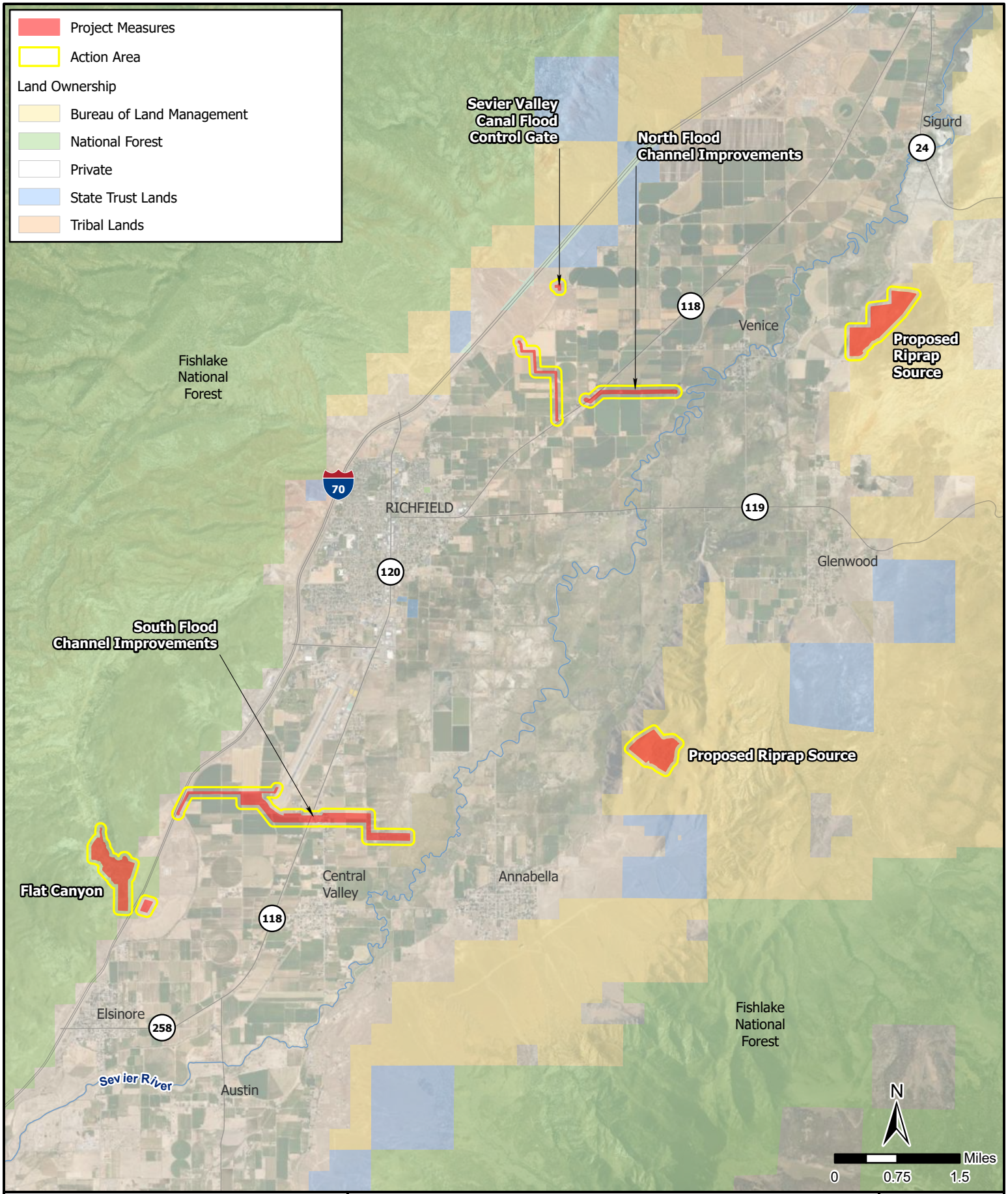
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Appendix A. Map



Jones & DeMille Engineering

- Shaping the Quality of Life -

800.748.5275 www.jonesanddemille.com

Richfield-West Sevier Watershed Plan

Sevier County

Biological Assessment - Project Map

Scale: 1" = 1.5 Miles

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Environmental\Sevier Watershed Plan.aprx - Map BA 01 Project Map

Project Number: 1804-224 | Drawn by: JWW 10-19 | Last Edit: 07/23/2025

Appendix B. USFWS IPaC Species Report

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Utah Ecological Services Field Office
2369 West Orton Circle, Suite 50
West Valley City, UT 84119-7603
Phone: (801) 975-3330 Fax: (801) 975-3331

In Reply Refer To: 06/03/2025 20:22:16 UTC
Project Code: 2024-0121864
Project Name: Richfield-West Sevier Watershed Plan

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:

The enclosed species list identifies threatened, endangered, proposed, and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological

evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

https://www.fws.gov/sites/default/files/documents/endangered-species-consultation-handbook.pdf

Migratory Birds: In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts, see https://www.fws.gov/program/migratory-bird-permit/what-we-do.

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable NEPA documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures, see https://www.fws.gov/library/collections/threats-birds.

In addition to MBTA and BGEPA, 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 concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Code in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List

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:

Utah Ecological Services Field Office
2369 West Orton Circle, Suite 50
West Valley City, UT 84119-7603
(801) 975-3330

PROJECT SUMMARY

Project Code: 2024-0121864
Project Name: Richfield-West Sevier Watershed Plan
Project Type: Dam - New Construction
Project Description: Watershed planning for flood prevention
Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@38.7575492,-112.13429507339248,14z



Counties: Millard and Sevier counties, Utah

ENDANGERED SPECIES ACT SPECIES

There is a total of 4 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.

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.

BIRDS

NAME	STATUS
Yellow-billed Cuckoo *Coccyzus americanus* Population: Western U.S. DPS There is **final** critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/3911	Threatened

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus* There is **proposed** critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/9743	Proposed Threatened
Suckley's Cuckoo Bumble Bee *Bombus suckleyi* Population: No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/10885	Proposed Endangered

FLOWERING PLANTS

NAME	STATUS
Ute Ladies'-tresses *Spiranthes diluvialis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/2159	Threatened

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.

IPAC USER CONTACT INFORMATION

Agency: County of Sevier
Name: Jenna Jorgensen
Address: 1535 S. 100 W.
City: Richfield
State: UT
Zip: 84701
Email jenna.j@jonesanddemille.com
Phone: 4358935203

LEAD AGENCY CONTACT INFORMATION

Lead Agency: Natural Resources Conservation Service

Appendix E.4. Utah Natural Heritage Program Online Species Search Report

Utah Division of Wildlife Resources
Utah Natural Heritage Program
1594 W. North Temple
PO Box 146301
Salt Lake City, UT 84116

Report Number: 15149
February 1, 2024

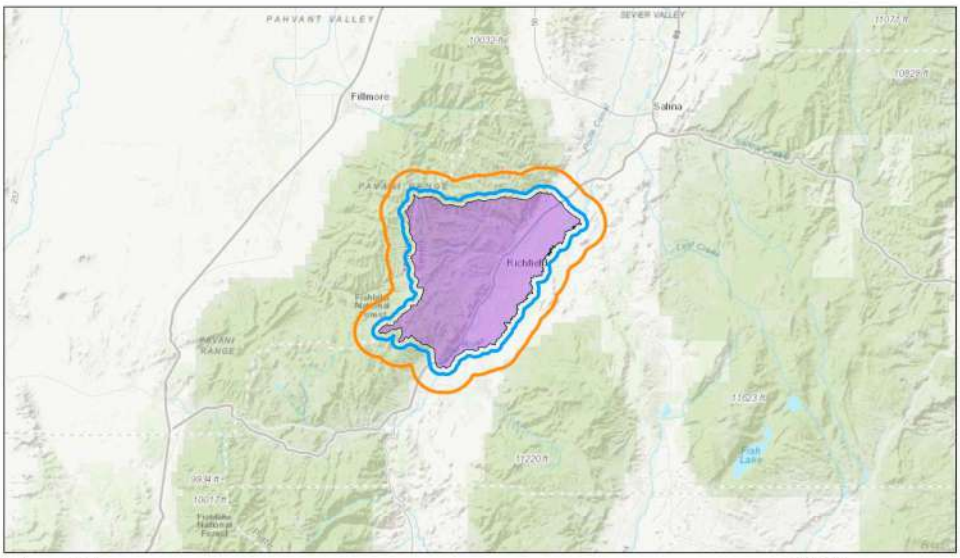
Utah Natural Heritage Program Online Species Search Report

Project Information

Project Name
Richfield-West Sevier Watershed Plan

Project Description
Flood

Location Description
Revised Richfield-West Sevier Watershed



Animals within a ½ mile radius

Common Name	Scientific Name	State Status	U.S. ESA Status	Last Observation Year
Bald Eagle	Haliaeetus leucocephalus	SGCN		2019
Band-tailed Pigeon	Patagioenas fasciata	SGCN		1969
Black Swift	Cypseloides niger	SGCN		1978
Burrowing Owl	Athene cunicularia	SGCN		1992
Carinate Glenwood Pyrg	Pyrgulopsis inopinata	SGCN		1998
Golden Eagle	Aquila chrysaetos	SGCN		2019
Northern Leopard Frog	Lithobates pipiens	SGCN		1978
Olive-sided Flycatcher	Contopus cooperi	SGCN		2014
Pinyon Jay	Gymnorhinus cyanocephalus	SGCN		2020
Southern Leatherside Chub	Lepidomeda aliciae	SGCN		2013
Townsend's Big-eared Bat	Corynorhinus townsendii	SGCN		1959

Plants within a ½ mile radius

Common Name	Scientific Name	State Status	U.S. ESA Status	Last Observation Year
No Species Found				

Animals within a 2 mile radius

Common Name	Scientific Name	State Status	U.S. ESA Status	Last Observation Year
American White Pelican	Pelecanus erythrorhynchos	SGCN		1989
Arizona Mountain Kingsnake	Lampropeltis pyromelana	SGCN		1951
Bald Eagle	Haliaeetus leucocephalus	SGCN		2019
Band-tailed Pigeon	Patagioenas fasciata	SGCN		1969
Black Swift	Cypseloides niger	SGCN		1978
Burrowing Owl	Athene cunicularia	SGCN		1992
Carinate Glenwood Pyrg	Pyrgulopsis inopinata	SGCN		1998
Golden Eagle	Aquila chrysaetos	SGCN		2019
Northern Leopard Frog	Lithobates pipiens	SGCN		1978
Olive-sided Flycatcher	Contopus cooperi	SGCN		2014
Otter Creek Pyrg	Pyrgulopsis fusca	SGCN		1993
Pinyon Jay	Gymnorhinus cyanocephalus	SGCN		2020
Southern Leatherside Chub	Lepidomeda aliciae	SGCN		2013
Townsend's Big-eared Bat	Corynorhinus townsendii	SGCN		1959

Plants within a 2 mile radius

Common Name	Scientific Name	State Status	U.S. ESA Status	Last Observation Year
No Species Found				

Definitions

State Status

SGCN	Species of greatest conservation need listed in the Utah Wildlife Action Plan

U.S. Endangered Species Act

LE	A taxon that is listed by the U.S. Fish and Wildlife Service as "endangered" with the probability of worldwide extinction
LT	A taxon that is listed by the U.S. Fish and Wildlife Service as "threatened" with becoming endangered
LE;XN	An "endangered" taxon that is considered by the U.S. Fish and Wildlife Service to be "experimental and nonessential" in its designated use areas in Utah
C	A taxon for which the U.S. Fish and Wildlife Service has on file sufficient information on biological vulnerability and threats to justify it being a "candidate" for listing as endangered or threatened
PT/PE	A taxon "proposed" to be listed as "endangered" or "threatened" by the U.S. Fish and Wildlife Service

Disclaimer

The information provided in this report is based on data existing in the Utah Division of Wildlife Resources' central database at the time of the request. It should not be regarded as a final statement on the occurrence of any species on or near the designated site, nor should it be considered a substitute for on-the-ground biological surveys. Moreover, because the Utah Division of Wildlife Resources' central database is continually updated, any given response is only appropriate for its respective request.

The UDWR provides no warranty, nor accepts any liability, occurring from any incorrect, incomplete, or misleading data, or from any incorrect, incomplete, or misleading use of these data.

The results are a query of species tracked by the Utah Natural Heritage Program, which includes all species listed under the U.S. Endangered Species Act and species on the Utah Wildlife Action Plan. Other significant wildlife values might also be present on the designated site. Please contact UDWR's regional habitat manager if you have any questions.

For additional information about species listed under the Endangered Species Act and their Critical Habitats that may be affected by activities in this area or for information about Section 7 consultation under the Endangered Species Act, please visit https://ecos.fws.gov/ipac/ or contact the U.S. Fish and Wildlife Service Utah Ecological Services Field Office at (801) 975-3330 or utahfieldoffice_esa@fws.gov.

Please contact our office at (801) 538-4759 or habitat@utah.gov if you require further assistance.

Your project is located in the following UDWR region(s): Southern region

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Report generated for:
Jenna Jorgensen
Jones and DeMille Engineering
1535 S. 100 W.
Richfield, UT 84754
(435) 896-8266
jenna.j@jonesanddemille.com

Appendix E.5. Fish and Wildlife Species of Concern

Species	Classification	Species likely occurrence in the project area and consideration for further analysis
American white pelican (*Pelecanus erythrorhynchus*)	Migratory Bird	**Considered**. Pelicans are associated with wetland and water habitats (Parrish et al. 2002), and may fish in the Sevier River.
Arizona mountain kingsnake (*Lampropeltis pyromelana*)	Utah SGCN[1]	**Considered**. Mountain kingsnakes typically occur in rocky terrain in canyons (UDWR 2015); kingsnakes could occur throughout the western portion of the watershed area.
Bald eagle (*Haliaeetus leucocephalus*)	USFS Sensitive; Utah SGCN[1]; Migratory bird	**Considered**. Bald eagles have been observed in the Sevier Valley as recently as 2019.
Band-tailed pigeon (*Patagioenas fasciata*)	Utah SGCN[1], UDWR-mapped habitat	Not considered. The most recent recorded observation within ½-mile of the watershed area was in 1969. The species is no longer known to occur in the Sevier Valley.
Black bear (*Ursus americanus*)	UDWR-mapped habitat	Not considered. UDWR-mapped crucial year-long habitat for black bear occurs within the western portion of the watershed, at higher elevations than project impacts are anticipated to occur. Black bear habitat is described as having "relatively inaccessible terrain, thick understory vegetation, and abundant sources of food" (UDWR 2010); this habitat does not occur within the valley.
Black swift (*Cypseloides niger*)	Utah SGCN[1]	Not considered. Black swifts nest in association with waterfalls but may forage in lowland riparian habitats (Parrish et al. 2002). Waterfalls do not occur within or near the watershed area, and the most recently recorded observation was in 1978.
Bonneville cutthroat trout (*Oncorhynchus clarki utah*)	USFS Sensitive	Not considered. Aquatic habitats do not occur within the project area on the Fishlake National Forest.
Boreal toad (*Bufo boreas*)	USFS Sensitive	Not considered. Potentially suitable wetland habitat does not occur within the project area on the Fishlake National Forest.
Brewer's sparrow (*Spizella breweri*)	MIS – sage nester guild[2]	Not considered. Potentially suitable sagebrush habitat does not occur within the project area on the Fishlake National Forest.
Burrowing owl (*Athene cunicularia*)	Utah SGCN[1]	**Considered**. Burrowing owls occupy "underground burrows in open and short-grass habitats" (UDWR 2015), and may occur within the watershed area. The most recent recorded observation was in 1992.
California gull (*Larus californicus*)	Migratory Bird	**Considered**. Gulls are associated with water habitats (Parrish et al. 2002), and may occur in association with the Sevier River.

California quail (*Callipepla californica*)	UDWR-mapped habitat	**Considered**. California quail are associated with oak and urban habitats in Utah (Parrish et al. 2002). Year-long crucial habitat is mapped throughout the valley bottom.
Carinate Glenwood pyrg (*Pyrgulopsis inopinata*)	Utah SGCN[1]	Not considered. The most recently recorded observation was in 1998, but the species is "native to only two springs in Utah" (UDWR 2015). Springs are not known to occur in the project areas.
Cassin's finch (*Carpodacus cassinii*)	Migratory bird	Not considered. Cassin's finch are associated with aspen and sub-alpine conifer habitats (Parrish et al. 2002), which occur in the higher elevations of the watershed and would not be impacted by project activities.
Chukar (*Alectoris chukar*)	UDWR-mapped habitat	**Considered**. Chukar are associated with desert scrub and shrubsteppe habitats (Parrish et al. 2002) in steep, rocky topography (UDWR 2003), which occur in the middle elevations of the watershed. The Bull Claim Hill riprap site is within UDWR-mapped year-long substantial habitat.
Clark's grebe (*Aechmophorus clarkii*)	Migratory bird	**Considered**. Clark's grebe are associated with wetland and water habitats (Parrish et al. 2002), and may occur in association with the Sevier River.
Clark's nutcracker (*Nucifraga columbiana*)	Migratory bird	Not considered. Clark's nutcrackers are associated with mixed and sub-alpine conifer habitats (Parrish et al. 2002), which occur in the higher elevations of the watershed and would not be impacted by project activities.
Colorado River cutthroat trout (*Oncorhynchus clarkii pleuriticus*)	USFS Sensitive	Not considered. Aquatic habitats do not occur within the project area on the Fishlake National Forest.
Desert bighorn sheep (*Ovis canadensis nelsoni*)	USFS Sensitive	Not considered. The watershed area is outside the bighorn sheep's known distributional range.
Dusky grouse (*Dendragapus obscurus*)	UDWR-mapped habitat	Not considered. UDWR-mapped crucial year-long habitat for dusky grouse occurs within the western portion of the watershed, at higher elevations than project impacts are anticipated to occur.

Flammulated owl (*Otus flammeolus*)	USFS Sensitive	Not considered. The flammulated owl is a cavity nester and an opportunistic insectivore (McCallum 1994) and could occur in the forested areas of the watershed. Potentially suitable forest nesting and foraging habitat occurs within the western portion of the watershed, at higher elevations than project impacts are anticipated to occur.
Golden eagle (*Aquila chrysaetos*)	Utah SGCN[1]; Migratory bird	**Considered**. Golden eagles have been observed in the Sevier Valley as recently as 2019.
Greater sage-grouse (*Centrocercus urophasianus*)	USFS Sensitive	Not considered. Suitable sagebrush habitat does not occur within or near the project area on the Fishlake National Forest.
Hairy woodpecker (*Leuconotopicus villosus*)	MIS – cavity nester[2]	Not considered. Suitable mature forest habitat does not occur within or near the project area on the Fishlake National Forest.
Lincoln's sparrow (*Melospiza lincolnii*)	MIS – riparian guild[2]	Not considered. Suitable riparian habitat does not occur within or near the project area on the Fishlake National Forest.
MacGillivray's warbler (*Geothlypis tolmiei*)	MIS – riparian guild[2]	Not considered. Suitable riparian habitat does not occur within or near the project area on the Fishlake National Forest.
Mountain bluebird (*Sialia currucoides*)	MIS – cavity nester[2]	Not considered. Suitable mature forest habitat does not occur within or near the project area on the Fishlake National Forest.
Mule deer (*Odocoileus hemionus*)	MIS[2], UDWR-mapped habitat	**Considered**. UDWR-mapped winter crucial habitat is mapped along the foothills on the west side of the Sevier Valley.
Northern goshawk (*Accipiter gentilis*)	USFS Sensitive, MIS[2]	Not considered. The northern goshawk uses a variety of habitats in Utah, ranging from Engelmann spruce and subalpine fir to pinyon-juniper woodlands (Graham et al. 1999); suitable forest habitats do not occur within or near the project area on the Fishlake National Forest.
Northern leopard frog (*Lithobates pipiens*)	Utah SGCN[1]	**Considered**. Northern leopard frog could occur in association with waters and wetlands within the watershed (Smith and Keinath 2007), including the Sevier River and canals.
Olive-sided flycatcher (*Contopus cooperi*)	Migratory bird	Not considered. Olive-sided flycatcher are associated with subalpine conifer habitats (Parrish et al. 2002), which occur in the higher elevations of the watershed and would not be impacted by project activities.

Otter Creek pyrg (*Pyrgulopsis fusca*)	Utah SGCN[1]	Not considered. The most recently recorded observation was in 1993, but the species is "found in three springs in Utah" (UDWR 2015). Springs are not known to occur in the project areas.
Peregrine falcon (*Falco peregrinus anatum*)	USFS Sensitive; Migratory bird	**Considered**. Suitable cliff nesting and proximal foraging habitat (USFWS 1984) occur within the watershed.
Pinyon jay (*Gymnorhinus cyanocephalus*)	Utah SGCN[1]; Migratory bird	**Considered.** Pinyon jay are associated with pinyon-juniper type habitat in Utah (Parrish et al. 2002), which occurs along the foothills on the west side of the Sevier Valley.
Pygmy rabbit (*Brachylagus idahoensis*)	USFS Sensitive	Not considered. Suitable tall sagebrush (*Artemisia tridentata*) habitat (Green and Flinders 1980) does not occur within or near the project area on the Fishlake National Forest.
Rocky Mountain elk (*Cervus elaphus nelsoni*)	MIS[2], UDWR-mapped habitat	Not considered. UDWR-mapped crucial winter and summer substantial habitat for elk occurs within the western portion of the watershed, at higher elevations than project impacts are anticipated to occur.
Rufous hummingbird (*Selasphorus rufus*)	Migratory bird	**Considered**. Rufous hummingbirds may occur in Utah during migration (Sibley 2003).
Sage thrasher (*Oreoscoptes montanus*)	MIS – sage nester guild[2]	Not considered. Potentially suitable sagebrush habitat does not occur within the project area on the Fishlake National Forest.
Song sparrow (*Melospiza melodia*)	MIS – riparian guild[2]	Not considered. Suitable riparian habitat does not occur within or near the project area on the Fishlake National Forest.
Southern leatherside chub (*Lepidomeda aliciae*)	Utah SGCN[1]; USFS Sensitive	**Considered**. Aquatic habitats do not occur within the project area on the Fishlake National Forest, but the species may occur within the Sevier River.
Spotted bat (*Euderma maculatum*)	USFS Sensitive	**Considered.** Spotted bats have been observed in Utah year-round and in a variety of habitats (Luce and Keinath 2007), and may occur within the watershed.
Three-toed woodpecker (*Picoides dorsalis*)	USFS Sensitive	Not considered. In Utah, three-toed woodpeckers generally nest and winter above 8,000 feet (2,400 meters) in elevation (Parrish et al. 2002). High-elevation forest habitat does not occur within or near the project area on the Fishlake National Forest.

Townsend's big-eared bat (*Corynorhinus townsendii*)	Utah SGCN[1], USFS Sensitive	**Considered.** Townsend's big-eared bats roost sites range from the lowest elevations in Utah up to 10,460 feet (Gruver and Keinath 2006), and may occur within the watershed. The most recent recorded observation was in 1959.
Turkey (*Meleagris gallopavo*)	UDWR-mapped habitat	**Considered**. Year-long turkey habitat is mapped along the Sevier River within the watershed area.
Vesper sparrow (*Pooecetes gramineus*)	MIS – sage nester guild[2]	Not considered. Potentially suitable sagebrush habitat does not occur within the project area on the Fishlake National Forest.
Virginia's warbler (*Vermivora virginiae*)	Migratory bird	**Considered**. Virginia's warbler are associated with oak and pinyon-juniper habitats in Utah (Parrish et al. 2002), which occur along the foothills on the west side of the Sevier Valley.
Western grebe (*Aechmorphorus occidentalis*)	Migratory bird	**Considered**. Western grebes are associated with wetland and water habitats (Parrish et al. 2002), and may occur in association with the Sevier River.
Western bluebird (*Sialia mexicana*)	MIS – cavity nester[2]	Not considered. Suitable mature forest habitat does not occur within or near the project area on the Fishlake National Forest.
White-tailed jackrabbit (*Lepus townsendii*)	UDWR-mapped habitat	**Considered**. The watershed is wholly within UDWR-mapped year-long habitat.
Yellow warbler (*Setophaga petechia*)	MIS – riparian guild[2]	Not considered. Suitable riparian habitat does not occur within or near the project area on the Fishlake National Forest.

[1] Species of greatest conservation need/BLM sensitive species

[2] Management indicator species as identified in the 1986 Fishlake National Forest LRMP

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Appendix E.6. Forest Service Biological Assessment/Biological Evaluation

Richfield-West Sevier Watershed Plan: Flat Canyon Site

Biological Evaluation

Prepared by: Jenna Jorgensen
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Contents

Introduction 1
Methodology 1
Project Action Area 1
General Setting 1
Forest Service-Sensitive Species Considered 1
Current Management Direction 2
Existing Environment 3
Species 3
Direct and Indirect Effects of the Proposed Action 4
Interrelated and Interdependent Effects 5
Cumulative Effects 5
Conclusion and Determination of Effect 6
References 7

Tables

Table 1. Forest Service-sensitive species that may occur or have suitable habitat in or around the project area. 1

Introduction

This biological evaluation (BE) analyzes the potential effects of the proposed project on species listed as sensitive on the Regional Forester's Sensitive Species List for the Intermountain Region (Region 4), and determines whether the likely effects on these species would result in a trend toward becoming federally listed.

The project description is detailed in chapter 3 of the EA.

Methodology

Impacts were assessed based on assumed presence or absence of species within the project area based on on-site review. The indicator for impacts to all present species is change in habitat effectiveness; this is evaluated on a qualitative basis. Where possible, direct impacts to suitable habitats were quantified.

Project Action Area

The proposed project action area includes the proposed Flat Canyon flood control features, and extends one-half (0.5) linear mile for potential noise disturbance impacts. The project would disturb up to 102.3 acres; the noise buffer includes approximately 1,400.9 acres (see map 1 in Appendix A).

Ongoing activities in the area include grazing, recreational off-highway vehicle (OHV) use, power line operation, and I-70 freeway use.

General Setting

The project area is within the Basin and Range – Colorado Plateau Transition physiographic subdivision of the Colorado Plateau. More specifically, the project area is located southwest of Richfield in central Utah on the Fishlake National Forest. Elevation of the proposed project is between 5,540 and 5,750 feet above sea level. A majority of the project area has been previously impacted by OHV use.

Forest Service-Sensitive Species Considered

The Forest Service-sensitive species that may occur or have suitable habitat in or around the project area are shown in Table 1.

Table 1. Forest Service-sensitive species that may occur or have suitable habitat in or around the project area.

Species	Habitat suitability or known occurrences of species in or near the project area	Species to be analyzed further? (Yes or No)*
Bald eagle (*Haliaeetus leucocephalus*)	Bald eagles are not known to nest or roost within or near the project area; suitable mature trees and open water do not occur within or near the project area. Any bald eagles would be incidental, and would likely avoid project activities.	No
Bonneville cutthroat trout (*Oncorhynchus clarki utah*)	Aquatic habitats do not occur within the project area.	No
Boreal toad (*Bufo boreas*)	Potentially suitable wetland habitat does not occur within the project area.	No

Species	Habitat suitability or known occurrences of species in or near the project area	Species to be analyzed further? (Yes or No)*
Colorado River cutthroat trout *(Oncorhynchus clarki pleuriticus)*	Aquatic habitats do not occur within the project area.	No
Desert bighorn sheep (*Ovis canadensis nelsoni*)	The project area is outside the bighorn sheep's known distributional range.	No
Flammulated owl (*Otus flammeolus*)	Potentially suitable forest nesting and foraging habitat does not exist within the project area.	No
Greater sage-grouse (*Centrocercus urophasianus*)	The project area is outside the species' known distributional range.	No
Northern goshawk (*Accipiter gentilis*)	Potentially suitable forest nesting and foraging habitat does not exist within the project area.	No
Peregrine falcon (*Falco peregrinus anatum*)	Potentially suitable cliff nesting habitat occurs adjacent to the project area.	**Yes**
Pygmy rabbit (*Brachylagus idahoensis*)	The species is not known to occur within the area; potentially suitable tall sagebrush habitat does not occur within the project area.	No
Southern leatherside chub (*Lepidomeda aliciae*)	Aquatic habitats do not occur within the project area.	No
Spotted bat (*Euderma maculatum*)	Potentially suitable cliff roosting habitat occurs adjacent to the project area, and the project area contains potentially suitable foraging habitat.	**Yes**
Three-toed woodpecker (*Picoides tridactylus*)	Potentially suitable forest nesting and foraging habitat does not exist within the project area.	No
Townsend's big-eared bat (*Corynorhinus townsendii)*	Potentially suitable roosting and foraging habitat occurs within the project area.	**Yes**
Sigurd townsendia (*Townsendia jonesii* var *lutea*)	Potentially suitable habitat occurs within the project area.	**Yes**
Elsinore buckwheat (*Eriogonum ostlundii*)	Potentially suitable habitat occurs within the project area.	**Yes**
Ward's penstemon (*Penstemon wardii*)	Potentially suitable habitat occurs within the project area.	**Yes**
*__Yes__ - The proposed project's potential effects on these species will be further analyzed in this document. *No – No further analysis is necessary, and a determination of "no impact" is made.		

Current Management Direction

Current policy as stated in the Forest Service Manual (FSM 2670.32) includes the following:

1. Assist states in achieving their goals for conservation of endemic species.

2. Review programs and activities as part of the National Environmental Policy Act of 1969 process through a Biological Evaluation, to determine their potential effect on sensitive species.
3. Avoid or minimize impacts to species whose viability has been identified as a concern.
4. Analyze, if impacts cannot be avoided, the significance of potential adverse effects on the population or its habitat within the area of concern and on the species as a whole.
5. Establish management objectives in cooperation with the states when projects on National Forest system lands may have a significant effect on sensitive species, population numbers, or distributions. Establish objectives for federal candidate species, in cooperation with FWS or NOAA Fisheries and the states.

Existing Environment

The existing environment within the project action area largely consists of cheatgrass (*Bromus tectorum*) and sparse shrub-steppe areas. The bottom of the canyon and alluvial area are disturbed by OHV tracks and power line tower pads. The steep canyon walls are relatively undisturbed, and may include scattered pinyon and juniper trees.

For more information concerning wildlife life history and species accounts, please refer to *Life History and Analysis of Endangered, Threatened, Candidate, Sensitive, and Management Indicator Species of the Fishlake National Forest* (Rodriguez 2006). This Forest Service document is incorporated here by reference and is considered to include some of the best available science on these species.

Species

Peregrine falcon

Potentially suitable cliff nesting habitat may occur within the project action area. The project area does not provide suitable riparian or open water habitat that would provide prey for foraging falcons, but the birds have been observed hunting on the treeless ridges and meadows along the crest of the Pahvant Mountains. Peregrine falcon have been found nesting on the Fillmore Ranger District in more arid habitat than is generally used in other areas.

Spotted bat

Potentially suitable cliff nesting habitat may occur within the project action area, and foraging may occur throughout the project area. The nearest documented occurrence is over 40 miles to the southeast, in Capitol Reef National Park.

Townsend's big-eared bat

Townsend's big-eared bat have been recorded in the immediate vicinity of Richfield; bats could roost within buildings near the project area. Suitable foraging habitat occurs throughout the project area.

Sigurd townsendia

Sigurd townsendia is known to occur in the foothills within Sevier Valley between 5,500 and 6,300 feet asl. Suitable habitat typically consists of "salt desert and mixed desert shrub and pinyon-juniper-sagebrush communities on semi-barren, white to red, fine-textured (often gypsiferous) shale and clay substrates" (Groebner 2005a). Suitable habitat likely occurs at numerous locations within the project area.

Elsinore buckwheat

Elsinore buckwheat is known to occur on "south-facing steep slopes of loose volcanic gravels and rocks in pinyon-juniper woodlands and shadscale scrub communities" between 5,500 and 6,500 feet asl (Clark 2005). Suitable habitat likely occurs at numerous locations within the project area.

Ward's penstemon

Ward's penstemon suitable habitat typically consists of semi-barren, white to gray, fine-textured substrates between 5,500 and 6,800 feet asl. Associated vegetation includes ephedra, rabbitbrush, shadscale, mountain mahogany, sagebrush, and pinyon-juniper communities (Groebner 2005b). Suitable habitat likely occurs at numerous locations within the analysis area.

Direct and Indirect Effects of the Proposed Action

Direct effects include the disturbance of up to 102.3 acres within the project area. Direct impacts to wildlife species could occur as a result of the removal of vegetation that may provide suitable habitat for foraging; however, habitat effectiveness in the area is decreased due to the existing disturbance and scarcity of suitable vegetation. The loss of habitat would be temporary, as appropriate areas would be reseeded upon project completion. Temporary disturbance (up to 1 year) to wildlife due to noise or the presence of equipment and personnel could occur during construction.

Operation of the basin would result in inundation of the basin behind the dam when storm flows were detained. Detained water may attract insect or bird species.

Maintenance of the system would require heavy equipment use on an as-needed basis, to clean sediment and debris out of the basin. Temporary disturbance to wildlife due to noise or the presence of equipment and personnel could occur.

Soils substrate that provides suitable habitat for sensitive plant species may be removed for use in the embankment. Areas of suitable habitat may also be inundated after storms.

Peregrine falcon

Although riparian foraging habitat does not occur within the project area, peregrine falcon eyries typically occur with 10 miles of an adequate prey source (USFWS 1984). Anecdotal observations also suggest that falcons hunt throughout the Sevier Valley. The project area is within a 10-mile radius of suitable riparian habitat in the valley; therefore, it is possible that falcons nest in suitable cliff habitat near the project area.

The recovery plan for the species recommends minimizing human activities within 1 mile of active eyries (USFWS 1984). If peregrine falcons were to nest on a cliff near the project area, they could be disturbed by construction activities. Construction activities would occur during breeding season due to temperature and weather constraints. Noise and human presence could result in displacement and abandonment of an active nest if peregrines happened to nest near the project. However, habitat suitability is likely decreased due to the project proximity with I-70 and the frequent OHV use in the area. Habitat effectiveness for nesting peregrine falcons would decrease only slightly as a result of project implementation. The proposed action would not adversely impact peregrine falcons.

Spotted bat and Townsend's big-eared bat

Potentially suitable bat roosting habitat would not be affected by construction of the dam, but suitable rocky roosting habitat could be temporarily inundated when the basin was detaining flood water. There would be little risk of disturbance to bats from the proposed construction activities, as the nocturnal bats

would be roosting during daytime project activities. Suitable roosting habitat above the inundation limit is abundant around the project area.

Bats could continue to forage within the project area, as prey insects would be available in both disturbed and undisturbed areas. Operation of the detention basin could provide open water, which attracts insects, and could increase foraging opportunities for up to 10 days, depending on the storm flows. Foraging habitat effectiveness would not decrease as a result of project implementation. The proposed action would not adversely impact bats.

Sigurd townsendia, Elsinore buckwheat, Ward's penstemon

Specific occurrences of each species within the project area are unquantified. Less than 102.3 acres of potentially suitable habitat below 8,000 feet asl would be impacted by project construction activities or basin inundation. Individuals of each species may be removed by project activities; however, due to the localized nature of the project within a highly disturbed area, project implementation would not significantly affect populations in the area. The proposed action would not adversely impact Forest Service-sensitive plant species.

Interrelated and Interdependent Effects

The project is not part of a larger action, nor would any other actions be dependent upon this project; therefore, there are no interrelated or interdependent effects of the proposed action.

Cumulative Effects

The purpose of the cumulative effects section is to describe the interaction among the effects of the proposed action and relevant past, present, and reasonably foreseeable actions. This interaction may be:

- Additive: the effects of the actions add together to make up the cumulative effect.
- Countervailing: the effects of some actions balance or mitigate the effects of other actions.
- Synergistic: the effects of the actions together is greater than the sum of their individual effects.

Spatial and Temporal Context for Effects Analysis

The Cumulative Effects Area (CEA) represents a landscape surrounding the project area where past, present, and reasonably foreseeable future management actions have occurred or will occur. The CEA for animal species is the Pahvant Mountain section of the Fillmore Ranger District (see map 2 in Appendix A). The CEA includes approximately 373,506 acres. The species included in this analysis will use part of this CEA during some portion of their life cycle.

Based on the published literature of ranges for the species (Utah Native Plant Society 2019), the CEA for sensitive plant species consists of the Fillmore Ranger District in Sevier County below 8,000 feet asl; this area is approximately 149,023 acres (see map 3 in Appendix A).

The temporal scope is permanent for direct and indirect impacts associated with implementation of the project. Ground-disturbing activities are expected to result in permanent disturbance; operation and maintenance would be ongoing and dependent on weather conditions at any given time.

Past, Present, and Reasonably Foreseeable Activities Relevant to Cumulative Effects Analysis

Management actions in the area include recreational OHV use, vegetation management (e.g., timber harvest, timber stand improvement, prescribed burning), livestock grazing and trailing, special uses (e.g., firewood collection, outfitters, and guides), and limited motorized access.

Peregrine falcon

Suitable remote nesting cliffs for peregrine falcons likely occur throughout the CEA. Construction and maintenance of the detention basin could lead to displacement of falcons into alternate or less suitable habitats, and behavioral disruption and stress due to noise and human presence; however, much of the remaining habitat in the CEA is relatively undisturbed. Less than three hundredths of a percent (0.027 percent) of the CEA would be disturbed by project activities. Falcons that avoided nesting near the area of project disturbance would have available remote cliff nesting opportunities elsewhere within the CEA. Habitat effectiveness within the larger CEA would not be noticeably impacted by the proposed project.

Implementation of the project would not adversely affect the species or affect the population trend of peregrine falcons on the Fishlake National Forest.

Spotted bat and Townsend's big-eared bat

Bats may roost or forage throughout the entire 373,506-acre CEA; however, less than three hundredths of a percent of the CEA would be disturbed by project activities. The nocturnal bats are unlikely to be affected by construction or operation of the basin, as these activities would occur during the day. Bats that avoided roosting near or foraging in the disturbed project area would have abundant available roosting and foraging opportunities within the CEA. Habitat effectiveness within the larger CEA would not be noticeably impacted by the proposed project.

Implementation of the project would not adversely affect the species or affect the population trend of spotted bat or Townsend's big-eared bat on the Fishlake National Forest.

Plant species (Sigurd townsendia, Elsinore buckwheat, Ward's penstemon)

Suitable habitat for these sensitive plant species occurs throughout the CEA. Less than 0.07 percent of the CEA for plants would be disturbed by project activities. Due to the limited potential for impacts from project activities and the small percentage of habitat impacted within the CEA, implementation of the project would not adversely affect these species or affect the population trends of sensitive plant species on the Fishlake National Forest.

Conclusion and Determination of Effect

As a result of this analysis, it is our professional determination that implementation of the proposed action may impact individuals or habitat of all sensitive species analyzed in this document, but would not likely contribute to a trend toward federal listing or cause a loss of persistence to these populations or species.

References

Clark, D. J. 2005. 2005 Survey Results for *Eriogonum ostlundii* (Elsinore Buckwheat). September 26, 2005.

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Appendix A. Maps

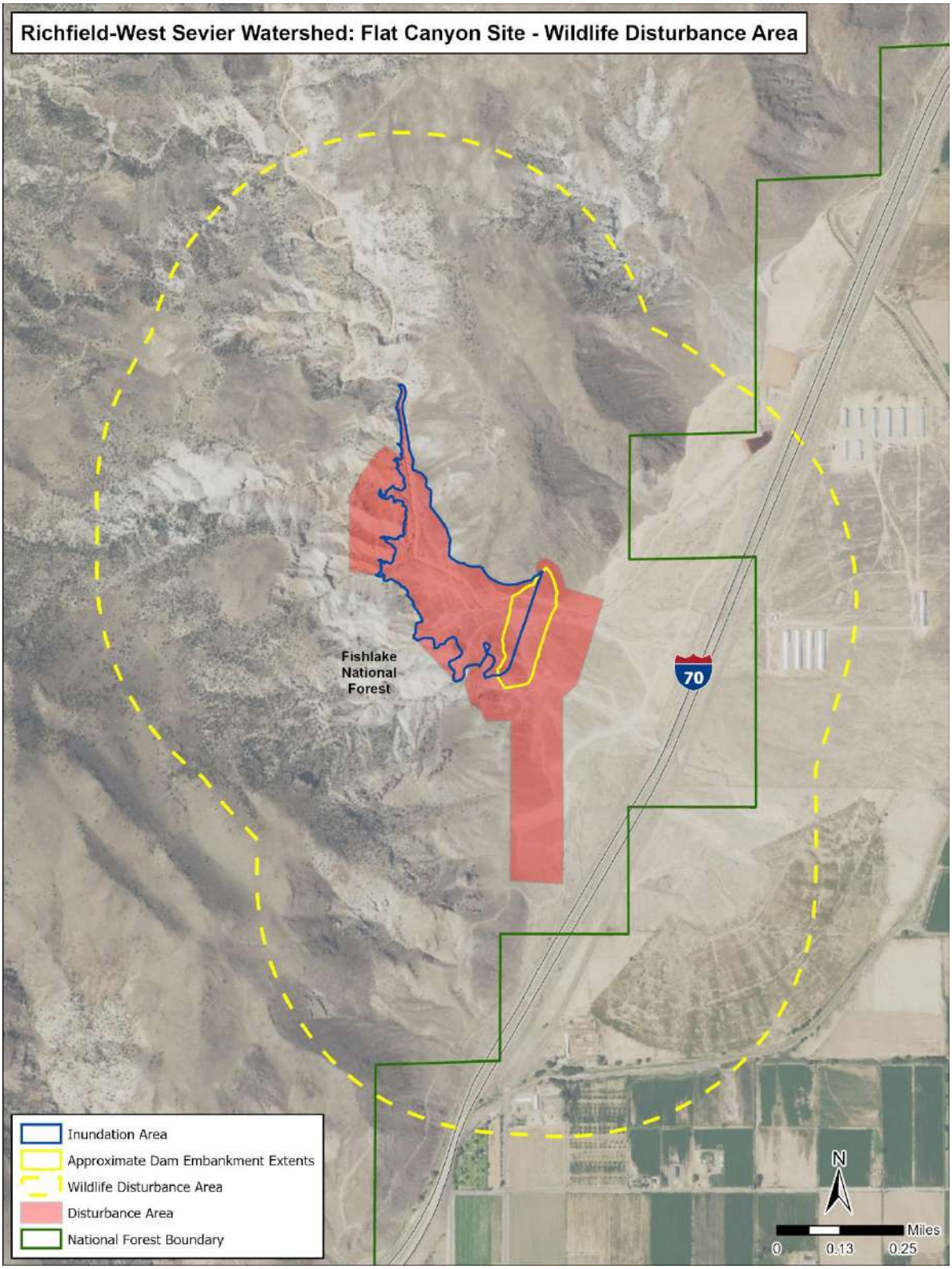


Figure 1. Project Action Area with ½-mile Noise Buffer

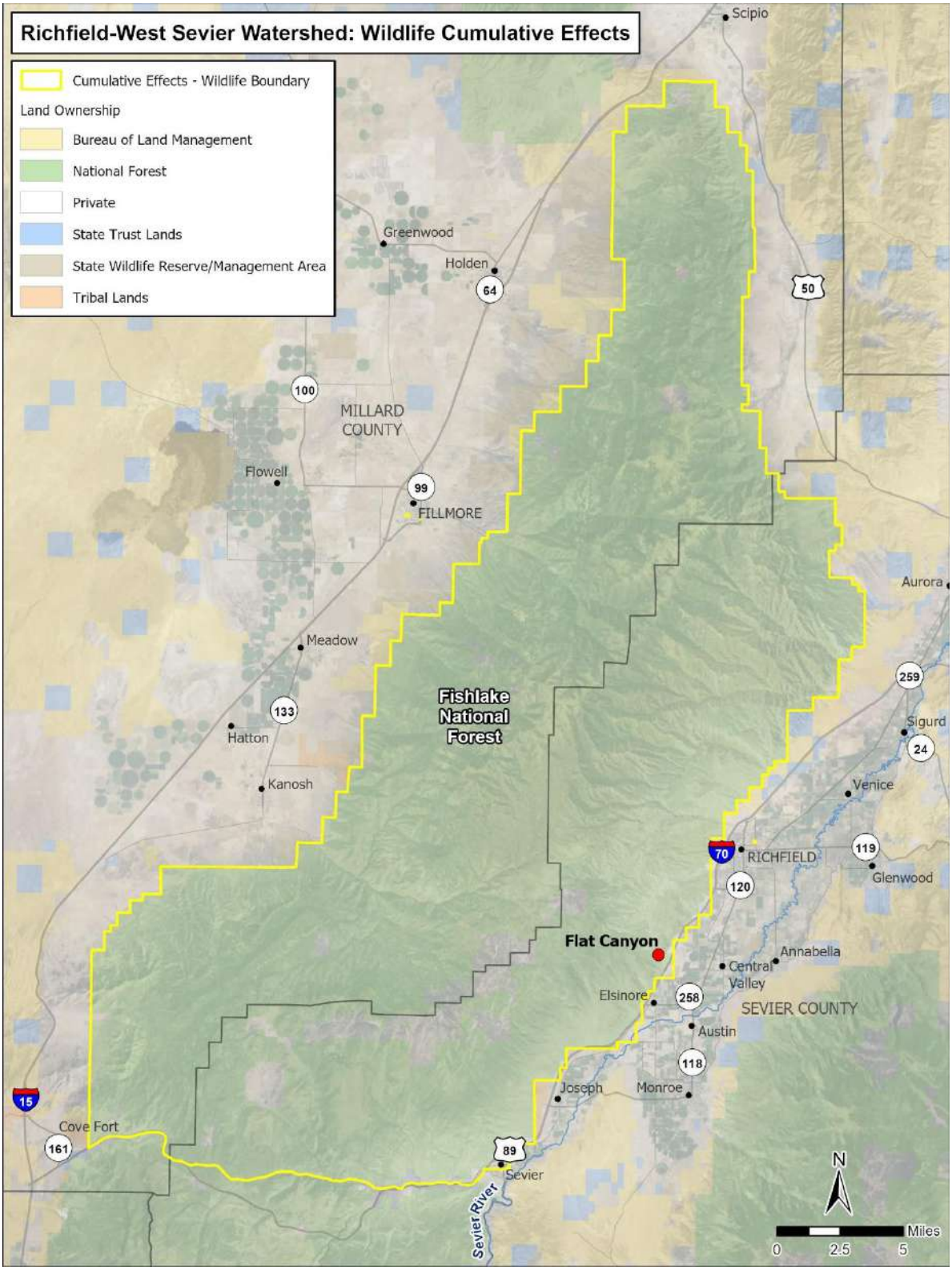


Figure 2. Sensitive Wildlife Cumulative Effects Area (CEA) Overview

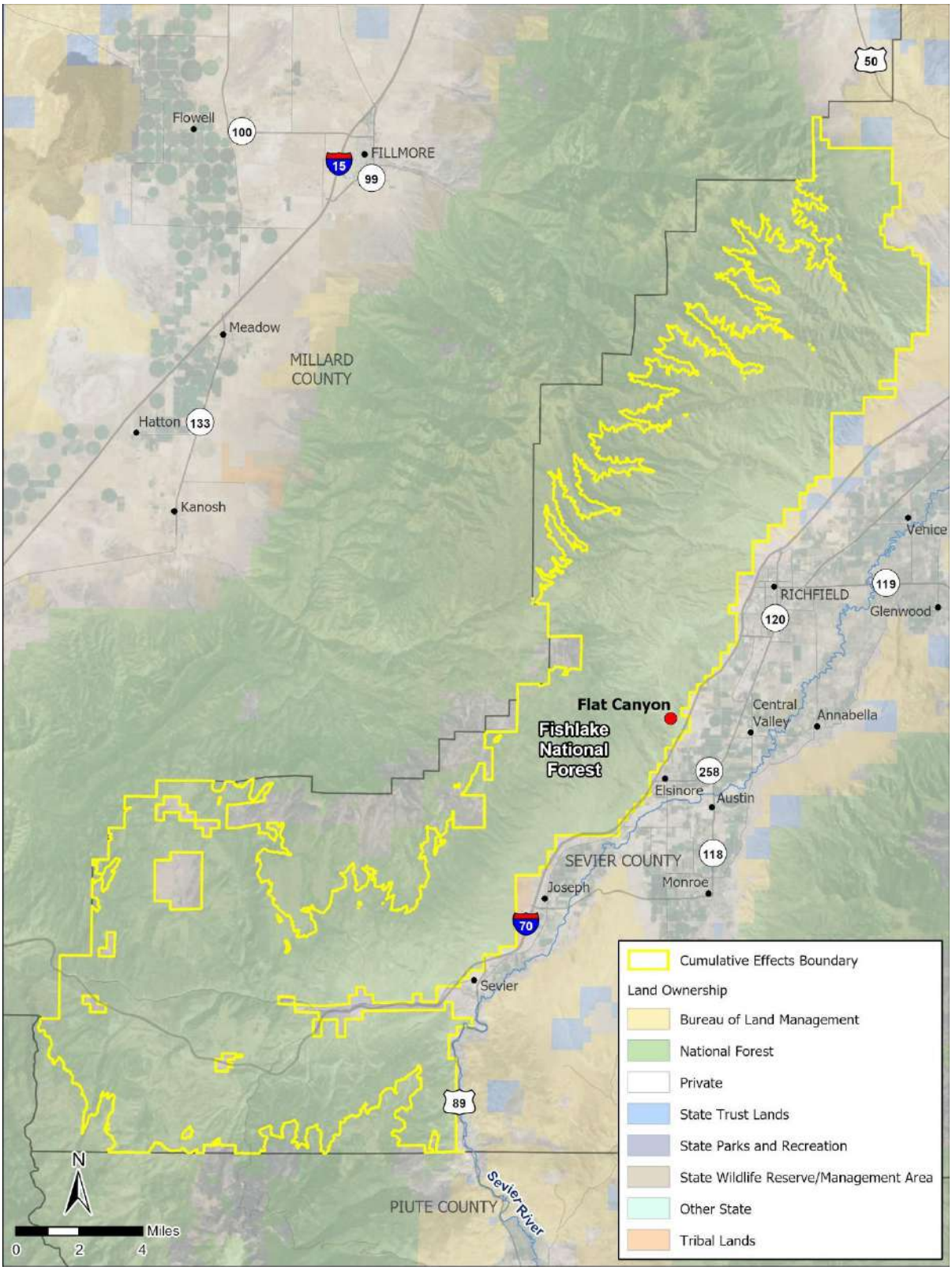


Figure 3. Sensitive Plant Cumulative Effects Area (CEA) Overview

Appendix E.7. Forest Service Biological Specialist Report

Richfield-West Sevier Watershed Plan: Flat Canyon Site

Biological Resources Report

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October 3, 2019

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Contents

Introduction 1
Project Description 1
Methodology 1
Project Action Area 1
General Setting 2
Affected Environment 2
Species Considered 2
Management Direction 3
Environmental Consequences 3
Proposed Action - Direct and Indirect Effects 3
Cumulative Effects 3
Regulatory Framework 3
Land and Resource Management Plan 3
Executive Orders 4
References Cited 5

Appendix A. Maps 6

Introduction

Wildlife species selected for this analysis are composed of the following four groups:

1. Species that are listed as threatened, endangered, or proposed under the Endangered Species Act. Based on the USFWS IPaC System (accessed 8-21-2019), there would be no effect to listed species or critical habitats (see Appendix E of the Environmental Assessment [EA] for list and rationale).
2. Species listed as sensitive on the Regional Forester's Sensitive Species List for the Intermountain Region (Region 4). A biological evaluation (BE) was prepared separately to disclose impacts of the proposed action and sensitive species will not be addressed further in this report, with the exception of the northern goshawk, which is also a management indicator species.
3. Management indicator species (MIS) as designated by the Fishlake National Forest Land and Resource Management Plan (USDA 1986, as amended):
    a. Rocky Mountain elk (*Cervus elaphus*)
    b. Mule deer (*Odocoileus hemionus*)
    c. Northern goshawk (*Accipiter gentilis*)
    d. Cavity nesters
        - Hairy woodpecker (*Leuconotopicus villosus*)
        - Mountain bluebird (*Sialia currucoides*)
        - Western bluebird (*Sialia mexicana*)
    e. Riparian dependent guild
        - Lincoln's sparrow (*Melospiza lincolnii*)
        - Song sparrow (*Melospiza melodia*)
        - Yellow warbler (*Setophaga petechia*)
        - MacGillivray's warbler (*Geothlypis tolmiei*)
    f. Sage nester guild
        - Brewer's sparrow (*Spizella breweri*)
        - Vesper sparrow (*Pooecetes gramineus*)
        - Sage thrasher (*Oreoscoptes montanus*)
4. Other Species of Concern. For this analysis, additional migratory bird species were not selected because effects to all impacted habitat types were analyzed for other species in this analysis.

Project Description

The project description is detailed in chapter 3 of the EA.

Methodology

Impacts were assessed based on assumed presence or absence of species within the project area. The indicator for impacts to all present species is change in habitat effectiveness; this is evaluated on a qualitative basis. Where possible, direct impacts to suitable habitats were quantified.

Project Action Area

The proposed project action area includes the proposed Flat Canyon flood control features, and extends one-half (0.5) linear mile for potential noise disturbance impacts. The project would disturb up to 102.3 acres; the noise buffer includes approximately 1,400.9 acres (see map 1 in Appendix A).

Ongoing activities in the area include grazing, recreational off-highway vehicle (OHV) use, power line operation, and I-70 freeway use.

General Setting

The project area is within the Basin and Range – Colorado Plateau Transition physiographic subdivision of the Colorado Plateau. More specifically, the project area is located southwest of Richfield in central Utah on the Fishlake National Forest. Elevation of the proposed project is between 5,540 and 5,750 feet above sea level. A majority of the project area has been previously impacted by OHV use.

Affected Environment

Land cover of the project area is dominated by cheatgrass (*Bromus tectorum*), with Russian thistle (*Kali tragus*) and scarce greasewood (*Sarcobatus vermiculatus*) and rabbitbrush (*Ericameria nauseosa*). Isolated juniper (*Juniperus osteosperma*) are also scattered along the drainage bottom. The bottom of the canyon and alluvial area are disturbed by OHV tracks and power line tower pads.

For more information concerning wildlife life history and species accounts, please refer to *Life History and Analysis of Endangered, Threatened, Candidate, Sensitive, and Management Indicator Species of the Fishlake National Forest* (Rodriguez 2006). This Forest Service document is incorporated here by reference and is considered to include some of the best available science on these species.

Species Considered

Rocky Mountain elk

The proposed project is outside of UDWR-mapped range for elk. Elk are unlikely to range to the low elevations of Flat Canyon. There would be no effect to elk, and the species will not be addressed further in this report.

Mule deer

The proposed project is within UDWR-mapped crucial winter range for mule deer. Forage and cover is extremely limited in the area, but mule deer may use Flat Canyon as a corridor to access agricultural lands within Sevier Valley to the east.

Northern goshawk

Potentially suitable nesting or foraging habitat does not occur within or near the project area, which lacks mature forest types. Any goshawks that may fly through the project area would be incidental, and would avoid project activities. There would be no effect to northern goshawk individuals or habitat. The northern goshawk will not be addressed further in this report.

Cavity nesters (hairy woodpecker, mountain bluebird, western bluebird)

Potentially suitable mature forest habitat does not occur within or near the project area; therefore, these species would not be affected by implementation of the project, and will not be addressed further in this report.

Riparian dependent nesters (Lincoln's sparrow, song sparrow, yellow warbler, MacGillivray's warbler)

Riparian habitats do not occur within the project area; therefore, the riparian guild species would not be affected by implementation of the project. Riparian nesters will not be addressed further in this report.

Sage nesters (Brewer's sparrow, vesper sparrow, sage thrasher)

Potentially suitable sagebrush habitat does not occur within the project analysis area; these species would not be affected by implementation of the project, and will not be addressed further in this report.

Management Direction

Species selected as MIS are used to monitor a particular habitat type. This is accomplished by assessing the habitat conditions and population changes of the MIS that occupy each habitat, as required in the National Forest Management Act of 1976 (published at 36 CFR parts 200 to 299, July 1, 2000 edition).

Environmental Consequences

Proposed Action - Direct and Indirect Effects

Direct effects include the disturbance of up to 102.3 acres within the project area. Direct impacts to wildlife species could occur as a result of the removal of vegetation that may provide suitable habitat for foraging; however, habitat effectiveness in the area is decreased due to the existing disturbance and scarcity of suitable vegetation. The loss of habitat would be temporary, as appropriate areas would be reseeded upon project completion. Temporary disturbance (up to 1 year) to wildlife due to noise or the presence of equipment and personnel could occur during construction, but is unlikely as most animals would be habituated to some level of disturbance from the existing recreational uses.

Operation of the basin would result in inundation of the basin behind the dam when storm flows were detained. Detained water may attract insect or bird species.

Maintenance of the system would require heavy equipment use on an as-needed basis, to clean sediment and debris out of the basin. Temporary disturbance to wildlife due to noise or the presence of equipment and personnel could occur.

Mule deer

Approximately 69 acres of UDWR-mapped winter crucial mule deer habitat would be impacted by the proposed action (see map 1 in Appendix A); however, the area lacks sufficient vegetation to provide forage or cover during winter use periods. If construction were feasible during winter use periods, project activities would occur during daylight hours. Deer would likely travel through the area at dawn and dusk to access agricultural lands with forage opportunities, and would avoid project activities. Deer would be able to move through the canyon during construction.

Upon project completion, deer would be able to travel over the embankment to move through the canyon. During periods of inundation, deer would likely travel higher up the canyon wall to enter or leave the canyon. Maintenance operations would be temporary on an as-needed basis, and would likely occur during daylight hours. There would be no noticeable effect to mule deer as a result of implementation of the project.

Cumulative Effects

Because there would be no direct or indirect effects to mule deer as a result of the proposed action, there would be no cumulative effects.

Regulatory Framework

Land and Resource Management Plan

This analysis incorporates by reference the direction provided in the Fishlake National Forest Land and Resource Management Plan (LRMP; 1986). The proposed analysis is project level analysis, and is not intended to re-examine the basic land use allocations made in the LRMP, nor does this project level planning propose broad changes in land use allocations. Instead, planning at the project level involves the

development, analysis, and disclosure of likely environmental impacts associated with the implementation of specific actions designed to achieve the overall goals and objectives of the LRMP. The project area is outside of designated management areas.

The LRMP provides standards and guidelines for management of wildlife resources. Relevant standards and guidelines include:

- Habitat for each species on the Forest will be maintained by protecting at least 40% of the ecosystems for existing species. Proper juxtaposition of ecosystems must be considered.

Executive Orders

E.O. 13186

Executive Order 13186, signed January 10, 2001, directs federal agencies to protect migratory birds by integrating bird conservation principles, measures, and practices into agency activities and by avoiding or minimizing, to the extent practical, adverse impacts on migratory birds' resources when conducting agency actions. This Order directs agencies to further comply with the Migratory Bird Treaty Act (MBTA), the Bald and Golden Eagle Protection Act, and other pertinent statutes. This analysis is compliant with the National Memorandum of Understanding between the USDA Forest Service and the USFWS to promote the conservation of migratory birds (USDA 2008).

References Cited

USDA. 2008. Memorandum of Understanding between the U.S. Department of Agriculture Forest Service and the U.S. Fish and Wildlife Service to promote the conservation of migratory birds. Abigail Kimball (Chief USDA Forest Service) and H. Dale Hall (Director US Fish and Wildlife Service). December 8.

Appendix A. Maps

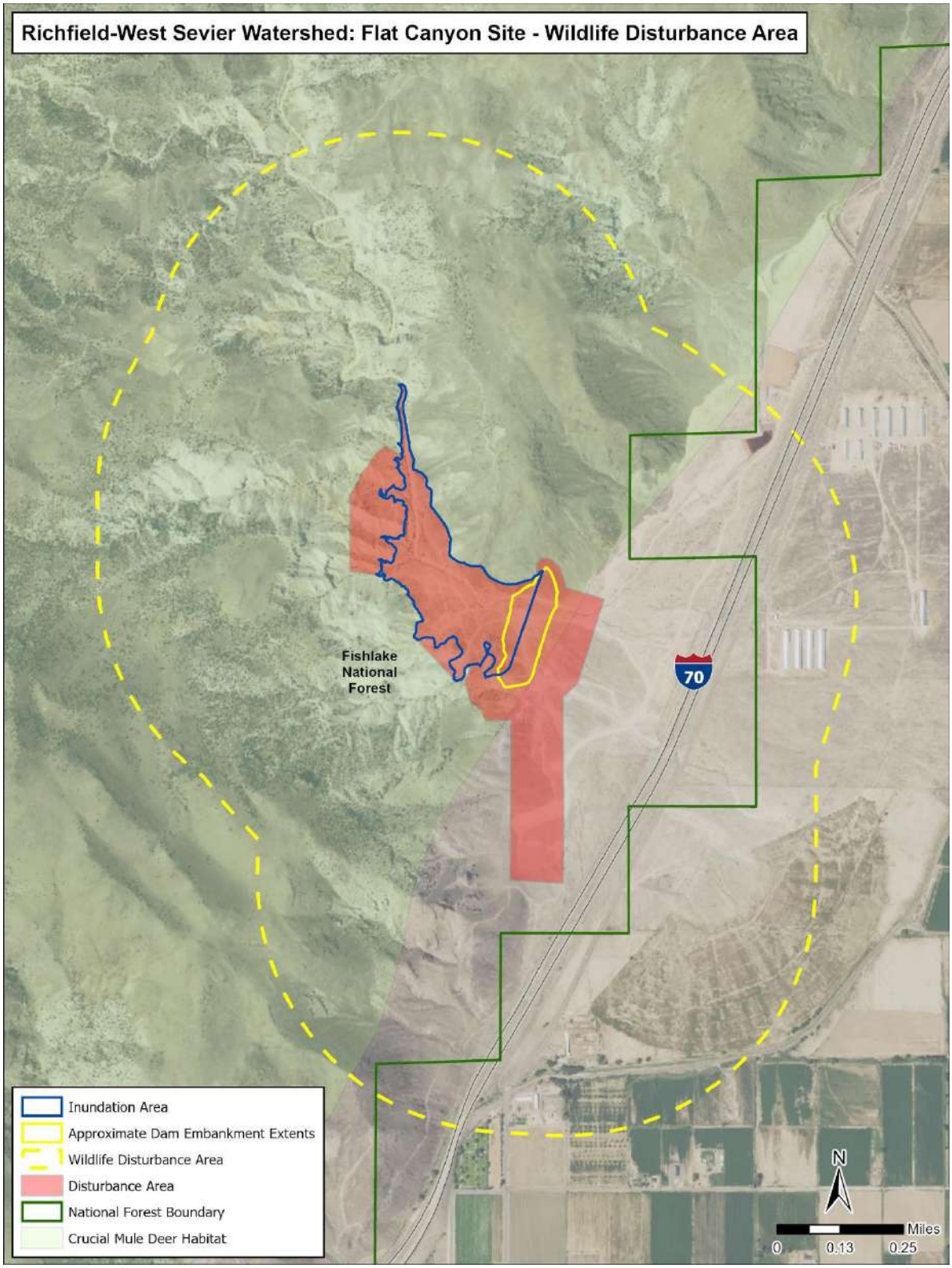


Figure 1. Project Action Area with ½-mile Noise Buffer and UDWR-mapped Mule Deer Habitat

Appendix E.8. Flat Canyon Clay Mine Plan

Mineral Materials Site Development and Reclamation Plan -Flat Canyon-

I. **Site Location**: Flat Canyon in Sevier County, UT
L3, L4, L6 Sec. 17 Township 24 S Range 3 W SLBM
38° 42' 50.78" N by 112° 8' 58.03" W
Elevation 5,700 feet

Access to Site: From Cove View Road parallel to I-70 south of Richfield, turn west and pass under I-70. Travel approximately 0.7 miles northwest on the dirt road, up the canyon. The material to be extracted makes up the hills on the west.

Operator:
Name: Sevier County
Address: 250 N. Main St, Richfield, UT 84701
Phone Number: (435) 893-0400
On-site Foreman: TBD
FS Representative: TBD
On-site Foreman Phone Number: TBD

II. **Existing Conditions Description**: Approximately 15.5 acres have been identified for clay material extraction, in two separate portions indicated on the attached map. The clay hills are adjacent to the proposed Flat Canyon debris basin, and form the western boundary of the proposed inundation area. The hills are sparsely vegetated with desert scrub. The southern site has been heavily disturbed by recreational OHV use; the northern site is relatively undisturbed. Aerial imagery of each site shows the relative disturbance.



Aerial image of southern proposed clay source



Aerial image of northern proposed clay source

III. **Mine Plan Development**: Over 5 years of operation (anticipated to begin 2023), approximately 101,200 cubic yards of material will be excavated and removed. Approximately 102 acres will be cleared through NEPA for construction, operation, and maintenance of the debris basin; the proposed clay extraction areas are contained within this area. The volume of material removed would be tracked for annual reporting purposes.

IV. **Environmental Protection Measures** – The following measures will be employed:

- The project area would be temporarily closed during construction for safety.
- Soil within the project area will be sprayed with water or another approved dust suppressant/soil binder. The quantity of water used for dust control will be minimized to prevent water from leaving the site.
- Procedures to reduce emissions during material transportation or handling may include wetting materials hauled in trucks, providing adequate freeboard (space from the top of the material to the top of the truck), or covering loads.
- Material stockpiles will be wetted to prevent wind-blown emissions.
- Appropriate emission-control devices will be required on all construction equipment.
- The use of cleaner burning fuels will be required.
- Only properly operating, well-maintained construction equipment will be used.
- Equipment servicing and refueling areas will be located at least 300 feet away from any stream channels. To ensure that accidental spills do not enter waters, the storage of petroleum-based fuels and the refueling of construction machinery would not occur outside of approved designated staging/batch plant areas. The project would comply with state and federal water quality standards and toxic effluent standards to minimize any potential adverse impacts from discharges to waters of the U.S.
- A stormwater pollution prevention plan (SWPPP) will be prepared by the construction contractor prior to initiation of ground disturbance. The SWPPP will detail the best management practices and site-specific control features to prevent sediment and other pollutants from discharging off the site during construction. BMPs may include silt fence, fiber wattles, and earthen berms.
- The project area will be kept free of any garbage and debris. Garbage will be removed from the site regularly and will be disposed of in approved facilities.
- Other disturbed areas on National Forest System lands will be seeded with an appropriate seed mix per FSM 2070.
- No construction materials would be stockpiled or deposited in or near any water bodies.
- Equipment will be washed and inspected prior to entering the project area to remove any soil and debris that may contribute to the spread of noxious weeds.
- Source material areas will be left with slope gradients that are safe for recreationists to use following construction activities.
- If construction activities occur between March 1 and September 30, clearance surveys for migratory birds within 10 days prior by a qualified biologist will be required. Appropriate spatial and temporal buffers will be applied if nesting birds are located.
- Fire Protection – The operator will take initial attack suppression actions for fires started as a result of operations. Fires must be reported to Richfield Interagency Fire Center at 435-896-8404 as soon as possible. Properly rated fire extinguishers will be provided in each on site vehicle and internal combustion engine. Pick-ups and dump trucks will have shovels. All gasoline- and diesel-powered equipment must be equipped with effective spark arrestors or mufflers. In addition, all electrical equipment must be properly insulated to prevent sparks.

- Fire restriction compliance requirement – Operations are subject to Forest Service and State of Utah fire restrictions and the Forest Service reserves the right to suspend operations during periods of high fire potential.
- Cultural/Historical values – No known historic or archaeological values exist in the area. If any cultural resources are encountered during project activities, activities will cease immediately and the Forest Service will be notified.
- Protection and replacement of survey markers – Section corners or other survey markers, including claim corners, in the project area must be located and flagged for preservation prior to commencement of surface disturbing activities. The removal, displacement, or disturbance of markers must be approved by the Forest Service. Replacement will be done by the Forest Service at the expense of the operator.

V. **Reclamation**

Due to the natural conditions and site capability of the sites, reclamation is anticipated to consist of grading to create slope gradients that are safe for recreationists to use following construction activities, and seeding where practicable.

Plan Authorized by Authorization Date

Appendix E.9. Unanticipated Archaeological Discoveries Procedures

In the event that any cultural materials identified during construction will be considered significant discoveries requiring longer-term work stoppage for consultation and mitigation, the NRCS will consult per 36 C.F.R. 800.6 to develop a Phase II data recovery (mitigation) plan to further mitigate adverse effects.

Depending on what is identified, the cultural remains will be recorded or treated as a discovery based on the criteria listed below. Procedures for responding to cultural resources discovered during monitoring are also discussed below.

Discovery Definition

For the purposes of this project, the criteria for determining significant discoveries will include, but are not limited to:

- Dense concentrations of prehistoric artifacts that appear to represent significant
- deposits or in situ artifact deposits rather than isolated artifacts.
- Dense concentrations of historical artifacts that appear to represent significant deposits or in situ artifact deposits rather than isolated artifacts.
- Prehistoric cultural features.
- Historical features considered to be significant.
- Any human bone.
- The types of artifacts and features that will not be considered significant discoveries and will be considered non-significant cultural resources include:
- Recent debris from use of the property.
- Individual prehistoric artifacts or groups of small number of artifacts with no apparent potential for further discovery of artifacts or features.
- Individual historical artifact or groups of small numbers of artifacts with no apparent potential for further discovery of artifacts or features.
- Individual non-human bones or groups of small numbers of bones with no apparent potential for further discovery of artifacts or features.

Discovery Procedures

If resources are encountered that are not cultural or are cultural but not significant, the resources will be documented and the construction will be allowed to continue after documentation is complete. Documentation will consist of illustrations (where relevant), photographs, detailed descriptions, and recording of the location of the cultural material. If a significant cultural resource is identified, the following procedures will be implemented depending on whether the discovery consists of features and artifacts other than human remains or whether it consists of human remains.

For cultural resources not involving human remains, the NRCS will provide the Utah SHPO, participating tribal governments, and as applicable, the USFS, the BLM, Utah TLA, or private landowner, with a proposed mitigation plan for review and comment. At the discretion of the NRCS cultural resource specialist, construction may be allowed to continue in the area of the discovery while the mitigation plan is under review by consulting parties. Under all circumstances, continuation of work following a discovery will be contingent upon approval by the NRCS cultural resource specialist in consultation with the Utah SHPO and other consulting parties.

If human remains are discovered under any circumstances, they will be secured and protected until such time as appropriate disposition has been determined in accordance with applicable local, state, and federal statutes. Construction activities in the immediate vicinity of the discovery will cease immediately within 15 meters (50 feet) of the discovery. The NRCS will immediately notify the local Sheriff's Department of the discovery, and will notify the Utah SHPO. The NRCS will consult to develop an appropriate mitigation plan that meets all the requirements of NAGPRA (Public Land) and Utah Code 9-8-309 (private land) for inadvertent discoveries. After approval of the plan, mitigation will proceed. Construction in the area of the remains may need to be halted throughout the review process. Continuation of work following a discovery will be contingent upon approval by the NRCS cultural resource specialist in consultation with the Utah SHPO and other consulting parties.

Appendix E.10. Technical Memoranda

TM001 – Design Criteria

TM002 – Hydrology

TM003 – Sedimentation

TM004 – Hydraulics

TM005 – Geotechnical

TM006 – Economics

TM007 – Design Drawings

TM008 – Probable Costs

TM009 – Hazard Classifications

Appendix E.10. Technical Memoranda

TM001 – Design Criteria

TM002 – Hydrology

TM003 – Sedimentation

TM004 – Hydraulics

TM005 – Geotechnical

TM006 – Economics

TM007 – Design Drawings

TM008 – Probable Costs

TM009 – Hazard Classifications

TM001 – Design Criteria

1.0 Introduction

There are significant flooding issues in Sevier County in and around the Richfield City area. The proposed solutions to mitigate these issues involve the construction of several detention/debris basins, flood channels, and overflow structures. The feasibility of constructing debris basins at Flat Canyon, Lind Canyon, Tank Canyon, and Wood Canyon was evaluated. A smaller sediment/debris trap structure was also considered at the mouth of Wood Canyon. The project would also require existing flood channels to be improved and extended, as the channels would receive attenuated flood waters from other hydraulic structures. Table 1-1 summarizes the applicable design standards that were considered for design.

Table 1-1. Design Criteria Considered for Each Project Element

Design Criteria & Practice Standards	Flat, Lind, Tank, and Wood Canyons Debris Basins	Wood Canyon Sediment Control Basin	North Flood Channel	South Flood Channel
NRCS Technical Release 210-60 (TR-60)	X			
Sedimentation Design Criteria	X			
Earth Embankments Design Criteria	X			
Principal Spillway Design Criteria	X			
Auxiliary Spillway Design Criteria	X			
Utah Administrative Code R655	X			
R655-11-6: Embankment Requirements	X			
R655-11-7: Outlet Requirements	X			
R655-11-8 Spillway Requirements	X			
NRCS Conservation Practice Standard (CPS) Structure for Water Control (Code 587)			X	X
NRCS CPS Open Channel (Code 582)			X	X
NRCS CPS Water and Sediment Control Basin (Code 638)		X		
NRCS CPS Lined Waterway or Outlet (Code 468)			X	X

2.0 Design Criteria

2.1 NRCS Technical Release 210-60 (TR-60)

TR-60 (NRCS 2019) provides minimum requirements for planning and designing earth dams and associated spillways. TR-60 applies to "all low hazard potential dams with a product of effective storage times the effective height of the dam of 3,000 acre-feet^2 or more, dams more than 35 feet in effective height, and all significant and high hazard dams." This standard includes criteria on dam hazard classification, design storms, freeboard, sedimentation, drawdown, embankment, and spillways. The guidelines also reference other applicable standards and requirements not listed here.

2.2 Utah Administrative Code R655

The following rules are the Utah Dam Safety standards that are applicable for detention/debris basins that are also considered dams.

- Utah Administrative Code "R655-10: Dam Safety Classifications, Approval Procedures and Independent Reviews" outlines the procedures necessary to obtain approval to design, construct, operate, and remove a dam (UAC 2016a).
- Utah Administrative Code "R655-11: Requirements for the Design, Construction and Abandonment of Dams" outlines the minimum design requirements for dams constructed in Utah (UAC 2016b).
- Utah Administrative Code "R655-12: Requirements for Operational Dams" outlines the minimum operational requirements for dams (UAC 2016c).

2.3 NRCS National Engineering Handbook (NEH)

The National Engineering Handbook (NEH; NRCS 2010a) provides design criteria for a number of different engineering applications.

2.4 NRCS Conservation Practice Standards (CPS)

NRCS conservation practice standards contain information on why and where each practice is applied, and set forth the minimum planning criteria that must be met during the implementation of each practice in order for it to achieve its intended purposes. The following CPS are considered for this project

2.4.1 Structure for Water Control (Code 587)

CPS Code 587 (NRCS 2017a) provides the minimum design criteria for water management systems that control the stage, discharge, distribution, delivery, or direction of water flow. The proposed design contains several culverts and hydraulic structures such as overflow weirs, dump gates, and overshot structures.

2.4.2 Open Channel (Code 582)

CPS Code 582 provides the minimum design criteria for improvement, construction, and restoration of open channels (NRCS 2015). The proposed project contains two flood channels. Both flood channels

require improvement and restoration of their existing condition. New portions of these flood channels would also be constructed to improve flood management and water conveyance.

2.4.3 Water and Sediment Control Basin (Code 638)

CPS Code 638 provides the minimum design criteria for water and sediment control basins (NRCS 2017b). The purpose of these sediment basins is to trap sediment and reduce and manage runoff. The proposed design contains two sediment control basins to be located below Wood Canyon to trap sediment and reduce runoff into the Sevier Valley Canal.

2.4.4 Lined Waterway or Outlet (Code 468)

CPS Code 468 describes the minimum design criteria for lined waterways or outlets (NRCS 2010b). One purpose is to provide for safe conveyance of runoff from structures without causing erosion or flooding. The design considers armoring of flood channels to prevent erosion.

3.0 References

Natural Resources Conservation Service (NRCS). 2010a. National Engineering Handbook (NEH).

——. 2010b. Lined Waterway or Outlet 468. Natural Resources Conservation Service.

——. 2015. CPS Open Channel 582. September 2015.

——. 2017a. CPS Structure for Water Control (Code 587). October 2017.

——. 2017b. CPS Water and Sediment Control Basin (Code 638). October 2017.

——. 2019. Technical Release 210-60: Earth Dams and Reservoirs (TR-60).

Utah Administrative Code (UAC). 2016a. R655-10: Dam Safety Classifications, Approval Procedures and Independent Reviews.

——. 2016b. R655-11: Requirements for the Design, Construction and Abandonment of Dams.

——. 2016c. R655-12: Requirements for Operational Dams.

TM002 – Hydrology

Table of Contents

1.0 Design Storms 1
1.1 Utah Dam Safety Criteria 1
1.2 NRCS Criteria 2
1.3 Precipitation Depths 3
2.0 Hydrologic Modeling Parameter Estimates 4
2.1 Subwatershed Topographic Characteristics 4
2.2 Hydrologic Soil-Cover Complexes and SCS Curve Numbers 4
2.3 Initial Abstraction 5
2.4 Lag Time 5
2.5 Transform Method 6
3.0 Hydrologic Modeling 6
3.1 Hydrologic Model Input 6
3.2 Hydrologic Modeling Results 7
4.0 References 9

Attachments

Attachment A. Hydrology Analysis Map
Attachment B. Hydrologic Model Input & Output
Attachment C. Hydrographs

Tables

Table 1-1. Precipitation Depth Summary 3
Table 2-1. Watershed Topographic Characteristics 4
Table 2-2. Summary of AMC II SCS Curve Numbers 5
Table 2-3. Area Weighted SCS Curve Numbers 5
Table 2-4. Initial Abstraction 5
Table 2-5. Estimated Lag Times using the SCS Velocity and Subwatershed Lag Methods 6
Table 3-1. Debris Basin Geometric Parameters 6
Table 3-2. Hydrologic Modeling Results for the Controlling Design Storms 7
Table 3-3. Minimum Required Spillway Sizing 8

1.0 Design Storms

This hydrology analysis focuses primarily on Flat Canyon. This report summarizes the hydrology approach at large, but primarily focuses on the analysis related to sizing a debris basin for Flat Canyon. However, the hydrology for frequency storms used to complete the economics and sizing of improvements other than debris basins is also documented for Flat Canyons.

The design storms used for the analysis of the debris basin sites were developed to meet the requirements of the NRCS and Utah Dam Safety. Applicable guidelines include Earth Dams and Reservoirs – Technical Release 210-60 (TR-60; NRCS 2019a) and Utah Dam Safety Rules R655-10 and R655-11. The design criteria were also based on the dam structures being classified as high hazard, as recommended in *TM009 – Hazard Classification*.

1.1 Utah Dam Safety Criteria

Utah Dam Safety Rule R655-11-4 requires the development of storms following Hydrometeorological Report No. 49 (HMR-49; NOAA 1984) and two studies specifically for Utah, namely the “2002 Update for Probable Maximum Precipitation, Utah 72 Hour Estimates to 5,000 sq. mi. - March 2003" (USUL; Jensen 2003) and "Probable Maximum Precipitation Estimates for Short Duration, Small Area Storms in Utah - October 1995 " (USUS; Jensen 1995). The USUL and USUS studies were developed after HMR-49 to provide a better representation of actual conditions in Utah.

Precipitation depths developed from USUL and USUS are referred to as the Spillway Evaluation Precipitation (SEP) values, whereas those depths developed strictly following HMR-49 are referred to as the Probable Maximum Precipitation (PMP). Hydrographs developed from the SEP values are referred to as the Spillway Evaluation Flood (SEF), whereas hydrographs developed from the PMP values are referred to as the Probable Maximum Flood (PMF). It was never intended that the precipitation depths developed following USUL and USUS would exceed those developed following HMR-49. Therefore, only the lowest precipitation depths between the SEPs and PMPs were considered.

The final Inflow Design Hydrograph (IDF) is determined by routing the SEF and PMF storms through a given reservoir to determine the critical event. This critical event is then compared to the 100-year 6-hour storm and the 100-year 24-hour storm with a saturated subwatershed (Antecedent Moisture Condition III [AMC III]). The state rules also require that the 100-year storms must be routed with appropriate allowances for freeboard. The final controlling storm is then adopted as the Utah Dam Safety IDF.

Freeboard requirements include 1) routing the IDF, 2) containing the wave action (wave height, runup, and setup) during a 100-mph wind event, 3) routing the 100-year storm event with enough freeboard to contain wave action resulting from a 50-mph wind event and 4) a minimum normal freeboard of 3 feet. For the purposes of this analysis, a reasonably conservative freeboard residual was reserved by oversizing the emergency spillway with a minimum height of 7.5 feet and a corresponding width as needed to pass the required design storms. This conservative approach gives us an approximate size for a 30% design and has a relatively small impact on the design and construction cost. The final design would include a more detailed analysis of freeboard requirements.

The principal spillways for the debris basins will not be equipped with a valve or gate to ensure the spillway is always open and functional. The outlet pipe will be protected against clogging by installation of oversized trash/debris racks integrated into the outlet structure. Therefore, the principal spillways were modeled as open during all storm events with a starting water surface elevation at the estimated 100-year sediment elevation (see *TM003-Sedimentation* for additional information).

Two computer programs were obtained from Utah Dam Safety to aid in the calculation of the SEP and PMP values as well as develop the SEF and PMF hyetographs. The program input includes the latitude and longitude of each drainage basin centroid. The program output was verified by comparing to independent estimates calculated using USUS, USUL, and HMR-49.

The 100-year 6-hour and 100-year 24-hour AMC III storms were developed by using the NOAA Atlas 14 precipitation depths and applying them to the temporal distributions published in the same report (Bonnin et al. 2011). The second quartile median distributions were used for the General Precipitation Area. The 100-year storms were also applied to the Soil Conservation Service (SCS) Type II distribution based on the location of the subwatersheds within the United States. This was done for comparison purposes in determining a reasonably conservative design. The SCS Type II distribution typically results in a more conservative design due to a high rainfall volume in a short period of time.

1.2 NRCS Criteria

The FBH and ASH are developed following the most applicable references from the National Weather Service (NWS). These references include HMR-49 in estimating the PMP and PMF, which are used as the FBH. The USUL and USUS special probable maximum precipitation studies used by Utah Dam Safety in conjunction with HMR-49 have been accepted by the NRCS for the purposes of the FBH (letter of acceptance dated March 6, 2007). Therefore, by following the Utah Dam Safety criteria in evaluating the local short-duration storm and general long-duration storm, the FBH is also evaluated. It should also be noted that TR-60 requires the evaluation of 6-hour and 24-hour storms. The local short-duration storm and general long-duration storm per Utah Dam Safety standards have durations of 6 hours and 72 hours, respectively; therefore, to meet both NRCS and Utah Dam Safety requirements, the 6-hour, 24-hour, and 72-hour storms were evaluated using USUL and USUS. The critical SEF or PMF as applicable is adopted as the FBH.

The ASH is developed by applying an equation from TR-60 Figure 2-2 to estimate the precipitation depth and applying to a short duration storm distribution. For a high hazard dam, this precipitation equation is P100 + 0.26*(PMP-P100). Conservatively, the PMP values (rather than the SEP values) were used to estimate the precipitation depths for this storm. Hyetographs were developed for each subwatershed by applying the precipitation depths to the temporal distributions published by NOAA (Bonnin et al. 2011). The second quartile median distributions were used for the General Precipitation Area. Both a 6-hour and 24-hour duration ASH were developed for each subwatershed to evaluate the spillway capacity.

The PSH for a high hazard dam is a 100-year 10-day duration storm that must be passed through the principal spillway without initiating the auxiliary spillway. The precipitation depths for this storm were taken from NOAA Atlas 14 (Bonnin et al. 2011) and the distribution was developed following the procedures outlined in National Engineering Handbook – Design Hydrographs (Section 4, Chapter 21) (NRCS 2019b). This storm was routed through the debris basins with the starting elevation set at the 100-year sediment storage elevation (see *TM003-Sedimentation* for additional information).

The capacity of the emergency spillway was evaluated by routing the FBH with no residual freeboard and the ASH with freeboard. The minimum freeboard can be estimated following guidance found in Technical Release No. 69 – Riprap for Slope Protection against Wave Action (Soil Conservation Service 1983a). However, the analysis found that the debris basins are capable of passing the ASH with a freeboard in excess of 5 feet; therefore, for the purposes of this study and a 30% design, this was assumed to be adequate.

In addition to the design storms for the proposed debris basins, the economic analysis in *TM006-Economics* required the development of eight frequency storm events. The return intervals evaluated are the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year events.

Precipitation depths for these storms were taken from NOAA Atlas 14 (Bonnin et al. 2011) and applied to the SCS Type II distribution based on the location of the subwatersheds within the United States. The drainage basins for these storms were extended downstream of the proposed debris basins to critical infrastructure such as the culvert crossings on I-70.

1.3 Precipitation Depths

Precipitation depths for each of the storm events were estimated for the SEP and PMP by using the Utah Dam Safety programs discussed earlier based on the centroid location of each drainage basin. The precipitation depths for the remaining storms were estimated by calculating the average precipitation depth over each drainage basin. This was done by downloading the NOAA Atlas 14 precipitation raster data and calculating the average over each drainage basin area using ArcGIS. A summary of the precipitation depths used is shown in Table 1-1.

Table 1-1. Precipitation Depth Summary

Storm Distribution	Storm Duration	Flat Canyon
Local SEP	Local Short Duration Storms (6-hour)	4.37
Local PMP	Local Short Duration Storms (6-hour)	10.81
General SEP	General Long Duration Storms (24-hour)	8.51
General PMP	General Long Duration Storms (24-hour)	9.40
General SEP	General Long Duration Storms (72-hour)	10.25
General PMP	General Long Duration Storms (72-hour)	14.36
10-year	6-hour storms	NA
100-year	6-hour storms	2.08
2-year	24-hour storms	1.30
5-year	24-hour storms	1.59
10-year	24-hour storms	1.83
25-year	24-hour storms	2.16
50-year	24-hour storms	2.43
100-year	24-hour storms	2.70
200-year	24-hour storms	2.86
500-year	24-hour storms	3.36
100-year	10-day storms	4.57

As shown in Table 1-1, the precipitation depth for the Local SEP is significantly smaller for Flat Canyon compared to the other storms. The reason for this is the aerial adjustment factor, which is based on the watershed size. This factor is applied automatically within the Utah Dam Safety computer program mentioned previously. As shown in Table 2-1, Flat Canyon has a larger watershed, resulting in a larger aerial reduction.

2.0 Hydrologic Modeling Parameter Estimates

Hydrologic modeling parameters were estimated for each of the subwatersheds as described below. In accordance with TR-60, the SCS Curve Number and SCS Unit Hydrograph methods were used in the model.

2.1 Subwatershed Topographic Characteristics

The best available LIDAR surface was obtained from the Utah Automated Geographic Reference Center (AGRC). This surface was utilized to determine the drainage basin boundaries, elevations, slopes, and longest watercourse lengths. The drainage basin boundaries are shown on the exhibit in Attachment A.

Note that the exhibit includes two drainage basin boundaries for Flat Canyon, with the larger drainage basin in the upper subwatershed to the mouth of the drainage, and the smaller drainage basin just downstream to features such as canals and major culverts. These areas were shown separately in order to estimate flows at different locations to support the sizing of improvements such as debris basins and channels, as well as different parts of the analysis that account for the larger area (e.g., economics analysis). For simplicity in presenting the analysis, only the larger upper subwatershed hydrology is presented below, focusing on the debris basin locations. The smaller downstream subwatersheds are shown to demonstrate how the subwatersheds were expanded slightly to include downstream areas as needed for the analysis. Table 2-1 presents a summary of the basin topography information for the subwatersheds draining to the mouth of each drainage.

Table 2-1. Watershed Topographic Characteristics

Parameter	Flat Canyon
Drainage basin area (square miles)	16.5
Longest watercourse length (miles)	9.1
Average drainage basin slope (%)	37.6

2.2 Hydrologic Soil-Cover Complexes and SCS Curve Numbers

The spatially distributed hydrologic soils data was obtained from the local USDA soils scientist. Soil data from the NRCS Web Soil Survey website was also reviewed and found to agree with this data where overlapping occurred; however, the soil data available through the Web Soil Survey was not as complete and detailed as the data provided by the local USDA office. Therefore, the more complete soil data set from the USDA soils scientist was used, which shows the Hydrologic Soil Group (HSG) ratings that range from A to D, with the majority of the subwatersheds being characterized with a HSG of B and D at 24% and 74% total subwatershed area, respectively.

Aerial imagery, field visits, and photographs were reviewed to characterize the land cover types of the subwatershed areas according to the tables found in Part 630 in the National Engineering Handbook (NEH), Chapter 9, Hydrologic Soil-Cover Complexes (NRCS 2004). The majority of the land cover in the subwatersheds consists of sage-grass and pinyon-juniper vegetative types with varying hydrologic conditions. Note that the hydrologic conditions account for the condition of the land cover itself and the percentage of ground cover. Most of the land cover types were assigned as poor or fair condition, with the exception of a relatively small portion that was assumed to be in good condition based aerial imagery and field visits. The exhibit in Attachment A shows the spatial distribution of each combination of land cover type and soil group within the study area.

Based on the HSGs, land cover types, and land cover hydrologic conditions, SCS curve number (CN) values for an antecedent moisture condition type II (AMC II) were selected based on Table 9-2 of the NEH (NRCS

2004). A summary of CNII values is provided in Table 2-2. The exhibit in Attachment A shows the spatial distribution of the soil-cover complexes and resulting CNII values.

Table 2-2. Summary of AMC II SCS Curve Numbers

Cover Type	Hydrologic Condition	Hydrologic Soil Group A	Hydrologic Soil Group B	Hydrologic Soil Group C	Hydrologic Soil Group D
Pinyon-juniper	Poor	69*	75	85	89
Pinyon-juniper	Fair	48*	58	73	80
Pinyon-juniper	Good	28*	41	61	71
Sage-grass	Poor	59*	67	80	85
Sage-grass	Fair	42*	51	63	70
Sage-grass	Good	26*	35	47	55

* CN_{II} values for soil group A have not been developed; therefore, CN numbers were extrapolated and found to match the trends of other soil-land cover complexes.

The area weighted average CN_{II} for each drainage basin was calculated. The saturated soil condition or antecedent moisture condition III (AMC III) area weighted CN (CN_{III}) was also calculated for each drainage basin using the following equation:

$$CN_{III} = \frac{23 * CN_{II}}{10 + 0.13 * CN_{II}}$$

The area weighted CN_{II} and CN_{III} values for each drainage basin are summarized Table 2-3.

Table 2-3. Area Weighted SCS Curve Numbers

Subwatershed	CN_{II}	CN_{III}
Flat Canyon	68.5	83.3

2.3 Initial Abstraction

The initial abstraction was estimated following the SCS methodology outlined in the National Engineering Handbook (NRCS 2004). The equations to estimate the initial abstraction only require a basin's CN number. See this reference for more detail on the equations and methodology. Table 2-4 shows the initial abstractions that were used in design.

Table 2-4. Initial Abstraction

Subwatershed	Ia – CN II (in)	Ia – CN III (in)
Flat Canyon	0.92	0.40

2.4 Lag Time

The lag times (Lg) for each the subwatersheds were estimated following two different methods for comparison from Chapter 15 – Time of Concentration of the NEH (NRCS 2010), namely, the velocity method and the subwatershed lag method. The velocity method consists of flow path segments broken up into sheet flow, shallow concentrated flow, and opened channel flow. Each segment requires the length and slope as well as the land cover type, flow type, and typical open channel geometry depending on the segment type. The watershed lag method uses an empirical equation that requires the subwatershed's watercourse length, average basin slope, CN, and area. These parameters were delineated and estimated

using topographic data, aerial imagery, and field visits. See the reference for these methods for further information on the equations and methodologies. Note that they both account for the land cover type and slope of each watershed. The estimated lag times for this study are shown in Table 2-5. The time of concentration velocity along the flow path for each lag time ranged from approximately 4 to 7 feet per second. The velocity method is considered more accurate due to the more detailed input required and is reasonably conservative in comparison with the estimates using the watershed lag method; therefore, the velocity method estimates were used for all hydrology.

Table 2-5. Estimated Lag Times using the SCS Velocity and Subwatershed Lag Methods

Subwatershed	Velocity Method (hr)	Subwatershed Lag Method (hr)
Flat Canyon	1.35	1.60

2.5 Transform Method

The SCS unit hydrograph was selected as the transform method for all hydrology as recommended and discussed in Chapter 16 – Hydrographs of the NEH (NRCS 2007). One variable of the SCS unit hydrograph is the Peak Rate Factor (PRF), which is generally adjusted depending on the steepness of a given watershed and to calibrate hydrology models. PRFs can range from 100 for a relativity flat watershed to 600 for a steep watershed. Given the watershed slopes of this study, the standard PRF of 484 was considered a reasonably conservative estimate where it is on the higher range of PRF values.

3.0 Hydrologic Modeling

The U.S. Army Corps of Engineers Hydrologic Modeling System (HEC-HMS, version 4.3) was used for all modeling. This model was used to estimate flows for the design and economic storms as well as to route the design storm hydrographs and size the proposed debris basin.

3.1 Hydrologic Model Input

The hydrology parameters discussed previously were input into the model. The model included the drainage basins as well as the debris basin to allow for the routing of hydrographs.

3.1.1 Sedimentation

TR-60 (NRCS 2019a) and Section 3 – Sedimentation of the NEH (SCS 1983b) discuss the need to account for sediment accumulation in debris basins. These guidelines recommend that storage is reserved for sediment accumulation over the design life of a dam, typically between 50 and 100 years. A 100-year sediment storage volume was accounted for in the hydrologic model by determining the height of the sediment volume and setting the model start elevation and principal spillway height at the sediment height. In this way, the bottom portion of the reservoir is modeled as full of sediment. For more information on how the sediment volumes were estimated, see *TM003-Sedimentation*. The 100-year sediment volumes and heights are shown in Table 3-1.

Table 3-1. Debris Basin Geometric Parameters

Metrics	Flat Canyon
Volume at emergency spillway crest (acre-feet)	827
Volume at dam crest (acre-feet)	1120
100-year sediment volume (acre-feet)	359

Metrics	Flat Canyon
100-year water storage volume (acre-feet)	468
Depth* to emergency spillway crest (feet)	55.0
Depth* to dam crest (feet)	65.0
Depth* to 100-year sediment volume (feet)	34.7
Elevation (NAVD 88) of bottom of debris basin (feet)	5544
Elevation (NAVD 88) of emergency spillway crest (feet)	5599
Elevation (NAVD 88) of dam crest (feet)	5609
Elevation (NAVD 88) of 100-year sediment (feet)	5578.7

• Depths are relative to upstream toe of dam to represent true depth of sediment or water.

3.1.2 Stage-Storage-Discharge Relationships

A stage-storage relationship for the proposed debris basin was developed using AutoCAD and is included in Attachment B. The parameters for the principal and emergency spillways of the proposed debris basin were input directly into the hydrologic model. For the 30% design, a simple orifice element was used to simulate the principal spillway outlet, and a broad-crested weir was used to simulate the emergency spillway. The emergency spillway height for Flat Canyon was set at 10 feet with a width of 40 feet to accommodate high flows. A summary of the proposed debris basin volumes, depths, and elevations is provided in Table 3-1.

3.2 Hydrologic Modeling Results

The Utah Dam Safety SEP and 100-year design storms, as well as the NRCS FBH, ASH, and PSH storms, were routed through the proposed debris basin to determine the critical event. The 6-hour local SEP controlled the design of all Utah Dam Safety storms and was therefore adopted as the IDF. The IDF was also adopted as the NRCS FBH. The 100-year storm with an AMC II condition and the PSH were used to size the principal spillway based on the criteria that the emergency spillway should not be engaged during these events and the downstream peak flow cannot exceed the limiting capacities discussed previously. The controlling storms and corresponding flows and depths are shown in Table 3-2. The minimum sizes for the principal spillway conduit and auxiliary spillway dimensions are shown in Table 3-3.

Table 3-2. Hydrologic Modeling Results for the Controlling Design Storms

Metrics	Controlling Storm	Flat Canyon
Peak inflow (cfs)	IDF/FBH (6-hour SEF)	6826.5
Peak outflow (cfs)	IDF/FBH (6-hour SEF)	3666.5
Peak water surface depth (feet)*	IDF/FBH (6-hour SEF)	64.5
Freeboard to dam crest (feet)	IDF/FBH (6-hour SEF)	0.5
Peak inflow (cfs)	100-year 24-hour (NOAA Distribution)	519.8
Peak outflow (cfs)	100-year 24-hour (NOAA Distribution)	178.3
Peak water surface depth (feet)*	100-year 24-hour (NOAA Distribution)	46.4

Metrics	Controlling Storm	Flat Canyon
Freeboard to emergency spillway crest (feet)	100-year 24-hour (NOAA Distribution)	8.6
Peak inflow (cfs)	100-year 24-hour (SCS Distribution)	1145.3
Peak outflow (cfs)	100-year 24-hour (SCS Distribution)	182.2
Peak water surface depth (feet)*	100-year 24-hour (SCS Distribution)	46.9
Freeboard to emergency spillway crest (feet)	100-year 24-hour (SCS Distribution)	8.1
Peak inflow (cfs)	PSH (10-day)	605.4
Peak outflow (cfs)	PSH (10-day)	232.7
Peak water surface depth (feet)*	PSH (10-day)	54.6
Freeboard to emergency spillway crest (feet)	PSH (10-day)	0.4

*Depths are relative to upstream toe of dam to represent true depth of sediment or water.

Table 3-3. Minimum Required Spillway Sizing

Spillway	Parameter	Flat Canyon
Principal	Inner Diameter (inches)	43.9
Auxiliary	Side Slope (H:V)	2:1
Auxiliary	Crest Length (feet)	40
Auxiliary	Depth (feet)	10

The modeling results show that the proposed design of the debris basin is sufficient in reducing peak flows from the 100-year storm to limiting downstream capacities.

4.0 References

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Attachment A. Hydrology Analysis Map

Proposed Project Locations
I-70 Culvert Crossings
Canals
Streams
Watersheds
Municipal Boundaries

Curve Number (Land Cover Type | Hydrologic Condition | Hydrologic Soil Group)

41 (Pinyon-juniper | Good | B)
47 (Sage-grass | Good | C)
51 (Sage-grass | Fair | B)
59 (Sage-grass | Poor | A)
61 (Pinyon-juniper | Good | C)
67 (Sage-grass | Poor | B)
70 (Sage-grass | Fair | D)
71 (Pinyon-juniper | Good | D)
75 (Pinyon-juniper | Poor | B)
80 (Pinyon-juniper | Fair | D)
85 (Sage-grass | Poor | D)
89 (Pinyon-juniper | Poor | D)

MILLARD COUNTY
SEVIER COUNTY

Wood Canyon
Wood Canyon - Lower
Wood Canyon WASCOBs
Wood Canyon I-70 Point of Discharge
Flat Canyon
Flat Canyon I-70 Point of Discharge
Flat Canyon Basin
Flat Canyon - Lower
Sevier Valley Canal
Elsinore Canal
Richfield Canal
Sevier River
Richfield
Central Valley
Annabella
Elsinore
119
120
118
258
70
N
0 0.5 1 Miles

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Sevier County

Sevier County Watershed Plan
Hydrology Analysis Map

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_HH\1804-224_HH.aprx - EXH_Hydrology_Overview
Project Number: 1804-224 | Drawn by: JWW 05-19 | Last Edit: 10/23/2024

Sevier County
Scale: 1" = 1 Miles
1

Attachment B. Hydrologic Model Input & Output

Stage-Storage Data for Flat Canyon Debris Basin

Depth (feet)	Elevation (feet)	Area (square feet)	Area (acre)	Incremental Volume (acre-feet)	Notes
0	5544	0	0.00	0.00	
2	5546	27,877.11	0.64	0.43	
4	5548	75,121.37	1.72	2.70	
6	5550	125,670.55	2.89	7.26	
8	5552	181,702.83	4.17	14.28	
10	5554	234,716.81	5.39	23.81	
12	5556	285,297.41	6.55	35.73	
14	5558	340,293.45	7.81	50.08	
16	5560	402,195.06	9.23	67.10	
18	5562	460,235.97	10.57	86.89	
20	5564	514,540.12	11.81	109.25	
22	5566	576,980.57	13.25	134.30	
24	5568	647,091.49	14.86	162.38	
26	5570	720,005.31	16.53	193.75	
28	5572	794,140.34	18.23	228.50	
30	5574	829,210.46	19.04	265.76	
32	5576	852,177.91	19.56	304.36	
34	5578	873,181.03	20.05	343.97	
36	5580	895,359.06	20.55	384.57	
38	5582	918,288.07	21.08	426.20	
40	5584	942,032.35	21.63	468.91	
42	5586	966,035.79	22.18	512.71	
44	5588	990,196.90	22.73	557.62	
46	5590	1,016,351.51	23.33	603.68	
48	5592	1,044,974.46	23.99	651.00	
50	5594	1,075,802.17	24.70	699.69	
52	5596	1,105,807.93	25.39	749.74	
54	5598	1,144,474.02	26.27	801.40	
55	5599	1,077,772.09	24.74	826.90	Spillway Crest
56	5600	1,183,644.92	27.17	854.84	
58	5602	1,225,793.02	28.14	910.15	
60	5604	1,267,024.99	29.09	967.38	
62	5606	1,311,388.83	30.11	1026.56	
64	5608	1,360,593.36	31.24	1087.90	
65	5609	1,397,243.86	32.08	1119.56	Dam Crest

Attachment C. Hydrographs

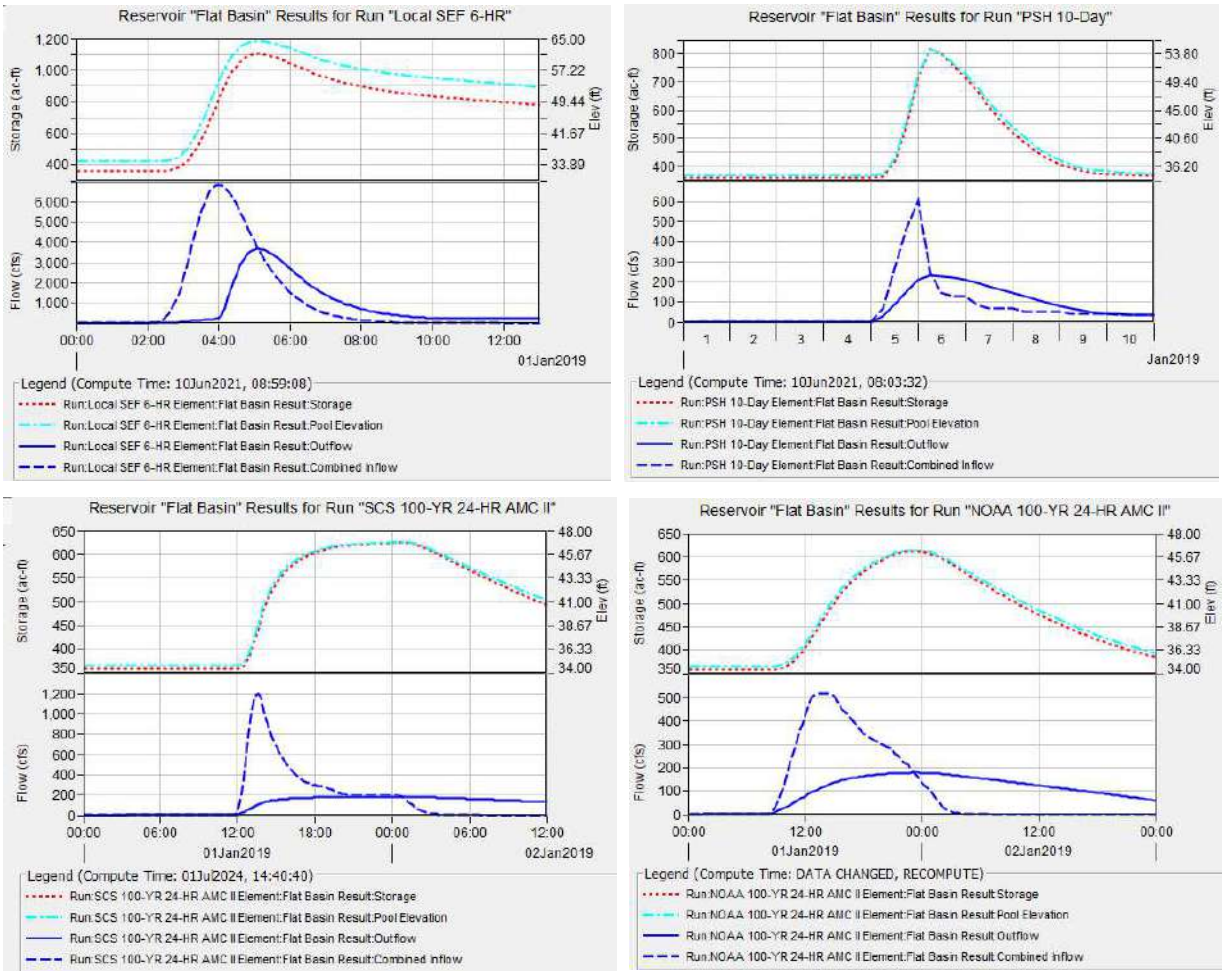


Figure C-1. Flat Canyon Hydrology Model Controlling Hydrographs

TM003 – Sedimentation

Table of Contents

1.0 Introduction 1
2.0 Observed Data 1
2.1 USDA Sedimentation Map 3
2.2 PSIAC Sediment Yield Method 4
2.3 RHEM Model 4
2.4 Design Sedimentation Rate 6
3.0 References 8

Attachments

Attachment A. Sedimentation Analysis Overview Map
Attachment B. Debris Basin Drawings
Attachment C. USDA Sedimentation Map
Attachment D. PSAIC Model Output

Figures

Figure 2-1. Dairy Canyon debris basin outlet with sediment level 2
Figure 2-2. Cottonwood Canyon debris basin outlet with sediment level 3

Tables

Table 2-1. Observed Sedimentation Data 1
Table 2-2. Sedimentation Yield Rate Estimates based on USDA Sedimentation Map 4
Table 2-3. PSIAC Method Sediment Yield Factors and Ratings 4
Table 2-4. RHEM Method Parameter Values 6
Table 2-5. Summary of Sediment Yield Rates 7
Table 2-6. Final Design Sedimentation Yield Rate Estimates based on PSIAC Method 7

1.0 Introduction

A sedimentation analysis was completed to predict the sediment loads resulting from the subwatersheds considered in the Watershed Plan. These sediment load rates were used in estimating sediment load volumes over time for debris basins and other hydraulic structures proposed in the Watershed Plan. In the late 1980s, two debris basins were constructed as part of a flood control project at the outlets of Dairy Canyon and Cottonwood Canyon. These basins are contiguous with the other subwatersheds being studied as part of the Watershed Plan and have been in operation and collected sediment for more than 30 years. While there are many methods that can be used to determine sedimentation rates, measured field data is considered the most reliable. Based on this assumption, all other methods were calibrated to the measured data. Four separate methods were used to estimate sedimentation rates for each subwatershed:

1. Observed data (measured data from Dairy Canyon and Cottonwood Canyon)
2. U.S. Department of Agriculture (USDA) mapped sedimentation rates for the State of Utah from 1973
3. Pacific Southwest Inter-Agency Committee (PSIAC) Method
4. Rangeland Hydrology and Erosion Model Web Tool (RHEM) Method

Each of these methods is discussed in the following sections. Attachment A shows a map with each subwatershed that was analyzed.

2.0 Observed Data

The sediment rates for the two existing debris basins (Dairy Canyon and Cottonwood Canyon) were calculated using the existing sediment elevations and stage-storage curves. LIDAR data collected in 2018 was used to obtain the elevations; the LIDAR data was collected by FEMA and was provided through the Utah Automated Geographic Reference Center (AGRC 2018). Table 2-1 shows the sediment pool elevation, depth of sediment, volume of sediment, operation life, average sediment deposition rates, and sedimentation yield rates.

Table 2-1. Observed Sedimentation Data

Basin	Existing elevation of sediment (feet)	Depth of sediment (feet)	Volume of sediment (acre-feet)	Operation life (years)	Deposition rate (acre-feet/year)	Yield rate (acre-feet/ mile^2/year)
Dairy Canyon	5473.3	9.3	23.0	32	0.72	0.38
Cottonwood Canyon	5431.7	5.7	113.0	32	3.53	0.17

Based on conversations with Richfield City and Sevier County, there has been no sediment removal from the Dairy Canyon basin. The Cottonwood Canyon basin has had some material removed in the past; however, based on feedback from Richfield City and others, the amount of sediment removed was relatively small. It has been assumed that the removal of the sediment was negligible and within the typical margin of error expected with this type of analysis. Figure 2-1 and Figure 2-2 show the sediment levels for both debris basins in relation to the outlets. The stage-storage curves that were used to determine volumes can be found in Attachment B.



Figure 2-1. Dairy Canyon debris basin outlet with sediment level



Figure 2-2. Cottonwood Canyon debris basin outlet with sediment level

2.1 USDA Sedimentation Map

The 1973 USDA map of sedimentation rates in Utah was referenced to determine the yield class for each subwatershed. Most subwatersheds did not fall within a single yield class, so an area-weighted yield rate was determined for each subwatershed. The average value for each yield class shown on the USDA map was used. The estimated sediment yield rates for each subwatershed are shown in Table 2-2. The USDA sedimentation map is included in Attachment C. Due to the nature of the data, this method was not calibrated using the observed data.

Table 2-2. Sedimentation Yield Rate Estimates based on USDA Sedimentation Map

Subwatershed	Subwatershed area (mile^2)	Yield rate (acre-feet/ mile^2/year)	Deposition rate (acre-feet/year)
Dairy Canyon	1.9	0.70	1.31
Cottonwood Canyon	20.7	0.21	4.32
Flat Canyon	16.4	0.41	6.75

2.2 PSIAC Sediment Yield Method

The Pacific Southwest Inter-Agency Committee (PSIAC) method for estimating sediment yield is based on a combination of nine physical factors affecting sedimentation in a subwatershed (PSIAC 1968). These factors have ranges according to various physical characteristics of the subwatershed and were estimated based on site visits, LIDAR data, soil data from USDA soil scientist, and land cover data (AGRC 2018, USGS 2018). The sum of these factors has an associated sedimentation rate that is based on several studies in which sedimentation rates were measured. Factor values for each of the subwatersheds are provided in Table 2-3. Physical factors such as channel erosion and sediment transport and upland erosion were calibrated within a reasonable range based on the observed data. After calibration, the results were found to be similar to the observed data approach. Attachment D shows the model output for each of the subwatersheds and a more detailed definition of each factor.

Table 2-3. PSIAC Method Sediment Yield Factors and Ratings

Factor	Rating Range	Dairy Canyon	Cottonwood Canyon	Flat Canyon
Surface Geology	0-5	4	3	3
Soils	0-10	8	3	3
Climate	0-10	4	4	4
Runoff	0-10	5	5	5
Topography	0-10	10	10	10
Ground Cover	-10-10	-7	-7	-7
Land Use	-10-10	-9	-9	-7
Upland Erosion	0-25	20	6	10
Channel Erosion and Sediment Transport	0-25	7	5	5

2.3 RHEM Model

The Rangeland Hydrology and Erosion Model Web Tool (RHEM; available at https://dss.tucson.ars.ag.gov/rhem/) is an event-based model that predicts soil loss according to relationships developed specifically for rangeland (Hernandez 2017, Nearing et al. 2011). Parameters used in the RHEM model for the subwatersheds are provided in

Table 2-4. Several of the subwatersheds were divided into smaller watershed basins for calculation purposes.

Table 2-4. RHEM Method Parameter Values

RHEM Parameters	Dairy Canyon	Cottonwood Canyon	Flat Canyon
Climate Station	Ferron	Bryce Canyon Natl PK	Koosharem
Rainfall (in)	8.19	15.12	9.06
Dominant Soil Texture Class	Sandy Loam	Sandy Loam	Sandy Clay Loam
Slope Shape	Uniform	Uniform	Uniform
Slope (ft/ft)	39.1	40.0	37.49
Cover- Bunchgrass	9%	9%	11%
Cover- Forbs/Annuals	5%	5%	5%
Cover- Shrubs	15%	15%	18%
Cover- Sod Grass	0%	0%	0%
Cover- Basal Plant Cover	9%	9%	10%
Cover- Rock Cover	15%	15%	16%
Cover- Litter Cover	30%	30%	29%
Cover- Biological Crust Cover	0%	0%	0%

The parameters used for each subwatershed were estimated based on a combination of site visits, LIDAR data, soil data from USDA soil scientist, land cover data, satellite imagery, and environmental surveys (AGRC 2018, USGS 2018). The online RHEM model uses existing climate stations to obtain rainfall data. In accordance with the RHEM model Tutorial Guide, climate stations with similar elevations to the average elevation of each subwatershed were used (Hernandez et al. 2016) to better obtain representative rainfall values based on elevation rather than site proximity.

The RHEM method was calibrated based on the results obtained from the observed data approach. In relation to other methods, the RHEM method has relatively few parameters to use in calibration. The rainfall and soil texture parameters are not suitable for calibration because any changes in these parameters produce a drastic change in the final model results. The cover characteristics were obtained by an environmental survey of the area, and the resulting values were used for both the PSIAC and RHEM methods. To remain consistent across methods, the cover characteristic parameters were not adjusted.

As a result, only the slope parameter was used to calibrate the model. While the initial values for slope were obtained from LIDAR, these values represented an average slope over the entire subwatershed. The equations used in the RHEM model are based on channel slopes rather than overland flow slopes. The final values used were adjusted within a reasonable range of channel slopes to produce a result similar to the observed data method.

2.4 Design Sedimentation Rate

The estimated sedimentation rates are summarized in Table 2-5. While the USDA Sedimentation Map is generally acceptable for broad-scale estimates of sedimentation rates, it is not recommended for specific sites, but rather for quick conservative estimates. After calibration, the RHEM method and the PSIAC method yielded results that were similar to observed data. However, the PSIAC method produced

sedimentation rates with a lowest percent error of 3 percent and 0 percent for Dairy Canyon and Cottonwood Canyon, respectively.

Table 2-5. Summary of Sediment Yield Rates

Subwatershed	Area (mile^2)	Method	Sedimentation rate (acre-feet/ mile^2/year)	Deposition rate (acre-feet /year)	100 years of sediment (acre-feet)
Dairy Canyon	1.9	USDA Sedimentation Map	0.70	1.33	133
		PSIAC	0.37	0.70	70
		RHEM	0.37	0.70	70
		Observed Data	0.38	0.72	72
Cottonwood Canyon	20.7	USDA Sedimentation Map	0.21	4.32	432
		PSIAC	0.17	3.53	353
		RHEM	0.19	3.94	394
		Observed Data	0.17	3.53	353
Flat Canyon	17.1	USDA Sedimentation Map	0.40	6.81	681
		PSIAC	0.21	3.59	359
		RHEM	0.25	4.28	428

The sedimentation rates obtained from the PSIAC method were considered the most reliable and the method selected for further use in the Watershed Plan. This selection is principally due to the method having been calibrated to yield results similar to the real-time observed data. The final design sedimentation rates for each basin are presented in Table 2-6. Attachment A shows an overview map of each subwatershed with each corresponding sedimentation rate and loading rate indicated.

Table 2-6. Final Design Sedimentation Yield Rate Estimates based on PSIAC Method

Subwatershed	Sediment rate (acre-feet/ mile^2/year)	Deposition rate (acre-feet/year)	100 years of sediment (acre-feet)
Flat Canyon	0.21	3.59	359

3.0 References

Automated Geographic Reference Center (AGRC). 2018. Utah Automated Geographic Reference Center. https://gis.utah.gov/data/. Accessed 10-23-2019.

Nearing, M.A., H. Wei, J. J. Stone, F. B. Pierson, K. E. Spaeth, M. A. Weltz, D. C. Flanagan, and M. Hernandez. 2011. A Rangeland Hydrology and Erosion Model. Transactions of the American Society of Agricultural and Biological Engineers (ASABE) 54:3.

Hernandez, M., M. A. Nearing, M. A. Weltz, K. E. Spaeth, G. Armendariz, F. B. Pierson, C. J. Williams, O. Z. Al-Hamdan, S. K. Nouwakpo, and C. Green. 2016. Rangeland Hydrology and Erosion Model Tutorial Guide: Desert Southwest Grassland, Limy Slopes 12-16" PZ Ecological Site. United States Department of Agriculture, Agricultural Research Service, Southwest Watershed Research Center, Tucson, Arizona, General Technical Report 1, March 2016. 26 p.

Hernandez, M., M.A. Nearing, O. Z. Al-Hamdan, F. B. Pierson, G. Armendariz, M. A. Weltz, K. E. Spaeth, C. J. Williams, S. K. Nouwakpo, D. C. Goodrich, C. L. Unkrich, M. H. Nichols, and C. D. Holifield Collins. 2017. The Rangeland Hydrology and Erosion Model: A Dynamic Approach for Predicting Soil Loss on Rangelands. American Geophysical Union.

Pacific Southwest Inter-agency Committee (PSIAC). 1968. Report of the Water Management Subcommittee on Factors Affecting Sediment Yield in the Pacific Southwest Area and Selection and Evaluation of Measures for Reduction of Erosion and Sediment Yield.

U.S. Geological Survey (USGS). 2018. National Land Cover Database. https://www.usgs.gov/centers/eros/science/national-land-cover-database?qt-science_center_objects=0#qt-science_center_objects. Accessed 10-23-2019.

Attachment A. Sedimentation Analysis Overview Map

Canals
Streams
Watersheds
Municipal Boundaries
Sedimentation Rate (Ac-Ft per Year per Sq Mi)
0.15
0.17
0.21
0.38

MILLARD COUNTY
SEVIER COUNTY

Wood Canyon
0.44Acre-ft
per Year

Cottonwood
Canyon
Calculated
3.53Acre-ft
per Year

Cottonwood Canyon Debris Basin
Built in 1987 (32-years old)
Existing Sediment Depth of 5.7 feet

Dairy Canyon Debris Basin
Built in 1987 (32-years old)
Existing Sediment Depth of 9.3 feet

Dairy Canyon
Calculated
0.72Acre-ft
per Year

Flat Canyon
3.59Acre-ft
per Year

70
119
120
118
258

Richfield
Richfield Canal
Sevier Valley Canal
Elsinore Canal
Sevier River
Annabella
Central
Valley
Elsinore

N
0 0.5 1 Miles

Jones & DeMille Engineering
- Shaping the Quality of Life -
800.748.5275 www.jonesanddemille.com

Sevier County

Sevier County Watershed Plan
Sedimentation Analysis Overview Map

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_HH\1804-224_HH.aprx - EXH_Sedimentation_Analysis

Project Number: 1804-224 | Drawn by: JWW 05-19 | Last Edit: 10/23/2024

Sevier County

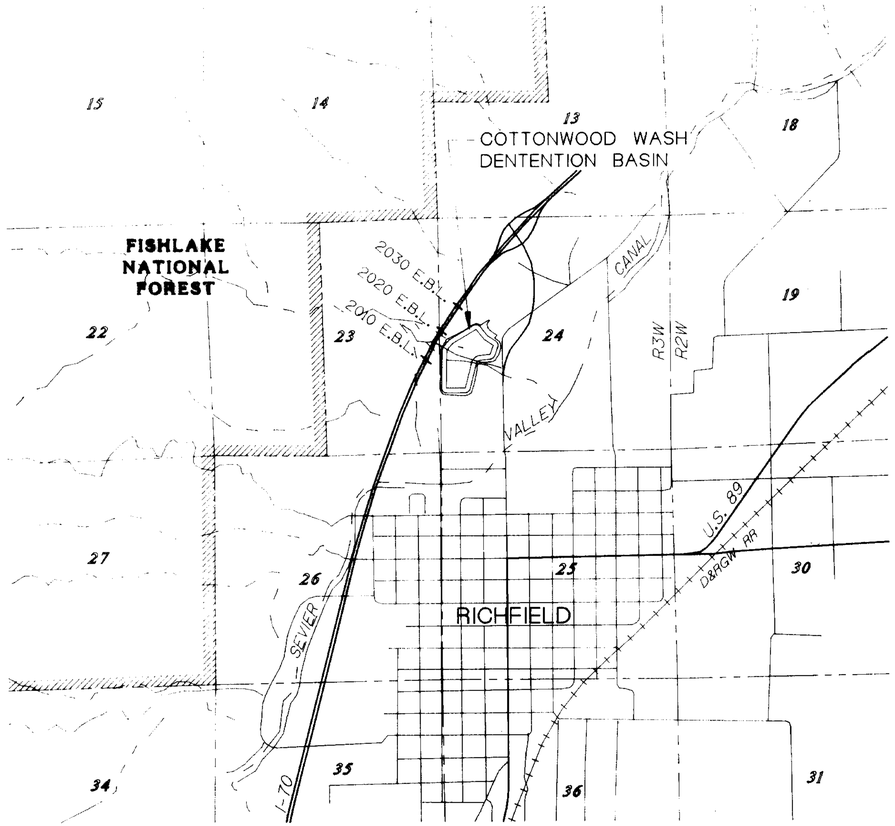
Scale: 1" = 1 Miles

1

Attachment B. Debris Basin Drawings

COTTONWOOD WASH DETENTION BASIN

DRAWING NO. RF-1



INDEX TO SHEETS

SHEET No.	DESCRIPTION
1	TITLE SHEET & INDEX TO SHEETS
2 & 2A	TYPICAL SECTIONS
3	SUMMARY SHEET
4	PLAN SHEET
5	OUTLET PIPE DETAILS
6	INLET STRUCTURE
7	OUTLET STRUCTURE
8	OUTLET ENERGY DISSIPATING STRUCTURE
9 & 10	IRRIGATION DIVERSION STRUCTURE
11 & 12	STEEL SCHEDULE
13 & 14	IRRIGATION DITCH PLAN AND PROFILE

GENERAL NOTES

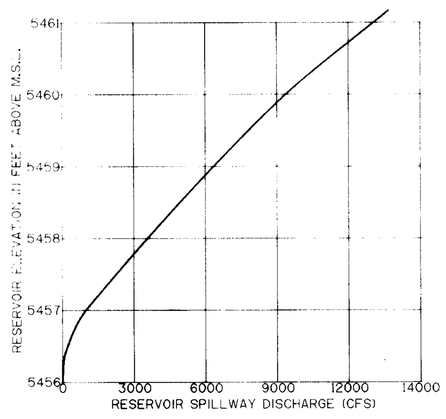
MATERIALS, CONSTRUCTION, AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE STATE OF UTAH STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, EDITION OF 1979, AND SUPPLEMENTS THERETO WHICH ARE IN EFFECT ON THE DATE OF REQUEST FOR BIDS.

ALL REINFORCING STEEL SHALL BE DEFORMED BILLET-STEEL BARS CONFORMING TO ASTM DESIGNATION A615, GRADE 60.

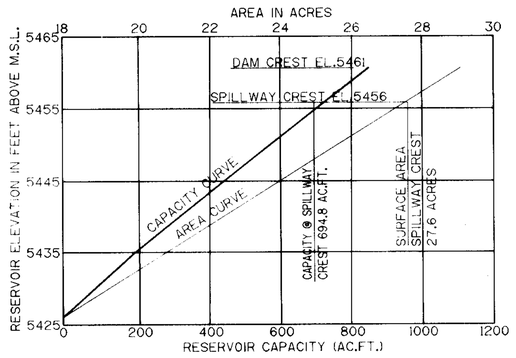
TYPE II CEMENT (LOW ALKALI) REQUIRED.

ALL STRUCTURAL STEEL SHALL BE STRUCTURAL CARBON STEEL CONFORMING TO AASHTO DESIGNATION M-183 (ASTM A36).

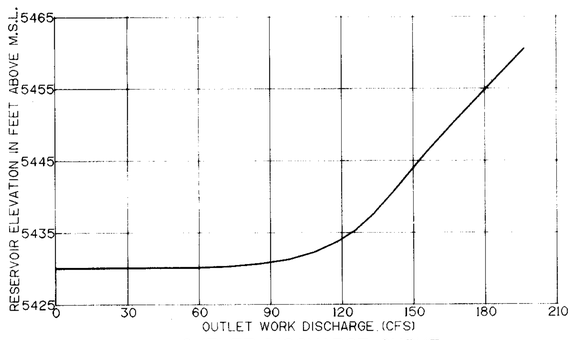
ALL EXPOSED STRUCTURAL STEEL SHALL BE HOT DIP GALVANIZED IN ACCORDANCE WITH ASTM 123.



SPILLWAY DISCHARGE CURVE



CAPACITY & AREA CURVES



OUTLET DISCHARGE CURVE

APPROVAL

IN ACCORDANCE WITH S 73-5-5, UTAH CODE ANNOTED 1953, AS AMENDED, APPROVAL IS HEREBY GIVEN FOR THE CONSTRUCTION OF THE COTTONWOOD WASH DETENTION BASIN NEAR RICHFIELD, UTAH.

Robert D. Morgan 2-20-86
UTAH STATE ENGINEER DATE

I DO HEREBY CERTIFY THAT THESE PLANS FOR THE CONSTRUCTION OF THE COTTONWOOD WASH DETENTION BASIN WERE PREPARED BY ME FOR RICHFIELD CITY, UTAH.

R. Steve Creamer 2/21/86
ENGINEER DATE

PROFESSIONAL LICENSE NO. 4678

PROJECT NUMBERS
I-70-1(24)40
& F-069(7)

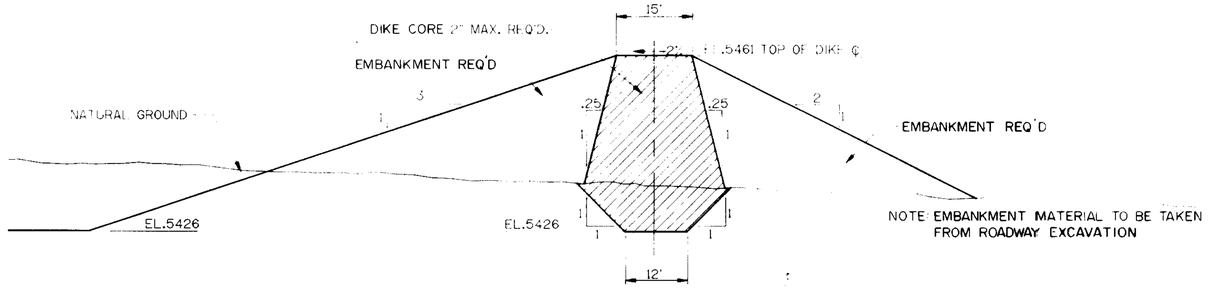
COTTONWOOD WASH
DETENTION BASIN
TITLE SHEET

DREAMER & REES ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
BEG	KRN		NONE
APPROVED	DATE	DRAWING NO.	
	2/86	RF-1	
REVISION	DATE	SHEET NO.	
		UT 644	1

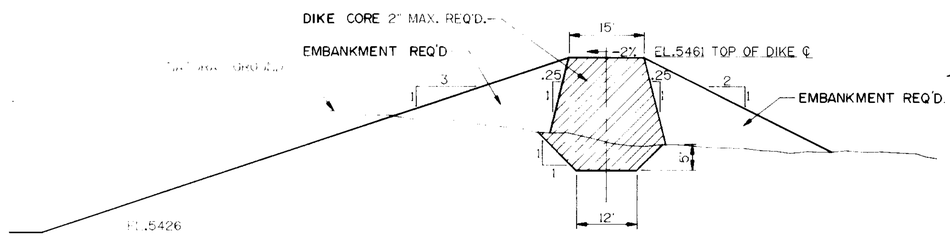
Title

TYPICAL SECTIONS



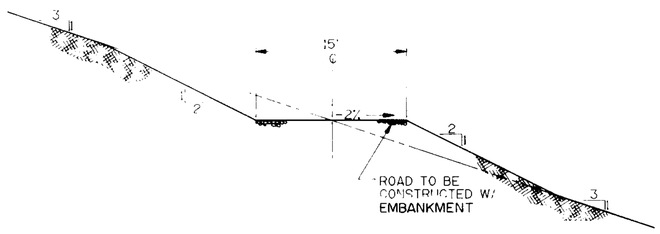
TYPICAL SECTION #1

DIKE FILL HEIGHT OVER 10 FEET



TYPICAL SECTION #2

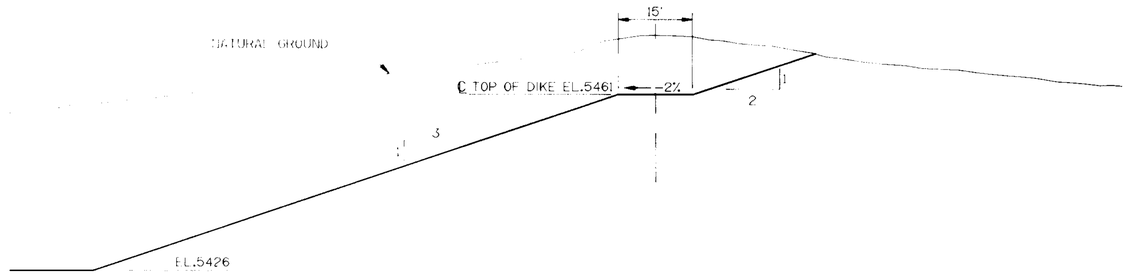
DIKE FILL HEIGHT UNDER 10 FEET



TYPICAL SECTION

ACCESS ROAD
INSIDE OF BASIN
DIKE BEGINS AT ℄ DIKE
STA. 15+00

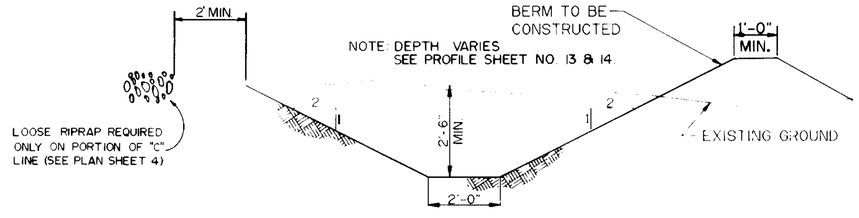
NOTE: MAINTAIN DITCH A MINIMUM OF 5' (ft.) FROM TOE OF DIKE.



TYPICAL SECTION #3

DIKE IN CUT

NOTE: BERM TO BE CONSTRUCTED ON LOWER SIDE OF DITCH



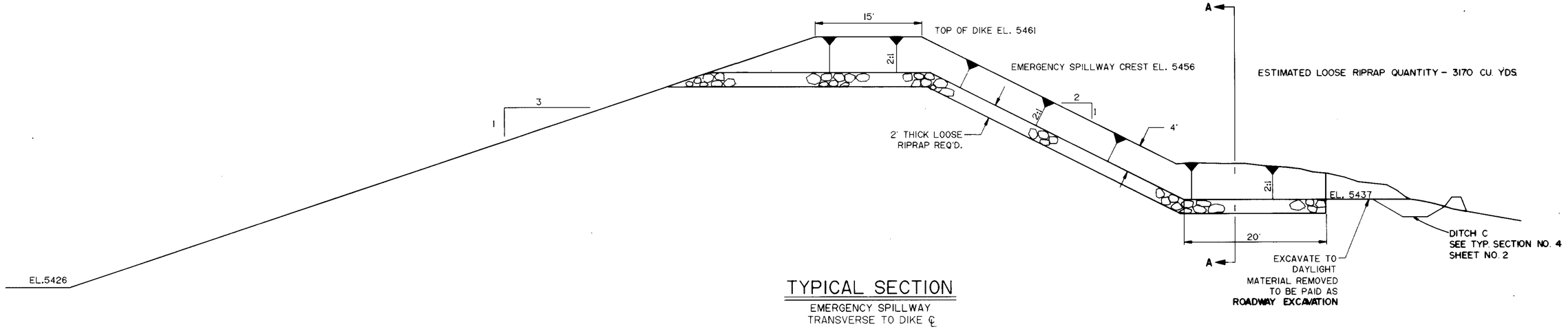
TYPICAL SECTION #4

SMALL DITCH EXCAVATION
(IRRIGATION DITCH)
DITCHES A, B, & C

PROJECT NUMBERS I-70-I(24)40 & F-069(7)	**COTTONWOOD WASH DETENTION BASIN** TYPICAL SECTIONS	CREAMER & NOBLE ENGINEERS ST. GEORGE, UTAH	DESIGNED BEG	CHECKED KRN	DRAWN LOB/AKB	SCALE NONE
			APPROVED	DATE	DRAWING NO. RF-1	
			REVISION	DATE	SHEET NO. 2	

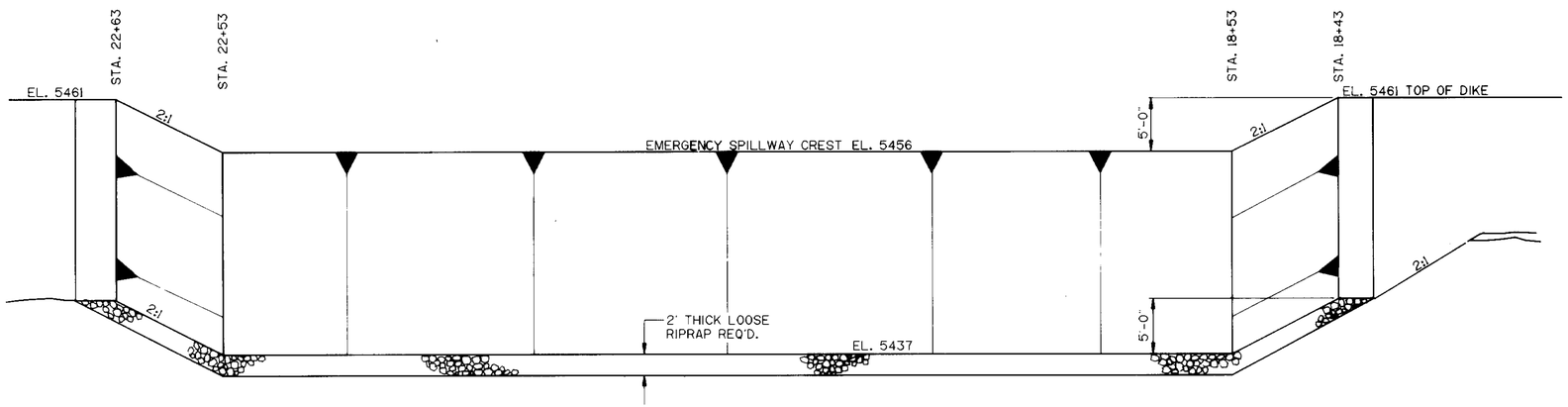
Typscc

TYPICAL SECTIONS



TYPICAL SECTION

EMERGENCY SPILLWAY
TRANSVERSE TO DIKE ℄



SECTION A-A

PROJECT NUMBERS I-70-1(24)40 & F-069(7)	**COTTONWOOD WASH** **DETENTION BASIN** TYPICAL SECTIONS	CREAMER & NIELSEN ENGINEERS ST. GEORGE, UTAH

DESIGNED BEG	CHECKED KRN	DRAWN LOB/AKB	SCALE NONE	
APPROVED	DATE	DRAWING NO. RF-1		
REVISION	DATE	SHEET NO. 2A		

SUMMARY OF ITEMS

CODE	ITEM	UNIT	QUANTITY
	ROADWAY EXCAVATION	CU.YD.	117,400
	DIKE CORE 2" MAX.	CU.YD.	~~81,852~~ 104,800
	CONCRETE CLASS AA(AE)	CU.YD.	~~729.719~~ 730
	CONCRETE SMALL STRUCTURES CLASS AA(AE)	CU.YD.	6.356 → 7
	REINFORCING STEEL	LB.	~~81,852~~ 70,300
	TRASHRACK / MANHOLE	LUMP	~~0~~ 1
	42" REINFORCED CONCRETE PIPE	LN.FT.	850
	LOOSE RIP RAP	CU.YD.	~~4057.90~~ 4,100
	SMALL DITCH EXCAVATION	CU.YD.	~~1098.9~~ 5,000
	~~30" PIPE CULVERT~~	~~LN.FT.~~	~~120~~
	6' CHAIN LINK FENCE TYPE I	LN.FT.	~~144.8~~ 22
	GRANULAR FILTER MATERIAL	CU.YD.	~~490.24~~ 500
	BRACED POST (9' METAL)	EACH	~~17~~ 5
	~~30" CORRUGATED METAL PIPE~~	~~LN.FT.~~	~~30~~

EARTHWORK SUMMARY

LANES OR LINE	FROM STATION	TO STATION	DIKE QUANTITIES EMBANKMENT CUBIC YDS.	DIKE QUANTITIES ~~DIKE CORE 2" MAX.~~ CUBIC YDS.	COMPACTION FACTOR	~~EMBANKMENT~~ X FACTOR CUBIC YDS.	~~DIKE CORE 2" MAX.~~ X FACTOR CUBIC YDS.	ROADWAY EXCAVATION	REMARKS
℄ DIKE	10+00	17+56.10	632	1,719	1.1	695	1,891		
	17+56.10	24+24.11	10,608	18,224		11,669	20,046		
	24+24.11	27+85.56	18,928	10,783		20,821	11,861		
	27+85.56	31+50.35	20,956	10,518		23,052	11,570		
	31+50.35	38+96.60	27,986	23,203		30,784	25,524		
	38+96.60	44+99.90	22,810	18,642		25,091	20,507		
	44+99.90	55+12.95	4,807	12,183		5,288	13,401		
	55+12.95	57+46	0	0					
TOTAL								951,400	TOTAL EXCAVATION FROM DETENTION BASIN
F-069(7)								- 51,532	TRANSFER TO SHT. RC-3B
I-70-I(24)40								- 677,668	TRANSFER TO SHT. 3B
								- 104,800	2" DIKE CORE MATERIAL (SEE SPECIAL PROVISION)
		TOTAL	106,727	~~95,272~~		117,400	104,800	117,400	
		USE		~~81,852~~ 104,800				117,400	

NOTE: TOTAL EXCAVATION FROM BASIN SHALL BE A MINIMUN OF 951,400 CU.YD.

SUMMARY OF STRUCTURAL ITEMS

ITEM	UNIT	QUANTITY
CONCRETE CLASS AA(AE)	CU.YD.	~~729.719~~ 730
CONCRETE SMALL STRUCTURES CLASS AA(AE)	CU.YD.	6.356 → 7
REINFORCING STEEL	LB.	~~81,852~~ 70,300
TRASHRACK / MANHOLE	LUMP	~~0~~ 1

MISCELLANEOUS SUMMARY

DESCRIPTION	UNIT	QUANTITY	REMARKS	CONST. SOURCE REFER. BOOK	PAGE
LOOSE RIP RAP	CU.YD.	~~4057.90~~ 4,100		35	60
SMALL DITCH EXCAVATION	CU.YD.	~~1098.9~~ 5,000			
42" REINFORCED CONCRETE PIPE	LN.FT.	850			
~~30" PIPE CULVERT~~	~~LN.FT.~~	~~120~~			
6' CHAIN LINK FENCE TYPE I	LN.FT.	~~144.8~~ 22		101	70,78
GRANULAR FILTER MATERIAL	CU.YD.	~~490.24~~ 500		35	57,58
BRACED POST (9' METAL)	EACH	~~17~~ 5		101	70,78
~~30" CORRUGATED METAL PIPE~~	~~LN.FT.~~	~~30~~			

PROJECT NUMBERS
I-70-I(24)40
& F-069(7)

COTTONWOOD WASH
DETENTION BASIN
SUMMARY SHEET

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED BEG	CHECKED KRN	DRAWN DRL	SCALE NONE
APPROVED	DATE	DRAWING NO.	RF-1
REVISION R.O.	DATE 9-22-05	SHEET NO.	3

CURVE DATA

MK	RAD.	ARC.	CRD.	TAN.
1	205.76	59.58	59.37	30.00
2	118.46	168.41	154.59	102.00
3	238.82	75.37	75.06	38.00
4	122.53	166.54	154.01	99.00
5	113.26	125.40	119.09	70.00
6	115.70	139.99	131.60	80.00
7	122.36	160.31	149.09	94.00
8	121.47	194.29	184.23	125.00
9	145.80	105.19	102.92	55.00

NOTE:
FOR DRILL HOLE LOGS SEE SHEET NO. 5

EXISTING POWER POLES
SMALL DITCH EXCAVATION LINE "B" REQ'D. SEE SHEET NO. 14
54" PIPE
PT 18+40.31
30 LN.FT. 60" PIPE CULVERT REQ'D.
CONC. DITCH
EMERGENCY SPILLWAY SEE SHEET NO. 2A
EXISTING DITCH
EXISTING COUNTY ROAD
CONC. DIV. BOX W/ 2 HAND SLIDE GATES
CONC. DITCH
CENTER LINE OF R.C.H.F.D. CONNECTOR ROAD
HAND SLIDE GATE
INLET CHANNEL REQ'D. SEE TYPICAL SECTION ON SHEET NO. 2J ON I-70 PORTION OF PLANS
N 165,890 E 1,833,130
N 165,590 E 1,833,375
ACCESS ROAD SEE TYPICAL SECTION SHEET NO. 2
N 165,510 E 1,832,490
① CONCRETE INLET STRUCTURE REQ'D SEE DETAILS ON SHEET NO. 6
24" 120' R.C.P.
90 LN.FT. 30" PIPE CULVERT REQ'D.
SMALL DITCH EXCAVATION LINE "C" REQ'D. SEE SHEET NO. 14
PT 55+65.53
MP 55+12.95
N 165,420 E 1,833,640
PT 25+07.38
STILLING BASIN REQ'D SEE DETAILS ON SHEET NO.6
OUTLET STRUCTURE REQ'D SEE DETAILS ON SHEET NO. 7 AND SHEET NO 5 FOR LOCATION
BOTTOM EL. 5426
WATER STORAGE CAPACITY - 615 ACRE FEET
SEDIMENT STORAGE CAPACITY - 79.8 ACRE FEET
D.H.3 N 166,315 E 1,838,310
EXISTING POWER POLES
PC 54+60.87
PC 30+80.36
MP 31+50.39
PC 27+22.86
MP 27+85.56
N 165,060 E 1,833,505
HIGHWAY R/W & N/A LINE
WEST BOUND LANE
EAST BOUND LANE
SEE SHEET #5 OF THE I-70 PORTION OF ROADWAY PLANS & STR. DWG. NO. 2308
30 LN.FT. 36" PIPE CULVERT REQ'D.
DROP INLET
24" x 72" R.C.P.
PT 32+20.35
N 165,020 E 1,833,125
D.H.4
INSTALL 850 L.N. FT. OF 42" R.C.P. OUTLET PIPE. SEE DETAILS ON SHEET NO. 5
INTERSECTION OF ℄ DIKE AND ℄ OUTLET PIPE LOCATED S 19°06'03" 3346.00 FEET FROM THE NW CORNER OF SECTION 24, T23S, R3W, S.L.B.&M.
℄ ROAD STA. 212+49
℄ PIPE STA. 16+65
OUTLET ENERGY DISSIPATING STRUCTURE REQ'D. SEE DETAILS ON SHEET NO. 8
EXISTING CHANNEL
HOSPITAL
CENTERLINE STA 2008+90
HIGHWAY R.W. & N/A LINE
SMALL DITCH EXCAVATION LINE "A" REQ'D. SEE SHEET NO. 13
PT 45+97.05
MP 44+99.90
PC 44+02.76
PC 38+76.45
MP 38+96.60
PT 39+76.75
N 164,272 E 1,832,285
N 164,275 E 1,832,930
EXISTING DITCH
D.H.1
D.H.2
D.H.5
D.H.6
D.H.7
D.H.9

NOTE:
ALL CONCRETE DITCHES PAID BY OTHERS

PROJECT NUMBERS
I-70-1(124)40
& F-069(7)

COTTONWOOD WASH DETENTION BASIN

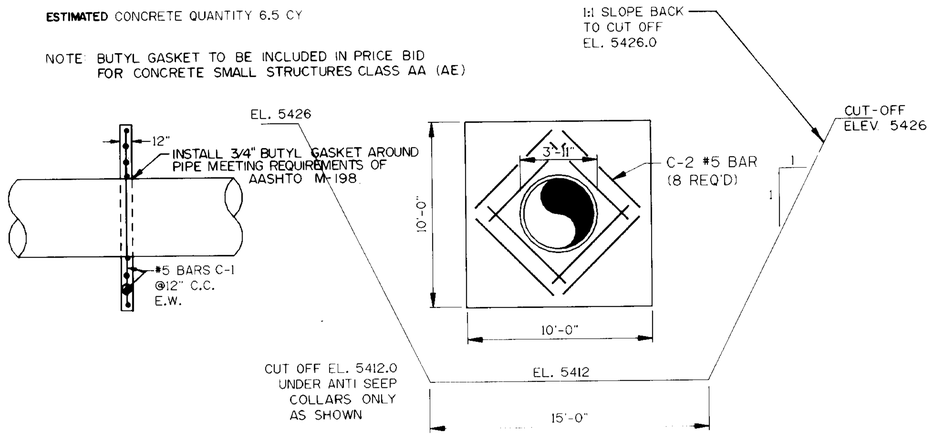
PLAN SHEET

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED BEG	CHECKED KRN	DRAWN AKB	SCALE
APPROVED	DATE	DRAWING NO. RF-1	
REVISION	DATE	SHEET NO. 4	

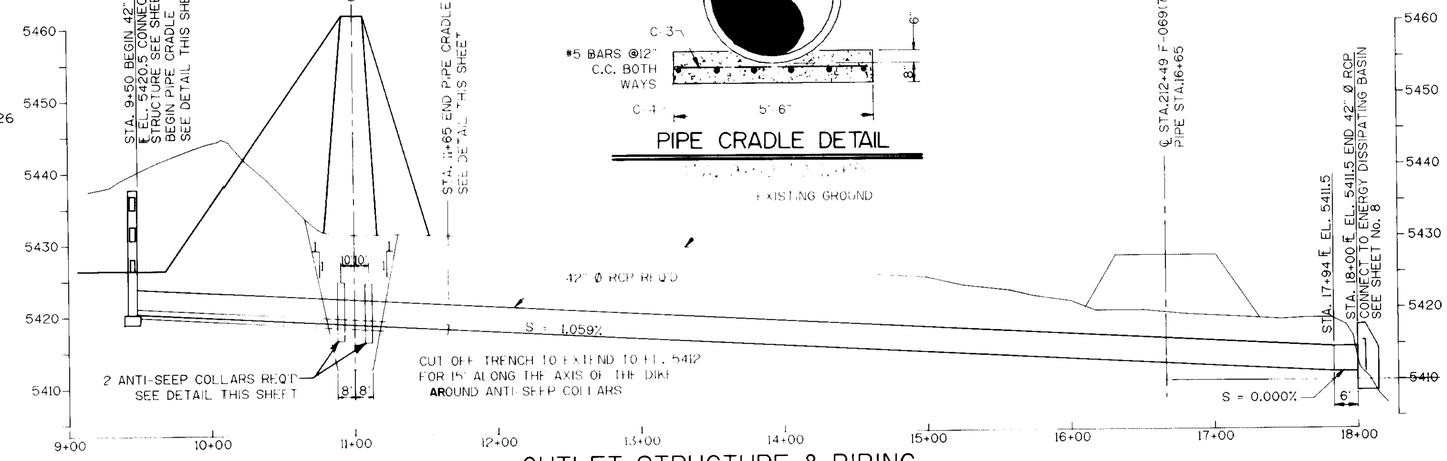
ESTIMATED CONCRETE QUANTITY 6.5 CY

NOTE: BUTYL GASKET TO BE INCLUDED IN PRICE BID FOR CONCRETE SMALL STRUCTURES CLASS AA (AE)

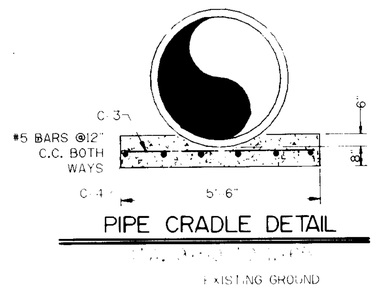


ANTI-SEEP COLLAR DETAIL

(2 REQ'D)



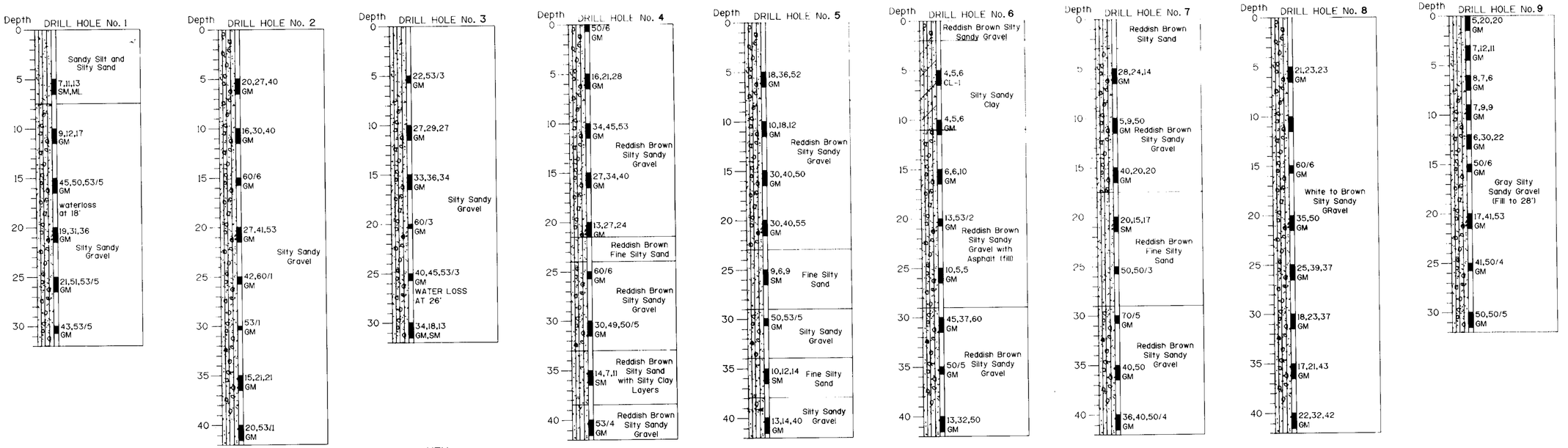
ESTIMATED CONCRETE QUANTITY 42.3 C.Y.



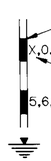
PIPE CRADLE DETAIL

OUTLET STRUCTURE & PIPING

NOTE: 42" RCP CLASS TO BE DETERMINED BY STD. DRAWING 605-20 OF THE UTAH DEPT. OF HIGHWAYS STANDARD PLANS FOR ROAD & BRIDGE CONSTRUCTION.



KEY



DRILL HOLE LOGS

FOR LOCATIONS SEE SHEET NO. 4

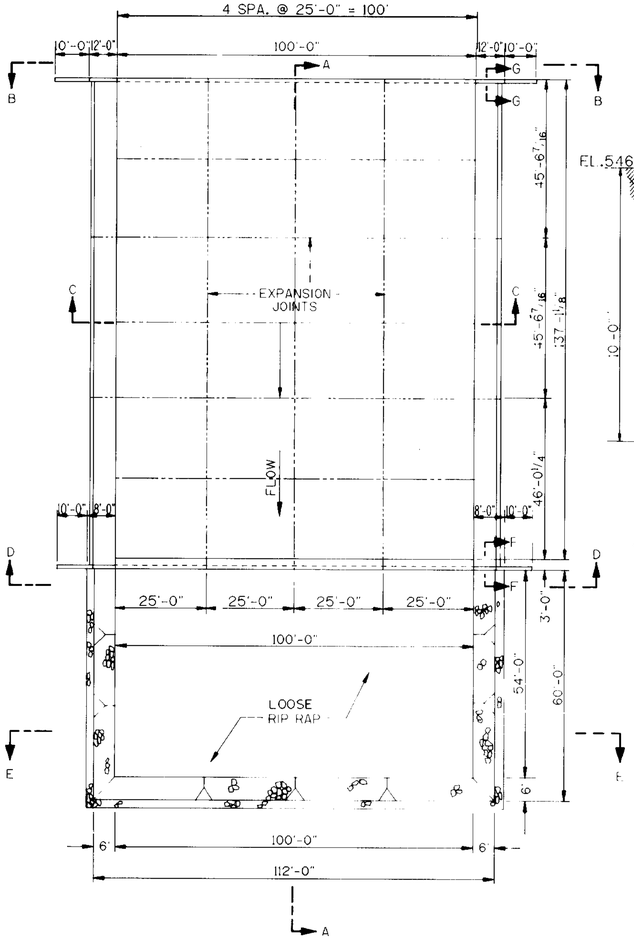
PROJECT NUMBERS
I-70-I(2)140
OF F-069(7)

COTTONWOOD WASH
DETENTION BASIN

OUTLET PIPE DETAILS - DRILL LOGS

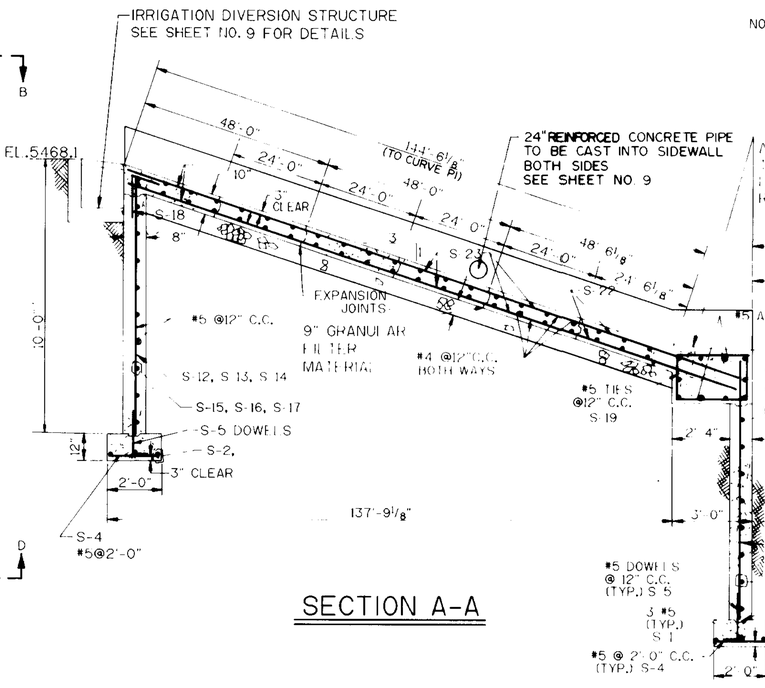
CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
BEG	KRN	LOB/AKB	NONE
APPROVED	DATE	DRAWING NO.	
		RF-1	
REVISION	DATE	SHEET NO.	5



PLAN

INLET STRUCTURE & STILLING BASIN

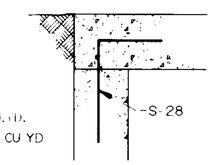


SECTION A-A

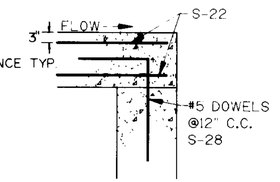
NOTES:
1. ALL STEEL WILL BE #4 BARS, UNLESS NOTED.
2. UNLESS OTHERWISE NOTED BAR SPACING WILL BE 12" C.C.
3. PAYMENT FOR JOINT SEALANT AND WATER STOP SHALL BE INCLUDED IN THE PRICE BID FOR CONCRETE CLASS AA(AE).

Δ = 18°26'06"
D = 5.00°
T = 5.95'
R = 18.49'

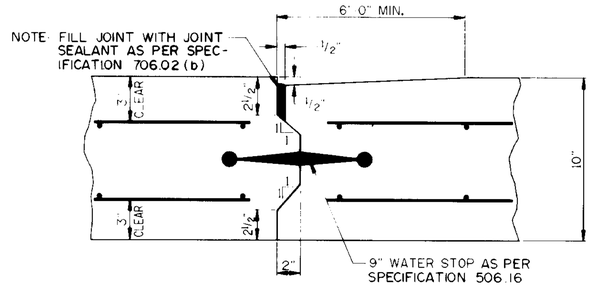
ESTIMATED CONCRETE QUANTITY - 670 CU YD.
ESTIMATED LOOSE RIPRAP QUANTITY - 917 CU YD



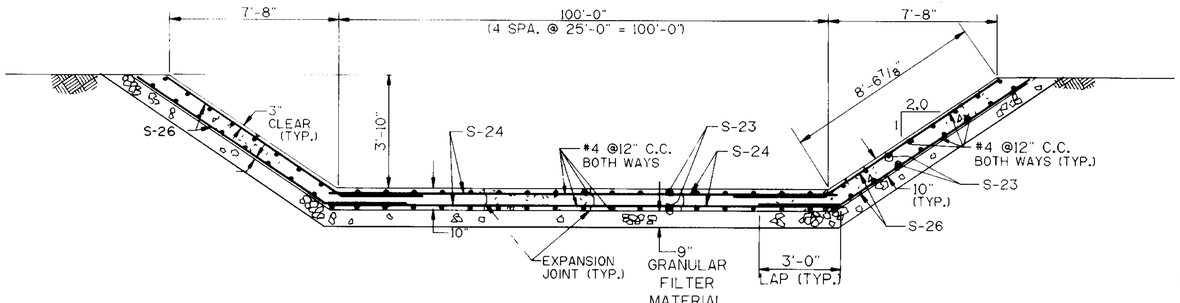
SECTION G-G



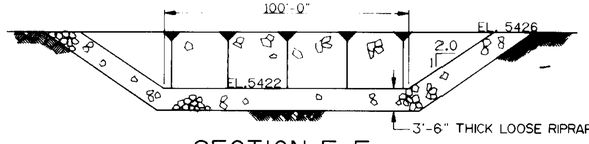
SECTION F-F



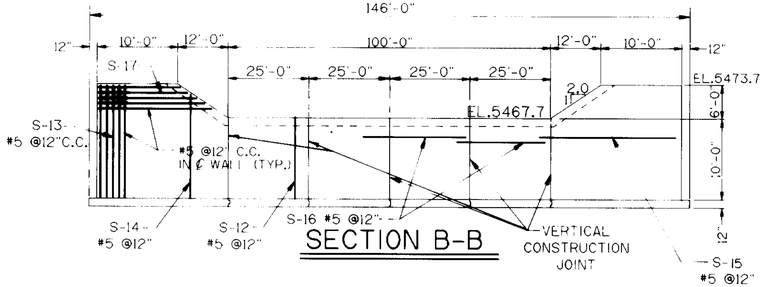
TYPICAL EXPANSION JOINT



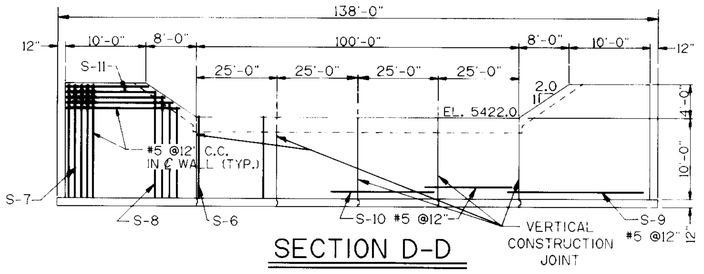
SECTION C-C



SECTION E-E



SECTION B-B



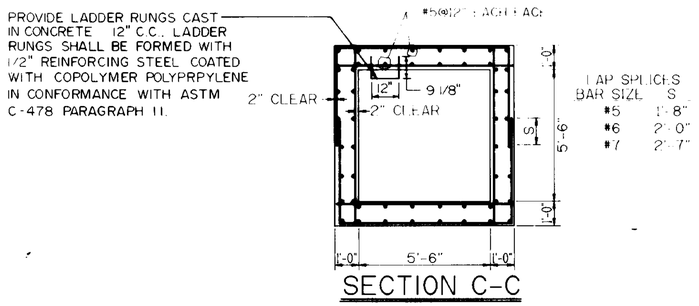
SECTION D-D

PROJECT NUMBERS I-70-1(24)40 & F-069(7)	**COTTONWOOD WASH DETENTION BASIN**	STREAMER & NOBLE ENGINEERS ST. GEORGE, UTAH	DESIGNED BEG / CHECKED KRN / DRAWN LOB / SCALE NONE
	INLET STRUCTURE		APPROVED / DATE / DRAWING NO. RF-1
			REVISION / DATE / SHEET NO. 6

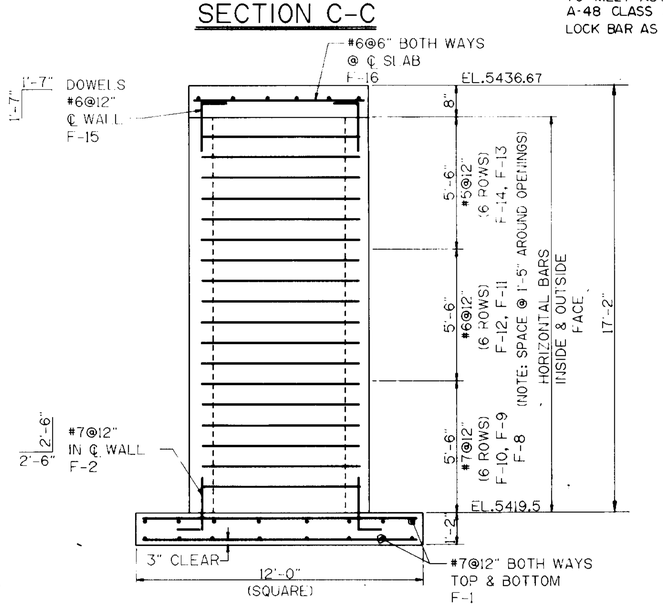
NOTES:

1. GATE CONSTRUCTED AS PER 705.02 OF THE STATE OF UTAH STANDARD SPECIFICATIONS FOR ROAD & BRIDGE CONSTRUCTION EDITION OF 1979 & SUBSEQUENT ADDENDA.
2. BITUMINOUS FILLER SHALL BE INCLUDED IN THE PRICE BID FOR 42" RCP.
3. LADDER RUNGS TO BE INCLUDED IN THE PRICE BID FOR CONCRETE CLASS AA(AE).
4. ALL EXPOSED STRUCTURAL STEEL SHALL BE HOT DIP GALVANIZED IN ACCORDANCE WITH ASTM123 JOINTS WELDED IN FIELD SHALL BE COATED WITH ONE COAT ZINC CHROMATE PRIMER FOLLOWED WITH A GRAY ENAMEL AS PER 713.02.

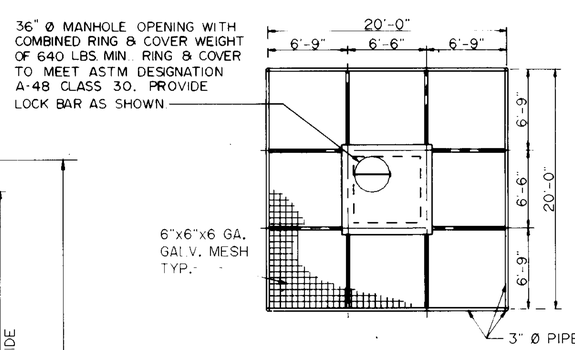
ESTIMATED CONCRETE QUANTITY - 22.4 CU.YD.

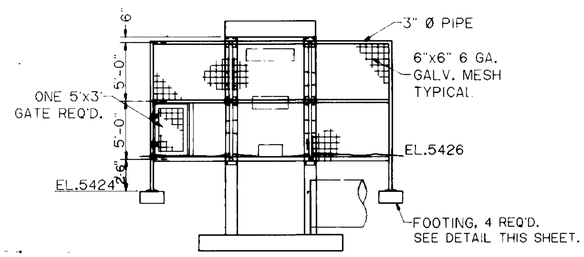


SECTION C-C

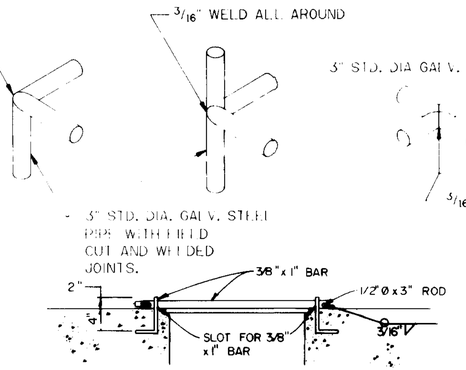


SECTION B-B

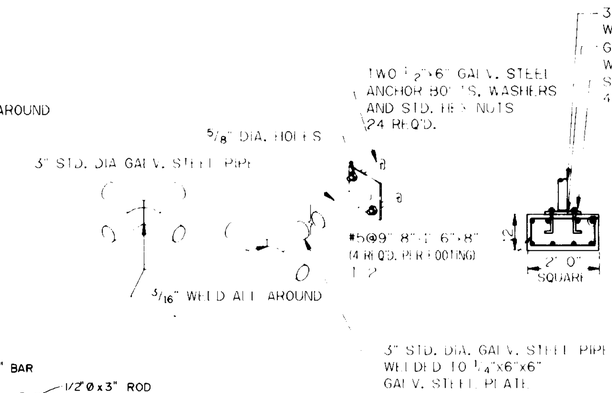




TRASH RACK DETAIL



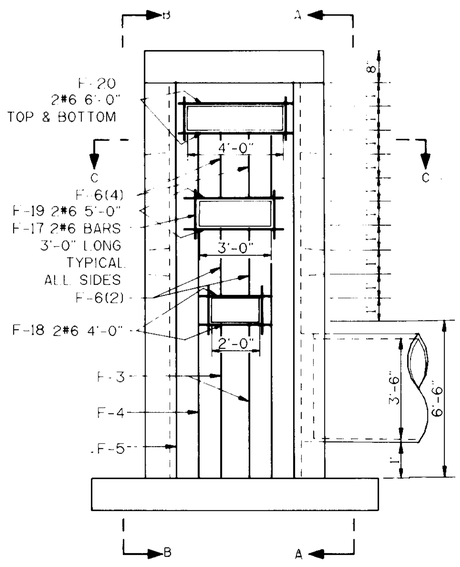
LOCK BAR DETAIL



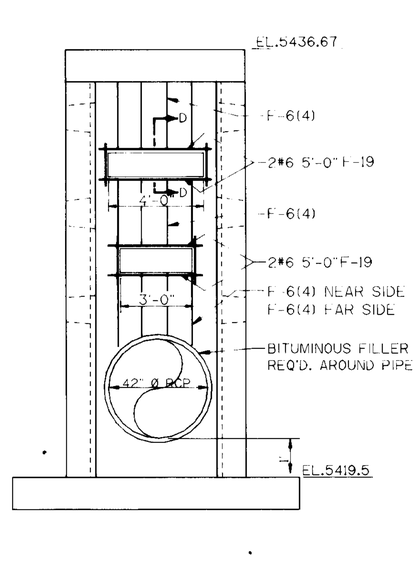
WIRE SUPPORT DETAILS



SECTION D-D



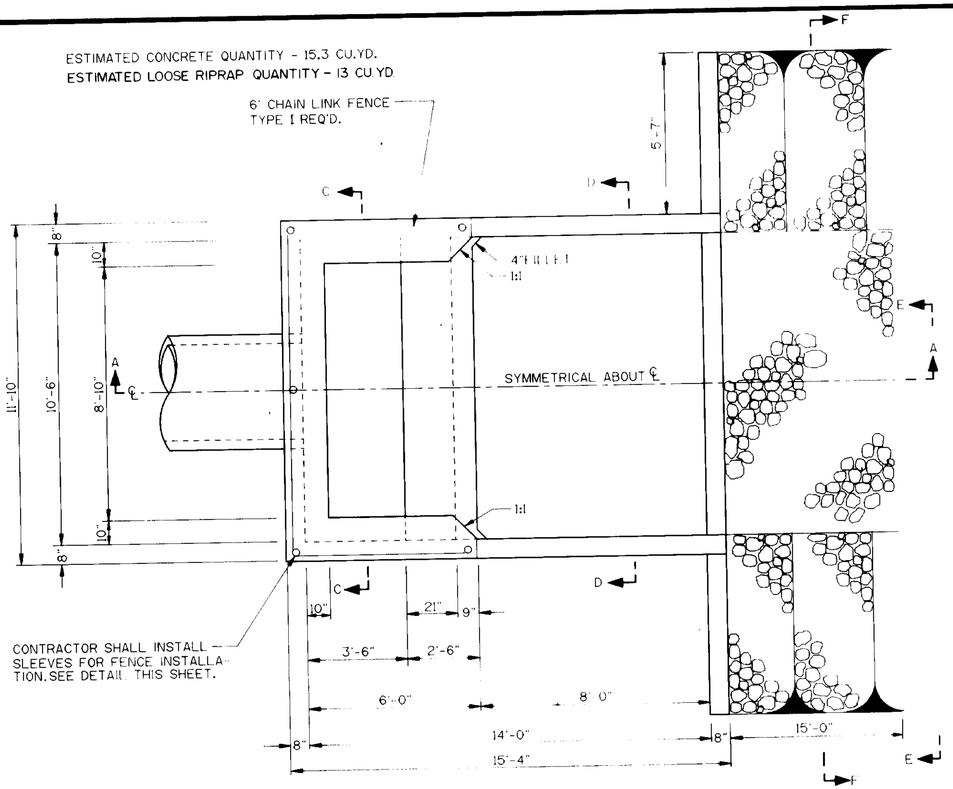
OUTLET STRUCTURE



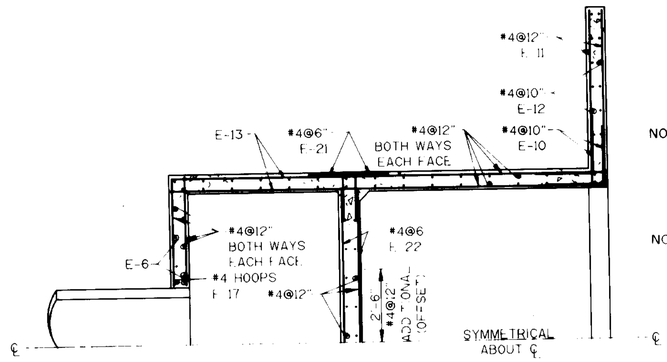
SECTION A-A

PROJECT NUMBERS I-70-I(24)40 & F-069(7)	**COTTONWOOD WASH DETENTION BASIN** OUTLET STRUCTURE	DREAMER & NOBLE ENGINEERS ST. GEORGE, UTAH	DESIGNED BEG / CHECKED KRN / DRAWN DRL / SCALE NONE
			APPROVED / DATE / DRAWING NO. RF-1
			REVISION / DATE / SHEET NO. 7

ESTIMATED CONCRETE QUANTITY - 15.3 CU.YD.
ESTIMATED LOOSE RIPRAP QUANTITY - 13 CU.YD.



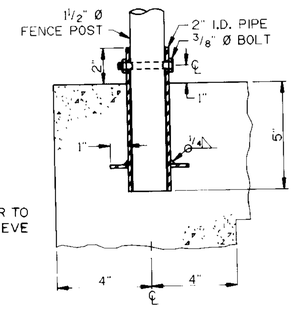
PLAN



SECTION B-B

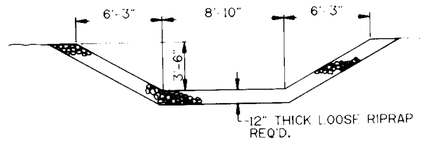
NOTE #1 FENCE SLEEVE TO BE INCLUDED IN BID PRICE FOR 6' CHAIN LINK FENCE TYPE I.

NOTE #2 FIELD BEND REBAR TO ACCOMODATE SLEEVE

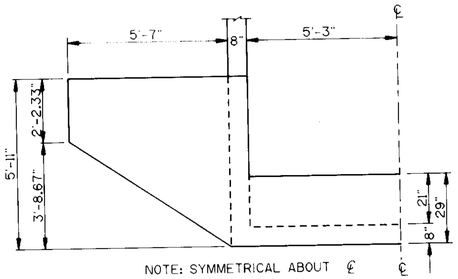


NOTE #3
ALL EXPOSED METAL WILL BE HOT DIP GALVANIZED IN ACCORDANED WITH ASTM-123

FENCE POST SLEEVE DETAIL

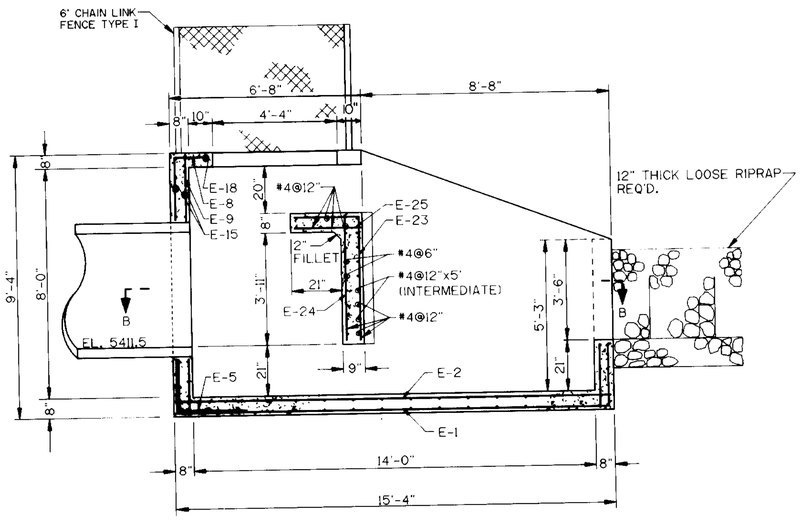


SECTION F-F

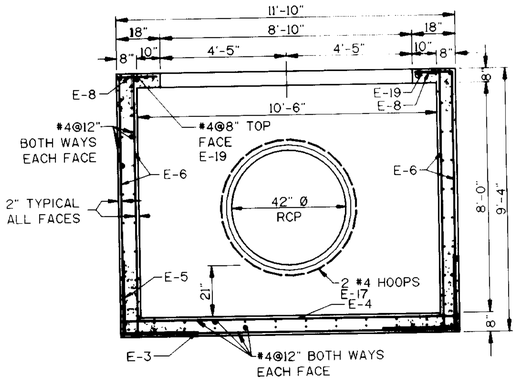


NOTE: SYMMETRICAL ABOUT ℄ ℄

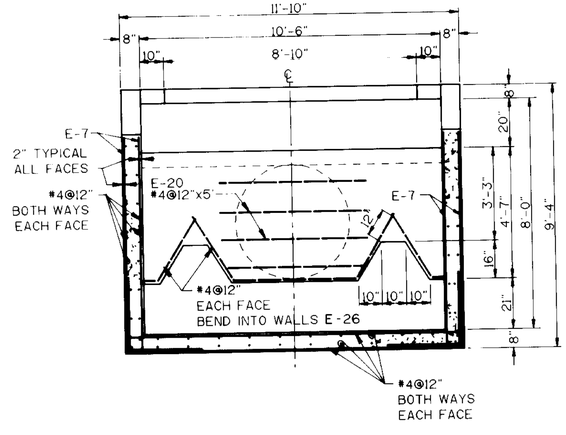
SECTION E-E



SECTION A-A



SECTION C-C



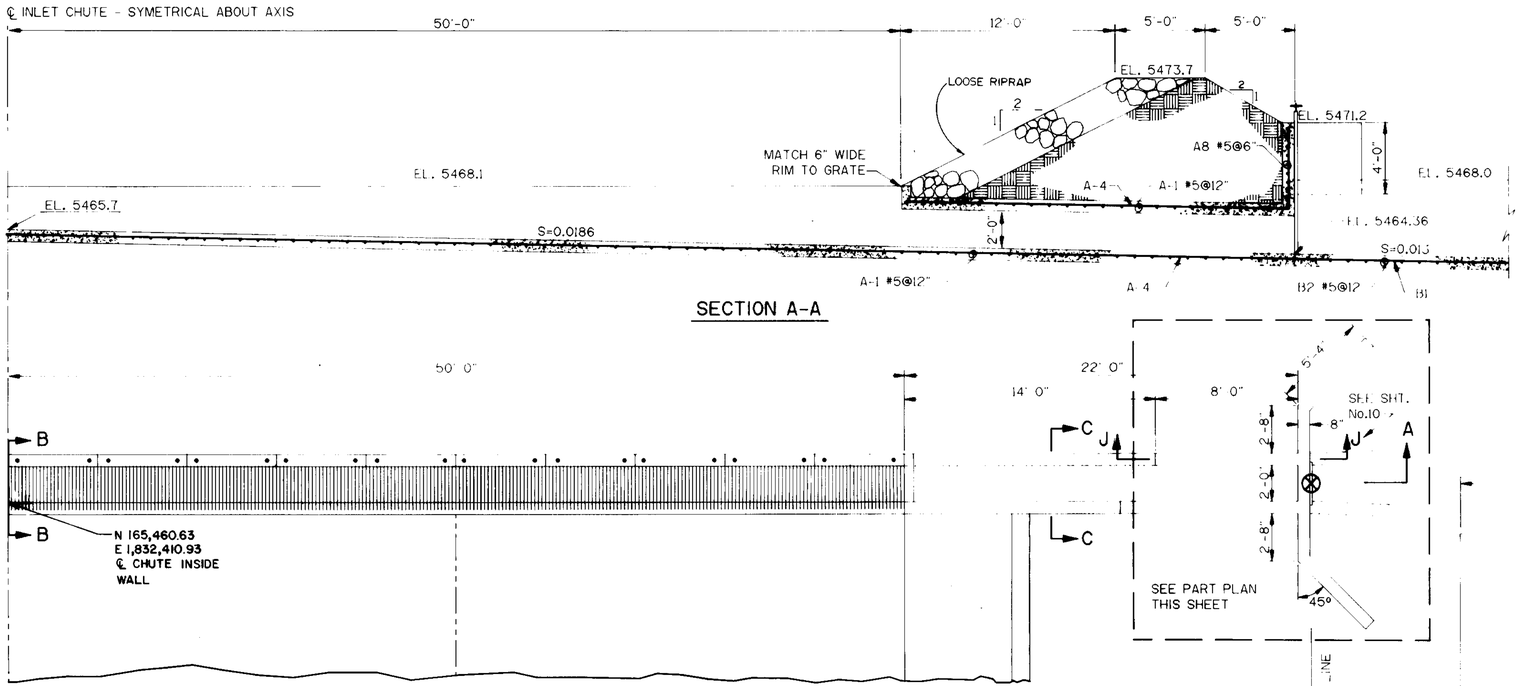
SECTION D-D

PROJECT NUMBERS
I-70-1(24)40
& F-069(7)

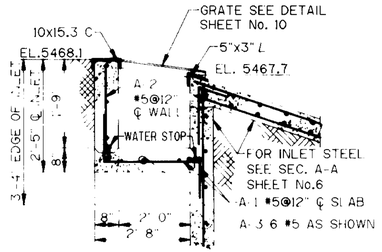
COTTONWOOD WASH
DETENTION BASIN
OUTLET ENERGY DISSIPATING STRUCTURE

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

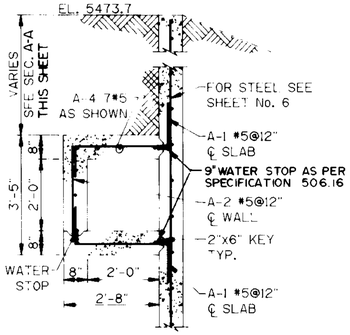
DESIGNED	CHECKED	DRAWN	SCALE
BEG	KRN	AKB	NONE
APPROVED	DATE	DRAWING NO.	
		RF-1	
REVISION	DATE	SHEET NO.	
		8	



SECTION A-A

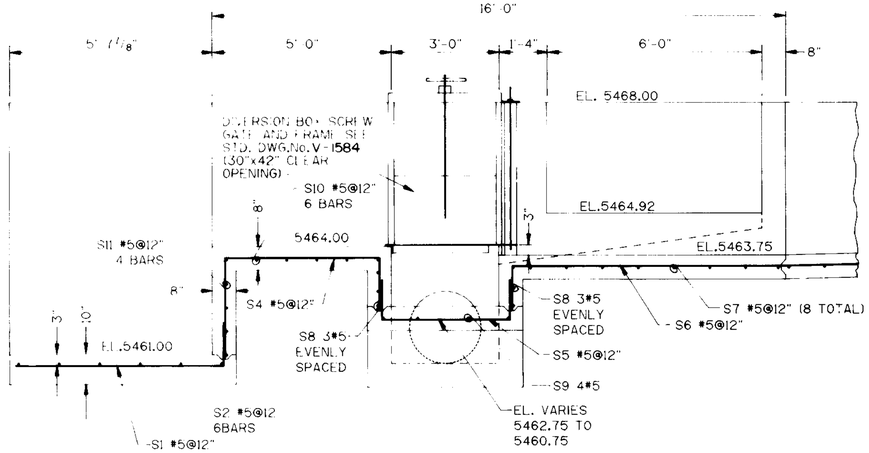


SECTION B-B

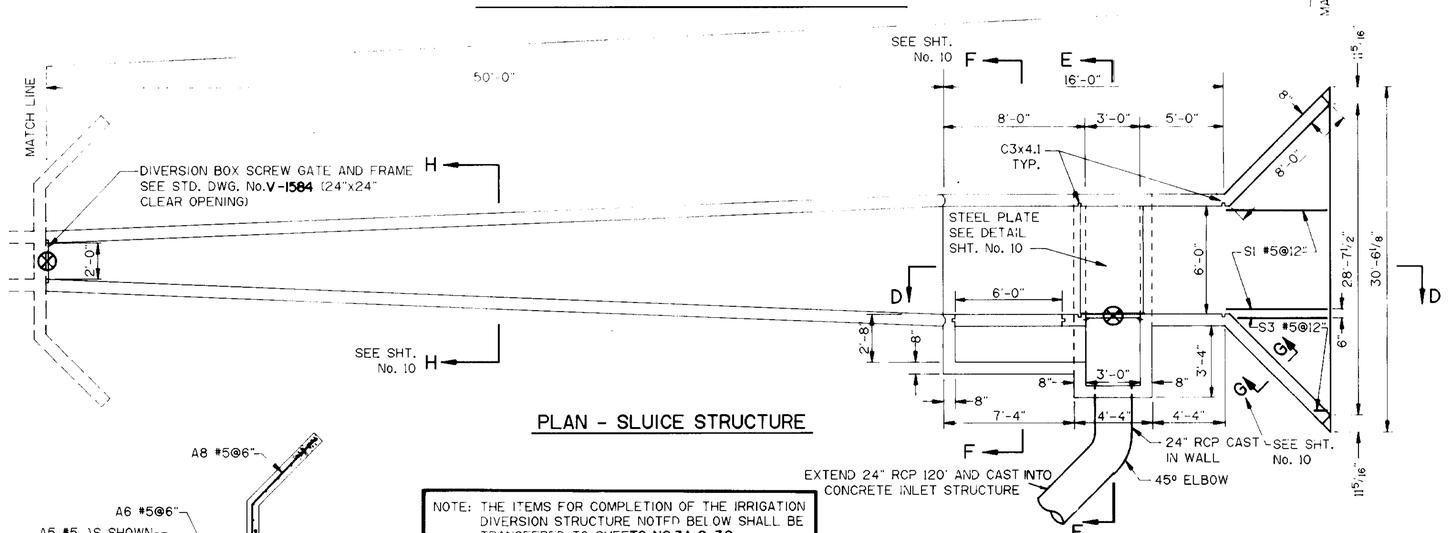


SECTION C-C

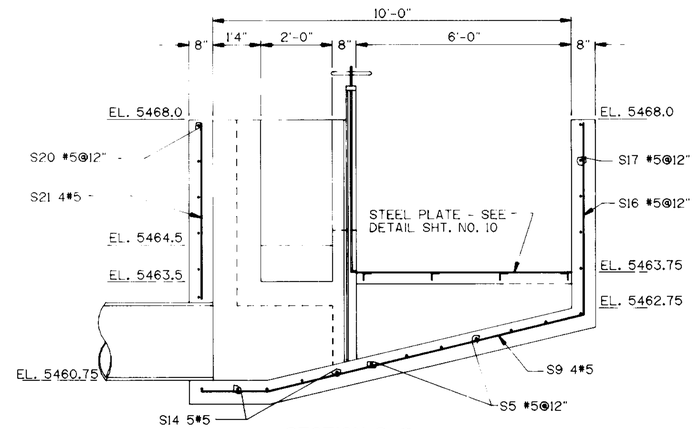
PLAN - IRRIGATION DIVERSION STRUCTURE



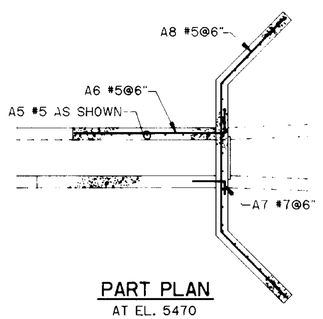
SECTION D-D



PLAN - SLUICE STRUCTURE



SECTION E-E



PART PLAN
AT EL. 5470

NOTE: THE ITEMS FOR COMPLETION OF THE IRRIGATION DIVERSION STRUCTURE NOTED BELOW SHALL BE TRANSFERED TO SHEETS NO 3A & 3G OF I-70 PORTION OF ROADWAY PLANS.

1- CONCRETE CLASS AA (AE) 90 CU. YD.

2- STRUCTURAL STEEL 9,100 LBS.

3- 2 EA. 24"x24" DIVERSION BOX SCREW GATE AND FRAME.

4- 2 EA. 34"x42" DIVERSION BOX SCREW GATE AND FRAME.

5- 240 LN. FT. 24" REINFORCED CONCRETE PIPE.

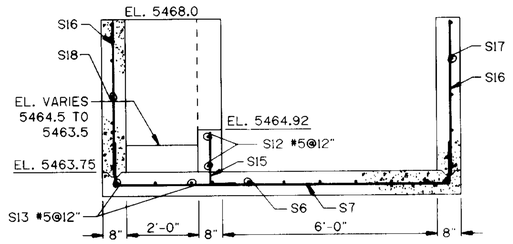
PROJECT NUMBERS
I-70-1(24)46
OF F-069(7)

COTTONWOOD WASH DETENTION BASIN

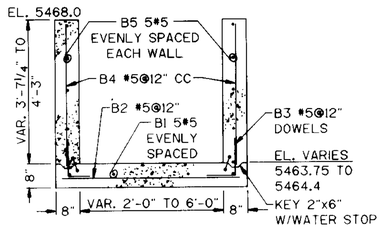
IRRIGATION DIVERSION STRUCTURE

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

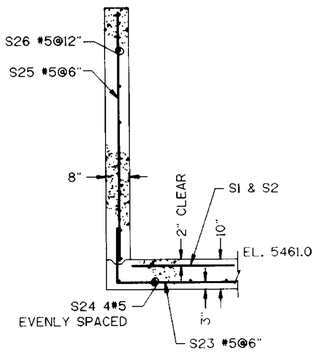
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APPROVED	DATE		RF-1
REVISION	DATE	SHEET NO.	9



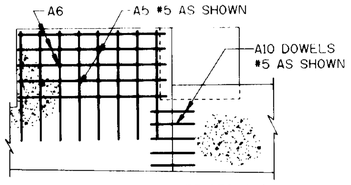
SECTION F-F



SECTION H-H



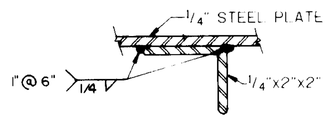
SECTION G-G



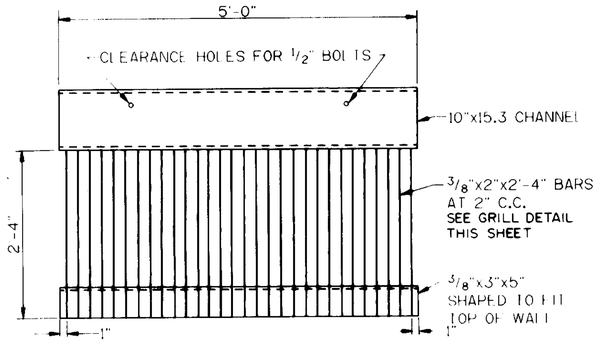
NOTE: FOR DIMENTIONS SEE SEC. A-A SHT. 9

SECTION J-J

NOTE: GRILL TO BE CONSTRUCTED IN 5 FT. LENGTHS AND GALVANIZED.



TYPICAL WELD DETAIL



DETAIL OF 5 FT. GRILL SECTION

STRUCTURE NOTES:

1. REINFORCING STEEL SHALL BE #5 @ 12" C.C. EACH WAY.
2. ALL REINFORCING STEEL SHALL BE POSITIONED IN THE CENTER OF THE WALL UNLESS OTHERWISE SPECIFIED.
3. LAP ALL REINFORCING STEEL 18" MIN. AND 30" MIN. AT ALL BENDS.
4. ALL EXPOSED CONCRETE EDGES SHALL BE CHAMFERED 1" OR ROUNDED.

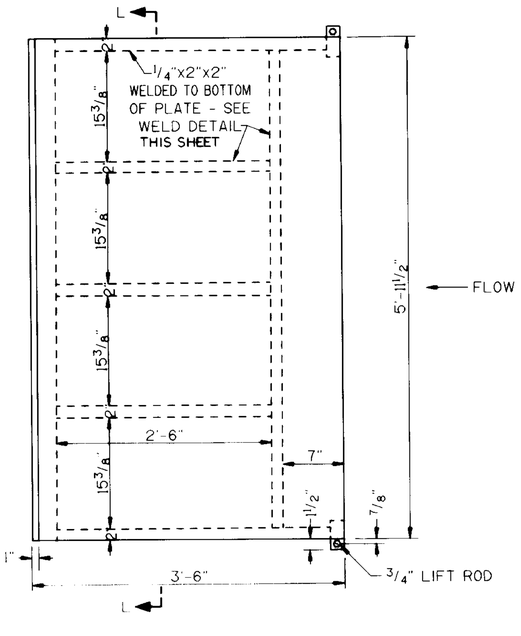
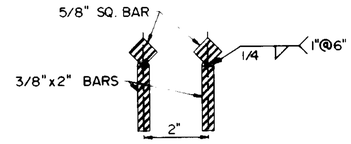
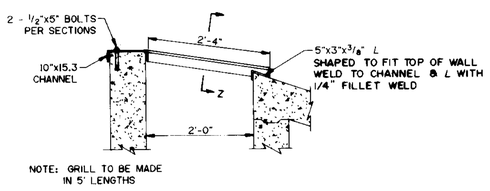


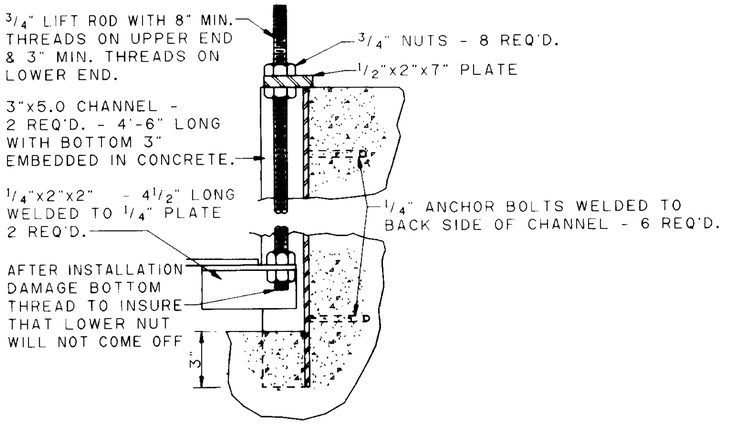
PLATE PLAN VIEW



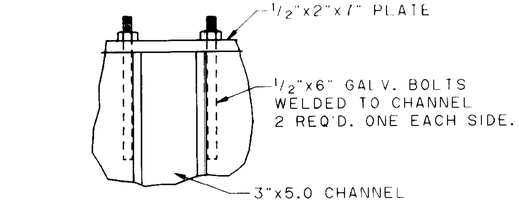
SECTION Z-Z



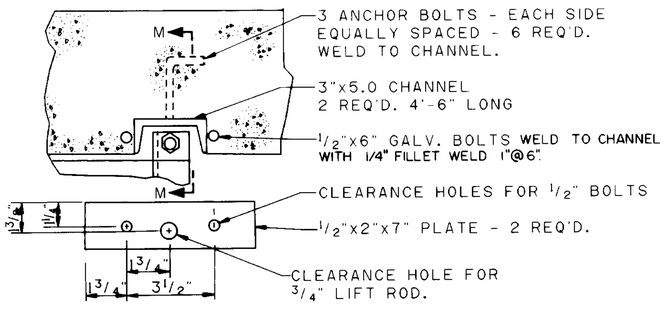
GRILL DETAIL



DETAIL SECTION M-M



FRONT VIEW



LIFT DETAIL

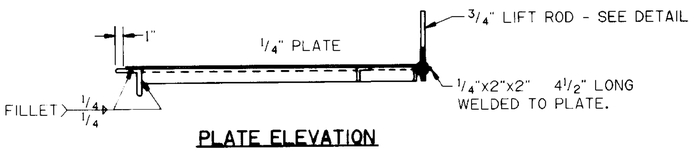


PLATE ELEVATION

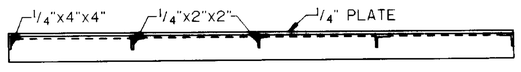


PLATE SECTION L-L

PROJECT NUMBERS I-70-1(124)40 & F-069(7)	**COTTONWOOD WASH DETENTION BASIN**	BRAASCH & NOBLE, ENGINEERS	DESIGNED BEG / CHECKED KRN / DRAWN DRL / SCALE NONE
	IRRIGATION DIVERSION STRUCTURE DETAILS		APPROVED / DATE / DRAWING NO. RF-1
			REVISION / DATE / SHEET NO. 10

STEEL SCHEDULE
INLET STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
STRAIGHT 4 SPLICES @ 1'-6"	#5	S-1	28'-10"	FOOTING	15	451
STRAIGHT 5 SPLICES @ 1'-6"	#5	S-2	25'-7"	FOOTING	18	480
(NOT USED)	-	S-3	-	(NOT USED)	-	-
STRAIGHT	#5	S-4	1'-6"	FOOTING	144	225
2'-9" / 1'-1"	#5	S-5	3'-10"	FOOTING	286	1143
STRAIGHT	#5	S-6	9'-6"	FOOTING WALL	101	1,001
STRAIGHT	#5	S-7	13'-6"	FOOTING WALL	20	282
CUT LINE, 13'-6", 9'-6", (9 BARS), 8 SPA.@ 1'-0"= 8'-0"	#5	S-8	103'-6"	FOOTING WALL	2 SETS	216
STRAIGHT	#5	S-9	19'-6"	FOOTING WALL	22	447
STRAIGHT	#5	S-10	26'-6"	FOOTING WALL	44	1216
9'-6", 4 SPA. @1'-0" =4'-0", (5 BARS), 17'-6"	#5	S-11	67'-6"	FOOTING WALL	2 SETS	141
STRAIGHT	#5	S-12	9'-6"	FOOTING WALL	101	1,001
STRAIGHT	#5	S-13	15'-6"	FOOTING WALL	20	323
(13 BARS), 15'-6", 9'-6", 12 SPA. @ 1'-0"= 12'-0"	#5	S-14	162'-6"	FOOTING WALL	2 SETS	339
STRAIGHT	#5	S-15	23'-6"	FOOTING WALL	22	539
STRAIGHT	#5	S-16	26'-6"	FOOTING WALL	44	1216
9'-6", (7 BARS), 6 SPA. @1'-0" =6'-0", 21'-6"	#5	S-17	108'-6"	FOOTING WALL	2 SETS	226
2'-0", 3, 1, 2'-0"	#5	S-18	4'-0"	WALL/SLAB	101	421
2'-6", 1'-6", 1'-6", 2'-6"	#5	S-19	9'-0"	SLAB	101	948
STRAIGHT	#5	S-20	26'-6"	SLAB	40	1106
(NOT USED)	-	S-21	-	(NOT USED)	-	-
STRAIGHT	#4	S-22	27'-0"	SLAB	248	4473
STRAIGHT	#4	S-23	23'-6"	SLAB	1240	19466
STRAIGHT	#4	S-24	24'-6"	SLAB	1200	19639
(NOT USED)	-	S-25	-	(NOT USED)	-	-
3'-0", 1, 2, 9'-5"	#4	S-26	12'-5"	SLAB	600	4977
(NOT USED)	-	S-27	-	(NOT USED)	-	-
2'-0", 2'-0"	#5	S-28	4'-0"	SLAB/WALL	50	209

STEEL SCHEDULE
OUTLET STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
STRAIGHT	#7	F-1	11'-6"	FOOTING	52	1,223
2'-6", 2'-6"	#7	F-2	5'-0"	FOOTING	24	246
STRAIGHT	#5	F-3	6'-3"	WALL	8	53
STRAIGHT	#5	F-4	10'-3"	WALL	8	86
STRAIGHT	#5	F-5	16'-3"	WALL	12	204
STRAIGHT	#5	F-6	2'-6"	WALL	32	84
STRAIGHT	#5	F-7	8'-3"	WALL	4	35
1'-2", 4'-10", 4'-10"	#7	F-8	16'-10"	WALL	6	207
7'-2", 4'-10", 1'-9"	#7	F-9	13'-9"	WALL	6	169
STRAIGHT	#7	F-10	7'-2"	WALL	21	308
7'-2", 4'-7", 4'-7"	#6	F-11	16'-4"	WALL	12	295
STRAIGHT	#6	F-12	7'-2"	WALL	24	259
7'-2", 4'-4", 4'-4"	#5	F-13	15'-10"	WALL	12	199
STRAIGHT	#5	F-14	7'-2"	WALL	24	180
1'-7", 1'-7"	#6	F-15	3'-2"	WALL/ROOF	24	115
STRAIGHT	#6	F-16	7'-2"	ROOF	18	194
STRAIGHT	#6	F-17	3'-0"	WALL	40	181
STRAIGHT	#6	F-18	4'-0"	WALL	8	49
STRAIGHT	#6	F-19	5'-0"	WALL	24	181
STRAIGHT	#6	F-20	6'-0"	WALL	8	73
STRAIGHT	#5	J-1	1'-8"	TRASH RACK FOOTING	32	56
1'-6", 8", 8", 1'-6"	#5	J-2	4'-4"	TRASH RACK FOOTING	16	73
STRAIGHT	#5	C-1	10'-0"	ANTI SEEP COLLAR	16	167
STRAIGHT	#5	C-2	6'-0"	ANTI-SEEP COLLAR	8	50
STRAIGHT	#5	C-3	5'-0"	PIPE CRADLE	216	1126
STRAIGHT 30 SPLICES @ 1'-6"	#5	C-4	37'-0"	PIPE CRADLE	36	1389

SUMMARY OF BARS
76,461.1 FEET OF #4 BARS @ 0.668 LBS./FT. = 51,076
14,987.5 FEET OF #5 BARS @ 1.043 LBS./FT. = 15,632
896.8 FEET OF #6 BARS @ 1.502 LBS./FT. = 1,347
1,053.3 FEET OF #7 BARS @ 2.044 LBS./FT. = 2,153
TOTAL = 70,208
USE = 70,300

STEEL SCHEDULE
OUTLET ENERGY DISSIPATING STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
2'-2", 15'-0", 2'-2"	#4	E-1	19'-4"	BOTTOM SLAB	11	143
STRAIGHT	#4	E-2	15'-0"	BOTTOM SLAB	11	111
2'-6", 11'-6", 2'-6"	#4	E-3	16'-6"	BOTTOM SLAB	16	177
STRAIGHT	#4	E-4	16'-6"	BOTTOM SLAB	16	177
2'-6", 2'-6"	#4	E-5	5'-0"	BOTTOM SLAB DOWEL	56	188
STRAIGHT	#4	E-6	8'-6"	WALL (VERT)	48	273
8'-2", 5'-1", 9 SPA. @1'-0"=9'-0"	#4	E-7	66'-3"	WALL (VERT)	4 SETS	178
1'-2", 2'-0"	#4	E-8	3'-2"	WALL/ROOF DOWEL	26	55
STRAIGHT	#4	E-9	2'-0"	WALL (VERT)	10	14
2'-0", 2'-0"	#4	E-10	4'-0"	WING WALL DOWEL	28	75
STRAIGHT	#4	E-11	5'-5"	WING WALL (HORIZ)	20	73
7 SPA. @ 10"=5'-10", 2'-0", 3'-9"	#4	E-12	31'-4"	WING WALL (VERT)	4 SETS	84
STRAIGHT	#4	E-13	15'-0"	WALL (HORIZ)	24	241
6'-4", 3 SPA. @1'-0" =3'-0", 15'-0"	#4	E-14	38'-8"	WALL (HORIZ)	4 SETS	104
2'-0", 11'-6", 2'-0"	#4	E-15	15'-6"	WALL (HORIZ)	12	125
3'-11", 2'-0"	#4	E-16	5'-11"	WALL (HORIZ)	20	80
1'-0" DIA.	#4	E-17	12'-8"	WALL	2	17
STRAIGHT	#4	E-18	11'-6"	ROOF	3	24
STRAIGHT	#4	E-19	6'-4"	ROOF	6	26
STRAIGHT	#4	E-20	5'-0"	BAFFLE	10	34
1'-8", 1'-8"	#4	E-21	3'-4"	BAFFLE	40	90
STRAIGHT	#4	E-22	10'-2"	BAFFLE	16	109
2'-2", 4'-3"	#4	E-23	6'-5"	BAFFLE	12	52
STRAIGHT	#4	E-24	4'-3"	BAFFLE	12	35
STRAIGHT	#4	E-25	2'-2"	BAFFLE	12	18
1'-6", 1.6, 1'-6"	#4	E-26	3'-0"	BAFFLE	4	8
1'-6", 1.6, 1'-6", 3'-10"	#4	E-27	6'-10"	BAFFLE	2	10

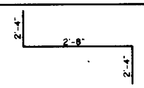
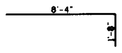
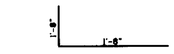
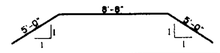
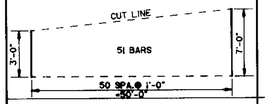
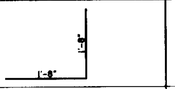
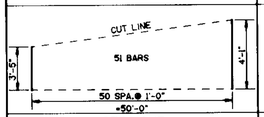
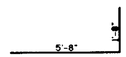
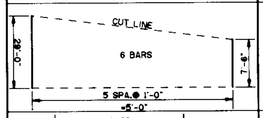
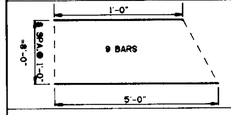
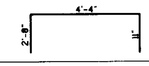
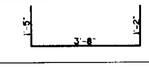
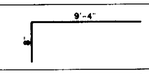
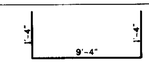
PROJECT NUMBERS
I-70-1(124)40
& F-069(7)

COTTONWOOD WASH
DETENTION BASIN
STEEL SCHEDULE

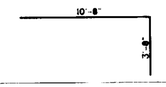
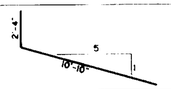
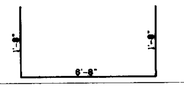
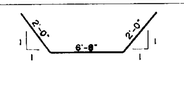
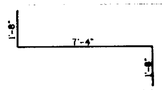
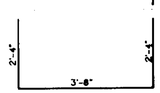
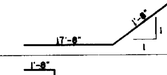
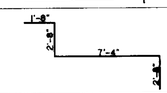
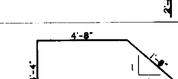
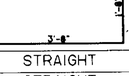
CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
BEG	KRN	DRL	NONE
APPROVED	DATE	DRAWING NO.	RF-1
REVISION	DATE	SHEET NO.	11

STEEL SCHEDULE
IRRIGATION DIVERSION STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
	#5	A-1	5'-4"	INLET BOX	192	1068.0
STRAIGHT	#5	A-2	2'-2"	INLET BOX	146	329.9
STRAIGHT	#5	A-3	37'-8"	INLET BOX	24	942.9
STRAIGHT	#5	A-4	21'-6"	INLET BOX	6	134.5
STRAIGHT	#5	A-5	7'-6"	INLET BOX	16	100.1
	#5	A-6	10'-0"	INLET BOX	36	375.5
	#5	A-7	3'-4"	INLET BOX	36	125.2
	#5	A-8	18'-8"	INLET BOX WING WALL	18	350.4
STRAIGHT	#5	A-9	3'-6"	WING WALL	38	138.7
	#5	A-10	3'-4"	DOWELS- INLET BOX OPEN CHANNEL-	26	90.4
STRAIGHT	#5	B-1	27'-0"	OPEN CHANNEL	20	563.2
	#5	B-2	255'-0"	OPEN CHANNEL	2 SETS	531.9
	#5	B-3	3'-4"	OPEN CHANNEL DOWELS- SLAB & WALL	204	709.2
	#5	B-4	191'-3"	OPEN CHANNEL	4 SETS	797.9
STRAIGHT	#5	B-5	27'-0"	OPEN CHANNEL	40	1126.4
	#5	P-1	7'-4"	SLUICE STR.	14	107.1
	#5	P-2	108'-0"	SLUICE STR.	2 SETS	225.3
	#5	P-3	27'-0"	SLUICE STR.	4 SETS	112.6
	#5	P-4	7'-11"	SLUICE STR.	14	115.6
	#5	P-5	6'-3"	SLUICE STR.	14	91.3
	#5	P-6	10'-0"	SLUICE STR.	14	146.0
	#5	P-7	12'-0"	SLUICE STR.	16	200.3

STEEL SCHEDULE
IRRIGATION DIVERSION STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
	#5	P-8	14'-4"	SLUICE STR.	12	179.4
	#5	P-9	13'-2"	SLUICE STR.	8	109.9
	#5	P-10	10'-0"	SLUICE STR.	12	125.2
	#5	P-11	10'-8"	SLUICE STR.	8	89.0
	#5	P-12	3'-4"	SLUICE STR.	18	62.6
	#5	P-13	10'-8"	SLUICE STR.	6	66.8
	#5	P-14	8'-4"	SLUICE STR.	10	86.9
STRAIGHT	#5	P-15	7'-4"	SLUICE STR.	4	30.6
STRAIGHT	#5	P-16	4'-0"	SLUICE STR.	86	358.8
	#5	P-17	19'-4"	SLUICE STR.	10	201.6
	#5	P-18	14'-4"	SLUICE STR.	10	149.5
	#5	P-19	10'-8"	SLUICE STR.	10	111.3
	#5	P-20	7'-0"	SLUICE STR.	12	87.6
STRAIGHT	#5	P-21	5'-0"	SLUICE STR.	8	41.7
STRAIGHT	#5	P-22	1'-0"	SLUICE STR.	10	10.4
	#5	P-23	7'-0"	SLUICE STR.	68	496.5
STRAIGHT	#5	P-24	7'-6"	SLUICE STR.	16	125.2
STRAIGHT	#5	P-25	6'-10"	SLUICE STR.	68	484.6
STRAIGHT	#5	P-26	7'-8"	SLUICE STR.	32	255.9
					TOTAL	11,455.9
					USE	11,500

NOTE: TOTAL REINFORCING STEEL QUANTITY TRANSFERRED TO SHEET NO. 36 OF I-70 PORTION OF ROADWAY PLANS.

PROJECT NUMBERS
I-70-1(24)40
& F-088(7)

COTTONWOOD WASH
DETENTION BASIN
STEEL SCHEDULE

CREAMER & NOBLE ENGINEERS
FT. COLLINS, COLO.

DESIGNED	CHECKED	DRAWN	SCALE
BEG	KRN	DRL	NONE
APPROVED	DATE	DRAWING NO.	RF-1
REVISION	DATE	SHEET NO.	12

PLAN
SURVEYED
PLOTTED
ALIGNMENT CHECKED
BY
DATE
NOTE BOOK
NO

PROFILE
SURVEYED
PLOTTED
GRADES CHECKED
STRUCTURE NO'S CHKD
NOTE BOOK
NO

N

DETENTION BASIN

10+00 BEGIN SMALL DITCH EXCAVATION SEE TYPICAL SECTION SHEET NO 2

P.C. 10+25

P.I. 11+20.92

IRRIGATION DIVERSION STRUCTURE. SEE SHT. NO. 9

Δ = 41° 20' 11"
R = 132.54'
A = 95.62'
C = 93.56'
T = 50.00'
P.I. STA. 10+75

S 1° 22' 23" W

30' OF 36" CORRUGATED METAL PIPE REQUIRED

DITCH A, SEE TYPICAL SECTION #4 ON SHEET NO 2

EXISTING IRRIGATION DITCH

STA 22+00
END SMALL DITCH EXCAVATION & MATCH EXISTING IRRIGATION DITCH

N/A LINE

2015
E B.L. CENTERLINE

SEE SHEET #5 OF THE I-70 PORTION OF THE ROADWAY PLANS

IRRIGATION DIVERSION STRUCTURE

V.P.I. 10+00 BEGIN SMALL DITCH EXCAVATION 5464.00

S = -1.00%

V.P.I. 13+65 5460.36

30' OF 36" CORRUGATED METAL PIPE REQUIRED

NATURAL GROUND

S = -1.36%

SMALL DITCH ℄

V.P.I. 18+25 5448.48

S = -2.14%

V.P.I. 22+44.39 5439.51 MATCH EXISTING IRRIGATION DITCH

5470 / 65 / 5460 / 55 / 5450 / 45 / 5440

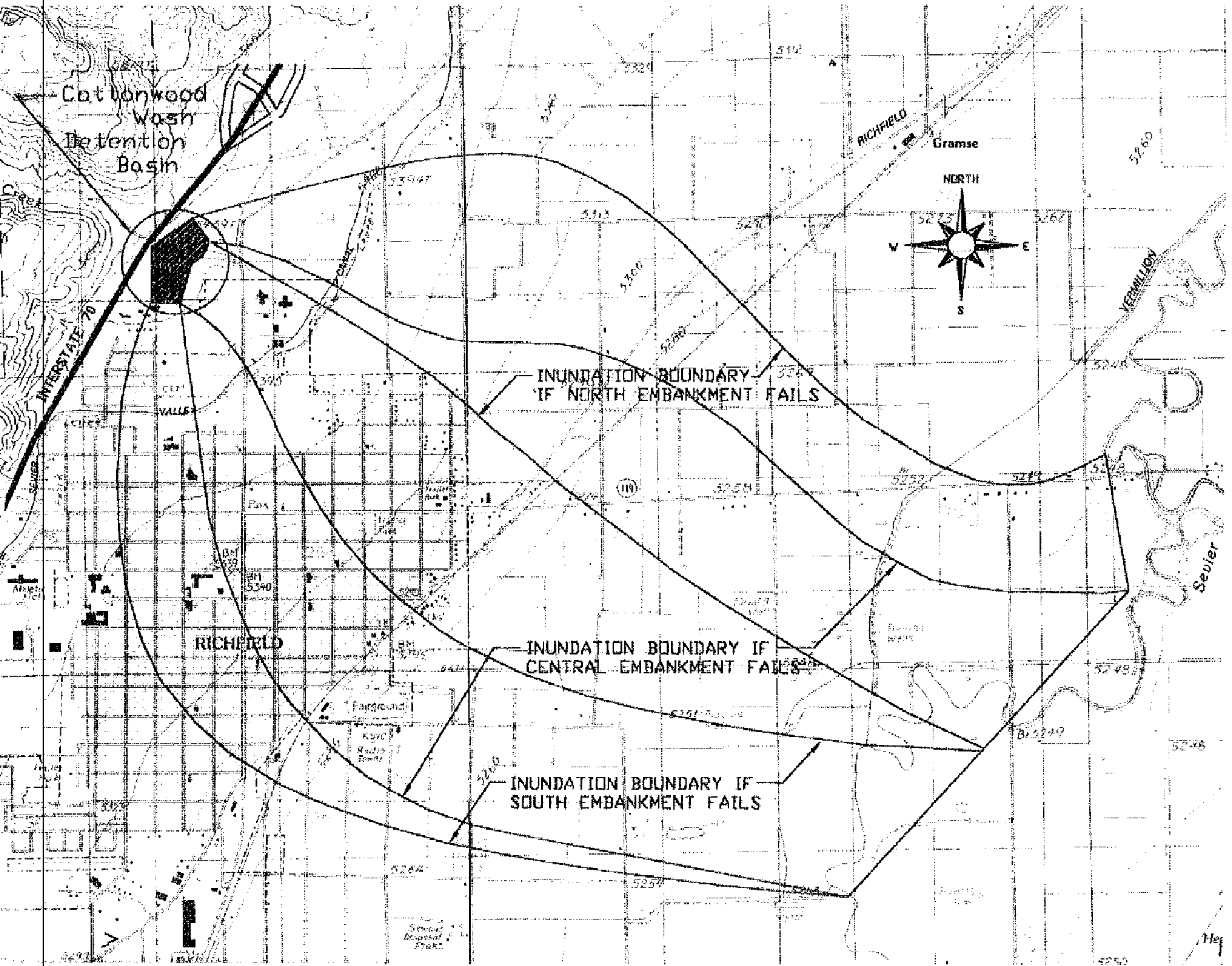
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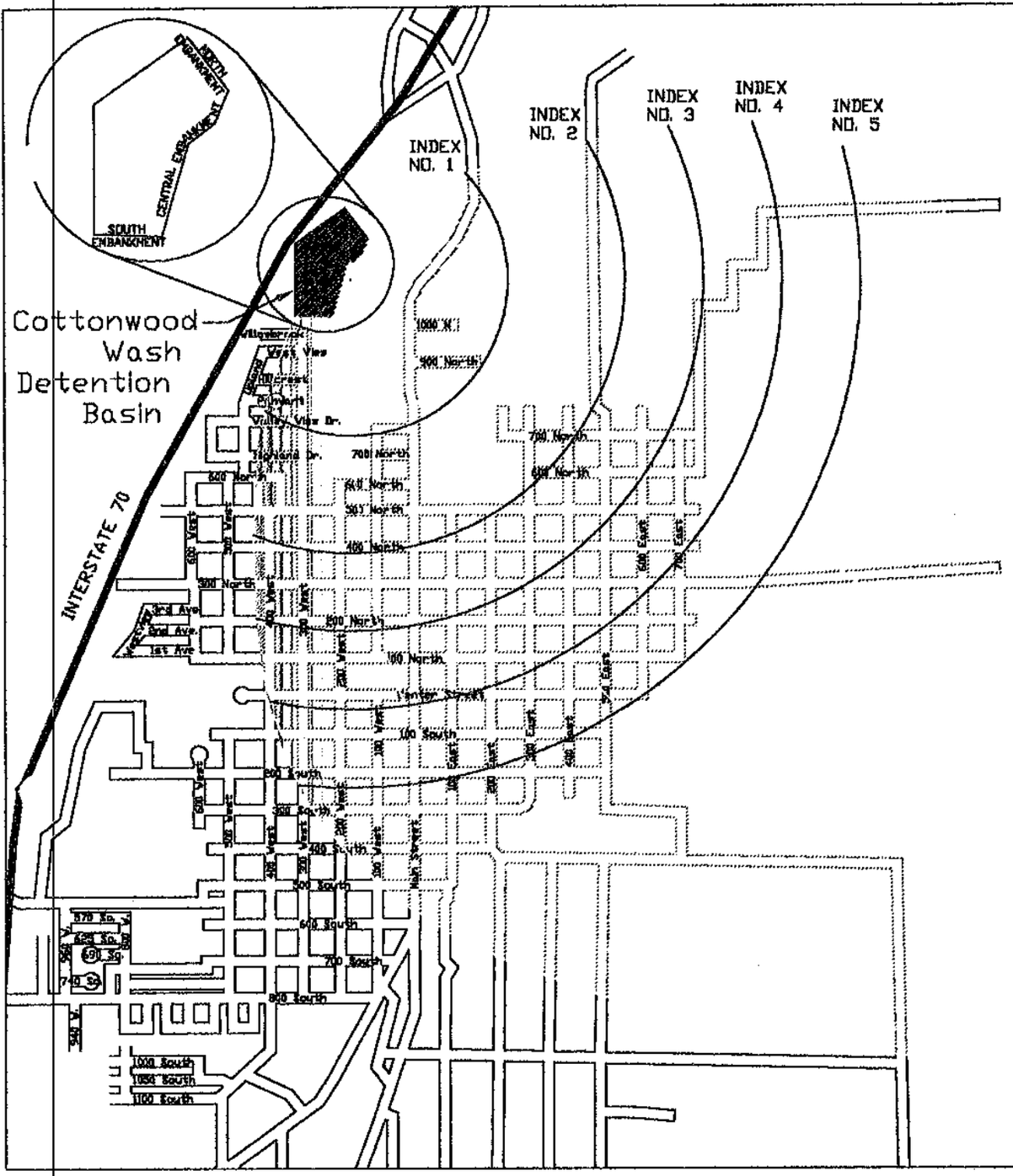
PROJECT NUMBERS
I-70-1(24)40
& F-069(7)

COTTONWOOD WASH
DETENTION BASIN
SMALL DITCH "A"

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
SEL	KRN	SEL	NONE
APPROVED	DATE	DRAWING NO.	RF-1
REVISION	DATE	SHEET NO.	13


Cottonwood Wash Detention Basin
INTERSTATE 70
RICHFIELD
Gramse
NORTH
W
E
S
VERMILLION
Sevier
INUNDATION BOUNDARY IF NORTH EMBANKMENT FAILS
INUNDATION BOUNDARY IF CENTRAL EMBANKMENT FAILS
INUNDATION BOUNDARY IF SOUTH EMBANKMENT FAILS
RICHFIELD
Fairgrounds



INDEX NO.	DISTANCE FROM DAM (MILES)	SUNNY DAY FAILURE			RAINY DAY FAILURE		
		TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)
1	0.4	0.50	2.6	13130	0.57	3.1	19756
2	0.7	0.63	2.0	10576	0.67	2.4	16800
3	0.9	0.73	2.1	9390	0.73	2.4	15681
4	1.1	0.83	1.2	8721	0.83	1.5	14879
5	1.3	1.00	1.7	7778	0.97	2.0	13627
6	2.8	1.97	1.0	1605	2.10	1.3	3278

Notes:
A sunny day failure is defined as a failure which occurs as a result of piping through the dam.
A rainy day failure is defined as a failure which occurs as a result of storm flows overtopping the dam.

THIS MAP SHOWS A TOTAL INUNDATION AREA. OTHER MAPS HAVE BEEN PROVIDED WHICH SHOW SPECIFIC AREAS OF INUNDATION IF CERTAIN SECTIONS OF THE EMBANKMENT FAIL, I.E. THE NORTH, CENTRAL, OR SOUTH EMBANKMENTS.

LICENSED PROFESSIONAL ENGINEER
LYNN D. WALL
No. 10076
5-22-92
STATE OF UTAH

NORTH
W
E
S

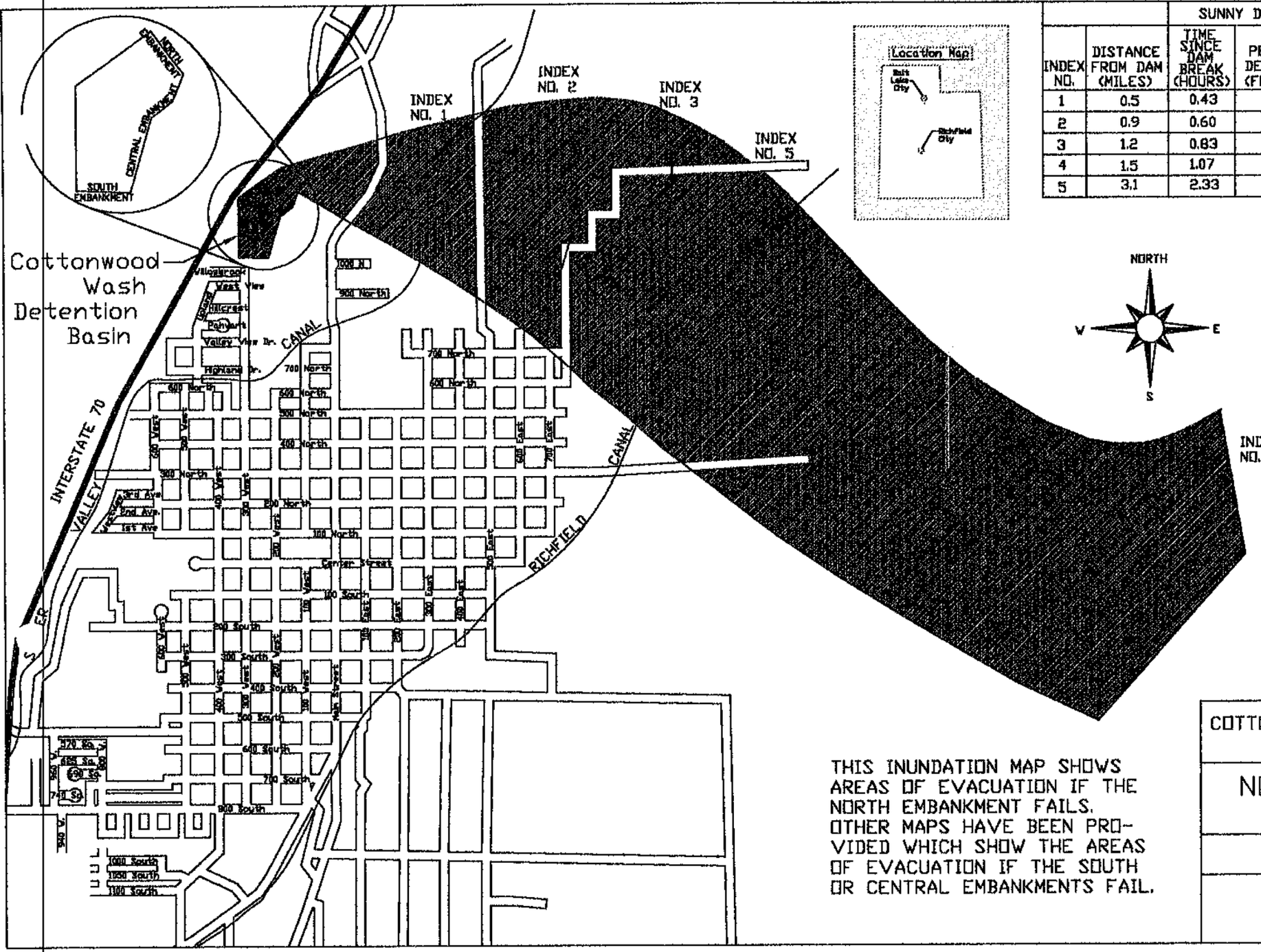
COTTONWOOD WASH DETENTION DAM
EMERGENCY ACTION PLAN

EMBANKMENT FAILURE

INUNDATION MAP

SCALE: NONE

INUNDATION AREA



		SUNNY DAY FAILURE			RAINY DAY FAILURE		
INDEX NO.	DISTANCE FROM DAM (MILES)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)
1	0.5	0.43	3.0	6104	0.43	3.9	12926
2	0.9	0.60	1.7	4770	0.60	2.3	10751
3	1.2	0.83	1.1	3628	0.80	1.5	8674
4	1.5	1.07	0.7	3231	0.97	1.1	7891
5	3.1	2.33	1.0	894	2.50	1.5	2945

Notes:
A sunny day failure is defined as a failure which occurs as a result of piping through the dam.
A rainy day failure is defined as a failure which occurs as a result of storm flows overtopping the dam.

LICENSED PROFESSIONAL ENGINEER
LYNN D. WALL
No. 10076
3-27-97
STATE OF UTAH

THIS INUNDATION MAP SHOWS AREAS OF EVACUATION IF THE NORTH EMBANKMENT FAILS. OTHER MAPS HAVE BEEN PROVIDED WHICH SHOW THE AREAS OF EVACUATION IF THE SOUTH OR CENTRAL EMBANKMENTS FAIL.

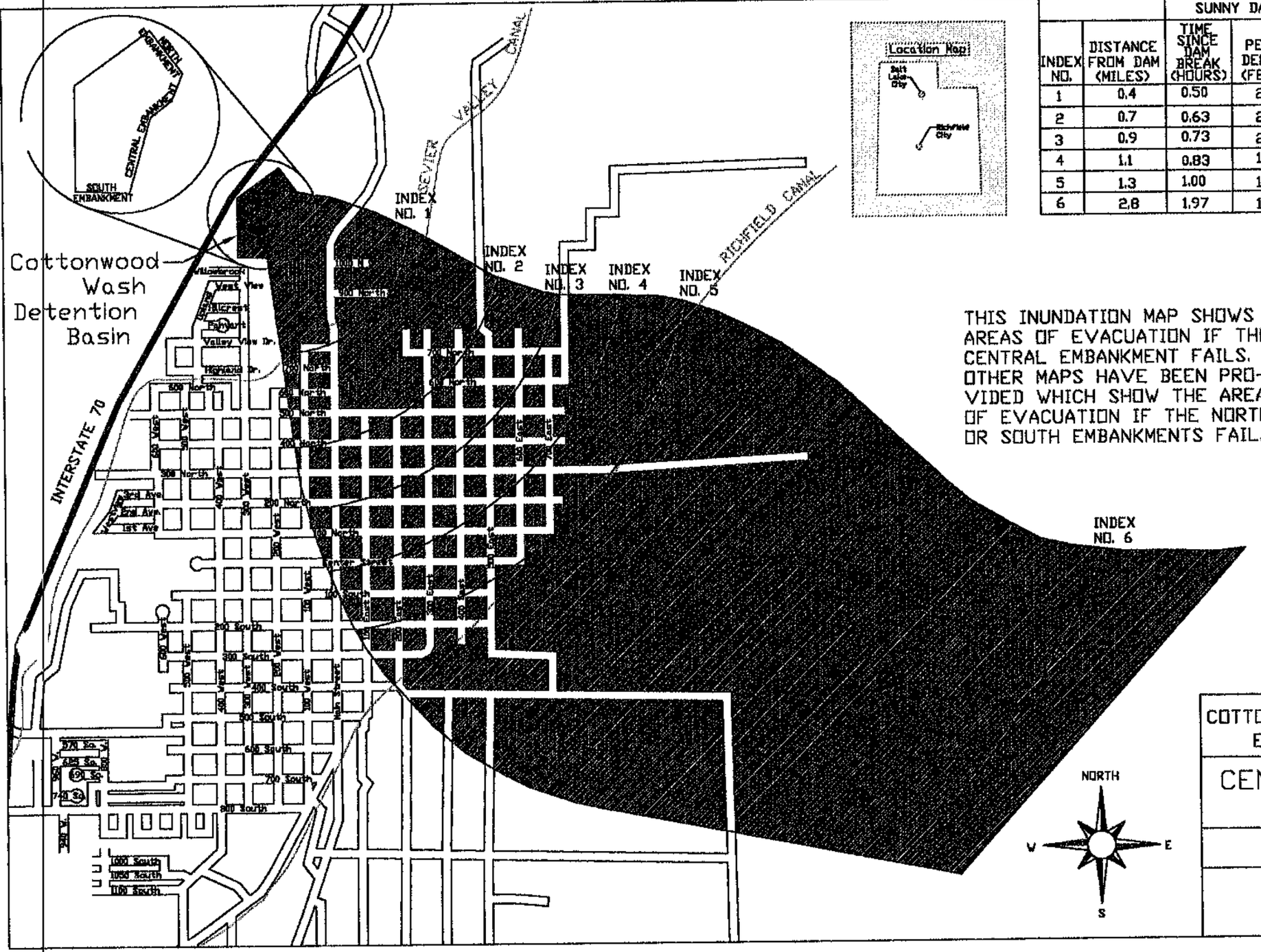
COTTONWOOD WASH DETENTION DAM
EMERGENCY ACTION PLAN

NORTH EMBANKMENT FAILURE

INUNDATION MAP

SCALE: NONE

INUNDATION AREA



INDEX NO.	DISTANCE FROM DAM (MILES)	SUNNY DAY FAILURE: TIME SINCE DAM BREAK (HOURS)	SUNNY DAY FAILURE: PEAK DEPTH (FEET)	SUNNY DAY FAILURE: PEAK FLOW (CFS)	RAINY DAY FAILURE: TIME SINCE DAM BREAK (HOURS)	RAINY DAY FAILURE: PEAK DEPTH (FEET)	RAINY DAY FAILURE: PEAK FLOW (CFS)
1	0.4	0.50	2.6	13130	0.57	3.1	19756
2	0.7	0.63	2.0	10576	0.67	2.4	16800
3	0.9	0.73	2.1	9390	0.73	2.4	15681
4	1.1	0.83	1.2	8721	0.83	1.5	14879
5	1.3	1.00	1.7	7778	0.97	2.0	13627
6	2.8	1.97	1.0	1605	2.10	1.3	3278

Notes:
A sunny day failure is defined as a failure which occurs as a result of piping through the dam.
A rainy day failure is defined as a failure which occurs as a result of storm flows overtopping the dam.

LICENSED PROFESSIONAL ENGINEER
LYNN D. WALL
No. 10076
3-22-97
STATE OF UTAH

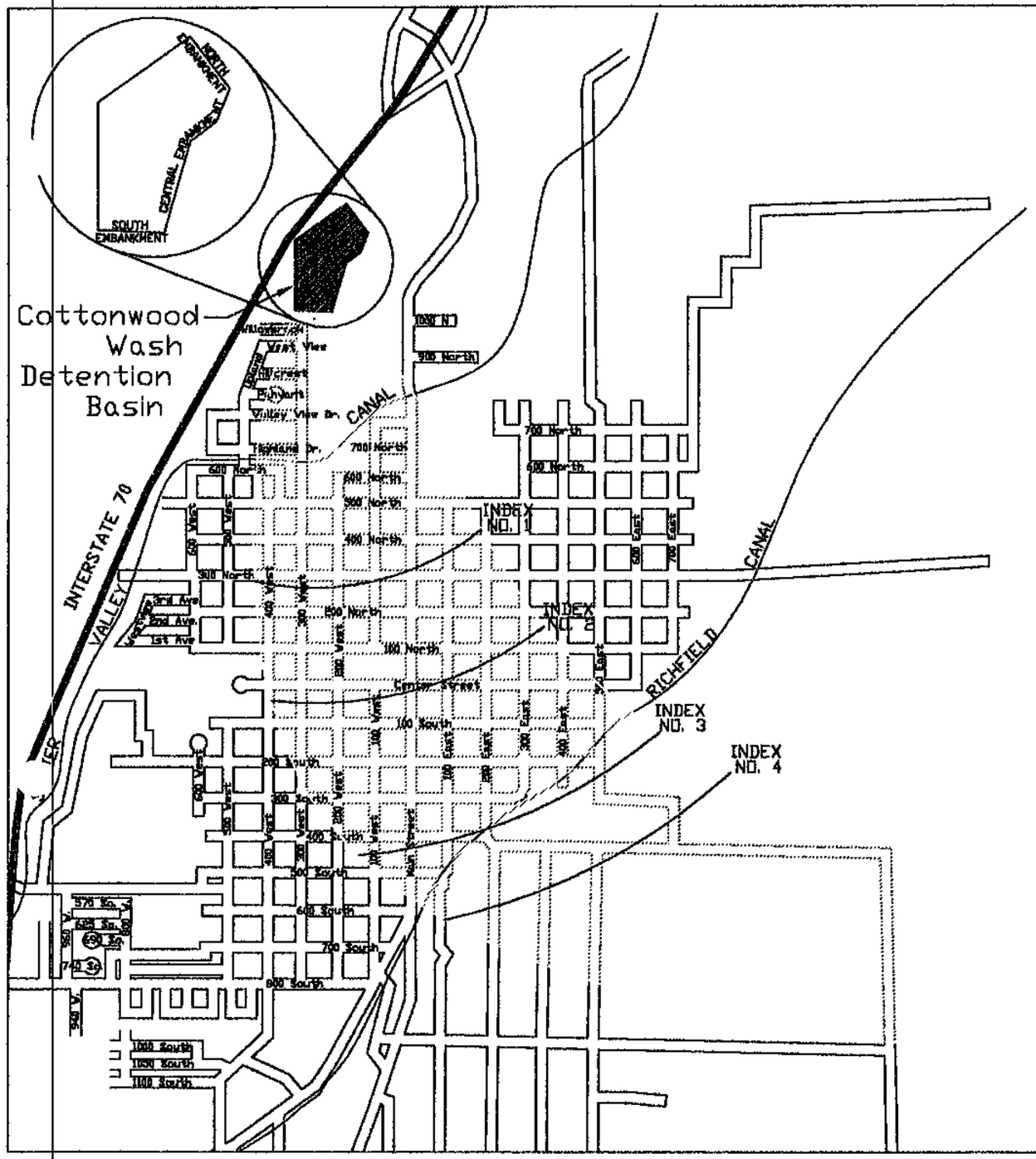
COTTONWOOD WASH DETENTION DAM
EMERGENCY ACTION PLAN

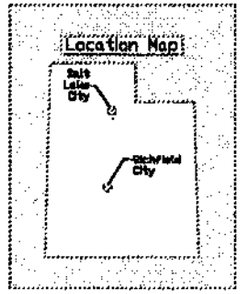
CENTRAL EMBANKMENT FAILURE

INUNDATION MAP

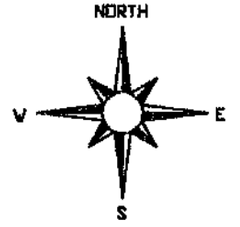
SCALE: NONE

INUNDATION AREA



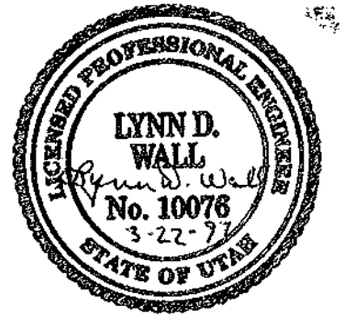


INDEX NO.	DISTANCE FROM DAM (MILES)	SUNNY DAY FAILURE			RAINY DAY FAILURE		
		TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)
1	0.7	0.50	1.5	6112	0.53	2.0	11886
2	1.0	0.70	2.1	5332	0.70	2.8	10680
3	1.4	0.97	1.1	4160	0.90	1.4	8947
4	1.6	1.13	1.3	3926	1.03	1.7	8586
5	3.1	2.43	1.2	1108	2.63	1.7	2980



Notes:
A sunny day failure is defined as a failure which occurs as a result of piping through the dam.
A rainy day failure is defined as a failure which occurs as a result of storm flows overtopping the dam.

THIS INUNDATION MAP SHOWS AREAS OF EVACUATION IF THE SOUTH EMBANKMENT FAILS. OTHER MAPS HAVE BEEN PROVIDED WHICH SHOW THE AREAS OF EVACUATION IF THE NORTH OR CENTRAL EMBANKMENTS FAIL.



COTTONWOOD WASH DETENTION DAM
EMERGENCY ACTION PLAN

SOUTH EMBANKMENT FAILURE

INUNDATION MAP

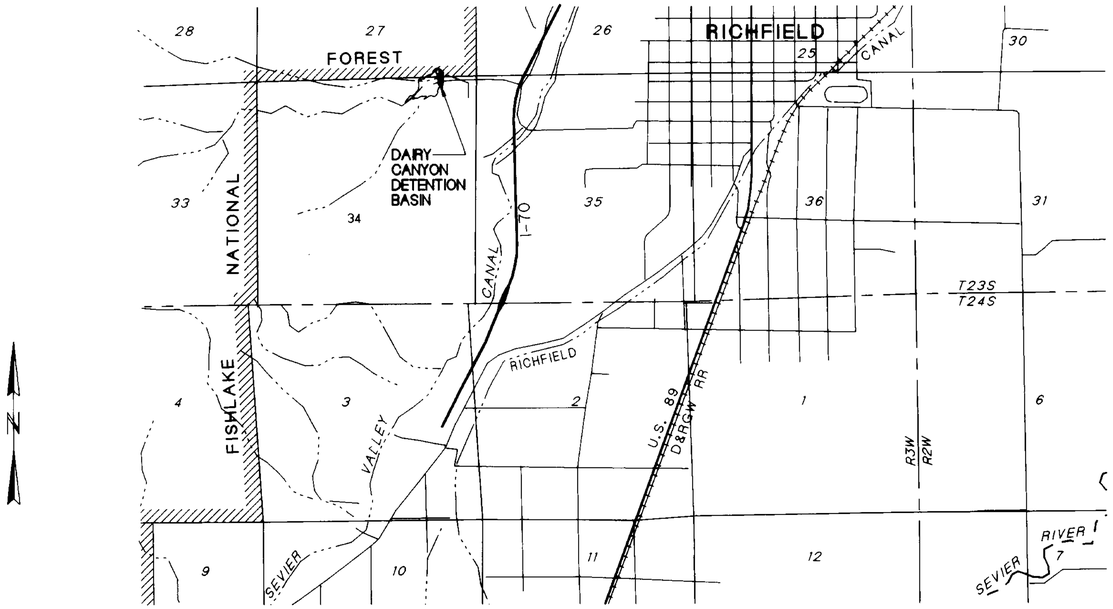
SCALE: NONE

INUNDATION AREA

"AS CONSTRUCTED"

DAIRY CANYON DETENTION BASIN

DRAWING NO. RF-2



INDEX TO SHEETS

SHEET No.	DESCRIPTION
1	TITLE SHEET & INDEX TO SHEETS
2	TYPICAL SECTIONS
3	SUMMARY SHEET
4	PLAN SHEET
5	DRILL HOLE & TEST PIT LOGS
6	OUTLET PIPE DETAILS
	STRUCTURAL
7	OUTLET STRUCTURE
8	ENERGY DISSIPATING STRUCTURE
9	STEEL SCHEDULE

GENERAL NOTES

MATERIALS, CONSTRUCTION, AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE STATE OF UTAH STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, EDITION OF 1979, AND SUPPLEMENTS THERETO WHICH ARE IN EFFECT ON THE DATE OF REQUEST FOR BIDS.

ALL REINFORCING STEEL SHALL BE DEFORMED BILLET-STEEL BARS CONFORMING TO ASTM DESIGNATION A615, GRADE 60, (EPOXY COATED).

TYPE II CEMENT (LOW ALKALI) REQUIRED.

ALL STRUCTURAL STEEL SHALL BE STRUCTURAL CARBON STEEL CONFORMING TO AASHTO DESIGNATION M-183 (ASTM A36).

ALL EXPOSED STRUCTURAL STEEL SHALL BE HOT DIP GALVANIZED IN ACCORDANCE WITH ASTM 123

OWNER'S ACCEPTANCE

RICHFIELD CITY HEREBY CERTIFIES THAT THE CITY ACCEPTS THE PLANS AND SPECIFICATIONS FOR THE CONSTRUCTION OF THE DAIRY CANYON DETENTION BASIN.

Jean Marie Young 8/20/87
DATE

ENGINEER'S CERTIFICATE

I DO HEREBY CERTIFY THAT THESE PLANS FOR THE CONSTRUCTION OF THE DAIRY CANYON DETENTION BASIN WERE PREPARED BY ME FOR RICHFIELD CITY, UTAH.

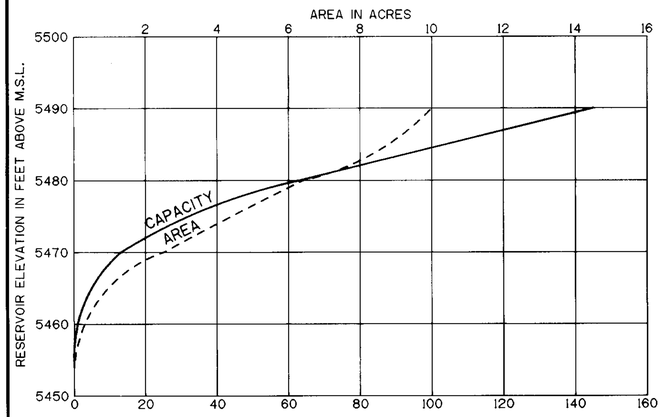
ENGINEER 8/20/87
DATE

PROFESSIONAL LICENSE NO. 4629

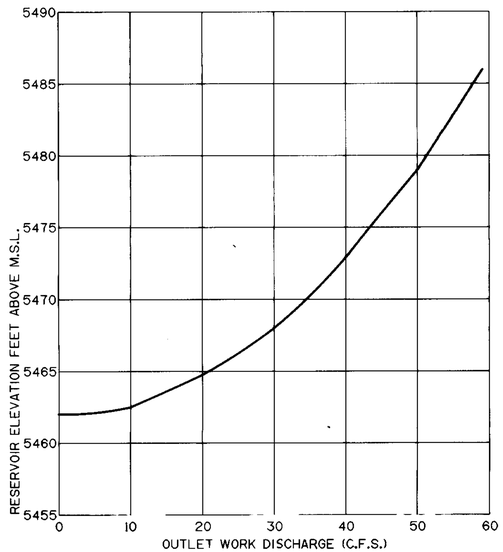
APPROVAL

IN ACCORDANCE WITH S 73-5-5, UTAH CODE ANNOTATED, 1953, AS AMMENDED, APPROVAL IS HEREBY GIVEN FOR THE CONSTRUCTION OF THE DAIRY CANYON DETENTION BASIN NEAR RICHFIELD, UTAH.

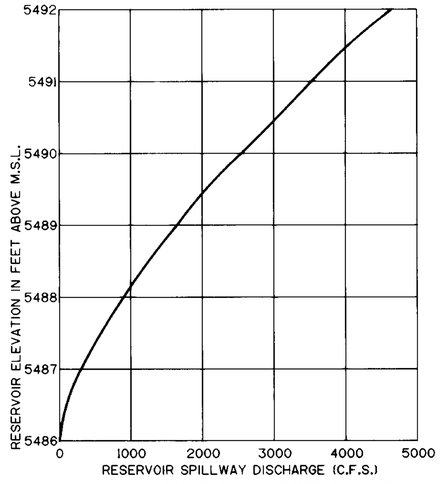
8-20-87
UTAH STATE ENGINEER DATE



CAPACITY & AREA CURVES



OUTLET DISCHARGE CURVE



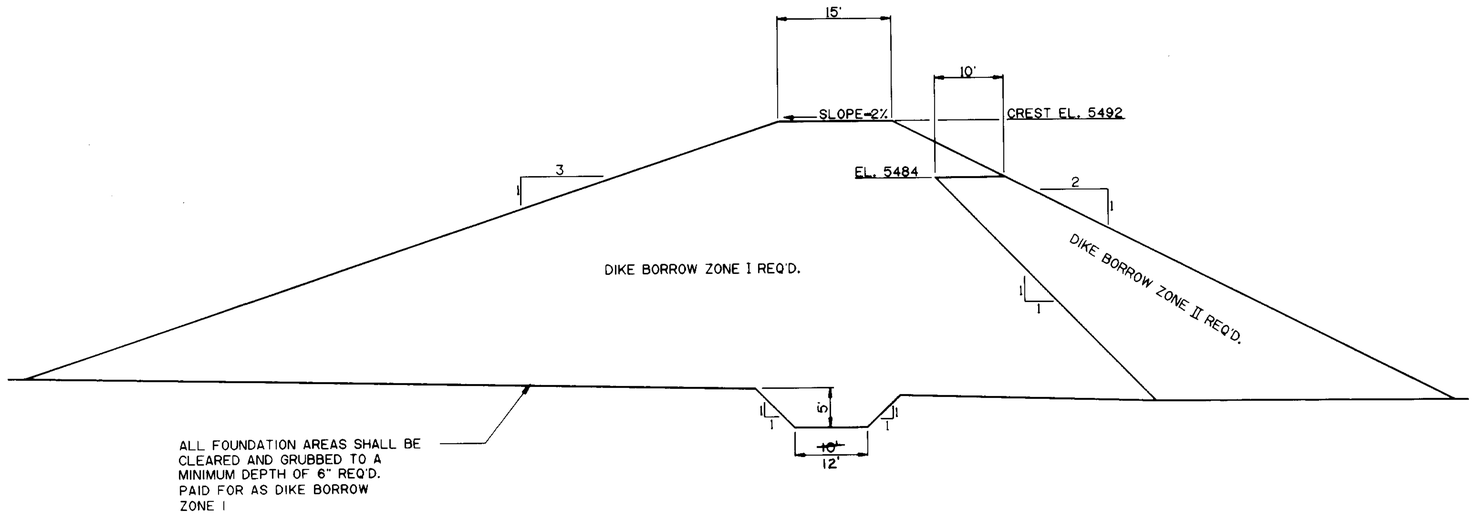
SPILLWAY DISCHARGE CURVE

PROJECT NUMBERS I-70-K23(3)6	DAIRY CANYON DETENTION BASIN	CREAMER & NOBLE ENGINEERS ST. GEORGE, UTAH	DESIGNED BBB / CHECKED KRN / DRAWN LOB / SCALE NONE
	TITLE SHEET & INDEX TO SHEETS		APPROVED / DATE / DRAWING NO. RF-2
			REVISION / DATE / SHEET NO. 1

As Built Dec. 1987

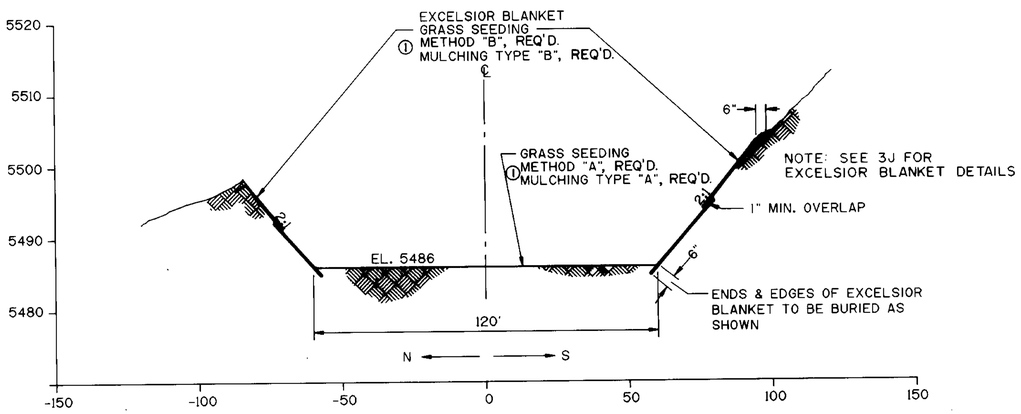
UT006

"AS CONST'D."



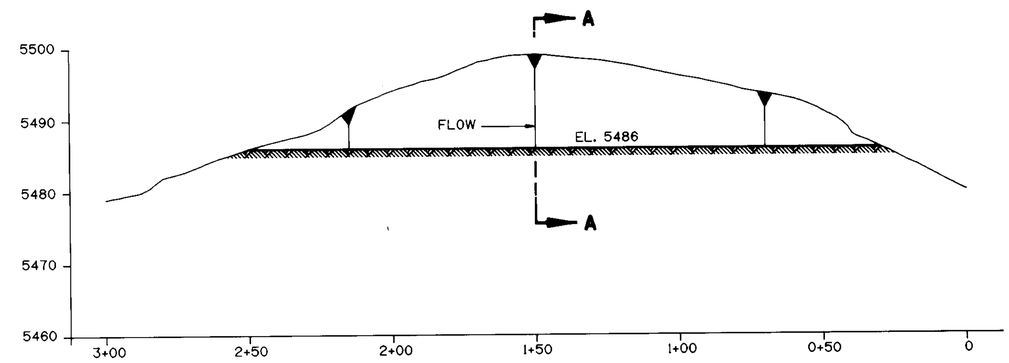
TYPICAL DIKE SECTION

STA. 10+70 TO STA. 16+45



SECTION A-A

STA. 1+50



TYPICAL SECTION

EMERGENCY SPILLWAY
ALONG SPILLWAY ℄

NO.	BY	DATE	TYPE	REMARKS
①	SEL	9/9		ADD "REQ'D"

REVISIONS

PROJECT NUMBER
I-70-1(22)86

DAIRY CANYON
DETENTION BASIN

TYPICAL SECTIONS

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
BBB	KRN	LOB	NONE
APPROVED	DATE	DRAWING NO.	
		RF-2	
REVISION	DATE	SHEET NO.	
		2	

TYPICAL.DGN

Gathers

"AS CONST'D."

SUMMARY OF ITEMS

CODE	ITEM	UNIT	QUANTITY
	DIKE BORROW ZONE I	CU.YD.	~~34,450~~ 33672.59
	DIKE BORROW ZONE II	CU.YD.	~~7,250~~ 7344.07
	LOOSE RIP RAP	CU.YD.	~~180~~ 219.5
	24" REINFORCED CONCRETE PIPE	LN.FT.	208
	CONCRETE CLASS AA(AE) (ESTIMATED QUANTITY 42 CU.YD.)	LUMP	●
	REINFORCING STEEL, EPOXY COATED	LB.	5,300
	TRASHRACK / MANHOLE	LUMP	●
	6' CHAIN LINK FENCE TYPE I	LN.FT.	~~21~~ 22
	BRACED POSTS	EACH	~~3~~
	SEEDING TYPE "A"	ACRE	1
	SEEDING TYPE "B"	ACRE	1
	MULCHING TYPE "A"	ACRE	1
	MULCHING TYPE "B"	ACRE	1
	EXCELSIOR BLANKET	SQ.YD.	1,500
	SUBGRADE PREPARATION	CU.YD.	~~1,000~~ 4769.51
	ROADWAY EXC — KEYWAY	CU.YD.	1457.15
	SMALL DITCH EXC.	CU.YD.	558.62

SUMMARY OF STRUCTURAL ITEMS

ITEM	UNIT	QUANTITY
CONCRETE CLASS AA(AE) (ESTIMATED QUANTITY 42 CU.YD.)	LUMP	●
REINFORCING STEEL, EPOXY COATED	LB.	5,300

EARTHWORK SUMMARY

LANES OR LINE	FROM STATION	TO STATION	BORROW DIKE BORROW ZONE I CUBIC YDS.	BORROW DIKE BORROW ZONE II CUBIC YDS.	COMPACTION FACTOR CUBIC YDS.	ZONE I EMBANKMENT X FACTOR CUBIC YDS.	ZONE II EMBANKMENT X FACTOR CUBIC YDS.		REMARKS
DIKE ℄	10+00	10+80	30	0	1.1	33	0		
DIKE ℄	10+80	11+30	348	0	1.1	383	0		
DIKE ℄	11+30	11+80	1016	72	1.1	1118	79		
DIKE ℄	11+80	12+30	2001	267	1.1	2201	294		
DIKE ℄	12+30	12+80	2770	530	1.1	3047	583		
DIKE ℄	12+80	13+30	3190	758	1.1	3509	834		
DIKE ℄	13+30	13+80	3393	872	1.1	3732	959		
DIKE ℄	13+80	14+30	3530	927	1.1	3883	1020		
DIKE ℄	14+30	14+80	3879	1049	1.1	4267	1154		
DIKE ℄	14+80	15+30	4977	1339	1.1	5475	1473		
DIKE ℄	15+30	15+80	5725	1144	1.1	6298	1258		
DIKE ℄	15+80	16+50	3570	263	1.1	3927	289		
		TOTAL	34,429	7,221		37,873	7,943		
		USE	34,450	7,250					

SEEDING SCHEDULE

SEED No.	NAME BOTANICAL	NAME COMMON	LBS. LIVE SEED PER ACRE METHOD "A"	METHOD "B"
1	AGROPYRON RIPARIUM	SODAR WHEATGRASS	5	10
2	AGROPYRON CRISTATUM	FAIRWAY CRESTED WHEATGRASS	5	10
3	SPOROBOLUS AIROIDES	ALKALI SACATON	5	10
4	MEDICAGO SATIVA	SPREADER II ALFALFA	2	4
		TOTAL POUNDS LIVE SEED PER ACRE	17	34

SEED SUBSTITUTION

SEED No.	SUBST.	NAME BOTANICAL	NAME COMMON	LBS. LIVE SEED PER ACRE METHOD "A"	METHOD "B"
1	A	AGROPYRON SMITHII	WESTERN WHEATGRASS	5	10
2	A	AGROPYRON DESERTORUM	CRESTED WHEATGRASS	5	10
3	A	AGROPYRON DASYSTACHYUM	THICKSPIKE WHEATGRASS	5	10
4	A	MEDICAGO SATIVA	ALFALFA "RAMBLER"	2	4

NOTES:

1. ALL AREAS 3:1 AND FLATTER WITHIN THE EMERGENCY SPILLWAY SEED BY METHOD "A" (DRILL) AND MULCH WITH TYPE "A"
2. ALL AREAS STEEPER THAN 3:1 WITHIN THE EMERGENCY SPILLWAY SEED BY METHOD "B" AND MULCH COMPLETE WITH EXCELSIOR MAT.

MISCELLANEOUS SUMMARY

DESCRIPTION	UNIT	QUANTITY	REMARKS	CONST. SOURCE REFER. BOOK	PAGE
LOOSE RIP RAP	CU.YD.	~~180~~ 213.5	DISSIPATION STRUCTURE & CHANNEL		
24" REINFORCED CONCRETE PIPE	LN.FT.	208			
6' CHAIN LINK FENCE TYPE I	LN.FT.	~~21~~ 22	DISSIPATION STRUCTURE		
BRACED POSTS	EACH	~~3~~ 4	DISSIPATION STRUCTURE		
TRASHRACK / MANHOLE	LUMP	●	OUTLET STRUCTURE		
SEEDING METHOD "A"	ACRE	1	EMERGENCY SPILLWAY		
SEEDING METHOD "B"	ACRE	1	EMERGENCY SPILLWAY		
MULCHING TYPE "A"	ACRE	1	EMERGENCY SPILLWAY		
MULCHING TYPE "B"	ACRE	1	EMERGENCY SPILLWAY		
EXCELSIOR BLANKET	SQ.YD.	1,500	EMERGENCY SPILLWAY		
SUBGRADE PREPARATION	CU.YD.	~~1000~~ 4769.51	BELOW BORROW		

PROJECT NUMBER I-70-K23)36

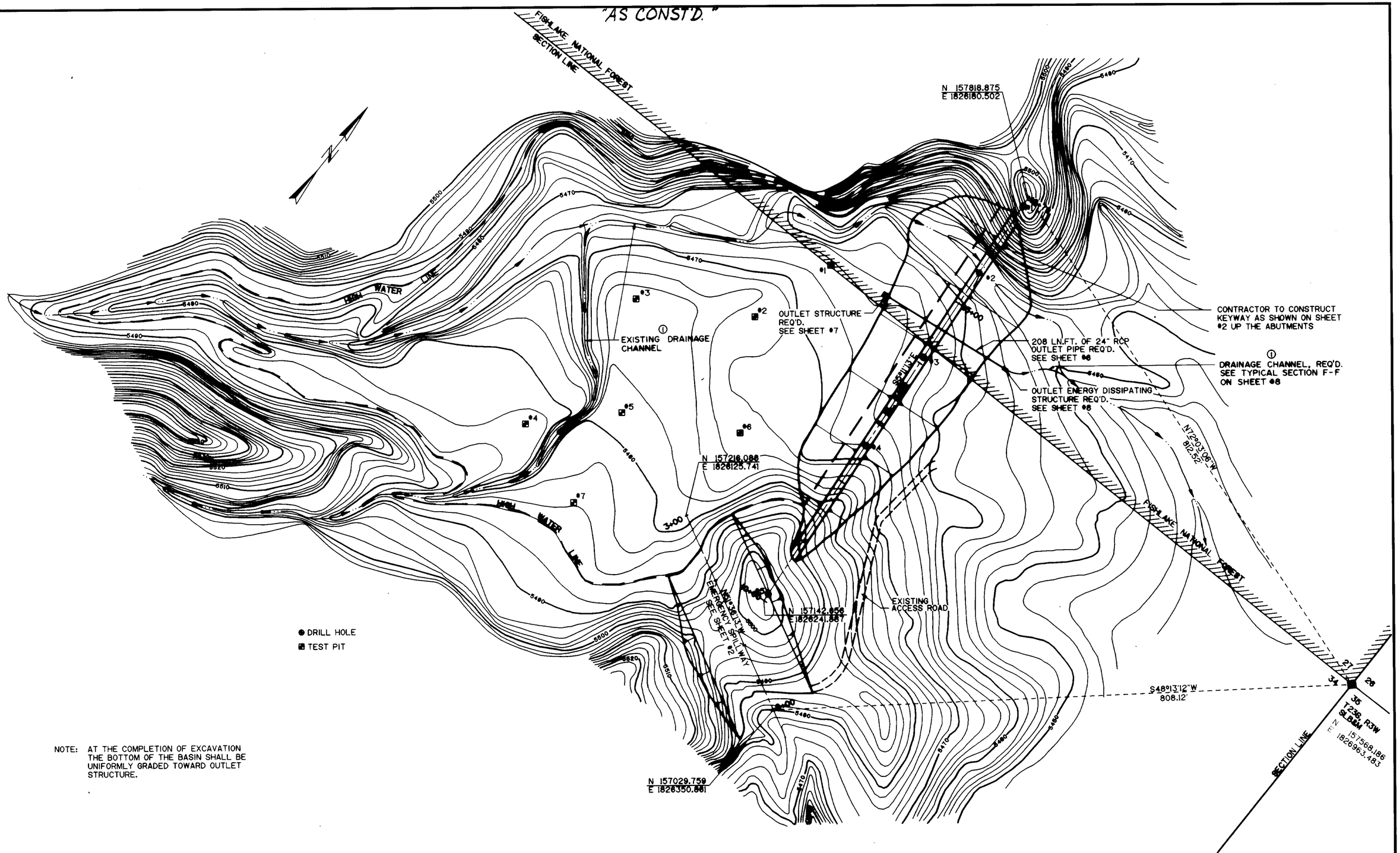
DAIRY CANYON
DETENTION BASIN
SUMMARY SHEET

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
BBB	KRN	AKB	NONE
APPROVED	DATE	DRAWING NO.	RF-2
REVISION	DATE	SHEET NO.	3

Summary

"AS CONST'D."



NOTE: AT THE COMPLETION OF EXCAVATION THE BOTTOM OF THE BASIN SHALL BE UNIFORMLY GRADED TOWARD OUTLET STRUCTURE.

NO.	BY	DATE	TYPE	REMARKS
①	SEL	9/9		ADD EXIST. & NEW DRAIN. CH.

REVISIONS

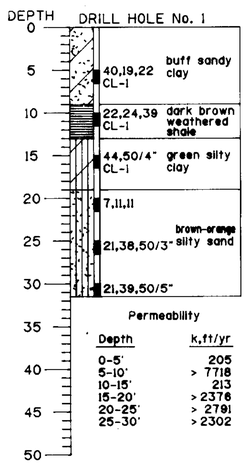
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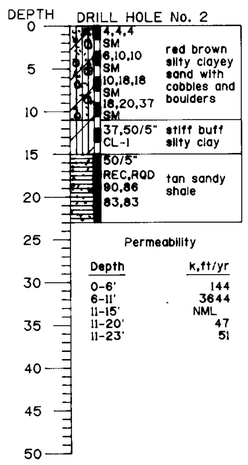
DAIRY CANYON
DETENTION BASIN
PLAN SHEET

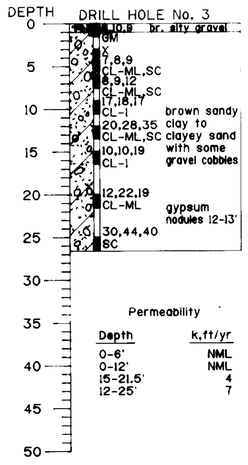
CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

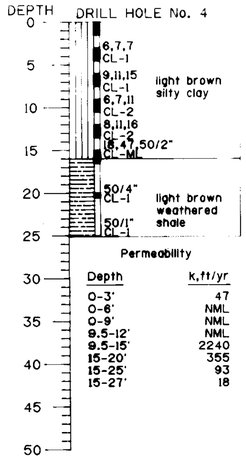
DESIGNED	CHECKED	DRAWN	SCALE
BBB	KRN	LOB	NONE
APPROVED	DATE	DRAWING NO.	RF-2
REVISION	DATE	SHEET NO.	4

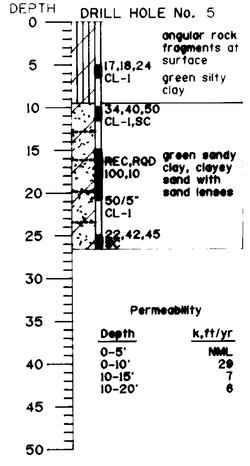
"AS CONST'D."

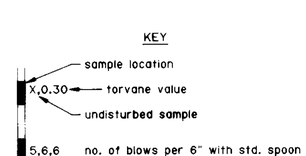


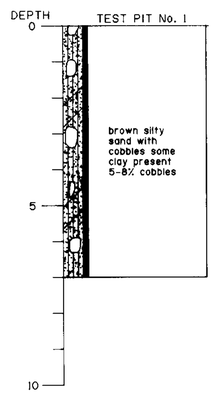


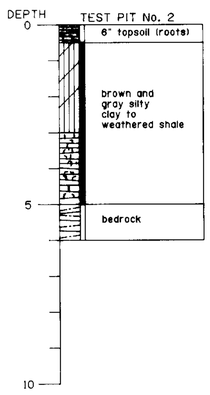


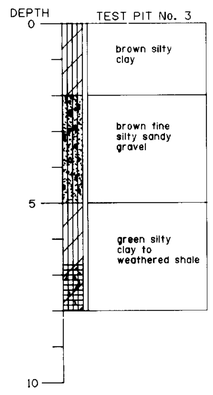


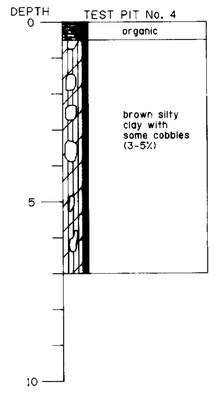


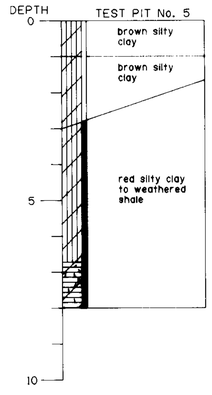


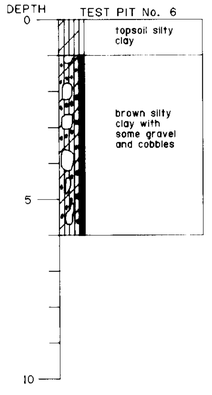


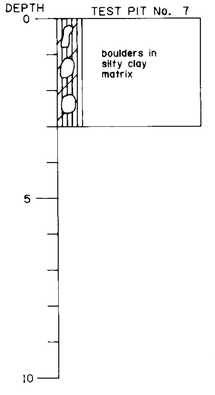












NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM USED TO DESIGNATE SOIL TYPE.

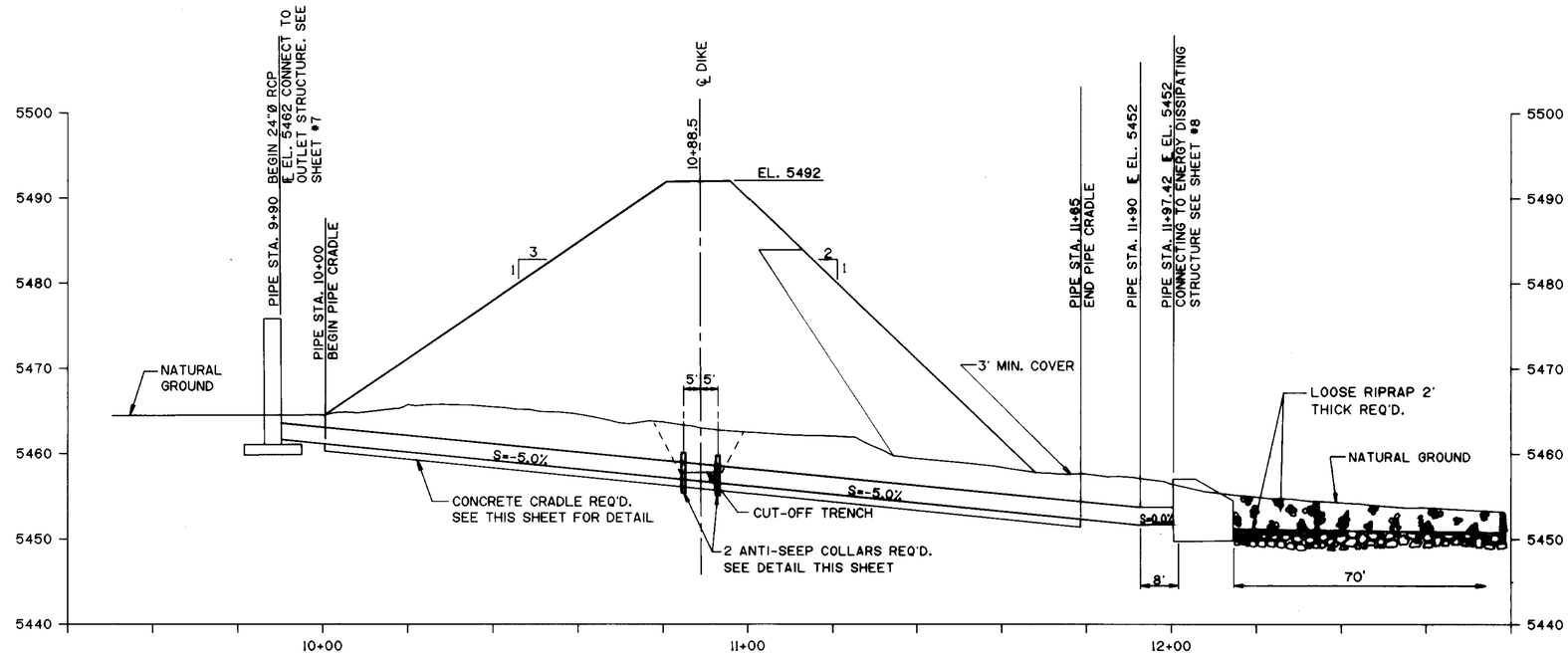
PROJECT NUMBER
I-70-K23(3)6

DAIRY CANYON
DETENTION BASIN
DRILL HOLE & TEST PIT LOGS

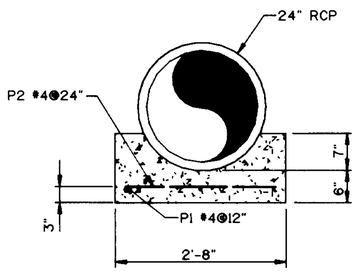
CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
BBB	KRN	LCJ	NONE
APPROVED	DATE	DRAWING NO. RF-2	
REVISION	DATE	SHEET NO. 5	

"AS CONST'D."



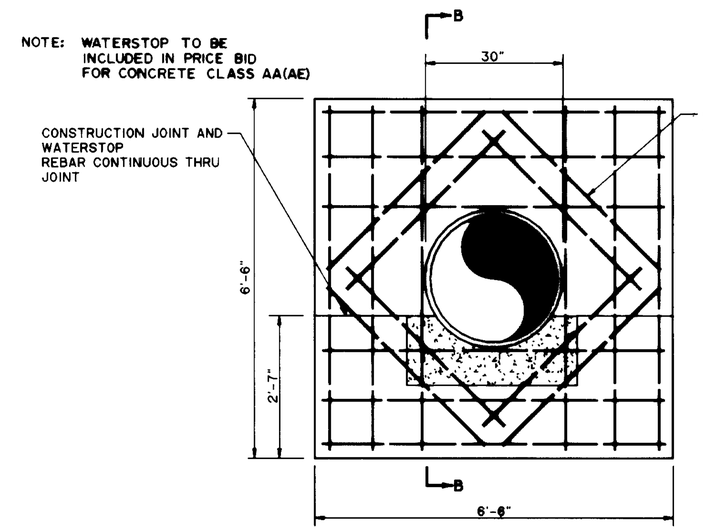
OUTLET PIPING DETAIL



PIPE CRADLE DETAIL

ESTIMATED CONCRETE QUANTITY 12.5 CU.YD.

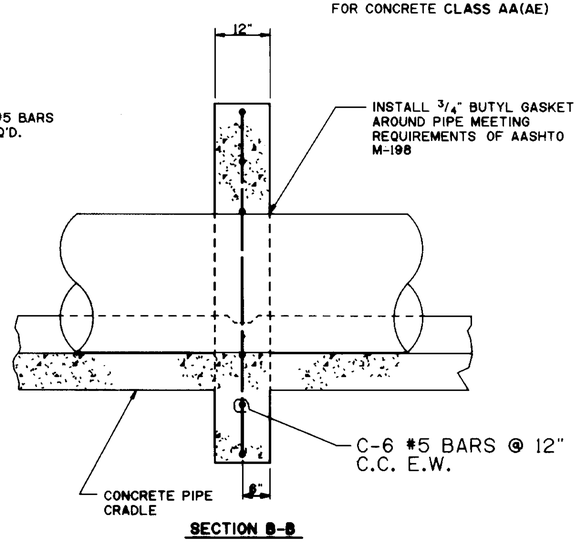
NOTE: WATERSTOP TO BE INCLUDED IN PRICE BID FOR CONCRETE CLASS AA(AE)



ANTI-SEEP COLLAR DETAIL

ESTIMATED CONCRETE QUANTITY 3 CU.YD. (2 REQ'D.)

NOTE: BUTYL GASKET TO BE INCLUDED IN PRICE BID FOR CONCRETE CLASS AA(AE)



SECTION B-B

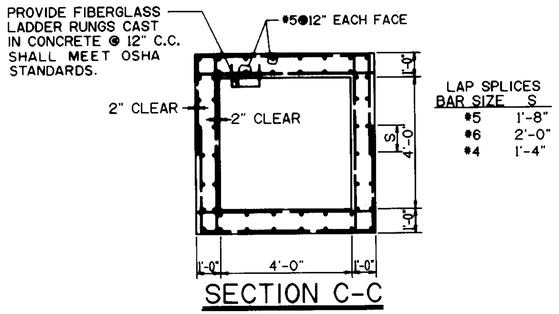
PROJECT NUMBER 1-TO-1328169	**DAIRY CANYON DETENTION BASIN** OUTLET PIPE DETAILS	DESIGNED RRB / APPROVED / REVISION	CHECKED MRM / DATE / DATE
		DRAWN L.C.J. / DRAWING NO. RF-2 / SHEET NO. 6	SCALE NONE

"AS CONST'D."

NOTES:

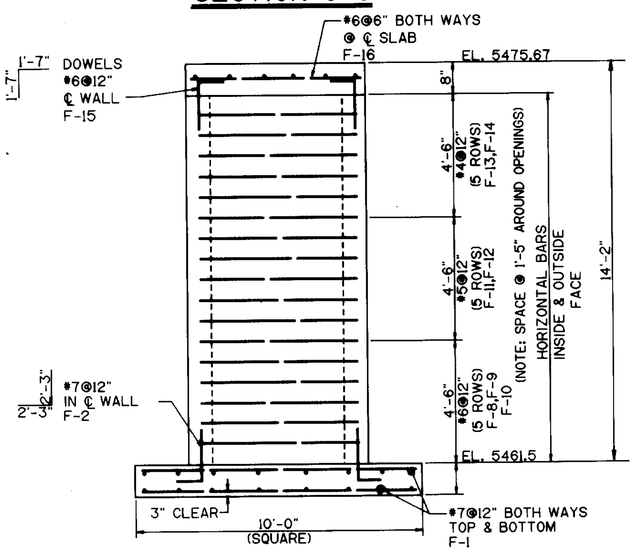
1. GATE CONSTRUCTED AS PER 705.02 OF THE STATE OF UTAH STANDARD SPECIFICATIONS FOR ROAD & BRIDGE CONSTRUCTION EDITION OF 1979 & SUBSEQUENT ADDENDUMS.
2. BUTYL GASKET SHALL BE INCLUDED IN THE PRICE BID FOR 24" RCP.
3. LADDER RUNGS TO BE INCLUDED IN THE PRICE BID FOR CONCRETE CLASS AA(AE).
4. PAINT WELDED JOINTS WITH ONE COAT ZINC CHROMATE PRIMER FOLLOWED WITH A GRAY ENAMEL AS PER 713.02
5. ALL EXPOSED STRUCTURAL STEEL SHALL BE HOT DIP GALVANIZED IN ACCORDANCE WITH ASTM 123.

ESTIMATED CONCRETE QUANTITY - 14.9 CU.YD.

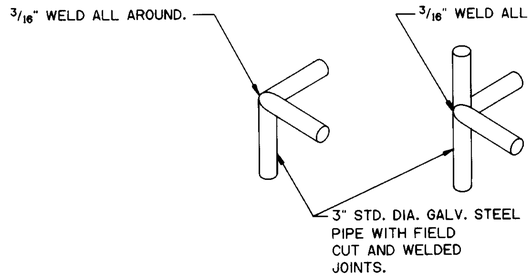


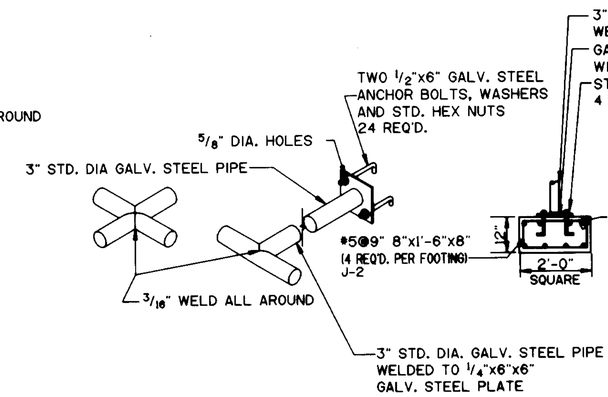
LAP SPLICES	
BAR SIZE	S
#5	1'-8"
#6	2'-0"
#4	1'-4"

SECTION C-C

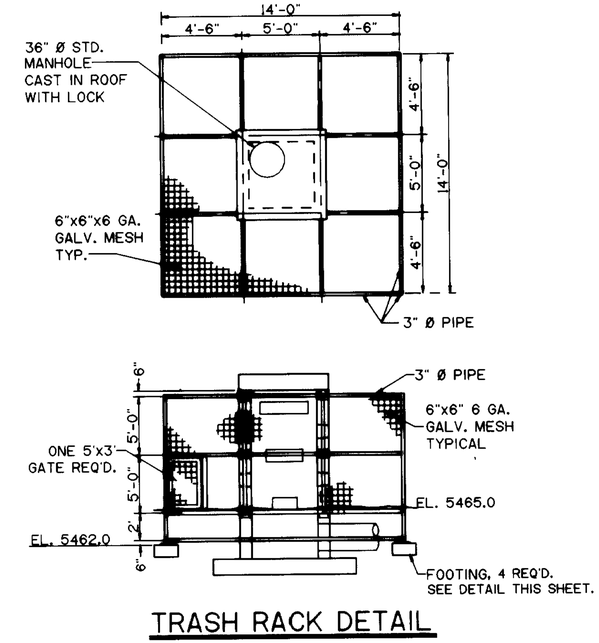


SECTION B-B

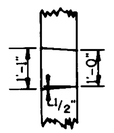




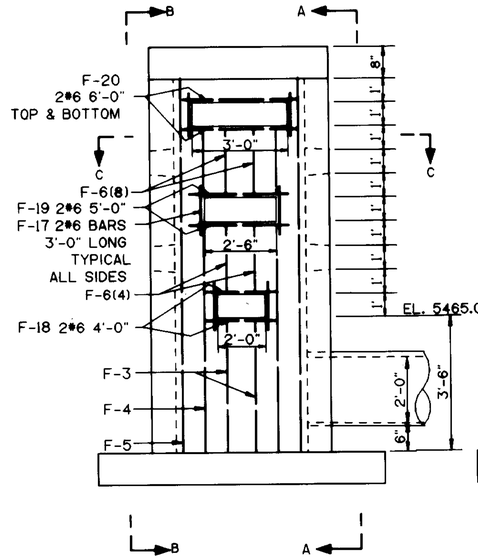
WIRE SUPPORT DETAILS



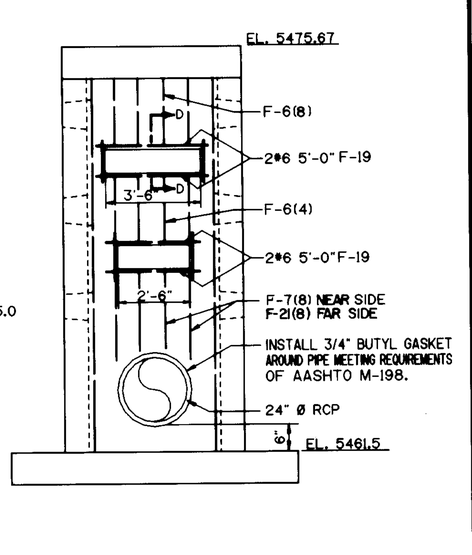
TRASH RACK DETAIL



SECTION D-D



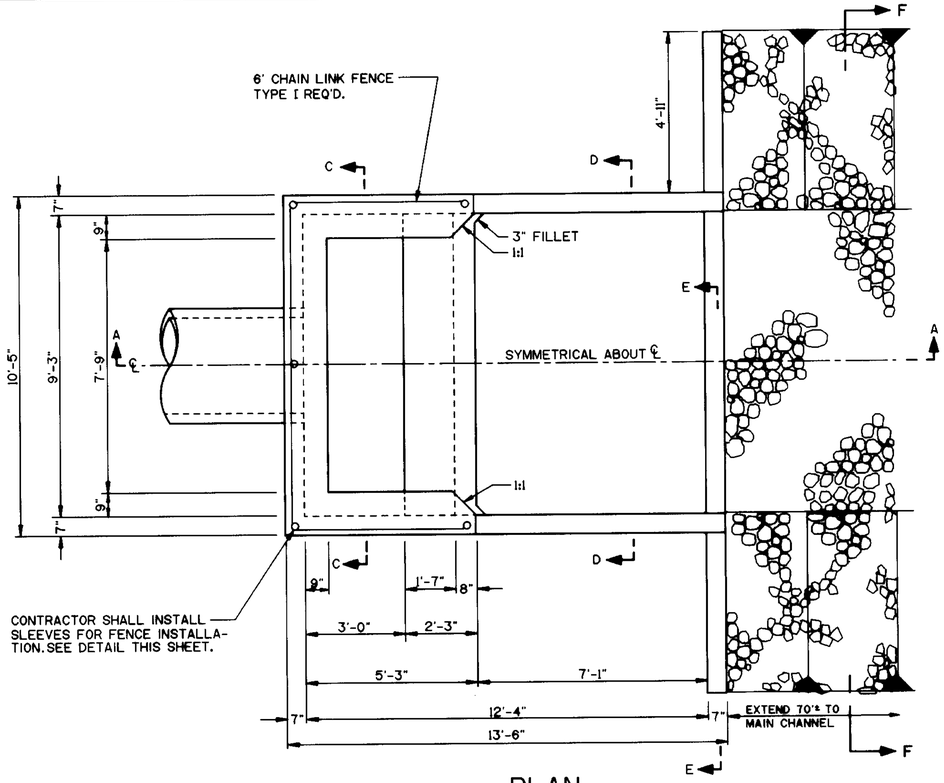
OUTLET STRUCTURE



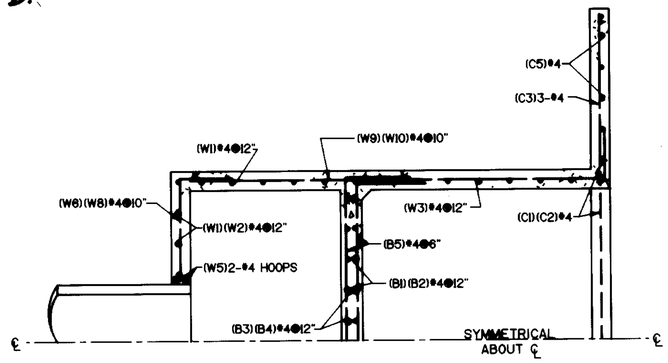
SECTION A-A

PROJECT NUMBER I-70-K23136	DAIRY CANYON DETENTION BASIN OUTLET STRUCTURE	CREAMER & NOBLE, ENGINEERS ST. GEORGE, UTAH	DESIGNED BEG / CHECKED KRN / DRAWN DRL / SCALE NONE APPROVED / DATE / DRAWING NO. RF-2 REVISION / DATE / SHEET NO. 7

"AS CONST'D."

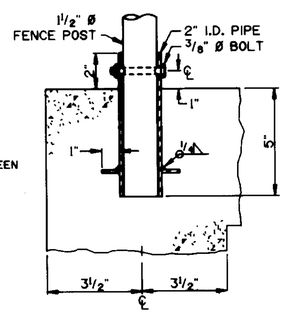


PLAN



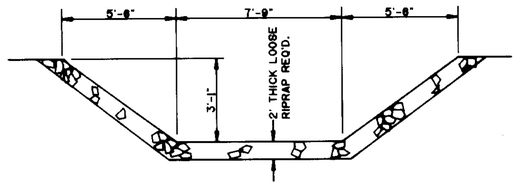
SECTION B-B

NOTE: FENCE SLEEVE TO BE INCLUDED IN BID PRICE FOR 6' CHAIN LINK FENCE TYPE I GROUT BETWEEN POST AND SLEEVE

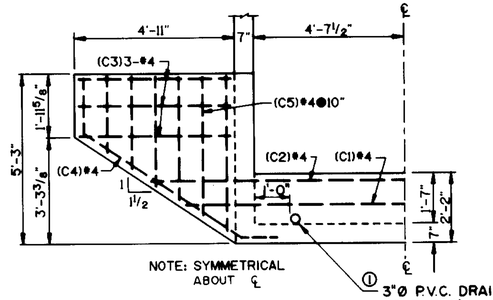


NOTE: ALL EXPOSED METAL WILL BE HOT DIP GALVANIZED IN ACCORDANCE WITH ASTM-123.

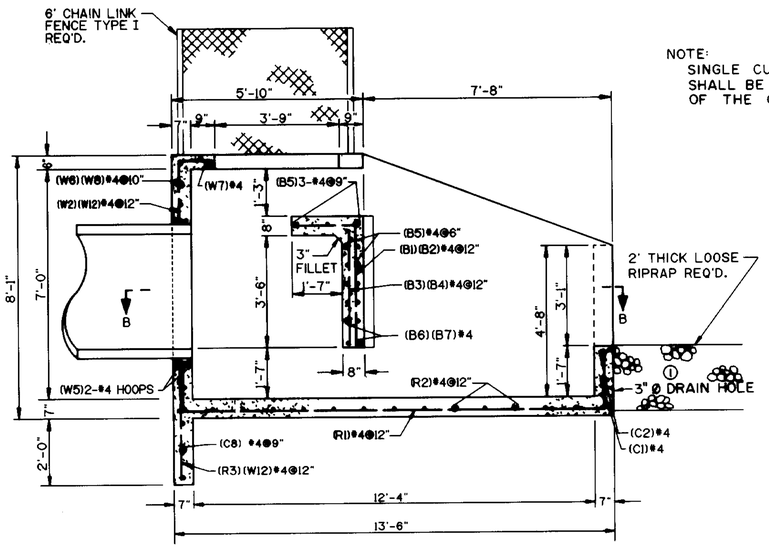
FENCE POST SLEEVE DETAIL



SECTION F-F

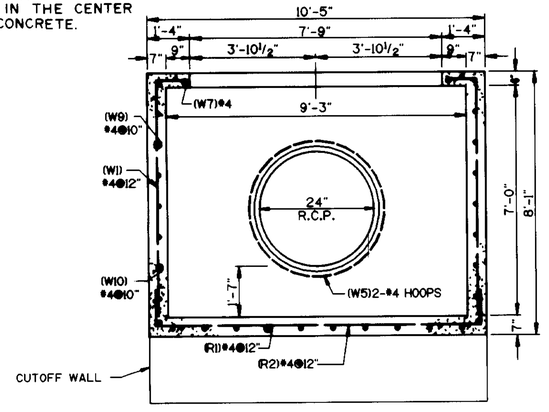


SECTION E-E

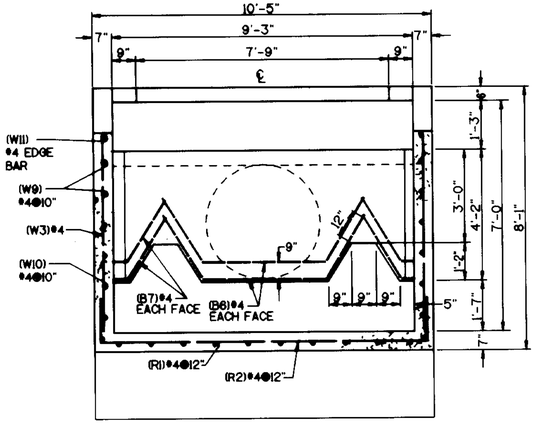


SECTION A-A

NOTE:
SINGLE CURTAIN OF STEEL SHALL BE IN THE CENTER OF THE CONCRETE.



SECTION C-C



SECTION D-D

ESTIMATED QUANTITIES
CONCRETE 11.3 CU.YD.

NO.	BY	DATE	TYPE	REMARKS
①	SEL	9/9		ADD 3"Ø P.V.C. PIPE HOLE

REVISIONS

PROJECT NUMBER I-70-K233(9)8

DAIRY CANYON DETENTION BASIN

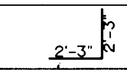
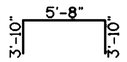
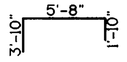
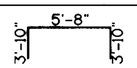
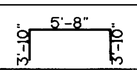
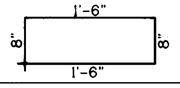
ENERGY DISSIPATING STRUCTURE

DREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

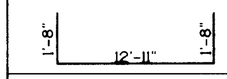
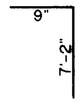
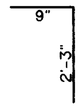
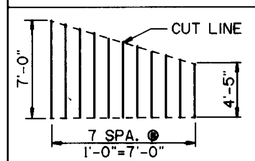
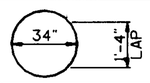
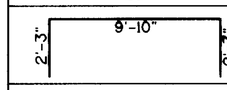
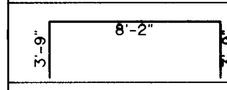
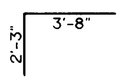
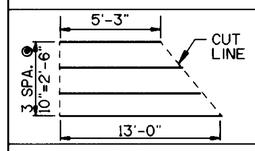
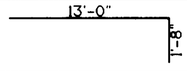
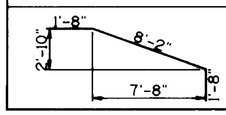
DESIGNED	CHECKED	DRAWN	SCALE
BGB	KRN	LOB	NONE
APPROVED	DATE	DRAWING NO.	
		RF-2	
REVISION	DATE	SHEET NO.	
		8	

"AS CONST'D."

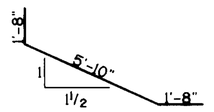
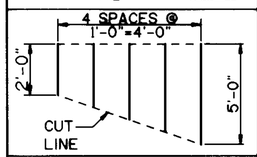
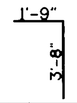
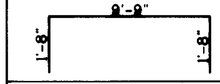
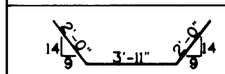
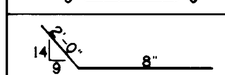
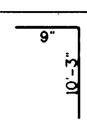
STEEL SCHEDULE
OUTLET STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
STRAIGHT	#7	F-1	9'-6"	FOOTING	44	855
	#7	F-2	4'-6"	FOOTING	22	202
STRAIGHT	#5	F-3	3'-3"	WALL	8	27
STRAIGHT	#5	F-4	7'-3"	WALL	8	60
STRAIGHT	#5	F-5	13'-11"	WALL	8	116
STRAIGHT	#5	F-6	2'-9"	WALL	48	138
STRAIGHT	#5	F-7	2'-6"	WALL	8	21
	#6	F-8	13'-4"	WALL	6	120
	#6	F-9	11'-4"	WALL	4	68
STRAIGHT	#6	F-10	5'-8"	WALL	18	153
	#5	F-11	13'-4"	WALL	10	139
STRAIGHT	#5	F-12	5'-8"	WALL	20	118
	#4	F-13	13'-4"	WALL	10	92
STRAIGHT	#4	F-14	5'-8"	WALL	20	76
	#6	F-15	3'-2"	WALL/ROOF	22	105
STRAIGHT	#6	F-16	5'-6"	ROOF	26	216
STRAIGHT	#6	F-17	3'-0"	WALL	40	180
STRAIGHT	#6	F-18	4'-0"	WALL	48	289
STRAIGHT	#6	F-19	5'-0"	WALL	24	180
STRAIGHT	#6	F-20	5'-8"	WALL	8	68
STRAIGHT	#5	F-21	5'-3"	WALL	8	44
STRAIGHT	#5	J-1	1'-8"	TRASH RACK FOOTING	32	56
	#5	J-2	4'-10"	TRASH RACK FOOTING	16	81
STRAIGHT	#4	P1	40'-0"	PIPE CRADLE	18	482
STRAIGHT	#4	P2	2'-2"	PIPE CRADLE	101	146
STRAIGHT	#5	C6	6'-0"	CUT OFF COLLAR	24	150
STRAIGHT	#5	C7	4'-0"	CUT OFF COLLAR	16	67

STEEL SCHEDULE
OUTLET ENERGY DISIPATING STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
	#4	R1	16'-3"	FLOOR	11	119
	#4	R2	14'-4"	FLOOR	13	124
	#4	W1	7'-11"	WALL	10	53
	#4	W2	3'-0"	WALL	3	6
	#4	W3	45'-8"	WALL	2 SETS	61
NOT USED	-	W4	-	NOT USED	-	-
	#4	W5	10'-4"	WALL	2	14
	#4	W6	14'-4"	WALL	6	57
	#4	W7	15'-8"	ROOF	1	10
	#4	W8	5'-11"	WALL	10	40
	#4	W9	36'-6"	WALL	2 SETS	49
	#4	W10	14'-8"	WALL	14	137
	#4	W11	11'-6"	WALL - EDGE BAR	2	15

STEEL SCHEDULE
OUTLET ENERGY DISIPATING STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
STRAIGHT	#4	C1	12'-7"	WINGWALL	1	8
STRAIGHT	#4	C2	14'-11"	WINGWALL	1	10
STRAIGHT	#4	C3	5'-0"	WINGWALL	6	20
	#4	C4	9'-2"	WINGWALL	2	12
	#4	C5	17'-6"	WINGWALL	2 SETS	23
	#4	B1	5'-5"	BAFFLE	8	30
	#4	B2	4'-3"	BAFFLE	2	6
STRAIGHT	#4	B3	3'-8"	BAFFLE	8	20
STRAIGHT	#4	B4	2'-6"	BAFFLE	2	3
	#4	B5	13'-1"	BAFFLE	11	96
	#4	B6	7'-11	BAFFLE	4	21
	#4	B7	2'-8"	BAFFLE	8	14
	#4	W12		WALL	8	55
STRAIGHT	#4	C8	9'-10"	CUTOFF WALL	3	20
STRAIGHT	#4	R3	3'-8"	CUTOFF WALL	4	10

SUMMARY OF BARS

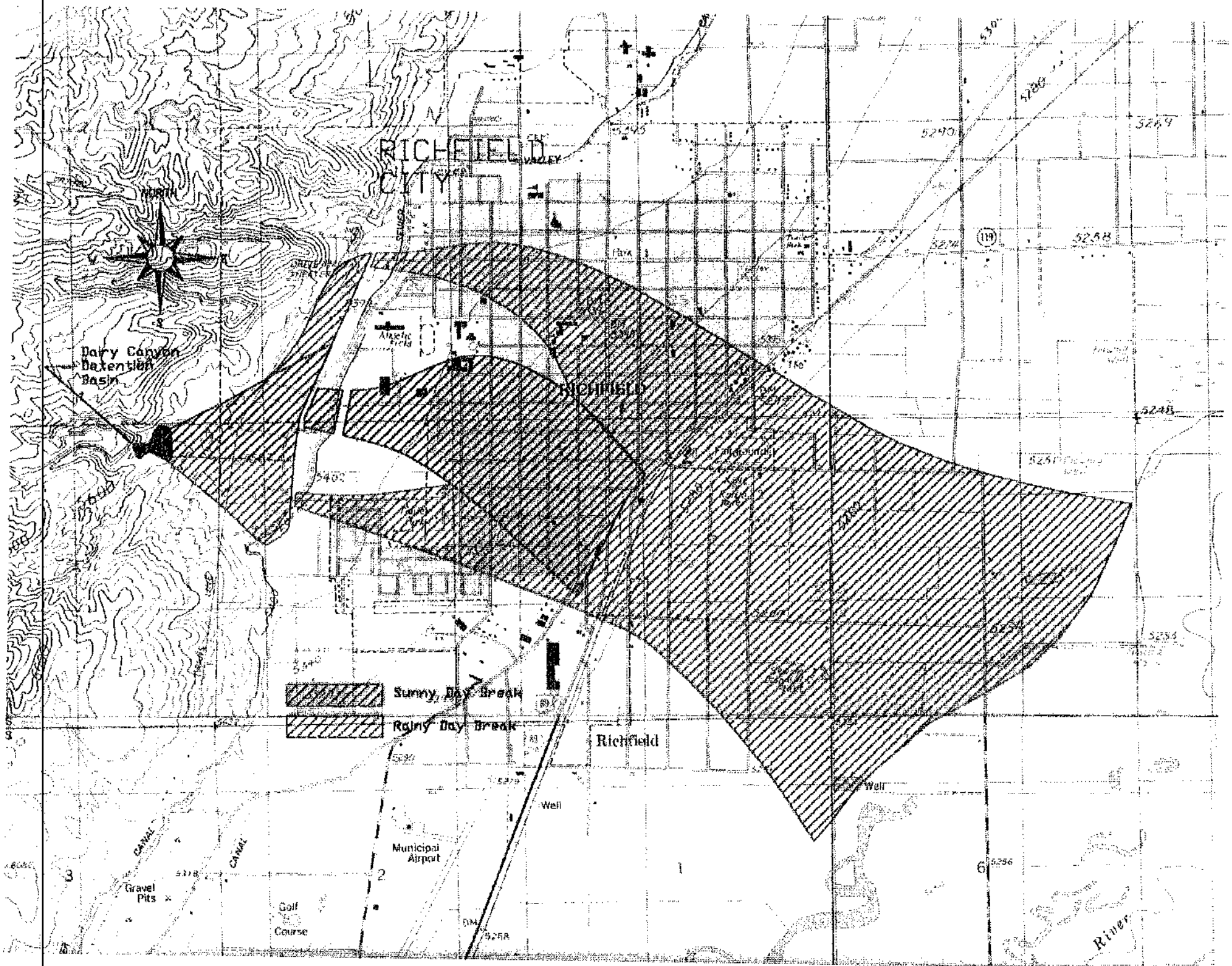
2738 FEET OF #4 BARS @ 0.668 LBS/FT.= 1830
974 FEET OF #5 BARS @ 1.043 LBS/FT.= 1017
917 FEET OF #6 BARS @ 1.502 LBS/FT.= 1378
517 FEET OF #7 BARS @ 2.044 LBS/FT.= 1056

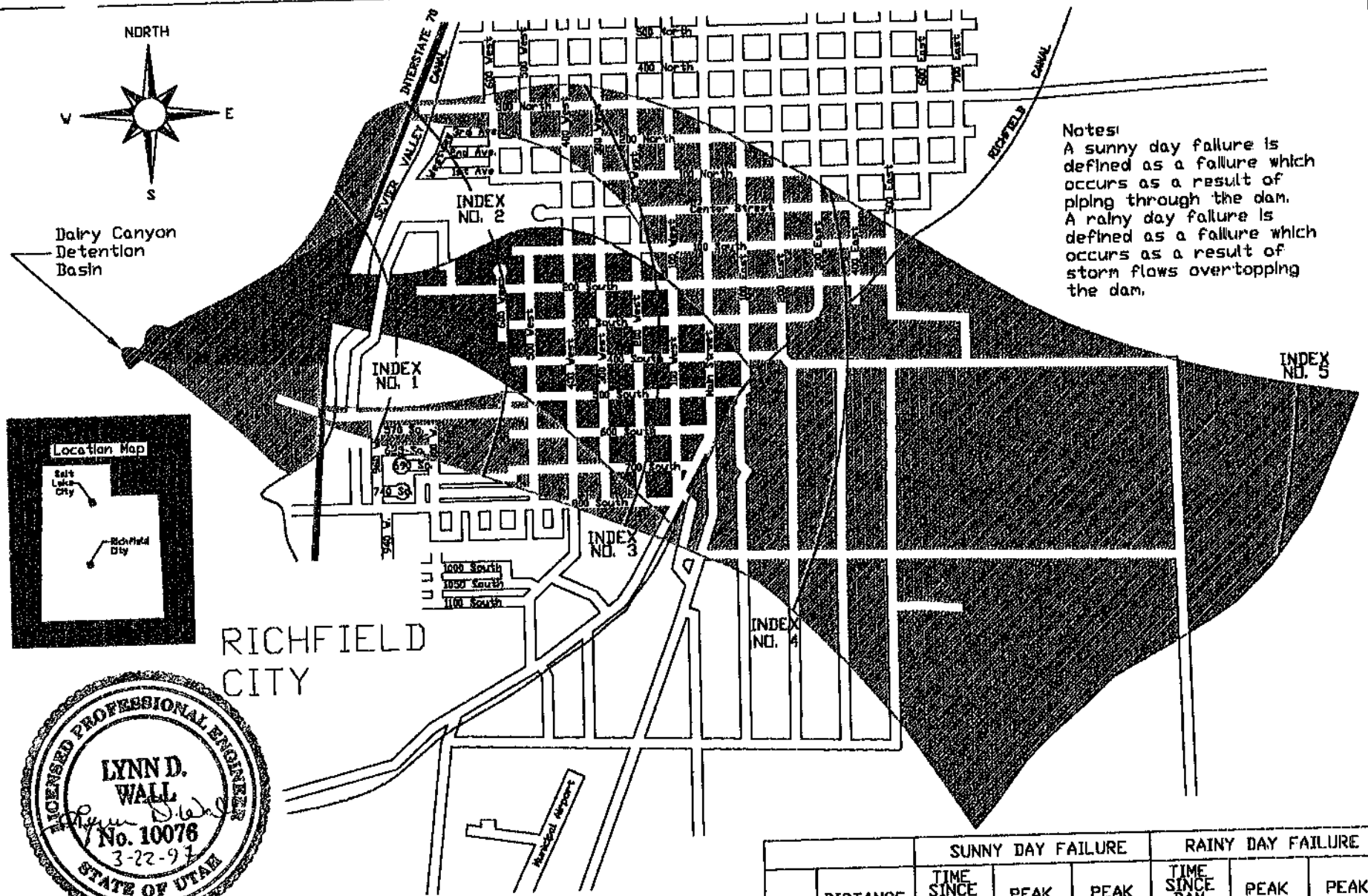
ALL REINFORCING STEEL SHALL BE EPOXY COATED

TOTAL WT. 5281
USE 5300

PROJECT NUMBER I-70-X23(36)	DAIRY CANYON DETENTION BASIN	STEEL SCHEDULE	STREAMER & NEBEKER ENGINEERS, ST. GEORGE, UTAH

DESIGNED BSB	CHECKED KRN	DRAWN AKB	SCALE NONE
APPROVED	DATE	DRAWING NO. RF-2	
REVISION	DATE	SHEET NO. 9	


RICHFIELD
CITY
NORTH
Dairy Canyon
Detention
Basin
Richfield
Sunny Day Break
Rainy Day Break
Richfield
Well
Well
Municipal
Airport
Gravel
Pits
Golf
Course
CANAL
CANAL
River
5240
5248
5256
5268
5272
5280
5288
5296
5304
5312
5320
5328
5336
5344
5352
5360
5368
5376
5384
5392
5400
5408
5416
5424
5432
5440
5448
5456
5464
5472
5480
5488
5496
5504
5512
5520
5528
5536
5544
5552
5560
5568
5576
5584



LICENSED PROFESSIONAL ENGINEER
LYNN D. WALL
No. 10076
3-22-97
STATE OF UTAH

		SUNNY DAY FAILURE			RAINY DAY FAILURE		
INDEX NO.	DISTANCE FROM DAM (MILES)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)
1	0.6	0.43	0.4	1634	0.50	0.7	4678
2	0.9	1.47	0.4	446	1.00	1.0	2488
3	1.3	2.20	0.5	350	1.43	0.9	1955
4	1.8	2.90	0.5	305	1.83	1.0	1678
5	3.0	4.53	0.5	148	3.06	1.0	800

SCALE: NONE

INUNDATION AREAS

SUNNY DAY FAILURE

RAINY DAY FAILURE

DAIRY CANYON DETENTION DAM EMERGENCY ACTION PLAN INUNDATION MAP

Attachment C. USDA Sedimentation Map

- EXPLANATION -

Yield Class	Yield Rate 1/ (Ac.Ft/Sq.Mi/Yr.)	Total Area (Sq.Mi.)
1	> 3.0	____
2	1.0-3.0	____
3	0.5-1.0	____
4	0.2-0.5	____
5	0.1-0.2	____
6	< 0.1	____

▼ 0.45 AVERAGE ANNUAL SUSPENDED SEDIMENT YIELDS DETERMINED FROM SEDIMENT TRANSPORT RECORDS. RATES ARE IN Ac.Ft/Sq.Mi/Yr.

80 - 20 ECT. (PERCENT OF SHEET AND RILL EROSION - PERCENT OF CHANNEL AND GULLY EROSION.

Subregion Number	Subregions
4	SNAKE
1	BEAR LAKE
1	GREAT SALT LAKE
1	SEVIER LAKE
2	GREEN RIVER
2	SAN JUAN - COLORADO
3	UPPER MAIN STEM
3	LOWER MAIN STEM

1/ DO NOT USE THESE RATES TO DETERMINE SEDIMENT YIELDS AT SPECIFIC SITES. LARGE VARIATIONS IN SEDIMENT RATES MAY OCCUR WITHIN THE DELINEATED AREAS.

SOURCES OF INFORMATION

1. GREAT BASIN, UPPER COLORADO AND LOWER COLORADO REGIONS, COMPREHENSIVE FRAMEWORK STUDY, APPENDICES VIII, WATERSHED MANAGEMENT, JUNE 1971, PACIFIC SOUTHWEST INTER-AGENCY COMMITTEE/WATER RESOURCES COUNCIL.
2. UTAH STATE SOILS MAP AND SOILS DESCRIPTIONS.
3. RESERVOIR SURVEYS BY SCS & USBR
4. SUSPENDED LOAD MEASUREMENTS BY USGS, USBR & SCS.
5. WATERSHED STUDIES BY SCS.
6. GENERAL KNOWLEDGE OF THE STATE FROM REGULAR SCS PROGRAM WORK.

ESTIMATED SEDIMENT YIELD RATES FOR THE STATE OF UTAH

EROSION & SEDIMENTATION -70
WESTERN U.S. WATER PLAN
AUGUST 1973
(SUBJECT TO REVISION)
prepared by
U.S.D.A., Soil Conservation Service
Geologist, Bob L. Bridges

10 5 0 5 10 15
scale in miles

Attachment D. PSAIC Model Output

Pacific Southwest Interagency Committee Sediment Yield Procedure (PSIAC) - Cottonwood Canyon

Watershed:	Westwd EWP	**Square Miles:**	21	**Acres (sq mi * 640):**	13,248
Factor	**Discipline**	**PSIAC Rating**			**Points**
(a) Surface Geology	Geologist	Marine shales and related mudstones and siltstones	Rocks of Medium Hardness Moderately weathered Moderately fractured	Massive, hard formations	
		5	3	0	3
(b) Soils	Soil Scientist	Fine textured; easily dispersed; saline alkaline; high shrink swell characteristcis; single grain silt and fine sands	Medium textured soil	High percentage of rock fragments	
		Single grain silt and fine sands	Occasional rock fragements Cliché layers	Aggregated clays High in organic matter	
		10	5	0	3
(c) Climate	Local	Storms of several day's duration with short periods of intense rainfall	Storms of moderate duration and intensity	Humid climate with rainfall of low intensity	
		Frequent intense convective storms	Infrequent convective storms	Precipitation in form of snow	
		Freeze-thaw occurrences		Arid climate, low intensity storm Arid climate; rare convective storms	
		10	5	0	4
(d) Runoff	Hydrologist	High peak flows per unit area	Moderate peak flows per unit area	Low peak flow per unit area	
		Large volume of flow per unit area	Moderate volume of flow per unit area	Low volume of runoff per unit area	
				Rare runoff events	
		10	5	0	5
(e) Topography	GIS Specialist	Steep upland slopes (in excess of 30%)	Moderate upland slopes (less than 20%)	Gentle upland slopes (less than 5%)	
		High relief; little or no floodplain development	Moderate fan or floodplain development	Extensive alluvial plains	
		10	5	0	10
(f) Effective Ground Cover	GIS Specialist	Ground cover does not exceed 20%	Cover not exceeding 40%	Area completely protected by vegetation, rock fragments, litter	
		Vegetation sparse; little or no litter	Noticeable litter		
		No rock in surface soil cover	If trees present, understory not well developed	Little opportunity for rainfall to reach erodible material	
		10	0	-10	-7
	Alternative Calculation	Alternative Calculation: Enter percent of surface covered by vegetation, litter and rock		Vegetation (%) Litter (%) Rock (%) Calculated Points	35 30 16 -7
(g) Land Type and Management Quality	GIS Specialist	Almost all of area overgrazed or historic overgrazing impacts still active	<50% of area overgrazed or with historic overgrazing impacts still active	No recent logging	
		All of area recently burned	<50% of area recently logged	Good grazing management or historic overgrazing impact under control	
		Roads in need of O&M or improved design	Ordinary road and other construction		
		Almost all of area is badlands with minimal armor	Almost all of area is badlands with 50% of area covered with armor	Badlands are totally armored	
		10	0	-10	-9
(h) Upland Erosion	Geologist	More than 50% of the area characterized by concentrated flow erosion with increasing gully development	About 25% of the area characterized by concentrated flow erosion with increasing gully development	No apparent signs of erosion	
		25	10	0	6
	Alternative Calculation	Percent of area with apparent erosion			22
				Calculated Points	10
(i) Channel Erosion and Sediment Transport	Geologist	Eroding banks, continously or at frequent intervals, with deep flow of long duration	Moderate flow depths, medium flow duration with occasionally eroding banks or bed	Wide shallow channels with flat gradients and shor flow duration	
		Active headcuts and degradation in tributary channels		Channels in massive rock, large boulders, or well vegetated Articially controlled channels	
		25	10	0	5

		Subtotal (a) thru (g)	9
		Subtotal (h) thru (i)	11
		Grand total	20
		Soil Bulk Density (gram/cm3)	NA
Watershed:	Westwd EWP	**Sediment Yield (Ac ft/sq mi/year)**	0.17
Acres:	13,248	**Sediment Yield (Tons/acre/year)**	0.52
		Total Sediment (Tons/year)	6,908

Pacific Southwest Interagency Committee Sediment Yield Procedure (PSIAC) - Dairy Canyon

Watershed:	Westwd EWP	**Square Miles:**	2	**Acres (sq mi * 640):**	1,216
Factor	**Discipline**	**PSIAC Rating**			**Points**
(a) Surface Geology	Geologist	Marine shales and related mudstones and siltstones	Rocks of Medium Hardness Moderately weathered Moderately fractured	Massive, hard formations	
		5	3	0	4
(b) Soils	Soil Scientist	Fine textured; easily dispersed; saline alkaline; high shrink swell characteristcis; single grain silt and fine sands	Medium textured soil	High percentage of rock fragments	
		Single grain silt and fine sands	Occasional rock fragements Cliché layers	Aggregated clays High in organic matter	
		10	5	0	8
(c) Climate	Local	Storms of several day's duration with short periods of intense rainfall	Storms of moderate duration and intensity	Humid climate with rainfall of low intensity	
		Frequent intense convective storms	Infrequent convective storms	Precipitation in form of snow	
		Freeze-thaw occurrences		Arid climate, low intensity storm Arid climate; rare convective storms	
		10	5	0	4
(d) Runoff	Hydrologist	High peak flows per unit area	Moderate peak flows per unit area	Low peak flow per unit area	
		Large volume of flow per unit area	Moderate volume of flow per unit area	Low volume of runoff per unit area	
				Rare runoff events	
		10	5	0	5
(e) Topography	GIS Specialist	Steep upland slopes (in excess of 30%)	Moderate upland slopes (less than 20%)	Gentle upland slopes (less than 5%)	
		High relief; little or no floodplain development	Moderate fan or floodplain development	Extensive alluvial plains	
		10	5	0	10
(f) Effective Ground Cover	GIS Specialist	Ground cover does not exceed 20%	Cover not exceeding 40%	Area completely protected by vegetation, rock fragments, litter	
		Vegetation sparse; little or no litter	Noticeable litter		
		No rock in surface soil cover	If trees present, understory not well developed	Little opportunity for rainfall to reach erodible material	
		10	0	-10	-7
	Alternative Calculation	Alternative Calculation: Enter percent of surface covered by vegetation, litter and rock		Vegetation (%) Litter (%) Rock (%) Calculated Points	35 30 16 -7
(g) Land Type and Management Quality	GIS Specialist	Almost all of area overgrazed or historic overgrazing impacts still active	<50% of area overgrazed or with historic overgrazing impacts still active	No recent logging	
		All of area recently burned	<50% of area recently logged	Good grazing management or historic overgrazing impact under control	
		Roads in need of O&M or improved design	Ordinary road and other construction		
		Almost all of area is badlands with minimal armor	Almost all of area is badlands with 50% of area covered with armor	Badlands are totally armored	
		10	0	-10	-9
(h) Upland Erosion	Geologist	More than 50% of the area characterized by concentrated flow erosion with increasing gully development	About 25% of the area characterized by concentrated flow erosion with increasing gully development	No apparent signs of erosion	
		25	10	0	20
	Alternative Calculation	Percent of area with apparent erosion			35
				Calculated Points	16
(i) Channel Erosion and Sediment Transport	Geologist	Eroding banks, continously or at frequent intervals, with deep flow of long duration	Moderate flow depths, medium flow duration with occasionally eroding banks or bed	Wide shallow channels with flat gradients and shor flow duration	
		Active headcuts and degradation in tributary channels		Channels in massive rock, large boulders, or well vegetated Articially controlled channels	
		25	10	0	7
				Subtotal (a) thru (g)	15
				Subtotal (h) thru (i)	27
				Grand total	42
				Soil Bulk Density (gram/cm3)	NA
		Watershed:	Westwd EWP	**Sediment Yield (Ac ft/sq mi/year)**	0.37
		Acres:	1,216	**Sediment Yield (Tons/acre/year)**	0.52
				Total Sediment (Tons/year)	634

Pacific Southwest Interagency Committee Sediment Yield Procedure (PSIAC) - Flat Canyon

Watershed:	Westwd EWP	**Square Miles:**	16	**Acres (sq mi * 640):**	10,496
Factor	**Discipline**	**PSIAC Rating**			**Points**
(a) Surface Geology	Geologist	Marine shales and related mudstones and siltstones	Rocks of Medium Hardness Moderately weathered Moderately fractured	Massive, hard formations	
		5	3	0	3
(b) Soils	Soil Scientist	Fine textured; easily dispersed; saline alkaline; high shrink swell characteristcis; single grain silt and fine sands	Medium textured soil	High percentage of rock fragments	
		Single grain silt and fine sands	Occasional rock fragements Cliché layers	Aggregated clays High in organic matter	
		10	5	0	3
(c) Climate	Local	Storms of several day's duration with short periods of intense rainfall	Storms of moderate duration and intensity	Humid climate with rainfall of low intensity	
		Frequent intense convective storms	Infrequent convective storms	Precipitation in form of snow	
		Freeze-thaw occurrences		Arid climate, low intensity storm Arid climate; rare convective storms	
		10	5	0	4
(d) Runoff	Hydrologist	High peak flows per unit area	Moderate peak flows per unit area	Low peak flow per unit area	
		Large volume of flow per unit area	Moderate volume of flow per unit area	Low volume of runoff per unit area	
				Rare runoff events	
		10	5	0	5
(e) Topography	GIS Specialist	Steep upland slopes (in excess of 30%)	Moderate upland slopes (less than 20%)	Gentle upland slopes (less than 5%)	
		High relief; little or no floodplain development	Moderate fan or floodplain development	Extensive alluvial plains	
		10	5	0	10
(f) Effective Ground Cover	GIS Specialist	Ground cover does not exceed 20%	Cover not exceeding 40%	Area completely protected by vegetation, rock fragments, litter	
		Vegetation sparse; little or no litter	Noticeable litter		
		No rock in surface soil cover	If trees present, understory not well developed	Little opportunity for rainfall to reach erodible material	
		10	0	-10	-7
	Alternative Calculation	Alternative Calculation: Enter percent of surface covered by vegetation, litter and rock		Vegetation (%) Litter (%) Rock (%) Calculated Points	33 29 16 -7
(g) Land Type and Management Quality	GIS Specialist	Almost all of area overgrazed or historic overgrazing impacts still active	<50% of area overgrazed or with historic overgrazing impacts still active	No recent logging	
		All of area recently burned	<50% of area recently logged	Good grazing management or historic overgrazing impact under control	
		Roads in need of O&M or improved design	Ordinary road and other construction		
		Almost all of area is badlands with minimal armor	Almost all of area is badlands with 50% of area covered with armor	Badlands are totally armored	
		10	0	-10	-7
(h) Upland Erosion	Geologist	More than 50% of the area characterized by concentrated flow erosion with increasing gully development	About 25% of the area characterized by concentrated flow erosion with increasing gully development	No apparent signs of erosion	
		25	10	0	10
	Alternative Calculation	Percent of area with apparent erosion			35
				Calculated Points	16
(i) Channel Erosion and Sediment Transport	Geologist	Eroding banks, continously or at frequent intervals, with deep flow of long duration	Moderate flow depths, medium flow duration with occasionally eroding banks or bed	Wide shallow channels with flat gradients and shor flow duration	
		Active headcuts and degradation in tributary channels		Channels in massive rock, large boulders, or well vegetated Articially controlled channels	
		25	10	0	5

		Subtotal (a) thru (g)	11
		Subtotal (h) thru (i)	15
		Grand total	26
		Soil Bulk Density (gram/cm3)	NA
Watershed:	Westwd EWP	**Sediment Yield (Ac ft/sq mi/year)**	0.21
Acres:	10,496	**Sediment Yield (Tons/acre/year)**	0.52
		Total Sediment (Tons/year)	5,473

Pacific Southwest Interagency Committee Sediment Yield Procedure (PSIAC) - Wood Canyon

Watershed:	Westwd EWP	**Square Miles:**	3	**Acres (sq mi * 640):**	1,856
Factor	**Discipline**	**PSIAC Rating**			**Points**
(a) Surface Geology	Geologist	Marine shales and related mudstones and siltstones	Rocks of Medium Hardness Moderately weathered Moderately fractured	Massive, hard formations	
		5	3	0	3
(b) Soils	Soil Scientist	Fine textured; easily dispersed; saline alkaline; high shrink swell characteristcis; single grain silt and fine sands	Medium textured soil	High percentage of rock fragments	
		Single grain silt and fine sands	Occasional rock fragements Cliché layers	Aggregated clays High in organic matter	
		10	5	0	2
(c) Climate	Local	Storms of several day's duration with short periods of intense rainfall	Storms of moderate duration and intensity	Humid climate with rainfall of low intensity	
		Frequent intense convective storms	Infrequent convective storms	Precipitation in form of snow	
		Freeze-thaw occurrences		Arid climate, low intensity storm Arid climate; rare convective storms	
		10	5	0	4
(d) Runoff	Hydrologist	High peak flows per unit area	Moderate peak flows per unit area	Low peak flow per unit area	
		Large volume of flow per unit area	Moderate volume of flow per unit area	Low volume of runoff per unit area	
				Rare runoff events	
		10	5	0	5
(e) Topography	GIS Specialist	Steep upland slopes (in excess of 30%)	Moderate upland slopes (less than 20%)	Gentle upland slopes (less than 5%)	
		High relief; little or no floodplain development	Moderate fan or floodplain development	Extensive alluvial plains	
		10	5	0	7
(f) Effective Ground Cover	GIS Specialist	Ground cover does not exceed 20%	Cover not exceeding 40%	Area completely protected by vegetation, rock fragments, litter	
		Vegetation sparse; little or no litter	Noticeable litter		
		No rock in surface soil cover	If trees present, understory not well developed	Little opportunity for rainfall to reach erodible material	
		10	0	-10	-5
	Alternative Calculation	Alternative Calculation: Enter percent of surface covered by vegetation, litter and rock		Vegetation (%) Litter (%) Rock (%) Calculated Points	25 29 14 -5
(g) Land Type and Management Quality	GIS Specialist	Almost all of area overgrazed or historic overgrazing impacts still active	<50% of area overgrazed or with historic overgrazing impacts still active	No recent logging	
		All of area recently burned	<50% of area recently logged	Good grazing management or historic overgrazing impact under control	
		Roads in need of O&M or improved design	Ordinary road and other construction		
		Almost all of area is badlands with minimal armor	Almost all of area is badlands with 50% of area covered with armor	Badlands are totally armored	
		10	0	-10	-9
(h) Upland Erosion	Geologist	More than 50% of the area characterized by concentrated flow erosion with increasing gully development	About 25% of the area characterized by concentrated flow erosion with increasing gully development	No apparent signs of erosion	
		25	10	0	5
	Alternative Calculation	Percent of area with apparent erosion			35
				Calculated Points	16
(i) Channel Erosion and Sediment Transport	Geologist	Eroding banks, continously or at frequent intervals, with deep flow of long duration	Moderate flow depths, medium flow duration with occasionally eroding banks or bed	Wide shallow channels with flat gradients and shor flow duration	
		Active headcuts and degradation in tributary channels		Channels in massive rock, large boulders, or well vegetated Articially controlled channels	
		25	10	0	5
				Subtotal (a) thru (g)	7
				Subtotal (h) thru (i)	10
				Grand total	17
				Soil Bulk Density (gram/cm3)	NA
		Watershed:	Westwd EWP	**Sediment Yield (Ac ft/sq mi/year)**	0.15
		Acres:	1,856	**Sediment Yield (Tons/acre/year)**	0.52
				Total Sediment (Tons/year)	968

TM004 – Hydraulics

Table of Contents

1.0 Flood Modeling 1
1.1 Hydraulic Model Setup 1
1.2 Modeling Scenarios 4
2.0 Flood Channel Analysis 5
2.1 Existing South Flood Channel Evaluation 5
2.2 South Flood Channel Proposed Measures 5
2.3 North Flood Channel Existing Condition 7
2.4 North Flood Channel Proposed Measures 8
3.0 References 11

Attachments

Attachment A. Historical Flood Maps
Attachment B. Flat Canyon Flood Inundation Maps
Attachment C. Hydraulic Analysis Support Information

Figures

Figure 1-1. Flat Canyon 2D Flow Mesh and Boundary Conditions 2
Figure 2-1. South Flood Channel Hydraulic Gradeline Profile 7
Figure 2-3. Eroded Banks on the North Flood Channel 8
Figure 2-4. North Flood Channel Hydraulic Gradeline Profile 10

Tables

Table 1-1. Computation Mesh Gride Size for Each Scenario 2
Table 1-2. Model Boundary Conditions 2
Table 1-3. Model Boundary Conditions 3
Table 2-1. South Flood Channel Pipeline Design Information. 6
Table 2-2. North Flood Channel Pipeline Design Information 9

1.0 Flood Modeling

A hydraulic analysis was performed to complete flood modeling to support the economic analysis and determine existing and proposed flood channel capacities.

Richfield has a long history of flooding; flood damage dates back to when the town was first settled (Schick International 1977, Bakaitis 2016). These studies document repeated floods in and around Richfield City back to 1950. More recent flood events have been documented by county emergency and road department personnel. These include 2014, 2016, and 2018 events. Attachment A shows a map of locations where historic flooding has occurred. Storm events have consistently revealed several infrastructure limitations:

- The watersheds west of Richfield produce large sediment-laden flows that drain directly into the Sevier Valley and Richfield canals. The canals are not designed to handle such flows and have breached in the past, impacting downstream properties.
- The canals convey flows through Richfield City and other populated areas of Sevier County, resulting in high flood damage and amplified risk.
- Agricultural lands are also impacted when storm flows overtop canals or where overshot structures convey flow directly onto these properties.

Local and county leaders provided additional information on frequent flooding locations. Measured flood data was not available for these events; therefore, this data could not be used to calibrate the hydraulic model. However, the results of the flood modeling closely simulated the general flooding areas of historic events.

1.1 Hydraulic Model Setup

The U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System (HEC-RAS 5.0.6) was used to create a combined one-dimensional (1D) and two-dimensional (2D) model to simulate flooding in Richfield and the surrounding area. This combined 1D\2D model can perform hydrodynamic routing within an unsteady flow analysis. The Sevier Valley Canal and Richfield Canal, which have historically overtopped and contributed to flooding, were modeled using the 1D unsteady-state flow portions of the model. These canals were then breached at critical locations. The breached flows were modeled using the 2D unsteady-state flow portions of the model.

1.1.1 Terrain Data

The surface used to build the model was derived from 2018 LiDAR data with a 1-meter resolution. The LiDAR data was downloaded from the Utah Automated Geographic Reference Center (AGRC) and processed using ESRI's ArcGIS software. The surface covers the entire project area so there was no need to supplement the analysis with additional data.

1.1.2 Computational Mesh

A 2D flow area was defined to encompass the inundation areas for the maximum storm event. This same 2D flow area was then used for all the smaller storm events. The grid size for each of the scenarios is shown in Table 1-1. Figure 1-1 shows the 2D flow areas and boundary conditions for the Flat Canyon model.

Table 1-1. Computation Mesh Gride Size for Each Scenario

Scenario	Grid Size (feet)
Flat Canyon	20

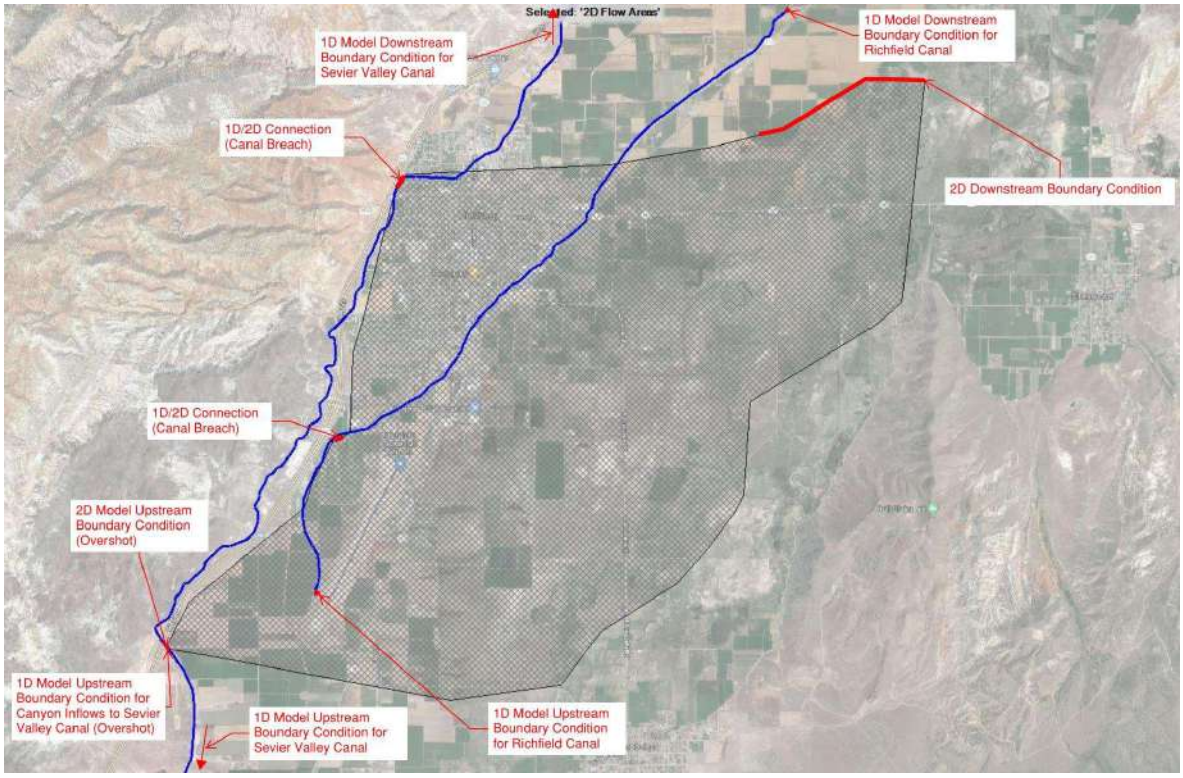


Figure 1-1. Flat Canyon 2D Flow Mesh and Boundary Conditions

1.1.3 Land Cover

Model Manning's roughness values were determined by utilizing the 2016 NLCD dataset for the modeling area. The Manning's n values were assigned to the following areas: the canals, agricultural fields, non-vegetated soils, parks and recreational areas, residential areas, and roads. The specific values were determined based on-site visits and photographs as well as guidance from various references including the book Open-Channel Hydraulics (Chow, 1959). The final land cover types and corresponding Manning's n values used in the HEC-RAS model are shown in Table 1-2.

Table 1-2. Model Boundary Conditions

Land Cover Type	Manning's n Value
Agricultural Field	0.06
None Vegetated Soil	0.025
Parks and Recreational Areas	0.04
Residential Areas	0.075
Roads	0.025

1.1.4 Boundary Conditions

Boundary conditions were defined for both the 1D and 2D positions of the model. Table 1-3 shows the type of boundary condition used for each model. Upstream boundary condition flow hydrographs are presented in *TM002 – Hydrology*. Refer to Figure 1-1 and for spatial placement of each boundary condition.

Table 1-3. Model Boundary Conditions

Modeling Parameters	Applicable Scenario	Type
1D Model Upstream Boundary Condition for Sevier Valley Canal	Flat	Flow Hydrograph
1D Model Upstream Boundary Condition for Canyon Inflows to Sevier Valley Canal (Overshot)	Flat	Lateral Inflow Hydrograph
1D Model Downstream Boundary Condition for Sevier Valley Canal	Flat	Normal Depth
1D Model Upstream Boundary Condition for Richfield Canal	Flat	Flow Hydrograph
1D Model Downstream Boundary Condition for Richfield Canal	Flat	Normal Depth
2D Model Upstream Boundary Condition (Overshot)	Flat	Flow Hydrograph
1D/2D Connection (Canal Breach)	Flat	Lateral Inflow Structure
2D Downstream Boundary Condition	Flat	Normal Depth

1.1.5 Assumptions

The model runtime was set to 72 hours to allow for the complete hydrographs to pass through the model domain. Some of the major assumptions of the hydraulic model included the following:

1. No infiltration or evaporation losses, i.e., attenuation is due solely to flood storage
2. Pressure distribution is hydrostatic
3. Hydraulic roughness based on steady, uniform, and fully turbulent flow
4. Channel elements are represented by uniform channel geometry and roughness
5. Minor culverts were considered plugged
6. Sevier Valley and Richfield Canals were modeled with 100 cfs of excess capacity each (200 cfs combined) for the existing conditions (based on discussions with the canal companies)
7. High-intensity localized storms generating isolated runoff

1.1.6 Model Calibration

Qualitative data (location of flooding, general flooding extents, etc.) was used to calibrate the model because limited measured flood and stormwater data were available for model calibration. While velocities and depths were evaluated to determine if values were within reasonable ranges, qualitative data was principally used. Historic flooding areas are identified on the map provided in Attachment A. This information was used to verify flood modeling results.

1.2

1.2 Modeling Scenarios

The hydraulic modeling scenarios were broken into existing and proposed conditions for Flat Canyon. The existing and proposed conditions were modeled for all eight recurrence intervals. The recurrence intervals modeled include the 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year 24-hour storm events. This resulted in a total of 16 separate model runs. Each canyon was modeled independently. A specific description of each of the modeled scenarios is described below.

1.2.1 Flat Canyon Existing Conditions Scenario

During smaller storm events, water from Flat Canyon flows across the canal and enters the south flood channel, eventually flowing into the Richfield Canal. During larger storm events, flows from Flat Canyon spill into the Sevier Valley Canal over the sides of the overshot structure; the remaining flows drain to the Richfield Canal via the south flood channel. Figure 1-4 shows the overshot structure during a larger storm event.

Flat Canyon storm flows entering the Sevier Valley Canal were modeled starting at the overshot structure, which was represented as a lateral inflow hydrograph boundary condition. A rating curve was generated to model the eight different storm events at the varying flows.



Figure 1.2-4. Sevier Valley Canal Overshot Structure near Flat Canyon (2016 Storm Event)

Breach parameters were defined at known critical problem areas along both the Sevier Valley Canal and Richfield Canal. Based on the modeling of higher flood events, both canals would breach at these specified locations, causing flooding. As discussed in Section 1.1.5, the existing conditions model assumed there was an additional 100 cfs of capacity and 1 foot of freeboard in both the Sevier Valley Canal and Richfield Canal (200 cfs combined capacity). During the model simulations, if the 1 foot of freeboard was exhausted and the water surface elevation exceeded the bank elevation by 0.25 feet, then the canal would breach. The breach location along the Sevier Valley Canal was located near 500 North and College Avenue in Richfield City. The breach location for the Richfield Canal was located near the golf course, west of Home Depot.

These breach locations can be seen on the series of maps provided in Attachment B; these maps also show the expected inundation depths and inundation boundaries for Flat Canyon.

1.2.2 Flat Canyon Proposed Conditions Scenario

The peak discharge from the proposed Flat Canyon debris basin for the 200- and 500-year events were determined to be 192.9 cfs and 231.9 cfs, respectively. This flow would be split, with 150 cfs going to the south flood channel and 50 cfs going to the Sevier Valley Canal. The 150 cfs in the south flood channel will again be split, with 50 cfs being diverted to the Richfield Canal and the remaining 100 cfs continuing down the south flood channel to be discharged to the Sevier River. The 50 cfs in the Sevier Valley Canal would be diverted into the north flood channel and discharged into the Richfield Canal (adding a total of 100 cfs to the Richfield Canal). 2,100 feet downstream of this confluence 100 cfs would be diverted from the Richfield Canal back into the north flood channel and discharged to the Sevier River. As mentioned previously, these canals can take 100 cfs with 1 foot of freeboard, each; which is why the 200- and 500-year events are contained. As a result, the post-project conditions resulted in no flooding up to the 500-year event

2.0 Flood Channel Analysis

2.1 Existing South Flood Channel Evaluation

The existing south flood channel starts near the mouth of Flat Canyon, on the east side of I-70 just below an existing metal overshot structure. The south flood channel is earthen with three relatively straight segments and two nearly 90-degree bends. The channel is approximately 8,000 linear feet long with an average slope of about 0.0121 feet/foot. The channel has a typical trapezoidal cross-section with a bottom width of 6 feet, a top width of 25 feet, and a depth of 6 feet. Using Manning's equation with an n value of 0.035, the capacity of the channel was calculated to be approximately 577 cfs. The channel terminates at the Richfield Canal near the Richfield Municipal Airport. Existing channel capacity calculations are provided in Attachment C.

The existing overshot structure currently directs flows over the county road, onto agricultural fields, through a pig farm, and into the south flood channel. Flows that overwhelm the overshot structure drain into the Sevier Valley Canal. Flows directed into the south flood channel are conveyed to the Richfield Canal. Both canals are often at capacity when major storm events occur within Flat Canyon. This increases the risk of the canals being breached.

2.2 South Flood Channel Proposed Measures

The proposed improvement is to enlarge the south flood channel to accommodate the attenuated 100-year storm flow from the proposed Flat Canyon debris basin. This would enable the channel to convey flows from Flat Canyon to the Sevier River while removing flows and associated risks from the canals during 100-year and smaller storm events.

2.2.1 South Flood Channel Flat Canyon Overshot Structure

The overshot structure would be reconstructed to allow flows to be bifurcated into the south flood channel and into the Sevier Valley Canal. The overshot would outlet to a grouted riprap rock chute with an energy dissipation pool at the head of the south flood channel. Assuming the attenuated flows from Flat Canyon to be 200 cfs, at least 150 cfs would be conveyed over the canal and into the south flood channel,

while up to 50 cfs would pass over the sides of the overshot into the Sevier Valley Canal. The sides of the overshot structure would act as lateral weirs. Calculation information is provided in Attachment C.

2.2.2 South Flood Channel Upgrades

Both bends in the south flood channel would be widened, reshaped, and armored with riprap to prevent erosion. The existing culverts, which include two parallel 12-foot by 5-foot concrete box culverts under I-70, one 6-foot-diameter corrugated metal culvert, and one 12-foot by 5-foot concrete box culvert, all have sufficient hydraulic capacity for the proposed design flows. Box culvert abutments and culvert pipe entrances will be armored with riprap. Any vertical channel banks would be reshaped to reduce bank erosion and meet the minimum cross-sectional area necessary to safely carry the flows. All work would be conducted within a 100-foot-wide corridor centered over the 7,900-linear-foot-long channel. The proposed channel capacity calculations are provided in Attachment C.

2.2.3 South Flood Channel Pipeline Inlet Structure

A pipe inlet structure would be installed in the channel to route flows through a flood pipeline to the Sevier River. The inlet structure would be located upstream of the Richfield Canal and would route flows either over or under the canal. The inlet structure would have a trash rack to protect the flood pipeline from flood debris. The trash rack would be over-sized for partial emergency plugging and be accessible to allow raking and cleaning of floating debris by backhoe or other large equipment.

2.2.4 Closed Conduit Flood Pipeline

The closed conduit flood pipeline would consist of one 48-inch-diameter pipeline beginning at the splitter structure. The pipe would pass under Highway 118 and cross private lands, with the top of the pipe buried below normal cultivation practice depths (two feet or more where possible). The estimated pipeline alignment length is 8,943 feet. The pipeline would be capable of conveying a maximum of 100 cfs and have access manholes at all angle points and spaced no more than 1,000 feet apart to allow for pipe inspection and regular cleaning. Placement of the manholes would be coordinated with agricultural landowners to reduce land use conflicts as much as possible. Table 2-1 shows additional design information.

Table 2-1. South Flood Channel Pipeline Design Information.

Parameter	Value
Proposed Pipe Size	48-inch (DR26)
Proposed Pipe Material	HDPE
Estimated Length (feet)	8,943
Maximum Flow Capacity (cfs)	100
Maximum Velocity (feet/second)	7.96
Maximum Pressure (psi)	30
Upstream Invert (feet)	5,336.32
Downstream Invert (feet)	5273
Average Slope (feet/foot)	0.0071

Figure 2-1 shows the pipeline elevation profile with the hydraulic gradeline, static pressure, and dynamic pressure.

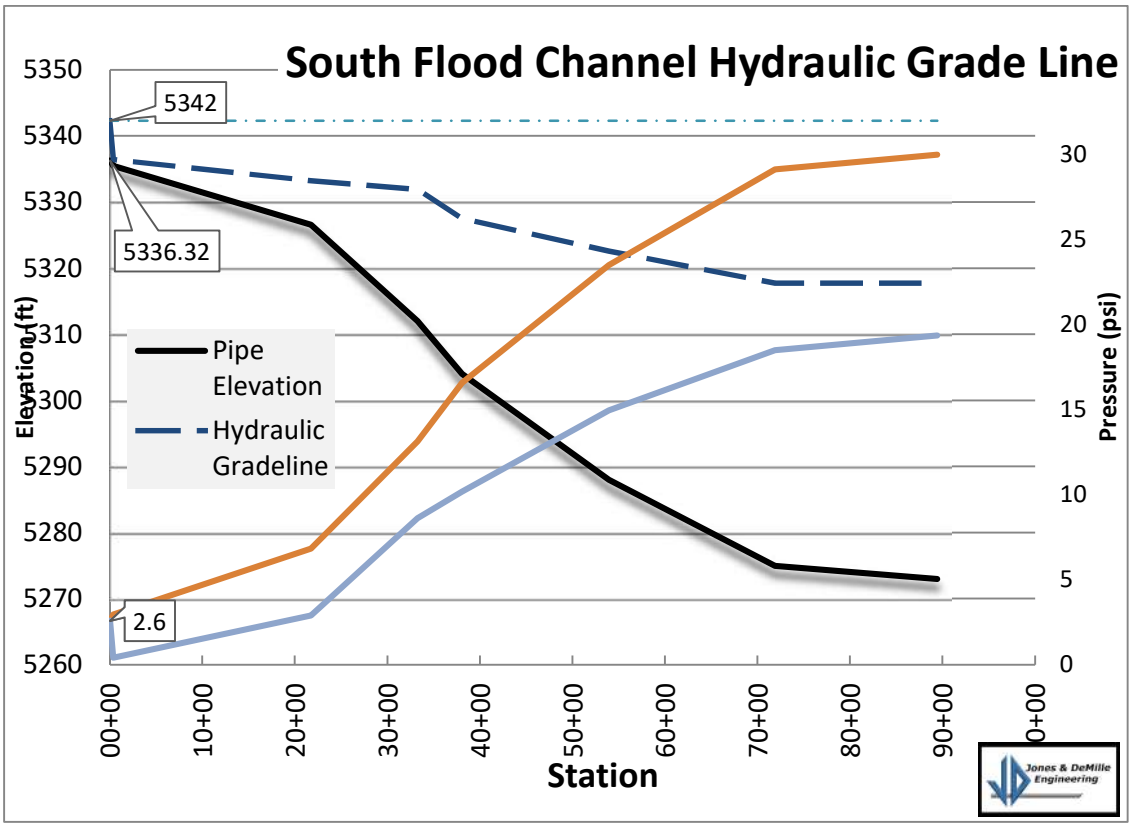


Figure 2-1. South Flood Channel Hydraulic Gradeline Profile

2.2.5 Pipe Outlet Structure and New Channel and Dike to Sevier River

The pipe outlet structure would consist of a concrete headwall with flap gate to prevent reverse flows.

A channel and dike would be constructed downstream of the outlet structure to convey water to the Sevier River. The channel would have a 15-ft bottom width with a depth of 3.33’ and side slopes of 3:1. The dike would be constructed on the south side of the channel with a 4’ top and 3:1 side slope. The height of the dike would vary as needed to achieve required freeboard.

Tailwater conditions were analyzed to ensure adequate channel capacity during Sevier River flood conditions. The maximum recorded flow for the Sevier River near Richfield is 1,078 cfs. LiDAR data were used to obtain ground surface elevations for the area below the proposed outlet. Assuming a Manning’s n value of 0.035 and a slope of 0.0003, the maximum flood depth was estimated to be 5.70 feet (EL = 5369 feet). This results in the maximum flood elevation being approximately 4 feet below the proposed outlet elevation. As a result, the tailwater conditions would not affect the flood channel capacity at the outlet.

2.3 North Flood Channel Existing Condition

The channel is approximately 7,100 linear feet of earthen channel and has an average slope of about 0.012 feet/foot. The channel has a typical trapezoidal cross-section with a bottom width of 6 feet, a top width of 26 feet, and a depth of 6 feet. Using Manning’s equation with an n value of 0.035, the capacity of the channel was calculated to be approximately 725 cfs with 1 foot of freeboard. The channel outlets into the Richfield Canal at the intersection of Highway 118 and 2070 East. Existing channel capacity calculations and cross-section information can be found in Attachment C.

There are several locations along the channel where the bank has eroded (see Figure 2-2). Modeling results indicate that maximum velocity could be as high as 10 feet per second.

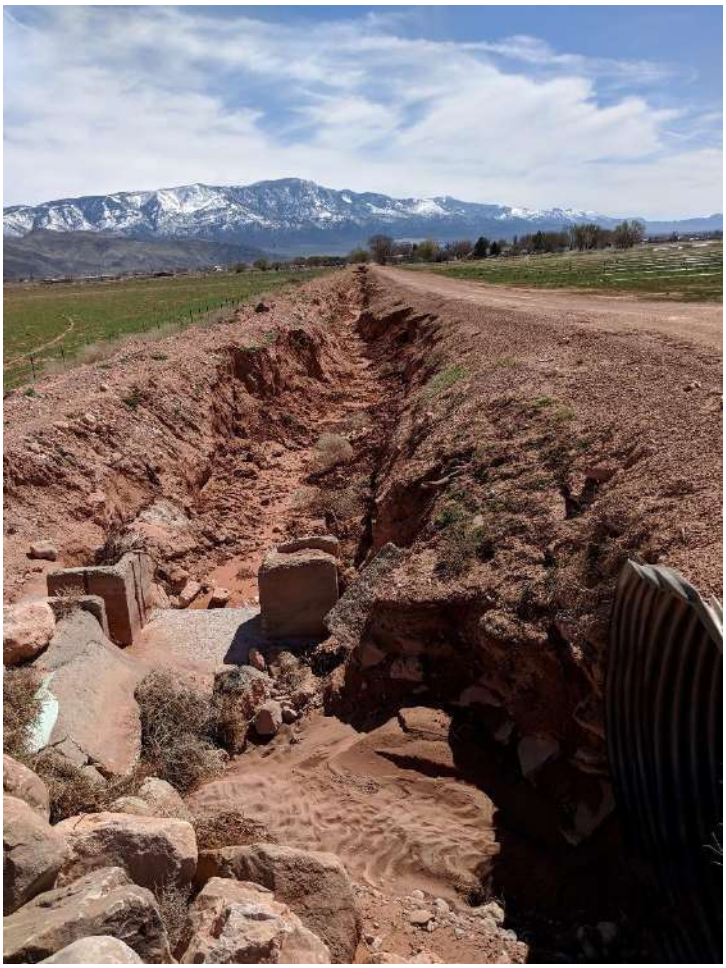


Figure 2-2. Eroded Banks on the North Flood Channel

2.4 North Flood Channel Proposed Measures

The existing flood channel would be re-shaped to convey the partially attenuated flows from up to the 100-year event as well as extend the channel to the Sevier River.

2.4.1 Sevier Valley Canal Emergency Overflow Structure

An emergency overflow structure would be constructed on the bank of the Sevier Valley Canal to divert up to 50 cfs from the canal into the north flood channel. The nearest outlets to the Sevier River from the proposed overflow structure are 8 miles upstream (proposed south flood channel) or 6.5 miles downstream (Wilkinson Wash Dump Gate). The emergency overflow structure would consist of a cast-in-place concrete headwall with a broad crested weir and spillway that transitions to a grouted riprap spillway and basin. The weir flowline would be set above the normal canal high water mark. There would also be an auxiliary emergency dump gate with conduit through the canal bank into the grouted riprap spillway basin that could be manually operated to divert up to approximately 50 cfs from the bottom of the canal in advance of a flood surge. A preliminary design of this structure is provided in Attachment C, which also provides a hydraulic flow rating table for the proposed structure.

2.4.2 North Flood Channel Upgrades

The existing channel is an earthen channel made up of five relatively straight reaches with five approximately 90-degree bends. The channel conveys flows through agricultural lands for approximately 6,800 feet before draining into the Richfield Canal. The 90-degree bends have been maintained and armored over the years with broken concrete, large rocks, and concrete grout.

The upgrades to the channel would include reshaping vertical banks and armoring the existing channel bends with riprap to maintain the existing hydraulic conveyance capacity of 725 cfs. Channel reshaping would include building up the banks where necessary to provide freeboard and meet the minimum consistent cross-sectional area necessary to safely carry the historic and design flows. All work would be conducted within a 100-foot-wide corridor centered on the channel. Preliminary channel geometry and riprap sizing can be found in Attachment C.

There are four culverts that have been installed in the channel to provide access for farms, private residences, and county roads. Based on the analysis, all four crossings have sufficient hydraulic capacity and would not need to be replaced. The results can be found in Attachment C.

2.4.3 Richfield Canal Emergency Overflow and Pipe Inlet Structure

An emergency overflow and a pipe inlet structure would be constructed in the bank of the Richfield Canal approximately 2,100 feet downstream of the north flood channel. The structure would divert up to 100 cfs from the canal into a pipeline that would convey flows to the Sevier River. The emergency overflow structure would consist of a cast-in-place concrete headwall with a broad-crested weir and spillway that transitions to a grated pipe inlet structure. The trash rack would be constructed to allow raking and cleaning of floating debris by backhoe or other large equipment. The weir flowline would be set above the normal canal high water mark. A preliminary design of this structure is provided in Attachment D, which also contains a hydraulic flow rating table for the proposed structure.

2.4.4 Closed Conduit Flood Pipeline

The closed conduit flood pipeline would be a buried 48-inch-diameter pipeline between the Richfield Canal and the Vermillion Canal dumpgate. The pipeline would cross under Highway 118, through agricultural lands below normal cultivation depths, and under the Vermillion Canal to drain into an existing channel that outlets to the Sevier River.

The estimated length of pipe is 6,700 feet. The pipeline would be capable of conveying a maximum of 100 cfs and have access manholes at all angle points spaced at no more than 1,000 feet apart to allow for pipe inspection and cleaning. Placement of the manholes would be coordinated with landowners to reduce surface use conflicts as much as possible. Table 2-2 shows additional design details. Figure 2-3 shows the pipeline elevation profile with the hydraulic gradeline, static pressure, and dynamic pressure.

Table 2-2. North Flood Channel Pipeline Design Information

Parameter	Value
Proposed Pipe Size	48-inch (DR26)
Proposed Pipe Material	HDPE
Estimated Length (feet)	6,700
Maximum Flow Capacity (cfs)	100
Maximum Velocity (feet/second)	9.43
Maximum Pressure (psi)	21

Parameter	Value
Upstream Invert (feet)	5289
Downstream Invert (feet)	5245
Average Slope (feet/foot)	0.0072

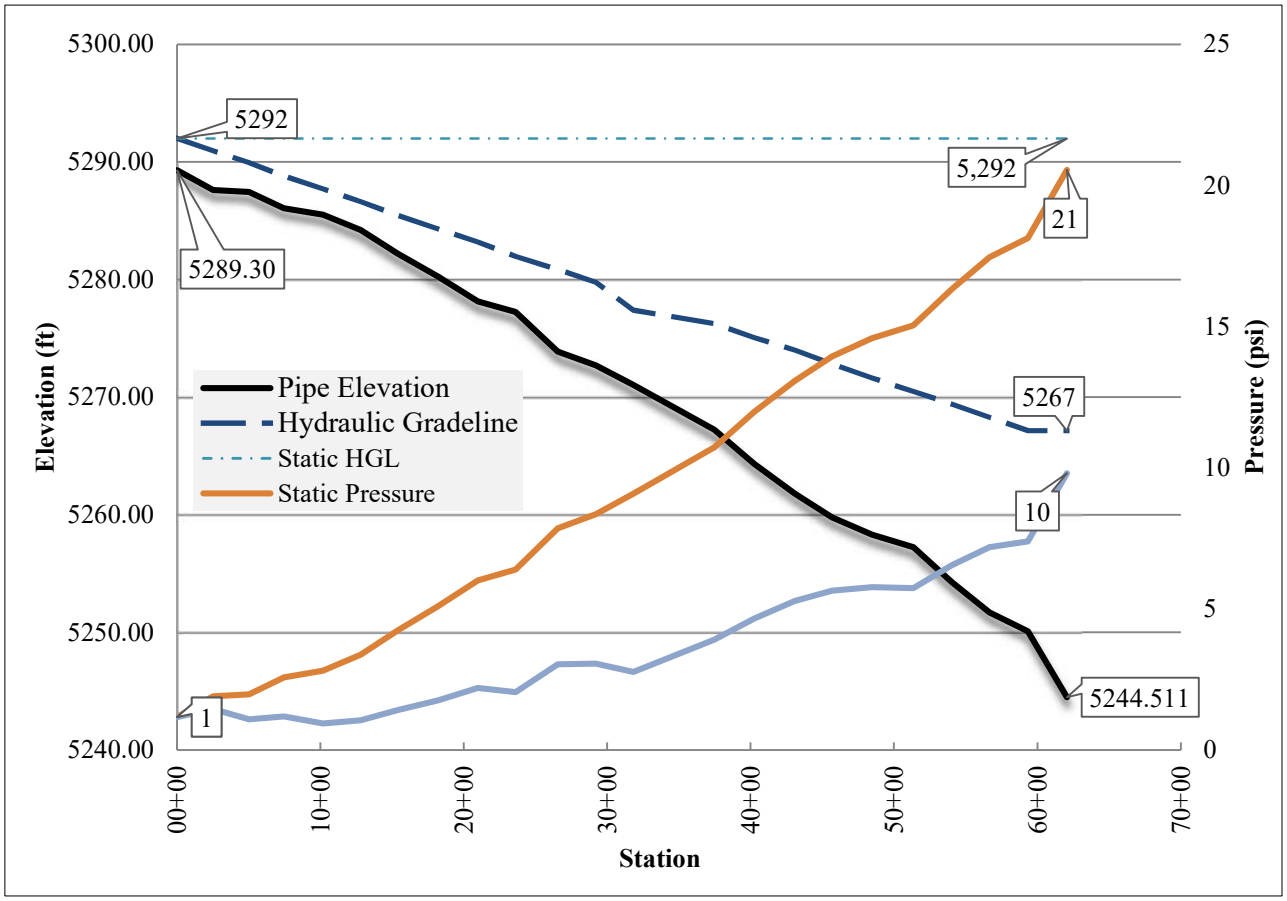


Figure 2-3. North Flood Channel Hydraulic Gradeline Profile

2.4.5 Pipe Outlet Structure to the Sevier River

The pipe outlet structure would consist of a concrete headwall with flap gate. Flows would drain into an existing 640-foot-long channel that drains directly into the Sevier River. The existing flood channel has a capacity of approximately 400 cfs with 1 foot of freeboard, which is adequate for the two maximum inflows. The channel capacity calculations can be found in Attachment C.

2.4.6 Sevier Valley Canal Control Gate Structure

As part of the north flood channel improvements, a flood control gate would be installed on the Sevier Valley Canal to increase conveyance capacity. There is currently a stop-log structure at the end of the Sevier Valley Canal that is used to increase the water surface elevation so that water can be delivered at turnouts along the canal. When flood water enters the canal, the operator must anticipate increased flows and manually remove the stop logs to decrease the water surface elevation and the risk of a canal breach. This method requires timely identification of a flood risk and having an operator available and able to access the site.

A new concrete structure with an automated control gate and downstream riprap armoring would be installed to replace the existing stop-log structure. The gates could be radial or Rubicon that would actuate when the water surface elevations exceed normal operating levels. The gate would open to allow the flood waters to continue downstream while maintaining canal operating levels and minimizing the risk of the canal breaching.

3.0 References

Bakaitis, C. 2016. Sevier County Natural Hazard Assessment for Pre-Disaster Mitigation. Available at: http://sixcounty.com/wp-content/uploads/2016/01/Section-6-Sevier-County.pdf (accessed 6-25-2019).

Chow, V. T. 1959. Open-Channel Hydraulics. A McGraw-Hill Classic Textbook Reissue. McGraw Hill Book Company, New York.

Natural Resources Conservation Service (NRCS). 2017. CPS Water and Sediment Control Basin (Code 638). October 2017.

Schick International. 1977. Richfield Flood Control Feasibility Investigation. Prepared for Utah State Soil Conservation Commission. June 1977.

Attachment A. Historical Flood Maps

Historical Flooding Issues
Watersheds
Canals
Streams

North Flood Channel
15
10
70
11
13
Wood Canyon
Wood Canyon - Lower
16
8
118
119
1
Cottonwood Canyon Debris Basin
9
Richfield
4
9
Cottonwood Canyon
2
120
17
Tank Canyon
5
1
14
9
Dariy Canyon Debris Basin
Lind Canyon
12
1
9
Dairy Canyon
7
21
20
Central Valley
Richfield Canal
Elsinore Canal
Sevier Valley and Piute Canal
19
Existing SouthFlood Channel
18
6
3
Flat Canyon - Lower
Two 20'x7' Box Culverts
NRCS Grade Control Strucutres
N
0 0.25 0.5 Miles

Map ID	Flooding Areas and Infrastructure
1	Active Development Area
2	Five 48" Culverts Used to Convey Tank Canyon Flows to Sevier Valley Canal
3	Flat Canyon Over Chute Structure
4	Frequent Flooding Area due to Flat Canyon Strom Flows from Richfield Canal
5	Frequent Flooding Area
6	Frequent Flooding of County Road due to Flat Canyon Flows from Over Chute
7	Golf Course Often Flooded with Flat Canyon Storm Flows from Richfield Canal
8	High Debris and Sediment Loads from Wood Canyon Impacting Sevier Valley Canal
9	High Risk Breach Location (County, 2018)
10	Homes Flooded due to North Flood Channel Flows from Richfield Canal (July 2018)
11	I-70 Closure due to Flooding (July 2018)
12	Known Problem Area (Backhoe Often Parked Here During Flood Events)
13	Known Problem Area (Flooding Occurs due Storm Flows Overtopping Sevier Valley Canal)
14	Known Problem Area (Strom Flows in Sevier Valley Canal Cause Flooding near Bridge)
15	Known Problem Area (Unprotected Bend in South Flood Channel)
16	One 20'x7' Box Culvert (Large Amounts of Sediment Reducing Culvert Capacity)
17	One 48" Culvert Used to Convey Lind Canyon Flows to Sevier Valley Canal
18	Regular Flooding Area due to Flat Canyon Flows from Over Chute
19	Regular Flooding Area due to Flat Canyon Flows from Over Chute and South Flood Channel
20	South Flood Channel Discharges Into Richfield Canal
21	Steep Canal Bank Susceptible to Breaching due to Flat Canyon Flows
*	**Flooding Areas Not Shown On Map:** Richfield Damed in All Sectors (May 1983), County Wide Flooding (1984), Property Damage (July 1985), Crop and Proerty Damage (August 1991), Poperty Damage (May 1994), Crop and Property Damage (August 1996), Property Damage (September 1997), Crop and Property Damage (September 1998), Property Damage (April-June 2005), Richfield Damage to Businesses Outdoor Property and Frontage Road Closure (July 2014)

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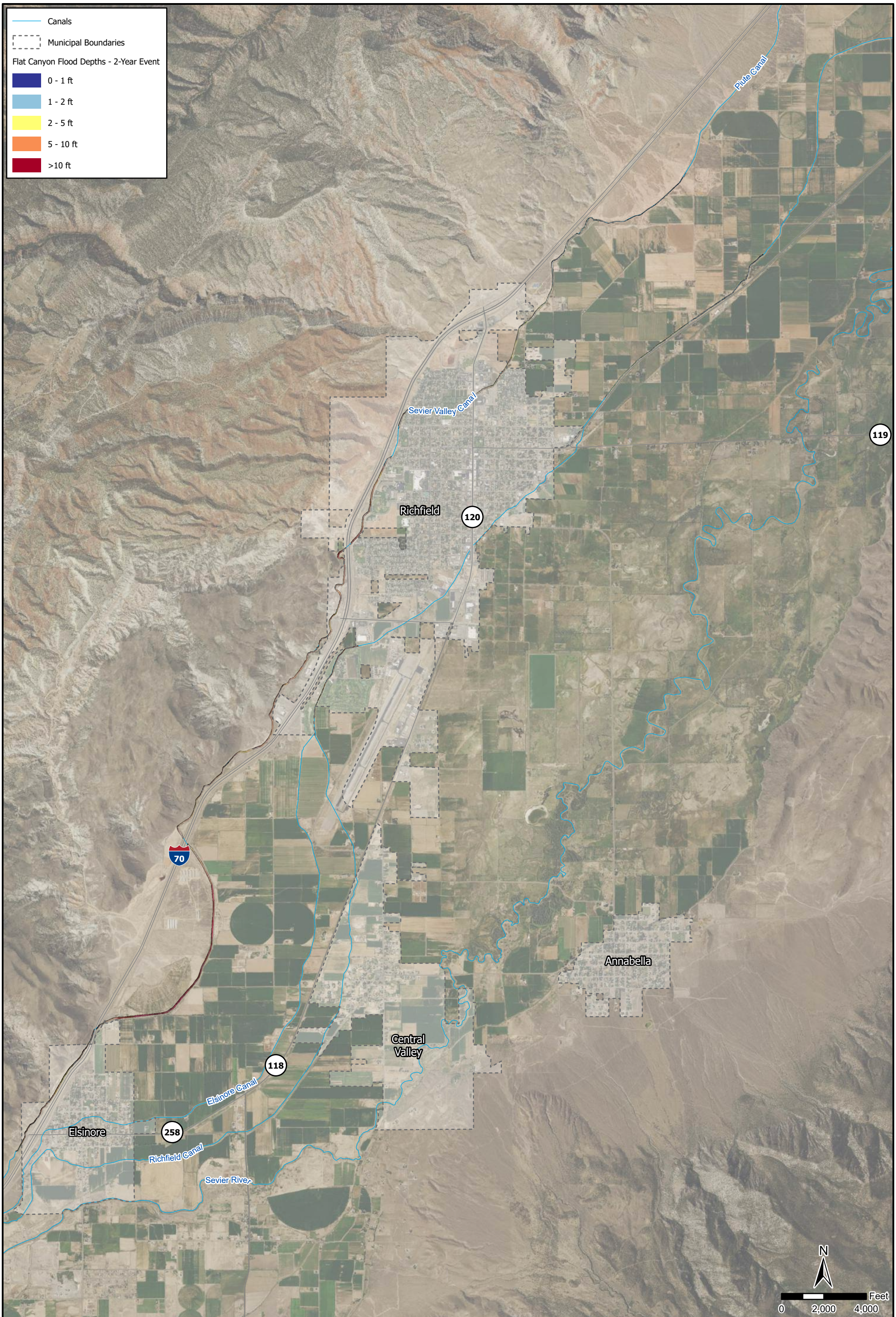
Sevier County

Sevier County Watershed Plan
Historical Floods

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_HH\1804-224_HH.aprx - EXH_Historical_Floods
Project Number: 1804-224 | Drawn by: JWW 05-19 | Last Edit: 05/17/2019

Sevier County
Scale: 1" = 0.5 Miles
1

Attachment B. Flat Canyon Flood Inundation Maps



No flooding occurs up to the 100-year event because the 100-year event is the design event for the project. Therefore, no flood depths are shown for with project condition.

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Sevier County Watershed Plan
Flat Canyon Flood Depths - 2-Year Event

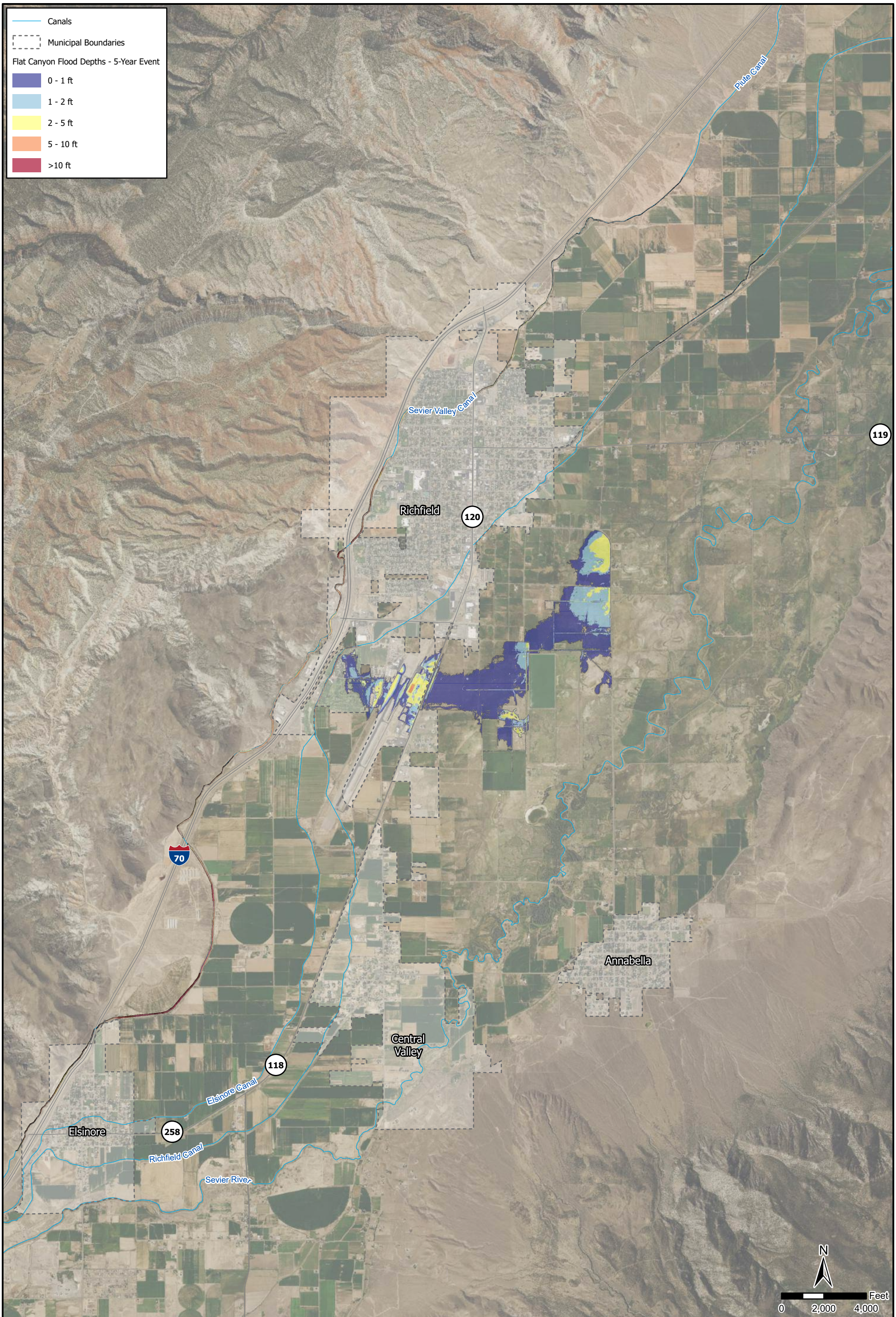
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Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

1



No flooding occurs up to the 100-year event because the 100-year event is the design event for the project. Therefore, no flood depths are shown for with project condition.

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Sevier County Watershed Plan
Flat Canyon Flood Depths - 5-Year Event

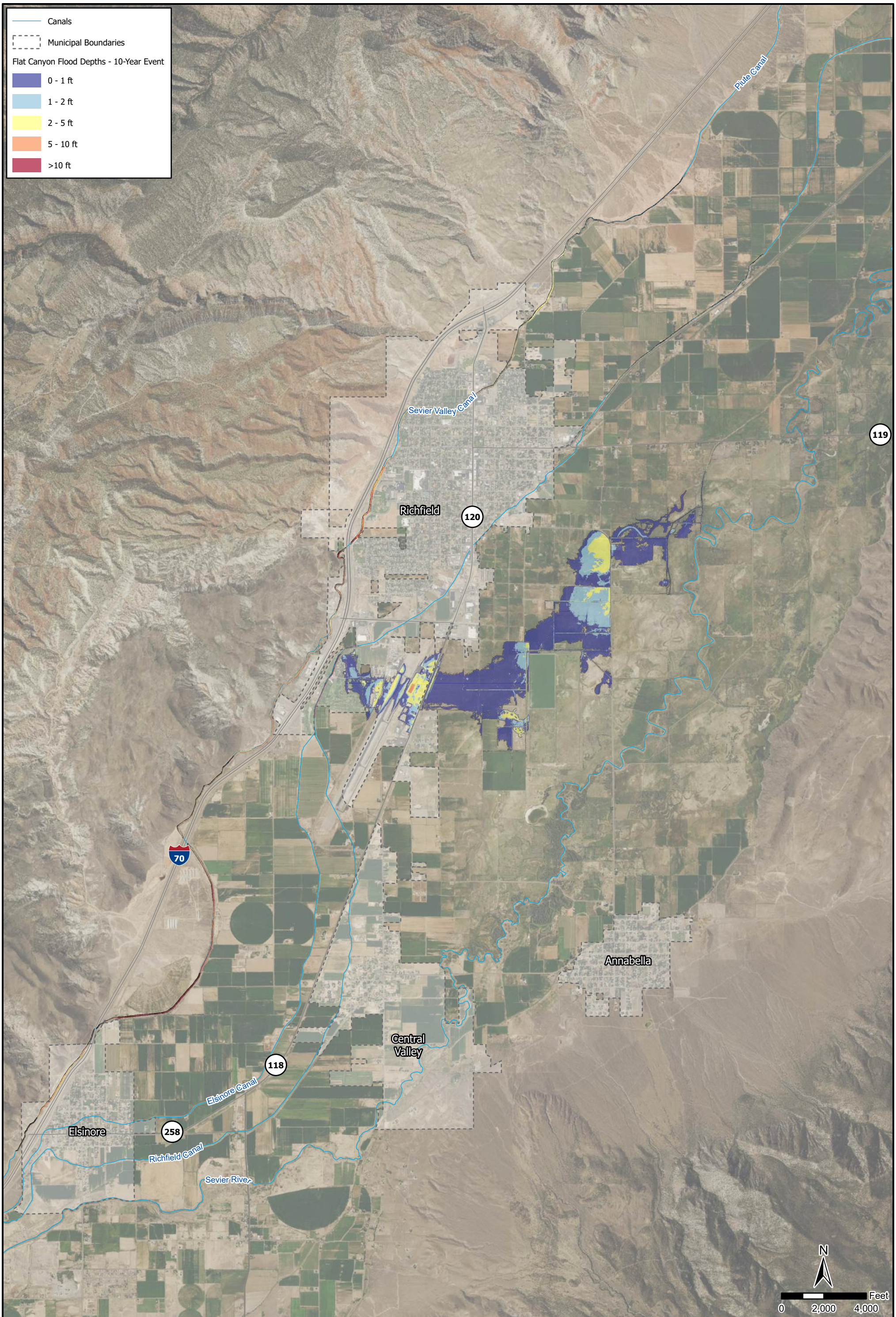
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Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

2



No flooding occurs up to the 100-year event because the 100-year event is the design event for the project. Therefore, no flood depths are shown for with project condition.

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Sevier County

Sevier County Watershed Plan
Flat Canyon Flood Depths - 10-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

3

Canals

Municipal Boundaries

Flat Canyon Flood Depths - 25-Year Event

0 - 1 ft

1 - 2 ft

2 - 5 ft

5 - 10 ft

>10 ft

Piute Canal

Sevier Valley Canal

Richfield

120

119

70

Annabella

Central Valley

118

Elsinore Canal

Elsinore

258

Richfield Canal

Sevier River

N

0 2,000 4,000 Feet

No flooding occurs up to the 100-year event because the 100-year event is the design event for the project. Therefore, no flood depths are shown for with project condition.

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Sevier County

Sevier County Watershed Plan
Flat Canyon Flood Depths - 25-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

4

Canals

Municipal Boundaries

Flat Canyon Flood Depths - 50-Year Event

0 - 1 ft

1 - 2 ft

2 - 5 ft

5 - 10 ft

>10 ft

Piute Canal

Sevier Valley Canal

Richfield

120

119

70

Annabella

Central Valley

118

Elsinore Canal

Elsinore

258

Richfield Canal

Sevier River

N

0 2,000 4,000 Feet

No flooding occurs up to the 100-year event because the 100-year event is the design event for the project. Therefore, no flood depths are shown for with project condition.

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Sevier County

Sevier County Watershed Plan
Flat Canyon Flood Depths - 50-Year Event

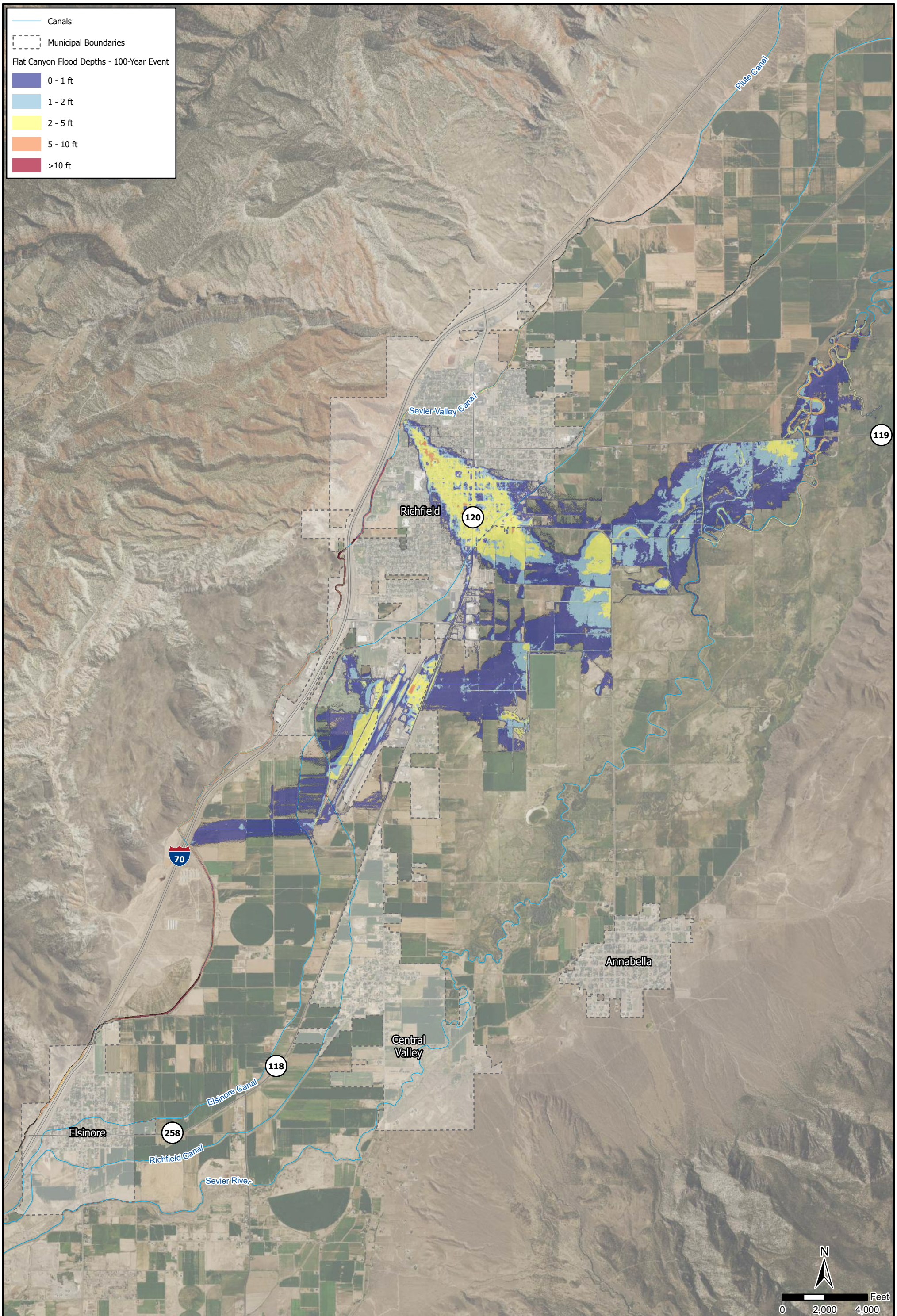
Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

5



No flooding occurs up to the 100-year event because the 100-year event is the design event for the project. Therefore, no flood depths are shown for with project condition.

Jones & DeMille Engineering

- Shaping the Quality of Life -

800.748.5275 www.jonesanddemille.com

Sevier County

Sevier County Watershed Plan
Flat Canyon Flood Depths - 100-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

6

Canals

Municipal Boundaries

Flat Canyon Without Project Flood Depths - 200-Year Event

0 - 1 ft

1 - 2 ft

2 - 5 ft

5 - 10 ft

>10 ft

Piute Canal

Sevier Valley Canal

Richfield

120

119

70

Annabella

Central Valley

118

Elsinore Canal

Elsinore

258

Richfield Canal

Sevier River

N

0 2,000 4,000 Feet

Jones & DeMille Engineering

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Sevier County

Sevier County Watershed Plan
Flat Canyon Without Project Flood Depths - 200-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

7

Canals

Municipal Boundaries

Flat Canyon Without Project Flood Depths - 500-Year Event

0 - 1 ft

1 - 2 ft

2 - 5 ft

5 - 10 ft

>10 ft

Piute Canal

Sevier Valley Canal

Richfield

119

120

70

Annabella

Central Valley

118

Elsinore Canal

Elsinore

258

Richfield Canal

Sevier River

N

0 2,000 4,000 Feet

Jones & DeMille Engineering

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Sevier County

Sevier County Watershed Plan
Flat Canyon Without Project Flood Depths - 500-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

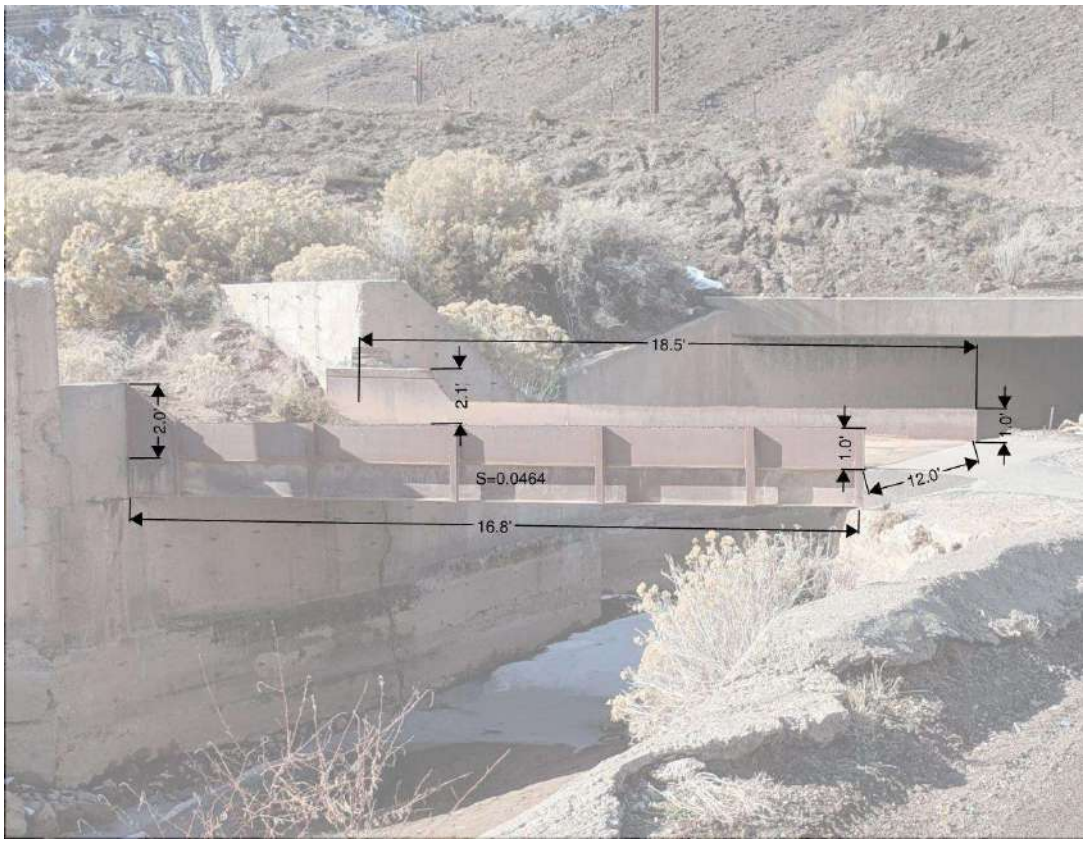
Scale: 1" = 4,000'

9

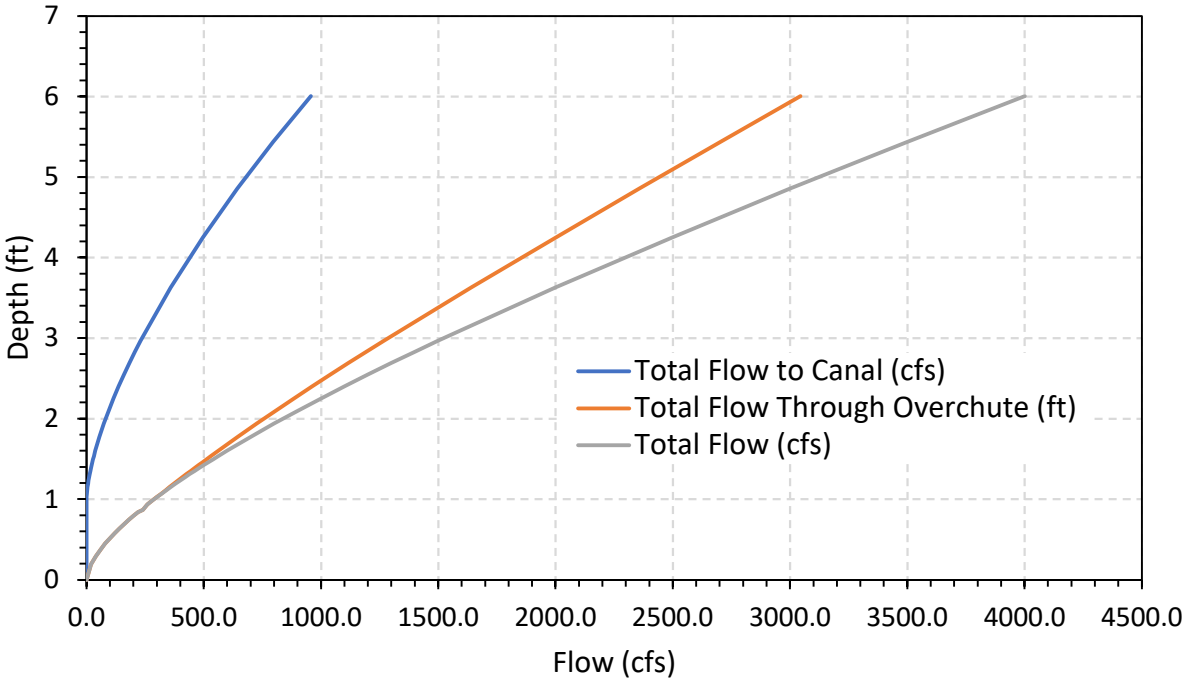
Attachment C. Hydraulic Analysis Support Information

South Flood Channel Design Information

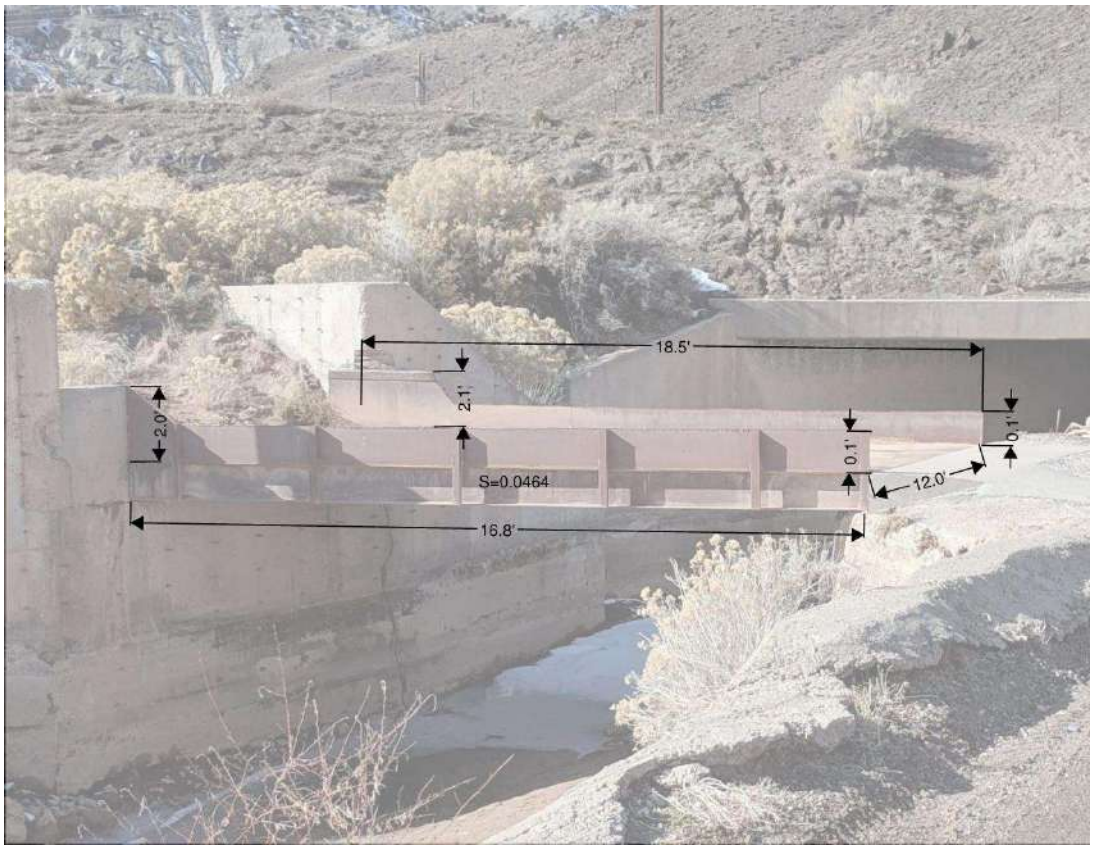
Existing Conditions: Overshot Structure



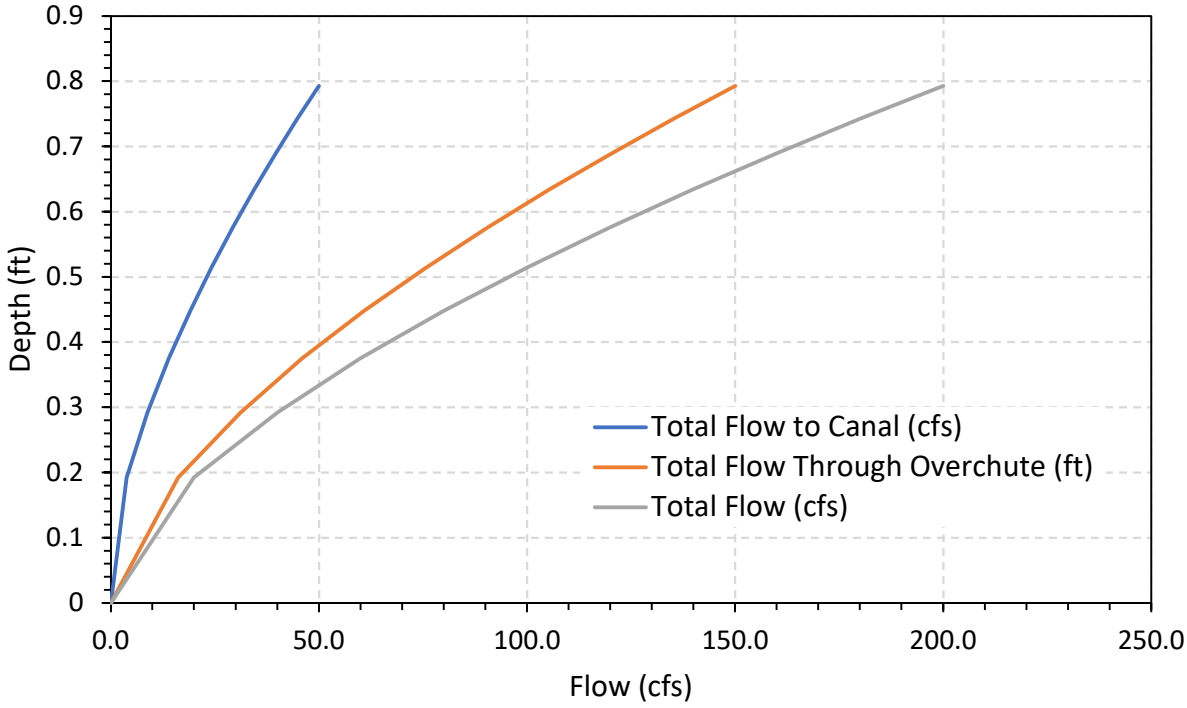
Existing Conditions: Overshot Structure Rating Curve



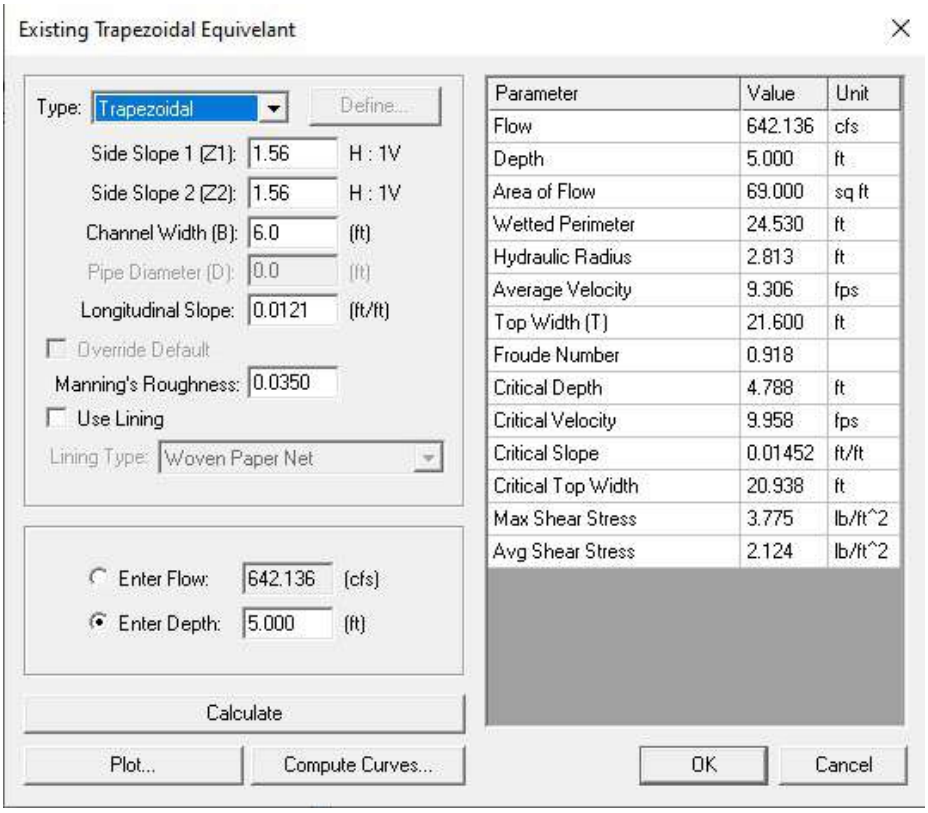
Proposed Conditions: Overshot Structure



Proposed Conditions: Overshot Structure Rating Curve

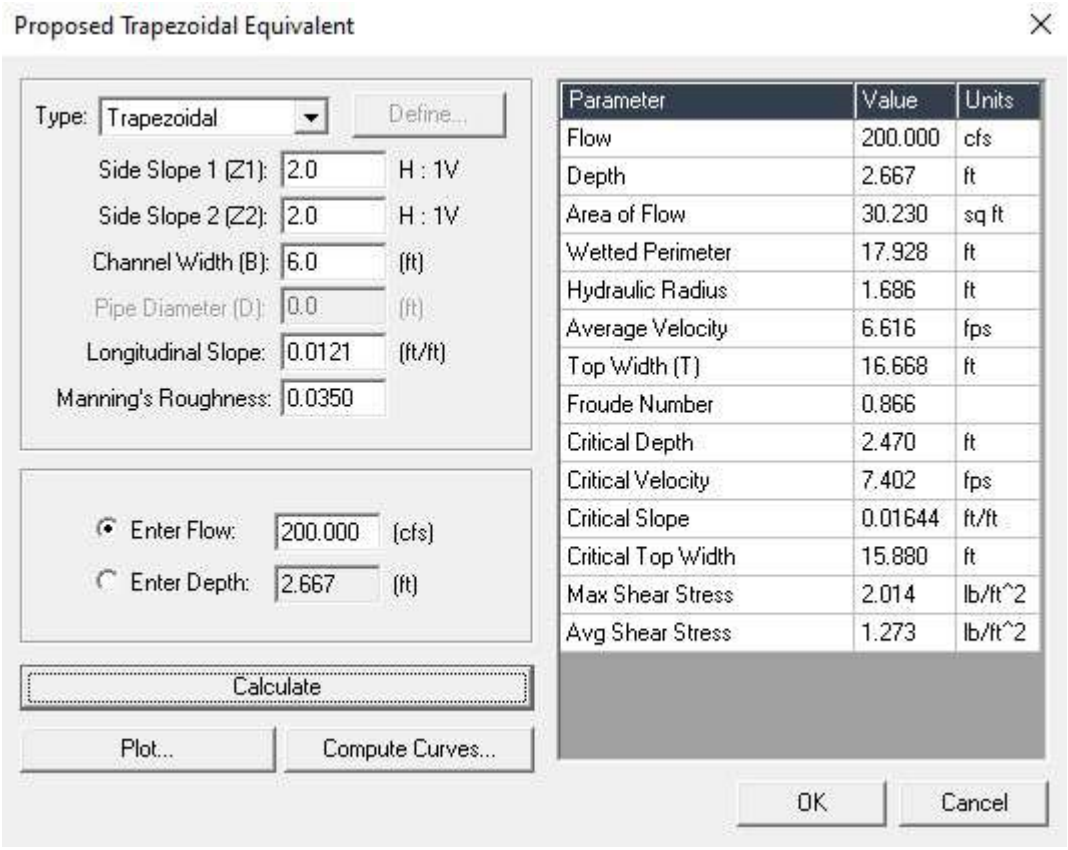


Existing Conditions: South Flood Channel

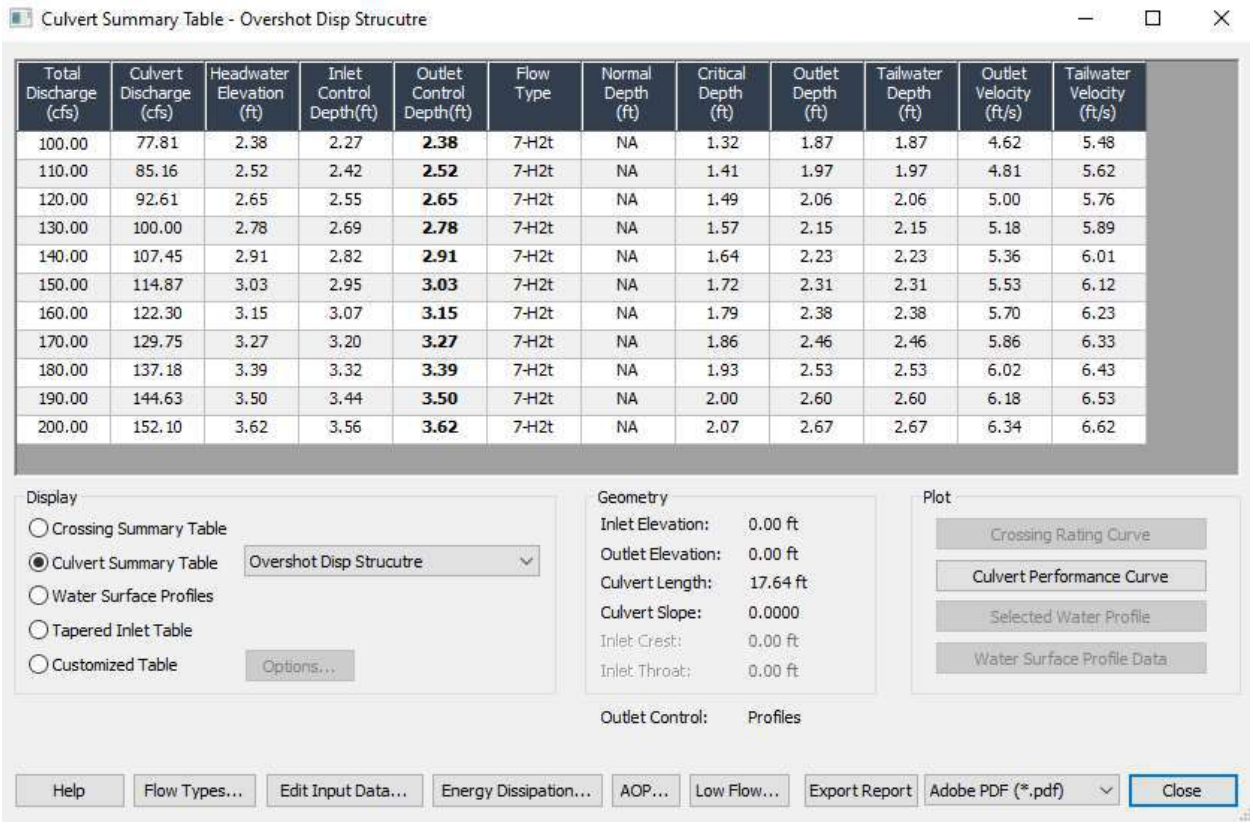


Parameter	Value	Unit
Flow	642.136	cfs
Depth	5.000	ft
Area of Flow	69.000	sq ft
Wetted Perimeter	24.530	ft
Hydraulic Radius	2.813	ft
Average Velocity	9.306	fps
Top Width (T)	21.600	ft
Froude Number	0.918	
Critical Depth	4.788	ft
Critical Velocity	9.958	fps
Critical Slope	0.01452	ft/ft
Critical Top Width	20.938	ft
Max Shear Stress	3.775	lb/ft^2
Avg Shear Stress	2.124	lb/ft^2

Proposed Conditions: South Flood Channel

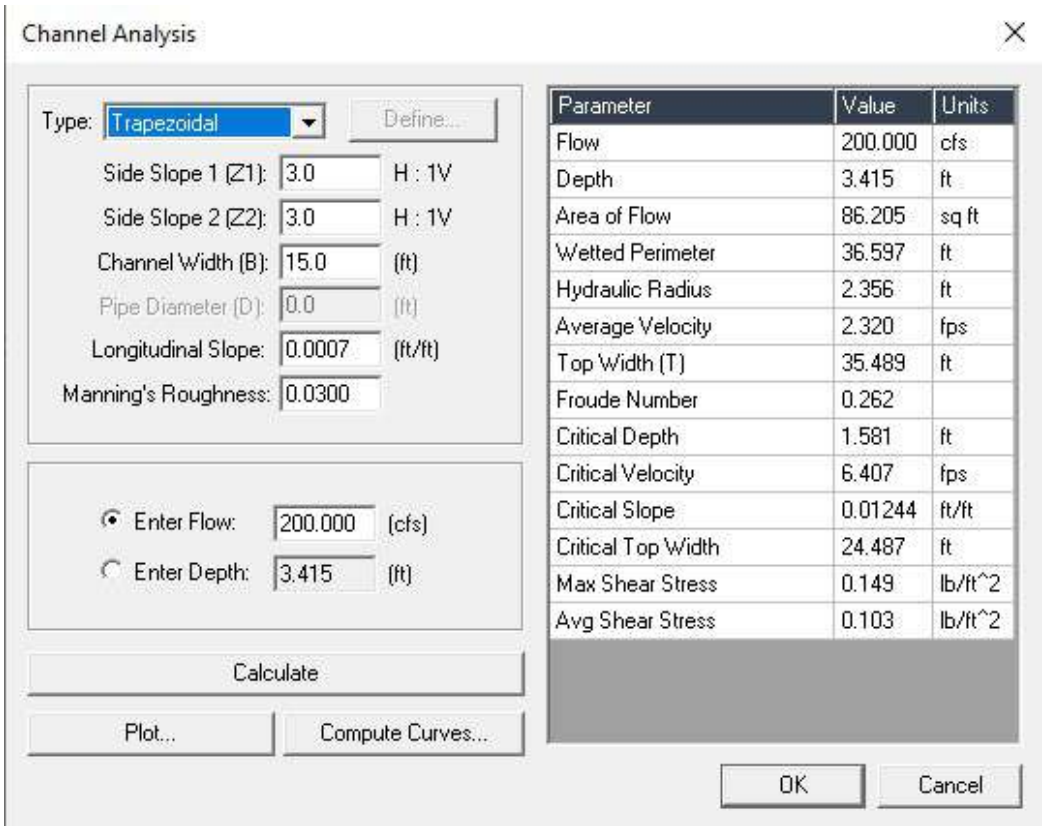


Proposed Conditions: South Flood Channel 48” Culvert



Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
100.00	77.81	2.38	2.27	**2.38**	7-H2t	NA	1.32	1.87	1.87	4.62	5.48
110.00	85.16	2.52	2.42	**2.52**	7-H2t	NA	1.41	1.97	1.97	4.81	5.62
120.00	92.61	2.65	2.55	**2.65**	7-H2t	NA	1.49	2.06	2.06	5.00	5.76
130.00	100.00	2.78	2.69	**2.78**	7-H2t	NA	1.57	2.15	2.15	5.18	5.89
140.00	107.45	2.91	2.82	**2.91**	7-H2t	NA	1.64	2.23	2.23	5.36	6.01
150.00	114.87	3.03	2.95	**3.03**	7-H2t	NA	1.72	2.31	2.31	5.53	6.12
160.00	122.30	3.15	3.07	**3.15**	7-H2t	NA	1.79	2.38	2.38	5.70	6.23
170.00	129.75	3.27	3.20	**3.27**	7-H2t	NA	1.86	2.46	2.46	5.86	6.33
180.00	137.18	3.39	3.32	**3.39**	7-H2t	NA	1.93	2.53	2.53	6.02	6.43
190.00	144.63	3.50	3.44	**3.50**	7-H2t	NA	2.00	2.60	2.60	6.18	6.53
200.00	152.10	3.62	3.56	**3.62**	7-H2t	NA	2.07	2.67	2.67	6.34	6.62

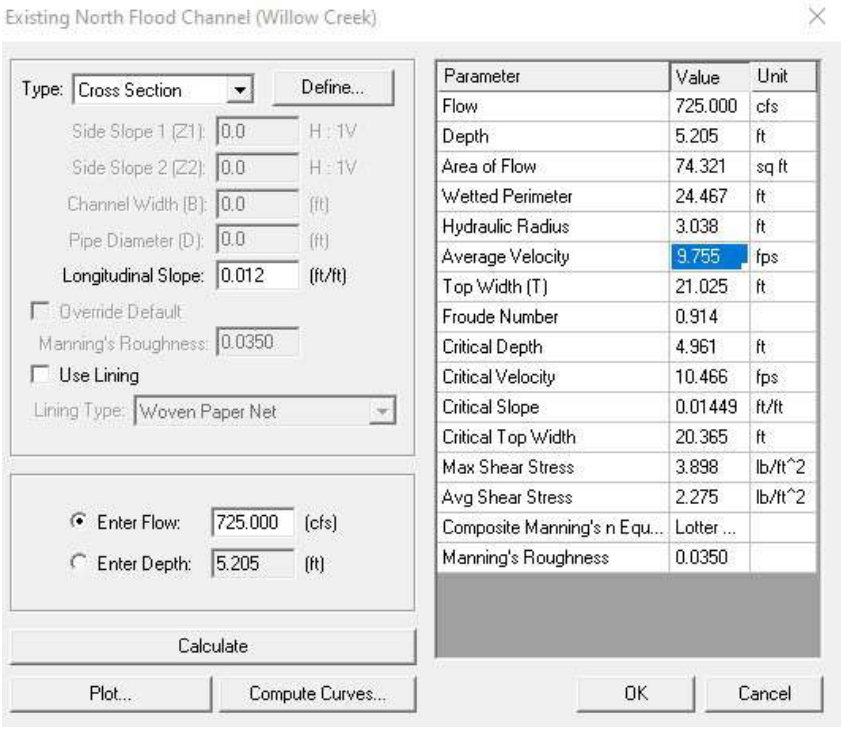
Proposed Condition: New Channel to Sevier River

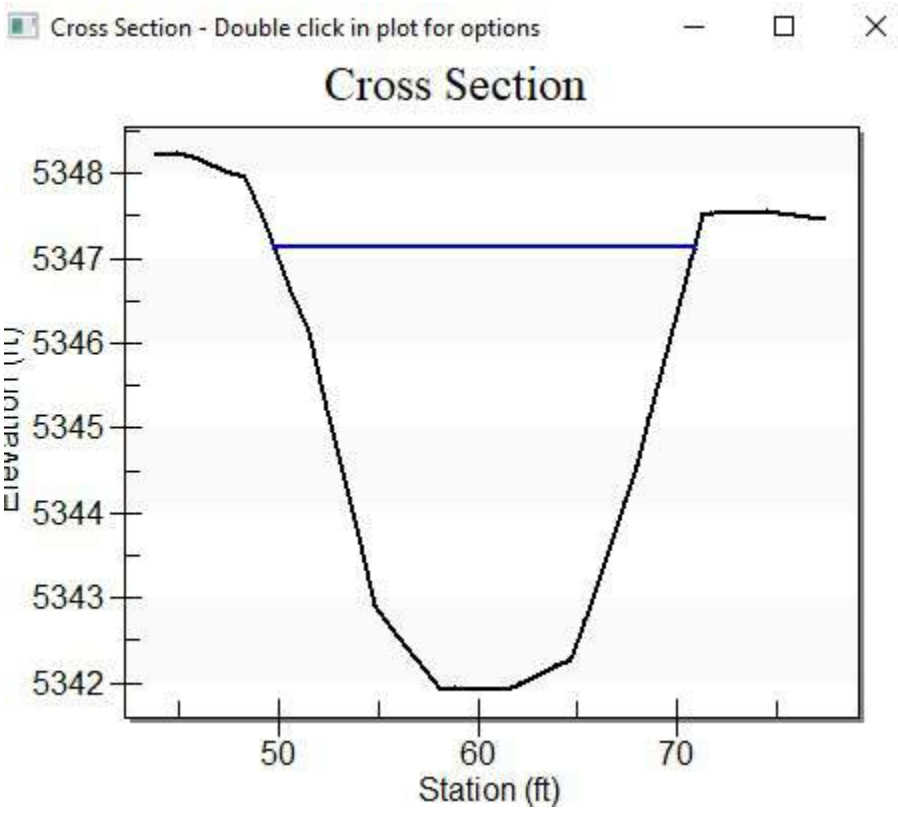


Parameter	Value	Units
Flow	200.000	cfs
Depth	3.415	ft
Area of Flow	86.205	sq ft
Wetted Perimeter	36.597	ft
Hydraulic Radius	2.356	ft
Average Velocity	2.320	fps
Top Width (T)	35.489	ft
Froude Number	0.262	
Critical Depth	1.581	ft
Critical Velocity	6.407	fps
Critical Slope	0.01244	ft/ft
Critical Top Width	24.487	ft
Max Shear Stress	0.149	lb/ft^2
Avg Shear Stress	0.103	lb/ft^2

North Flood Channel Design Information

Existing Conditions: Willow Creek Flood Channel





Proposed Conditions: Willow Creek Flood Channel

Proposed North Flood Channel (Willow Creek)

Type: Trapezoidal — Define...

Side Slope 1 (Z1):	2.0	H : 1V
Side Slope 2 (Z2):	2.0	H : 1V
Channel Width (B):	6.0	(ft)
Pipe Diameter (D):	0.0	(ft)
Longitudinal Slope:	0.012	(ft/ft)
Override Default		
Manning's Roughness:	0.0350	
Use Lining		
Lining Type:	Woven Paper Net	

Enter Flow: 725.000 (cfs)

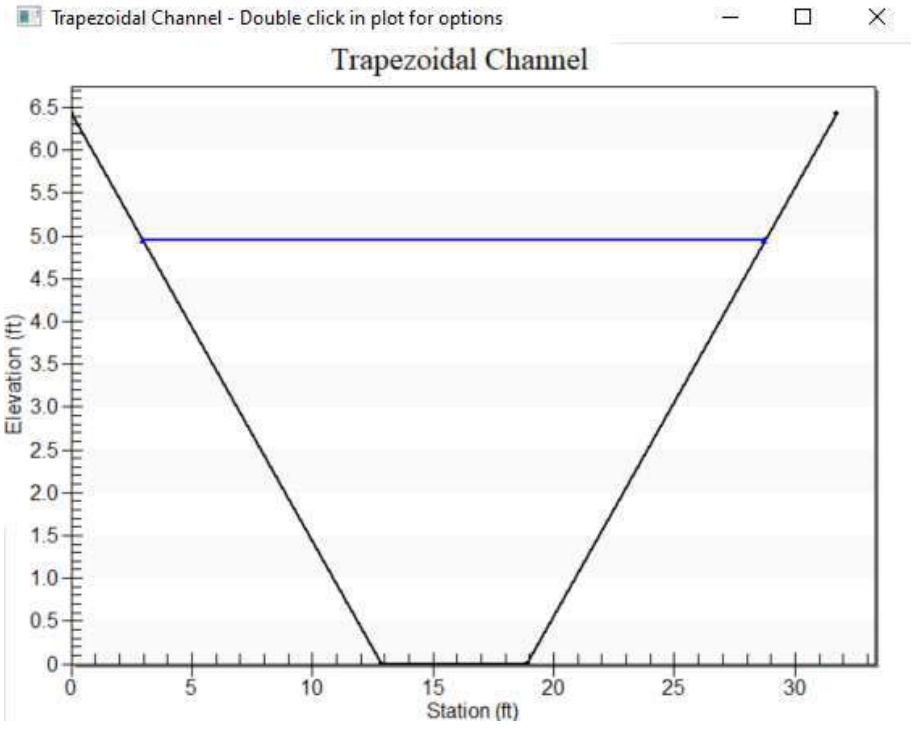
Enter Depth: 4.945 (ft)

Calculate

Plot... Compute Curves...

Parameter	Value	Unit
Flow	725.0...	cfs
Depth	4.945	ft
Area of Flow	78.574	sq ft
Wetted Perimeter	28.114	ft
Hydraulic Radius	2.795	ft
Average Velocity	9.227	fps
Top Width (T)	25.780	ft
Froude Number	0.931	
Critical Depth	4.776	ft
Critical Velocity	9.761	fps
Critical Slope	0.013...	ft/ft
Critical Top Width	25.104	ft
Max Shear Stress	3.703	lb/ft^2
Avg Shear Stress	2.093	lb/ft^2

OK Cancel



Proposed North FLood Channe Riprap

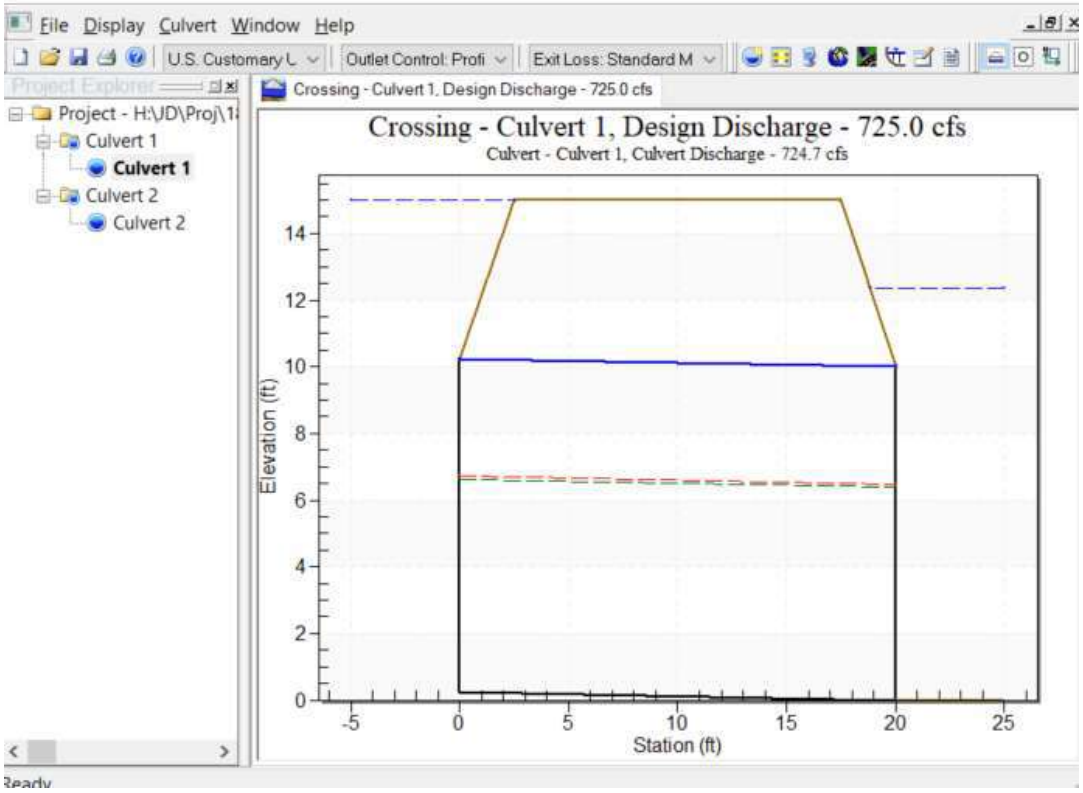
Lining: Riprap, Cobble, or Gravel

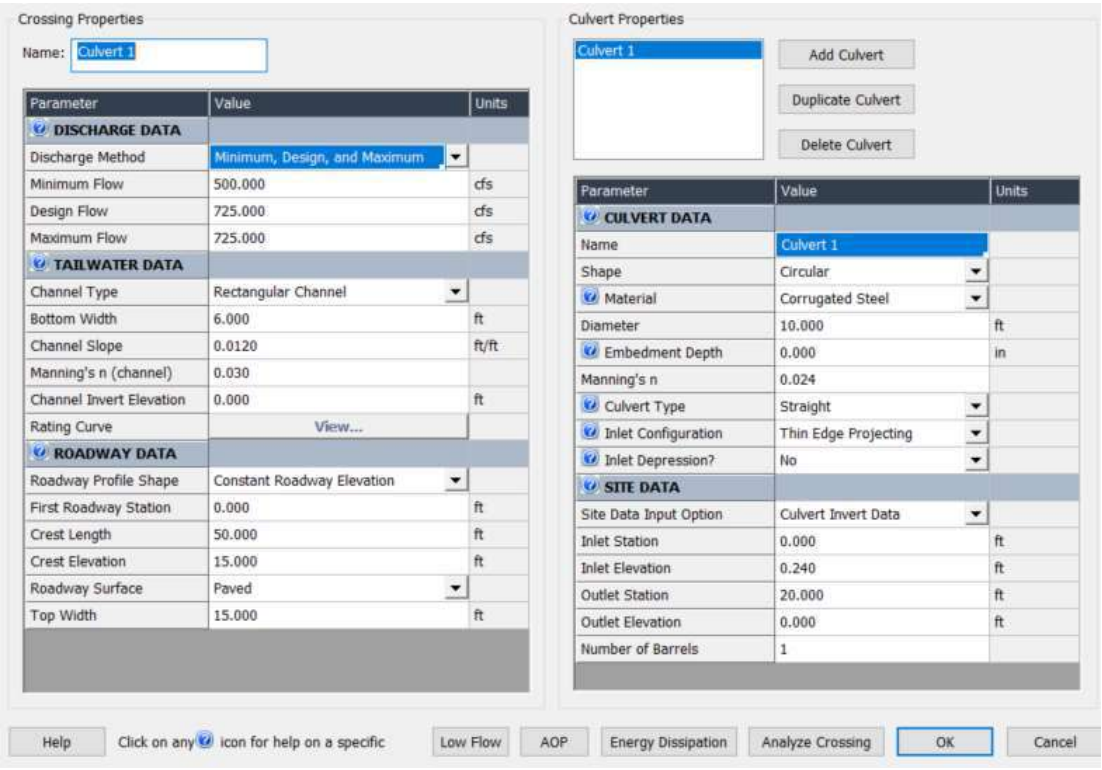
Parameter	Value	Units	Notes
	Channel Calculator...		
Design Flow	725.000	cfs	
Channel Depth	6.894	ft	
Slope	0.012	ft/ft	
Bottom Width	6.000	ft	
Side Slope 1	2.000	ft/ft	
Side Slope 2	2.000	ft/ft	
Area	136.425	ft^2	
Top Width	33.577	ft	
Wetted Perimeter	36.832	ft	
Hydraulic Radius	3.704	ft	
Average Velocity	5.314	ft/s	
Input Parameters			
D50	1.500	ft	
Riprap Specific Weight	165.000	lb/ft^3	
Water Specific Weight	62.400	lb/ft^3	
Riprap Shape	angular		This is used with D50 to compute the angle of repose (See HEC-1...
Safety Factor	1.000		
Calculated Safety Factor	**1.500**		
Results			
Riprap Properties			
Angle of Repose	41.900	Degre...	
Manning's n			
Relative Flow Depth	2.709		
n (Blodgett)	0.073		
Bottom Shear			
V*	1.632		
Reynold's Number	201168.947		
Shield's Parameter	0.150		
Maximum Shear Stress on the Channel Bottom	5.162	lb/ft^2	
Permissible Shear	23.085	lb/ft^2	
The channel bottom is stable			
Stable D50	0.503	ft	
Side Shear			
K1	0.802		
K2	0.743		
Kb	2.000		
Side Shear	4.140	lb/ft^2	
Permissible Side Shear	17.145	lb/ft^2	
The channel side is stable			
Stable Side D50	0.543	ft	
Bend Shear			
Curvature Radius	40.000	ft	No further correction will occur once R/T > 10
Shear in Bend Bottom	10.325	lb/ft^2	
The bottom of the bend is stable			
Length of Protection beyond PT	37.698	ft	
Additional Freeboard Required because of Su...	0.737	ft	
Shear on Bend Side	8.280	lb/ft^2	
The side of the bend is stable			

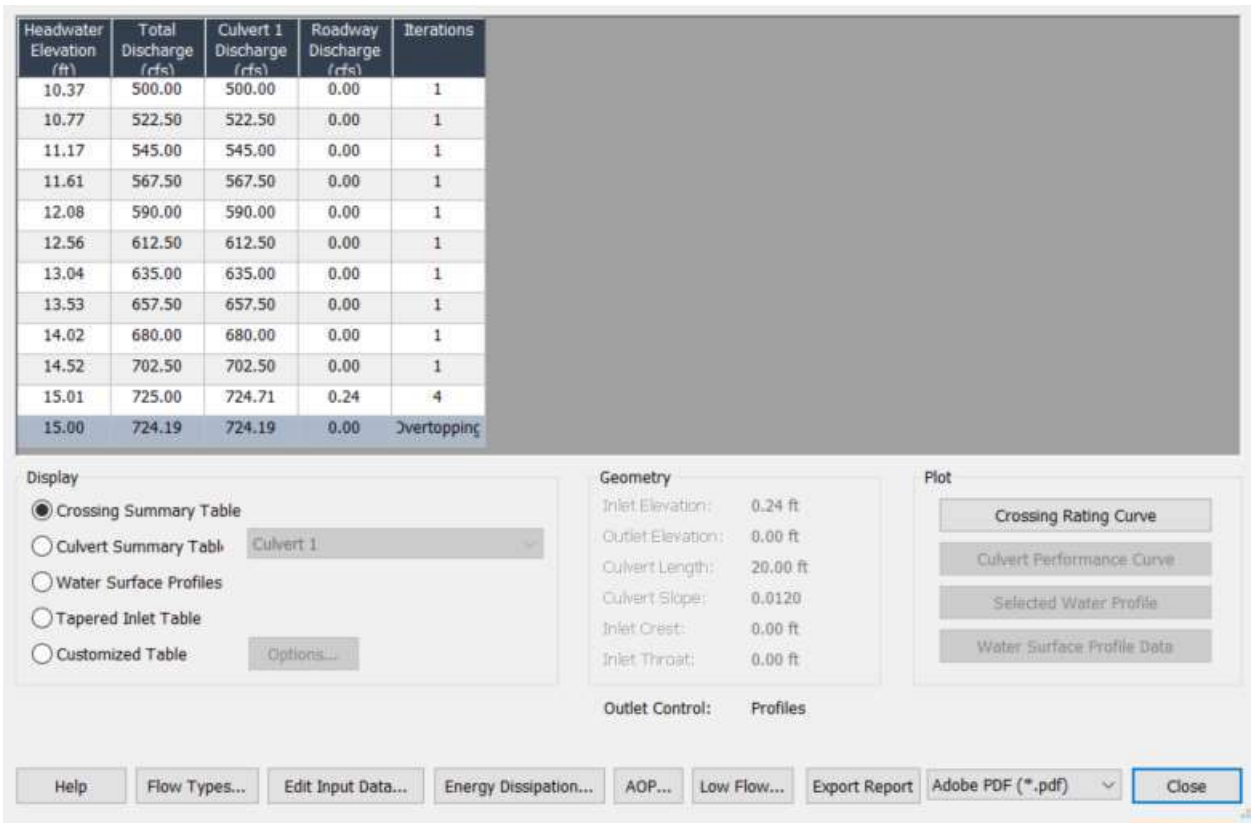
North Flood Channel: Culvert Exhibit



North Flood Channel: Culvert 1





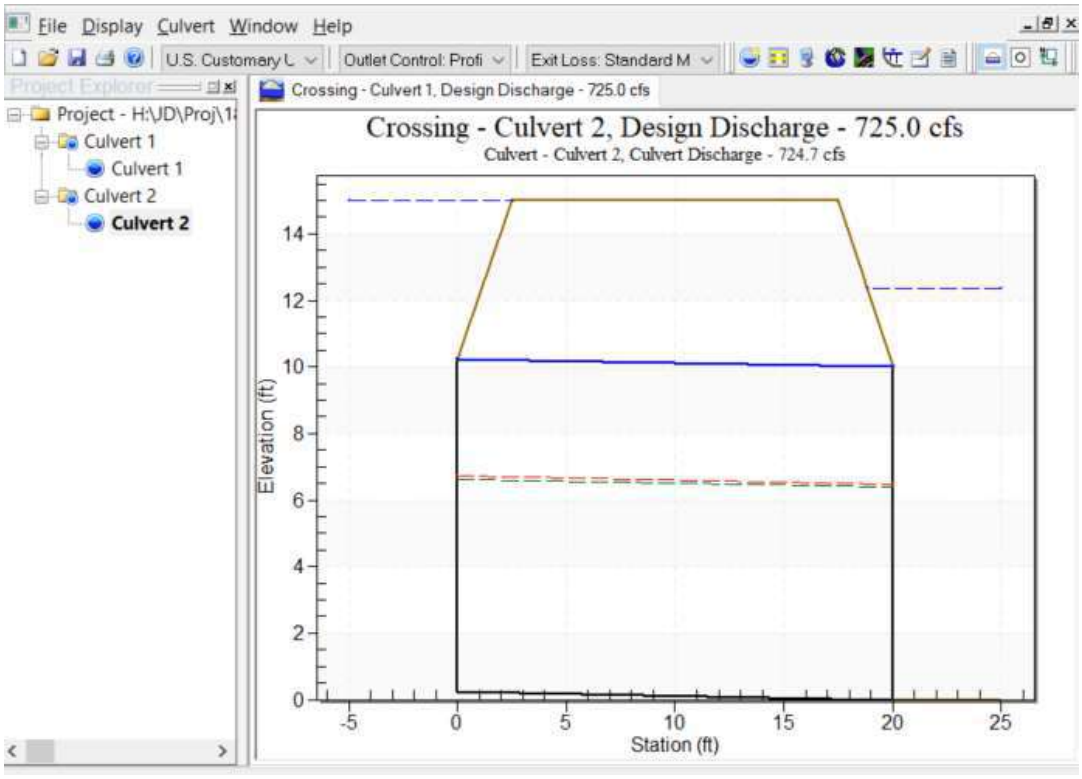


Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
10.37	500.00	500.00	0.00	1
10.77	522.50	522.50	0.00	1
11.17	545.00	545.00	0.00	1
11.61	567.50	567.50	0.00	1
12.08	590.00	590.00	0.00	1
12.56	612.50	612.50	0.00	1
13.04	635.00	635.00	0.00	1
13.53	657.50	657.50	0.00	1
14.02	680.00	680.00	0.00	1
14.52	702.50	702.50	0.00	1
15.01	725.00	724.71	0.24	4
15.00	724.19	724.19	0.00	Overtopping





North Flood Channel: Culvert 2



Crossing Properties

Name: Culvert 2

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	500.000	cfs
Design Flow	725.000	cfs
Maximum Flow	725.000	cfs
TAILWATER DATA		
Channel Type	Rectangular Channel	
Bottom Width	6.000	ft
Channel Slope	0.0120	ft/ft
Manning's n (channel)	0.030	
Channel Invert Elevation	0.000	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	50.000	ft
Crest Elevation	15.000	ft
Roadway Surface	Paved	
Top Width	15.000	ft

Culvert Properties

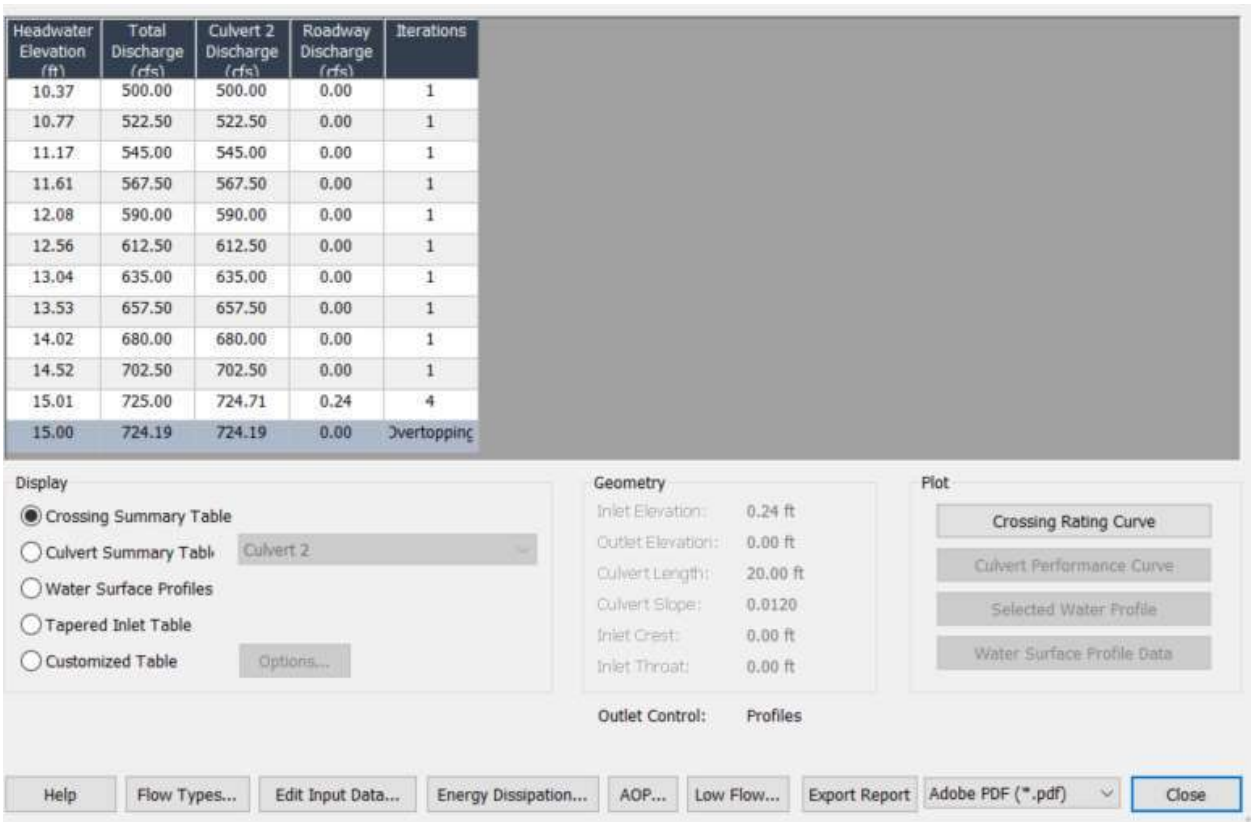
Culvert 2

Add Culvert

Duplicate Culvert

Delete Culvert

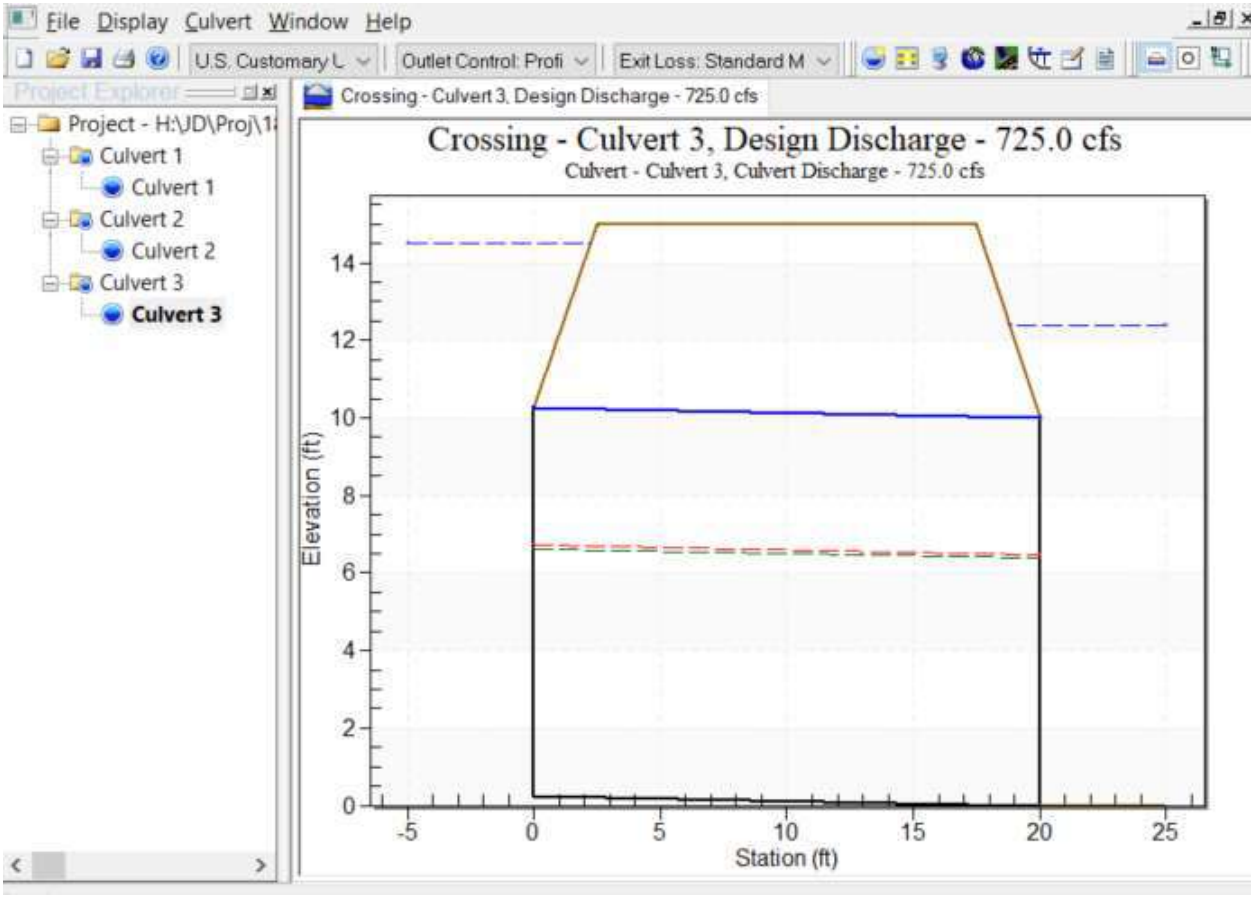
Parameter	Value	Units
CULVERT DATA		
Name	Culvert 2	
Shape	Circular	
Material	Corrugated PE	
Diameter	10.000	ft
Embedment Depth	0.000	in
Manning's n	0.024	
Culvert Type	Straight	
Inlet Configuration	Thin Edge Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	0.240	ft
Outlet Station	20.000	ft
Outlet Elevation	0.000	ft
Number of Barrels	1	



Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
10.37	500.00	500.00	0.00	1
10.77	522.50	522.50	0.00	1
11.17	545.00	545.00	0.00	1
11.61	567.50	567.50	0.00	1
12.08	590.00	590.00	0.00	1
12.56	612.50	612.50	0.00	1
13.04	635.00	635.00	0.00	1
13.53	657.50	657.50	0.00	1
14.02	680.00	680.00	0.00	1
14.52	702.50	702.50	0.00	1
15.01	725.00	724.71	0.24	4
15.00	724.19	724.19	0.00	Overtopping



North Flood Channel: Culvert 3



Crossing Properties

Name: Culvert 3

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	500.000	cfs
Design Flow	725.000	cfs
Maximum Flow	725.000	cfs
TAILWATER DATA		
Channel Type	Rectangular Channel	
Bottom Width	6.000	ft
Channel Slope	0.0120	ft/ft
Manning's n (channel)	0.030	
Channel Invert Elevation	0.000	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	50.000	ft
Crest Elevation	15.000	ft
Roadway Surface	Paved	
Top Width	15.000	ft

Culvert Properties

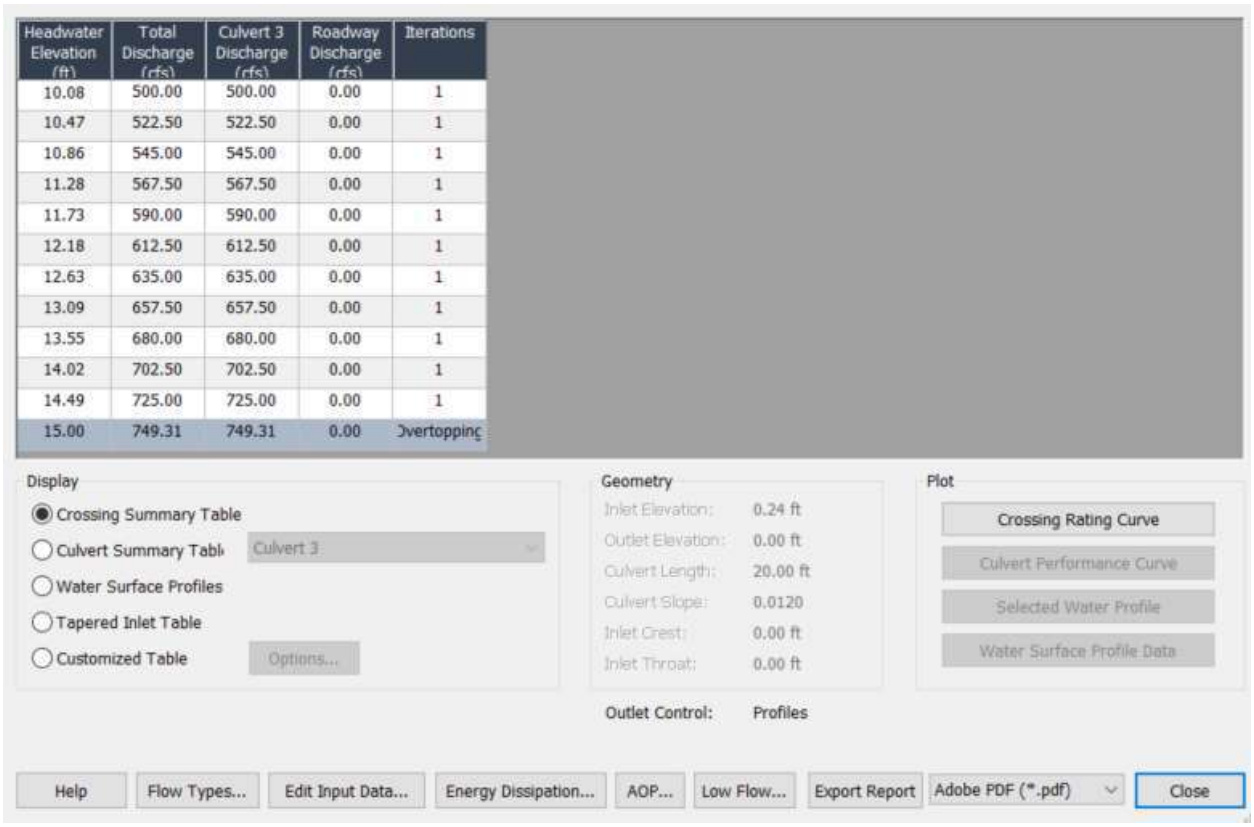
Culvert 3

Add Culvert

Duplicate Culvert

Delete Culvert

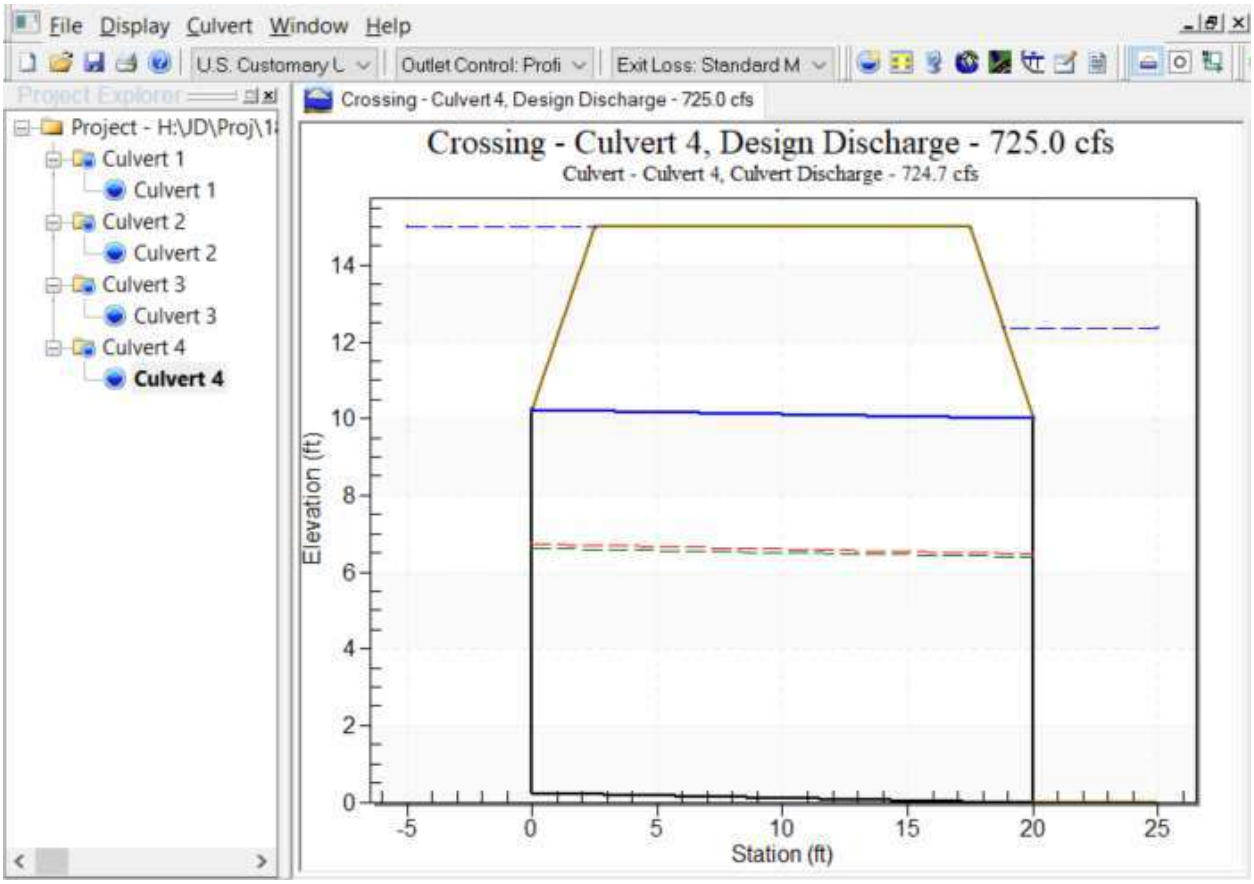
Parameter	Value	Units
CULVERT DATA		
Name	Culvert 3	
Shape	Circular	
Material	Corrugated Steel	
Diameter	10.000	ft
Embedment Depth	0.000	in
Manning's n	0.024	
Culvert Type	Straight	
Inlet Configuration	Square Edge with Headwall	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	0.240	ft
Outlet Station	20.000	ft
Outlet Elevation	0.000	ft
Number of Barrels	1	



Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 3 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
10.08	500.00	500.00	0.00	1
10.47	522.50	522.50	0.00	1
10.86	545.00	545.00	0.00	1
11.28	567.50	567.50	0.00	1
11.73	590.00	590.00	0.00	1
12.18	612.50	612.50	0.00	1
12.63	635.00	635.00	0.00	1
13.09	657.50	657.50	0.00	1
13.55	680.00	680.00	0.00	1
14.02	702.50	702.50	0.00	1
14.49	725.00	725.00	0.00	1
15.00	749.31	749.31	0.00	Overtopping



North Flood Channel: Culvert 4



Crossing Properties

Name: Culvert 4

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	500.000	cfs
Design Flow	725.000	cfs
Maximum Flow	725.000	cfs
TAILWATER DATA		
Channel Type	Rectangular Channel	
Bottom Width	6.000	ft
Channel Slope	0.0120	ft/ft
Manning's n (channel)	0.030	
Channel Invert Elevation	0.000	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	50.000	ft
Crest Elevation	15.000	ft
Roadway Surface	Paved	
Top Width	15.000	ft

Culvert Properties

Culvert 4

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 4	
Shape	Circular	
Material	Corrugated Steel	
Diameter	10.000	ft
Embedment Depth	0.000	in
Manning's n	0.024	
Culvert Type	Straight	
Inlet Configuration	Thin Edge Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	0.240	ft
Outlet Station	20.000	ft
Outlet Elevation	0.000	ft
Number of Barrels	1	

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 4 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
10.37	500.00	500.00	0.00	1
10.77	522.50	522.50	0.00	1
11.17	545.00	545.00	0.00	1
11.61	567.50	567.50	0.00	1
12.08	590.00	590.00	0.00	1
12.56	612.50	612.50	0.00	1
13.04	635.00	635.00	0.00	1
13.53	657.50	657.50	0.00	1
14.02	680.00	680.00	0.00	1
14.52	702.50	702.50	0.00	1
15.01	725.00	724.71	0.24	4
15.00	724.19	724.19	0.00	Overtopping

Display

- (●) Crossing Summary Table
- ( ) Culvert Summary Table — Culvert 4
- ( ) Water Surface Profiles
- ( ) Tapered Inlet Table
- ( ) Customized Table — Options...

Geometry

Inlet Elevation:	0.24 ft
Outlet Elevation:	0.00 ft
Culvert Length:	20.00 ft
Culvert Slope:	0.0120
Inlet Crest:	0.00 ft
Inlet Throat:	0.00 ft

Outlet Control: Profiles

Plot

- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Existing Conditions: Richfield Canal for North Flood Channel

Existing Richfield Canal

Type: Cross Section | Define...

Side Slope 1 (Z1): 0.0 H : 1V

Side Slope 2 (Z2): 0.0 H : 1V

Channel Width (B): 0.0 (ft)

Pipe Diameter (D): 0.0 (ft)

Longitudinal Slope: 0.0016 (ft/ft)

Override Default

Manning's Roughness: 0.0300

Use Lining

Lining Type: Woven Paper Net

Enter Flow: 100.000 (cfs)

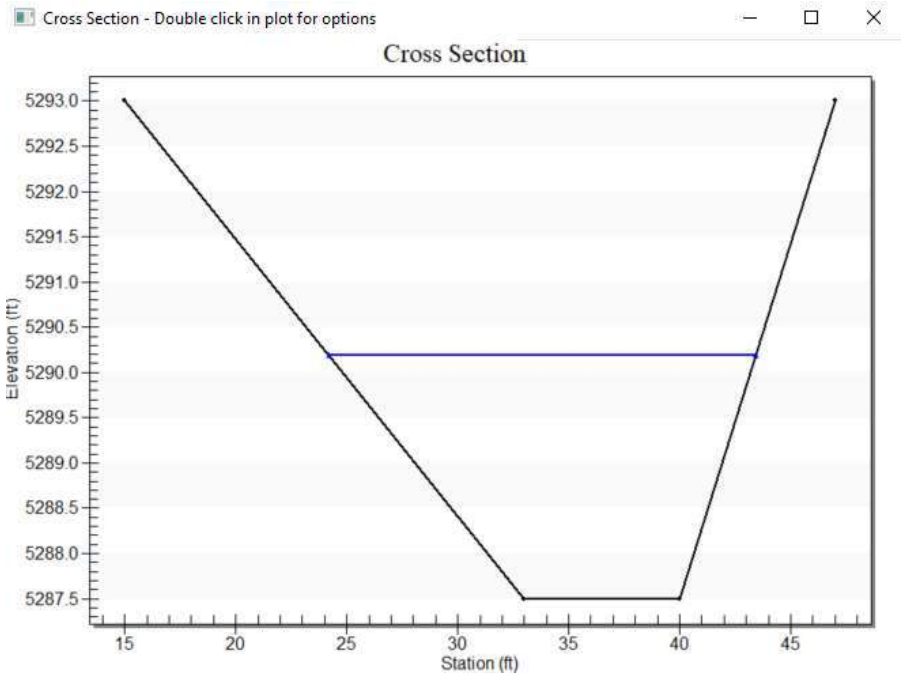
Enter Depth: 2.688 (ft)

Calculate

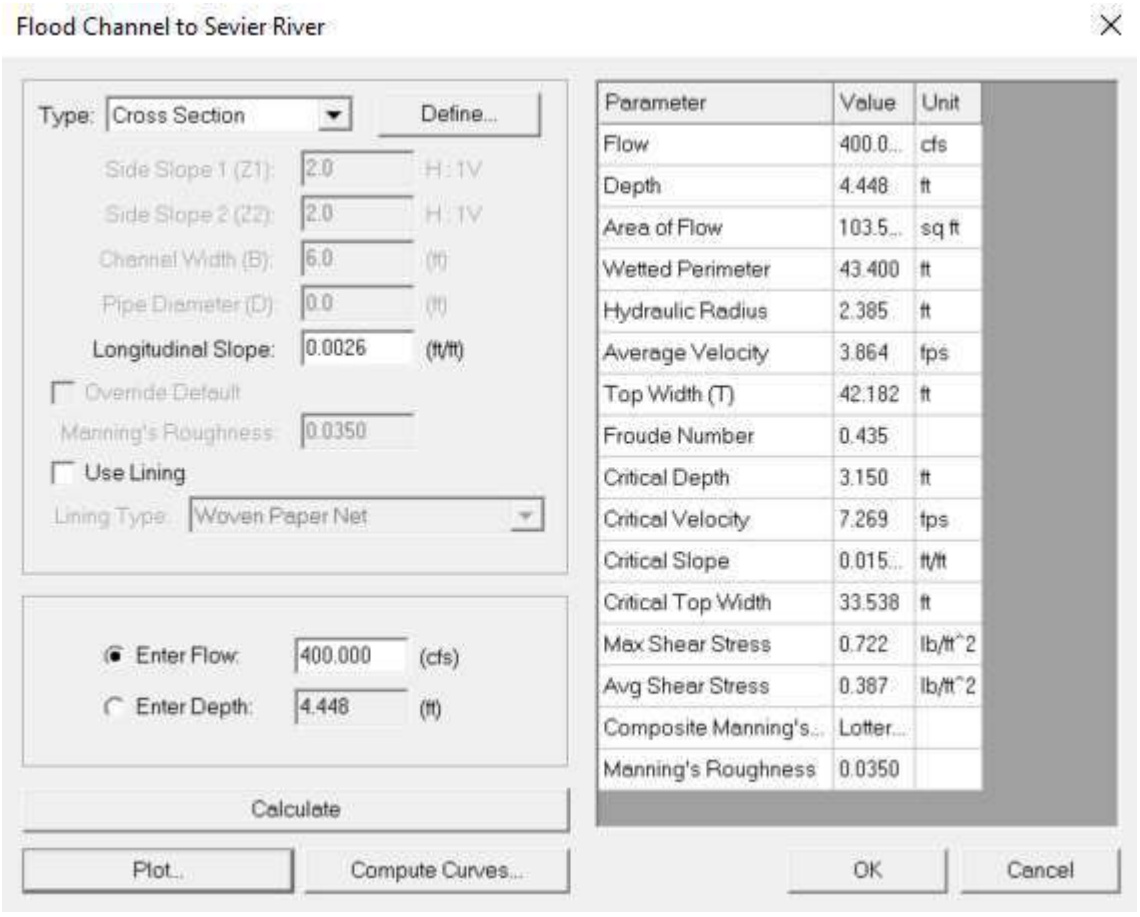
Plot... | Compute Curves...

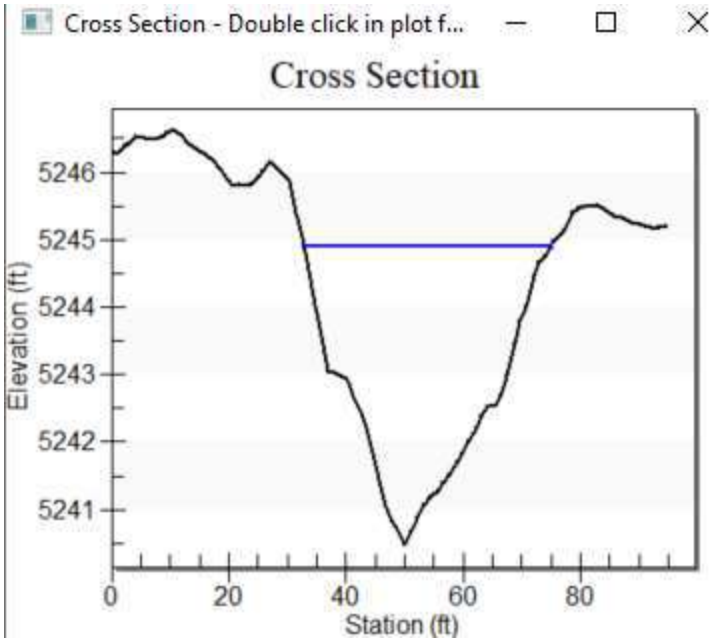
Parameter	Value	Unit
Flow	100.0...	cfs
Depth	2.688	ft
Area of Flow	35.232	sq ft
Wetted Perimeter	20.548	ft
Hydraulic Radius	1.715	ft
Average Velocity	2.838	fps
Top Width (T)	19.217	ft
Froude Number	0.369	
Critical Depth	1.552	ft
Critical Velocity	6.119	fps
Critical Slope	0.013...	ft/ft
Critical Top Width	14.056	ft
Max Shear Stress	0.268	lb/ft^2
Avg Shear Stress	0.171	lb/ft^2
Composite Manning's...	Lotter...	
Manning's Roughness	0.0300	

OK | Cancel

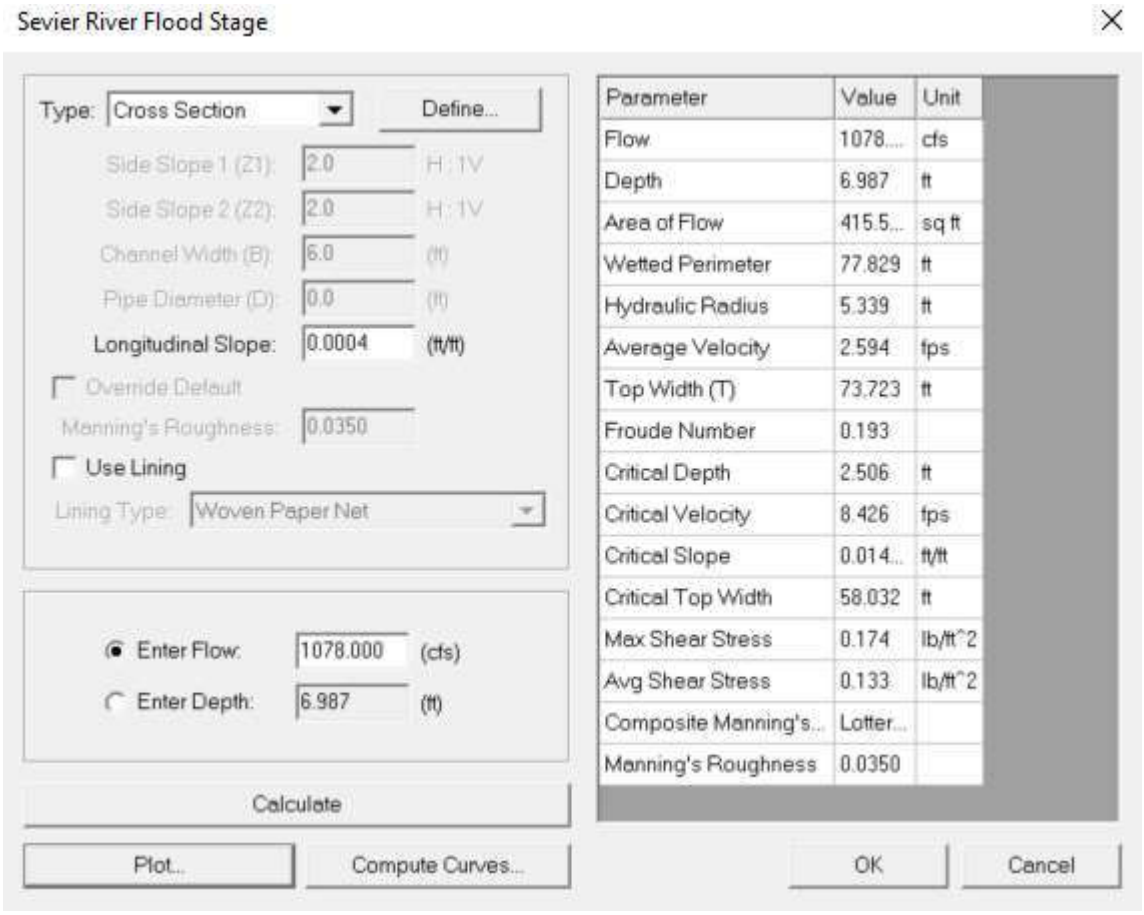


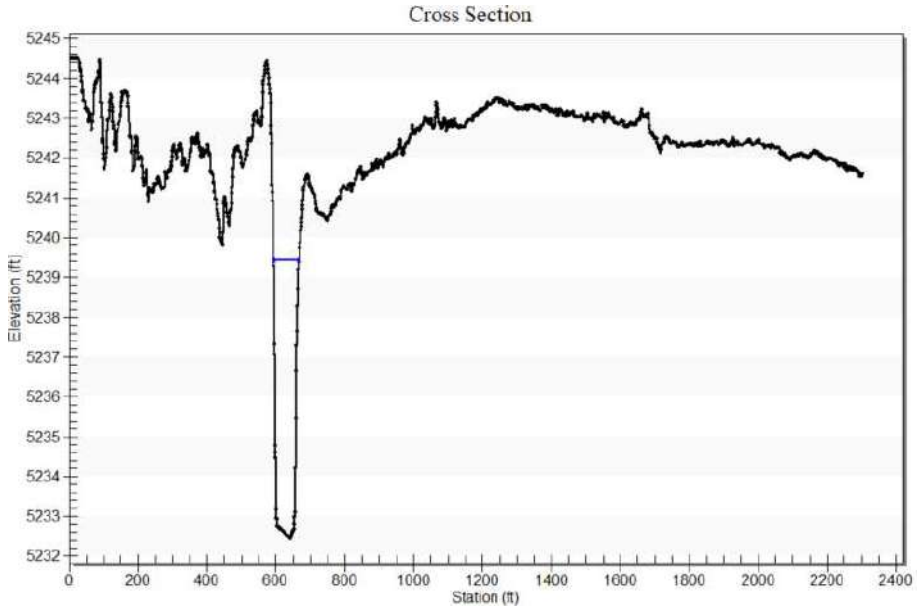
North Flood Channel to Sevier River



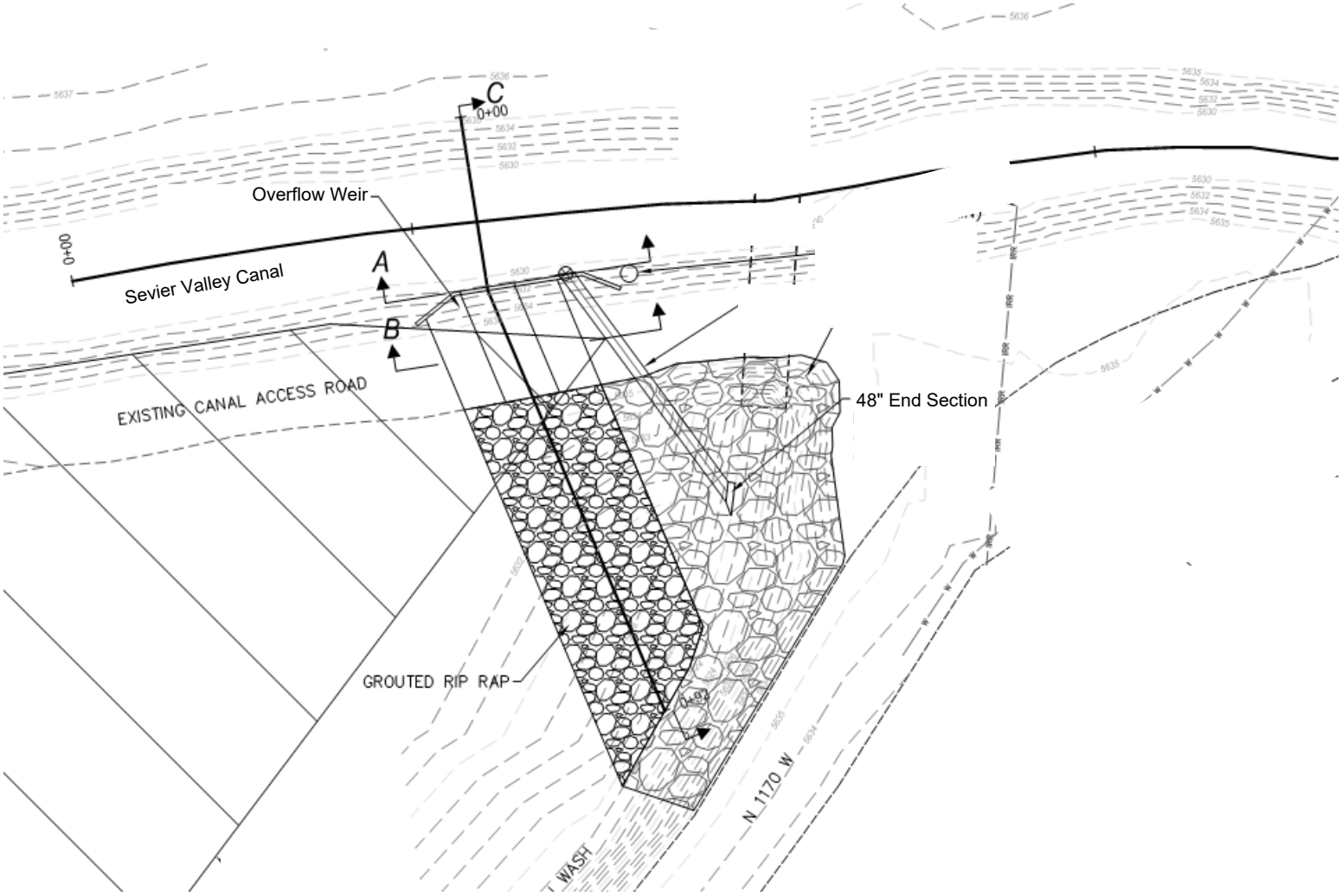


North Flood Channel Sevier River Tailwater Analysis

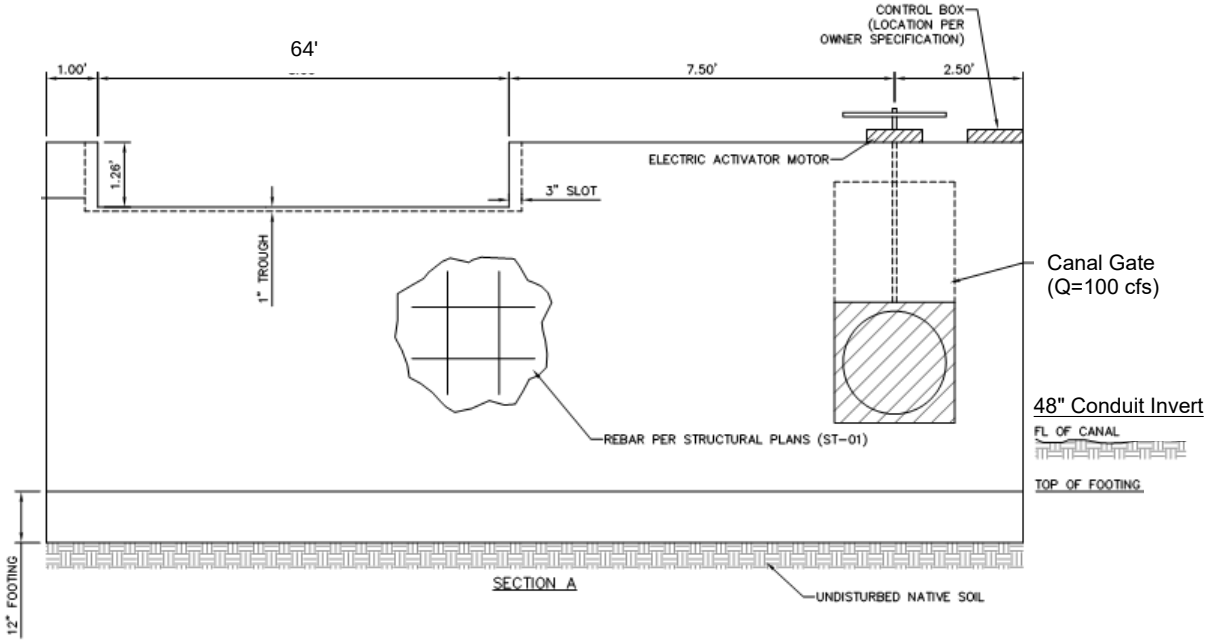




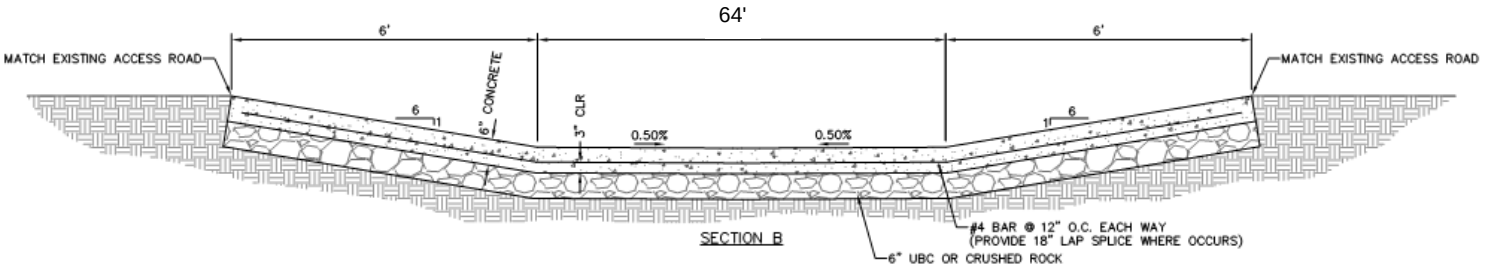
Attachment D. Overflow Weir Details



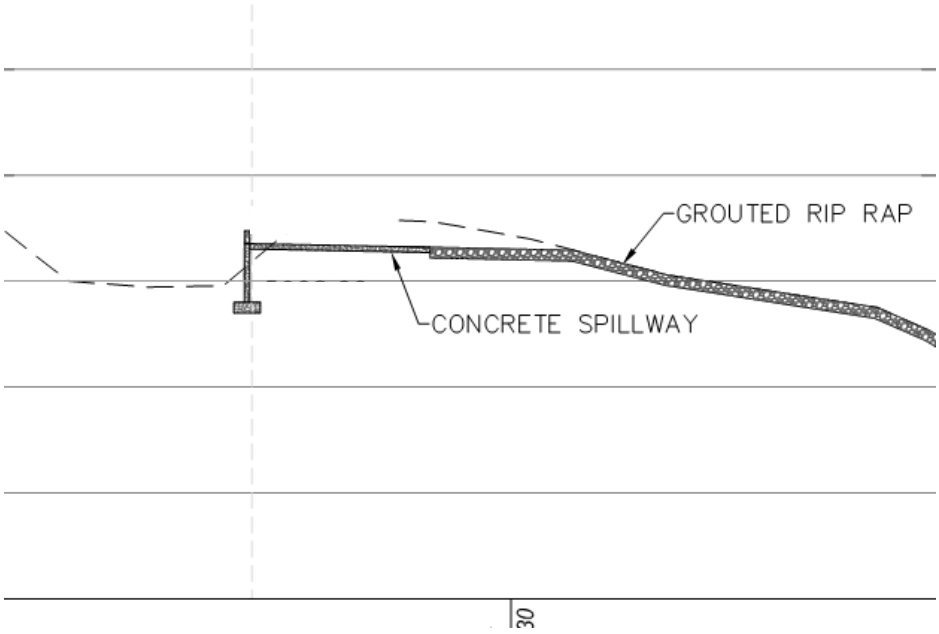
Sevier Valley Canal Emergency Overflow Plan View



Section A



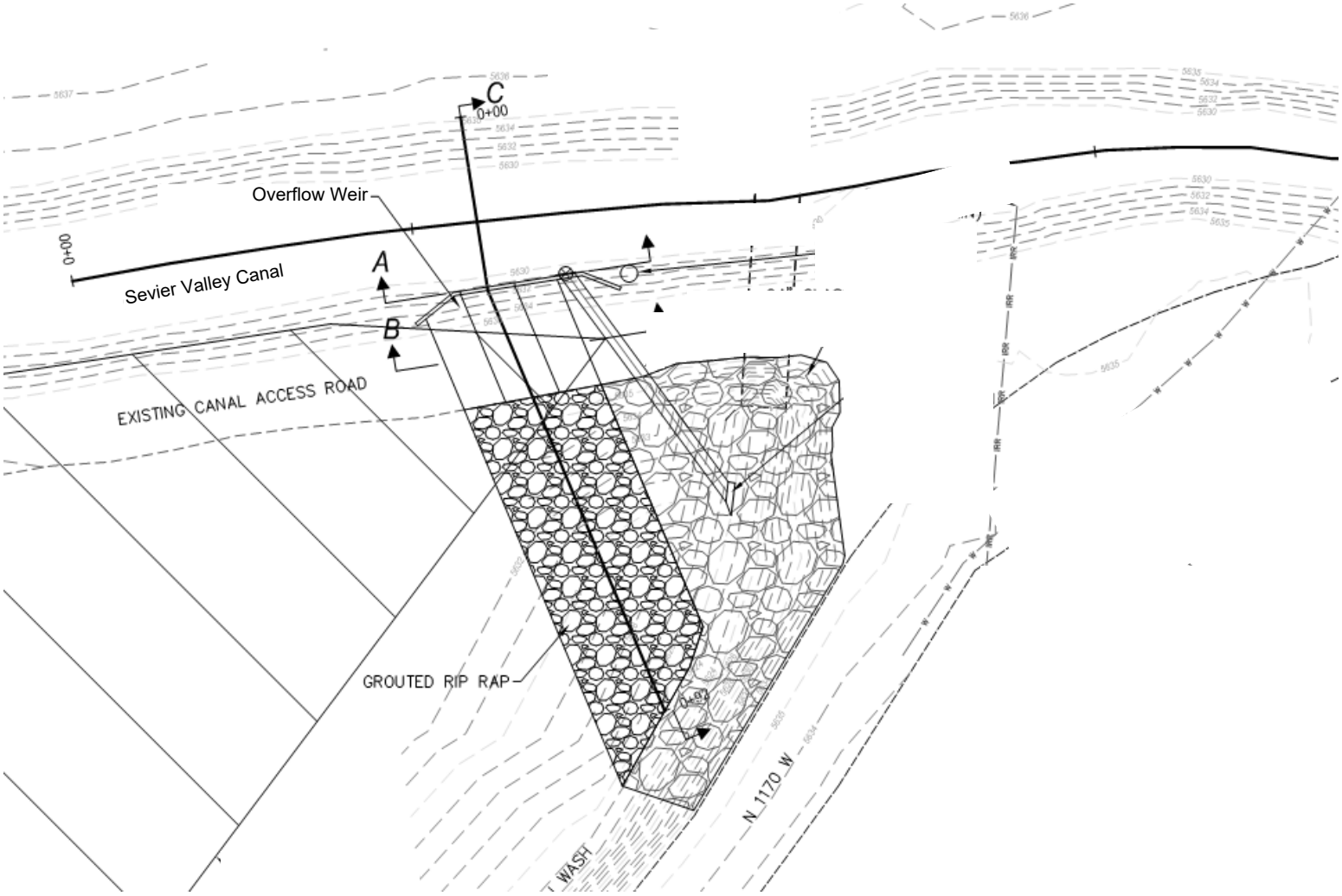
Section B



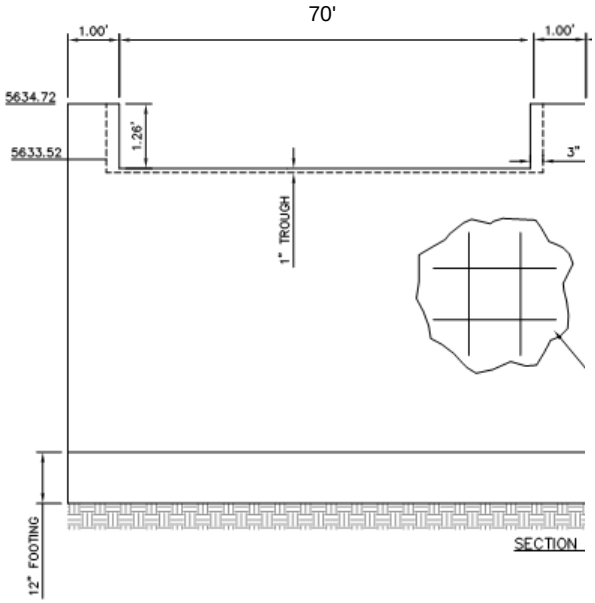
Section C

Canal Depth (ft)*	Canal Flows (cfs)*	Weir Head (ft)	Weir Flow (cfs)
2.825	150	0	0.0
2.861	154	0.036	0.9
2.921	161	0.096	3.8
2.981	168	0.156	7.9
3.038	175	0.213	12.6
3.095	182	0.27	18.0
3.15	189	0.325	23.7
3.204	196	0.379	29.9
3.256	203	0.431	36.2
3.308	210	0.483	43.0
3.359	217	0.534	49.9
3.408	224	0.583	57.0
3.457	231	0.632	64.3
3.505	238	0.68	71.8
3.552	245	0.727	79.3
3.598	252	0.773	87.0
3.644	259	0.819	94.9
3.689	266	0.864	102.8
3.733	273	0.908	110.7
3.776	280	0.951	118.7
3.819	287	0.994	126.8
3.861	294	1.036	135.0
3.903	301	1.078	143.3
3.944	308	1.119	151.5
3.984	315	1.159	159.7
4.024	322	1.199	168.1
4.063	329	1.238	176.3
4.102	336	1.277	184.7
4.14	343	1.315	193.0
4.178	350	1.353	201.4

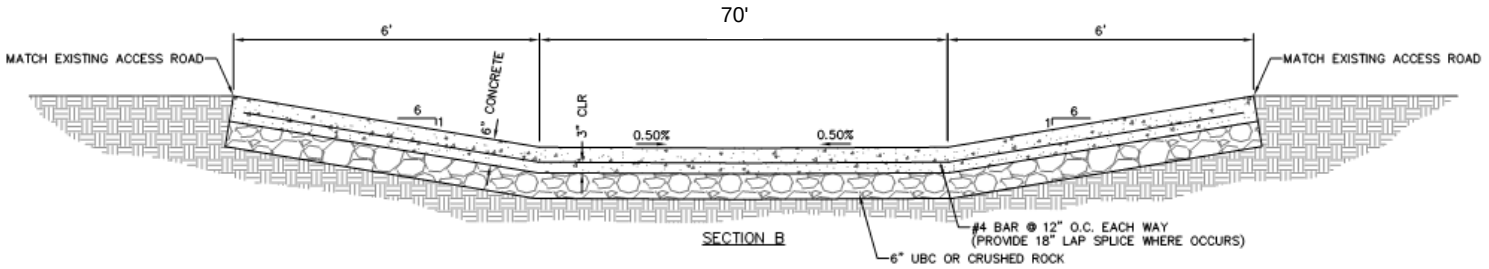
Flow Table



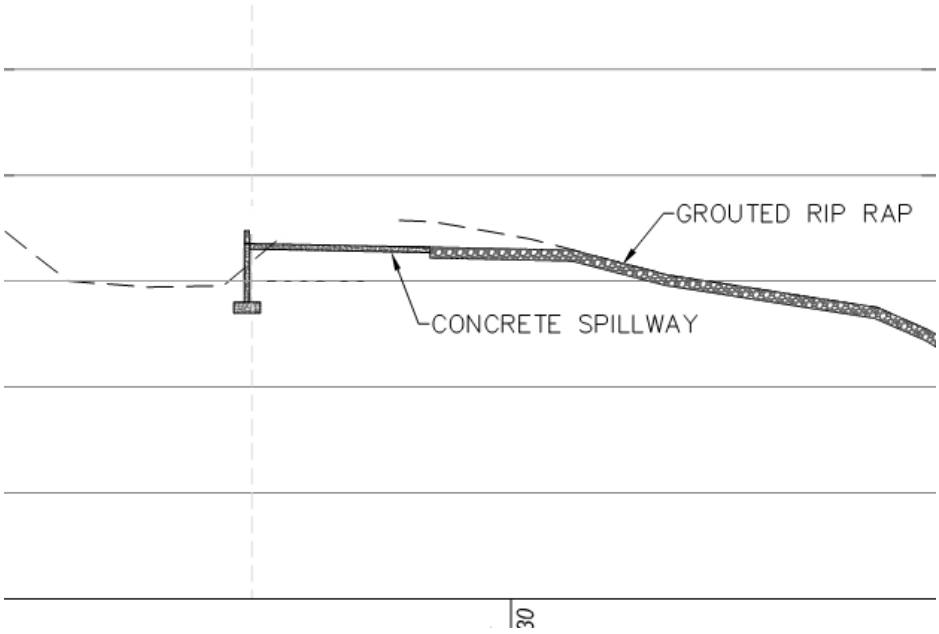
Richfield Canal Emergency Overflow Plan View



Section A



Section B



Section C

Canal Depth (ft)*	Canal Flows (cfs)*	Weir Head (ft)	Weir Flow (cfs)
3.805	204.0	0.036	1.0
3.858	210.0	0.089	3.7
3.91	216.0	0.141	7.4
3.961	222.0	0.192	11.8
4.011	228.0	0.242	16.7
4.061	234.0	0.292	22.1
4.11	240.0	0.341	27.9
4.158	246.0	0.389	34.0
4.205	252.0	0.436	40.3
4.252	258.0	0.483	47.0
4.298	264.0	0.529	53.9
4.343	270.0	0.574	60.9
4.388	276.0	0.619	68.2
4.432	282.0	0.663	75.6
4.476	288.0	0.707	83.2
4.519	294.0	0.75	90.9
4.562	300.0	0.793	98.9

Flow Table

TM005 - Geotechnical



TM005 Geotechnical

Sevier Watershed Plan and Environmental Assessment
Sevier County, Utah

Jones & DeMille Engineering, Inc.

Project reference: Sevier Watershed Plan
Project number: 60598028

August 12, 2019

Darin Robinson, Principal
1535 South 100 West
Richfield, UT 84701

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Revision History

Revision	Revision date	Details	Authorized	Name	Position
0	06/26/2019	Initial	BWF		
1	08/12/2019	Flat Canyon Elevation 5609 feet	BWF		

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Table of Contents

1. INTRODUCTION 6
1.1 Scope of Services 6
1.2 Project Description 6
1.3 Site Description 7
1.4 Existing Geotechnical Reports 8
2. SITE CHARACTERIZATIONS 9
2.1 Regional geology 9
2.1.1 Faulting and Mass Movement 10
2.1.1.1 Elsinore Fault 10
2.1.1.2 Bedding-Plane Slip 10
2.1.1.3 Mass Movement Age 11
2.1.2 Local Geology 11
2.1.2.1 Wood Canyon 11
2.1.2.2 Tank Canyon 13
2.1.2.3 Lind Canyon 15
2.1.2.4 Flat Canyon 17
2.2 Geologic Hazards 19
2.2.1 Seismicity 19
2.2.1.1 Seismic Design 19
2.2.1.2 Liquefaction 20
3. FIELD INVESTIGATION AND LABORATORY TESTING 21
3.1 Field Explorations 21
3.2 Site Conditions 24
3.2.1 Wood Canyon 24
3.2.2 Tank Canyon 25
3.2.3 Lind Canyon 26
3.2.4 Flat Canyon 26
3.2.5 Groundwater 26
3.3 Laboratory Testing 27
4. GEOTECHNICAL ANALYSIS 28
4.1 Embankment Geometry 28
4.2 Seepage Analysis 28
4.2.1 Model Parameters 29
4.2.2 Results 29
4.3 Slope Stability Analysis 30
4.3.1 Analysis Cases 30
4.3.1.1 Steady-State Drained Case 30
4.3.1.2 Undrained (End of Construction) Case 31
4.3.1.3 Pseudostatic Case 31
4.3.1.4 Post-Earthquake Case 31
4.3.1.5 Rapid (Instantaneous) Drawdown 31
4.3.2 Material Properties 31
4.3.3 Phreatic Conditions 32
4.3.4 Results 32
4.4 Filter Compatibility 33
4.5 Settlement 33

5. CONCLUSIONS AND RECOMMENDATIONS 34
6. LIMITATIONS 36
7. REFERENCES 37

Tables

Table 1-1. Summary of Debris Basin Geometries Considered for Geotechnical Analysis 7
Table 2-1. Summary of NRCS Seismic Design Parameters 20
Table 2-2. Summary of Utah Administrative Code Seismic Design Parameters 20
Table 3-1. Summary of AECOM Field Explorations 21
Table 3-2. Summary of Selected Laboratory Test Results 27
Table 4-1. Summary of Seepage Model Parameters 29
Table 4-2. Summary of Estimated Toe Drain Discharge 30
Table 4-3. Summary of Required Minimum Factors of Safety 30
Table 4-4. Summary of Selected Unit Weight and Strength Material Properties 32
Table 4-5. Summary of Factors of Safety against Slope Instability 32

Figures

Figure 2-1. Geologic map of Wood Canyon Site (Willis 1994). 13
Figure 2-2. Geologic map of Tank Canyon Site (Willis 1994). 15
Figure 2-3. Geologic Map of Lind Canyon Site (Willis 1994) 16
Figure 2-4. Geologic Map of Flat Canyon Site (Hintze 2003) 17

Photographs

Photo 2-1. Photograph of Exposed Flagstaff Formation, Upper Red Member. 12
Photo 2-2. Photograph of the North Embankment Area of Tank Canyon Site Showing V-Folded Syncline. 14
Photo 2-3. Photograph of the Center Embankment Area of Tank Canyon. 14
Photo 2-4. Photograph of the Center Embankment Area of Lind Canyon 16
Photo 2-5. Photograph of Boulder in Flat Canyon wash. 18
Photo 2-6. Photograph of Flat Canyon Wash. 18
Photo 3-1: View of a Track-Mounted Drill Rig Used for Drilling 23
Photo 3-2: View of a Track-Mounted Excavator Used for Test Pitting 24
Photo 3-3: View of Floor and Wall in Wood Canyon Wash 25

List of Attachments

Attachment A Figures
Attachment B Existing Reports
Attachment C Boring Logs
Attachment D Test Pit Logs
Attachment E Laboratory Test Data
Attachment F Seepage and Slope Stability Results
Attachment G Recommended Filter Bands

1. INTRODUCTION

AECOM Technical Services, Inc., (AECOM) is pleased to provide this geotechnical report presenting findings and recommendations in support of the Sevier Watershed Plan and Environmental Assessment (EA) performed by Jones & DeMille Engineering, Inc., (Jones & DeMille). The purpose of this study was to provide an assessment of geotechnical-related considerations pertaining to the proposed project sites based on our subsurface explorations, laboratory testing, and analysis. The findings and recommendations presented in this report are based on our understanding of the project and encountered surface and subsurface conditions at the project sites.

Based on information provided to us by Jones & DeMille, the general location of each of the basins considered in this report is near the mouths of drainages at Wood Canyon, Tank Canyon, Lind Canyon, and Flat Canyon. The debris basins will reduce peak flows during a flood and capture loose material such as sediment, gravel, boulders, and vegetative debris that are washed out of the canyons during storms. This will greatly reduce the potential for debris to block existing channels and overflow. These improvements will help protect the homes, businesses, roads, and utilities below the basins from damage during a high runoff storm event. AECOM also understands that the proposed design will retain enough storage volume within each basin to provide 100 years of sediment storage and still contain the design inflow.

1.1 Scope of Services

AECOM's geotechnical scope of services for this study included the following:

- Review of available geotechnical data, aerial photographs, and published geologic maps, soil data, and literature.
- Coordination and mobilization for subsurface exploration. Marking existing public utilities was conducted through Blue Stakes of Utah.
- Drilling, test pitting, logging, and sampling of 4 exploratory borings and 12 test pits to depths ranging from 6 to 59 feet near the locations of potential debris basin embankment sites. The purposes of the subsurface explorations were to gather data regarding subsurface conditions and to obtain soil samples for laboratory testing.
- Assignment and performance of laboratory tests to provide physical and engineering properties of subsurface soils, consisting of gradation, Atterberg limits, and modified proctor.
- Compilation and analysis of the accumulated data for seepage, slope stability, settlement, and filter compatibility, for proposed embankment sections.
- Preparation of this report presenting our data, findings, and engineering recommendations.

1.2 Project Description

The project comprises four debris basins in four different canyons including Wood Canyon, Tank Canyon, Lind Canyon, and Flat Canyon. Dam cross sections developed in this report are preliminary in nature to determine project feasibility and require additional investigations and assessments in future designs. Jones & DeMille performed engineering analysis and development of hydrology, sediment and water storage volume, and embankment height. AECOM's understanding of each embankment's proposed location, height, and length, are based on Jones & DeMille's work.

The proposed basin in Wood Canyon would contain the tallest embankment being approximately 65 feet tall and providing approximately 89 acre-feet of storage at the spillway crest. The 100-year sediment storage volume for Wood Canyon would be approximately half of this volume. The embankment in Flat Canyon would be approximately 67 feet tall making this basin in Flat Canyon the largest storage volume at approximately 809 acre-feet. The 100-year

sediment storage volume for Flat Canyon would be approximately half of this at approximately 359 acre-feet of sediment.

The embankments in Tank and Lind Canyons are proposed to be constructed in two segments bisected by existing geologic features. The embankments in Tank and Lind Canyons would be approximately 32 and 30 feet tall, respectively. Tank Canyon would provide approximately 40 acre-feet of storage while Lind Canyon would provide approximately 63 acre-feet of storage at the spillway crest. The 100-year sediment storage volume for these basins would be approximately 50 to 60 percent of this volume. Design plan, section, and profile drawings, which were considered in this report and which were used for supporting geotechnical analysis, are provided in Attachment A.

The embankments are each to be constructed with zoned soils consisting of a clay core, a downstream filter zone with a toe drain, and upstream and downstream shells composed of compacted granular fill from within the basins. The upstream slopes are planned with slopes of 3 horizontal to 1 vertical (3H:1V) and downstream slopes as 2.5H:1V. The crest widths were assumed to be 12 feet wide for preparation of this document; however, during final design, embankment crest widths of at least 14 feet should be considered in accordance with TR-210-60 (Natural Resources Conservation Service [NRCS] 2019) for embankments that more than 25-feet tall and less than 95 feet tall. The basic geometries of each of the analyzed embankments are summarized in Table 1-1.

The Utah Division of Water Rights, Dam Safety, and Natural Resources Conservation Service (NRCS), in accordance with guidelines outlined in TR-210-60 (NRCS 2019), classify dams considering a number of different factors and may include the damage that might occur to existing and future developments as a result of a breach, effect of major infrastructure and utilities, effect of failure on public confidence, site characteristics, and potential for loss of life. Because failure may result in downstream losses to both life and property, impacts to important public utilities and main highways, embankment height, and basin storage volume, these structures are assumed to be high hazard potential facilities.

Table 1-1. Summary of Debris Basin Geometries Considered for Geotechnical Analysis

Debris Basin	Embankment Height (ft)	Crest Elevation (ft)	Spillway Elevation (ft)	100-Year Sediment Elevation (ft)	Design Water Depth at 100 Years (ft)	Crest Width [1] (ft)	Upstream Slope [1] (H:V)	Downstream Slope [1] (H:V)
Wood Canyon [2]	65	5,670	5,662	5,650	12	--	--	--
Flat Canyon	67	5,609	5,599	5,579	22	12	3:1	2.5:1
Tank Canyon	32	5,457	5,449	5,444	5	12	3:1	2.5:1
Lind Canyon	30	5,450	5,442	5,434	8	12	3:1	2.5:1

Notes: ft = feet; H = horizontal; V = vertical, '--' denotes a blank entry

1. The crest width, upstream slope, and downstream slope dimensions shown here were assumed for geotechnical analysis presented in this document. Accordingly, these parameters may not be consistent with NRCS and Utah Dam Safety design recommendations, which are presented elsewhere.
2. It was concluded that the abutments were not suitable for dam construction without significant modification. Accordingly, the following subsections only present analysis and results for Tank Canyon, Lind Canyon, and Flat Canyon, structures; Wood Canyon was excluded from analysis and further consideration.

1.3 Site Description

The proposed basins and drainages are located approximately west of Richfield, Utah, and just west of Interstate Highway 70 (I-70) through Central Utah. The project sites are generally bounded by steep canyon walls at either end of each proposed embankment. Each of the proposed basin sites was accessible by unpaved road and covered with sparse vegetation, generally consisting of brush and grasses. Very few trees were observed.

There are no existing buried facilities that were identified at any of the project sites. However, the Tank and Lind Canyon sites contain existing geologic features bisecting the proposed embankment that support overhead power poles. These poles support power lines overhead across some parts of the proposed embankment footprints. Flat Canyon also has overhead powerlines, but these were not observed in the vicinity of the proposed footprint of the embankment.

1.4 Existing Geotechnical Reports

Schick International, Inc., performed a feasibility-level investigation and prepared a report for flood control basins to mitigate flood damages resulting from discharge from 23 square miles of mountainous area west of Richfield, Utah (Schick International Inc. 1977). This report presented flood plan information along with preliminary hydrologic, geologic, and economic discussion. Deming and Bridges (1976) also prepared a geologic report addressing faulting and seismicity in the area. This report specifically addressed geologic conditions in Flat, Dairy-Rulon Lind, and Tank Canyons. These documents were reviewed and considered in preparation of this geotechnical report. The Schick International Inc. (1977) report is included as an attachment to TM002 and the Deming and Bridges (1976) report is included as Attachment B to this document.

2. SITE CHARACTERIZATIONS

The following sections provide descriptions of regional geology, geologic hazards, and mapped soil conditions for the proposed projects.

2.1 Regional geology

The study area is located west of Richfield, Utah, on the margin between the eastern lower slopes of the Pahvant Range and Sevier Valley and is part of the High Plateaus province of Central Utah. Sevier valley is bounded by active normal faults, Elsinore fault on the west and Sevier fault on the east (Willis 1994). Strata beneath the valley are assumed to be folded into a broad syncline and cut by high angle faults (Elsinore and Sevier). Pahvant Range and Sevier Valley are located in an area of complicated local geology and are located in a transitional zone between highly extended block-faulted terrain of the Basin and Range province (west of Pahvant Range) and the mostly undeformed Colorado Plaueau (east of the Sevier Plateau) (Willis 1994). The study area is located on the western margin of Sevier Valley, a north-south trending valley, formed between the Pahvant Range and Sevier Plateau.

Exposed rocks in the Pahvant Range are Tertiary in age and dip eastward approximately 5-10 degrees (Willis 1994). The study is near the northern edge of the Maryvale volcanic field and may have also received material derived from the Tintic or Thomas-Drum volcanic fields to the northwest. A generalized stratigraphic column is provided in Attachment A and is generally based on the Utah Geological Survey, Open File Report 309 (Willis 1994) and Utah Geological Survey Map 135 (Hintze 2003). Mapped lithologic units in the study area are shown on the generalized stratigraphic column are listed below.

- Osiris Tuff (To) – reddish-brown, moderately ,crystal-rich, densely welded rhyodacitic ash-flow tuff, 23 million years ago (Ma), maximum thickness 200 feet
- Tuff of Albinus Canyon (Ta) – red to gray, crystal poor, densely welded, trachytic ash-flow tuff, 25.3 Ma, maximum thickness 650 feet
- Bullion Canyon Volcanic (Tb), Three Creek Tuff Member (Tbt)– light gray to light brown, crystal-rich, moderately to densely welded dacitic ash-flow tuff, 27 Ma, maximum thickness 720 feet
- Aurora Formation (Tau) – yellow gray to pale brown, bentonitic siltstone and claystone, with thin beds of gray limestone, pebble to cobble conglomerate, fine grained sandstone, contains upwardly increasing amounts of fine grained rhyolitic and reworked volcanic detritus, 38-40 Ma, maximum thickness 1,200 feet
- Crazy Hollow Formation (Tch, Tchs) – brownish orange to brownish red very thin to thin planar bedded fine grained sandstone, siltstone, and mudstones, interbedded, thin to zero southwest of Richfield, Utah, early Oligocene, maximum thickness 350 feet
- Dipping Vat Formation (Tdv) – light gray to pale bluish gray, volcanic clastic sandstone, conglomerate, and reworked volcanic tuff, 35-27 Ma, maximum thickness 600 feet
- Green River Formation (Tg, Tgs)– yellowish gray to pale brown cherty algal and oolitic limestone and dolomite calcareous, fine grained sandstone, early Eocene, maximum thickness 800 feet
- Flagstaff Formation (Tf, Tfuw, Tfur) – pinkish-weathered freshwater limestone, sandstone, siltstone, mudstone, and conglomerate, typically bioturbates, southwest of Pahvant Range lithology is dominated by conglomerate exposure, early Paleocene, maximum thickness 3,500 feet
  - Upper White Member – pale gray, pale purplish gray, or pale yellowish gray, calcareous mudstone, siltstone, sandstone, and sandy limestone, maximum thickness 170 to 185 feet
  - Upper Red Member – dark reddish brown, calcareous mudstone, siltstone, sandstone, with local conglomerate, interbedded, maximum thickness 50 to 162 feet

The bedding planes dip along the eastern margin of the Pahvant Range in an easterly valley making the lower slopes prone to mass movement (landslides and slumps). The entire eastern margin of the Pahvant Range is extensively mapped as mass movement departs. The eastern lower slopes of the Pahvant Range are susceptible to mass movement for the following reasons (Willis 1994):

- The bedrock bedding planes dip 5-10 degrees in easterly direction towards the valley;
- The bedrock consists of alternating layers of fractured permeable and impermeable layers;
- Surface water percolates downward through the fractured permeable bedrock and accumulates on impermeable layers;
- Impermeable layers are largely comprised of fine grained material, inorganic clays, that significantly loses strength when surface of the fine grain layer becomes fully hydrated or saturated; and
- Structural uplift and tilting of the Pahvant Range has developed high topographic relief and has removed down slope support.

Complex landside departs located on the eastern slopes of the Pahvant Range make mapping and structural interpretation challenging and extensive bedding-plane slides and discordant slumps dominate the shallow surficial geology of the area. The landslide and slump blocks vary greatly from highly jumbled large and massive bedrock blocks (several hundred feet across or larger) to jumble brecciated masses with few or no large intact bedrock blocks (Willis 1994). In areas, the bedrock has experienced moderate slumping but still mainly intact and have been mapped over low angle faults or detachments.

2.1.1 Faulting and Mass Movement

Basin and Range faulting in the Sevier Valley likely began as early as early-middle Miocene, approximately 17 million years ago. The Sevier River Formation overlapped rocks now exposed on the range indicating the range did not significantly rise until after its deposition. Faulting along the Pahvant Range likely did not occur until after deposition of the Sevier River Formation, placing the timing of the Pahvant Range uplift from 15 million years ago to 5 million years ago (Willis 1994).

2.1.1.1 Elsinore Fault

The Elsinore fault is located on the eastern flanks of the Pahvant Range and has been intermittently active since Pahvant Range uplift began. The fault is largely concealed beneath active Quaternary alluvial fans and little to no Quaternary fault scarps have been mapped in the area. Alluvial fan depositions along the eastern slopes of the Pahvant Range are very active and rapidly destroy any evidence of faulting along the Elsinore fault (Willis 1994). The fault origination and slip directions along the Pahvant Range may be incompatible with the existence of a major range fault and due to the lack of a preserved quaternary fault scarp, the Elsinore fault has been speculated to be a southeast-facing monocline over a major buried fault at depth (Hecker 1993).

2.1.1.2 Bedding-Plane Slip

Bedding-plane slip is common within the study area and involves movement on low-angle surface detachments toward the Sevier Valley. Bedding-plane slip is concentrated on three main detachment surfaces as listed below (Willis 1994):

- Base of the Upper White Member of the Flagstaff Formation
- Near the base of the Green River Formation
- Near the base of the Aurora Formation

Other bedding surfaces have detached locally through the eastern slopes of the Pahvant Range.

Large landslides have been mapped south of Willow Creek Canyon as QMS and have experienced large and extensive movement down-slope topographically towards the valley. Blocks are highly fractured and disjointed with bedrock beds deformed. Little to no in-place bedding planes remain in this area. The primary detachment is near the base of the Green River Formation (Willis 1994). The detachment is exposed at the surface in the northern part of Cottonwood Creek Canyon and plunges beneath the surface in a southward direction along the front of the mountain range. Southwest of Richfield, the detachment is estimated to be approximately 300 feet below the ground surface and the shallow alluvial fill is thought to be an insufficient buttress to impede slow movement of slump material along the detachment (Willis 1994).

2.1.1.3 Mass Movement Age

The age of landslide and slump movement is not well understood and is poorly constrained. Pedogenic carbonate within the landslide and slump blocks is stage 1 to stage 1+, indicating the movement likely occurred during late Quaternary period. Landsides and slump block movement along the eastern slopes of the Pahvant Range likely occurred during the last glacial wet cycle (15,000 to 25,000 years ago) (Willis 1994). During the last wet cycle in Utah (1983 to 1985) no mass movement was observed along the eastern slopes of the Pahvant Range. This could mean the landslide and slump areas were not extensively monitored during the 1980's or could indicate that movement only occurs over wet-cycle time periods (Willis 1994).

2.1.2 Local Geology

Site specific geology at the four sites studied are dominated by interbedded siltstone, sandstone, mudstone, and weathered volcanics. Landslides and slump blocks, which are present at all sites, dominate the local geology creating jumbled bedrock blocks along the front of the Pahvant Range. The rocks at the sites are highly fractured with slumps and landslide movement towards Sevier valley along low angle detachments. Below are summaries of the sites geology.

2.1.2.1 Wood Canyon

The rocks in Wood Canyon are highly fractured but are relatively undeformed. The bedding-plane detachment is located above the site along the south ride line near the contact between the Flagstaff and Green River formation resulting in relative undeformed bedrock at the site (Photo 2-1: The Upper Red and White Members within Wood Canyon are highly fractured. The Upper Red Member is composed of alternating layers of siltstone and sandstone. Detachment located near the top of the south ridge; Figure 2-1: Approximate embankment location shown with green line. Note the detachment near the top of the south ridge. Map not to scale. North is up.). The bedrock exposed at the site is Upper Red Member of the Flagstaff Formation and is composed of alternating layers of highly fractured siltstone and sandstone. The Upper Red Member forms cliffs along the south side of the canyon which are prone to rock spalling. The site is located approximately 300 feet west of the Elsinore fault. A large alluvial fan has formed at the mouth of Wood Canyon and portions have been mined for sand and gravel. Exposed alluvium in the lower canyon is substantially comprised of debris flow deposits with large boulders.

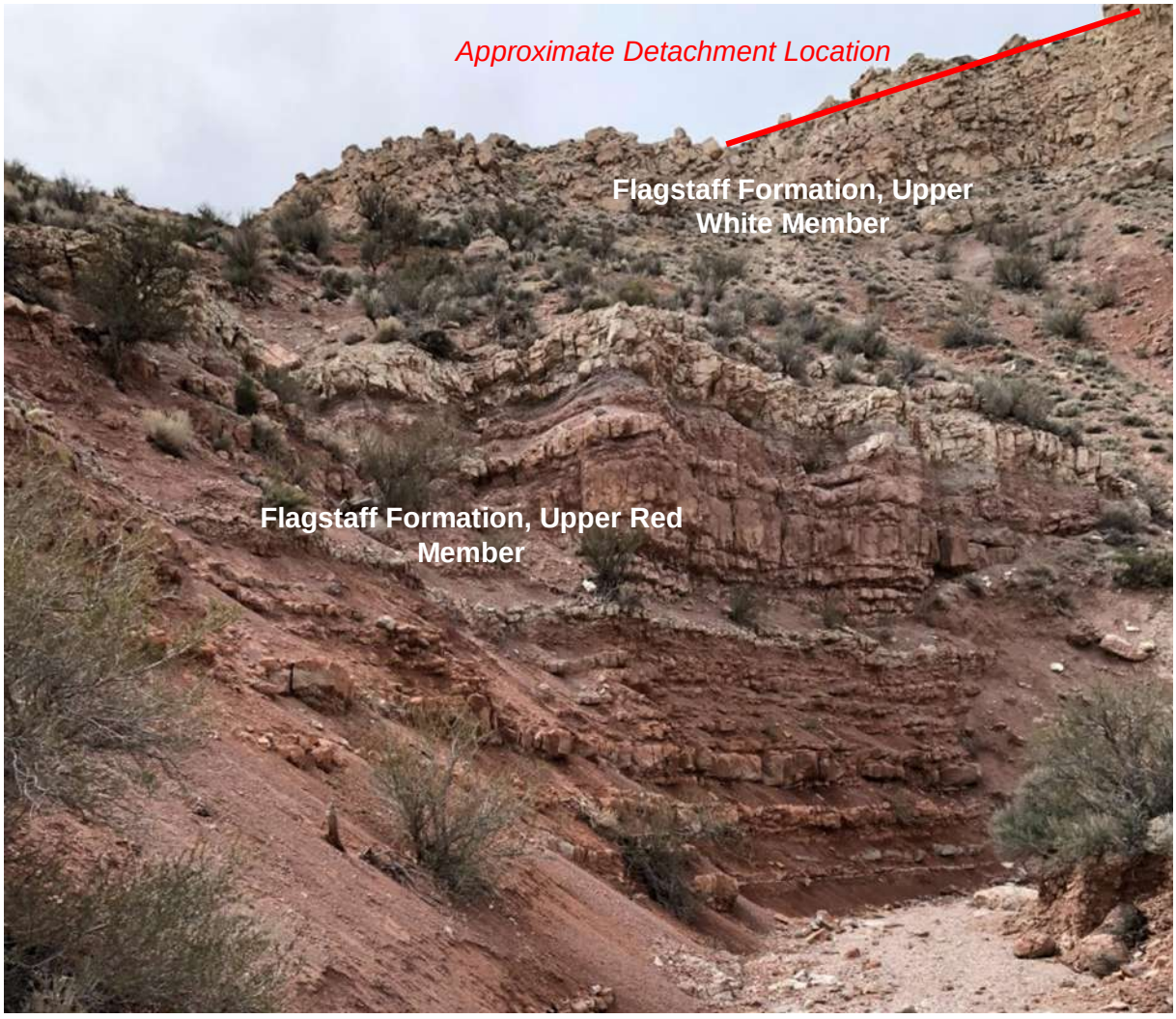


Photo 2-1. Photograph of Exposed Flagstaff Formation, Upper Red Member.

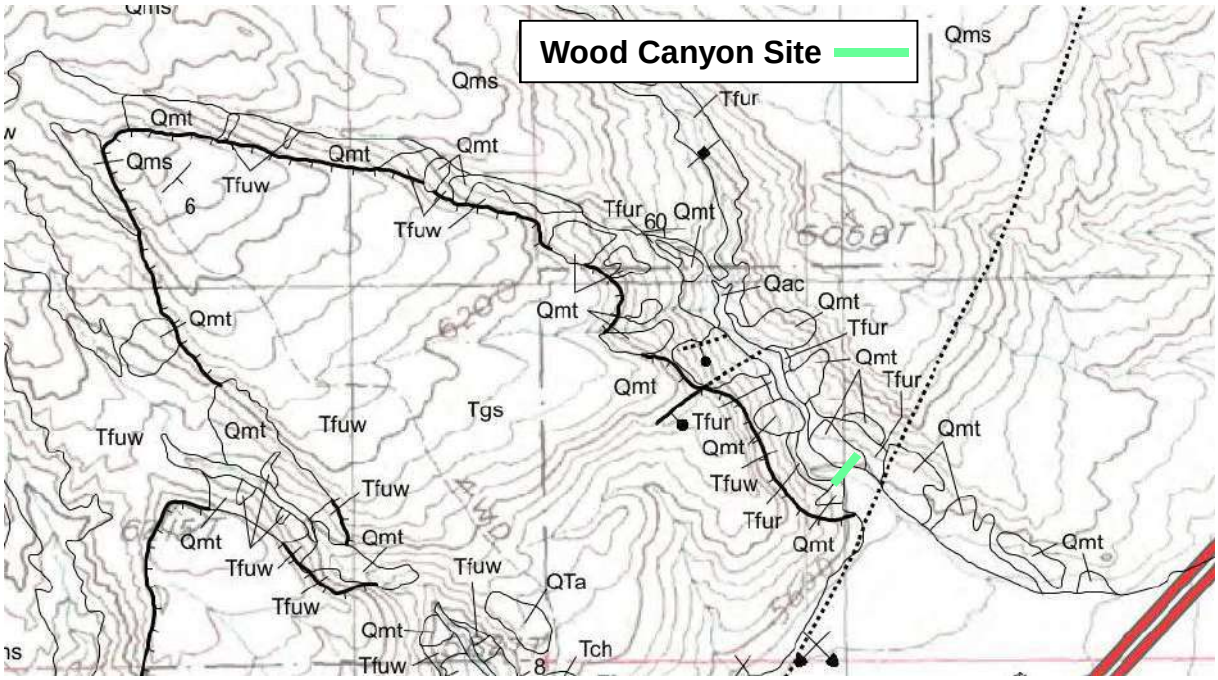


Figure 2-1. Geologic map of Wood Canyon Site (Willis 1994).

2.1.2.2 Tank Canyon

The rocks on both sides and center of Tank Canyon are highly fractured and deformed by a bedding-plane slip along low-angle surface detachments downslope toward the Sevier Valley. The detachment plunges likely in an easterly or southeasterly direction beneath the surface of the Pahvant Range towards the valley. The exact depth of the detachment at Tank Canyon is not known but it is thought to be at least a few hundred feet below ground surface at the site. The bedding planes along the north side of Tank Canyon have been folded into a V-shape syncline (Photo 2-2; Figure 2-2: Approximate embankment locations are shown as green lines. Note the syncline and detachment locations on the map. Map not to scale. North is up.). Directly east of the concrete water tank is small hill comprised of a large detached bedrock block consisting mainly of the Crazy Horse Formation. This detached bedrock block forms the center portion of the dam and the block has been rotated approximately 90 degrees in contrast to the beds on the north and south as seen in Photo 2-3 (Dashed red lines show approximate azimuth or strike of the beds. Hill in the center of Tank Canyon is rotated 90 degrees from the beds on the north and south sides of the canyon. Bedrock in the central hill is detached.). This rotation could indicate the bock is sitting on unconsolidated alluvium or other jumbled bedrock blocks. The site is located approximately 1,800 feet west of the Elsinore fault. The area east and south of the site has been mined for sand and gravel.

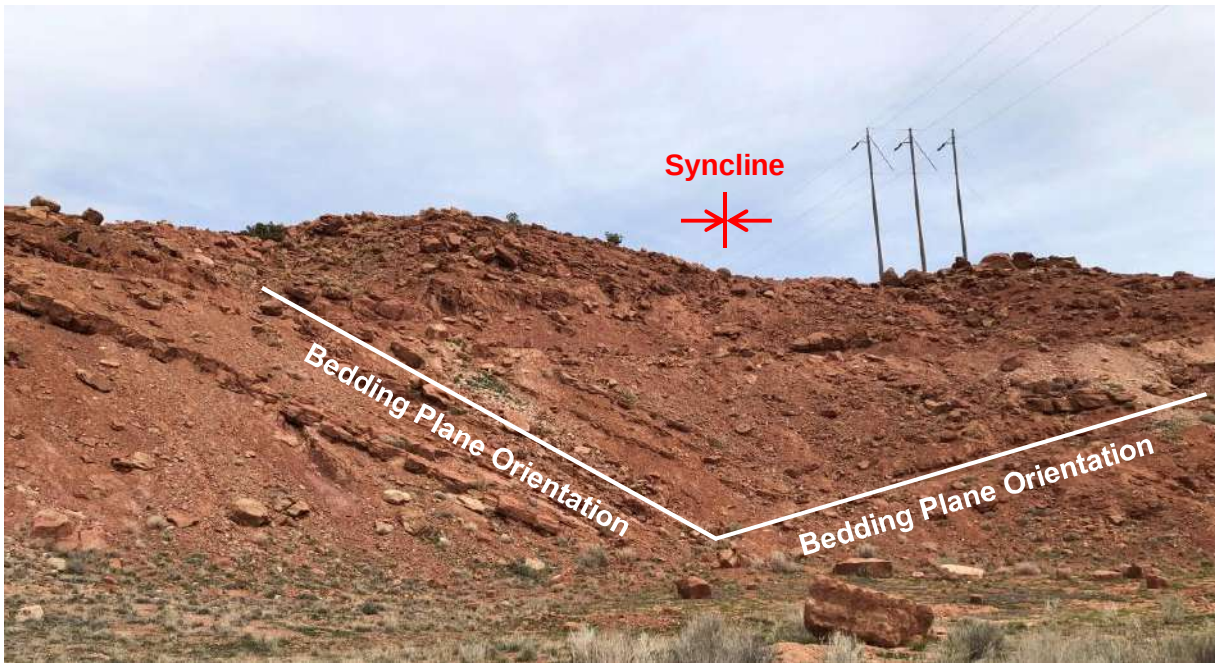


Photo 2-2. Photograph of the North Embankment Area of Tank Canyon Site Showing V-Folded Syncline.



Photo 2-3. Photograph of the Center Embankment Area of Tank Canyon.

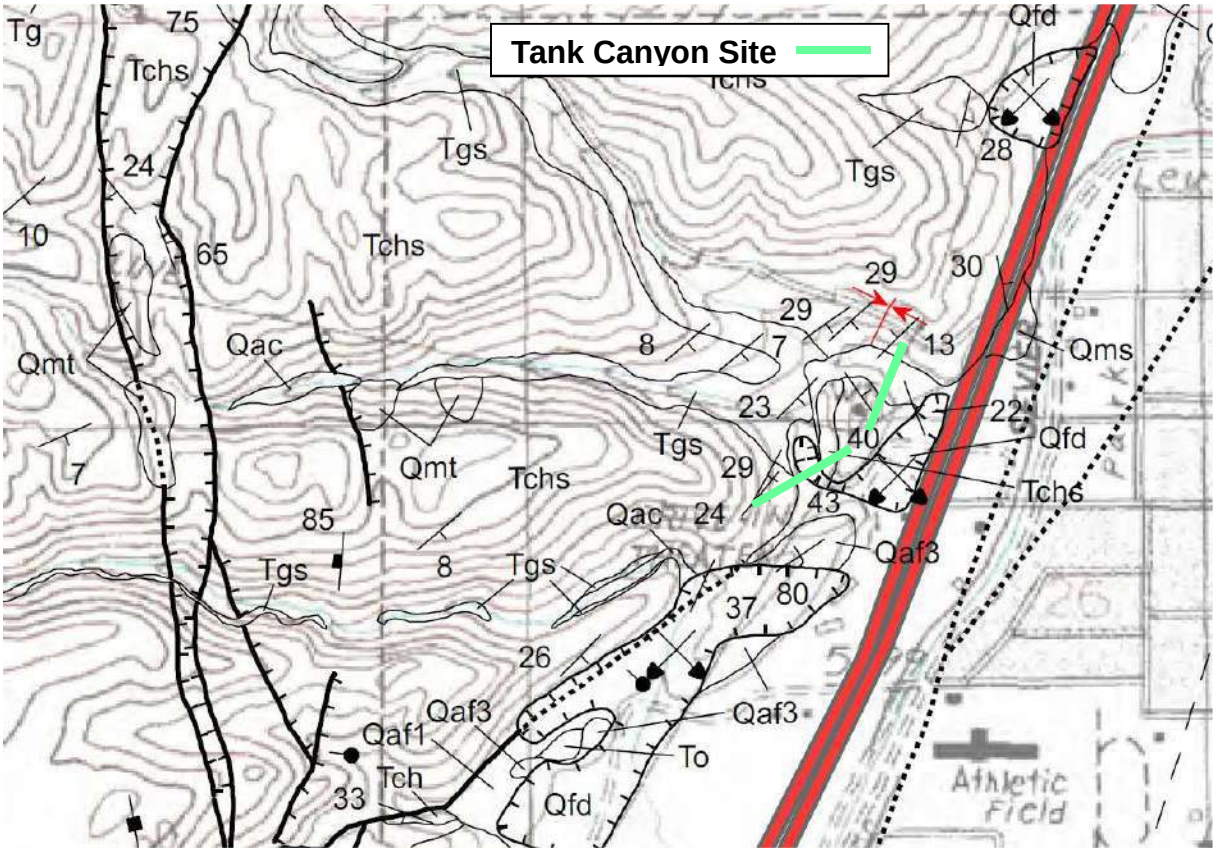


Figure 2-2. Geologic map of Tank Canyon Site (Willis 1994).

2.1.2.3 Lind Canyon

The rocks west of the site in Lind Canyon are highly fractured and deformed by bedding-plane slip along low-angle surface detachments downslope toward the Sevier Valley and are similar to Tank Canyon. The site for Lind Canyon is at the mouth of the canyon located within alluvial deposits (Photo 2-4: The site was formerly mined for sand and gravel and the central hill was mined around it to protect overhead power infrastructure; Figure 2-3: Approximate embankment location shown with green line. Note that the site is located within the footprint of a large former sand and gravel mine. Center point of site is unmined alluvium left to protect overhead power infrastructure. Map not to scale. North is up.). The site is located approximately 1,800 feet west of the Elsinore fault. The site is located within a former sand and gravels mine. Exposed alluvium at the site is substantially comprised of debris flow deposits with very few large boulders. The majority of the alluvium consists of sand and gravel with a minor amount of cobbles.



Photo 2-4. Photograph of the Center Embankment Area of Lind Canyon.

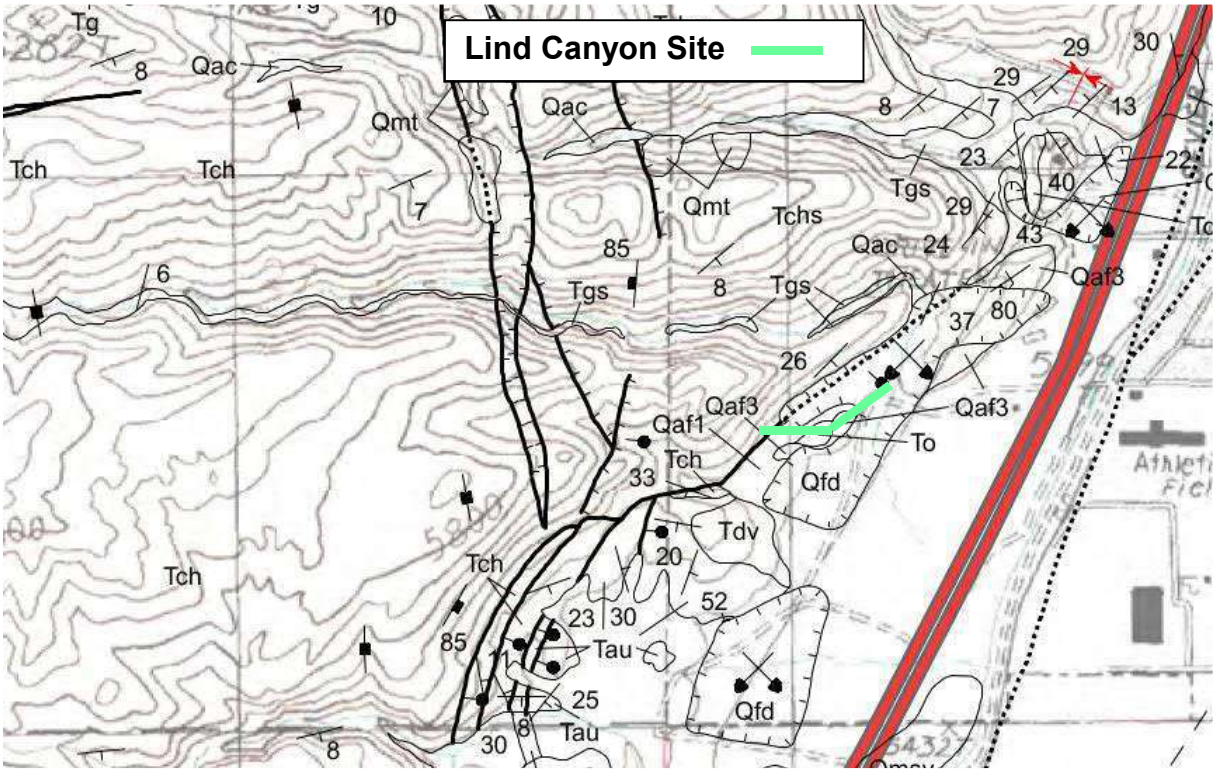


Figure 2-3. Geologic Map of Lind Canyon Site (Willis 1994).

2.1.2.4 Flat Canyon

The rocks within Flat Canyon are highly fractured and deformed by bedding-plane slip and or slumping along low-angle surface detachments downslope toward the Sevier Valley as seen in Figure 2-4 (Map not to scale. North is up.) (Hintze 2003). The detachment plunges likely in an easterly or southeasterly direction beneath the surface of the Pahvant Range towards the valley (Willis 1994). The exact depth of the detachment at Flat Canyon is not known but it is thought to be at least a hundred feet or so below ground surface at the site. The bedding plane slip surface is likely near the base of the Aurora Formation (Hintze 2003). The drainage basin is sufficiently large enough to produce substantial flow during heavy monsoon (August) rain events and has produced flow large enough to transport large boulders downstream to the leading edge of the alluvial fan as seen in Photo 2-5 (Note the large boulder within the channel. Similar boulders are found through Flat Canyon alluvial fan and a larger boulder field has been weathered out between Interstate 70 and the mouth of Flat Canyon.). The exposed rock at the site are Tuff of Albinus Canyon (Tac), a crystal, poorly densely welded trachytic ash-flow tuff and Aurora Formation (Tau), a bentonitic siltstone and claystone with reworked volcanic detritus. Numerous slump and bedding plane detachment surfaces have been mapped along the south side of the canyon. The trachytic ash-flow tuff is substantially more competent with large outcrops present on the north side of the canyon. The southern side of the canyon is dominated by weathered volcanic and bentonitic siltstone and claystone that have slipped or moved downslope towards the Sevier valley (Photo 2-6: Looking south towards numerous bedding plane slip and slump blocks). Some competent trachytic ash-flow tuff is present within the proposed southern embankment area. The site is located approximately 1,800 feet west of the Elsinore fault.

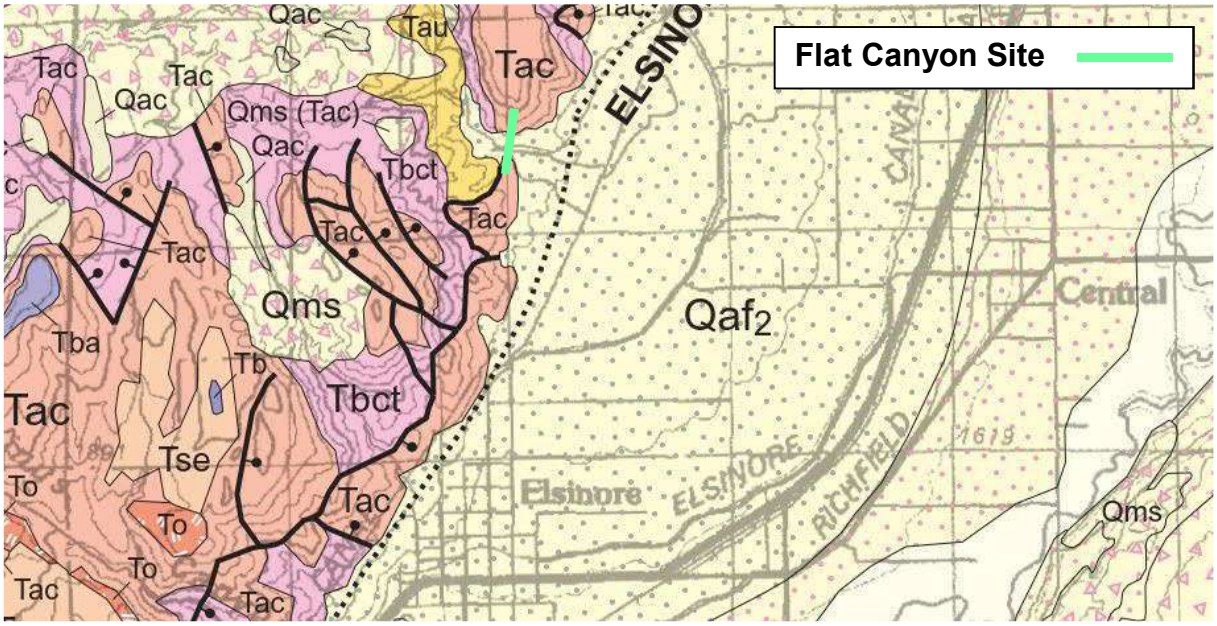


Figure 2-4. Geologic Map of Flat Canyon Site (Hintze 2003).



Photo 2-5. Photograph of Boulder in Flat Canyon wash.



Photo 2-6. Photograph of Flat Canyon Wash.

2.2 Geologic Hazards

A geologic hazard is an adverse geologic condition, which is capable of causing loss or damage to life or property and may occur suddenly or gradually with time. These hazards are often associated with natural disasters, but may also include less devastating, more frequent phenomena. The following subsections provide descriptions of geologic hazards to which the project sites may be subject and discuss potential impacts each hazard may have at the project sites.

2.2.1 Seismicity

The Sevier Valley is located within the Intermountain Seismic Belt (ISB), one of the most seismically active areas in the interior, western United States (US). The east and west margins of the valley are formed by the Elsinore Fault to the west and Sevier Fault to the east. The Elsinore fault is characterized as a normal fault and is mapped to be approximately 28 kilometers long and has a strike north to northeast along the base of the mountains on the west side of the Sevier Valley. The Elsinore fault is mapped to be within 1 mile of each of the proposed debris basin sites. Other minor faults have been mapped in the area that are presumed to be the result of seismic activity associated with the Sevier or Elsinore fault zones. The Sevier and Elsinore faults are the predominant contributors to the seismic hazard at the basin sites.

In recent history, seismic activity and damaging ground motions have been documented (Schick International, Inc. 1977). Plots of earthquake epicenters suggest that the southern portion of the Elsinore fault is the most active portion of the fault; however, evidence of fault movement was also observed in the northern portions of the fault (Deming and Bridges 1976). Deming and Bridges (1976) performed fault mapping and a seismic evaluation for several debris basin sites along the Elsinore fault. They suggest that seismic adjustment is still occurring along the Elsinore fault and the maximum credible earthquake that can be expected from Elsinore fault zone is estimated at 7.4 Richter magnitude. On November 13, 1901, an earthquake with an estimated Richter magnitude of 6.5 or larger occurred and was likely centered near Richfield and was associated with the Elsinore fault. Large surface displacements estimated to be up to 8 feet are also possible. For a full overview of their fault mapping and seismic evaluation, the entire Deming and Bridges (1976) report is provided as Attachment B. The Schick International Inc. (1977) report, which also summarizes the seismic hazard for several of the basins, is also provided as an attachment to TM002.

2.2.1.1 Seismic Design

The NRCS recommends that earthquake loading be considered for all dams (NRCS 2019). According to NRCS design guidelines for earth dams, the maximum deign earthquake (MDE) corresponds to a return period of 10,000 years for high consequence of failure facilities. As a minimum, the NRCS recommends that the operating basis earthquake (OBE) correspond to a return period of 500 years for high consequence of failure facilities. The seismic design parameters associated with the MDE and OBE for the debris basin sites are summarized in Table 2-1.

According to Utah Administrative Code (UAC) Title R655, Chapter 11, Part 5, seismic analysis of dams should include a seismological investigation to determine design ground motions and to consider potential fault rupture. Due to the relative proximity of the basin sites to known mapped active faults, strong ground shaking should be considered. In accordance with UAC, both the maximum credible earthquake (MCE) and OBE should be considered in design. The MCE should be evaluated using both deterministic and probabilistic methods. A deterministic seismic hazard analysis is not within the scope of this work and was not performed for the basin sites; however, probabilistic ground motions for each of the basin sites were developed using the United States Geological Survey (USGS) Unified Hazard Tool for the MCE and OBE having a return period of 5,000 and 200 years, respectively. The seismic design parameters associated with the MCE and OBE for the debris basin sites are summarized in Table 2-2.

Table 2-1. Summary of NRCS Seismic Design Parameters

Location and Event	Peak Ground Acceleration, PGA (g)	Mean Magnitude (-)	Mean Distance (km)	Modal Magnitude (-)	Modal Distance (km)
Wood Canyon MDE	0.49	6.08	9.69	6.5	8.16
Wood Canyon OBE	0.14	5.93	18.97	5.1	9.95
Tank Canyon MDE	0.47	6.13	10.65	6.3	9.19
Tank Canyon OBE	0.14	5.94	19.39	5.1	10.54
Lind Canyon MDE	0.47	6.13	10.65	6.3	9.19
Lind Canyon OBE	0.14	5.94	19.39	5.1	10.54
Flat Canyon MDE	0.47	6.14	10.58	6.5	8.74
Flat Canyon OBE	0.14	5.94	19.25	5.1	10.73

Notes: MCE = “maximum design earthquake”; OBE = “operating basis earthquake” with 500-year return period; km = “kilometers”

Source: United States Geological Survey (USGS) Unified Hazard Tool; Dynamic: Conterminous U.S. 2014 (v.4.1.1) seismic source model: https://earthquake.usgs.gov/hazards/interactive/

Table 2-2. Summary of Utah Administrative Code Seismic Design Parameters

Location and Event	Peak Ground Acceleration, PGA (g)	Mean Magnitude (-)	Mean Distance (km)	Modal Magnitude (-)	Modal Distance (km)
Wood Canyon MCE	0.47	6.23	9.99	6.1	9.1
Wood Canyon OBE	0.1	6.02	23.95	5.1	11.08
Tank Canyon MCE	0.46	6.27	10.55	6.3	9.7
Tank Canyon OBE	0.1	6.01	23.57	5.1	11.01
Lind Canyon MCE	0.46	6.27	10.55	6.3	9.7
Lind Canyon OBE	0.1	6.01	23.57	5.1	11.01
Flat Canyon MCE	0.48	6.26	10.01	6.1	8.91
Flat Canyon OBE	0.1	6.0	22.15	5.1	11.46

Notes: MCE = “maximum considered earthquake”; OBE = “operating basis earthquake” with 200-year return period; km = “kilometers”

Source: United States Geological Survey (USGS) Unified Hazard Tool; Dynamic: Conterminous U.S. 2014 (v.4.1.1) seismic source model: https://earthquake.usgs.gov/hazards/interactive/

Due to the proximity of active faults in the area, the potential for ground fault rupture is relatively high and should be considered in final design. It is possible that active sedimentation at the basin sites may have covered evidence of recent or historical fault rupture activity in the area (Deming and Bridges 1976).

2.2.1.2 Liquefaction

Seismically-induced liquefaction occurs from development of excess pore pressures with earthquake loading, within typically loose, saturated, and cohesionless soils. The generation of excess pore pressures leads to lowered effective stresses within the liquefied soil layer, weakening the soil. Liquefaction effects can include sand boils, settlement, lateral spread, and loss of bearing capacity. Based on the relatively deep groundwater relative to the height of the embankment and the low likelihood that the basin would be filled with appreciable water during an earthquake, liquefaction is not anticipated at any of the project sites and is not considered in any underlying analysis.

3. FIELD INVESTIGATION AND LABORATORY TESTING

The following sections provide a summary of the field investigation, subsurface materials and conditions, and laboratory testing for the project.

3.1 Field Explorations

AECOM performed geotechnical explorations, which included four (4) boreholes and 13 test pits, to assess subsurface conditions at the proposed debris basin sites. The exploration locations were selected for preliminary embankment locations based on information collected during a January 11, 2019, site visit to each of the proposed sites, existing geologic maps and reports, and AECOM's understanding of proposed basin designs. The field explorations were performed between February 19, 2019, and February 23, 2019. The explorations performed at the project sites are summarized in Table 3-1.

Table 3-1. Summary of AECOM Field Explorations

Field Exploration	Ground Surface Elevation (ft)	Total Depth Explored (ft)	Encountered Groundwater Depth (ft)
BH19-WC-01	5,591 [1]	21.0	-- [3]
BH19-TC-01	5,422 [1]	50.3	32
BH19-LC-01	5,423 [1]	21.4	-- [3]
BH19-FC-01	5,571 [1]	59.0	-- [3]
TP19-FC-01	-- [2]	21.0	-- [3]
TP19-FC-02	-- [2]	19.0	-- [3]
TP19-FC-03	-- [2]	21.0	-- [3]
TP19-LC-01	-- [2]	12.0	-- [3]
TP19-LC-02	-- [2]	16.0	-- [3]
TP19-LC-03	-- [2]	25.0	-- [3]
TP19-LC-04	-- [2]	20.0	-- [3]
TP19-TC-01	-- [2]	8.0	-- [3]
TP19-TC-02	-- [2]	15.0	-- [3]
TP19-WC-01	-- [2]	16.0	-- [3]
TP19-WC-02	-- [2]	17.0	-- [3]
TP19-WC-03	-- [2]	6.0	-- [3]
TP19-WC-04	-- [2]	19.0	-- [3]

Notes: ft = feet; '--' denotes a blank entry

3. Ground surface elevation was not surveyed, but was estimated from elevation contours of each site.
4. Ground surface elevation was not surveyed.
5. Groundwater not encountered at the time of exploration.

The drilling was performed by ConeTec, Inc., of Salt Lake City, Utah, under subcontract to AECOM. Exploration locations are indicated on the geotechnical drawings provided in Attachment A. The exploratory borings were advanced using 4.25-inch inner diameter (ID) hollow-stem-auger drilling methods to depths ranging from 21 to 59 feet below the existing ground surface. Drilling equipment included a CME-850 track-mounted drill rig equipped with a two-pronged spade bit.

Penetration resistances were obtained from the number of hammer blows observed to drive a split-spoon standard penetration test (SPT) sampler or a non-standard-size split-spoon, 3-inch outside diameter (OD) sampler. A 140-pound hammer weight was dropped onto the sampler rod helmet from a height of 30 inches using an automatic hammer. The resistance to sampler penetration (blowcount or N-value) is noted as “N” in the logs and refers to the number of hammer blows needed to advance the sampler a distance of 12 inches, beginning after an initial 6 inches of penetration into the subsurface materials (i.e., the number of hammer blows for 18 inches of sampler penetration minus the number of hammer blows for the first 6 inches of penetration). The blowcount at each sample depth was corrected for drilling conditions, rod length, sampler size, hammer energy, and overburden stress to obtain the N_{60} and $(N_1)_{60}$ values. The calibrated average energy transfer ratio for the hammers used on the CME-850 drill rig is 79.2 percent based on relatively recent calibration testing.

Boreholes in Tank, Lind, and Flat Canyons were abandoned using portland cement bentonite grout filling the hole from the bottom of the hole to the ground surface by tremie pipe. The single borehole performed in Wood Canyon encountered an obstruction on one side of the hole at approximately 20 feet, which caused the augers to bind up. Consequently, a test pit was performed at the location of BH19-WC-01, which encompassed the borehole. Because the test pit was performed at this location, grout was not used to abandon the hole.

AECOM engineering personnel observed the subsurface explorations (see Photo 3-1), maintained detailed logs of subsurface conditions encountered, performed visual soil classification, and collected soil samples for laboratory testing. Encountered soils were classified using the Unified Soil Classification System (USCS) at the time of drilling in general accordance with standard procedures described in ASTM D2488 (ASTM Standard D2488 2017). Logs of subsurface conditions encountered in the exploratory borings and a boring log key to symbols and terms are provided in Attachment C.



Photo 3-1: View of a Track-Mounted Drill Rig Used for Drilling

The test pitting was performed by A&D Jensen Contractors, Inc., of Richfield, Utah, under subcontract to Jones & DeMille. Test pits are indicated on the design plan drawings used as the basis for geotechnical analysis, which are provided in Attachment A. The test pitting was performed using a Link-Belt 225 track-mounted excavator with a 22-foot maximum dig depth and maximum heaped bucket capacity of 1.75 cubic yards. AECOM directed the excavator operator to designated test pit locations. Tests pits were abandoned using excavated soils tamped loosely into place.

AECOM engineering personnel observed the test pitting (see Photo 3-2), maintained detailed logs of conditions encountered, performed visual soil classification, and collected soil samples for laboratory testing. Soils encountered in the test pits were classified (USCS) at the time of excavation in general accordance with standard procedures described in ASTM D2488 (ASTM Standard D2488 2017). Logs of conditions encountered in the test pits are provided in Attachment D.



Photo 3-2: View of a Track-Mounted Excavator Used for Test Pitting

3.2 Site Conditions

Generalized descriptions of local stratigraphy and native soil encountered during the field investigation are provided in the following subsections by basin site.

3.2.1 Wood Canyon

The site of the embankment for the debris basin in Wood Canyon is located within a wash at the canyon floor. The wash is about 20 feet wide and about 8 feet deep with approximately vertical sides. Soils visible on the floor and walls of the wash consist of silts, sands, and gravel, with occasional cobbles, boulders, or organic and other debris (see Photo 3-3). Visible wash soils were highly stratified in 3 to 6 inch layers of silt, sand, or gravel, in a loose, visibly unstable, matrix. Voids that were visible on the wall of the wash ranged from about 1/16 inch in diameter to a few inches in diameter. The ground surface outside the wash and some of the canyon slopes are covered with numerous cobbles and boulders up to 5 or 6 feet in diameter. Vegetation consists of desert brush, some sparse grass, and very few trees.



Photo 3-3: View of Floor and Wall in Wood Canyon Wash

Four (4) test pits and one (1) borehole were performed at the Wood Canyon site, two on each side of the wash at the floor of the canyon. BH19-WC-01 was advanced to a depth of 21 feet before refusal of the augers. The test pits were excavated to depths of between 6 and 19 feet. TP19-WC-03 and TP19-WC-04 were excavated until refusal on rock at depths of 6 and 19 feet, respectively; however, the other two test pits did not reach refusal and were extended to the limits of the excavator. Encountered soils were low-plasticity silty to silty, clayey coarse to fine sand and gravel. Encountered rock consisted of highly weathered clay and siltstone. The rock outcroppings exposed on the canyon slopes included sandstone.

3.2.2 Tank Canyon

The embankment for the debris basin in Tank Canyon is located at the site of an abandoned aggregate mining operation. Excavation from the mining operations resulted in the removal of approximately 50 feet of material from within the footprint of the embankment; however, a raised portion of, what appears to be, the original ground surface remains. The ground surface outside the wash and some of the canyon slopes are covered with numerous cobbles and boulders up to 5 or 6 feet in diameter. Vegetation consists of desert brush, some sparse grass, and very few trees.

Two (2) test pits and one (1) borehole were performed at the Tank Canyon site. Test pits were performed at the foundation-abutment contact on either side of the raised surface bisecting the two segments of the proposed embankment. The test pits were excavated to depths of between 8 and 15 feet. TP19-TC-01 and TP19-TC-02 refused on rock. BH19-TC-01 was located near the maximum section of the northern segment of the proposed embankment. It was advanced to a depth of approximately 50 feet where blowcount refusal was reached at the last sample taken at 50 feet. Encountered soils were mainly nonplastic silty fine sand and coarse to fine gravel, but localized shallow (1-2 feet thick) layers of clayey soils were observed near the ground surface. Encountered rock consisted of clay/silt/sandstone and limestone; rock outcroppings exposed on the canyon slopes included sandstone.

3.2.3 Lind Canyon

The embankment for the debris basin in Lind Canyon is also located at the site of an abandoned aggregate mining operation. Historic aerials show that this area was an alluvial fan deposited at the mouth of the canyon. Mining operations resulted in the removal of approximately 30 feet of material over much of the area and from within the footprint of the embankment. A raised portion of, what appears to be, the original ground surface remains intact with a power pole situated on top of it. The ground surface and canyon slopes are covered with numerous cobbles and boulders. Vegetation consists of desert brush, some sparse grass, and very few trees.

Four (4) test pits and one (1) borehole were performed at the Lind Canyon site. Test pits were performed on the southern abutments of each proposed embankment segment, the northern abutment of the northern segment, and within the basin. The test pits were excavated to depths of between 12 and 25 feet. All of the test pits performed encountered cobbles and boulders during excavation. TP19-LC-01 refused at 12 feet because of large cobbles and boulders. TP19-LC-02 encountered boulders less than 4 feet in diameters from approximately 4 to 11 feet below the ground surface before encountering weathered, green gray to brown gray siltstone or clay stone, which was not encountered elsewhere. The remaining test pits encountered very few boulders and only occasional cobbles.

BH19-LC-01 was located near the maximum section of the south segment of the proposed embankment. It was advanced to a depth of approximately 21 feet where auger refusal and blowcount refusal was reached at the last sample taken at 50 feet. Encountered soils were largely nonplastic silty fine sands and coarse to fine gravels, but localized (1-2 feet thick) layers of clayey soils were encountered in the borehole.

In consideration of potential clay borrow sources, AECOM acquired soil samples obtained from sediment contained in nearby Dairy Canyon. This material was classified as silt clay and would likely be suitable for use as a clay core or in surface applications, such as a top soil constituent; however, the soil also contained a significant volume of organics and other debris.

3.2.4 Flat Canyon

The embankment for the debris basin in Flat Canyon is located on a large alluvial fan deposited at the mouth of the canyon. The ground surface is gently sloping from the mouth of the canyon down toward the main highway. At the time of the field investigation, movement at the site was hindered by the wet clayey ground surface. The canyon slopes are covered with numerous cobbles and boulders; large boulders are protruding from, or resting, on the surface in the alluvial fan. Vegetation consists of desert brush, some sparse grass, and no obvious trees.

Three (3) test pits and one (1) borehole were performed at the Flat Canyon site. Test pits were performed within the basin. The test pits were excavated to depths of between 19 and 21 feet. All test pits performed encountered a few cobbles and boulders during excavation. BH19-FC-01 was located near the footprint of the proposed embankment near the middle of the mouth of the canyon. The borehole was advanced to a depth of approximately 59 feet where auger refusal was reached. Encountered soils were largely poorly graded, coarse to fine sands and gravels with low plasticity silts and clays.

In consideration of potential clay borrow sources for use as an embankment core, Jones & DeMille acquired and tested three samples from potential borrow areas within Flat Canyon. Two of the clay borrow area samples were lean clay described as “native red clay,” and one, higher-plasticity fat clay was also identified and tested from flat canyon. The native red clay has suitable plasticity and fines and is likely suitable to use as the embankments clay core. Fat clay tends to be very sensitive to moisture content, which can make it very difficult to place and compact.

3.2.5 Groundwater

The occurrence of groundwater in the Sevier basin is largely within the unconsolidated basin fill material. East of Richfield, groundwater is confined and under artesian conditions (Lambert et al. 1995). Groundwater along the eastern margin of the Pahvant Range is present in both consolidated and unconsolidated aquifer and is largely unconfined (Lambert et al., 1995). The groundwater system within the Sevier Valley is largely interconnected with multiple layers consisting mainly of interbedded clay, silt, sand, and gravel. The consolidated rocks along the western portions of the valley contain limited amounts of groundwater. Ground water discharges from the Flagstaff Formation west of Richfield (Lambert et al. 1995). Generally, the consolidated rock of the Pahvant Range act as groundwater

barrier at depth and localized source of recharge to the shallow unconsolidated valley fill groundwater system. Based on a review of available well logs from Utah Water Rights, depth to groundwater between Richfield and the Pahvant Range varies from 121 to 410 feet below ground surface and is largely found in unconsolidated aquifer.

Shallow groundwater was encountered at approximately 32 feet below ground surface in BH19-TC-01 during the field exploration located in Tank Canyon. None of the other field exploration locations, which were performed in 2019, encountered groundwater. Because shallow groundwater was not observed in other boring during this investigation, the shallow groundwater observed in Tank Canyon at BH19-TC-01 is thought to be likely perched groundwater accumulating on less permeable fine grain layers at depth within the unconsolidated alluvium deposits of Tank Canyon. The source of the water is not known but could be leakage from the municipal water supply concrete tank or discharge of groundwater from the consolidated bedrock aquifer at depth to the unconsolidated sediments of Tank Canyon.

3.3 Laboratory Testing

Laboratory testing was performed by Jones & DeMille, of Richfield, Utah, on selected soil samples, which were collected from the exploratory borings and test pits completed at the project site during the 2019 AECOM field investigation. The laboratory testing program included testing to aid in the classification of on-site soils, to assess physical and engineering properties of tested materials, and included particle-size gradation (mechanical and hydrometer), atterberg limits, and moisture/density relationships (modified proctor). Laboratory test data are summarized in the remarks column of the boring log from which each sample was obtained and more detailed laboratory testing results from the borings located at the project site are provided in Attachment E. Summaries of selected laboratory tests are shown in Table 3-2.

Table 3-2. Summary of Selected Laboratory Test Results

Laboratory Test	Wood Canyon	Tank Canyon	Lind Canyon	Flat Canyon	Clay Core Borrow[1]
Atterberg Limits					
Liquid Limit	NP to 21	NP	NP	NP to 25	25 to 27
Plastic Limit	NP to 17	NP	NP	NP to 20	13
Plasticity Index	NP to 7	NP	NP	NP to 8	12 to 14
Percent Gravel (%)	28.7 to 57.4	0.1 to 40.9	11.9 to 57.3	0.3 to 57.7	13.3 to 14.6
Percent Sand (%)	25.4 to 38.2	38.7 to 57.4	34.3 to 53.9	30.3 to 59.3	21.7 to 21.9
Material passing #200 sieve (%)	15 to 33	19 to 54	7 to 35	12 to 46	63.7 to 64.8
Maximum Dry Density (pcf)	137.7 to 138.6	134	125.4 to 136.5	130.4 to 136.6	--
Optimum Moisture Content (%)	6.7 to 6.9	7.2	6.9 to 10.5	6.8 to 8.3	--

Notes: '--' denotes a blank entry; NP = nonplastic; pcf = pounds per cubic foot;
1. Samples were taken from potential clay core borrow source in Flat Canyon.

4. GEOTECHNICAL ANALYSIS

The following sections provide a summary of the geotechnical analyses performed in support of the Sevier Watershed Plan and EA. Geotechnical analyses included seepage and slope stability, filter compatibility, and settlement.

Prior to the geotechnical analysis performed for this evaluation, a senior geologist and a senior dam engineer visited each of the proposed embankment sites. During the visit of Wood Canyon, it was concluded that the abutments were not suitable for dam construction without significant modification. Accordingly, the following subsections only present analysis and results for Tank Canyon, Lind Canyon, and Flat Canyon structures; Wood Canyon was excluded from analysis and further consideration.

4.1 Embankment Geometry

The typical sections will propose using a clay core, where the top of the core was assumed to begin 3 feet below the crest with side slopes assumed to be 0.25H:1V. The top of the core was assumed to be 8 feet wide and centered along the centerline of the crest. The core extended a distance equal to half the height of the dam for Tank and Lind Canyons and at least 20 feet below the base of the dam for Flat Canyon. The slopes of the core in the cutoff trench were also assumed to be 0.25H:1V. A filter drain, which was approximately 4.5 feet wide, was placed adjacent to the entire height of and downstream of the core. At the base of the embankment, a 3-foot-thick blanket drain extended to a toe trench and drain terminating approximately 6 feet upstream of the downstream toe of the embankment slope.

As an alternative to the traditional clay core option, AECOM also considered a section using an internal filter and gravel drain in place of a core. The top of the filter and gravel drain was assumed to begin 3 feet below the crest with side slopes, both of which sloped toward the downstream end of the dam, assumed to be 0.25H:1V. The top of the filter and gravel was assumed to be 12-feet wide (4-foot-wide filter, 4-foot-wide gravel, and 4-foot-wide filter) with a minimum of a 2-foot-thick filter over the top of the gravel. The drain was completely surrounded by filter material with a minimum thickness of 2 feet measured vertically and 4 feet measured horizontally. The filter and drain system extended a distance equal to 3 feet below the base of the dam. At this depth, a 6-foot-thick blanket filter and gravel drain (2-foot-thick filter, 2-foot-thick gravel, and 2-foot-thick filter) extended to a toe trench and drain terminating approximately 6 feet (measured horizontally) upstream of the downstream toe of the embankment. Approximately half of the drain extending along the base of the embankment was assumed to be below the base of the embankment.

AECOM assumes that a local borrow source will be used to provide soils for construction of the embankment shells and clay core. It is assumed that the embankment shells will be constructed from soils found within each of the proposed basins. Where a clay core is used, AECOM assumed that soil would be obtained from the native red clay borrow area in Flat Canyon. Filter and drain materials were assumed to be sand- and gravel-sized aggregates that would be produced onsite or delivered from an offsite source.

4.2 Seepage Analysis

AECOM estimated steady-state seepage conditions for two representative sections: (1) the embankment in Flat Canyon and (2) the embankment in Tank and Lind Canyons; the embankment at Wood Canyon was excluded from analysis. The representative section for Tank and Lind Canyons was analyzed with two alternatives; one alternative used a clay core and one alternative used a filter and gravel drain system. These sections were selected based on encountered foundation soil types, groundwater conditions, and embankment height. Steady-state seepage conditions were estimated for each section assuming (1) a basin filled with water to the spillway elevation, (2) a basin filled to the spillway elevation and which contains 100 years of sediment, and (3) a basin just after drawdown of the water to the bottom of the basin. The steady-state seepage conditions were estimated using SEEP/W version 8.16.2.14053, which is part of the GeoStudio 2016 software package (GEO-SLOPE International Ltd. 2016a).

Based on information provided by Jones & DeMille regarding the anticipated retention time, each of the basins will experience peak inflows and completely discharge the volume of the reservoir in eight days or less. This period of time is probably insufficient to develop for steady-state seepage conditions within the embankment; however, the potential for obstructed outlet works or sustained inflows, which could prolong this retention period, may result in

steady-state seepage conditions. Accordingly, the results reported and discussed in subsequent subsections are performed under long-term steady-state seepage conditions, which are not anticipated.

4.2.1 Model Parameters

The hydraulic conductivity was assumed using published ranges (Budhu 2010; Das 2011) or assumed based on past experience. Where possible, the selected hydraulic conductivity was checked against correlations using available grain-size distribution data. The anisotropy ratios (k_v/k_h) were assumed. Volumetric water content and hydraulic conductivity functions were estimated using SEEP/W's estimate feature. The hydraulic conductivity function was estimated using the Van Genuchten method as available in SEEP/W. Required inputs include: saturated water content, material type, and residual water content. These parameters were estimated for this analysis and are summarized in Table 4-1 with selected saturated horizontal hydraulic conductivity (k_h) and anisotropy ratio by model material.

Table 4-1. Summary of Seepage Model Parameters

Material	Material Type	Saturated Water Content ft^3/ft^3	Residual Water Content ft^3/ft^3	Anisotropy Ratio (k_v/k_h)	Saturated k_h	
					cm/s	ft/s
Flat Canyon Foundation	Silty Sand	0.35	0.04	0.1	$1.0x10^{-3}$	$3.3x10^{-5}$
Tank/Lind Canyon Foundation	Silty Sand	0.35	0.04	0.1	$1.0x10^{-2}$	$3.3x10^{-4}$
Flat Canyon Embankment Shell	Silty Sand	0.35	0.04	0.1	$1.0x10^{-3}$	$3.3x10^{-5}$
Tank/Lind Canyon Embankment Shell	Silty Sand	0.35	0.04	0.1	$1.0x10^{-2}$	$3.3x10^{-4}$
Embankment Core	Clay	0.45	0.05	0.5	$1.0x10^{-8}$	$3.3x10^{-10}$
Basin Sediments	Silty Clay	0.40	0.04	0.5	$1.0x10^{-5}$	$3.3x10^{-7}$
Filter Drain	Sand	0.30	0.03	1	$1.0x10^{-1}$	$3.3x10^{-3}$
Gravel Drain	Gravel	0.30	0.03	1	$1.0x10^{0}$	$3.3x10^{-2}$

Notes: ft = feet; cm = centimeter; s = seconds

4.2.2 Results

The results of the seepage analysis indicate that the maximum gradient in saturated zones is approximately 2.5-3 for the embankment sections with a clay core, and slightly lower at 2-2.5 for the embankment section with a filter and gravel drain system instead of a clay core.

Estimated discharge from the toe drain, which was modeled in each of the considered sections, is summarized in Table 4-2. The discharge was estimated per unit length of the embankment at the maximum section for the entire length of the embankment is also summarized in Table 4-2. Because the analysis was performed at the maximum section and disregard three-dimensional effects, these values are likely conservative. The reason for the significant disparity between the larger Flat Canyon embankment and the Tank and Lind Canyon embankments with cores is the lower fines content and plasticity of the foundation soil encountered at the Tank and Lind Canyon sites. The 2-stage filter drain scenario has the highest discharge rate. A summary of seepage results is provided in Attachment F.

Table 4-2. Summary of Estimated Toe Drain Discharge

Analysis Section	Estimated Discharge		
	Per Unit Length	Entire Length of Embankment [1]	
	(cfs)	(cfs)	(gpm)
Flat Canyon with Impervious Core	$3.0x10^{-4}$	0.4	160
Tank/Lind Canyons with Impervious Core	$1.2x10^{-3}$	1.2	540
Tank/Lind Canyons with Filter/Gravel Drain	$3.6x10^{-3}$	3.6	1,600

Notes: cfs = cubic feet per second; gallons per minute

1. Tank/Lind Canyon results are separated into two separate embankments and the flow shown here is the combined discharge for the entire length of all embankment structure.

4.3 Slope Stability Analysis

AECOM calculated the factor of safety against slope instability for steady-state drained, undrained (end of construction), rapid (instantaneous) drawdown, pseudostatic, and post-earthquake cases using limit-equilibrium software, SLOPE/W version 8.16.2.14053, which is part of the GeoStudio 2016 software package (GEO-SLOPE International Ltd. 2016b). Spencer's method of slices was used to calculate the factor of safety against slope instability for each section. Analyzed sections were the same sections described in Section 4.2. In accordance with UAC Title R655, Chapter 11, Requirements for the Design, Construction and Abandonment of Dams, all dams should meet or exceed minimum factors of safety under normal loading conditions. Table 4-3 summarizes the required minimum factors of safety by stability case. These are consistent with NRCS design guidelines (NRCS 2019), where a minimum factor of safety is established.

Table 4-3. Summary of Required Minimum Factors of Safety

Loading Case	Required Minimum Factor of Safety
End of Construction	1.3 [1]
Steady-State Drained	1.5
Rapid (Instantaneous) Drawdown	1.2
Pseudostatic	1.0 [2]
Post-Earthquake	1.2 [3]

1. A minimum factor of safety of 1.4 is required for failure surface extending into foundation layers (NRCS 2019).
2. Requirement is only applicable to embankments, foundations, and abutments that are not subject to liquefaction or significant strength loss with a maximum acceleration of 0.2g or 0.35g (clay embankment on clay or rock foundation).
3. Requirement is only applicable to embankments, foundations, and abutments that are subject to liquefaction or significant strength loss with a maximum acceleration. Calculated deformation and settlement of the embankment crest should also be estimated.

Source: Utah Administrative Code Title R655, Chapter 11, Parts 5C and 6A

4.3.1 Analysis Cases

The following slope stability cases were considered in analysis. The NRCS design guidance document recommends that analysis be performed for a flood surcharge case, which uses the reservoir elevation at freeboard hydrograph pool level (NRCS 2019). Because of the nature of the flood, the duration over which the flood is anticipated to occur, and the retention time for flood water, a flood surcharge analysis was not analyzed.

4.3.1.1 Steady-State Drained Case

The steady-state drained case represents the long-term stability due to the phreatic surface coming to steady-state conditions at the spillway elevation. Materials were modeled using effective stress drained shear strength parameters.

4.3.1.2 Undrained (End of Construction) Case

The construction case represents the stability of the embankment following construction. The clay core was considered using undrained strengths for this case. Foundation soils were not considered susceptible to undrained loading. AECOM conservatively assumed that the basin was completely filled with water for an extended period of time immediately after construction. Upstream and downstream failure surfaces were analyzed. Materials were modeled using total stress undrained shear strength parameters.

4.3.1.3 Pseudostatic Case

The pseudostatic case corresponds to an earthquake effect simulated by applying a static horizontal force to the potential sliding mass. The clay core was modeled using peak undrained and all other free-draining materials were modeled using drained shear strength parameters, depending on the materials potential for generating excess pore pressures during loading. Free-draining soils were deemed not susceptible to excess pore pressure generation.

The 10,000-year accelerations were used for these slopes stability analyses in lieu of the MCE, the development of which was beyond the scope of this work. These were above the thresholds provided by UAC for which a pseudostatic analysis is allowed; however, for this level of design, using the 10,000-year return period in conjunction with simplified analysis methods is appropriate. These analyses did not consider the smaller acceleration associated with the OBE. The peak acceleration at the embankment crest was estimated based on published peak transverse crest accelerations as a function of peak transverse base acceleration data (Koester et al. 2000). These crest accelerations were then reduced by approximately 65 percent (Makdisi and Seed 1978). The assumed horizontal seismic coefficient used for all embankments in these analyses was 0.245.

4.3.1.4 Post-Earthquake Case

The post-earthquake case represents the stability with soil strengths after an earthquake. To account for any potential softening of the embankment core, 80 percent of the peak undrained strength was used for post-earthquake load conditions. It is unclear whether the clay core would be saturated or not, but AECOM conservatively assumed the core was saturated during the seismic event. Free-draining soils were deemed not susceptible to post-liquefaction strength loss.

4.3.1.5 Rapid (Instantaneous) Drawdown

The rapid drawdown case represents the stability of an embankment after quickly drawing down the water level in the basin. The rate of drawdown may result in drained or undrained loading of the clay core. Freely-draining soils would be subjected to drained loading. The 3-stage rapid drawdown analysis, which considers the minimum shear strength at any time during drawdown, was used to simulate instantaneous drawdown as implemented by SLOPE/W. Rapid drawdown strength parameters were assumed for this analysis (Duncan and Wright 2005).

4.3.2 Material Properties

Soil unit weights were assumed based on material type and anticipated placement methods or assumed insitu condition. The soil strengths for the foundation soils were based on blowcount correlations and engineering judgement. The soil strengths for embankment soils were selected based on published ranges, engineering judgement, and past experience. AECOM believes that selected values are appropriate for the assumed borrow sources and assumes sufficient compaction effort will be applied during construction. Material properties used for the limit-equilibrium analyses are summarized in Table 4-4 by model material.

Table 4-4. Summary of Selected Unit Weight and Strength Material Properties

Material	Unit Weight (pcf)	Drained Strength		Undrained Strength [1]		Rapid Drawdown Strength	
		ϕ' (deg)	c' (psf)	S_u/σ'_c	Minimum S_u (psf)	ϕ_R (deg)	c_R (psf)
Flat Canyon Foundation	130	33	0	--	--	--	--
Tank/Lind Canyon Foundation	125	30	0	--	--	--	--
Flat Canyon Embankment Shell	130	34	0	--	--	--	--
Tank/Lind Canyon Embankment Shell	125	34	0	--	--	--	--
Embankment Core	125	28	0	0.4	0	16	400
Basin Sediments	115	26	0	0.3	0	16	400
Filter Drain	120	36	0	--	--	--	--
Gravel Drain	120	36	0	--	--	--	--

Notes: pcf = pounds per cubic foot; deg = degrees; psf = pounds per square foot; '--' denotes a blank entry

1. Undrained strength was reduced by 20 percent for post-earthquake analysis.

4.3.3 Phreatic Conditions

For steady-state drained, undrained, and post-earthquake cases, the phreatic conditions resulting from seepage condition (1) was used (see Section 4.2). This represents the full basin under steady-state seepage conditions. Although steady-state seepage conditions are unlikely, they were considered plausible for this analysis. For the pseudostatic analysis, the encountered depth to groundwater from the field exploration was used. This is because of the low likelihood that the earthquake would occur while the debris basin contains water. For the rapid drawdown analyses, the phreatic surfaces resulting from the seepage analyses for seepage conditions (1) to (3) were used (see Section 4.2).

4.3.4 Results

The calculated minimum factors of safety meet or exceed the required minimum factors of safety defined by the State. If the seismic coefficient is increased or full seepage conditions are assumed for the pseudostatic analysis, a flatter slope may be required. A summary of the slope stability results is provided in Attachment F.

Table 4-5. Summary of Factors of Safety against Slope Instability

Analysis Section	Calculated Minimum Factor of Safety [1]									
	End of Construction [1.3]		Drained Steady-State [1.5]		Pseudostatic [1.0]		Post-Earthquake [1.2]		Rapid Drawdown [1.2]	
	Down	Up	Down	Up	Down	Up	Down	Up	Down	Up
Flat Canyon with Impervious Core	1.8	2.9	1.8	2.9	1.2	1.3	1.8	2.8	1.9	2.1
Tank/Lind Canyons with Impervious Core	1.6	2.4	1.7	2.4	1.1	1.2	1.6	2.3	1.8	2.0
Tank/Lind Canyons with Filter/Gravel Drain	-- [2]	-- [2]	1.7	3.1	1.1	1.2	-- [2]	-- [2]	-- [2]	-- [2]

Notes: '--' denotes a blank entry; Down = Downstream Slope; Up = Upstream Slope

1. Minimum required factor of safety, as defined by the State, is shown in brackets.
2. Cohesive materials were not present in this analysis. Consequently, end of construction, post-earthquake, and rapid drawdown analyses were not required.

4.4 Filter Compatibility

Each of the embankments will include a filter and drain system. The sloping filter/chimney drain will consist of filter material designed to minimize the potential for natural cementation and arrest the progression of any internal erosion mechanism. AECOM performed a filter compatibility analysis based on the NRCS guidance document (Natural Resources Convervation Service [NRCS] 2017) for gradation design of sand and gravel filters using field and laboratory available at the time this document was prepared. Selected filter bands and suggested standard aggregate gradations are included in Attachment G.

Based on the preliminary filter compatibility analysis, ASTM C33 Sand [Fine Aggregate (ASTM Standard C33 2018)] may be used as filter material for embankment shells and clay core constructed using the native red clay from Flat Canyon (Zone 1 Filter). ASTM C33 Gravel [Size No. 89 Coarse Aggregate (ASTM Standard C33 2018)] may be used as filter/drain material for a filter constructed of ASTM C33 sand (Zone 2 Filter).

4.5 Settlement

Settlement was estimated using Settle3D 4.008 (Rocscience Inc. 2017) and assuming settlement parameters based on SPT blowcount, experience, soil type, and consistency of soils encountered during this field investigation. Because the foundation soils were cohesionless, constrained moduli were selected to represent soil behavior under new loading. AECOM selected constrained moduli of 3.5-million and 2-million pounds per square foot for Flat Canyon and Tank/Lind Canyon, respectively. Each embankment was modeled assuming a crest width of 12 feet, downstream slopes of 2.5H:1V, upstream slopes of 3H:1V, soil unit weight of embankment material presented in Table 4-4, and an embankment height presented in Table 1-1. The estimated total settlements for Flat and Tank/Lind Canyons were 6-8 and 4-6 inches, respectively. This is immediate settlement that is anticipated during construction.

5. CONCLUSIONS AND RECOMMENDATIONS

AECOM identifies key takeaways and recommendations of this geotechnical evaluation. This section discusses these items, which are to be addressed and considered in final design. The following list summarizes AECOM's key takeaways and recommendations and subsequent paragraphs provide a more detailed explanation of these points:

- The abutments in Wood Canyon are not suitable for dam construction without extensive excavation into the foundation and both abutments, significant grouting of foundation and both abutments, extensive rock characterization, great expense, or relocation.
- AECOM recommends that future field investigations include provisions to locate, sample, and identify soils, which may be susceptible to collapse when wetted.
- Based on drilling conditions encountered during AECOM's 2019 field investigation, air- or mud-rotary drilling methods are recommended for future field investigations in Wood, Lind, and Flat Canyon.
- Because of the frequent cobbles and boulders encountered during the field investigation, the use of CPTs is not recommended as a tool for subsurface characterization.
- Future field investigations should include provisions that support the development of a site-specific seismic hazard analysis, which should include development of the MCE and OBE.
- Dispersive clays should be identified during final design so that they can be treated or avoided altogether.
- Significant effort, which may include fault mapping or trenching, may be necessary during final design to properly assess the seismic hazard for each site.
- AECOM recommends a minimum embankment core width of 10 feet be considered for final design.
- A detailed field investigation of the proposed abutments including packer testing and lugeon analyses is recommended for future design.
- For this preliminary report, the core should be extended into each abutment; 50 feet from the crest of the embankment into each abutment is assumed for Flat Canyon due to the nature of the tuff observed.
- Provisions for Zone 1 and filter placed along the downstream embankment to abutment contact to intercept and control abutment seepage is recommended.
- A depth below the embankment (cutoff) equal to half the height of the embankment (maximum of 20 feet in Flat Canyon) is assumed for a clay core or drain.
- Filter material (Zone 1 Filter) should meet the requirements for ASTM C33 Fine Aggregate or fall within the recommended Zone 1 filter band (presented in Attachment G) compatible with the native red clay core material.
- The gravel drain (Zone 2 Filter) should meet the requirements for ASTM C33 No. 89 Coarse Aggregate or fall within the recommended Zone 2 filter band (presented in Attachment G) compatible with the ASTM C33 Fine Aggregate.
- Hydraulic conductivity testing (ASTM Standard D5084 2016) should be performed on all embankment, core, and filter materials, during final design.
- Thorough foundation preparation, adequate compaction with appropriate compaction equipment, and sufficient quality control testing of embankment soils during placement is necessary during construction.
- The upstream embankment face and spillway should be armored with rip-rap of sufficient gradation and thickness to prevent degradation during the design flood event.

The embankment core zone must have a width of at least 8 feet to provide adequate water retention; however, the NRCS guidance document (NRCS 2019) recommends a minimum zone width of 10 feet. Accordingly, during final design, a minimum core width of 10 feet should be considered. The core of the dam should have 3 feet of cover on the crest of the dam and the center of the clay core should be collocated with the centerline of the embankment crest. To prevent seepage around the embankment, the core should be extended into each abutment, the distance of which will to be established in subsequent designs. For this preliminary report, a value of 50 feet from the crest of the

embankment into each abutment is assumed for Flat Canyon due to the nature of the tuff observed. A depth below the embankment (cutoff) equal to half the height of the embankment (maximum of 20 feet in Flat Canyon) is also assumed.

Unlike ordinary clays that are stable and somewhat resistant to erosion, dispersive clay soils can be highly erosive. Ordinary clays have a flocculated or aggregated structure while the dispersive clays have minute soil particles that are repulsed rather than attracted to one another. The crumb test (ASTM Standard D6572 2013) and double hydrometer (ASTM Standard D4221 2018) usually define this property adequately, but in some cases, pinhole (ASTM Standard D4647 2013) and chemical tests may also be required (NRCS 2017). According to the NRCS filter design guidance document, generally, soils with a crumb dispersion rating of 2 or less and a double hydrometer percentage of dispersive clay less than 30 can be assumed to not contain sufficient dispersive clay to be problematic. AECOM recommends that sufficient testing should be performed on selected clay source materials to adequately characterize its dispersive properties during final design. These types of clays should be identified so that they can be treated or avoided altogether. If dispersive clays are identified, the engineer should reassess the suitability of the clay borrow source, delineate any necessary restrictions to its use, and revise the filter design accordingly.

Detailed abutment characterization is beyond the scope of this investigation and further evaluation of each of the proposed abutments for grouting requirements will be required in subsequent designs. During the visit of Wood Canyon, it was concluded that the abutments were not suitable for dam construction without extensive excavation into the foundation and both abutments, significant grouting of foundation and both abutments, extensive rock characterization, great expense, or relocation. Extensive grouting of the Flat Canyon abutments is anticipated due to the highly fractured nature of the tuff geological formations observed. During final design activities, drilling of the abutments and foundations with packer testing and lugeon analyses will assist engineers to determine the suitability of the abutments for the dams. Excavation into the abutments of 50 feet or more may be necessary to encounter competent rock for grouting to abut the embankment and develop positive cutoff of seepage flows.

Filter material (Zone 1 Filter) should meet the requirements for ASTM C33 Fine Aggregate or fall within the recommended Zone 1 filter band (presented in Attachment G) compatible with the native red clay core material. The chimney filter should be a minimum of 4.5 feet wide (measured horizontally) on the downstream side of the core and a minimum thickness (measured vertically) of 3 feet should be used for the blanket drain. Provisions for Zone 1 and filter placed along the downstream embankment to abutment contact to intercept and control abutment seepage is recommended.

For the alternative filter and gravel drain system considered in Tank and Lind Canyons, the gravel drain (Zone 2 Filter) should meet the requirements for ASTM C33 No. 89 Coarse Aggregate or fall within the recommended Zone 2 filter band (presented in Attachment G) compatible with the ASTM C33 Fine Aggregate. The Zone 1 Filter should be used in conjunction with the Zone 2 Filter to maintain filter compatibility. The Zone 2 Filter material should be encapsulated by Zone 1 Filter material (minimum of 2 feet thick vertically and 4 feet horizontally) and not be placed in direct contact with embankment shell, foundation, or clay core material. To maintain proper seepage conditions during operation, the Zone 1 and 2 filters should be constructed with the dimensions outlined in Section 4.1.

AECOM recommends that hydraulic conductivity testing (ASTM Standard D5084 2016) should be performed on all embankment, core, and filter materials during final design. This data will help characterize seepage flow volumes for sizing of the toe drain and seepage collection systems. Additionally, sufficient samples should be obtained and appropriate testing should be performed to ensure that adequate volumes of Flat Canyon and native red clay are identified, which also have acceptable fines content, plasticity, and permeability.

Based on drilling conditions encountered during AECOM's 2019 field investigation, air- or mud-rotary drilling methods are recommended for future field investigations in Wood, Lind, and Flat Canyon. Rock coring should be anticipated in Wood Canyon, but may also be necessary at any of the other sites. Groundwater was encountered at a depth of approximately 32 feet below the ground surface. Accordingly, mud-rotary drilling methods are recommended for future boreholes in Tank Canyon that are drilled to depths greater than 32 feet. Because of the frequent cobbles and boulders encountered during the field investigation, the use of CPTs is not recommended as a tool for subsurface characterization.

There are a number of soils, including aeolian, alluvial, colluvial, mudflow, residual, and volcanic tuff, which may be susceptible to collapse upon wetting. Typically these soils are found in arid and semiarid regions where soils have

moisture contents less than saturation (Knodel 1992). Alluvial-type collapsible soils are mainly formed by flash flood and mudflows from large precipitation events (Howayek et al. 2011). Such deposits are usually poorly graded and may contain a significant clay fraction. In residual soils, clays, silts, and large cobbles and boulders, high void ratio structures may develop by leaching of soluble and fines from between the larger particles (Howayek et al. 2011). Collapsible soils often have low plasticity fines or are nonplastic (Knodel 1992), have dry unit weight below about 100-110 pounds per cubic foot, and may have very small (pinhole-sized) to moderate voids visible to the naked eye. AECOM did not encounter collapsible soils during the 2019 field investigation. However, voids or other loose materials were observed in the wash in Wood Canyon. Additionally, based on the depositional environment, encountered soils, and observed site conditions, collapsible soils may be present within the footprint of the proposed embankments. AECOM recommends that future field investigations include provisions to locate, sample, and identify soils, which may be susceptible to collapse when wetted.

AECOM performed a preliminary evaluation of the seismic hazards for each of the facilities. The findings of this evaluation are presented in Section 2.2.1. The proposed basin sites are in close proximity to mapped faults and slip zones. Accordingly, significant effort, which may include fault mapping or trenching, may be necessary during final design to properly assess the seismic hazard for each site. Future field investigations should include provisions that support the development of a site-specific seismic hazard analysis, which should include development of the MCE and OBE. Such provisions may include downhole seismic testing or geophysical methods.

Before embankment construction, all vegetation, debris, and all top soil should be stripped and removed from within the footprint of the embankment. Any protruding boulders should be removed and replaced. Any rock outcroppings should be excavated to provide a clean competent surface onto which soil may be compacted. Fills should be compacted to a minimum density of 95% of the maximum dry density based on ASTM D1557 (ASTM Standard D1557 2012) (Modified Proctor). The clay core should be compacted at a moisture content of 1 percent dry and 2 percent wet of optimum. The fill should be compacted in horizontal lifts no more than 6 inches in compacted thickness using a “sheeps-foot” roller for the clay core and vibratory compaction equipment for the embankment shell, filter, and gravel drain materials. Testing for compacted embankment fill, or native silty sand should be conducted at a frequency no less than 3 tests per 2,500 square feet of compacted lift, or 3 tests per lift, whichever is greater.

6. LIMITATIONS

This report was prepared by AECOM and is intended for the sole use by Jones & DeMille. The scope of services performed for this study may not be appropriate to satisfy the needs of other users, and any use or re-use of this document or of the findings, conclusions, or recommendations presented herein is at the sole risk of said user.

Professional judgments, analyses, and evaluations are presented in this report based in part on project discussions, discussion with third parties, file information, information or reports prepared by others and provided by Jones & DeMille and documented in this report, and in part by AECOM experience on similar projects and understanding of the proposed project. This information and its corresponding assumptions, although thought to be reasonable and appropriate, may not prove to be true in the future, including during future design efforts. The conclusions and recommendations of AECOM are conditioned upon this information and its corresponding assumptions described in this report.

There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction; however, uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. This report has been prepared for the use of Jones & DeMille and their designated representatives. The work completed is of a preliminary nature and may not contain sufficient information for the purposes of other parties or for other uses.

AECOM represents that our services were performed within the limits prescribed by the client, in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation to the client, expressed or implied, and no other warranty or guarantee is included or intended.

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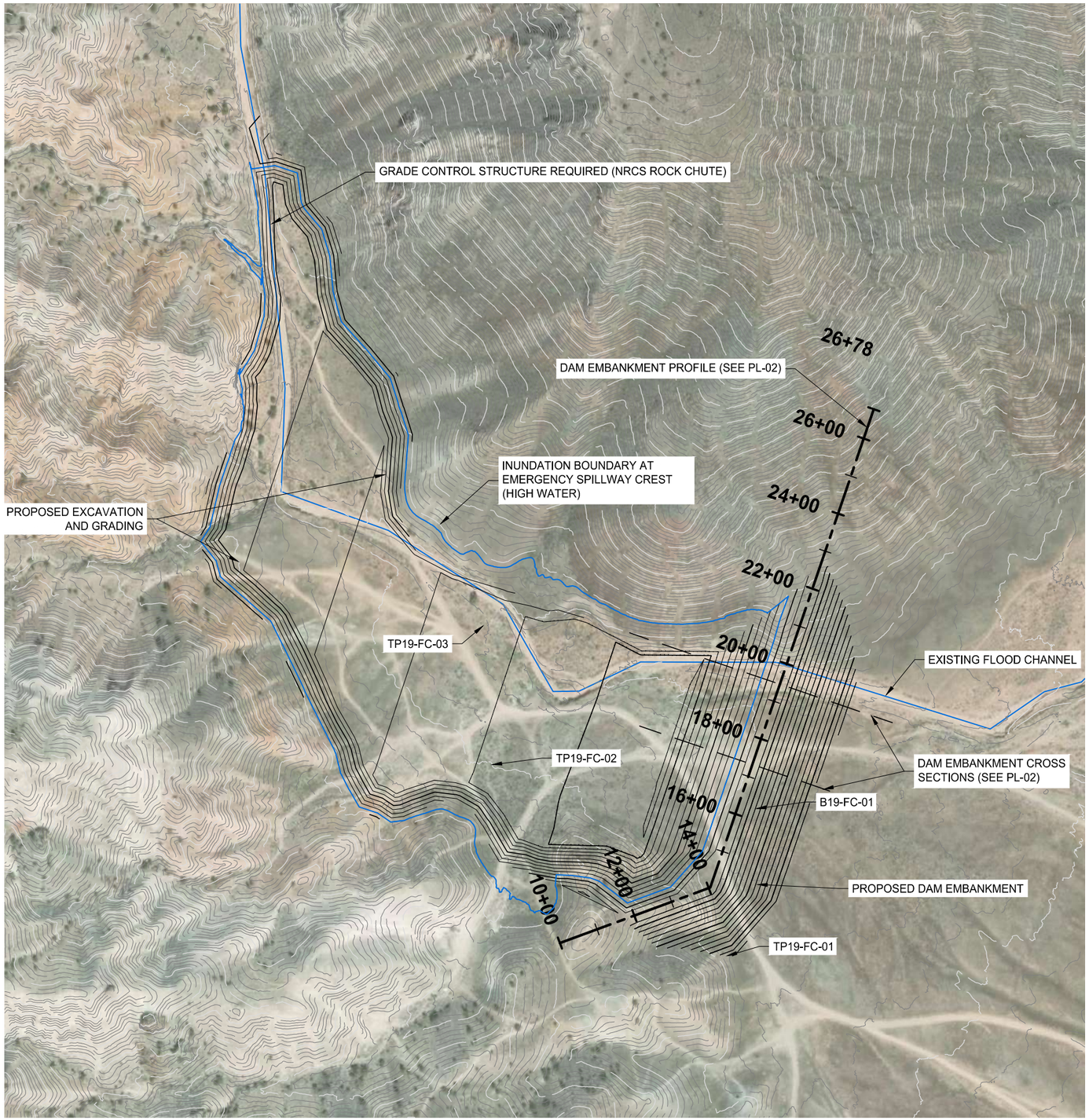
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Attachment A. Figures



NOTE: GEOTECHNICAL DESIGN EXHIBIT ONLY. FULL DESIGN DRAWING SET PROVIDED ELSEWHERE WITH ADDITIONAL INFORMATION

N

5 FOOT CONTOUR INTERVAL
SCALE: 1" = 300'

DAM CREST ELEVATION = 5609.0
EMERGENCY SPILLWAY CREST ELEVATION = 5599.0
STORAGE AT EMERGENCY SPILLWAY CREST = 826.9 AC.FT.
EARTHWORK VOLUME OF DAM = 316347 C.Y.



NO.	DATE	REMARKS
		REVISIONS

SCALE: 1" = 300'
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UPDATED: 8/7/2019
PLOTTED: 8/7/2019

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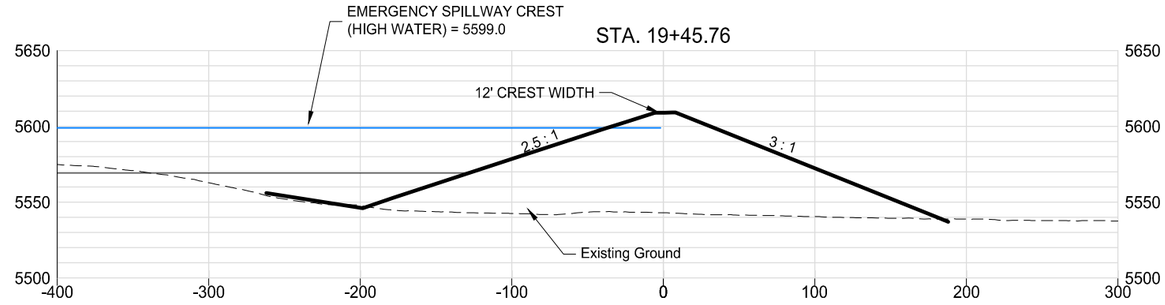
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FLAT CANYON
PLAN
PROJECT NUMBER: 1804-224

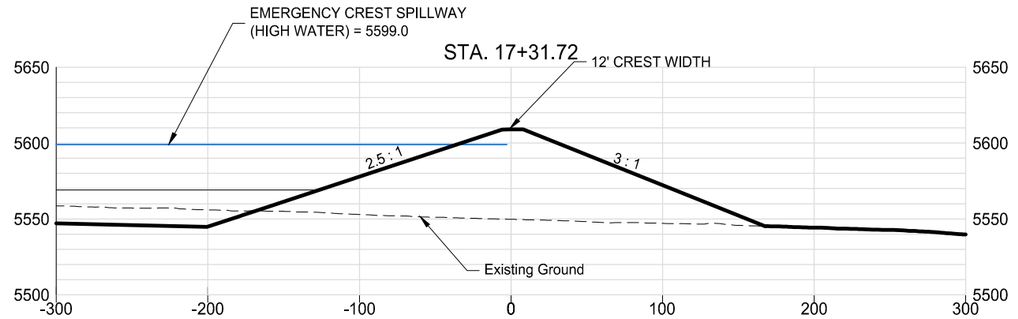
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COUNTY

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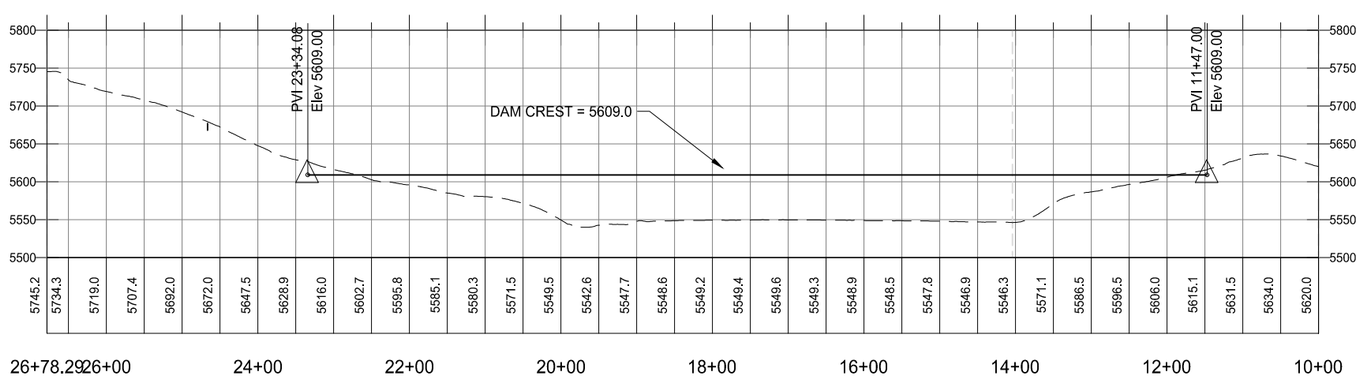
FLAT CANYON CROSS SECTIONS

NOTE: GEOTECHNICAL DESIGN EXHIBIT ONLY.
FULL DESIGN DRAWING SET PROVIDED
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INFORMATION





FLAT CANYON DAM PROFILE



REVISIONS

NO.	DATE	REMARKS

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UPDATED: 8/7/2019
PLOTTED: 8/7/2019

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FLAT CANYON

CROSS SECTIONS AND PROFILE

PROJECT NUMBER: 1804-224

SEVIER
COUNTY

SHEET NO. PL-02

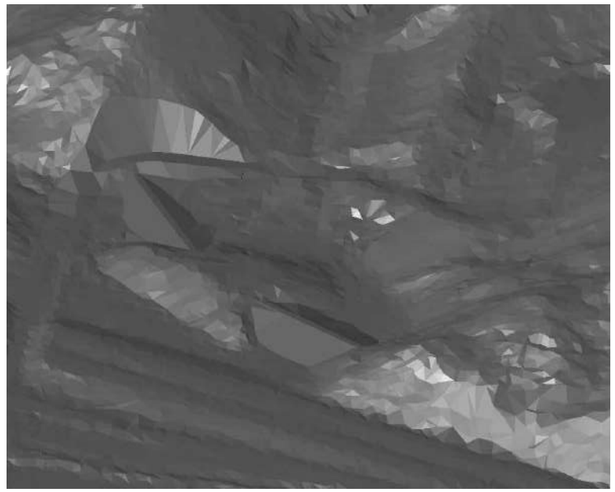


NOTE: GEOTECHNICAL DESIGN EXHIBIT ONLY.
FULL DESIGN DRAWING SET PROVIDED ELSEWHERE WITH ADDITIONAL INFORMATION

N

5 FOOT CONTOUR INTERVAL
SCALE: 1" = 200'

DAM CREST = 5457.0
EMERGENCY SPILLWAY CREST ELEVATION = 5449.0
STORAGE AT EMERGENCY SPILLWAY CREST = 39.6 AC.FT.
EARTHWORK VOLUME OF DAM = 49,150 C.Y.



REVISIONS

NO.	DATE	REMARKS

UPDATED: 8/7/2019
PLOTTED: 8/7/2019

DWG NAME: H:\JD\Proj\1804-224\dwg\TankCynGEO.dwg

SCALE: 1" = 200'

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GEOTECHNICAL DESIGN EXHIBIT
TANK CANYON
PLAN

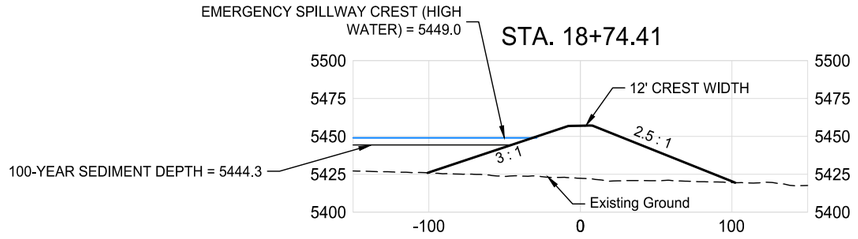
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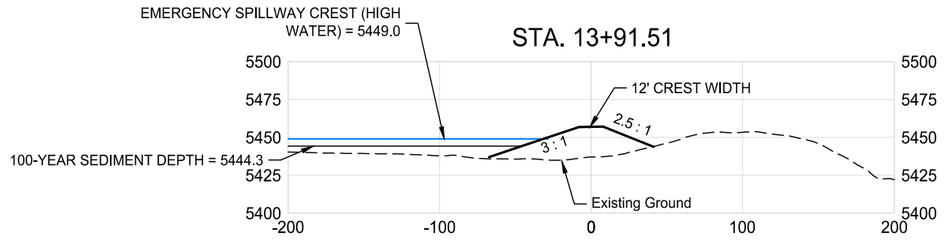
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COUNTY

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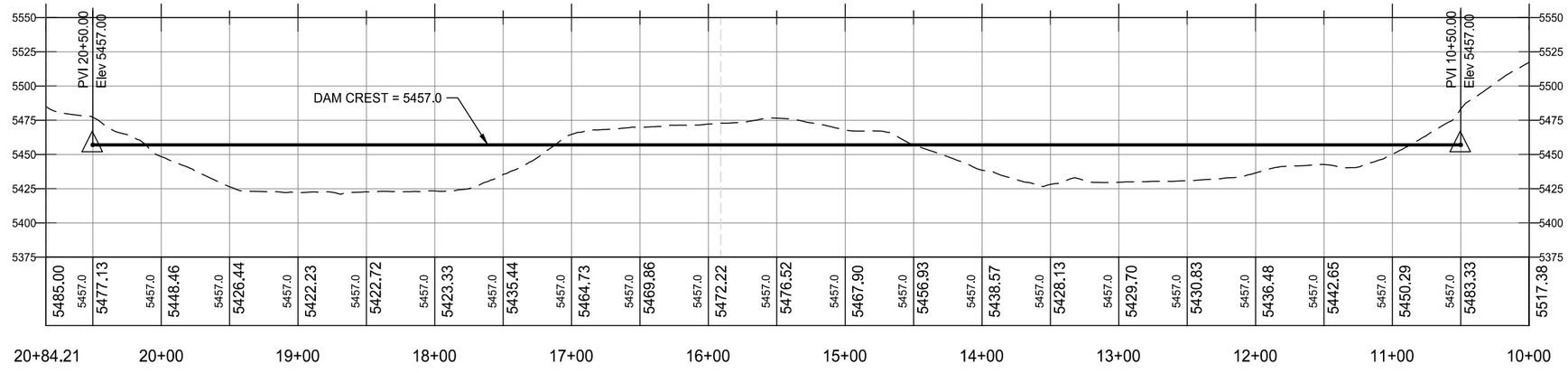
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TANK CANYON DAM CROSS SECTIONS





TANK CANYON DAM PROFILE



NO.	DATE	REMARKS
		REVISIONS

SCALE: 1" = 200'

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UPDATED: 8/7/2019

PLOTTED: 8/7/2019

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APPROVED QUALITY MANAGEMENT REVIEW DATE

GEOTECHNICAL DESIGN EXHIBIT

TANK CANYON

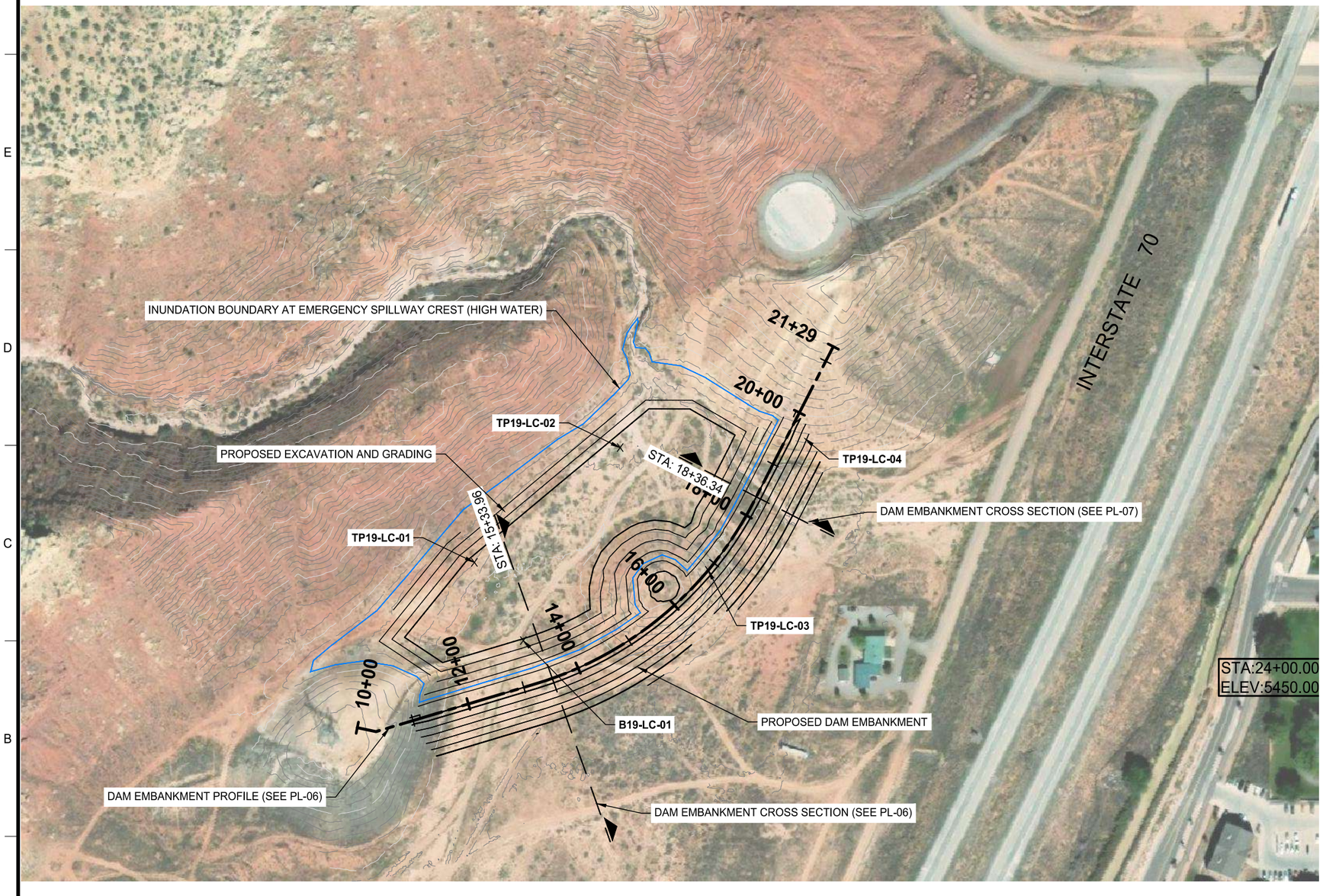
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PROJECT NUMBER: 1804-224

SEVIER COUNTY

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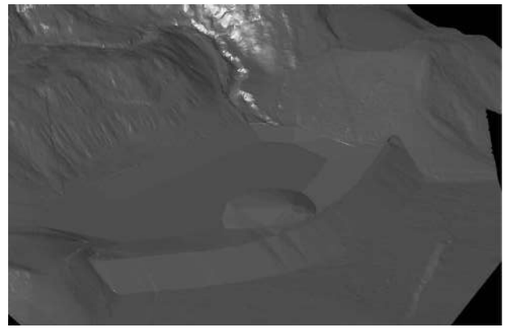
NOTE: GEOTECHNICAL DESIGN EXHIBIT ONLY.
FULL DESIGN DRAWING SET PROVIDED ELSEWHERE WITH ADDITIONAL INFORMATION



N

5 FOOT CONTOUR INTERVAL
SCALE: 1" = 200'

DAM CREST ELEVATION = 5450.0
EMERGENCY SPILLWAY CREST ELEVATION = 5442.0
STORAGE AT EMERGENCY SPILLWAY CREST = 63.4 AC.FT.
EARTHWORK VOLUME OF DAM = 58,272 C.Y.



NO.	DATE	REMARKS
		REVISIONS

SCALE: 1" = 200'
DWG NAME: H:\JD\Proj\1804-224\dwg\LindCynGEO.dwg
UPDATED: 8/7/2019
PLOTTED: 8/7/2019

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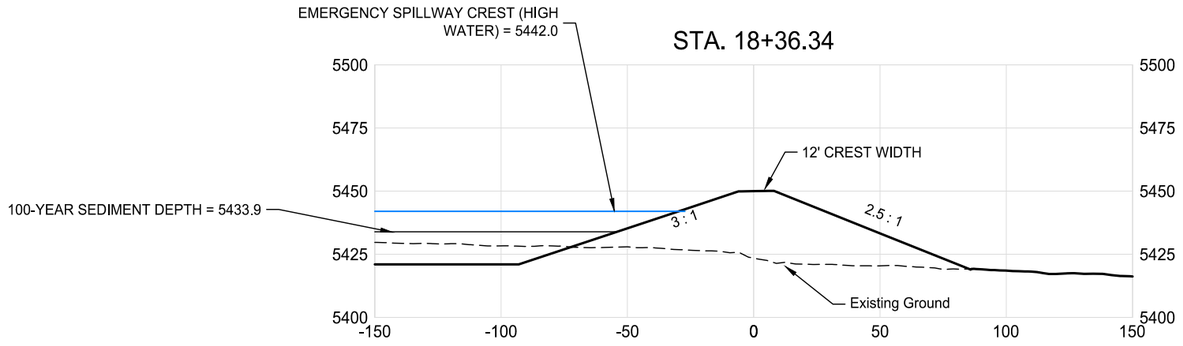
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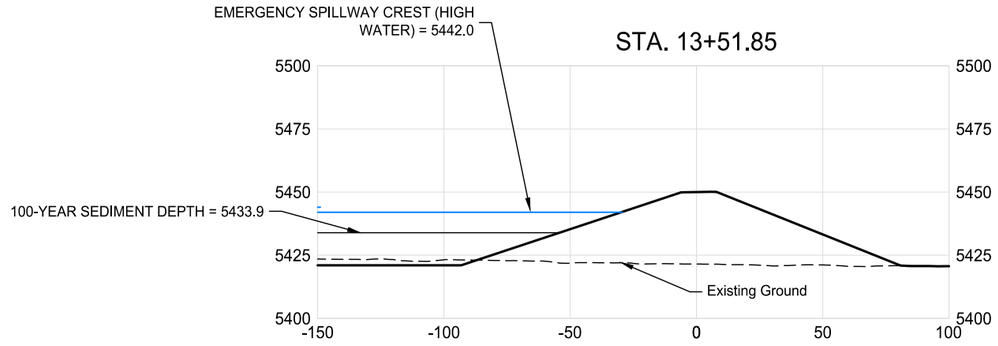
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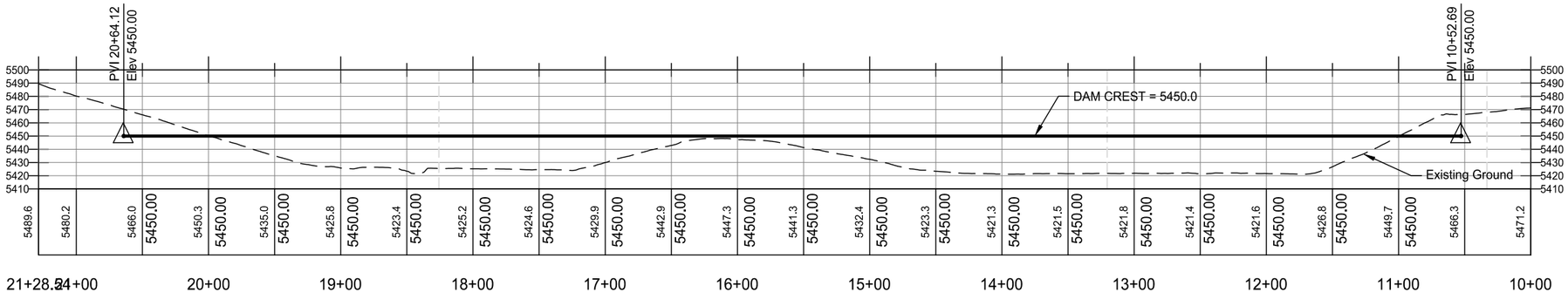
LIND CANYON CROSS SECTIONS

NOTE: GEOTECHNICAL DESIGN EXHIBIT ONLY.
FULL DESIGN DRAWING SET PROVIDED
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INFORMATION





LIND CANYON DAM PROFILE



NO.	DATE	REMARKS
		REVISIONS

UPDATED: 8/7/2019
PLOTTED: 8/7/2019

DWG NAME: H:\JD\Proj\1804-224\dwg\LindCynGEO.dwg

SCALE: 1" = 200'

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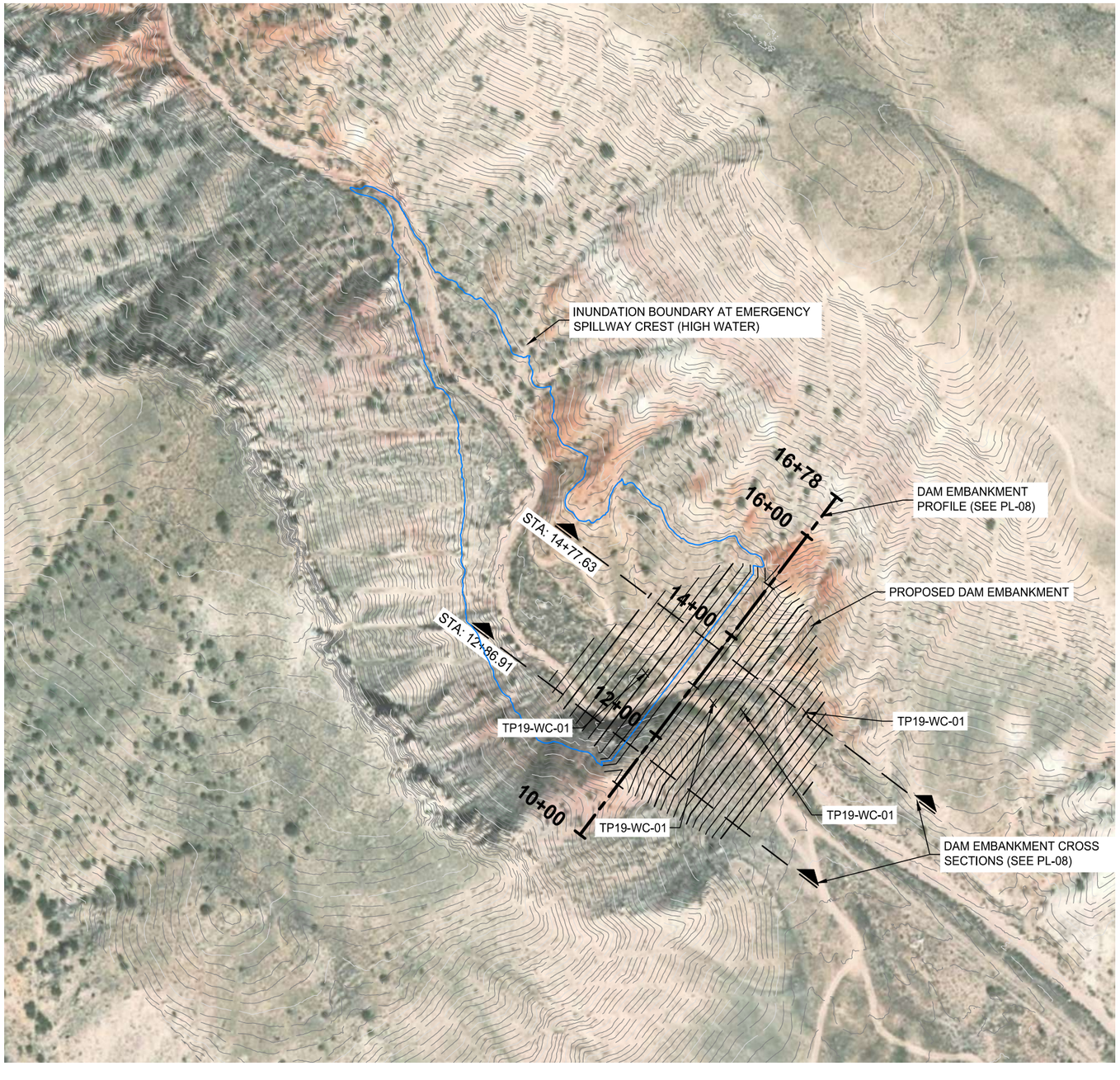
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GEOTECHNICAL DESIGN EXHIBIT
LIND CANYON
CROSS SECTIONS AND PROFILE

PROJECT NUMBER: 1804-224

SEVIER
COUNTY

SHEET NO. PL-06

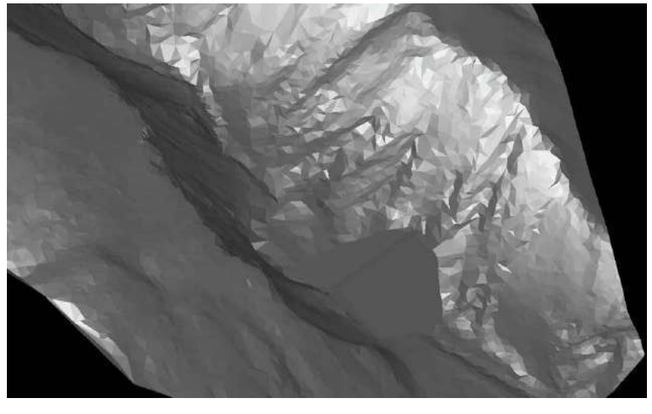


NOTE: GEOTECHNICAL DESIGN EXHIBIT ONLY. FULL DESIGN DRAWING SET PROVIDED ELSEWHERE WITH ADDITIONAL INFORMATION

N

5 FOOT CONTOUR INTERVAL
SCALE: 1' = 200'

DAM CREST ELEVATION = 5670.0
EMERGENCY SPILLWAY CREST ELEVATION = 5662.0
STORAGE AT EMERGENCY SPILLWAY CREST = 88.7 AC.FT.
EARTHWORK VOLUME OF DAM = 152,000 C.Y.



NO.	DATE	REMARKS
		REVISIONS

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UPDATED: 8/7/2019
PLOTTED: 8/7/2019

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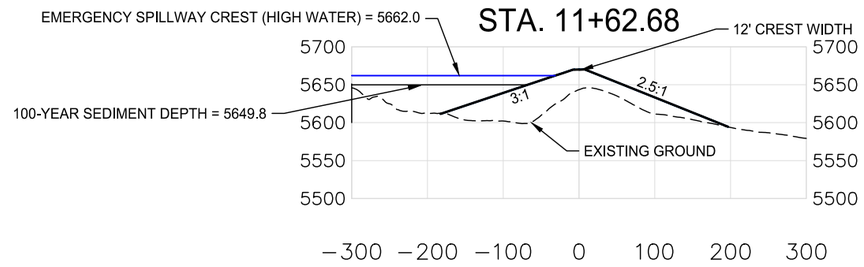
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PLAN
PROJECT NUMBER: 1804-224

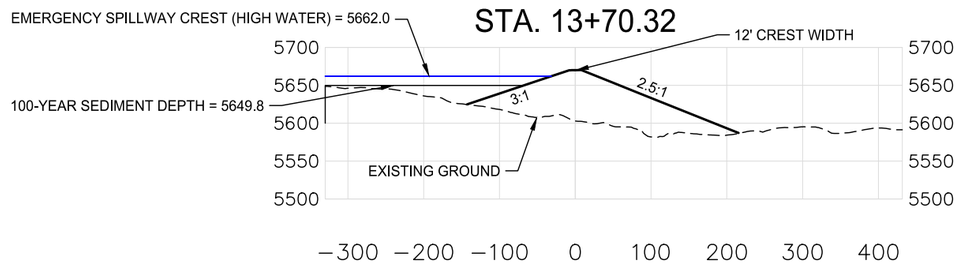
SEVIER
COUNTY

SHEET NO. PL-07

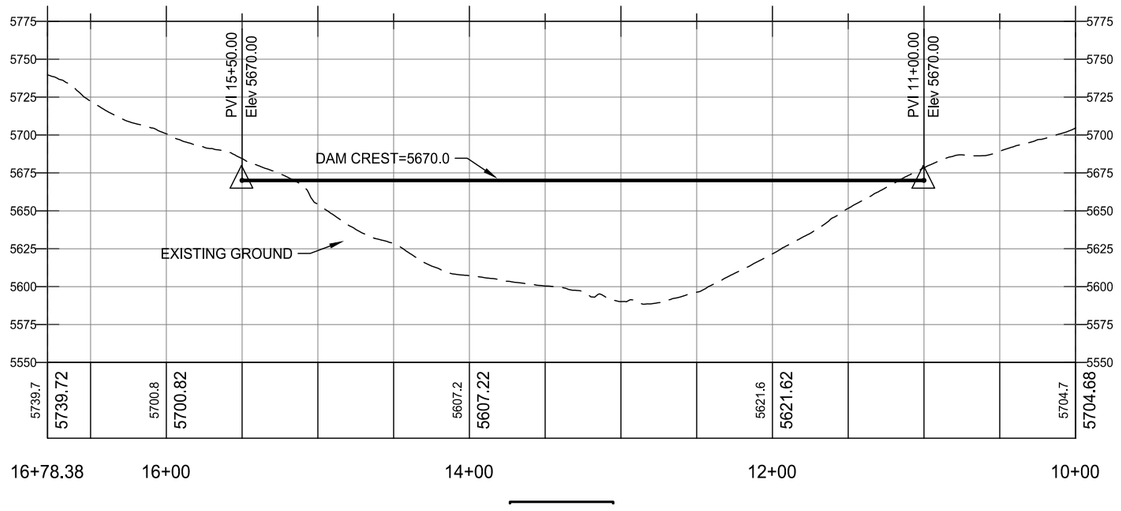
WOOD CANYON DAM CROSS SECTIONS

NOTE: GEOTECHNICAL DESIGN EXHIBIT ONLY. FULL DESIGN DRAWING SET PROVIDED ELSEWHERE WITH ADDITIONAL INFORMATION





WOOD CANYON DAM PROFILE



REVISIONS

NO.	DATE	REMARKS

SCALE: NTS

DWG NAME: H:\JD\Proj\1804-224\dwg\WoodCynGEO.dwg

UPDATED: 8/7/2019
PLOTTED: 8/7/2019

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APPROVED QUALITY MANAGEMENT REVIEW DATE

GEOTECHNICAL DESIGN EXHIBIT

WOOD CANYON

CROSS SECTION AND PROFILE

PROJECT NUMBER: 1804-224

SEVIER COUNTY

SHEET NO. PL-08

Pahvant Range

Generalized Stratigraphic Column

Period	Epoch	Formations
Quaternary	Holocene & Pleistocene	Younger Alluvial Fan Deposits
		Older Alluvial Fan Deposits
		Mass Movement Talus
		Mass Movement Slides and Sumps
Tertiary	Miocene	Osiris Tuff
	Oligocene	Tuff of Albinus Canyon
		Bullion Canyon Formation, Three Creek Tuff Member
		Aurora Formation
		Crazy Hollow Formation
		Dipping Vat Formation
	Eocene	Green River Formation
		Flagstaff Formation: Upper Member: White Member
		Flagstaff Formation: Upper Member: Red Member
		Flagstaff Formation: Middle Member
		Flagstaff Formation: Lower Member

Description of Map Units

- Qaf$_1$ — Younger alluvial-fan deposit
- Qaf$_2$ — Older alluvial-fan deposit
- Qmt — Mass movements, talus
- Qms — Mass movement, slides and slumps
- To — Osiris Tuff (undivided)
- Tac — Tuff of Albinus Canyon (undivided)
- Tbct — Three Creeks Tuff of Bullion Canyon Volcanics
- Tau — Aurora Formation (undivided)
- Tch, Tchs — Crazy Hollow Formation (undivided)
- Tdv — Dipping Vat Formation (undivided)
- Tg, Tgs — Green River Formation (undivided)
- Tf — Flagstaff Formation (Undivided)
  - Tfuw — Upper White Member of Flagstaff Formation
  - Tfur — Upper Red Member of Flagstaff Formation

Key

- Approximate bedding plane slip surface
- Fault or facture bounding shallow detachment block
- Contact, dashed where approximately located
- High-angle fault, dashed wehre approximately located, dotted where concealed, bar and ball on down-thrown side
- Unconformity
- Strike and dip of bedding
- Gravel or road-fill pit, hachured line shows approximate edge of pit

Sevier Watershed Plan
Richfield, Utah

Generalized Stratigraphic Column

Figure 1

Drafted By: NA | **Date:** May 26, 2019

Reviewed By: Lawrence Cannon | **Project Number:** 60598028

AECOM

Attachment B. Existing Reports

GEOLOGIC REPORT

OF

FAULT MAPPING FINDINGS

AND

SEISMIC EVALUATION

FOR

RICHFIELD-WEST SEVIER WATERSHED

SEVIER COUNTY, UTAH

Prepared by

Michael R. Deming
and
Bob L. Bridges
Geologists
SCS

August 1976

GEOLOGIC REPORT OF FAULT MAPPING FINDINGS

AND SEISMIC EVALUATION FOR

RICHFIELD-WEST SEVIER WATERSHED

SEVIER COUNTY, UTAH

SUMMARY

Detailed fault mapping of the Richfield-West Sevier Watershed between Elsinore and Aurora, Utah, shows that the Elsinore fault zone is active.

Six of seven proposed debris basin sites are located on faults, and the Cottonwood Debris Basin site is also located on a landslide.

Geologic mapping of the Elsinore fault disclosed a zone of intense faulting from Elsinore, Utah, to Denmark Wash, a distance of approximately 22 miles. Width of the zone varies from 1.0 mile near Elsinore to 4 miles near the Cedar Ridge drainages. Two zones or directions of trend were mapped, a northeast zone and a northwest zone. The northwest zone appears to be the most active.

Evidence of recent movement was found in alluvial fan deposits at the mouth of Big Fan Canyon and Dry Red Canyon. Apparent displacement was also found in the fan near Willow Creek.

A search of the seismic record indicates that seismic adjustment is still occurring along the Elsinore fault.

The maximum probable earthquake that can be expected on the Elsinore fault zone during the design life of the project is estimated at 6.5 Richter magnitude.1/ Estimated displacement with an event of 6.5 magnitude is approximately 2 to 4 feet (vertical).

The maximum credible earthquake that can be expected on the Elsinore fault zone is estimated at 7.4 Richter magnitude.1/ Estimated displacement with this event may exceed 8 feet (vertical).

CONCLUSIONS

1. The Elsinore fault zone is active and still undergoing seismic adjustment.

2. An earthquake with a Richter magnitude of 6.5 can be expected during the design life of the project (100 years). The maximum credible earthquake that could be expected on the Elsinore fault is estimated at 7.4 Richter magnitude.

3. Six of seven proposed debris basin sites are located over faults. All of the faults are considered part of an active seismic zone. Displacement could occur along any of the faults associated with the proposed sites.

4. The Flat Canyon, Dairy-Rulon Lind, Tank, Cottonwood, Willow, and North Aurora sites are considered geologically poor locations for construction of dams because of active faults under the proposed embankments.

5. Strong ground motion from earthquakes can also be expected at any of the seven debris basin sites.

6. Part of the foundation and the left abutment of the Cottonwood Debris Basin site is located on a landslide.

7. Plots of earthquake epicenters indicate that the southern portion of the Elsinore fault zone is presently the most active, but all evidence of movement in recent alluvial deposits was observed along the northern portion of the fault zone.

REPORT OF FAULT MAPPING FINDINGS AND SEISMIC EVALUATION BY SITES

Following are individual dam site reports on the seven proposed structures. The reports discuss location of faults with relationships to dam location, findings of the mapping investigation, and conclusions as to geologic suitability of each site. The reports also discuss alternate dam site locations:

FLAT CANYON DEBRIS BASIN SITE

Findings:

Detailed geologic field mapping of faults in the Flat Canyon area disclosed a system of parallel normal faults trending northeast through the Flat Canyon fan along with an associated system trending northwest. The northwest trending faults are responsible for the initial development of Flat Canyon and are about 1 to 1.75 miles in length. Two of the northeast trending faults (N 30-35° E) pass through the debris basin site. They are spaced 450-500 feet apart and are downthrown to the east with an estimated total displacement of 200 feet. Fault length is estimated at 3.5 miles. These faults pass through the wind dikes. The eastern fault passes through the northern wing dike near the P.I. with the main portion of the dam. A third fault is believed to pass approximately 200

feet east of the main centerline of the dam and is over 4.5 miles in length.

All of the faults mapped are part of the Elsinore fault zone. The northeast trending faults appear to form the main stem of the fault zone.

No evidence of recent surface rupture was found in the area even though several large damaging earthquakes have occurred in Elsinore since 1900. Several earthquake epicenters have been plotted within 5 miles of the site. The largest damaging earthquake occurred in 1910 with a Richter magnitude of 6.7. Another quake occurred in 1921 with a magnitude of 6.1. Active sedimentation in the Flat Canyon area has probably covered any evidence of recent activity in the fan, including historical.

Conclusions:

1. The Flat Canyon Debris Basin site is presently located over two normal faults and approximately within 200 feet of a third fault. An additional number of faults have been located within 0.25 miles of the site.

2. The faults passing through the site are part of an active seismic zone. Damage from large magnitude earthquakes has occurred within one mile of the site and possible at the site. Any of the faults could move or areas in between may also be subject to displacement.

3. Moving the debris basin site 3,100 feet downstream (down fan) would move it off of faults mapped during the latest investigation. This might reduce the potential of actual displacement in the dam; however, it would still be subject to strong ground motion from earthquakes on the Elsinore fault. Moving the dam downstream does not completely eliminate the potential for displacement since faults (which could not be mapped) may be concealed by alluvium in the lower fan area.

DAIRY-RULON LIND SITE

Findings:

Northeast trending faults and east-west cross faults have broken the rock beds beneath the proposed site. The northeast trending faults have a total downthrow of approximately 200 feet to the northwest and an average length of 2 miles. The shorter east-west trending cross faults are downthrown both to the north and to the south with approximately 20-30 feet displacement at the site. All of the faults are branches of the Elsinore fault zone. The main Elsinore fault zone is believed to be near the Sevier Valley Canal in this area, and it roughly parallels the axis of the dam.

The dam foundation is underlain by fine to moderately coarse-textured alluvium. Volcanic tuffs, siltstones, shales and sandstones underlie the alluvial cover, which is over 50 feet deep in some areas.

Conclusions:

1. Geologically, the site is unfavorable because of recorded earthquakes in the vicinity. Displacement may occur along one of the several faults, which have broken the rocks beneath the foundation. Also, strong ground motion will occur in the alluvium if movement takes place along the main fault zone.

2. A more favorable site could not be located.

TANK CANYON DEBRIS BASIN SITE

Findings:

1. A series of parallel faults trending N 50° E have broken the rocks in and adjacent to the Tank Canyon Reservoir Basin. These faults range from 1 to over 2 miles long and total downthrow to the east is approximately 250 feet. The fault on the west side of Water Tank Knoll trends diagonally across the axis of the north dam and has a displacement of approximately 25 feet at the site.

2. North-south trending faults are evident along the road near the north end of the north dam. The largest fault trends N 10° E through the reservoir basin and across the axis of the south dam. Displacement along this fault increases to the south, and it probably exceeds 30 feet near the axis of the dam. Sinkholes and large open cracks were observed along the fault north of the old rock quarry, below the Forest Service road.

   An east-west cross fault has apparently broken the rocks along the west side of Water Tank Knoll with a downthrow to the north.

   All of the faults at the site are branches of the Elsinore fault zone.

Conclusions:

1. Part of the north dam is underlain by fractured, cavernous limestone. High water losses are expected from the basin, and this may cause piping of the fill. Geologic conditions can be improved by moving the site approximately 200 feet downstream. Shales, siltstones and sandstones will underlie the embankment in the area; however, they are broken by the east-west trending cross fault.

2. Although the rocks in the south dam are broken by faulting, they are expected to be stable and relatively impervious. The emergency spillway located at the north end of the dam is underlain by fractured broken limestones, which overlie weathered siltstones and

shales. Foundation conditions at the south dam will improved if the south end is moved 50-75 feet downstream.

3. Geologically, the Tank Canyon site is unfavorable because five branches of the Elsinore fault zone are located in the reservoir basin. These branch faults are all considered active because of recorded earthquakes in the vicinity.

4. Ponding water at the site will probably affect the Richfield Spring.

COTTONWOOD DEBRIS BASIN SITE

Findings:

1. The left abutment is composed of moderately consolidated landslide deposits derived mainly from limestones, siltstones, sandstones, and shales. Generally, the deposit is a heterogeneous mixture of poorly graded gravel (broken limestone fragments), silty gravel, clayey gravel, and gravelly clay. Based on information in the drilling logs, over 50 percent of the deposit is estimated to be broken limestone fragments and blocks. The poorly graded gravels are highly pervious and loose. Pockets of weathered shale and siltstone were found at several locations within the landslide mass. The landslide undoubtedly occurred during an earthquake in the area. The slide is younger than the other landslides in the vicinity and is probably less than 500 years old.

2. Rocks at the site are broken by two parallel faults, which trend approximately N 45° E. Both faults trend diagonally across the axis of the proposed dam and join the main Elsinore fault approximately 1 mile to the northeast. The fault on the north is located under the landslide deposit in the left abutment and has a displacement of approximately 30 feet at the site. The fault on the south is located in the right abutment and downstream part of the foundation. This fault extends for over four miles and has a displacement of 75-100 feet at the site.

Conclusions:

1. Geologically, the site is unfavorable for the construction of a dam 110 feet high because of possible settlement and piping in the left abutment and recurring movement along one of the faults, which trends diagonally across the dam axis.

2. A site approximately 600 feet downstream is recommended. A site on the Cottonwood Creek fan just upstream from the hospital is preferred; however, this location has been eliminated in the planning because of land rights and design problems.

3. Because of the recent landslide on the left abutment, unstable rock ledges just upstream from the right abutment, fresh fault scarps in the vicinity, and connection with the main Elsinore fault, the faults mapped at the site are believed to be active.

WILLOW CREEK DEBRIS BASIN SITE

Findings:

Detailed geologic mapping of the Elsinore fault zone, in the Willow Creek area, disclosed intense faulting. The largest number of faults found during the mapping investigation were found at the mouth of Willow Creek Canyon and along the fan. These faults trend northeast (N 30-35° E) and are spaced from 5 to 600 feet apart. Near the mouth of the canyon, faults were so closely spaced that individual faults could not be mapped. Displacement along the fault system is estimated at over 2,000 feet.

Evidence of recent movement was found north of Willow Creek in two places. Both displacements are in alluvial fans, which are estimated to be less than 1,000 years old. One displacement is estimated to be younger than 200 years since it has affected tree roots along the scarp.

Two (2) northeast trending faults pass through the debris basin site. The upper fault has an estimated displacement of 100 feet and the lower fault is displaced approximately 400 feet. In addition, it appears that the upper end of the south wing dike rests on the toe of the Cottonwood-Willow landslide.

Conclusions:

1. The present Willow Creek debris basin site is located over two (2) normal faults. In addition, fourteen (14) or more faults have been mapped within 4,500 feet of the site.

2. Because of the evidence of recent seismic activity, intense faulting in the Willow Creek area and faulting through the basin, the present site is geologically and seismologically a poor location for a debris basin.

3. Site conditions could be improved by relocating the site approximately 1,500 to 2,400 feet downstream. This would somewhat reduce the potential for displacement in the dam, but would not completely eliminate the possibility since faults concealed by alluvium may also exist in this area. The relocation would not eliminate damage caused by ground motion from earthquakes along the Elsinore fault zone.

NORTH AND SOUTH CEDAR RIDGE DEBRIS BASIN SITE

Findings:

Detailed geologic mapping in the North Cedar Ridge-South Cedar Ridge Canyon area indicates that the Elsinore fault zone is primarily located west of the proposed debris basin site. The distance to the closest fault from the proposed centerline is approximately 2,800 feet with the main portion of the fault zone lying approximately 5,000 feet west of the site. The maximum displacement, along the Elsinore fault, occurs west of the site at the mouth of the Cedar Ridge Canyon where an extimated 2,000 feet of vertical separation can be observed.

A northwest-southeast trending fault could possibly pass under the debris basin site, but evidence as to its location is lacking in the active alluvial fan. Good evidence of the northwest-southeast fault crossing of all the northeast trending faults were also lacking, but is suspected.

The Cedar Ridge area is in a transition zone where the northeast trending Elsinore fault zone (N 30-35° E) is intersected by a recently very active fault zone trending northwest (N 20-55° W) to Scipio (may also be part of the Elsinore fault). The crossing of the two fault zones form a cross hatch pattern in the area west of the site. Evidence of the most recent and modern seismic activity was found about 1.5 miles northwest of the site. In addition, earthquake epicenters have been plotted in the same area indicating a high degree of seismic activity.

Displacement in the Cedar Ridge alluvial fans could not be observed, possibly because of active sedimentation.

Conclusions:

1. Evidence of faulting at the North and South Cedar Ridge site is lacking, although one (1) northwest-southeast trending fault is suspected.

2. Although faults were not mapped through the debris basin site, seismic activity and recent fault displacement is more evident in this area than at any other point mapped. The potential for recurrent seismic activity may be highest in this area.

3. The proposed dam probably can be constructed at the proposed site, but is in a highly active seismic area where strong ground motion can be expected. The embankment should be designed with this in mind.

NORTH AURORA DEBRIS BASIN SITE

Findings:

After field mapping of faults near the North Aurora site, the closest displacement appeared to be a northeast trending normal fault approximately 370 feet west of the proposed centerline. However, after reviewing drill hole logs and cross sections done by Neil Murdock (Geologist-Schick International) it appears probable that a northwest to west trending fault crosses the centerline of the dam (perpendicular to axis).

This fault is downthrown to the south and explains the geologic differences in the dam abutments, which is hard to explain by erosion. Estimated displacement along the west trending fault is in excess of 100 feet.

The northeast trending fault upstream of the basin is downthrown to the west with approximately 75 feet of displacement and trends N 50° E. This fault helps form a natural basin. The probable west trending fault through the dam would explain the notch through the northeast trending hogback, which forms the dam site.

The Aurora site is in the more active section of the Elsinore fault and recurrent seismic activity can be expected in this area. Earthquake epicenters have been plotted approximately 2.5 miles southwest of the site. A suspected fresh scarp was also located in the epicenter area. A fault which breaks late Pliocene or early Pleistocene formation was uncovered in a bentonite pit about 4,500 feet northwest of the site.

Surface evidence near Round Valley 8 miles northwest of the site indicates that the northwest to west trending faults have had recent movement and are still undergoing adjustments.

Conclusions:

1. The North Aurora site is in an active seismic area subject to both surface rupture by faulting and ground motion from earthquakes.

2. The probable fault suspected of running through the dam site would have to be confirmed by intense field mapping and possible some additional drilling in the right abutment. If the presence of a west trending fault is confirmed, the present site would be geologically unsound for construction of a debris basin.

REGIONAL SEISMIC SUMMARY

The Richfield-West Sevier Watershed is located near the transition zone between the Basin and Range Province of western Utah and the High Plateaus

of western Utah. The watershed is located on the eastern side of the Pavant Mountains, a Basin and Range type structure. This area is located within the "Intermountain Seismic Belt."[2/] The seismic belt is thought to extend from the Gulf of California into western British Columbia crossing through western Arizona, central Utah, southeast Idaho, western Wyoming, and western Montana (Wollard, 1959).[2/] The seismic system is thought to be a "branch of the active rift system associated with the landward extension of the East Pacific Rise into the North American Continent" (Menard, 1960; Heezen, 1960; Cook, 1962, 1966).[2/]

Major fault zones located within 50 miles of the Richfield region include the Thousand Lake, Hurricane, and Southern Wasatch faults. Major faults within 20 miles of the watershed include the Elsinore, Sevier, and Dry Wash faults. The Elsinore fault zone passes directly through the watershed along the eastern toe of the Pavant Mountains. All of the faults mentioned are considered active faults as the area is still undergoing seismic adjustment.

Numerous earthquake epicenters have been plotted along the Elsinore, Sevier, and Dry Wash faults since the area was settled in the mid 1800's. All three of these faults displace Tertiary strata, and field investigations have revealed Quaternary and modern sediment deposits have been displaced in some localities. Earthquakes with Richter magnitudes less than 1.0 to a maximum of 6.7 have been associated with the three faults. A total of 278 earthquakes have been listed as plotting within a 50-mile (approximately) radius of the site between 1850 and 1975. (See attached epicenter listings).

WATERSHED FAULT MAPPING AND SEISMIC INVESTIGATION

During August of 1976, Bob Bridges and Mike Deming (geologists, Soil Conservation Service) made a detailed mapping study of the Elsinore fault zone. The fault zone passes northeast through the Richfield-West Sevier Watershed along the toe of the Pavant Mountains. The zone was mapped from Elsinore, Utah, north to Denmark Wash (north of Aurora, Utah). The corridor mapped varied from approximately 1 mile wide on the south end to 4 miles wide near the northern end. Purpose of the fault mapping was to determine the relationship between proposed damsite locations and faults, to determine the activity of faults, and to estimate the age or most recent activity occurring along the zone. Large faults outside the watershed were considered less hazardous since the active Elsinore fault zone passes directly through the watershed structure sites.

Faults and other geologic hazards were mapped on 1974 aerial photographs at a scale of 1:24,000. Special aerial photographs used for planning the damsites (at scales of 1 inch equals 1,000 feet and 1 inch equals 500 feet) were also used. Faults were traced on the ground and located on the 1974 photographs. The 1974 photos were later spliced together to

make 1 mosaic of the corridor. Displacement along individual faults was estimated from field investigation. Areas showing recent surface rupture are located on the map.

A paper by Michael C. Schneider, Department of Geology, DePauw University; Geology of the Pavant Mountains West of Richfield, Sevier County, Utah, 1963, and an unpublished PhD thesis by Herman Kenneth Lautenschlager, Ohio State University; and the Geology of the Central Part of the Pavant Range, Utah, 1952, were used for reference.[3 & 4] Guidebook to the Geology of Utah, No. 4, The Transition Between the Colorado Plateaus and the Great Basin in Central Utah, by Edmun M. Speiker, 1949, was also used as a reference.[5]

WATERSHED SEISMIC SUMMARY

General Geology

The Pavant Mountains form a tilted block which dips approximately 12° to the southeast and is bounded on the east and west by normal faults. At the east toe of the mountain range is the Sevier Valley, a structural trough with the Elsinore fault zone, paralleling the east edge and the Sevier fault on the west edge.

Tertiary sedimentary and volcanic rocks comprise all of the exposed outcrops on the eastern dip slope of the Pavant Range with local outcrops of Quaternary-Tertiary sedimentary deposits. Quaternary and modern alluvial deposits cover much of the upper edge of the Sevier Valley along the toe of the range. Beginning with the youngest consolidated deposits, the following stratographic column can be constructed from exposers in the range: Axtell formation - unknown feet thick (sed.); Dry Hollow formation - 150-200 feet thick (vol. and sed.); Bullion Canyon Volcanics - (vol).; Bald Knoll formation - 475 ± feet thick (sed.); Crazy Hollow - 260 ± feet thick (sed.); Green River formation - 56-60 feet thick (sed.); Flagstaff formation - 400-2,300 feet thick (sed.); and North Horn formation - 2,300 ± feet thick (sed.).

Green River and Flagstaff formations are the key stratagraphic marker and structural beds in the watershed. The Green River formation is a light green to gray limestone, which forms on large massive bed in the Richfield area, but in areas where it has been faulted, breaks into blocks and small pieces. The Flagstaff formation is dominantly bright red and purple shales, sandstone, limestone, and conglomerate. The shale in the contact zone between the Flagstaff and overlying Green River formation forms a smooth surface, which in the Cottonwood and Willow Creek areas has allowed the Green River to slide over the Flagstaff formation along the Sevier fault and in places has slid over itself. Movement along the slide plane is thought to have been the

result of dip slope in combination with Seismic activity along the Elsinore fault. Sliding within the Bald Knoll shales is also common.

Past Seismic Activity of the Elsinore Fault Zone

The Elsinore fault zone first appears near Joseph, Utah, and traverses northeast (about N 35° E) along the eastern toe of the Pavant Mountains to the foothills west-southwest of Aurora where a northwest trending fault system intersects the northeast zone. The northwest zone trends N 20° - 55° W and can be traced along the northeast face of the Pavant Mountains to Scipio, Utah. The northwest trending system may be an extension of the Elsinore fault zone.

The northeast trending zone of normal faults traverses from the southern end of the watershed to the Denmark Wash area on the north forming a corridor of deformation about 1/2 to 2 miles wide with 4 to 5 visible parallel faults near Elsinore increasing to as many as 16+ parallel breaks near Willow Creek Canyon. Near the mouth of Willow Creek Canyon, faults were so closely spaced that individual faults could not be mapped.

Faults are spaced from 5 to 800 feet apart along the zone, and displacement ranges from less than 5 to several hundred feet. Displacement along most faults was estimated at 30 to 200 feet. The total combined displacement of the faults is estimated at over 2,000 feet. These parallel faults form a series of steps along the east edge of the Pavant Mountains with most of the downthrown on the east side of each break. Several faults are downthrown to the west forming horst and graben structures, locally. Fault planes that could be observed in the field were nearly vertical (75°+ from horizontal) generally dipping to the southeast but in some cases were vertical. The intensity of faulting appears to decrease both east and west of the corridor mapped; however, alluvial fans and valley fill probably cover faults west of the mapped area.

Isolated outcrops of Tertiary Volcanics and Green River formation east of the main fault scarp indicate that faults probably exist east of the corridor mapped. Isolated outcrops which hold the key to fault locations may exist farther out (west) in the Sevier Valley, but are covered by alluvial fan and Sevier River deposits (valley fill).

Fault length varied from 800 feet to approximately 4 miles, and indications are that longer length faults exist but are obscured by alluvium.

The absence of folding, especially drag folding, indicates that faulting and displacement may have occurred quickly along some faults. This is also indicated by the steep smooth fault scarps.

Displacement increases in the section between Willow Creek and North Cedar Ridge where the northwest zone begins to appear and maximum displacement, estimated at over 2,000 feet, can be observed.

Historic Seismic Activity

A list of 278 earthquake epicenters have been plotted within a 50-mile radius (approximately) of Richfield between 1850 and 1975. About 45 epicenters have been plotted along the Elsinore fault zone between 1850 and 1968. Between 1968 and 1975 earthquakes of Richter magnitude 1.0 to 4.6 have occurred at a rate of one every two years. The last quake of mentionable size to occur was in 1972 and is thought to have occurred along the Elsinore fault zone. The largest seismic event to occur on the Elsinore fault was in 1901 at a Richter magnitude of 6.7. About 35 fore and after shocks were associated with the event. Damage occurred in Elsinore, Richfield and several towns on the west side of the Sevier Valley.

An earthquake of Richter magnitude 6.1 occurred in 1921 on the Elsinore fault with approximately 26 fore and after shocks ranging from 2.0 to 5.5 Richter magnitude. Following is an account of that event taken from Earthquake History of the United States, Publication 41-1, revised edition (through 1970), page 70.[6/]

EARTHQUAKES OF SPETEMBER 29 AND OCTOBER 1, 1921

Epicenter -- Elsinore, Utah
Area affected -- Considerable
Intensity -- Eight
Description -- Elsinore is in Sevier Valley, 150 miles south of Salt Lake City and 5,335 feet above sea level. It is fairly old, and the early houses were built of sun-dried brick and fragments of black basaltic lava. Later houses are of modern construction. At the time of the earthquake, there were about 1,000 inhabitants. The valley is about 5 miles wide and is flanked by abrupt rise of plateaus to several hundred feet.

After several weeks of preliminary tremors, the first sharp shock occurred at 7:12 on September 29. It lasted 7 to 10 seconds, was unaccompanied by noise, and was probably of intensity 8. It threw down scores of chimneys, plaster fell from ceilings, and walls were fractured. Another shock intensity 7 occurred at 19:30 the same day. At 8:32 on October 1, there was another shock like the blow of a great hammer, unaccompanied by noise except from creaking buildings and falling chimneys and was probably of intensity 8. The country was very dry and great clouds of dust arose.

The first shock was strongest at Elsinore but did damage at Richfield and Monroe. The greatest damage was to the Elsinore schoolhouse. Although it was a new two-story brick building, a part of the wall went down and if it had been during school hours there would have been a heavy loss of life. Near by, an old building of rectangular blocks of rock had little damaged. Half the buildings were damaged in some way with chimneys thrown down or otherwise rendered unsafe. Plaster fell

from ceilings, pictures were thrown from the walls. One chimney was twisted through 45°. It is stated that a hot spring with oxide iron in the water ran blood red for a time after the earthquake,

Shocks lasted from September 12 to December 20, the most important being those of October 27, felt sharply at Richfield, and of November 1.

The historic record of the Elsinore fault zone indicates that the fault zone is still quite active and can be expected to remain in that status.

LIST OF DAMAGING EARTHQUAKES
RICHFIELD AREA
(50 Mile Radius)

Date	Location of Greatest Damage
7-31-1873	Beaver
11-14-1901	Richfield, Elsinore
1-12-1910	Elsinore, Richfield
9-29-1921	Elsinore, Richfield, Monroe, Joseph
9-30-1921	Elsinore, Richfield
10- 1-1921	Elsinore
11-18-1945	Glenwood
4-16-1969	Ephraim

Age of The Elsinore Fault Zone

Faulting in the Pavant area has probably been occurring since Precambrian times, but older formations do not outcrop. In Lautenschlager's PhD thesis, he indicates that the last series of large seismic events were quite recent.[4] This is indicated by rupture of all Tertiary formations in the area and by Tertiary-Quaternary deposits, which have been displaced. Many fault scarps appear to be quite recent in that little erosion has taken place and vegetation has not established itself.

Schneider indicates in his paper that northwest-southeast trending faults appear to be younger than the northeast trending zone.[3]

During the field investigation, evidence of recent faulting was observed between Willow Creek and South Cedar Ridge at the mouth of Big Fan Canyon where an alluvial fan, estimated to be less than 1,000 years old, has been displaced and a tree root system affected. This fault movement may have occurred less than 200 years ago. The amount of displacement could not be estimated, but displacement was to the west. Some indication of faulting was noted low on the fans between Willow Creek and South Cedar Ridge, but low sun angle photography are needed to make a better determination.

Moving north from the Willow-South Cedar Ridge area to the mouth of Dry Red Canyon, clear evidence of faulting in the Dry Red alluvial fan was discovered. Displacement was to the west and was estimated at 8 to 10 feet. Downstream approximately 2,200 feet from the alluvial scarp, a sharp fresh break trending N 80° E was found in alluvial material. This break is about 1,500 to 2,000 feet long with a maximum displacement of 30 feet. It was not determined if this is a fresh fault scarp because of gravel excavation in the area but interviewing old time residents may clear this point. If it is a fresh scarp, indications are that it may have occurred within the last 200 years. After reviewing the epicenter plot map (see attached map), one epicenter was located in the area just south of the Dry Red fan, which occurred in 1962. Magnitude of the quake is unknown. The freshness of scarps in the area and epicenter plottings in the same area indicate that this area is active and undergoing adjustment.

Investigating the Maple Grove area about 8 miles northwest of Aurora disclosed a displacement of about 30 feet in an alluvial fan and another fresh scarp in bedrock where vegetation has not yet covered the ruptured surface. Lautenschlager discusses these fresh scarps in his reports that a series of scarplets were found in the Maple Grove to Herbert's Ranch area. The scarplets are mostly in alluvial fans.4/

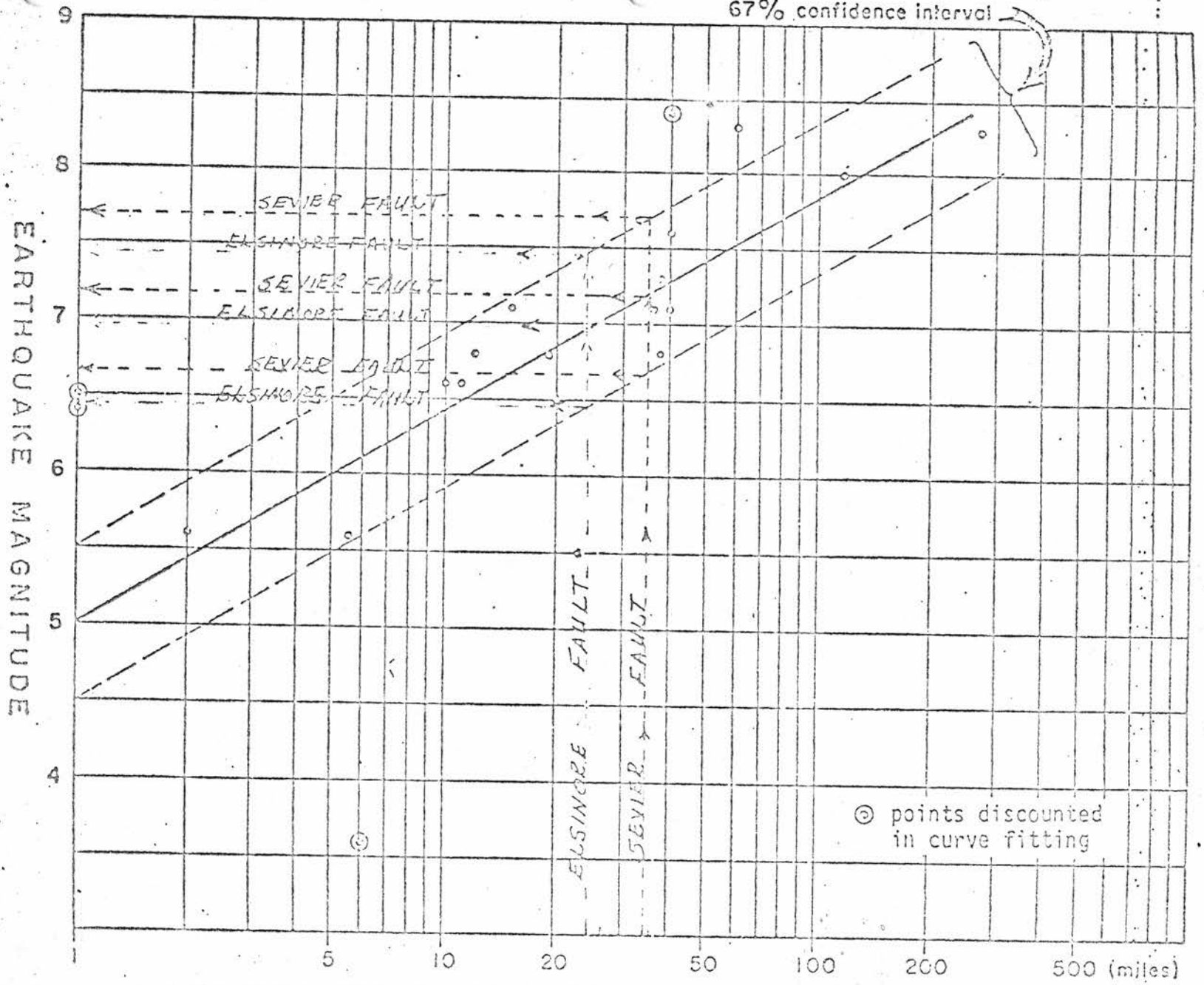
Although plots of epicenters indicate that most seismic activity is occurring along the southern portion of the Elsinore fault zone, evidence of recent surface rupture is more evident from Willow Creek Canyon north. Further, recent surface rupture and most displacement appears to be along the northwest trending fault zone northwest of Aurora. Evidence of displacement in alluvium along the northeast trending zone is most evident between Big Fan Canyon and Dry Red Canyon, but scarps do not appear as fresh as those near Maple Grove along the northwest zone.

ESTIMATING THE MAXIMUM PROBABLE AND MAXIMUM CREDIBLE EARTHQUAKES FOR RICHFIELD-WEST SEVIER WATERSHED

Since two of the most active faults in Utah are located in and near the watershed and their seismic history indicates that they have produced larger quakes than faults within an effecting radius, the Elsinore and Sevier faults were used for obtaining a rough estimate of maximum earthquakes.

Maximum Probable Earthquake (MPE)1/

A Maximum Probable Earthquake (MPE) for the Elsinore fault was roughly estimated, strictly from the one hundred year seismic history of the area (see definitions - end of report). Two earthquakes with Richter magnitudes of 6.0 or greater have occurred within the past one hundred years on the Elsinore and associated fault zone. The largest was of



Earthquake magnitude versus fault rupture length. (From Greensfelder, 1973)

FIG. 1

magnitude 6.7 with an intensity of nine (XI), while the small quake was 6.1 Richter magnitude with an intensity of eight (VIII). Therefore, it appears both logical and possible that events greater than 6.0 could be expected within the next one hundred years. This would give an approximate Maximum Probable Earthquake of Richter magnitude 6.5 for the Elsinore fault.

A study of the historic record for the Sevier fault indicates that the Maximum Probable Earthquake would be somewhat less than can be expected on the Elsinore or at least has not produced as large an earthquake. With this difference in mind, it would appear that the MPE should be the estimated figure for the Elsinore fault. The Elsinore fault should also be used since it is directly related to the proposed structures.

Maximum Credible Earthquake (MCE)[2/]

To derive a rough estimate of the MCE (see definition - end of report) which could be expected, a curve derived by Greensfelder which is published in a report by C. E. Stearns called Seismic Risk Evaluation, September 1974, was used.[1/] This curve was developed for California and although some different types of faults are used to base the evaluation on, it appears to give reasonable estimates of earthquake magnitudes which could be expected. A rupture length of twenty-five miles was used for the Elsinore fault. Fault length shown on the current state geology map was extended to twenty-five miles after tracing the fault further north in field investigations. Going into Greensfelder's curve with a rupture length of twenty-five miles gave a range of about 6.4 to 7.4 in what he calls the sixty-seven percent confidence interval. It appears from the figures obtained from this curve that a value of 7.4 Richter magnitude may be an acceptable estimate MCE for the Elsinore fault.

A rupture length of thirty-five miles was used for the Sevier fault to obtain a MCE magnitude from Greensfelder's curve. The rupture length was obtained from the longest continuous fault line (traced and inferred) shown on the state geology map near Richfield. Values obtained from the curve gave a range of 6.7 to 7.8 Richter magnitude. The value obtained from the lower end of the curve appears higher than the historic record indicates and the upper end of the curve would also appear to be somewhat high.

Evaluation of Data Obtained for the Maximum Probable and Credible Earthquakes

Results obtained form Greensfelder's curve correlates well with historic data as to what the MPE might be for the Elsinore fault.[1/] This is assuming that the lower lines on the curve may correlate somewhat with a one hundred year interval and that the highest line on the curve may represent the largest event that could be expected on a given fault.

Data obtained for the Sevier fault appears too high based on the historic record available. The use of obtained values from Greensfelder's curve should be evaluated in greater detail, but may indicated that the earthquake potential on the Sevier fault is higher than the Elsinore.[1/]

Estimating Displacement on the Elsinore Fault for Maximum Probable and Maximum Credible Earthquakes

Seismic evaluation for the Richfield-West Sevier Watershed takes into consideration two things: (1) strong ground motion and (2) actual surface rupture and displacement where structures rests on faults.

Evidence of recent fault movement (1,000 Years or less) has been confirmed and mapped. This was discussed earlier in the report. Indications from both observed recent activity and the earthquake history of the area show that the Elsinore fault zone is active. To obtain some idea of possible displacement that can be expected along the fault zone the following data has been tabled from faults of similar type.

FAULT NAME	DATE OF EARTHQUAKE	RICHTER MAGNITUDE	MAXIMUM DISPLACEMENT
Hansel Valley Utah	4-12-34	6.6 & 6.0	4 feet from both quakes
Hebgen, Montana	8-17-59	7.1	15 feet
East Cache Fault	8-30-62	5.7	Unknown
Wasatch	9-5-62	5.1	Unknown
Northern Utah Pocatello Valley	4-75	5.6	13 cm's of subsidence

Based on the sketchy information available as to magnitude and displacement, the following rough estimates for expected displacement along the Elsinore fault are proposed. Maximum Probable Earthquake of Richter magnitude of 6.5 could have an expected displacement of 2 to 4 feet. Maximum Credible Earthquake of Richter magnitude of 7.4 could have an expected displacement from 8 to 20 feet.

DEFINITIONS

1. Fault - A fracture or fracture zone along which there has been displacement of the two sides relative to one another parallel to the fracture. The displacement may be a few inches to many miles.

2. Active Fault - A fault that has shown historical activity. Some may be presently active and undergoin creep.

3. Potentially Active Fault - A fault along which no know historical ruptures have occurred. Available evidence indicates geologically recent activity. Estimated recurrence period could be short enough to be of engineering significance. Age of last fault offset should be documented.

4. Inactive Fault - Surface faulting has not occurred in the recent geologic past. Estimated recurrence interval is long enough to be of no engineering significance. Age of last fault offset should be documented.

5. Design Earthquake - It is a specification of the ground motion that a project is required to successfully survive. Successful survival is avoidance of loss of life, acceptable damage and acceptable interruption of service.

6. Maximum Credible Earthquake - The largest earthquake that could ever occur on a given fault. Used as the only design earthquake by the California Department of Water Resources, Division of Dam Safety.

7. Maximum Probable Earthquake - The strongest earthquake most likely to occur during the design life of the project i.e. the 100-year probable earthquake. It is a statistical earthquake.

8. Earthquake Focus - The location of first release of energy located at depth on the fault plane.

9. Earthquake Epicenter - The point on the earth's surface vertically above the focus.

10. Magnitude (or Richter Magnitude) - A measure of the energy of an earthquake at its source. The maximum amplitude of the earthquake waves recorded on a seismogram is transformed to a numerical figure by means of a log scale. Therefore, an increase of one number on the scale (magnitude 4 to 5) represents a tenfold increase in the

size of the earthquake record. One unit of magnitude also represents an increase of thirty-two times the amount of energy released by the quake.

11. Intensity (Modified Mercalli) - Intensity is a rating of the severity of the ground motion at a specific location. The scale of measurement is based on the sensations of persons and upon the physical damage to natural and man-made objects.

Definitions are from Seismic Risk Evaluation, handout document by C.E. Stearns, 1974.[1/]

REFERENCES AND FOOTNOTES

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Seismic History
of
Richfield-West Sevier Area
(50 Mile Radius)

YEAR	MO	DAY	HR	MN	SEC	LAT-N	LONG-W	MAG	INT	DEP	S	D	REMARKS
1876	DEC	30	05	15	----	-----	------	3.1	III		W		RICHFIELD COVE CREEK TUSHAR FAULT
1877	JAN	01	--	--	----	-----	------	3.7	IV		W		RICHFIELD FELT 3,000 SQ MI TUSHAR FLT
1877	JAN	15	12	00	----	-----	------	3.1	III		W		SEVIER CITY TUSHAR FAULT 2 SHOCKS
1878	AUG	14	--	--	----	-----	------	4.3	V		W		COVE CREEK HURRICANE FAULT
1878	AUG	15	13	40	----	-----	------	2.0	II		W		COVE CREEK HURRICANE FAULT
1878	AUG	15	14	40	----	-----	------	2.0	II		W		COVE CREEK HURRICANE FAULT
1878	AUG	16	02	44	----	-----	------	3.7	IV		W		COVE CREEK HURRICANE FAULT
1881	AUG	04	04	30	----	-----	------	3.1	III		W		BEAVER HURRICANE FAULT 5 SHOCKS
1881	AUG	04	18	30	----	-----	------				W		BEAVER HURRICANE FAULT
1885	OCT	26	08	00	----	-----	------	3.1	III		W		BEAVER CO FRISCO BEAVER MTN FAULT
1885	OCT	26	09	00	----	-----	------	3.1	III		W		BEAVER CO FRISCO BEAVER MTN FAULT
1885	DEC	17	01	00	----	-----	------	3.7	IV		W		CIRCLEVILLE TUSHAR FAULT
1885	DEC	17	03	20	----	-----	------	3.1	III		W		TEASDALE THOUSAND LAKE FAULT
1887	DEC	05	15	30	----	-----	------	5.5	VII		W		KANAB SEVIER FAULT DAMAGE
1889	DEC	07	11	00	----	-----	------	3.7	IV		W		MANTI THOUSAND LAKE FAULT
1895	JUL	27	22	25	----	-----	------	3.7	IV		W		MT PLEASANT THOUS LAKE FAULT DAMAGE
1899	NOV	10	09	00	----	-----	------	3.7	IV		W		BEAVER HURRICANE FAULT
1901	NOV	14	--	--	----	-----	------	2.0	II		W		RICHFIELD SHOCKS NOV 14 to NOV 30
1901	NOV	14	04	39	----	-----	------	6.7	IX		W		RICHFIELD ABOUT 35 SHOCKS TUSHAR FLT
1902	JUN	01	--	--	----	-----	------	3.1	III		W		BEAVER SEVERAL SHOCKS HURRICANE FLT
1902	JUL	31	07	00	----	-----	------	4.3	V		W		BEAVER CO BEAVER HURRICANE FAULT
1903	JUL	12	16	30	----	-----	------	3.1	III		W		RICHFIELD TUSHAR FAULT
1906	FEB	21	05	30	----	-----	------				W		SEVIER CO ELSINORE TUSHAR FAULT
1910	JAN	10	13	00	----	-----	------	4.9	VI		W		ELSINORE TUSHAR FAULT
1910	JAN	10	13	30	----	-----	------	4.9	VI		W		ELSINORE TUSHAR FAULT
1910	JAN	10	18	45	----	-----	------	4.9	VI		W		ELSINORE TUSHAR FAULT
1910	JAN	10	20	25	----	-----	------	4.9	VI		W		ELSINORE TUSHAR FAULT
1910	JAN	10	21	30	----	-----	------	4.9	VI		W		ELSINORE TUSHAR FAULT

YEAR	MO	DAY	HR	MN	SEC	LAT-N	LONG-W	MAG	INT	DEP	S	D	REMARKS
1910	JAN	11	04	00	----	-----	------	4.9	VI		W		ELSINORE TUSHAR FAULT
1910	JAN	12	03	00	----	-----	------	4.9	VI		W		ELSINORE TUSHAR FAULT DAMAGE
1910	JAN	12	03	15	----	-----	------	4.9	VI		W		ELSINORE TUSHAR FAULT
1913	OCT	20	10	00	----	-----	------	3.7	IV		W		PANGUITCH SEVIER FAULT
1915	OCT	25	17	13	----	-----	------	3.1	III		W		JOSEPH TUSHAR FAULT
1920	AUG	18	08	20	----	-----	------	3.1	III		W		BEAVER HURRICANE FAULT
1921	SEP	12	10	18	----	-----	------	3.7	IV		W		RICHFIELD TUSHAR FAULT
1921	SEP	12	10	22	----	-----	------	3.7	IV		W		RICHFIELD TUSHAR FAULT
1921	SEP	12	13	27	----	-----	------	3.7	IV		W		RICHFIELD TUSHAR FAULT
1921	SEP	13	09	30	----	-----	------	4.3	V		W		RICHFIELD TUSHAR FAULT 2 SHOCKS
1921	SEP	28	--	--	----	-----	------	2.0	II		W		ELSINORE TUSHAR FLT MANY SHOCKS
1921	SEP	29	14	12	----	-----	------	6.1	VIII		W		ELSINORE TUSHAR FAULT DAMAGE
1921	SEP	30	02	30	----	-----	------				W		ELSINORE SEVIER VALLEY
1921	SEP	30	13	30	----	-----	------				W		ELSINORE
1921	OCT	01	02	00	----	-----	------	2.0	II		W		ELSINORE TUSHAR FAULT
1921	OCT	01	15	32	----	-----	------	6.1	VIII		W		ELSINORE TUSHAR FAULT DAMAGE
1921	OCT	01	17	30	----	-----	------	2.0	II		W		ELSINORE TUSHAR FAULT
1921	OCT	02	01	05	----	-----	------	2.0	II		W		ELSINORE TUSHAR FAULT
1921	OCT	04	03	09	----	-----	------	2.0	II		W		ELSINORE TUSHAR FAULT
1921	OCT	04	17	25	----	-----	------	2.0	II		W		ELSINORE TUSHAR FAULT
1921	OCT	08	20	30	----	-----	------	2.0	II		W		ELSINORE TUSHAR FAULT
1921	OCT	10	08	30	----	-----	------	2.0	I		W		ELSINORE TUSHAR FAULT
1921	OCT	10	09	45	----	-----	------	2.0	I		W		ELSINORE TUSHAR FAULT
1921	OCT	15	11	15	----	-----	------	3.1	III		W		ELSINORE TUSHAR FAULT
1921	OCT	15	12	27	----	-----	------	3.1	III		W		ELSINORE TUSHAR FAULT
1921	OCT	27	14	15	----	-----	------	5.5	VII		W		ELSINORE TUSHAR FAULT 2 SHOCKS
1921	DEC	20	09	45	----	-----	------	3.7	IV		W		ELSINORE TUSHAR FAULT
1921	DEC	20	10	35	----	-----	------	3.7	IV		W		ELSINORE TUSHAR FAULT
1921	DEC	20	12	15	----	-----	------	3.7	IV		W		ELSINORE TUSHAR FAULT
1921	DEC	20	13	00	----	-----	------	3.7	IV		W		ELSINORE TUSHAR FAULT
1921	DEC	20	14	50	----	-----	------	3.7	IV		W		ELSINORE TUSHAR FAULT
1921	DEC	20	15	15	----	-----	------	3.7	IV		W		ELSINORE TUSHAR FAULT
1924	JAN	01	23	15	----	-----	------	3.1	III		W		KANE CO ORDERVILLE SEVIER FAULT
1926	MAY	15	19	51	----	-----	------	3.1	III		W		KANE CO ORDERVILLE SEVIER FAULT

YEAR	MO	DAY	HR	MN	SEC	LAT-N	LONG-W	MAG	INT	DEP	S	D	REMARKS
1926	JUN	01	05	20	----	-----	------	2.0	II		W		ORDERVILLE SEVIER FAULT
1926	JUN	05	11	00	----	-----	------	3.1	III		W		ORDERVILLE SEVIER FAULT
1926	JUN	22	03	40	----	-----	------	2.0	II		W		ORDERVILLE SEVIER FAULT
1926	JUN	28	06	00	----	-----	------	2.0	II		W		ORDERVILLE SEVIER FAULT
1926	JUL	12	05	20	----	-----	------	3.1	III		W		ORDERVILLE SEVIER FAULT
1926	JUL	15	--	--	----	-----	------	2.0	II		W		ORDERVILLE SEVIER FAULT
1926	OCT	01	15	15	----	-----	------	3.1	III		W		ORDERVILLE SEVIER FAULT
1926	OCT	14	20	30	----	-----	------	3.1	III		W		ORDERVILLE SEVIER FAULT
1926	OCT	23	00	00	----	-----	------	3.1	III		W		ORDERVILLE SEVIER FAULT
1926	NOV	12	03	40	----	-----	------	3.1	III		W		ORDERVILLE SEVIER FAULT
1926	NOV	16	14	15	----	-----	------	3.1	III		W		ORDERVILLE SEVIER FAULT
1927	MAY	22	05	00	----	-----	------	3.1	III		W		ORDERVILLE SEVIER FAULT
1927	NOV	23	02	45	----	-----	------	2.0	II		W		RICHFIELD TUSHAR FAULT
1927	NOV	23	09	30	----	-----	------	3.1	III		W		ORDERVILLE SEVIER FAULT
1931	MAR	09	04	29	----	-----	------	2.0	II		W		ELSINORE TUSHAR FAULT
1932	MAY	22	06	00	----	-----	------	2.0	I		W		VENICE
1937	FEB	18	04	15	----	-----	------	3.7	IV		W		PANGUITCH, PAROWAN, AND CEDAR CITY
1937	FEB	18	06	30	----	-----	------	3.7	IV		W		PANGUITCH, PAROWAN, AND CEDAR CITY
1937	FEB	18	09	00	----	-----	------	3.7	IV		W		PANGUITCH SEVIER FAULT
1937	FEB	21	08	30	----	-----	------	3.1	III		W		PANGUITCH SEVIER FAULT
1937	FEB	26	01	30	----	-----	------	3.7	IV		W		PANGUITCH SEVIER FAULT
1937	MAR	13	11	40	----	-----	------	2.0	II		W		PANGUITCH SEVIER FAULT
1937	APR	01	04	41	----	-----	------	2.0	II		W		PANGUITCH SEVIER FAULT
1940	NOV	23	13	00	----	-----	------	3.7	IV		W		MANTI THOUSAND LAKE FAULT
1940	NOV	23	13	22	----	-----	------	3.7	IV		W		MANTI THOUSAND LAKE FAULT
1940	NOV	25	12	30	----	-----	------	2.0	II		W		MANTI THOUSAND LAKE FAULT
1940	NOV	25	13	10	----	-----	------	2.0	II		W		MANTI THOUSAND LAKE FAULT
1940	NOV	25	14	25	----	-----	------	3.7	IV		W		MANTI THOUSAND LAKE FAULT
1942	MAR	28	14	10	----	-----	------	3.7	IV		W		CIRCLEVILLE TUSHAR FAULT
1942	MAR	28	16	00	----	-----	------	3.7	IV		W		CIRCLEVILLE TUSHAR FAULT
1942	JUN	04	23	04	----	-----	------	4.3	V		W		SANPETE CO EPHRAIM TO NEPHI
1943	MAR	12	13	45	----	-----	------	3.7	IV		W		EPHRAIM THOUSAND LAKE FAULT
1943	NOV	03	10	30	----	-----	------	4.3	V		W		SEVIER TUSHAR FAULT
1943	NOV	03	12	30	----	-----	------	3.1	III		W		SEVER TUSHAR FAULT

YEAR	MO	DAY	HR	MN	SEC	LAT-N	LONG-W	MAG	INT	DEP	S	D	REMARKS
1943	NOV	04	03	00	----	-----	------	3.1	III		W		SEVIER TUSHAR FAULT
1944	JUN	05	15	45	----	-----	------	2.0	II		W		MONROE SEVIER FAULT
1945	NOV	18	01	15	----	-----	------	4.9	VI		W		GLENWOOD SEVIER FAULT DAMAGE
1948	NOV	04	13	18	----	-----	------	4.3	V		W		MANTI THOUSAND LAKE FAULT
1953	APR	18	05	15	----	-----	------	3.7	IV		C		MONROE
1973	OCT	22	03	00	----	-----	------	4.3	V		C		PANGUITCH DAMAGE
1953	OCT	24	20	50	----	-----	------				C		PANGUITCH
1959	SEP	17	06	20	----	-----	------	3.7	IV		C		MARYSVALE
1961	APR	16	05	02	39.3	39.33	111.65	4.9	VI	4C	U	D	6 MI NW OF EPHRAIM DAMAGE
1961	OCT	15	21	05	01.8	39.25	111.56			20	U	D	SAN PETE CO 6 MI E OF MANTI
1961	OCT	16	19	13	06.5	39.2	111.5			18	C		CENTRAL UTAH
1961	OCT	17	00	59	41.8	39.2	111.5			21	C		CENTRAL UTAH
1961	OCT	17	03	54	39.3	39.23	111.57			20	U	D	SAN PETE CO 5 MI SE OF MANTI
1962	FEB	17	03	29	26.9	38.6	111.6			33	C		NE OF PANGUITCH
1962	JUN	05	22	29	45.0	38.0	112.1			33	C		NE OF PANGUITCH
1962	JUN	08	19	21	27.0	37.5	112.5			33	C		S OF PANGUITCH
1963	JUN	19	08	38	47.6	37.9	112.5	4.2		36	C		NW OF PANGUITCH
1963	NOV	13	06	17	32.8	38.25	112.72	3.8		20	U	D	BEAVER CO 5 MI SW OF BEAVER
1964	JAN	17	00	15	05.1	38.16	112.69			20	U	D	BEAVER CO 8 MI S BEAVER
1964	JAN	17	00	15	37.3	38.18	112.72			20	U	D	BEAVER CO 6 MI S BEAVER
1964	MAR	03	03	24	54.1	38.58	112.28			20	U		SEVIER CO 18 MI SW OF RICHFIELD
1964	MAR	26	22	01	39.1	38.57	112.47	2.4		20	U		MILLARD CO 5 MI E OF COVE FORT
1964	JUL	06	19	27	35.7	38.35	112.27			20	U		PIUTE CO 7 MI SW OF MARYSVALE
1964	AUG	24	01	41	17.6	38.92	112.28			20	U		MILLARD CO 6 MI SE OF FILLMORE
1964	AUG	24	01	51	02.9	38.76	112.23	3.2		20	U	D	MILLARD CO 14 MI NE OF FILLMORE
1964	AUG	24	01	55	37.2	39.09	112.08	3.0		20	U	D	MILLARD CO SCIPIO LAKE
1964	SEP	06	19	03	37.7	39.26	111.59	3.3		20	U	D	SAN PETE CO 3 MI E OF MANTI
1964	SEP	21	00	36	25.9	38.88	112.30	3.4		20	U		MILLARD CO 7 MI OF FILLMORE
1964	OCT	02	20	48	02.4	38.46	112.59			20	U		BEAVER CO 14 MI N OF BEAVER
1964	NOV	29	09	31	41.3	39.33	112.10			20	U		MILLARD CO 25 MI E OF DELTA
1965	FEB	03	20	15	43.9	38.54	112.10			20	U		SEVIER CO 16 MI S RICHFIELD
1965	MAR	16	05	37	14.6	38.66	112.45	3.4		20	U	D	SEVIER CO 21 MI WSW RICHFIELD
1965	MAY	16	19	04	04.6	38.18	112.67	3.4		20	U		BEAVER CO 7 MI S BEAVER
1965	JUN	13	01	41	39.5	38.86	112.12	2.0		20	U	D	SEVIER CO 6 MI NW RICHFIELD

YEAR	MO	DAY	HR	MN	SEC	LAT-N	LONG-W	MAG	INT	DEP	S	D	REMARKS
1965	JUL	05	17	17	08.5	39.30	111.40	2.7		20	U	D	SANPETE CO NEAR EPHRAIM
1965	SEP	10	21	47	46.7	39.40	111.40			20	U		SANPETE CO EAST OF EPHRAIM
1966	APR	23	21	20	30.0	39.50	111.60	2.2		0	U		SANPETE CO MORONI
1968	JAN	16	08	57	19.9	39.40	112.00	2.2		20	U		JUAB CO SEVIER BRIDGE RESERVOIR AREA
1968	JAN	16	09	20	13.3	39.33	112.15	3.1		20	U	D	JUAB CO SEVIER BRIDGE RESERVOIR AREA
1968	JAN	16	09	28	55.4	39.45	111.99	2.1		10	U		JUAB CO SEVIER BRIDGE RESERVOIR AREA
1968	JAN	16	09	39	53.3	39.43	112.01	2.2		20	U	D	JUAB CO SEVIER BRIDGE RESERVOIR AREA
1968	JAN	16	10	38	44.7	39.69	112.16	2.1		20	U		JUAB CO SEVIER BRIDGE RESERVOIR AREA
1968	JAN	17	04	27	15.4	39.33	112.10	2.8		20	U	D	JUAB CO SEVIER BRIDGE RESERVOIR AREA
1968	JAN	17	04	36	01.9	39.53	111.83	2.0		20	U		JUAB CO SEVIER BRIDGE RESERVOIR AREA
1968	JAN	19	11	19	28.5	39.38	112.02	2.4		20	U		JUAB CO SEVIER BRIDGE RESERVOIR AREA

DATE	ORIGIN		LATITUDE		LONGITUDE		UTM-N	UTM-E	DEPTH	MAG	NO	RMS
740120	2500	.58	39	25.58	111	5.09	4363.8834	492.6982	4.64	2.30	5	.05
740125	1326	36.23	39	23.06	111	.87	4359.2191	498.7512	2.00	2.00	5	.30
740208	1632	42.56	39	19.19	111	57.93	4352.5054	418.7704	1.17	1.40	4	.25
740209	1736	4.48	39	22.37	111	1.15	4357,9430	498.3491	2.00	2.40	5	.03
740219	1004	40.89	39	58.05	111	34.53	4424.0986	450.8508	1.30	1.70	5	.28
740220	443	51.55	39	53.96	111	29.25	4416.4882	458.3250	4.69	1.60	7	.23
740220	805	1.54	39	54.57	111	27.78	4417.6053	460.4253	7.00	1.60	6	.33
740222	1515	56.11	39	48.25	111	29.76	4405.9299	457.5397	2.13	1.50	4	.62
740222	1731	28.58	39	51.98	111	16.73	4375.7548	476.0369	2.00	1.30	4	.29
740318	43	54.04	38	36.39	111	39.23	4273.1065	443.0695	7.00	1.70	7	.35
740416	1819	53.85	38	23.96	111	46.91	4250.2060	431.7289	15.02	2.20	6	.34
740515	228	56.99	39	29.22	111	3.67	4370.6144	494.7399	2.00	1.90	5	.23
740517	427	25.78	39	21.57	111	57.76	4356.9050	417.0616	3.12	1.80	5.	.10
740523	907	17.54	39	18.93	111	4.91	4351.5834	492.9453	1.00	2.00	5	.58
740527	1058	30.99	39	25.28	111	1.32	4363.3254	498.1063	2.00	2.10	5	.48
740527	1146	15.21	39	20.42	110	54.60	4354.3398	507.7560	11.64	2.00	4	.22
740528	303	47.73	38	37.61	111	53.42	4275.5359	422.4985	7.00	2.40	6	.53
740529	720	18.92	39	1.11	111	27.99	4318.7250	459.6144	3.48	2.70	5	.12
740712	836	3.78	39	23.48	112	6.76	4360.5864	404.1816	2.61	2.60	6	.31

DATE	ORIGIN		LATITUDE		LONGITUDE		UTM-N	UTM-E	DEPTH	MAG	NO	RMS
740814	1431	30.89	38	40.28	111	56.31	4280.5157	418.3562	10.07	2.70	7	.40
740515	228	56.99	39	29.22	111	3.67	4370.6144	494.7399	2.00	1.90	5	.23
740517	427	25.78	39	21.57	111	57.76	4356.9050	417.0616	3.12	1.80	5	.10
740527	1058	30.99	39	25.28	111	1.32	4363.3254	498.1063	2.00	2.10	5	.48
740528	303	47.76	38	37.61	111	63.42	4275.5359	422.4985	7.00	2.40	6	.53
740529	720	18.92	39	1.11	111	27.99	4318.7250	459.6144	3.48	2.70	5	.12
740412	836	3.78	39	23.48	112	6.76	4360.5864	404.1816	2.61	2.60	6	.31
740722	903	44.21	39	31.77	111	55.04	4375.7310	421.1593	7.00	2.20	7	.37
740814	1431	30.89	38	40.28	111	56.31	4280.5157	418.3562	10.07	2.70	7	.40
740903	1122	51.71	39	48.06	111	35.49	4405.6282	449.3620	7.00	2.10	6	.39
740912	1738	31.67	39	59.87	111	44.61	4427.5713	436.5311	.70	2.30	5	.22
740916	1608	48.31	38	43.98	112	37.70	4288.1993	358.4636	15.43	2.80	7	.20
740920	1454	39.66	38	45.19	112	21.67	4290.0579	381.7204	12.47	2.60	8	.17
741104	507	6.37	38	27.28	112	20.53	4256.9096	382.8873	7.00	2.30	6	.73
741106	1235	24.64	39	27.59	111	2.53	4367.5987	496.3725	7.00	2.20	4	.61
741106	2047	17.74	39	51.48	112	41.40	4413.1537	355.4362	7.00	.40	3	.58
741112	445	46.26	38	24.05	112	12.75	4250.7791	394.1233	7.00	2.40	4	.16
741117	431	55.99	39	11.73	111	28.52	4338.3564	461.8310	2.95	2.40	6	.60
741118	1537	55.78	39	50.91	111	35.96	4410.9045	448.7264	7.00	2.30	10	.21
731118	2317	31.30	39	50.32	111	32.39	4409.7806	453.8104	6.68	2.30	10	.33
741127	9	7.30	39	56.75	112	52.54	4423.2200	339.7580	7.00	1.90	3	.50
741130	1606	.44	39	18.58	112	53.36	4352.6349	337.1048	7.00	3.00	3	.00
741202	2045	24.17	39	12.88	112	5.59	4340.9596	405.6239	1.28	2.40	8	.23
741205	2645	31.47	39	53.50	112	47.91	4417.0718	346.2297	7.00	2.20	3	.46
731210	1313	33.84	39	12.12	112	45.00	4340.4437	348.8876	7.00	1.80	3	.00
741216	956	49.59	39	52.30	111	38.50	4413.5007	445.1235	7.00	.80	0	.34
741117	431	55.99	39	11.73	111	26.52	4338.3564	461.8310	2.95	2.40	6	.60
741118	1537	55.78	39	50.91	111	35.96	4410.9045	448.7267	7.00	2.30	10	.21
741118	2317	31.30	39	50.32	111	32.39	4409.7806	453.8104	6.68	2.30	10	.33
741127	9	7.30	39	56.75	112	52.54	4423.2200	339.7580	7.00	1.90	3	.50
741130	1306	.44	39	18.58	112	53.36	4352.6349	337.1048	7.00	3.00	3	.00
741202	2045	24.17	39	12.88	112	5.59	4340.9596	405.6239	1.28	2.40	8	.23
741206	2645	31.47	39	53.50	112	47.91	4417.0718	346.2297	7.00	2.20	3	.46
741210	1313	33.84	39	12.12	112	45.00	4340.4437	348.8876	7.00	1.80	3	.00

DATE	ORIGIN	LATITUDE	LONGITUDE	UTM-N	UTM-E	DEPTH	MAG	NO	RMS
741213	958 49.59	39 52.30	111 38.50	4413.5007	445.1235	7.00	.80	0	.34
741215	350 19.29	39 55.71	112 7.82	4420.2231	403.4109	7.00	.80	0	.00
731215	1850 5.47	39 49.16	111 49.32	4407.8187	429.6475	9.83	.90	9	.47
741228	1039 13.00	38 26.62	112 23.92	4255.7623	377.9385	11.65	2.10	8	1.15
741225	50 39.05	39 59.72	111 49.46	4427.3546	429.6281	7.00	.70	3	.11
741225	120 37.44	39 58.58	111 47.60	4425.2217	432.2558	7.00	.90	3	.10
741225	204 20.14	39 58.84	111 53.56	4425.7828	423.7782	.97	1.10	6	.14
741225	308 51.85	39 59.73	111 47.60	4427.3490	432.2747	7.00	1.20	3	.25
741225	310 23.95	39 55.60	112 8.16	4420.0258	402.9241	7.00	1.10	3	.20
741225	2348 .91	39 46.96	111 12.27	4403.4461	482.4883	15.12	.90	5	.13
741228	152 35.02	39 52.41	111 8.23	4413.5163	448.2697	4.05	1.20	8	.31
741228	764 11.47	39 58.83	111 49.46	4425.7081	429.6129	7.00	.80	3	.21
741228	917 17.11	39 59.16	111 49.46	4426.3186	429.6185	7.00	1.20	6	.13
741227	1151 58.43	39 58.69	111 52.66	4425.4927	425.0563	.84	.90	4	.10
741231	2210 53.08	39 59.83	111 45.00	4427.5020	435.9756	1.88	2.00	11	.45
750104	2044 40.76	39 37.09	111 14.68	4385.1981	478.9990	7.00	2.20	6	.36
750105	449 51.72	39 24.28	111 3.83	4361.4775	494.5041	2.51	2.60	11	.42
750107	2352 14.12	39 55.61	112 36.79	4420.6723	362.1469	18.22	1.70	5	.09
750110	434 2.67	38 39.50	112 40.26	4279.9801	354.6037	19.16	2.70	5	.51
750112	959 56.52	38 1.79	112 57.92	4210.7426	327.5064	1.27	2.80	7	.50
741225	2348 .91	39 46.96	111 12.27	4403.4461	482.4883	15.12	.90	5	.13
741226	152 35.02	39 62.41	111 8.23	4413.51	488.2697	4.05	1.20	8	.31
741226	734 11.47	39 58.83	111 49.46	4425.70	429.6129	7.00	.80	3	.21
741226	917 17.11	39 59.16	111 49.46	4426.3186	429.6185	7.00	1.20	6	.13
741227	1151 58.43	39 58.69	111 52.66	4425.4927	425.0563	.84	.90	4	.10
741231	2210 53.08	39 59.83	111 45.00	4427.5020	435.9756	1.88	2.00	11	.45
750104	2044 40.76	39 37.09	111 14.68	4386.1981	478.9990	7.00	2.20	6	.36
750105	449 51.72	39 24.28	111 3.83	4361.4775	494.5041	2.51	2.60	11	.42
750107	2352 14.12	39 55.61	112 36.79	4420.6723	362.1469	18.22	1.70	5	.09
750110	434 2.67	38 39.50	112 40.26	4279.9801	354.6037	19.16	2.70	5	.51
750111	1820 24.80	38 4.99	113 25.46	4217.6130	287.3701	1.16	3.00	6	.23
750112	959 56.52	38 1.79	112 57.92	4210.7426	327.5064	1.27	2.80	7	.50
750116	2202 38.39	39 21.31	111 2.30	4355.9830	496.6973	1.03	1.90	5	.50
750115	712 23.59	39 24.79	111 3.68	4362.4205	494.7200	.86	1.40	6	.49

DATE	ORIGIN		LATITUDE		LONGITUDE		UTM-N	UTM-E	DEPTH	MAG	NO	RMS
750115	714	23.96	39	25.16	111	4.80	4363.1061	493.1136	.91	1.60	5	.35
750115	803	53.91	39	35.60	111	10.37	4382.4277	485.1595	3.24	1.60	4	.22
750129	127	35.80	39	22.99	111	7.82	4359.0977	488.7751	.59	2.70	15	.32
750129	200	38.06	39	20.30	111	7.23	4354.1210	489.6153	1.75	2.40	10	.41
750129	234	6.36	39	22.46	111	6.78	4358.1154	490.2667	.20	2.50	10	.19
750129	1724	33.18	39	15.40	112	8.73	4345.6765	401.1647	1.27	2.00	11	.35
750203	1400	5.20	39	26.65	111	52.78	4366.2283	424.3041	3.62	2.20	12	.29
750205	1309	42.20	39	33.52	111	4.07	4378.5684	494.1725	2.33	2.10	8	.12
750207	1619	56.09	39	16.13	112	6.22	4346.9819	404.7907	11.63	1.70	5	.04
750219	314	36.11	39	24.09	112	4.45	4361.6746	407.5106	4.75	2.60	16	.24
750219	1541	47.79	39	18.56	112	4.79	4351.4517	406.9004	1.09	2.10	11	.28
750219	2207	52.48	39	59.99	111	47.60	4427.8300	432.2790	1.48	2.30	7	.52
750222	142	44.45	39	26.91	112	1.20	4366.8365	412.2336	3.44	1.30	5	.33
750225	1817	13.14	39	9.28	112	11.70	4334.4119	396.7444	.52	1.70	7	.27
750207	1819	38.09	39	18.16	112	8.22	4348.9819	404.7907	11.63	1.70	5	.04
750219	314	36.11	39	24.09	112	4.45	4361.6746	407.5106	4.75	2.60	16	.24
750219	1541	47.79	39	18.56	112	4.79	4351.4517	406.9004	1.09	2.10	11	.28
750222	142	44.45	39	26.91	112	1.20	4366.8365	412.2336	3.44	1.30	5	.33
750225	1817	13.14	39	9.28	112	11.70	4334.4119	396.7444	.52	1.70	7	.27
750310	2123	26.96	39	22.77	112	13.37	4359.3958	394.6764	3.89	1.40	6	.25
750311	2130	15.65	39	59.96	111	46.06	4427.7924	434.4698	2.38	2.00	9	.10
750319	2121	3.53	39	58.30	111	43.33	4424.6521	438.3287	7.00	2.30	11	.43
750321	1816	6.04	39	52.42	113	4.29	4415.5798	322.8404	7.00	2.20	12	.42
750310	2123	26.96	39	22.77	112	13.37	4359.3958	394.6764	3.89	1.50	6	.25
750311	2130	15.65	39	59.96	111	46.06	.7924	434.4698	2.38	2.00	9	.10
750317	1818	25.65	39	49.26	113	1.87	4409.6547	326.1753	3.40	1.40	7	.21
750319	2121	3.53	39	58.30	111	43.33	4424.6521	438.3287	7.00	2.30	11	.43
75321	1813	6.04	39	52.42	113	4.29	4415.5798	322.8404	7.00	2.20	12	.42
750327	2302	44.31	39	52.36	113	3.37	4415.4385	324.1493	7.00	1.50	7	.30

DATE	ORIG	TIME	LAT-N	LONG-W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	Q
750718	1658	16.62	39-12.91	111-20.39	7.00*	1.8	8	320	84.3	.42	8.4	3.6	D1
750729	1829	17.38	38-40.49	112-45.01	7.00*	2.1	6	164	114.4	.35	6.1	12.0	D1

DATE	ORIG	TIME	LAT-N	LONG-W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	Q
7508	2043	45.06	39-16.25	111-47.38	7.00*	1.2	7	282	92.6	.29	10.9	4.1	D1
750905	23 1	10.50	39-19.25	111-27.60	7.00*	1.6	6	275	64.7	.28	30.6	4.0	D1
750906	1634	44.54	39-30.26	111-13.79	7.00*	1.6	6	188	38.2	.28	4.2	5.9	D1
750910	839	42.98	38-36.99	112-41.36	7.00*	2.9	8	159	96.0	.35	3.1	2.0	D1
750911	830	31.94	39-20.83	111-29.08	7.00*	2.4	8	153	59.1	.45	2.9	2.9	D1
750926	044	38.70	39-28.36	112-14.03	7.00	1.0	7	177	11.5	.24	3.4	13.8	O1
750928	628	7.72	39-26.31	111-49.93	7.00*	1.2	10	244	29.8	.46	4.5	2.5	D1

YR	DATE	ORIG	TIME	LAT-N	LONG-W	DEPTH	MAG	NO	GAP	DMIN	RMS	Q
75	1005	0155	17.07	39-36.90	111-11.93	7.00*	1.7	9	203	33.8	.22	D
75	1005	0253	55.71	39-35.52	111-13.78	7.00*	2.1	10	209	36.5	.27	C
75	1005	1120	18.17	39-33.30	111-13.73	7.00*	1.4	6	226	36.9	.10	D
75	1006	1550	48.15	39- 9.74	111-29.82	7.00*	3.2	11	169	62.9	.51	D
75	1006	2041	45.68	38-57.69	111-25.83	7.00*	1.6	6	267	77.9	.28	D
75	1009	0142	1.81	39- 3.88	111-28.35	7.00*	1.7	8	181	69.7	.26	C
75	1009	1728	21.22	39-39.09	111- 5.37	7.00*	1.2	5	317	65.7	.16	C
75	1011	1305	23.83	39-40.93	111-10.37	7.00*	1.2	7	189	32.7	.18	C
75	1022	2113	35.12	39-27.59	111-51.84	7.00*	1.4	8	179	27.8	.46	C
75	1104	2318	13.59	39-26.89	111-49.44	7.00*	1.5	14	118	30.7	.50	C
75	1219	1116	51.30	39-31.36	111-15.07	7.00*	1.4	6	235	39.4	.31	D
75	1227	1022	25.64	39-11.10	111-51.95	7.00*	1.1	7	195	34.0	.31	D

Attachment C. Boring Logs

Key to Boring Logs

CONSISTENCY OR CONDITION OF SOILS

Fine-Grained Soils (Silt and Clay): Major portion passing #200 sieve

Relative Consistency	N_{60} SPT, Blows/foot	Shear Strength, tsf	Unconfined Compressive Strength, tsf	Field Behavior
Very Soft	< 2	< 0.13	< 0.25	Easily penetrated several inches by fist
Soft	2 - 4	0.13 - 0.25	0.25 - 0.5	Easily penetrated several inches by thumb
Medium Stiff	5 - 8	0.25 - 0.5	0.5 - 1	Penetrated several inches by thumb with moderate effort
Stiff	9 - 15	0.5 - 1	1 - 2	Readily indented by thumb but penetrated only with great effort
Very Stiff	16 - 30	1 - 2	2 - 4	Readily indented with thumbnail
Hard	> 30	> 2	> 4	Indented with difficulty by thumbnail

Coarse-Grained Soils (Sand and Gravel): Major portion retained on #200 sieve

Apparent Density	$(N_1)_{60}$ SPT, Blows/foot	Relative Density, %	Field Test with 1/2-in Steel Rod
Very Loose	< 5	0 - 20	Very easily penetrated when pushed by hand
Loose	5 - 10	20 - 40	Easily penetrated when pushed by hand
Medium Dense	11 - 30	40 - 70	Easily penetrated when driven with 5-lb hammer
Dense	31 - 50	70 - 85	Penetrated 1 ft with difficulty when driven with 5-lb hammer
Very Dense	> 50	85 - 100	Penetrated less than 3 in. when driven with 5-lb hammer

Particle Size Descriptions for Sand and Gravel

Description	Gravel Size	Sand Size	Size Requirement
Coarse	3-in. to 3/4-in.	#4 to #10 sieve	<30% medium to fine sand or <12% fine gravel
Coarse to medium	- -	- -	<12% fine sand
Medium	- -	#10 to #40 sieve	<12% coarse sand and >30% medium sand
Medium to fine	- -	- -	<30% medium sand or <12% coarse gravel
Fine	3/4-in. to #4 sieve	#40 to #200 sieve	<30% medium sand or <12% coarse gravel
Coarse to fine	- -	- -	>12% of each size

Moisture Conditions

Dry	No indication of moisture, dusty
Slightly Moist	Appears dry, but some moisture present
Moist	Damp but no visible water
Wet	Visible free water

Structure and Layering of Soils

Stratum	>12 inches thick
Layer	1/2 inch to < 12 inches
Seam	1/16 inch to 1/2 inch
Parting	< 1/16 inch
Frequent	More than one per foot
Varved	Frequent alternating layers, seams, or partings of sand, silt, or clay
Pocket	Small erratic deposit
Lens	Non-continuous lenticular deposit

Plasticity of Fine-Grained Soils

Nonplastic	1/8-in thread cannot be rolled at any water content
Low	Thread can barely be rolled and lump cannot be formed when drier than the plastic limit
Medium	Thead is easy to roll with little time required to reach plastic limit. Thread cannot be rerolled after reaching the plastic limit.
High	Considerable time rolling and kneading to reach plastic limit. Thread can be rerolled several times after reaching plastic limit.

Unified Soil Classification System

Major Divisions			Symbols: Graphic	Symbols: Letter
Coarse-Grained Soils: More than 50% of Material is Retained on No. 200 Sieve	Gravels: More than 50% of Coarse Fraction is Retained on No. 4 Sieve	Clean Gravels (little or no fines)		GW
				GP
		Gravels with Fines (appreciable amount of fines)		GM
				GC
	Sands: More than 50% of Coarse Fraction Passes No. 4 Sieve	Clean Sand (little or no fines)		SW
				SP
		Sands with Fines (appreciable amount of fines)		SM
				SC
Fine-Grained Soils: More than 50% of Material Passes No. 200 Sieve	Silts and Clays	Liquid Limit Less than 50		ML
				CL
				OL
	Silts and Clays	Liquid Limit 50, or more		MH
				CH
				OH
Highly Organic Soils				PT

Note: Dual Symbols are used to indicate borderline soil classifications

TYPICAL SAMPLER GRAPHIC SYMBOLS

- 3.25" OD Dames & Moore Sampler
- 3" OD Shelby Tube
- Non-standard Sample
- 2" OD Split Spoon (SPT)
- Piston Sample
- Grab Sample

TYPICAL WATER LEVEL SYMBOLS

- Measured Water Level after minimum of 24 hours
- Estimated or observed water level at time of drilling

KEY TERMINOLOGY

CBR	- California bearing ratio
CONS	- One-Dimensional Consolidation Test
CORR	- Corrosion tests
DS	- Direct shear test
F	- Percent fines by weight passing #200 sieve
G	- Percent gravel by weight
γ_d	- Dry unit weight
$\gamma_{d\text{-}max}$	- Maximum dry unit weight as per ASTM D698 or D1557
LL	- Liquid Limit
N	- Number of blows to drive sampler through the second and third 6-inch soil intervals using a 140-lb hammer dropped 30 inches
N_{60}	- SPT N value corrected for field procedures
$(N_1)_{60}$	- SPT N_{60} value corrected for effective overburden pressure
NP	- Nonplastic
OD	- Outer diameter
PI	- Plasticity index
PP	- Pocket penetrometer
S	- Percent sand by weight
SG	- Specific gravity
SPT	- Standard Penetration Test
SS	- Direct simple shear test
TV	- Torvane
TXCD	- Consolidated drained triaxial test
TXCU	- Consolidated undrained triaxial test
TXCY	- Cyclic triaxial test
TXUU	- Unconsolidated undrained triaxial test
UC	- Unconfined compression test
W	- Moisture content
W_{opt}	- Optimum moisture content associated with ASTM D698 or D1557

Descriptions and layers are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

AECOM

Project: 2019 Sevier Watershed Plan
Project Location: Sevier County, UT
Project Number: 60598028

Log of Boring B19-TC-01

Sheet 1 of 2

Date(s) Drilled:	**2/20/2019**	Drill Rig Type:	**CME-850 Track Rig**	Logged By: **BWF**	Checked By: **CJT**
Drilling Contractor:	**Conetec, Inc.**	Hammer Information:	**140-pound Automatic Hammer, 30-inch Drop, ER=79.2%**	Total Depth of Borehole:	**50.25 feet**
Drilling Method: Bit Size/Type:	**Hollow Stem Auger 8" OD/ 4.25" ID 2-Prong Spad Bit**	Borehole Backfill:	**Portland Cement Bentonite Grout**	Surface Elevation:	**5422 feet**
Sampling Method(s):	**18-inch Standard Split Spoon, Modified California with Rings**	Estimated Groundwater Level at Time of Drilling:	**32 feet**	Groundwater Level and Date Measured:	**Not Measured**
Location:	**38.77387° N 112.09958° W**			Survey Datum:	**WGS84**

Elevation feet	Depth, feet	Type	Number	Blows/6inch	SPT N_{60} blowcount	SPT $(N_1)_{60}$ blowcount	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0								Sandy SILT (ML); hard, moist, orange brown, fine sand, fine gravel, low plasticity	
5420										
			S-1	19 21 20 N=41	27	42	67			NP; G=0.1%; S=45.8%; F=54%
	5		S-2	6 7 9 N=16	15	20	61		...very stiff	
5415										
			S-3	14 47 31 N=78	59	72	61		Silty GRAVEL with Sand (GM); very dense, moist, orange brown, fine sand, coarse to fine gravel	G=40.9%; S=40%; F=19%
	10		S-4	11 13 18 N=31	30	35	78		Silty SAND (SM); dense, moist, orange brown	
5410										
	15		S-5	3 5 6 N=11	9	9	39		...less gravel; loose	
5405										
	20		S-6	3 3 3 N=6	7	6	83		...some (trace) gravel; loose, fine sand, fine gravel	G=2.6%; S=57.4%; F=40%
5400										
	25									

AECOM

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Project: 2019 Sevier Watershed Plan
Project Location: Sevier County, UT
Project Number: 60598028

Log of Boring B19-TC-01

Depth, feet	Elevation feet	SAMPLES Type	Number	Blows/6inch	SPT N_{60} blowcount	SPT $(N_1)_{60}$ blowcount	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
25	5395		S-7a S-7b	11 30 29 N=59	50	42	78		...with gravel; dense	
									Silty SAND with Gravel (SM); very dense, dry to moist, orange brown; fine sand, coarse to fine gravel, larger particles of rock fractured into spoon	
30	5390		S-8	28 25 38 N=63	73	58	78			NP; G=38.5%; S=38.7%; F=23%
									▽ Poorly Graded SAND (SP); medium dense, wet, orange brown to brown, fine to medium sand	Inferred ground water; significantly softer
35	5385		S-9	9 14 32 N=46	41	31	83		Clayey GRAVEL with Sand (GC); dense, wet, fine to coarse gravel, coarse sand	
									Poorly graded SAND (SP); medium dense, wet, orange brown to brown, fine to coarse sand	
40	5380		S-10	4 8 23 N=31	36	27	78		...with gravel	
45	5375		S-11	26 20 26 N=46	53	38	100		Clayey SAND with Gravel (SC), dense, wet, orange brown to brown, fine to coarse sand, fine to coarse sand	
50	5370		S-12	50/3"	-	-	0		Rock/Boulder	Potentially 2-3 inches of heave in bottom
									End of Boring	Auger Refusal

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Project: 2019 Sevier Watershed Plan
Project Location: Sevier County, UT
Project Number: 60598028

Log of Boring BH19-FC-01

Date(s) Drilled:	**2/22/2019-2/23/2019**	Drill Rig Type:	**CME-850 Track Rig**	Logged By: **BWF**	Checked By: **CJT**
Drilling Contractor:	**Conetec, Inc.**	Hammer Information:	**140-pound Automatic Hammer, 30-inch Drop, ER=79.2%**	Total Depth of Borehole:	**59 feet**
Drilling Method: Bit Size/Type:	**Hollow Stem Auger 8" OD/ 4.25" ID 2-Prong Spad Bit**	Borehole Backfill:	**Portland Cement Bentonite Grout**	Surface Elevation:	**5571 feet**
Sampling Method(s):	**18-inch Standard Split Spoon, Modified California with Rings**	Estimated Groundwater Level at Time of Drilling:	**Not Encountered**	Groundwater Level and Date Measured:	**Not Measured**
Location:	**38.71081° N 112.14402° W**			Survey Datum:	**WGS84**

Elevation feet	Depth, feet	SAMPLES Type	Number	Blows/6inch	SPT N_{60} blowcount	SPT $(N_1)_{60}$ blowcount	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
5570	0								Silty SAND with Gravel (SM); very dense, dry, light brown to brown, coarse to fine sand, coarse to fine gravel, with cobbles	
			S-1	3 7 47 N=54	36	55	44			G=26.8%; S=36.6%; F=37%
5565	5		S-2	50/2"	-	-	0			Dust recovered; rock to drill past
									...medium dense, fine gravel	
			S-3	9 10 8 N=18	18	22	67			G=12%; S=51.7%; F=36%
5560	10		S-4	7 13 10 N=23	23	26	44			
5555	15		S-5	32 50/3"	-	-	28		...interbedded strata (1-1.5 ft thick) with gravel; very dense, light brown	
5550	20		S-6	25 34 50/5"	-	-	72		...more gravel	
	25									

AECOM

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Project: 2019 Sevier Watershed Plan
Project Location: Sevier County, UT
Project Number: 60598028

Log of Boring BH19-FC-01

Elevation feet	Depth, feet	SAMPLES Type	Number	Blows/6inch	SPT N_{60} blowcount	SPT $(N_1)_{60}$ blowcount	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	25									
5545			S-7	44 50/3"	-	-	100		...less gravel	G=32.4%; S=47.7%; F=20%
	30									
5540			S-8	42 50/4"	-	-	100			
	35									
5535			S-9	35 50/5"	-	-	91			
	40									
5530			S-10	42 50/5"	-	-	91			G=24.2%; S=52%; F=24%
	45									
5525			S-11	20 31 34 N=65	75	50	83		...fine to medium sand	
	50									
5520			S-12	30 50 50/3"	-	-	67		...some fragments of clayey sand	
									Clayey SAND (SC); medium dense, dry to moist, brown to brown gray, no gravel, fine sand, low plasticity	
	55									

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Project: 2019 Sevier Watershed Plan
Project Location: Sevier County, UT
Project Number: 60598028

Log of Boring BH19-FC-01

Elevation feet	Depth, feet	SAMPLES Type	Number	Blows/6inch	SPT N_{60} blowcount	SPT $(N_1)_{60}$ blowcount	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	55									
5515		S-13		9 11 11 N=22	25	15	78			
		S-14		18 19 23 N=42	49	28	100		...with gravel, moist, fine gravel	LL=25; PI=5; G=0.3%; S=54%; F=46%
									End of Boring	Auger Refusal
5510										
5505										
5500										
5495										
5490										

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Project: 2019 Sevier Watershed Plan
Project Location: Sevier County, UT
Project Number: 60598028

Log of Boring BH19-LC-01

Sheet 1 of 1

Date(s) Drilled: **2/22/2019**	Drill Rig Type: **CME-850 Track Rig**	Logged By: **BWF**	Checked By: **CJT**
Drilling Contractor: **Conetec, Inc.**	Hammer Information: **140-pound Automatic Hammer, 30-inch Drop, ER=79.2%**	Total Depth of Borehole: **21.4 feet**	
Drilling Method: **Hollow Stem Auger** Bit Size/Type: **8" OD/ 4.25" ID 2-Prong Spad Bit**	Borehole Backfill: **Portland Cement Bentonite Grout**	Surface Elevation: **5423 feet**	
Sampling Method(s): **18-inch Standard Split Spoon, Modified California with Rings**	Estimated Groundwater Level at Time of Drilling: **Not Encountered**	Groundwater Level and Date Measured: **Not Measured**	
Location: **38.76958° N 112.10377° W**		Survey Datum: **WGS84**	

Elevation feet	Depth, feet	SAMPLES Type	Number	Blows/6inch	SPT N_{60} blowcount	SPT $(N_1)_{60}$ blowcount	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0								Silty SAND with Gravel (SM); very dense, dry to moist, orange brown to brown, with cobbles, fine sand, coarse to fine gravel	
5420			S-1	21 60 69 N=129	86	131	100			G=27.5%; S=47.4%; F=25%
	5		S-2	16 18 22 N=40	37	50	78		...dense	
5415			S-3	6 12 19 N=31	23	29	67		...medium dense	
	10		S-4	27 47 37 N=84	63	72	67		...very dense, trending to light orange brown to light brown, coarse to fine sand, coarse to fine gravel	G=36.9%; S=42.8%; F=20%
5410									Lean CLAY with Sand (CL); hard, dry to moist, orange brown	
	15		S-5	15 24 38 N=62	68	69	89			Slow drilling; very hard
5405									Clayey SAND (SC); very dense, dry, orange brown to brown, fine sand	
	20		S-6	19 38 50/5"	-	-	82			
									End of Boring	Auger Refusal
5400										

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Project: 2019 Sevier Watershed Plan
Project Location: Sevier County, UT
Project Number: 60598028

Log of Boring BH19-WC-01

Sheet 1 of 1

Date(s) Drilled:	**2/20/2019**	Drill Rig Type:	**CME-850 Track Rig**	Logged By: **BWF**	Checked By: **CJT**
Drilling Contractor:	**Conetec, Inc.**	Hammer Information:	**140-pound Automatic Hammer, 30-inch Drop, ER=79.2%**	Total Depth of Borehole:	**21 feet**
Drilling Method: **Hollow Stem Auger** Bit Size/Type: **8" OD/ 4.25" ID 2-Prong Spad Bit**		Borehole Backfill:	**Cuttings**	Surface Elevation:	**5591 feet**
Sampling Method(s):	**18-inch Standard Split Spoon, Modified California with Rings**	Estimated Groundwater Level at Time of Drilling:	**Not Encountered**	Groundwater Level and Date Measured:	**Not Measured**
Location:	**38.79707° N 112.08313° W**			Survey Datum:	**WGS84**

Elevation feet	Depth, feet	SAMPLES Type	Number	Blows/6inch	SPT N_{60} blowcount	SPT $(N_1)_{60}$ blowcount	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0								Silty, Clayey SAND with Gravel (SC-SM); very dense, dry to moist, with cobbles, fine to coarse sand, coarse to fine gravel, low plasticity	
5590			S-1	10 21 39 N=60	40	61	100			
	5		S-2	16 18 20 N=38	35	47	78		...dense	LL=21; PI=6; G=28.7%; S=38.2%; F=33%
5585			S-3	14 34 39 N=73	55	68	67		Silty GRAVEL with Sand (GM); very dense, dry to moist, orange brown, coarse to fine sand, coarse to fine gravel	G=44.3%; S=29.8%; F=26%
	10		S-4	12 18 19 N=37	36	41	69		...dense	
5580			S-5	75/5"	-	-	100		Silty CLAY (CL-ML); very hard, dry, orange brown	
	15		S-6	20 45 50/3"	-	-	60		Weathered Rock/CLAYSTONE; orange brown to dark red	
5575									...streaks of dark olive green color	
	20		S-7	50/3"	-	-	67			
5570									End of Boring	Auger Refusal

AECOM

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Attachment D. Test Pit Logs

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-FC-01
Datum: WGS84
Latitude: 38.70979°
Longitude: -112.14427° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Flat Canyon SW of Richfield (southeast test pit 15 ft up on hill)		**Date:** 2/20/2019
Field Investigator: B. Barrett		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bag, Bucket	
Depth of Excavation: 21 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bag	0-2	Silty SAND with gravel (SM), slightly moist, some organics, orange brown; few cobbles	
S-2 Bucket	2-21	Poorly graded GRAVEL with clay and sand (GC), slightly moist, orange brown; pockets/layers with higher gravel fraction, few cobbles and boulders, fine sand, coarse to fine gravel, low plasticity	LL=25; PI=8; G=57.7%; S=30.3%; F=12%; $\gamma_{d\text{-}max}$=136.6 pcf; w_{opt}=6.8% (AASHTO T180)

Photograph/Sketch

Description
Right: Note pockets/layers in excavation sidewall with higher gravel fraction Left: Sample piles of excavated material





Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-FC-02
Datum: WGS84
Latitude: 38.71110°
Longitude: -112.14636° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Flat Canyon SW of Richfield (southern test pit in basin)		**Date:** 2/20/2019
Field Investigator: B. Barrett		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bag, Bucket	
Depth of Excavation: 19 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bag	0-2	Silty fine to medium SAND (SM), medium dense, moist, some organics, gray brown; (approx. 15% silt)	
S-2 Bucket	2-19	Silty SAND with gravel (SM), slightly moist, gray brown; few cobbles, coarse to fine sand and gravel, low plasticity	NP; G=26.1%; S=59.3%; F=15%; $\gamma_{d\text{-}max}$=130.4 pcf; w_{opt}=8.3% (AASHTO T180)
	16	…more cobbles, few boulders	

Photograph/Sketch

Description





Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-FC-03
Datum: WGS84
Latitude: 38.71206°
Longitude: -112.14645° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Flat Canyon SW of Richfield (northern test pit in basin – south of wash)		**Date:** 2/20/2019
Field Investigator: B. Barrett		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bucket	
Depth of Excavation: 21 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bucket	0-4	Silty SAND with gravel (SM), moist, orange brown; coarse to fine sand and gravel	G=35%; S=42.1%; F=23%
S-2 Bucket	4-21	Poorly graded GRAVEL with silty clay and sand (GP-GC), slightly moist, orange brown; few cobbles, coarse to fine sand and gravel, low plasticity	LL=20; PI=4; G=56.1%; S=31.9%; F=12%; $\gamma_{d\text{-}max}$=140.8 pcf; w_{opt}=6.2% (AASHTO T180)

Photograph/Sketch

Description



Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-LC-01
Datum: WGS84
Latitude: 38.76995°
Longitude: -112.10407° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Lind Canyon W of Richfield (southwestern most test pit)		**Date:** 2/19/2019
Field Investigator: B. Franke		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bucket	
Depth of Excavation: 12 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bucket	0-1	Sandy Lean CLAY (CL), moist, orange brown; contains gravel, cobbles (3-6” diameter)	
S-2 Bucket	1-12	Poorly graded GRAVEL with silt and sand (GP-GM), moist to dry; cobbles (3-12” diameter), boulders (3-4’ diameter), fine sand, coarse to fine gravel, low plasticity	NP; G=57.3%; S=34.3%; F=7%
		Refusal on boulders/rock	

Photograph/Sketch

Description



Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-LC-02
Datum: WGS84
Latitude: 38.77050°
Longitude: -112.10319° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Lind Canyon W of Richfield (northwestern most test pit)		**Date:** 2/19/2019
Field Investigator: B. Franke		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bucket, Bag	
Depth of Excavation: 16 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bucket	0-3.5	Silty SAND (SM), moist, brown to orange brown; some cobbles (less than 10" diameter), fine sand, coarse to fine gravel, some roots and vegetation	G=14.6%; S=53.9%; F=32%
S-2 Bucket	3.5-10.5	…boulders (less than 4' diameter), low plasticity	NP; G=11.9%; S=52.8%; F=35%; $\gamma_{d\text{-}max}$=125.4 pcf; w_{opt}=10.5% (AASHTO T180)
S-3 Bucket & Bag	10.5-16	Weathered siltstone or claystone, slightly moist, green gray to brown gray	broken into angular 2-4" fragments; effervesces with dilute hydrochloric acid

Photograph/Sketch

Description
Upper Left: Fragments of siltstone/claystone Lower Left: Large boulders removed during excavation Right: sidewall of test pit showing siltstone/claystone at bottom







Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-LC-03
Datum: WGS84
Latitude: 38.76992°
Longitude: -112.10265° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Lind Canyon W of Richfield (southeastern test pit 10 ft up on hill)		**Date:** 2/19/2019
Field Investigator: B. Franke/B. Barrett		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bag, Bucket	
Depth of Excavation: 25 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bag	0-4	Poorly graded SAND with gravel (SP), slightly moist, orange brown	
S-2 Bucket	4-9	Silty GRAVEL with sand (GM), slightly moist, orange brown; fine sand, coarse to fine gravel	G=51.9%; S=34.5%; F=14%
S-3 Bucket	9-25	Silty SAND with gravel (SM), slightly moist, orange brown; few cobbles, fine sand, coarse to fine gravel, low plasticity	NP; G=32.9%; S=51.8%; F=15%

Photograph/Sketch

Description
Left: Sidewalls of Test pit Right: Location of test pit up on hill





Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-LC-04
Datum: WGS84
Latitude: 38.77055°
Longitude: -112.10207° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Lind Canyon W of Richfield (northeast test pit 5 ft up on hill)		**Date:** 2/19/2019
Field Investigator: B. Barrett		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bucket	
Depth of Excavation: 20 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bucket	0-20	Silty SAND with gravel (SM), slightly moist, orange brown; some cobbles, few boulders, irregular pockets (approx. 2-4 ft diameter) of fine sand, irregular pockets (approx. 5-10 ft diameter) of coarse to fine gravel with sand, low plasticity	NP; G=39.6%; S=44.6%; F=16%; $\gamma_{d\text{-}max}$=136.5 pcf; w_{opt}=6.9% (AASHTO T180)

Photograph/Sketch

Description
Note pockets of fine sand, pockets of gravel, and large boulder in sidewall of excavation



Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-TC-01
Datum: WGS84
Latitude: 38.77303°
Longitude: -112.10066° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Tank Canyon W of Richfield (south test pit, on hill north of road)		**Date:** 2/19/2019
Field Investigator: B. Franke		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bucket	
Depth of Excavation: 8 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bucket	0-2	Sandy Silty CLAY with gravel (CL-ML), moist, orange brown; contains some cobbles (approx. 6" diameter), some organics/vegetation	
S-2 Bucket	2-8	Silty SAND with gravel (SM), slightly moist, orange brown; contains some cobbles 3-8" diameter, contains rock fragments, fine sand, coarse to fine gravel, low plasticity	NP; G=28.3%; S=43.8%; F=28%; $\gamma_{d\text{-}max}$=134 pcf; w_{opt}=7.2% (AASHTO T180)
		Refusal	

Photograph/Sketch

Description
Left: Location of test pit up on hill Right: Sidewalls and bottom of test pit; refusal on rock or siltstone/claystone





Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-TC-02
Datum: WGS84
Latitude: 38.77401°
Longitude: -112.10043° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Tank Canyon W of Richfield (northern most test pit)		**Date:** 2/19/2019
Field Investigator: B. Franke		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bag	
Depth of Excavation: 15 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bag	0-2	Sandy lean CLAY with gravel and cobbles (CL), moist, orange brown; contains roots/vegetation	
S-2 Bag	2-6	Matrix supported conglomerate, silty fine grain sand matrix with angular gravel up to 1-inch in diameter, orange brown to brown gray (dark brown matrix, light brown particles)	effervesces with dilute hydrochloric acid
S-3 Bag	6-15	…brown gray with orange brown staining	

Photograph/Sketch

Description		
Left: Sidewalls and bottom of test pit showing fractured rock Right: Location of test pit		

Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-WC-01
Datum: WGS84
Latitude: 38.79701°
Longitude: -112.08300° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Wood Canyon NW of Richfield (south of wash)		**Date:** 2/20/2019
Field Investigator: B. Barrett		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bucket	
Depth of Excavation: 16 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bucket	0-4	Silty GRAVEL with sand (SM), slightly moist, some organics, orange brown; fine sand, coarse to fine gravel, low plasticity	NP; G=53.2%; S=28.2%; F=19%
S-2 Bucket	4-16 9	Silty, clayey GRAVEL with sand (GC-GM), slightly moist, orange brown; few cobbles and boulders, coarse to fine sand and gravel, low plasticity …1 foot layer of fine SAND with cobbles	LL=21; PI=4; G=47.1%; S=30.4%; F=23%

Photograph/Sketch

Description	
	

Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-WC-02
Datum: WGS84
Latitude: 38.79701°
Longitude: -112.08265° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Wood Canyon NW of Richfield (north of wash)		**Date:** 2/20/2019
Field Investigator: B. Barrett		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bucket	
Depth of Excavation: 17 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bucket	0-3	Silty SAND with gravel (SM), slightly moist, some organics, brown	
S-2 Bucket	3-17	Silty, clayey GRAVEL with sand (GC-GM), slightly moist, orange brown; few cobbles and occasional boulders, coarse to fine sand and gravel, low plasticity	LL=21; PI=7; G=57.4%; S=27.8%; F=15%

Photograph/Sketch

Description



Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-WC-03
Datum: WGS84
Latitude: 38.79718°
Longitude: -112.08355° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Wood Canyon NW of Richfield (TP northwest of wash)		**Date:** 2/20/2019
Field Investigator: B. Barrett		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bag, Bucket	
Depth of Excavation: 6 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bag	0-2	Sandy SILT (ML), trace gravel, slightly moist, some organics, orange brown	
S-2 Bucket	2-6	Silty GRAVEL with sand (SM), slightly moist, orange brown; occasional cobbles and boulders, coarse to fine sand and gravel	G=43.1%; S=25.4%; F=32%; $\gamma_{d\text{-}max}$=137.7 pcf; w_{opt}=6.9% (AASHTO T180)
	6+	Siltstone or claystone	unable to penetrate in approx. 3ft x 14ft bottom of excavation

Photograph/Sketch

Description



Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Surface and Shallow Soil Sampling Log

AECOM

Log ID: TP19-WC-04
Datum: WGS84
Latitude: 38.79705°
Longitude: -112.08317° **Elevation:** NM

General Information

Project Number: 60598028	**Project Name:** 2019 Sevier Watershed Plan	**Page:** 1 of 1
Location: Wood Canyon NW of Richfield (test pit at location of BH19-WC-01)		**Date:** 2/20/2019
Field Investigator: B. Barrett		A&D Jensen Contractors
Sampling Excavation Method: Link-Belt 225 Excavator	**Sampling Method:** Bag, Bucket	
Depth of Excavation: 19 ft	**Depth to Water:** Not Enc.	**Backfill Material:** Excavated Material

Sample Information

Sample Number	Depth (ft)	Lithologic Description	Comments /Analysis Requested
S-1 Bucket	0-3	Silty SAND with gravel (SM), slightly moist, some organics, orange brown	
S-2 Bucket	3-15	Silty GRAVEL with sand (GM), slightly moist, orange brown; some cobbles, few boulders, fine sand, coarse to fine gravel, low plasticity	NP; G=55.4%; S=27.6%; F=17%; $\gamma_{d\text{-}max}$=138.6 pcf; w_{opt}=6.7% (AASHTO T180)
S-3 Bag	15-19	Weathered clay or claystone, orange brown to dark red; harder with depth	unable to penetrate beyond 19 ft in approx. 3ft x 9ft bottom of excavation
S-4 Bag	17	…Some dark olive green color, fractured to weathered clay/claystone pieces	

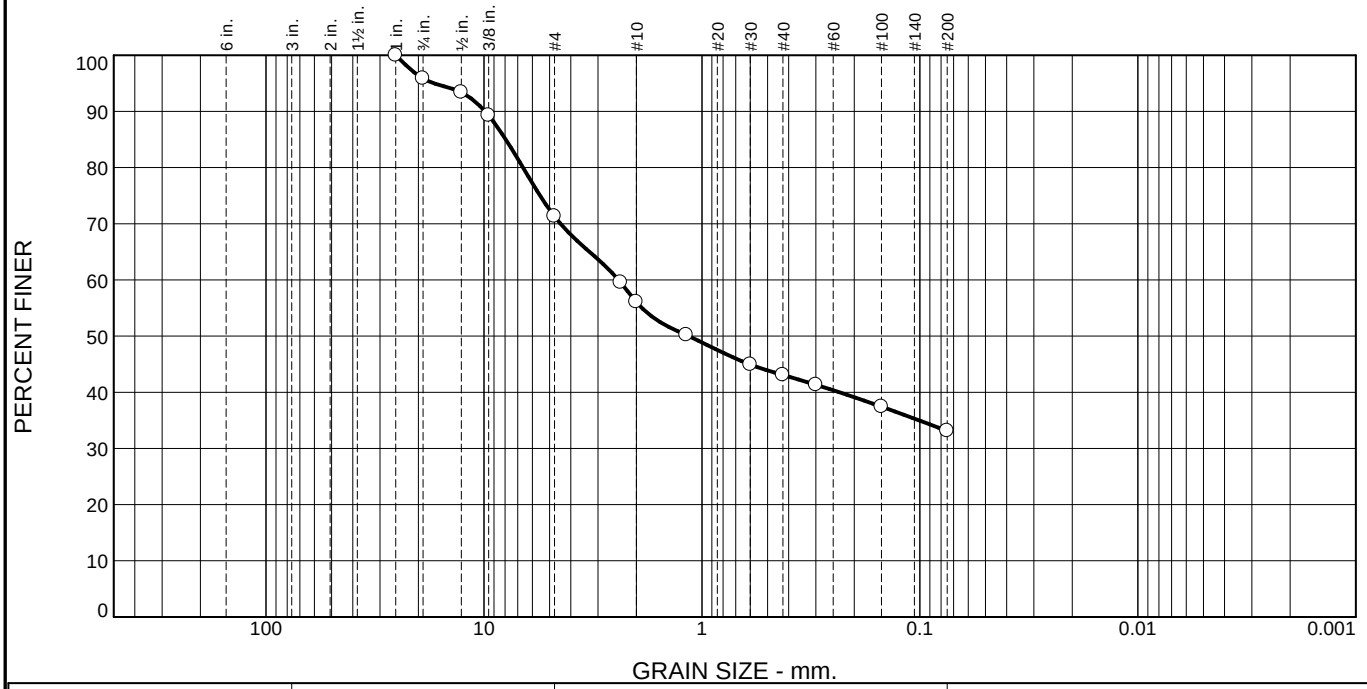
Photograph/Sketch

Description		
Left: Note rock in near end of trench unable to be removed or penetrated Right: Note vertical, relatively smooth sidewall of excavation below approx. 15 ft		

Recorded By: B. Franke	Date : 05/14/2019	Checked By: C. Tanner	Date: 05/14/2019

Attachment E. Laboratory Test Data

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	4.1	24.6	15.2	13.0	10.0	33.1	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	95.9		
1/2"	93.4		
3/8"	89.3		
#4	71.3		
#8	59.5		
#10	56.1		
#16	50.2		
#30	44.9		
#40	43.1		
#50	41.3		
#100	37.4		
#200	33.1		

* (no specification provided)

Material Description

BH-19, WC-01, Sample 2, 5-6.5'

Atterberg Limits (ASTM D 4318)

PL= 14.5 **LL=** 20.6 **PI=** 6.1

Classification

USCS (D 2487)= SC-SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 9.8750 D_{85}= 7.9425 D_{60}= 2.4150
D_{50}= 1.1511 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/1/19 **Date Tested:** 3/5/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: BH19 WC-01, S-2
Sample Number: 19-S-051

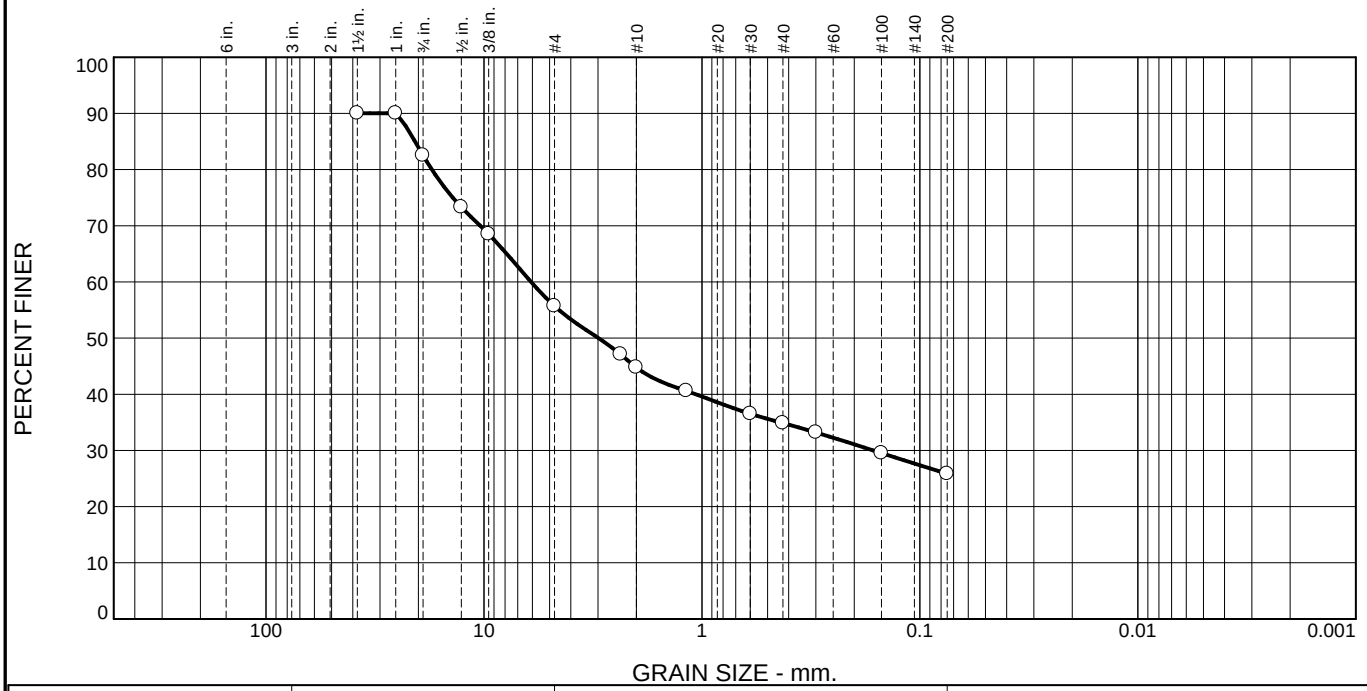
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JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		26.8	10.9	9.9	9.0	25.9	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	90.0		
1"	90.0		
3/4"	82.5		
1/2"	73.3		
3/8"	68.5		
#4	55.7		
#8	47.1		
#10	44.8		
#16	40.6		
#30	36.5		
#40	34.9		
#50	33.2		
#100	29.5		
#200	25.9		

* (no specification provided)

Material Description

BH19 WC-01, Sample 3, 7.5-9

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 25.3680 D_{85}= 20.7254 D_{60}= 6.0805
D_{50}= 2.9854 D_{30}= 0.1639 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/1/19 **Date Tested:** 3/6/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: BH19 WC-01, S-3
Sample Number: 19-S-059

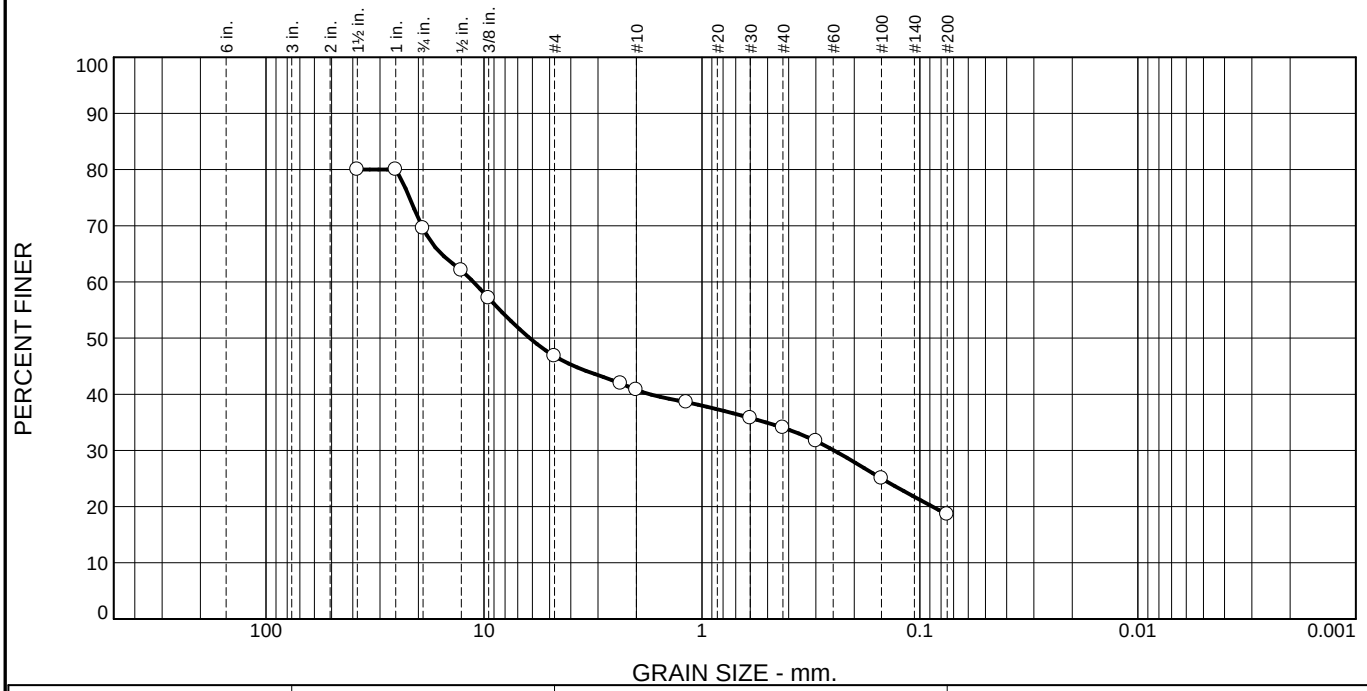
Date Sampled: 2/20/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		22.8	6.0	6.8	15.4	18.6	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1 1/2"	80.0		
1"	80.0		
3/4"	69.6		
1/2"	62.1		
3/8"	57.1		
#4	46.8		
#8	41.9		
#10	40.8		
#16	38.6		
#30	35.8		
#40	34.0		
#50	31.7		
#100	25.0		
#200	18.6		

* (no specification provided)

Material Description

TP19 WC-01, Sample 1, 0-4'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= GM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= D_{85}= D_{60}= 11.1762
D_{50}= 6.1694 D_{30}= 0.2478 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/8/2019 **Date Tested:** 3/11/2019

Tested By: Matt Murphree

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 WC-01, S-1
Sample Number: 19-S-079

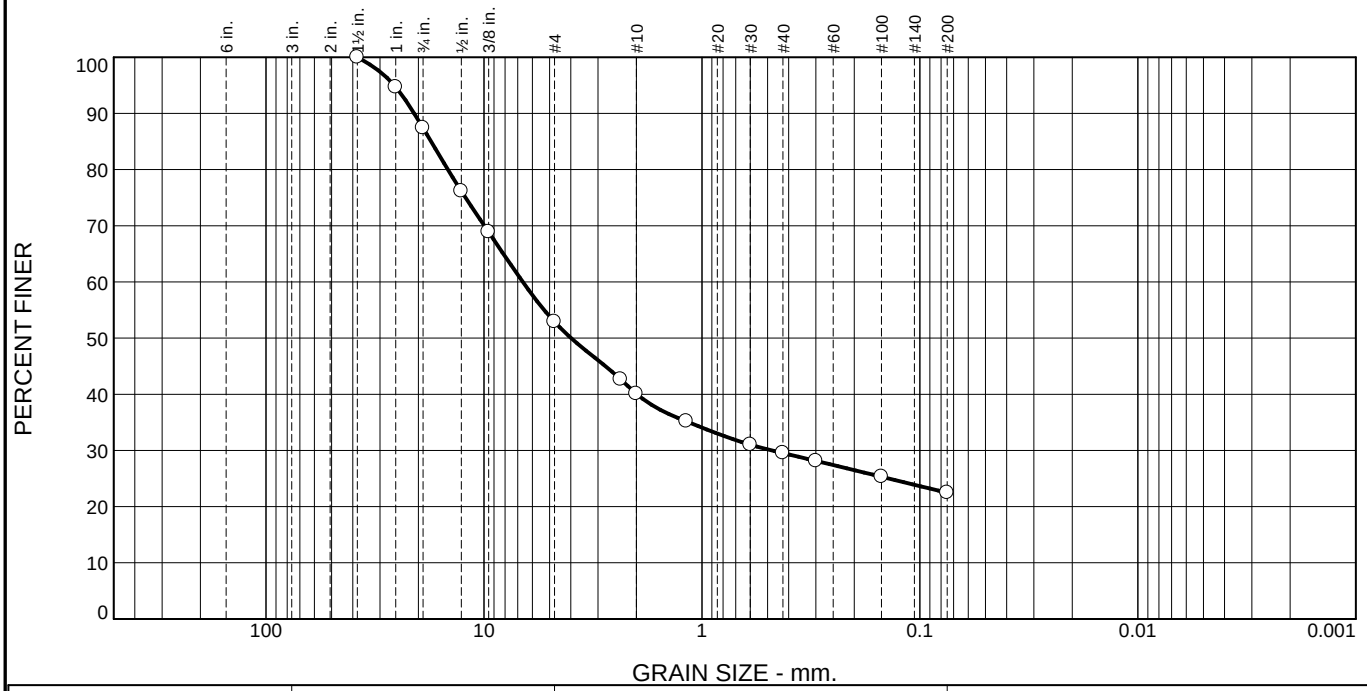
Date Sampled: 2/20/2019

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Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	12.6	34.5	12.8	10.6	7.0	22.5	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100.0		
1"	94.7		
3/4"	87.4		
1/2"	76.2		
3/8"	68.9		
#4	52.9		
#8	42.7		
#10	40.1		
#16	35.2		
#30	31.0		
#40	29.5		
#50	28.1		
#100	25.3		
#200	22.5		

* (no specification provided)

Material Description

TP19 WC-01, Sample 2, 4-16'

Atterberg Limits (ASTM D 4318)

PL= 17.2 **LL=** 21.1 **PI=** 3.9

Classification

USCS (D 2487)= GC-GM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 20.9113 D_{85}= 17.4925 D_{60}= 6.6388
D_{50}= 3.9835 D_{30}= 0.4771 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/8/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 WC-01, S-2
Sample Number: 19-S-077

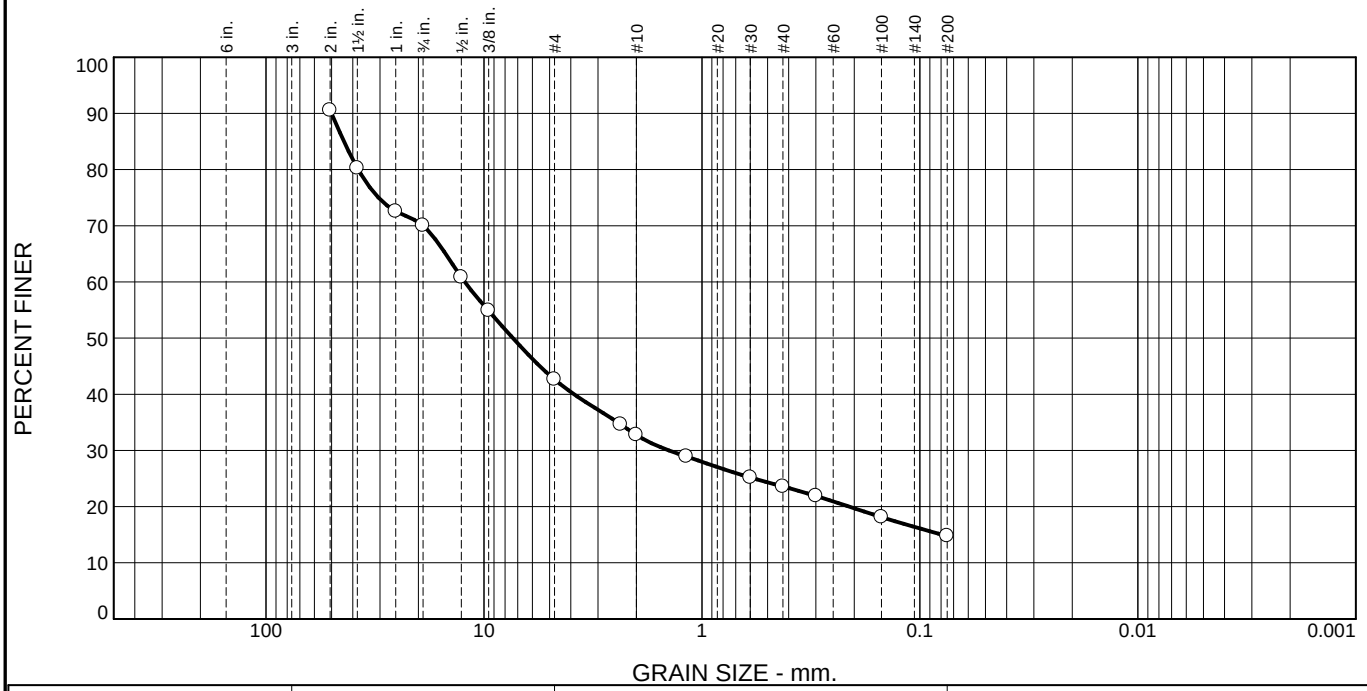
Date Sampled: 2/20/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		27.4	9.8	9.2	8.8	14.8	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2"	90.5		
1.5"	80.3		
1"	72.6		
3/4"	70.0		
1/2"	60.8		
3/8"	54.9		
#4	42.6		
#8	34.6		
#10	32.8		
#16	28.9		
#30	25.2		
#40	23.6		
#50	21.9		
#100	18.1		
#200	14.8		

* (no specification provided)

Material Description

TP19 WC-02, S-2, 3-17'

Atterberg Limits (ASTM D 4318)

PL= 14.0 **LL=** 21.4 **PI=** 7.4

Classification

USCS (D 2487)= GC-GM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 50.0858 D_{85}= 43.8782 D_{60}= 12.2542
D_{50}= 7.3715 D_{30}= 1.4167 D_{15}= 0.0790
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/18/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 WC-02, S-2
Sample Number: 19-S-080

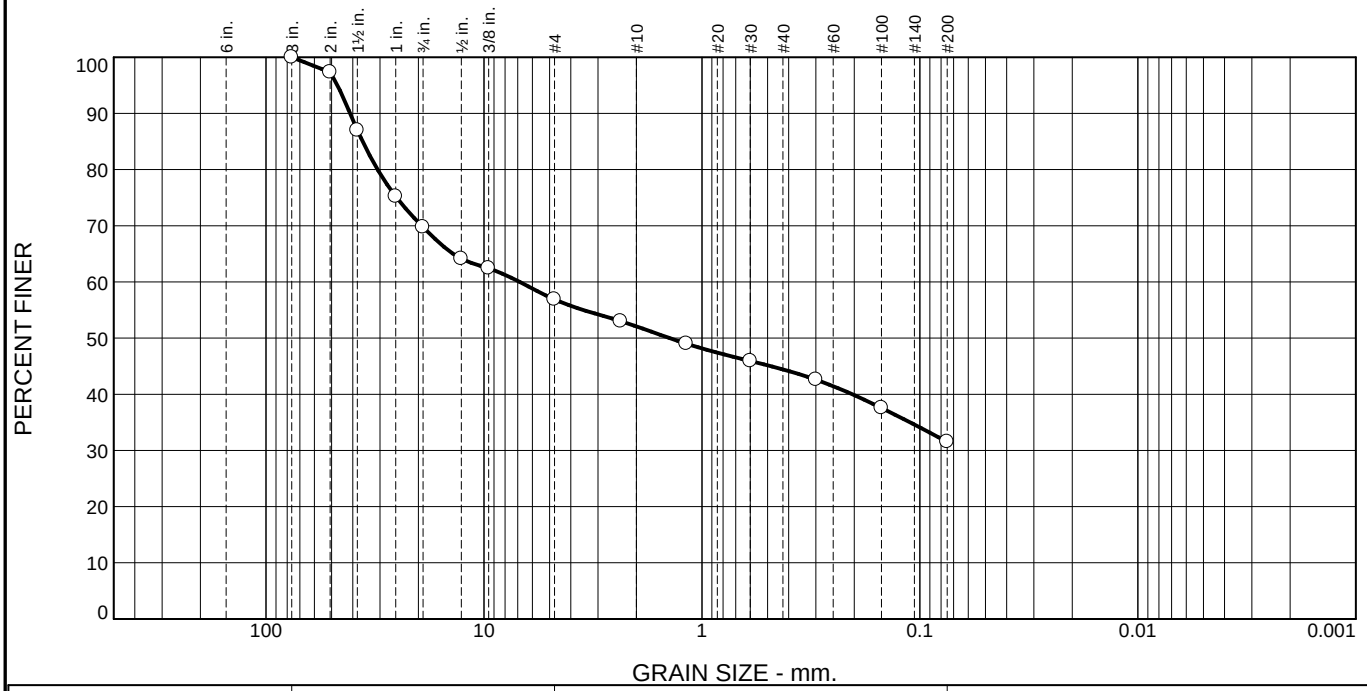
Date Sampled: 2/20/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	30.2	12.9	4.8	7.7	12.9	31.5	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3"	100.0		
2"	97.3		
1.5"	87.0		
1"	75.2		
3/4"	69.8		
1/2"	64.1		
3/8"	62.4		
#4	56.9		
#8	53.0		
#16	49.0		
#30	45.9		
#50	42.6		
#100	37.6		
#200	31.5		

* (no specification provided)

Material Description

TP19 WC-03, Sample 2, 2-6'

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 41.1435 D_{85}= 36.0499 D_{60}= 6.8658
D_{50}= 1.4074 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/4/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 WC-03, S-2
Sample Number: 19-S-043

Date Sampled: 2/20/19

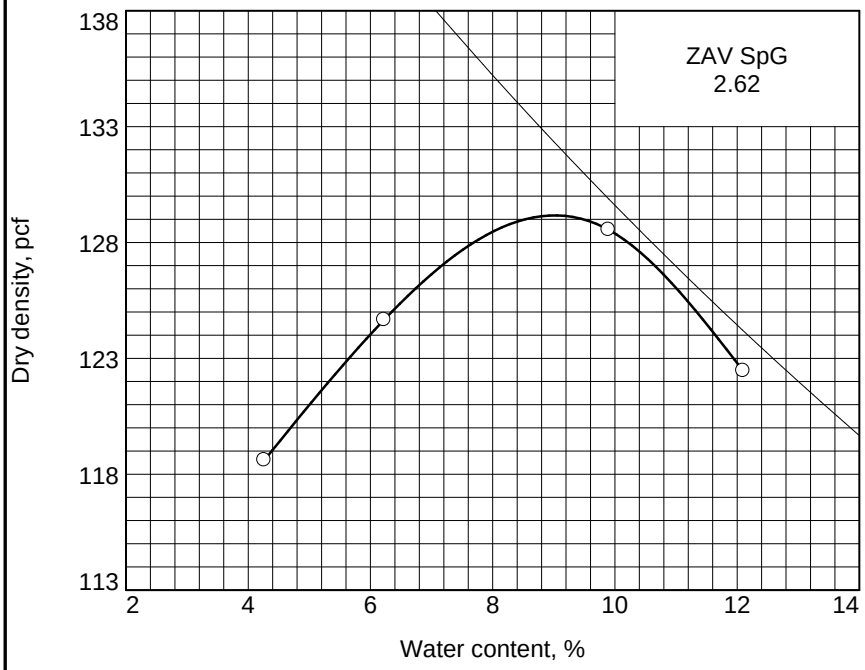
JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

COMPACTION TEST REPORT

Curve No. 043



Preparation Method: -3/4" Material
Rammer: Wt. 10 lb. Drop 18 in.
Type: automatic
Layers: No. five Blows per 56
Mold Size: 0.075 cu. ft.
Test Performed on Material Passing 3/4 in. Sieve

%>3/4 in. 30.2 %<No.200 31.5
Atterberg (D 4318): LL PI
NM (D 2216) Sp.G. (D 854) 2.62
USCS (D 2487)
AASHTO (M 145)
Date: Sampled 2/20/19
Received 2/22/19
Tested 3/4/19
Tested By Mark Rappleye

COMPACTION TESTING DATA
AASHTO T 180-15 Method D Modified
AASHTO T 224-01 Oversize Correction Applied to Final Results

	1	2	3	4	5	6
WM + WS	10707.0	11005.0	11306.0	11170.0		
WM	6500.0	6500.0	6500.0	6500.0		
WW + T #1	868.7	781.9	794.2	914.6		
WD + T #1	842.9	750.6	744.5	842.4		
TARE #1	237.8	247.7	242.3	245.6		
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	4.3	6.2	9.9	12.1		
DRY DENS.	118.6	124.7	128.6	122.5		

SIEVE TEST RESULTS
AASHTO T 27 AASHTO T 11

Opening Size	% Passing	Specs.
3"	100.0	
2"	97.3	
1.5"	87.0	
1"	75.2	
3/4"	69.8	
1/2"	64.1	
3/8"	62.4	
#4	56.9	
#8	53.0	
#16	49.0	
#30	45.9	
#50	42.6	
#100	37.6	
#200	31.5	

ROCK CORRECTED TEST RESULTS

Maximum dry density = 137.7 pcf

Optimum moisture = 6.9 %

Material Description

TP19 WC-03, Sample 2, 2-6'

Remarks:

Project No. 1804-224 **Client:** Sevier County

Project: Sevier County Watershed Plan & Flood Protection

○ **Location:** TP19 WC-03, S-2 **Sample Number:** 19-S-043

Checked by: Mark Rappleye

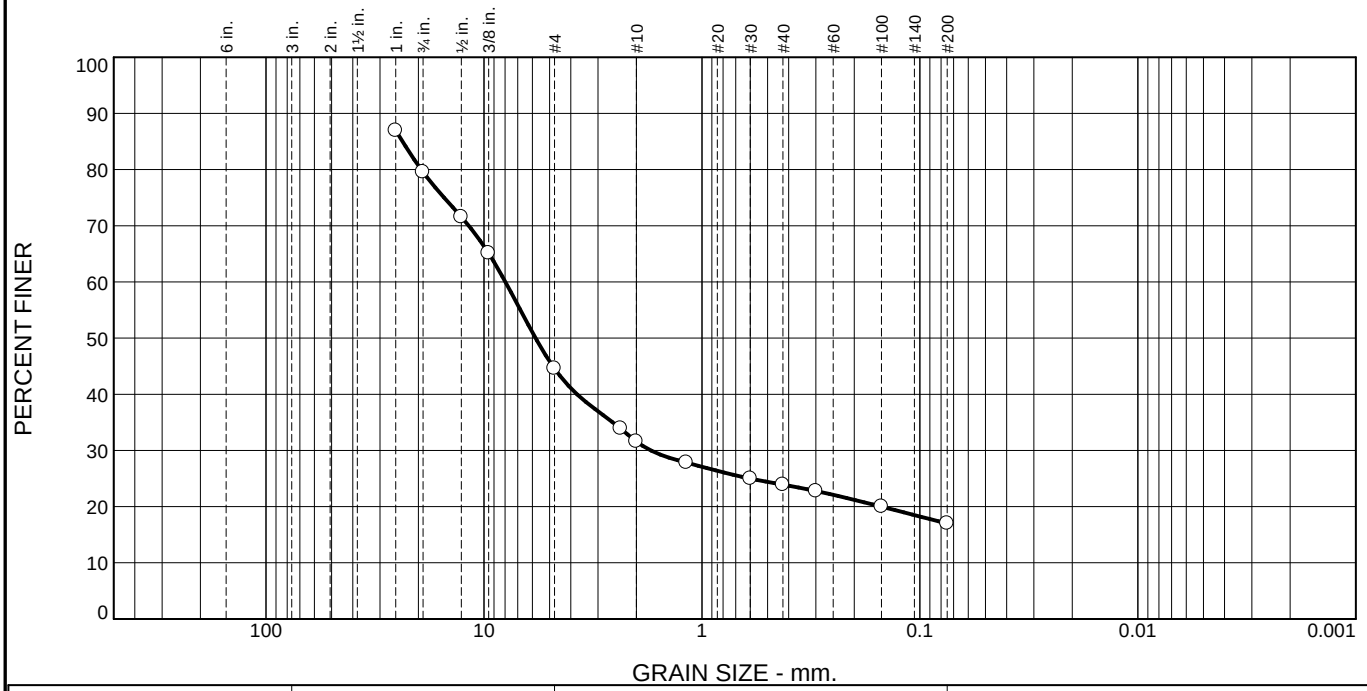
Title: Lab Manager

JONES & DEMILLE ENGINEERING INC.

Richfield, Utah

Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		35.0	13.0	7.7	6.9	17.0	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	86.9		
3/4"	79.6		
1/2"	71.6		
3/8"	65.1		
#4	44.6		
#8	33.9		
#10	31.6		
#16	27.8		
#30	25.0		
#40	23.9		
#50	22.8		
#100	20.0		
#200	17.0		

* (no specification provided)

Material Description

TP19 WC-04, Sample 2, 3-15'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= GM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= D_{85}= 23.6435 D_{60}= 7.9775
D_{50}= 5.8000 D_{30}= 1.7156 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/5/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 WC-04, S-2
Sample Number: 19-S-047

Date Sampled: 2/20/19

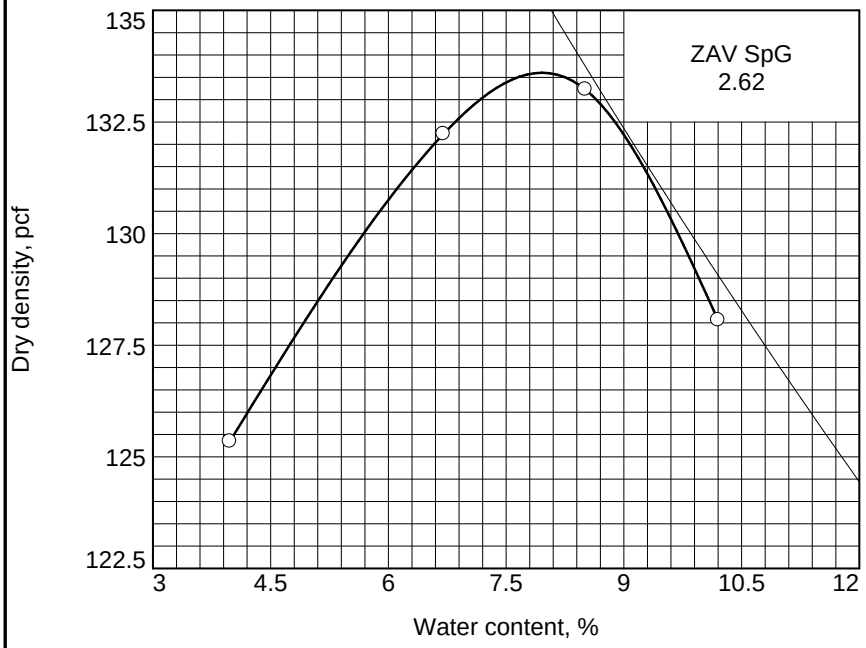
JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

COMPACTION TEST REPORT

Curve No. 047



Preparation Method	-3/4" Material
Rammer: Wt.	10 lb. Drop 18 in.
Type	automatic
Layers: No.	five Blows per 56
Mold Size	0.075 cu. ft.
Test Performed on Material Passing	3/4 in. Sieve
%>3/4 in.	20.4 %<No.200 17.0
Atterberg (D 4318): LL	NV PI NP
NM (D 2216)	Sp.G. (D 854) 2.62
USCS (D 2487)	GM
AASHTO (M 145)	A-1-b
Date: Sampled	2/20/19
Received	2/22/19
Tested	3/5/19
Tested By	Mark Rappleye

COMPACTION TESTING DATA
AASHTO T 180-15 Method D Modified
AASHTO T 224-01 Oversize Correction Applied to Final Results

	1	2	3	4	5	6
WM + WS	10934.0	11300.0	11418.0	11301.0		
WM	6500.0	6500.0	6500.0	6500.0		
WW + T #1	804.4	856.9	886.6	892.9		
WD + T #1	782.7	818.5	837.4	833.5		
TARE #1	237.5	245.6	259.1	251.1		
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	4.0	6.7	8.5	10.2		
DRY DENS.	125.3	132.2	133.2	128.1		

SIEVE TEST RESULTS
AASHTO T 27 AASHTO T 11

Opening Size	% Passing	Specs.
1"	86.9	
3/4"	79.6	
1/2"	71.6	
3/8"	65.1	
#4	44.6	
#8	33.9	
#10	31.6	
#16	27.8	
#30	25.0	
#40	23.9	
#50	22.8	
#100	20.0	
#200	17.0	

ROCK CORRECTED TEST RESULTS

Maximum dry density = 138.6 pcf

Optimum moisture = 6.7 %

Material Description

TP19 WC-04, Sample 2, 3-15'

Remarks:

Project No. 1804-224 **Client:** Sevier County

Project: Sevier County Watershed Plan & Flood Protection

○ **Location:** TP19 WC-04, S-2 **Sample Number:** 19-S-047

JONES & DEMILLE ENGINEERING INC.

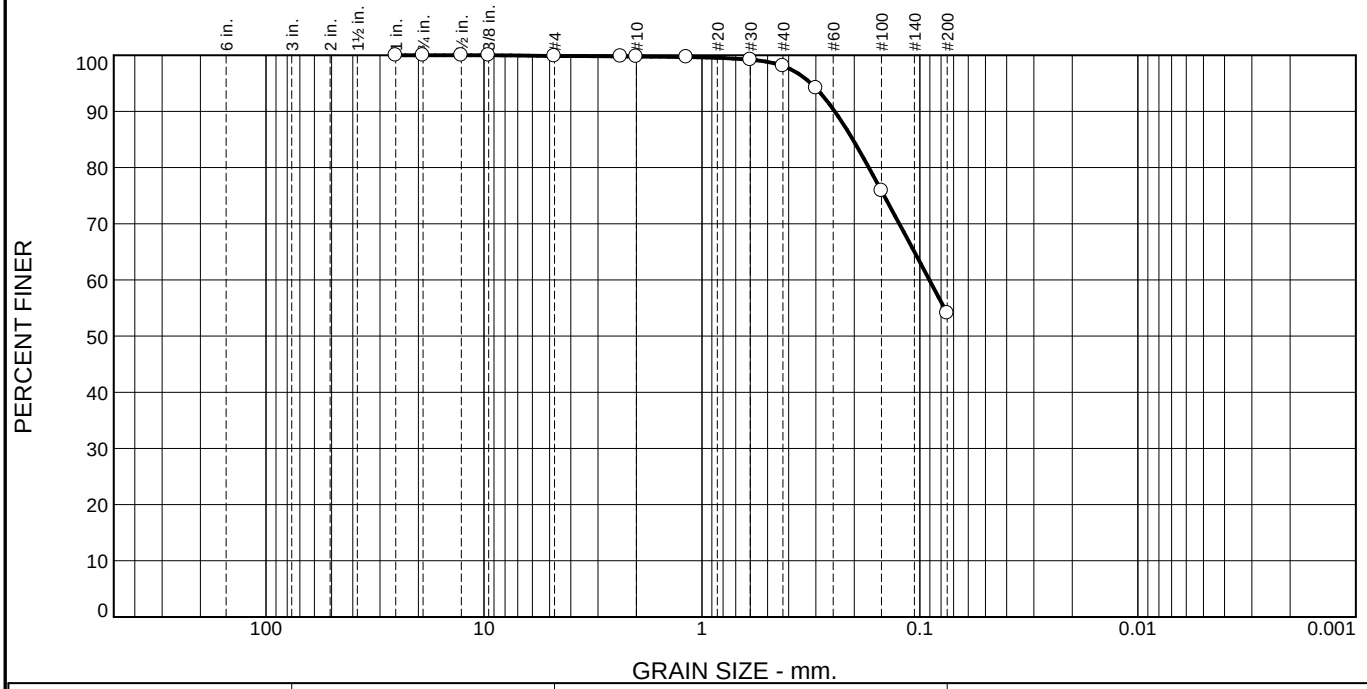
Richfield, Utah

Checked by: Mark Rappleye

Title: Lab Manager

Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.1	1.7	44.0	54.1	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	100.0		
1/2"	100.0		
3/8"	100.0		
#4	99.9		
#8	99.8		
#10	99.8		
#16	99.7		
#30	99.2		
#40	98.1		
#50	94.2		
#100	75.9		
#200	54.1		

* (no specification provided)

Material Description

BH19 TC-01, Sample 1, 2.5-4'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.2456 D_{85}= 0.2031 D_{60}= 0.0905
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/1/19 **Date Tested:** 3/6/19

Tested By: Matt Murphree

Checked By: Mark Rappleye

Title: Lab Manager

Location: BH19 TC-01, S-1
Sample Number: 19-S-060

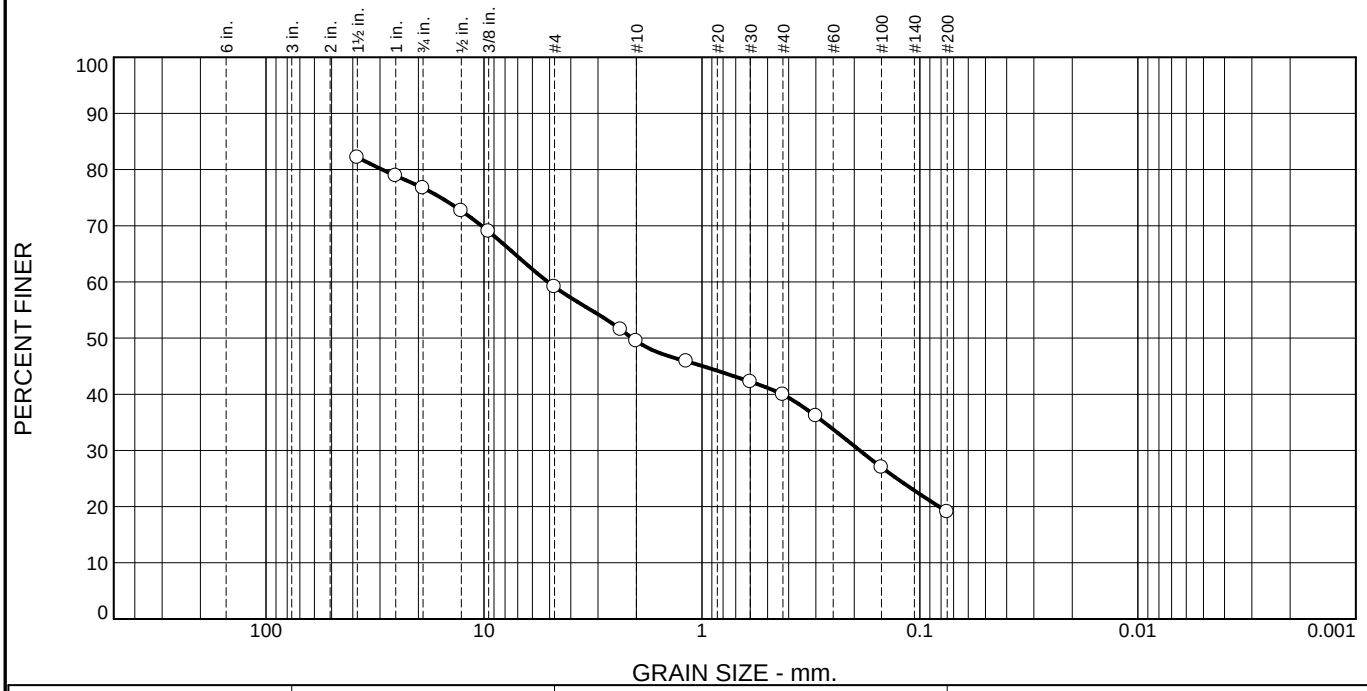
Date Sampled: 2/20/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		17.6	9.6	9.6	20.8	19.1	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	82.1		
1"	78.9		
3/4"	76.7		
1/2"	72.7		
3/8"	69.0		
#4	59.1		
#8	51.5		
#10	49.5		
#16	45.9		
#30	42.2		
#40	39.9		
#50	36.1		
#100	27.0		
#200	19.1		

* (no specification provided)

Material Description

BH19 TC-01, Sample 3, 7.5-9'

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= D_{85}= D_{60}= 5.0882
D_{50}= 2.0917 D_{30}= 0.1889 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/1/19 **Date Tested:** 3/5/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: BH19 TC-01, S-3
Sample Number: 19-S-052

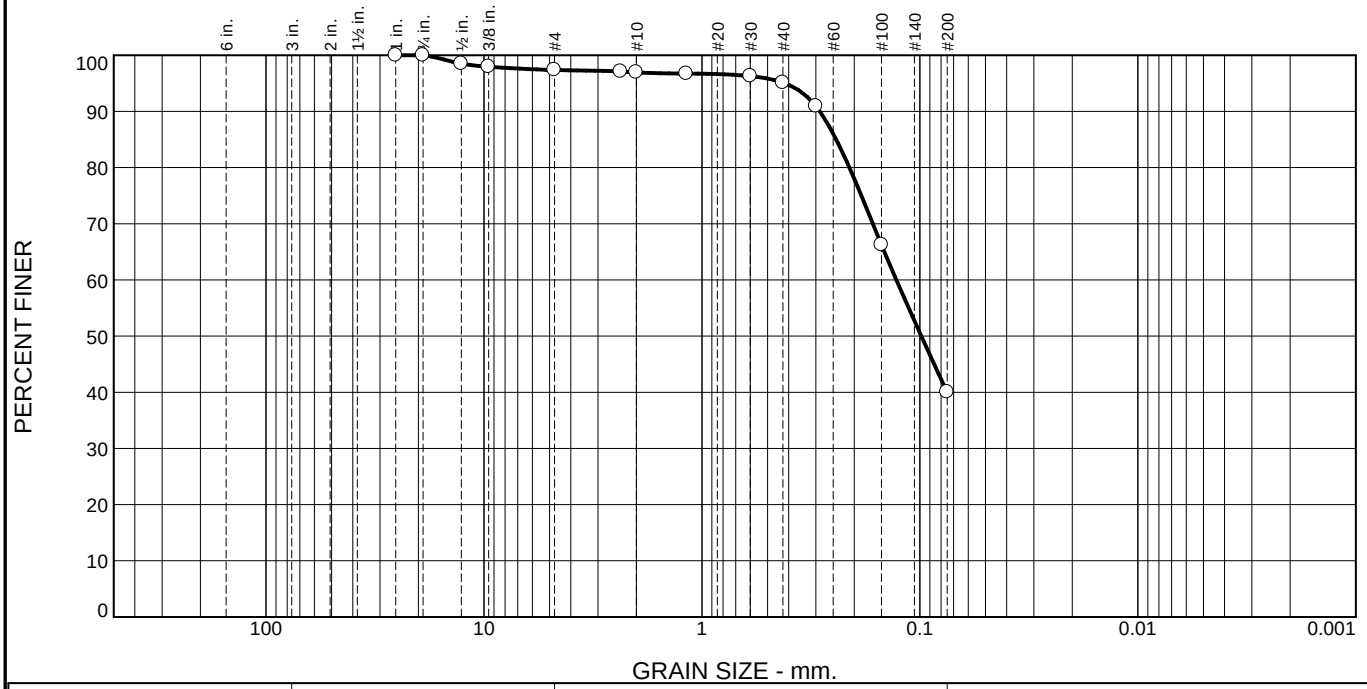
Date Sampled: 2/20/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.6	0.5	1.8	55.1	40.0	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	100.0		
1/2"	98.5		
3/8"	98.0		
#4	97.4		
#8	97.1		
#10	96.9		
#16	96.7		
#30	96.3		
#40	95.1		
#50	90.9		
#100	66.2		
#200	40.0		

* (no specification provided)

Material Description

BH 19 TC-01, Sample 6, 20'

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 0.2878 D_{85}= 0.2420 D_{60}= 0.1282
D_{50}= 0.0985 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/7/19

Tested By: Matt Murphree

Checked By: Mark Rappleye

Title: Lab Manager

Location: BH19 TC-01, S-6
Sample Number: 19-S-067

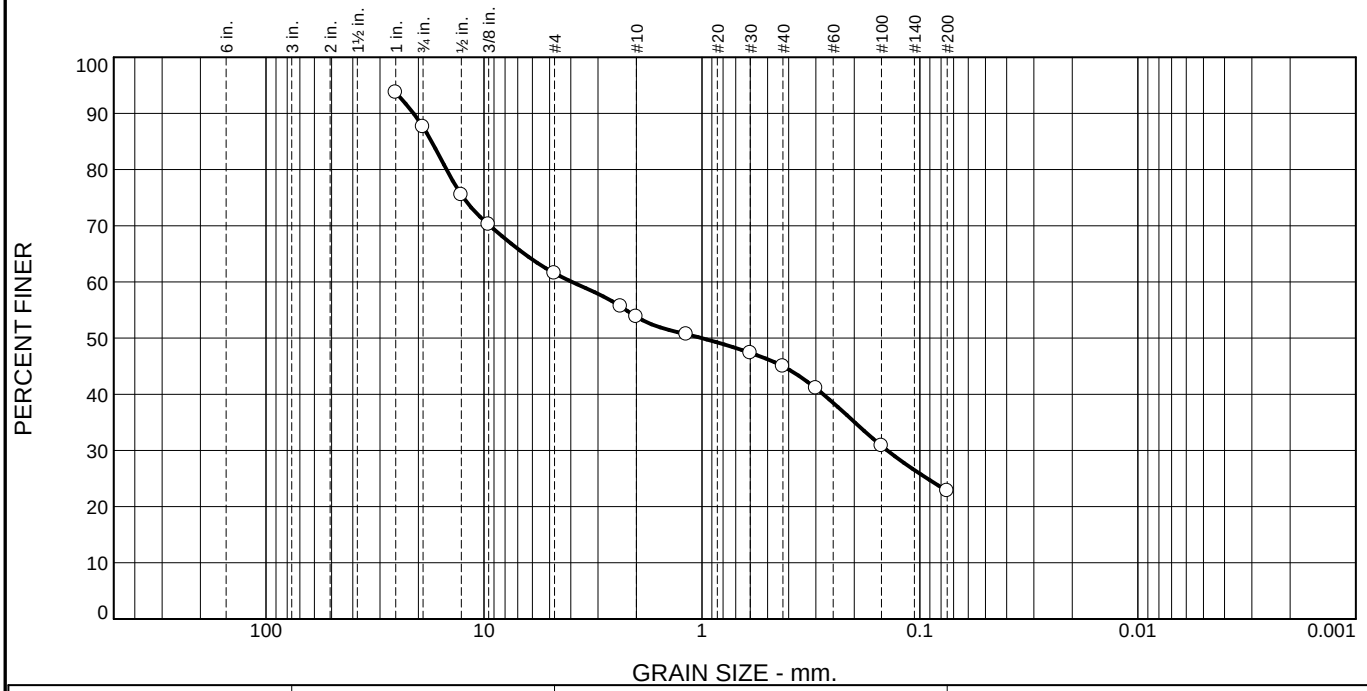
Date Sampled: 2/22/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		26.1	7.7	8.8	22.2	22.8	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	93.7		
3/4"	87.6		
1/2"	75.5		
3/8"	70.2		
#4	61.5		
#8	55.6		
#10	53.8		
#16	50.7		
#30	47.4		
#40	45.0		
#50	41.1		
#100	30.8		
#200	22.8		

* (no specification provided)

Material Description

BH19 TC-01, Sample 8, 30-31.5'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 21.0409 D_{85}= 17.4049 D_{60}= 3.9503
D_{50}= 1.0034 D_{30}= 0.1412 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/1/19 **Date Tested:** 3/6/19

Tested By: Matt Murphree

Checked By: Mark Rappleye

Title: Lab Manager

Location: BH19 TC-01, S-8
Sample Number: 19-S-061

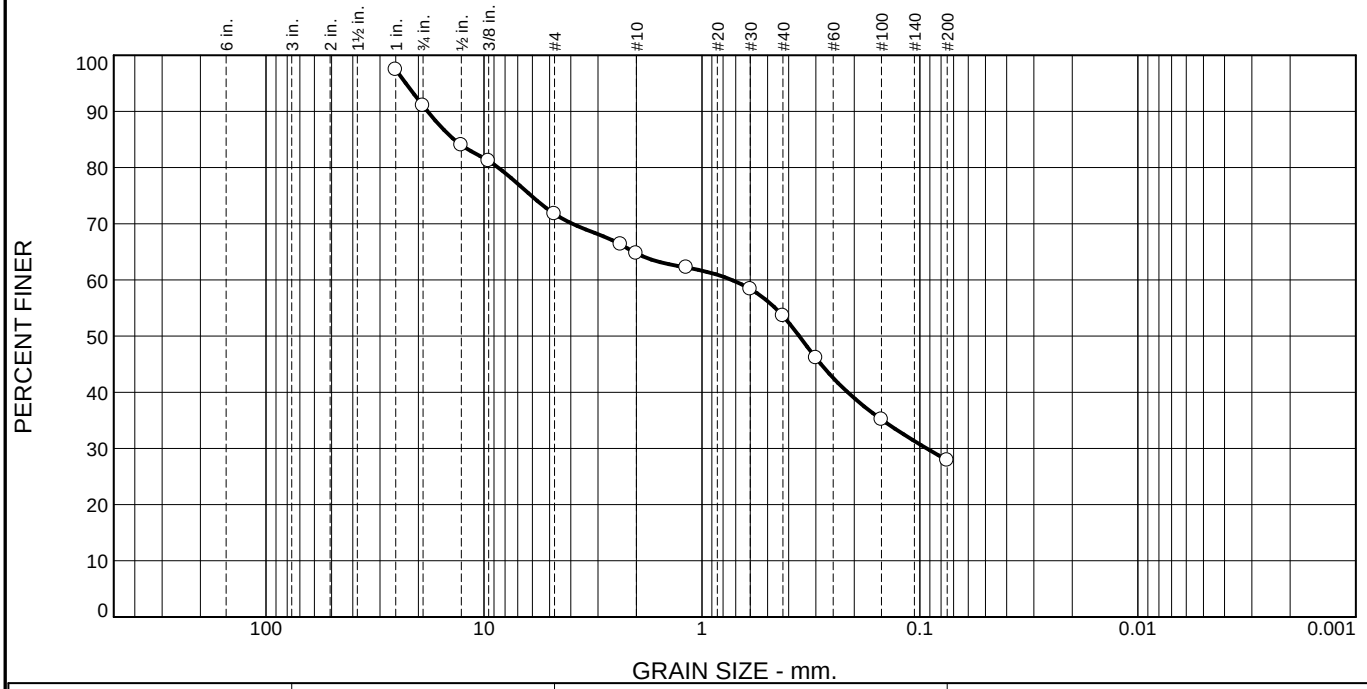
Date Sampled: 2/21/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		19.3	7.0	11.1	25.7	27.9	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	97.4		
3/4"	91.0		
1/2"	84.0		
3/8"	81.2		
#4	71.7		
#8	66.3		
#10	64.7		
#16	62.2		
#30	58.4		
#40	53.6		
#50	46.1		
#100	35.1		
#200	27.9		

* (no specification provided)

Material Description

TP19 TC-01, Sample 2, 2-8'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 18.1456 D_{85}= 13.7172 D_{60}= 0.7297
D_{50}= 0.3577 D_{30}= 0.0931 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/4/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 TC-01, S-2
Sample Number: 19-S-044

Date Sampled: 2/20/19

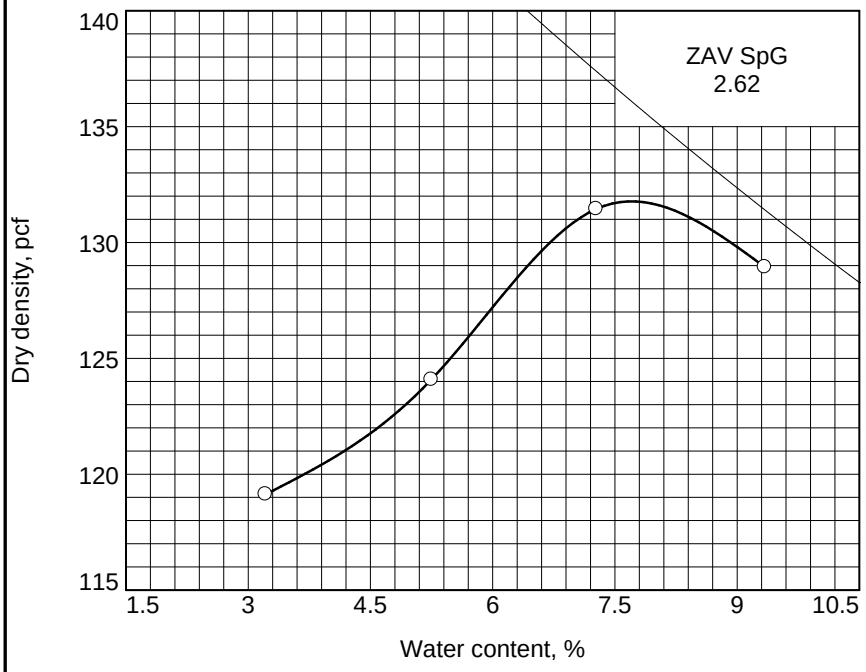
JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

COMPACTION TEST REPORT

Curve No. 044



Preparation Method	-3/4" Material
Rammer: Wt.	10 lb.
Drop	18 in.
Type	automatic
Layers: No.	five
Blows per	56
Mold Size	0.075 cu. ft.
Test Performed on Material Passing	3/4 in. Sieve
%>3/4 in.	9.0
%<No.200	27.9
Atterberg (D 4318): LL	NV
PI	NP
NM (D 2216)	
Sp.G. (D 854)	2.62
USCS (D 2487)	SM
AASHTO (M 145)	A-2-4(0)
Date: Sampled	2/20/19
Received	2/22/19
Tested	3/4/19
Tested By	Mark Rappleye

COMPACTION TESTING DATA
AASHTO T 180-15 Method D Modified
AASHTO T 224-01 Oversize Correction Applied to Final Results

	1	2	3	4	5	6
WM + WS	9915.0	10175.0	10529.0	10528.0		
WM	5732.0	5732.0	5732.0	5732.0		
WW + T #1	850.0	839.7	737.9	831.9		
WD + T #1	831.6	810.1	704.6	782.3		
TARE #1	259.0	246.2	246.7	251.2		
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	3.2	5.2	7.3	9.3		
DRY DENS.	119.1	124.1	131.4	128.9		

SIEVE TEST RESULTS
AASHTO T 27 AASHTO T 11

Opening Size	% Passing	Specs.
1"	97.4	
3/4"	91.0	
1/2"	84.0	
3/8"	81.2	
#4	71.7	
#8	66.3	
#10	64.7	
#16	62.2	
#30	58.4	
#40	53.6	
#50	46.1	
#100	35.1	
#200	27.9	

ROCK CORRECTED TEST RESULTS

Maximum dry density = 134.0 pcf

Optimum moisture = 7.2 %

Material Description

TP19 TC-01, Sample 2, 2-8'

Remarks:

Project No. 1804-224 **Client:** Sevier County

Project: Sevier County Watershed Plan & Flood Protection

○ **Location:** TP19 TC-01, S-2 **Sample Number:** 19-S-044

Checked by: Mark Rappleye

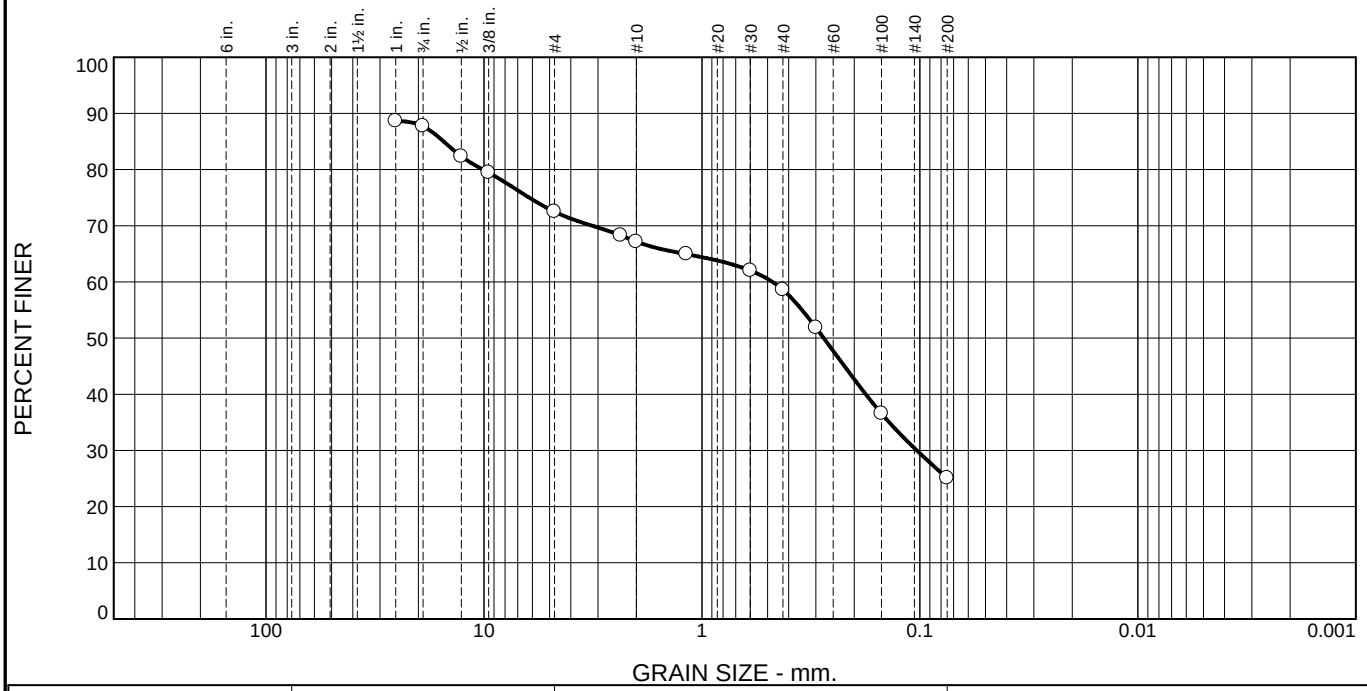
Title: Lab Manager

JONES & DEMILLE ENGINEERING INC.

Richfield, Utah

Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		15.2	5.3	8.6	33.5	25.1	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	88.7		
3/4"	87.7		
1/2"	82.3		
3/8"	79.5		
#4	72.5		
#8	68.3		
#10	67.2		
#16	64.9		
#30	62.0		
#40	58.6		
#50	51.9		
#100	36.6		
#200	25.1		

* (no specification provided)

Material Description

BH19 LC-01, Sample 1, 2.5-4'

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= D_{85}= 15.3055 D_{60}= 0.4737
D_{50}= 0.2760 D_{30}= 0.1034 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/5/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: BH19 LC-01, S-1
Sample Number: 19-S-049

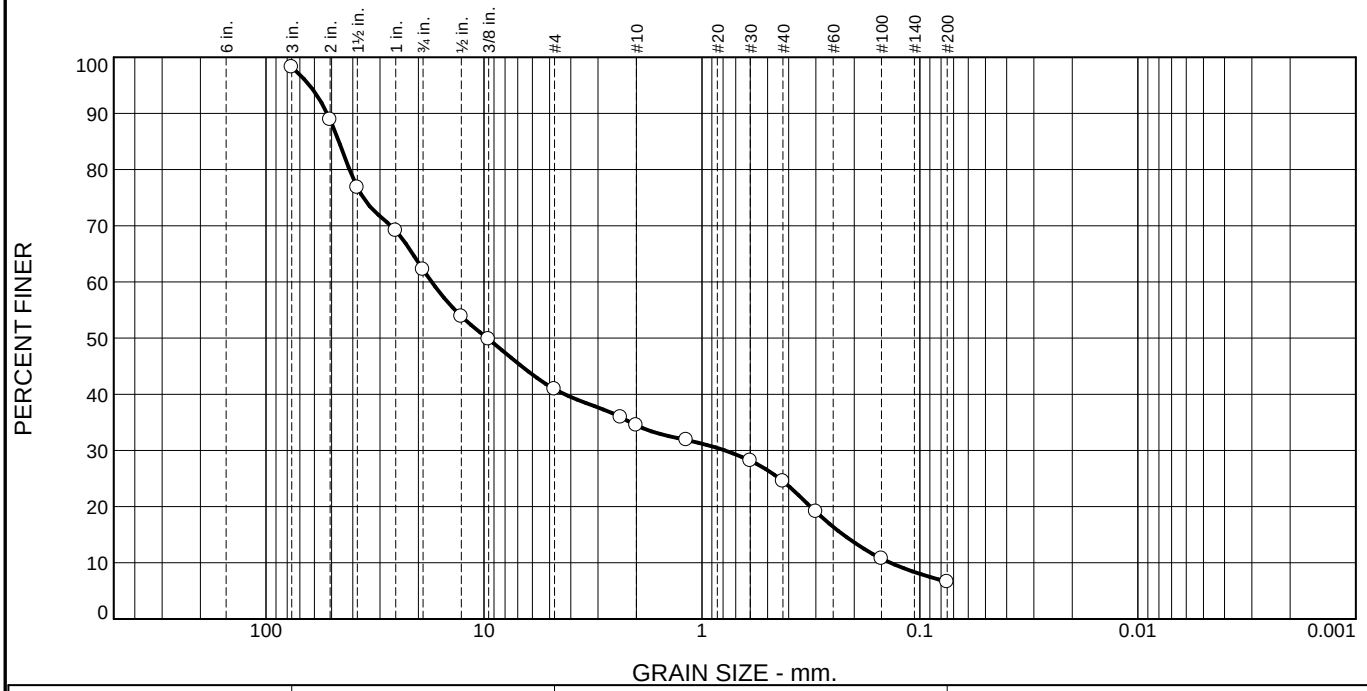
Date Sampled: 2/22/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
	36.0	21.3	6.4	10.0	17.9	6.6	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3"	98.2		
2"	88.9		
1.5"	76.8		
1"	69.1		
3/4"	62.2		
1/2"	53.9		
3/8"	49.8		
#4	40.9		
#8	35.9		
#10	34.5		
#16	31.9		
#30	28.2		
#40	24.5		
#50	19.1		
#100	10.7		
#200	6.6		

* (no specification provided)

Material Description

TP19 LC-01, Sample 2, 1-12'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= GP-GM **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 52.4006 D_{85}= 46.3281 D_{60}= 17.3957
D_{50}= 9.6586 D_{30}= 0.7849 D_{15}= 0.2246
D_{10}= 0.1366 C_u= 127.33 C_c= 0.26

Remarks

Date Received: 2/19/2019 **Date Tested:** 3/11/2019

Tested By: Matt Murphree

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 LC-01, S-2
Sample Number: 19-S-078

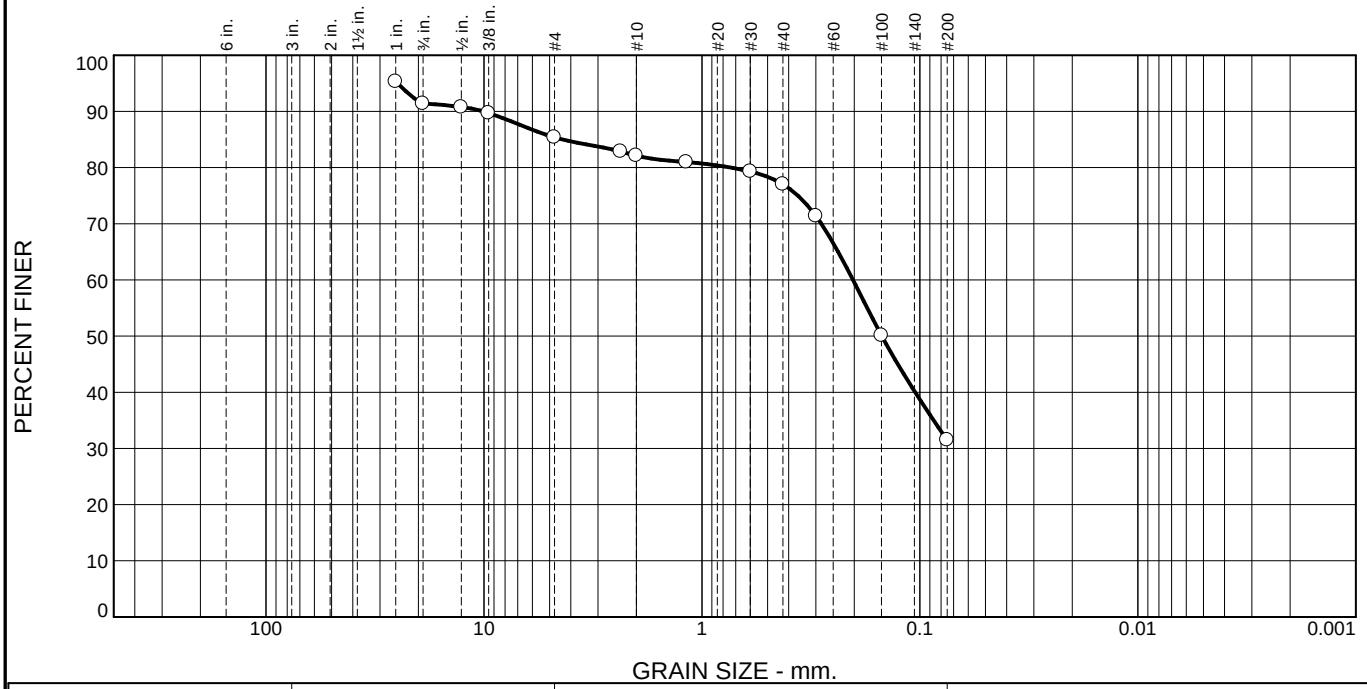
Date Sampled: 2/19/2019

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		6.0	3.3	5.1	45.5	31.5	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	95.3		
3/4"	91.4		
1/2"	90.7		
3/8"	89.7		
#4	85.4		
#8	82.9		
#10	82.1		
#16	81.0		
#30	79.3		
#40	77.0		
#50	71.4		
#100	50.1		
#200	31.5		

* (no specification provided)

Material Description

TP19 LC-02, Sample 1, 0-3.5'

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 10.0711 D_{85}= 4.3590 D_{60}= 0.2028
D_{50}= 0.1494 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/7/19

Tested By: Matt Murphree

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 LC-02, S-1
Sample Number: 19-S-069

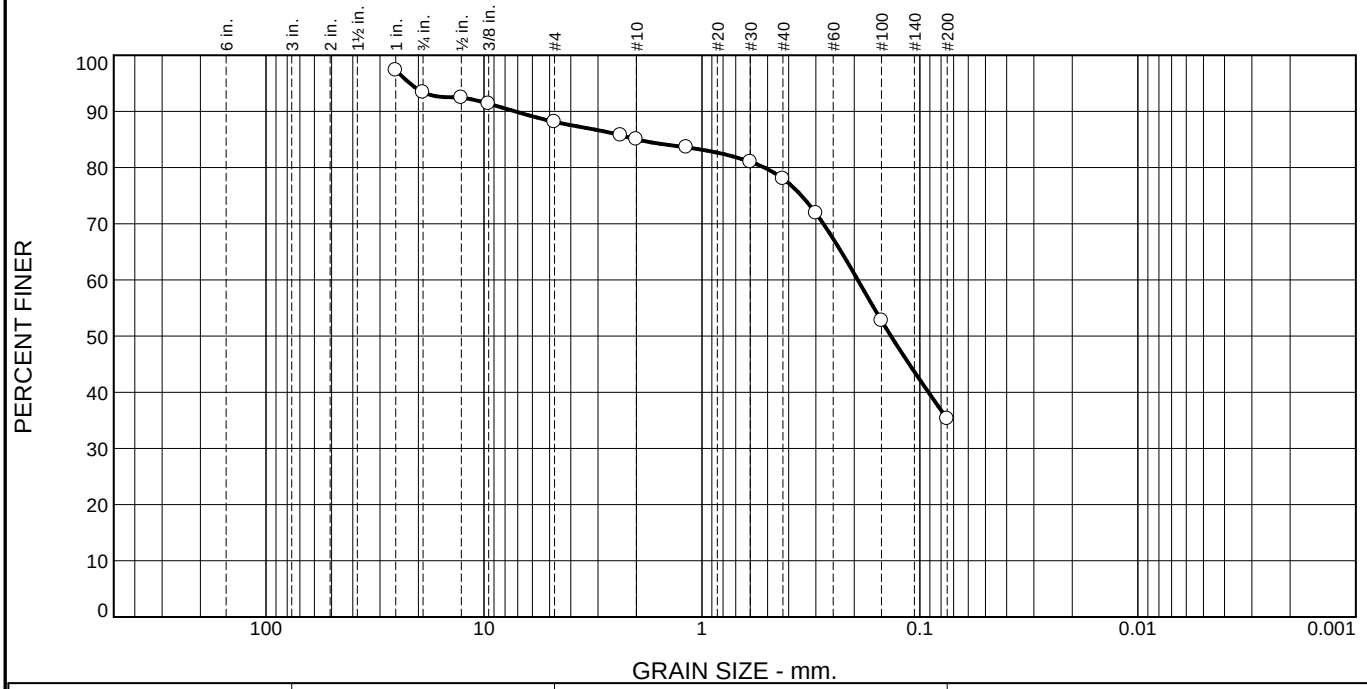
Date Sampled: 2/19/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		5.3	3.1	7.0	42.7	35.3	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	97.3		
3/4"	93.4		
1/2"	92.4		
3/8"	91.4		
#4	88.1		
#8	85.8		
#10	85.0		
#16	83.6		
#30	81.0		
#40	78.0		
#50	71.9		
#100	52.7		
#200	35.3		

* (no specification provided)

Material Description

TP19 LC-02, Sample 2, 3.5-10.5'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 7.1971 D_{85}= 1.9845 D_{60}= 0.1928
D_{50}= 0.1357 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/8/19

Tested By: Matt Murphree

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 LC-02, S-2
Sample Number: 19-S-072

Date Sampled: 2/19/19

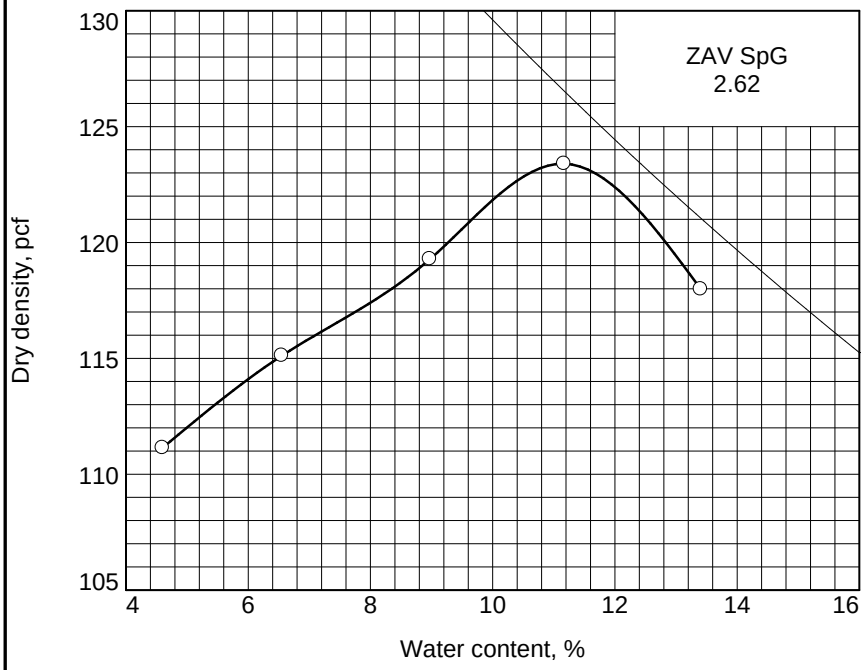
JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

COMPACTION TEST REPORT

Curve No. 072



Preparation Method	-3/4" Material
Rammer: Wt.	10 lb. Drop 18 in.
Type	manual
Layers: No.	five Blows per 56
Mold Size	0.075 cu. ft.
Test Performed on Material Passing	3/4 in. Sieve
%>3/4 in.	6.6 %<No.200 35.3
Atterberg (D 4318): LL	NV PI NP
NM (D 2216)	Sp.G. (D 854) 2.62
USCS (D 2487)	SM
AASHTO (M 145)	A-2-4(0)
Date: Sampled	2/19/19
Received	2/22/19
Tested	3/8/19
Tested By	Mark Rappleye

COMPACTION TESTING DATA
AASHTO T 180-15 Method D Modified
AASHTO T 224-01 Oversize Correction Applied to Final Results

	1	2	3	4	5	6
WM + WS	10454.0	10671.9	10921.1	11165.9	11051.0	
WM	6499.1	6499.1	6499.1	6499.1	6499.1	
WW + T #1	1014.8	934.2	1004.1	1080.8	808.9	
WD + T #1	981.0	891.9	941.5	997.0	742.3	
TARE #1	246.1	246.3	243.9	246.7	245.5	
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	4.6	6.6	9.0	11.2	13.4	
DRY DENS.	111.1	115.1	119.3	123.4	118.0	

SIEVE TEST RESULTS
AASHTO T 27 AASHTO T 11

Opening Size	% Passing	Specs.
1"	97.3	
3/4"	93.4	
1/2"	92.4	
3/8"	91.4	
#4	88.1	
#8	85.8	
#10	85.0	
#16	83.6	
#30	81.0	
#40	78.0	
#50	71.9	
#100	52.7	
#200	35.3	

ROCK CORRECTED TEST RESULTS

Maximum dry density = 125.4 pcf

Optimum moisture = 10.5 %

Material Description

TP19 LC-02, Sample 2, 3.5-10.5'

Remarks:

Project No. 1804-224 **Client:** Sevier County

Project: Sevier County Watershed Plan & Flood Protection

○ **Location:** TP19 LC-02, S-2 **Sample Number:** 19-S-072

Checked by: Mark Rappleye

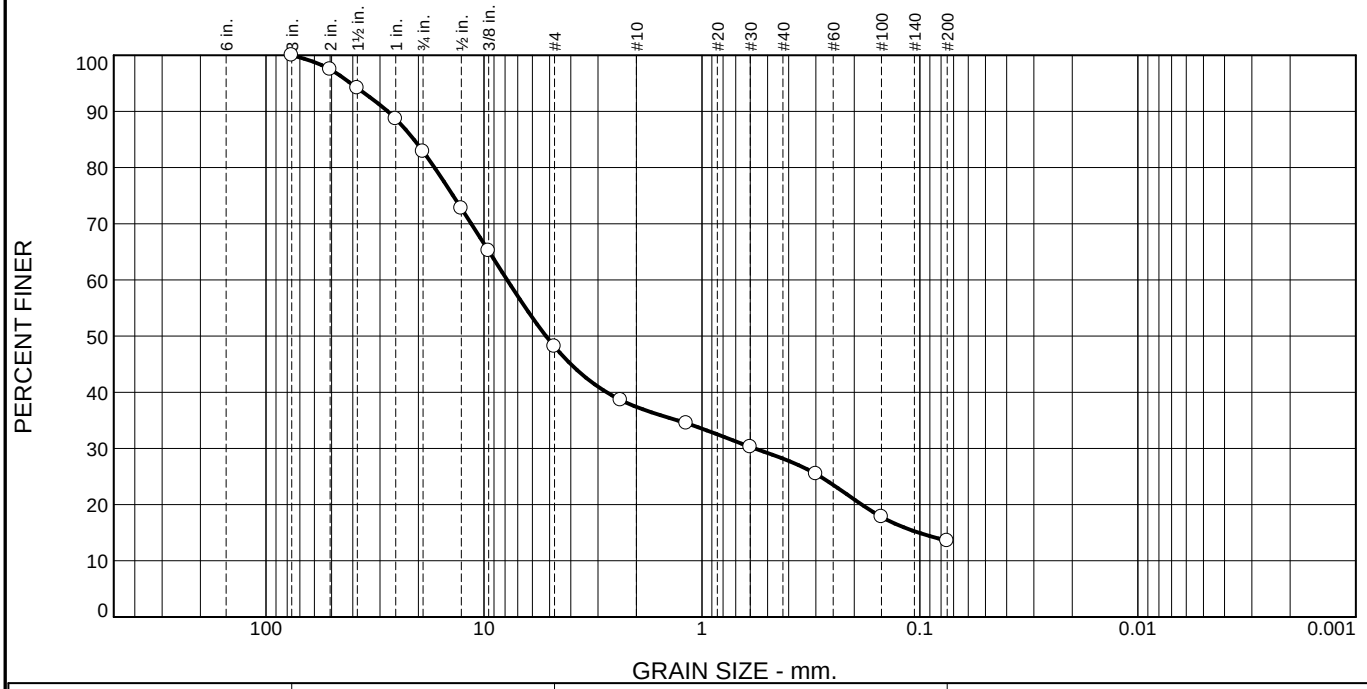
Title: Lab Manager

JONES & DEMILLE ENGINEERING INC.

Richfield, Utah

Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	17.1	34.8	10.7	9.2	14.6	13.6	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3"	100.0		
2"	97.5		
1.5"	94.1		
1"	88.7		
3/4"	82.9		
1/2"	72.7		
3/8"	65.2		
#4	48.1		
#8	38.6		
#16	34.5		
#30	30.3		
#50	25.5		
#100	17.8		
#200	13.6		

* (no specification provided)

Material Description

TP19 LC-03, Sample 2, 4-9'

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 27.6285 D_{85}= 20.9668 D_{60}= 7.8300
D_{50}= 5.1955 D_{30}= 0.5732 D_{15}= 0.1012
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/4/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 LC-03, S-2
Sample Number: 19-S-048

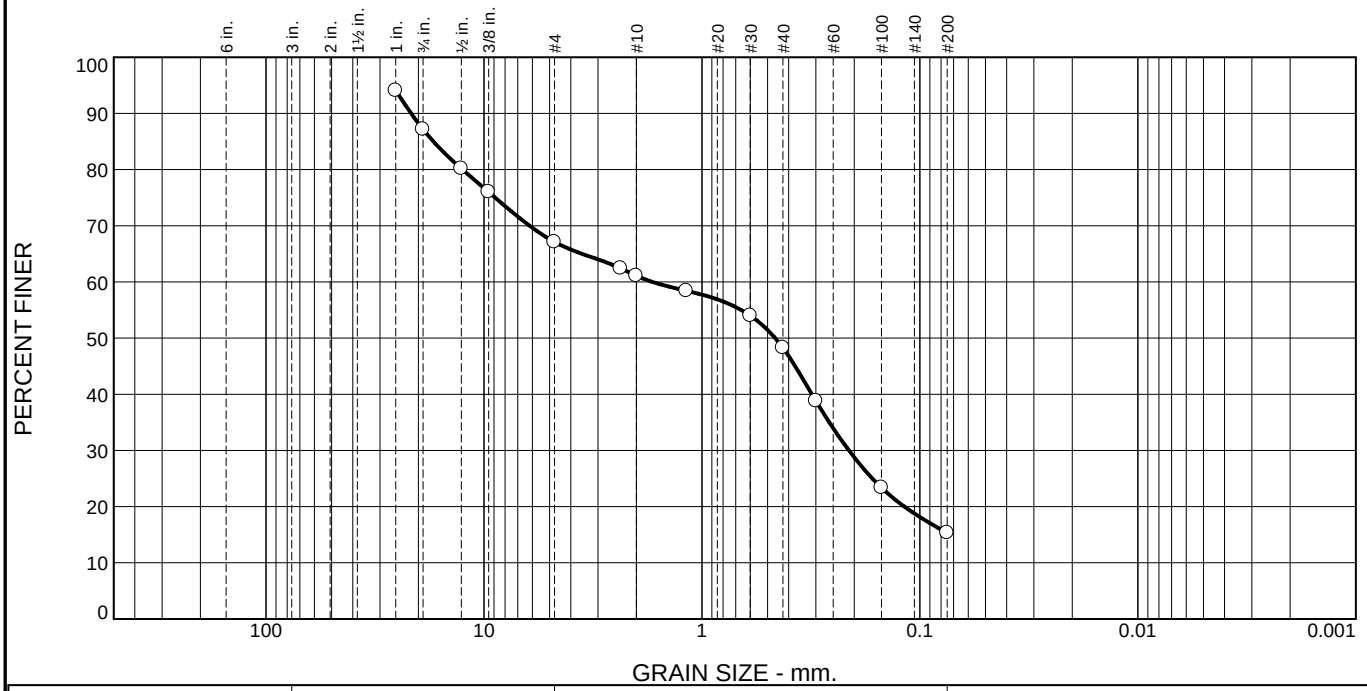
Date Sampled: 2/19/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		20.1	6.0	12.8	33.0	15.3	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	94.1		
3/4"	87.2		
1/2"	80.2		
3/8"	76.0		
#4	67.1		
#8	62.4		
#10	61.1		
#16	58.4		
#30	54.0		
#40	48.3		
#50	38.8		
#100	23.4		
#200	15.3		

* (no specification provided)

Material Description

TP19 LC-03, Sample 3, 9-25'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 21.5824 D_{85}= 17.0902 D_{60}= 1.6890
D_{50}= 0.4611 D_{30}= 0.2116 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/1/19 **Date Tested:** 3/5/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 LC-03, S-3
Sample Number: 19-S-053

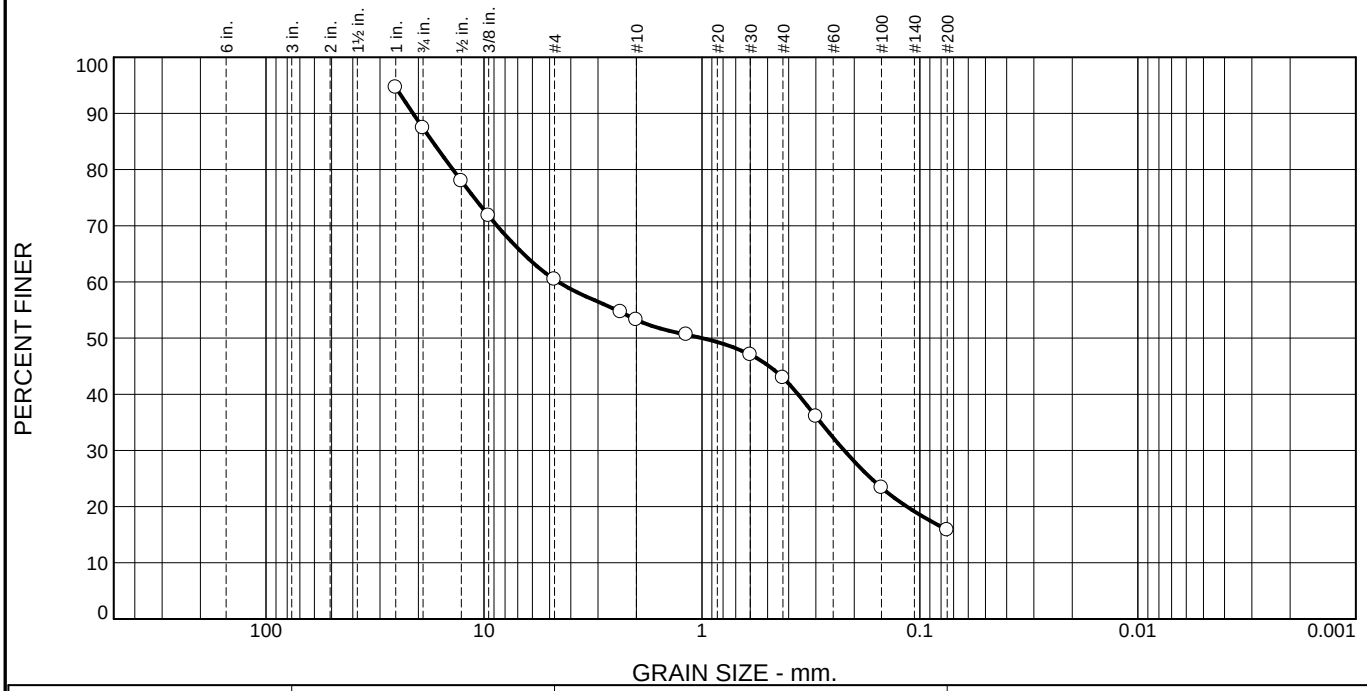
Date Sampled: 2/19/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		27.0	7.1	10.4	27.1	15.8	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	94.6		
3/4"	87.4		
1/2"	78.0		
3/8"	71.8		
#4	60.4		
#8	54.6		
#10	53.3		
#16	50.6		
#30	47.0		
#40	42.9		
#50	36.0		
#100	23.4		
#200	15.8		

* (no specification provided)

Material Description

TP19 LC-04. Sample 1, 0-20'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 21.1584 D_{85}= 17.2405 D_{60}= 4.5623
D_{50}= 1.0000 D_{30}= 0.2224 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/6/19

Tested By: Matt Murphree

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 LC-04, S-1 **Date Sampled:** 2/19/19
Sample Number: 19-S-055

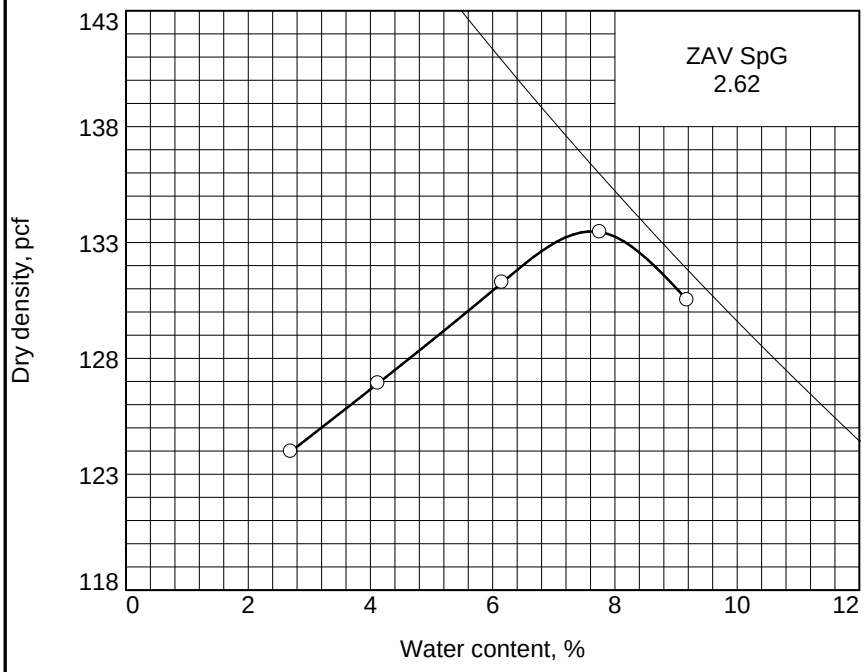
JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

COMPACTION TEST REPORT

Curve No. 055



Preparation Method	-3/4" Material
Rammer: Wt.	10 lb. Drop 18 in.
Type	automatic
Layers: No.	five Blows per 56
Mold Size	0.075 cu. ft.
Test Performed on Material Passing	3/4 in. Sieve
%>3/4 in.	12.6 %<No.200 15.8
Atterberg (D 4318): LL	NV PI NP
NM (D 2216)	Sp.G. (D 854) 2.62
USCS (D 2487)	SM
AASHTO (M 145)	A-1-b
Date: Sampled	2/19/19
Received	2/22/19
Tested	3/6/19
Tested By	Matt Murphree

COMPACTION TESTING DATA
AASHTO T 180-15 Method D Modified
AASHTO T 224-01 Oversize Correction Applied to Final Results

	1	2	3	4	5	6
WM + WS	10063.2	10227.5	10472.2	10623.8	10579.5	
WM	5731.7	5731.7	5731.7	5731.7	5731.7	
WW + T #1	988.4	1023.2	1086.2	973.2	1001.1	
WD + T #1	968.8	992.4	1038.2	920.9	937.6	
TARE #1	242.2	245.6	258.3	246.7	246.0	
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	2.7	4.1	6.2	7.8	9.2	
DRY DENS.	124.0	126.9	131.3	133.5	130.5	

SIEVE TEST RESULTS
AASHTO T 27 AASHTO T 11

Opening Size	% Passing	Specs.
1"	94.6	
3/4"	87.4	
1/2"	78.0	
3/8"	71.8	
#4	60.4	
#8	54.6	
#10	53.3	
#16	50.6	
#30	47.0	
#40	42.9	
#50	36.0	
#100	23.4	
#200	15.8	

ROCK CORRECTED TEST RESULTS

Maximum dry density = 136.5 pcf

Optimum moisture = 6.9 %

Material Description

TP19 LC-04. Sample 1, 0-20'

Remarks:

Project No. 1804-224 **Client:** Sevier County

Project: Sevier County Watershed Plan & Flood Protection

○ **Location:** TP19 LC-04, S-1 **Sample Number:** 19-S-055

Checked by: Mark Rappleye

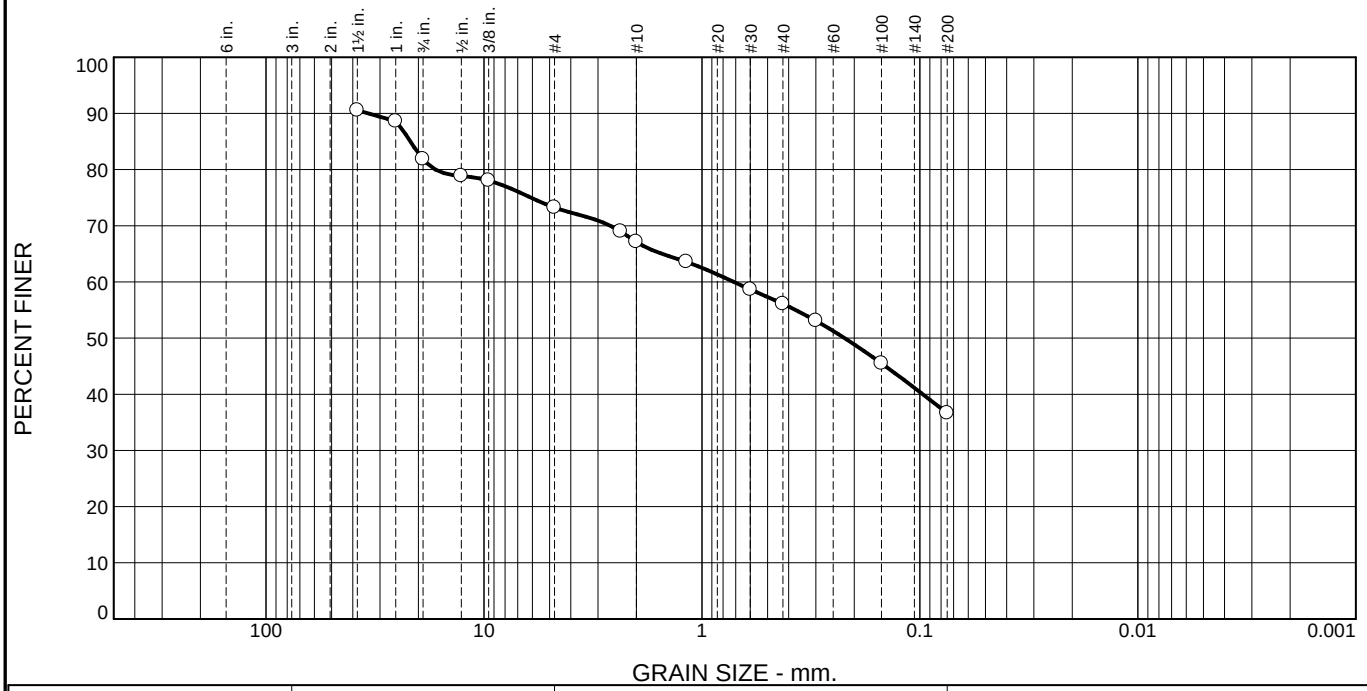
Title: Lab Manager

JONES & DEMILLE ENGINEERING INC.

Richfield, Utah

Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		8.7	6.1	11.0	19.5	36.6	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	90.5		
1"	88.6		
3/4"	81.9		
1/2"	78.9		
3/8"	78.1		
#4	73.2		
#8	69.0		
#10	67.1		
#16	63.6		
#30	58.7		
#40	56.1		
#50	53.1		
#100	45.5		
#200	36.6		

* (no specification provided)

Material Description

BH19 FC-01, Sample 1, 2.5-4'

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 33.9894 D_{85}= 21.7562 D_{60}= 0.7148
D_{50}= 0.2217 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/1/19 **Date Tested:** 3/6/19

Tested By: Matt Murphree

Checked By: Mark Rappleye

Title: Lab Manager

Location: BH19 FC-01, S-1
Sample Number: 19-S-063

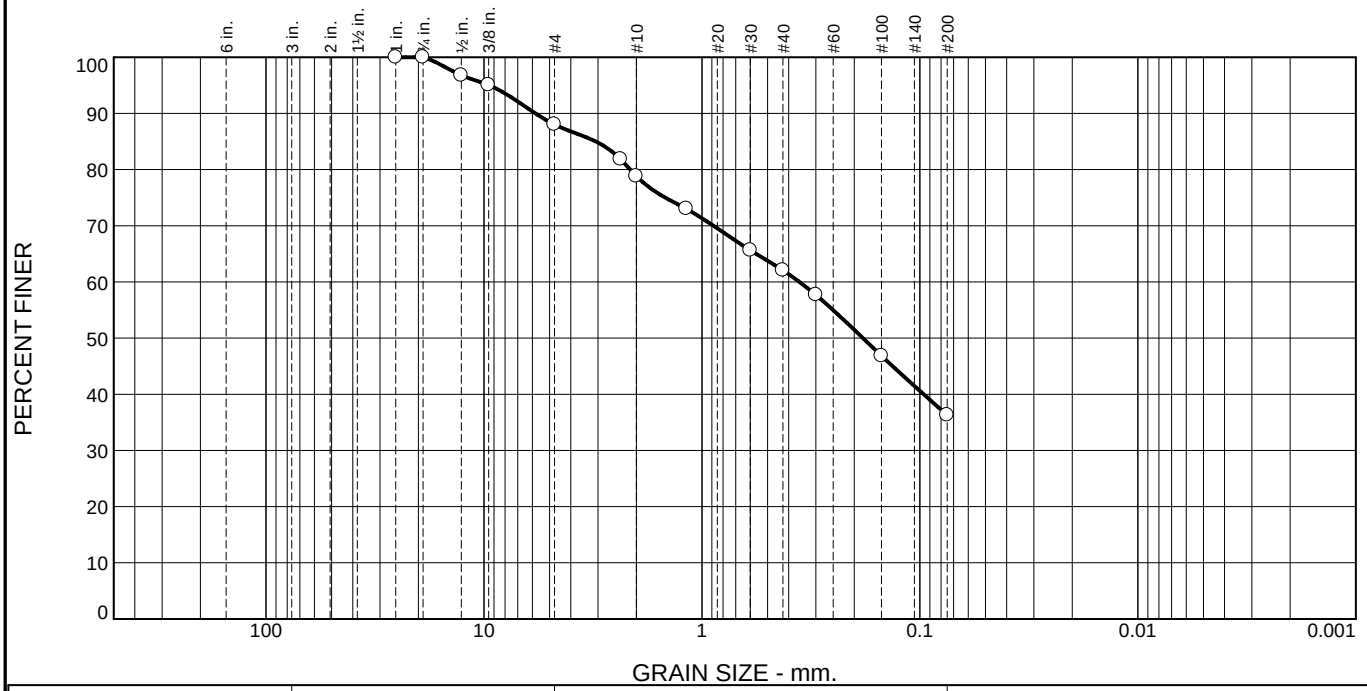
Date Sampled: 2/22/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	12.0	9.2	16.7	25.8	36.3	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	100.0		
1/2"	96.8		
3/8"	95.1		
#4	88.0		
#8	81.8		
#10	78.8		
#16	73.0		
#30	65.6		
#40	62.1		
#50	57.7		
#100	46.8		
#200	36.3		

* (no specification provided)

Material Description

BH19 FC-01, Sample 3, 7.5-9'

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 5.8068 D_{85}= 3.0662 D_{60}= 0.3570
D_{50}= 0.1825 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/1/19 **Date Tested:** 3/6/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: BH19 FC-01, S-3
Sample Number: 19-S-058

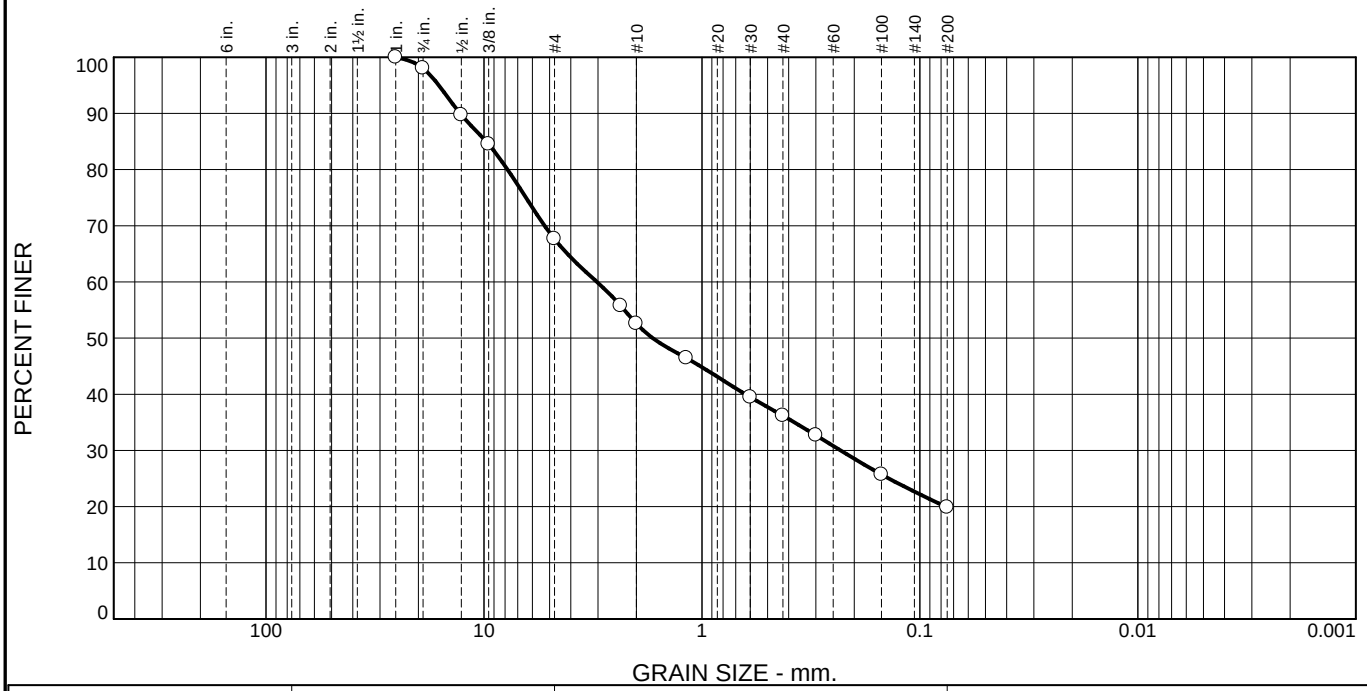
Date Sampled: 2/22/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	1.9	30.5	15.0	16.4	16.3	19.9	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	98.1		
1/2"	89.7		
3/8"	84.5		
#4	67.6		
#8	55.8		
#10	52.6		
#16	46.5		
#30	39.5		
#40	36.2		
#50	32.7		
#100	25.7		
#200	19.9		

* (no specification provided)

Material Description

BH19 FC-01, Sample 7, 25-26'

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 12.8761 D_{85}= 9.7718 D_{60}= 3.0336
D_{50}= 1.6822 D_{30}= 0.2309 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/1/19 **Date Tested:** 3/6/19

Tested By: Matt Murphree

Checked By: Mark Rappleye

Title: Lab Manager

Location: BH19 FC-01, S-7
Sample Number: 19-S-062

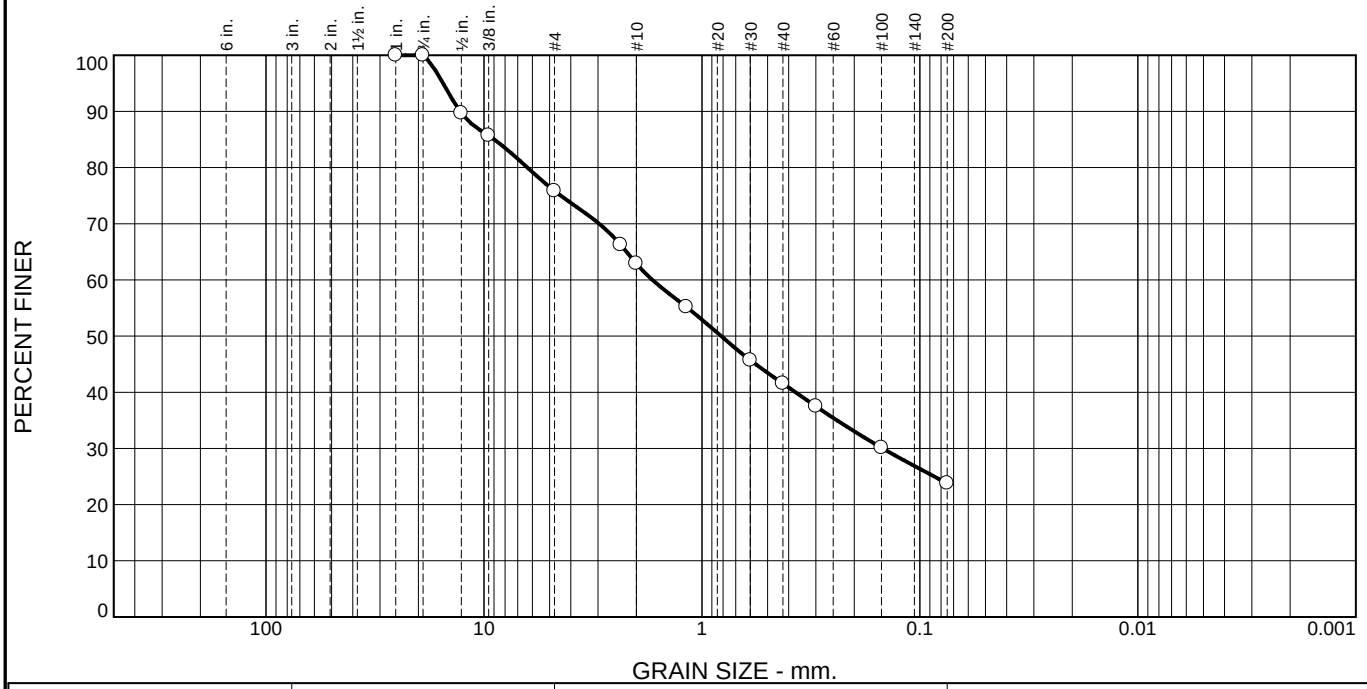
Date Sampled: 2/23/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	24.2	12.9	21.3	17.8	23.8	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	100.0		
1/2"	89.7		
3/8"	85.7		
#4	75.8		
#8	66.3		
#10	62.9		
#16	55.2		
#30	45.7		
#40	41.6		
#50	37.5		
#100	30.1		
#200	23.8		

* (no specification provided)

Material Description

BH19 FC-01, Sample 10, 40-41'

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 12.8676 D_{85}= 8.9696 D_{60}= 1.6881
D_{50}= 0.8169 D_{30}= 0.1481 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/23/19 **Date Tested:** 3/7/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: BH19 FC-01, S-10
Sample Number: 19-S-068

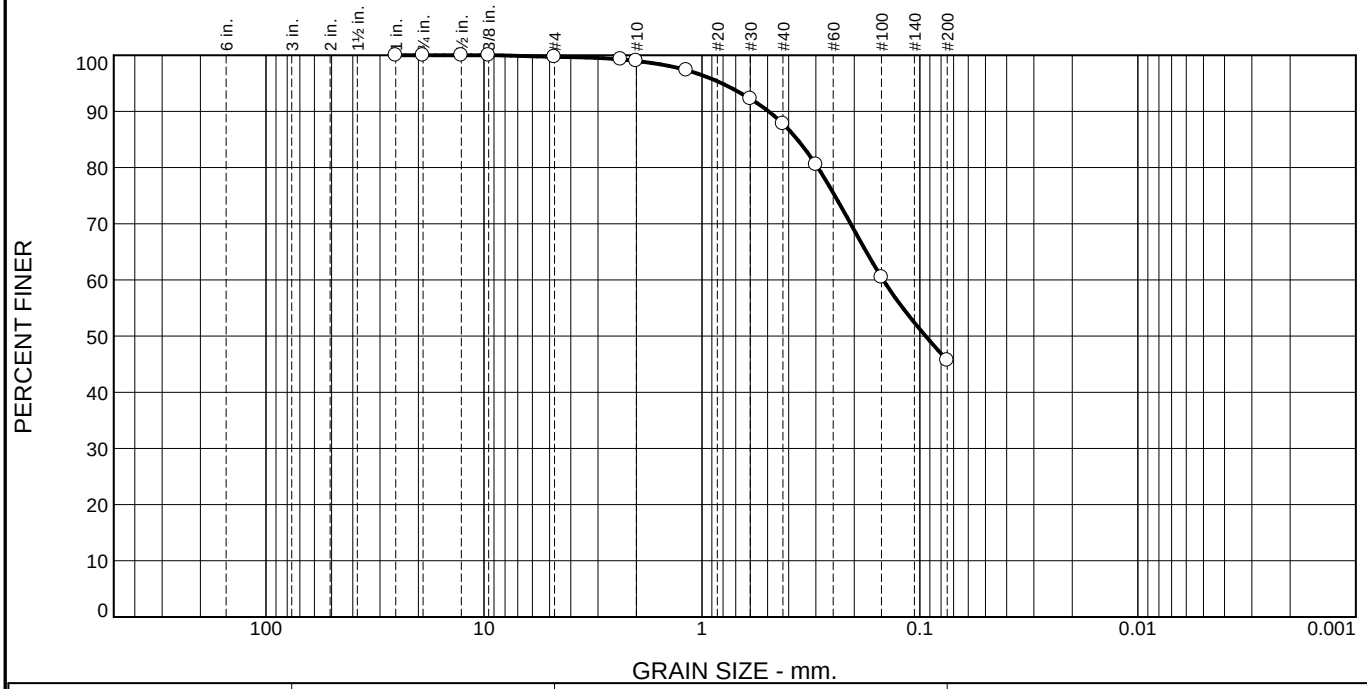
Date Sampled: 2/23/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.3	0.7	11.2	42.1	45.7	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	100.0		
1/2"	100.0		
3/8"	100.0		
#4	99.7		
#8	99.3		
#10	99.0		
#16	97.4		
#30	92.3		
#40	87.8		
#50	80.5		
#100	60.5		
#200	45.7		

* (no specification provided)

Material Description

BH19 FC-01, Sample 14, 57.5-59'

Atterberg Limits (ASTM D 4318)

PL= 19.8 **LL=** 24.8 **PI=** 5.0

Classification

USCS (D 2487)= SC-SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.4941 D_{85}= 0.3647 D_{60}= 0.1473
D_{50}= 0.0941 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 3/1/19 **Date Tested:** 3/5/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: BH19 FC-01, S-14
Sample Number: 19-S-050

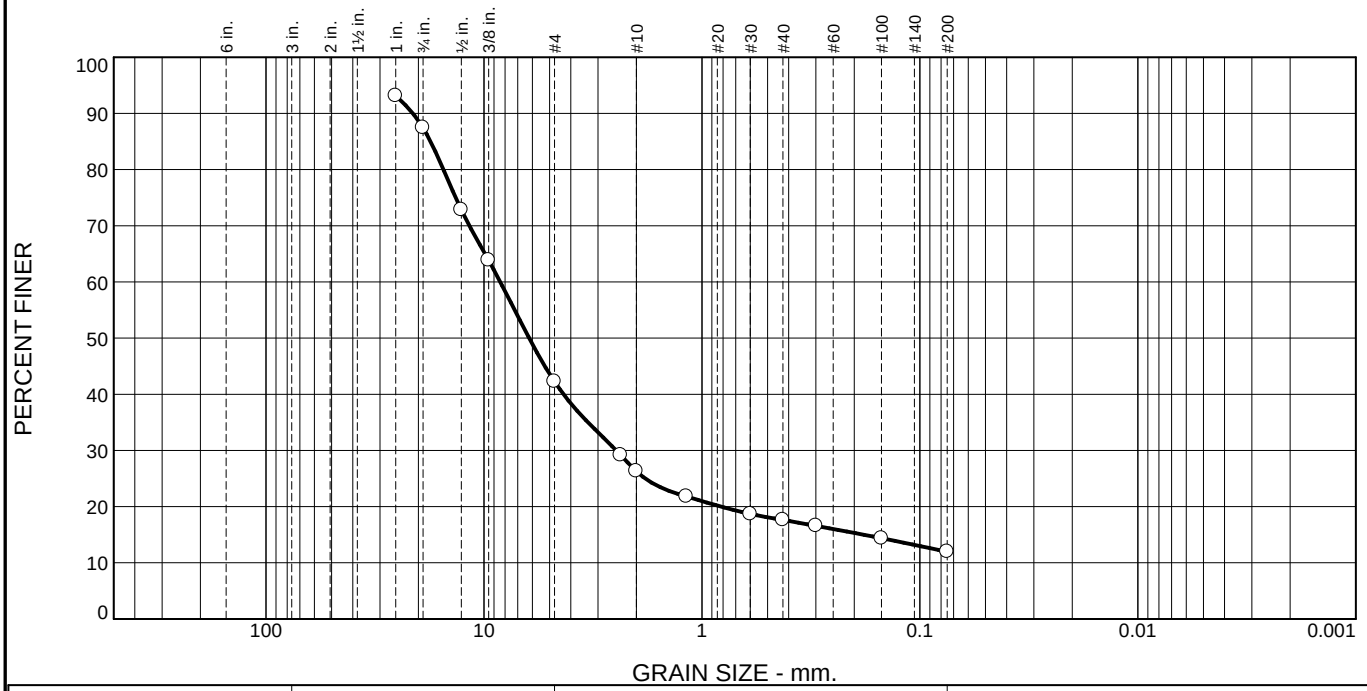
Date Sampled: 2/23/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		45.2	16.0	8.7	5.6	12.0	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	93.1		
3/4"	87.5		
1/2"	72.8		
3/8"	63.9		
#4	42.3		
#8	29.2		
#10	26.3		
#16	21.8		
#30	18.7		
#40	17.6		
#50	16.6		
#100	14.4		
#200	12.0		

* (no specification provided)

Material Description

TP19 FC-01, Sample 2, 2-21'

Atterberg Limits (ASTM D 4318)

PL= 16.7 **LL=** 25.1 **PI=** 8.4

Classification

USCS (D 2487)= GP-GC **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 21.1791 D_{85}= 17.5957 D_{60}= 8.4260
D_{50}= 6.2049 D_{30}= 2.4730 D_{15}= 0.1816
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/7/19

Tested By: Matt Murphree

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 FC-01, S-2
Sample Number: 19-S-070

Date Sampled: 2/20/19

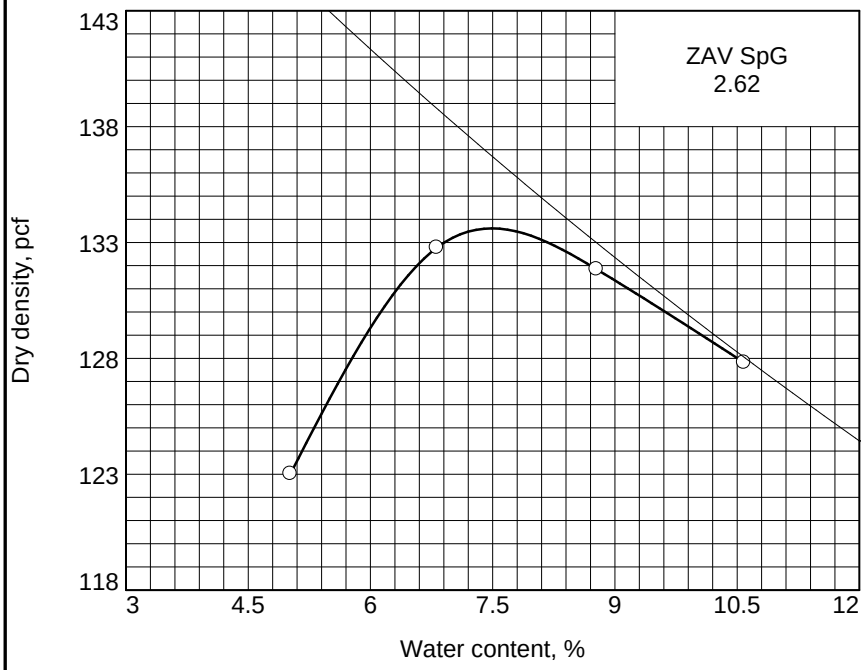
JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

COMPACTION TEST REPORT

Curve No. 070



Preparation Method	-3/4" Material
Rammer: Wt.	10 lb. Drop 18 in.
Type	automatic
Layers: No.	five Blows per 56
Mold Size	0.075 cu. ft.
Test Performed on Material Passing	3/4 in. Sieve
%>3/4 in.	12.5 %<No.200 12.0
Atterberg (D 4318): LL	25.1 PI 8.4
NM (D 2216)	Sp.G. (D 854) 2.62
USCS (D 2487)	GP-GC
AASHTO (M 145)	A-2-4(0)
Date: Sampled	2/20/19
Received	2/22/19
Tested	3/7/19
Tested By	Matt Murphree

COMPACTION TESTING DATA
AASHTO T 180-15 Method D Modified
AASHTO T 224-01 Oversize Correction Applied to Final Results

	1	2	3	4	5	6
WM + WS	10894.7	11324.2	11378.3	11308.0		
WM	6499.4	6499.4	6499.4	6499.4		
WW + T #1	949.0	993.1	1158.1	1052.4		
WD + T #1	915.0	945.2	1084.5	975.2		
TARE #1	237.5	242.3	245.6	245.8		
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	5.0	6.8	8.8	10.6		
DRY DENS.	123.0	132.8	131.8	127.8		

SIEVE TEST RESULTS
AASHTO T 27 AASHTO T 11

Opening Size	% Passing	Specs.
1"	93.1	
3/4"	87.5	
1/2"	72.8	
3/8"	63.9	
#4	42.3	
#8	29.2	
#10	26.3	
#16	21.8	
#30	18.7	
#40	17.6	
#50	16.6	
#100	14.4	
#200	12.0	

ROCK CORRECTED TEST RESULTS

Maximum dry density = 136.6 pcf

Optimum moisture = 6.8 %

Material Description

TP19 FC-01, Sample 2, 2-21'

Remarks:

Project No. 1804-224 **Client:** Sevier County

Project: Sevier County Watershed Plan & Flood Protection

○ **Location:** TP19 FC-01, S-2 **Sample Number:** 19-S-070

Checked by: Mark Rappleye

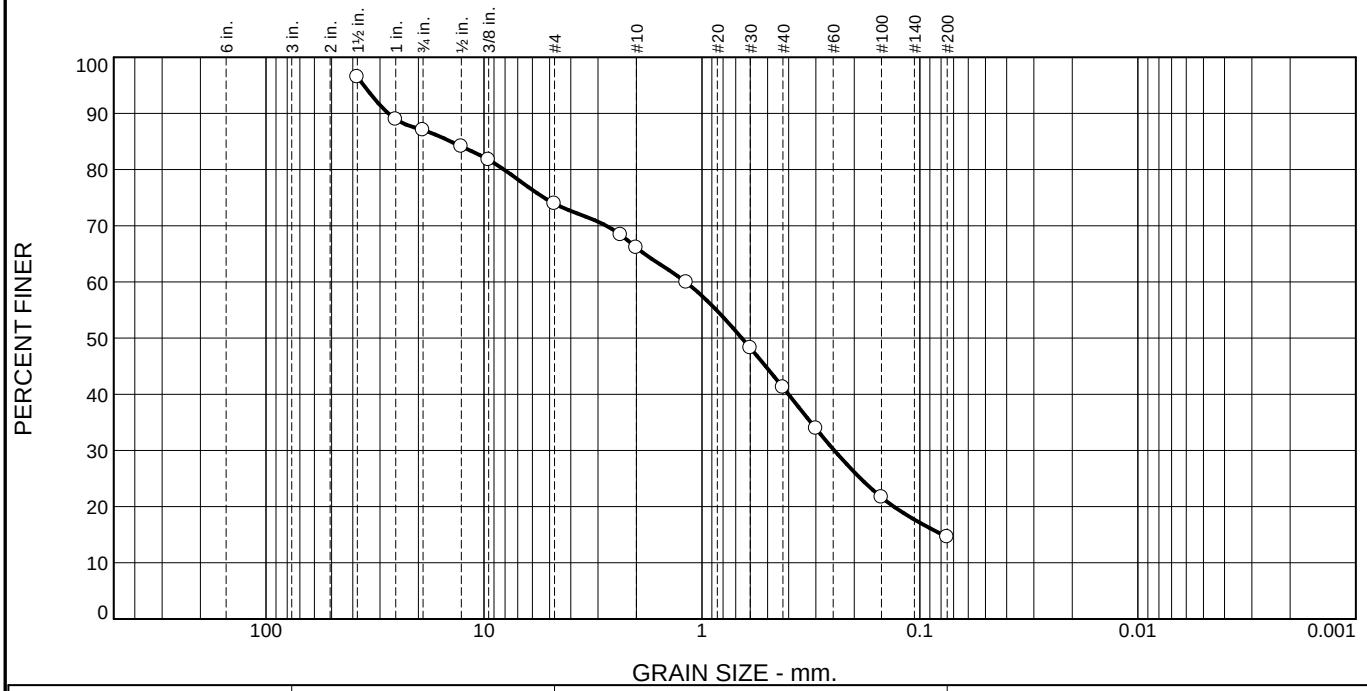
Title: Lab Manager

JONES & DEMILLE ENGINEERING INC.

Richfield, Utah

Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		13.1	7.8	24.9	26.6	14.6	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	96.5		
1"	89.0		
3/4"	87.0		
1/2"	84.1		
3/8"	81.7		
#4	73.9		
#8	68.4		
#10	66.1		
#16	59.9		
#30	48.2		
#40	41.2		
#50	33.9		
#100	21.7		
#200	14.6		

* (no specification provided)

Material Description

TP19 FC-02, Sample 2, 2-19'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 27.4905 D_{85}= 14.2083 D_{60}= 1.1878
D_{50}= 0.6565 D_{30}= 0.2469 D_{15}= 0.0787
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/7/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 FC-02, S-2
Sample Number: 19-S-065

Date Sampled: 2/20/19

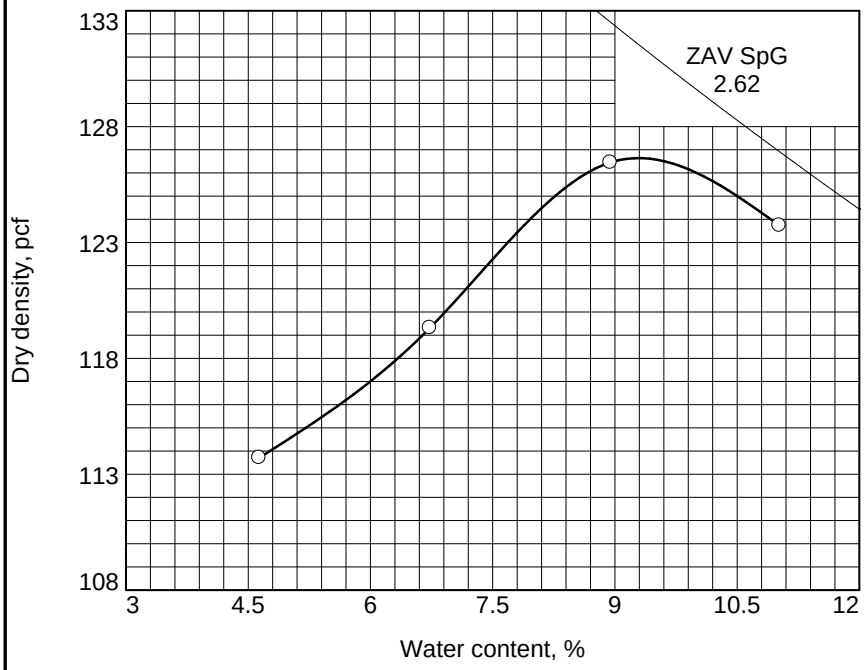
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Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

COMPACTION TEST REPORT

Curve No. 065



Preparation Method	-3/4" Material
Rammer: Wt.	10 lb. Drop 18 in.
Type	automatic
Layers: No.	five Blows per 56
Mold Size	0.075 cu. ft.
Test Performed on Material Passing	3/4 in. Sieve
%>3/4 in.	13.0 %<No.200 14.6
Atterberg (D 4318): LL	NV PI NP
NM (D 2216)	Sp.G. (D 854) 2.62
USCS (D 2487)	SM
AASHTO (M 145)	A-1-b
Date: Sampled	2/20/19
Received	2/22/19
Tested	3/7/19
Tested By	Matt Murphree

COMPACTION TESTING DATA
AASHTO T 180-15 Method D Modified
AASHTO T 224-01 Oversize Correction Applied to Final Results

	1	2	3	4	5	6
WM + WS	9778.6	10063.0	10417.6	10404.2		
WM	5730.9	5730.9	5730.9	5730.9		
WW + T #1	920.5	913.2	922.4	998.7		
WD + T #1	890.6	870.6	867.3	925.3		
TARE #1	245.6	237.6	251.3	259.1		
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	4.6	6.7	8.9	11.0		
DRY DENS.	113.7	119.3	126.5	123.7		

SIEVE TEST RESULTS
AASHTO T 27 AASHTO T 11

Opening Size	% Passing	Specs.
1.5"	96.5	
1"	89.0	
3/4"	87.0	
1/2"	84.1	
3/8"	81.7	
#4	73.9	
#8	68.4	
#10	66.1	
#16	59.9	
#30	48.2	
#40	41.2	
#50	33.9	
#100	21.7	
#200	14.6	

ROCK CORRECTED TEST RESULTS

Maximum dry density = 130.4 pcf

Optimum moisture = 8.3 %

Material Description

TP19 FC-02, Sample 2, 2-19'

Remarks:

Project No. 1804-224 **Client:** Sevier County

Project: Sevier County Watershed Plan & Flood Protection

○ **Location:** TP19 FC-02, S-2 **Sample Number:** 19-S-065

Checked by: Mark Rappleye

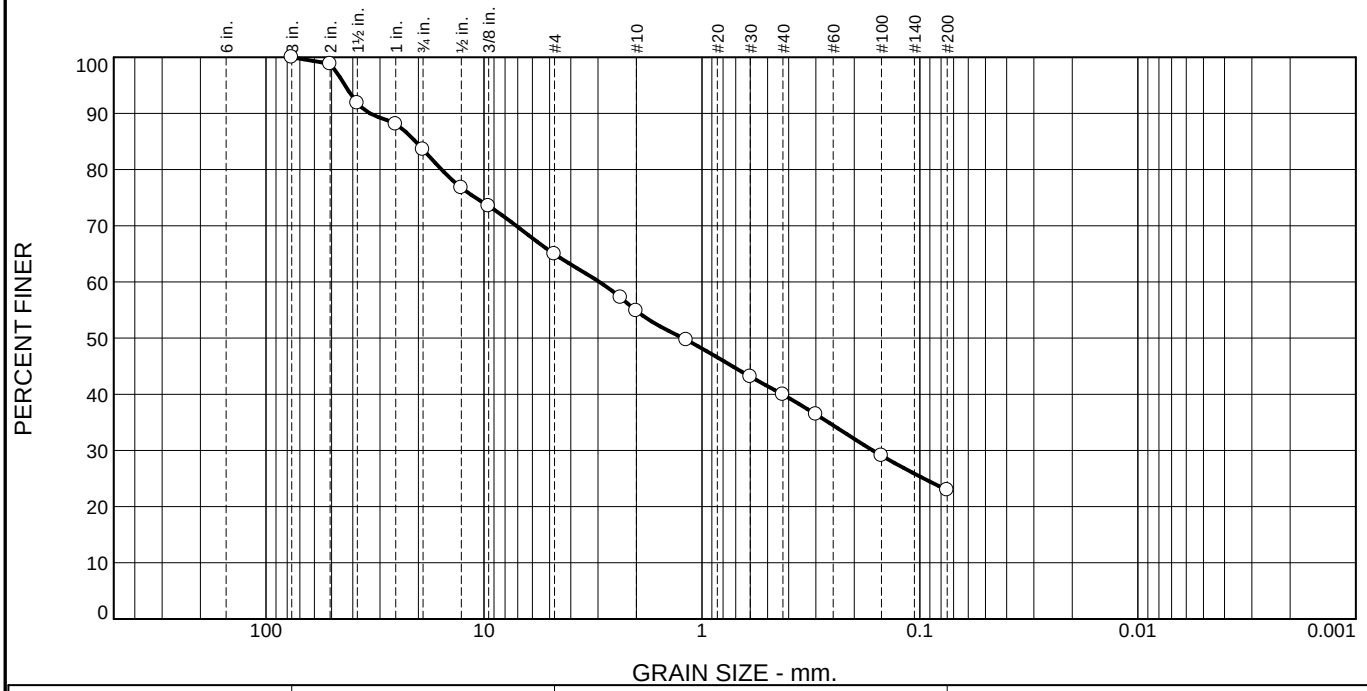
Title: Lab Manager

JONES & DEMILLE ENGINEERING INC.

Richfield, Utah

Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	16.4	18.6	10.1	15.0	17.0	22.9	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3"	100.0		
2"	98.8		
1.5"	91.8		
1"	88.1		
3/4"	83.6		
1/2"	76.8		
3/8"	73.5		
#4	65.0		
#8	57.2		
#10	54.9		
#16	49.7		
#30	43.1		
#40	39.9		
#50	36.4		
#100	29.1		
#200	22.9		

* (no specification provided)

Material Description

TP19 FC-03, Sample 1, 0-4'

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 33.3846 D_{85}= 20.6039 D_{60}= 2.9585
D_{50}= 1.2232 D_{30}= 0.1644 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/5/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP-19 FC-03, S-1
Sample Number: 19-S-054

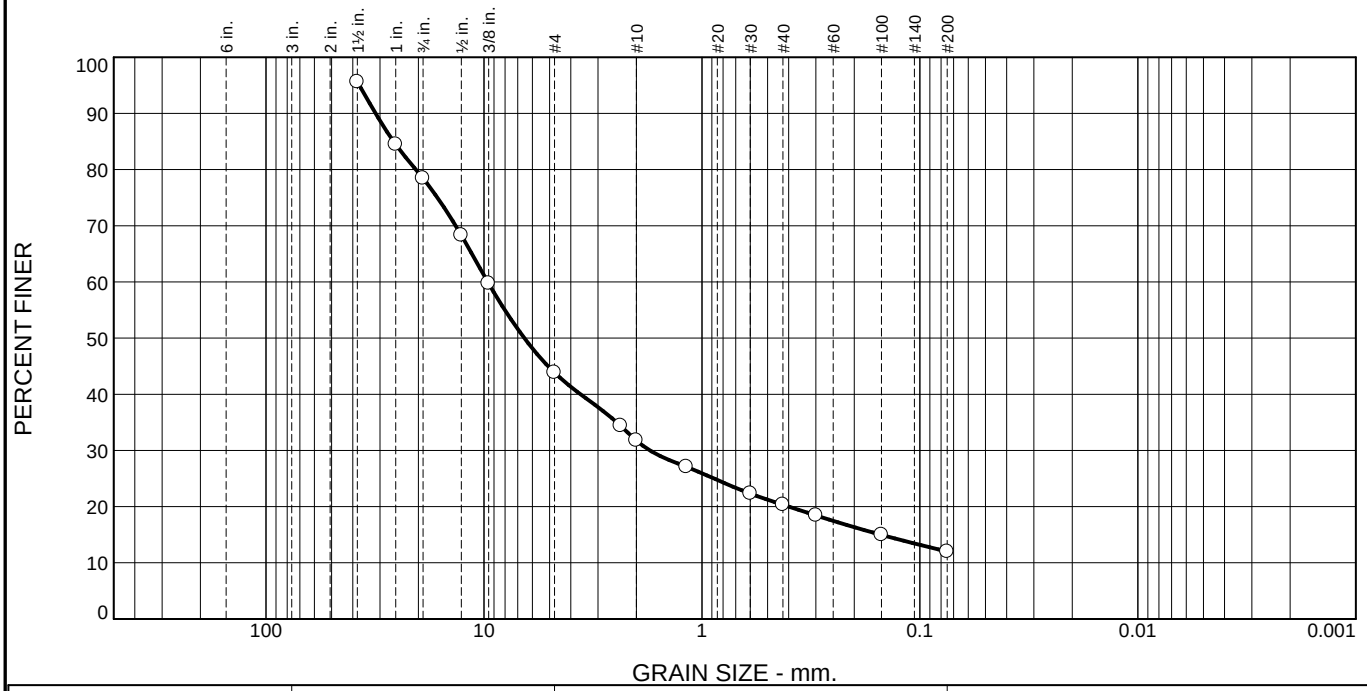
Date Sampled: 2/20/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		34.6	12.1	11.5	8.3	12.0	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	95.6		
1"	84.5		
3/4"	78.5		
1/2"	68.3		
3/8"	59.7		
#4	43.9		
#8	34.4		
#10	31.8		
#16	27.1		
#30	22.3		
#40	20.3		
#50	18.4		
#100	15.0		
#200	12.0		

* (no specification provided)

Material Description

TP19 FC-03, Sample 2, 4-21'

Atterberg Limits (ASTM D 4318)

PL= 16.2 **LL=** 19.9 **PI=** 3.7

Classification

USCS (D 2487)= GP-GC **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 31.4380 D_{85}= 25.9844 D_{60}= 9.6105
D_{50}= 6.5292 D_{30}= 1.7315 D_{15}= 0.1512
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/6/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 FC-03, S-2
Sample Number: 19-S-056

Date Sampled: 2/20/19

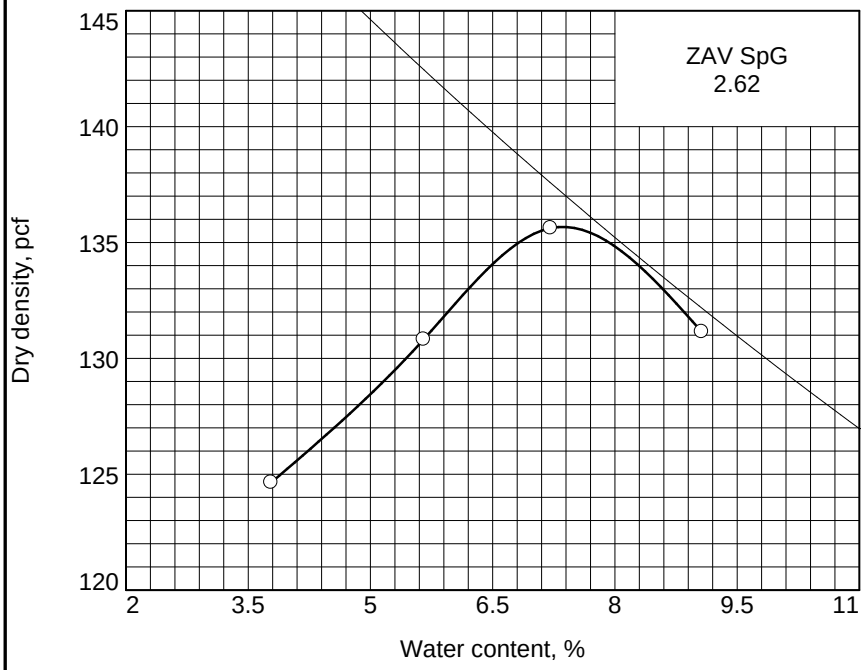
JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

COMPACTION TEST REPORT

Curve No. 056



Preparation Method	-3/4" Material
Rammer: Wt.	10 lb. Drop 18 in.
Type	automatic
Layers: No.	five Blows per 56
Mold Size	0.075 cu. ft.
Test Performed on Material Passing	3/4 in. Sieve
%>3/4 in.	21.5 %<No.200 12.0
Atterberg (D 4318): LL	19.9 PI 3.7
NM (D 2216)	Sp.G. (D 854) 2.62
USCS (D 2487)	GP-GC
AASHTO (M 145)	A-1-a
Date: Sampled	2/20/19
Received	2/22/19
Tested	3/6/19
Tested By	Matt Murphree

COMPACTION TESTING DATA
AASHTO T 180-15 Method D Modified
AASHTO T 224-01 Oversize Correction Applied to Final Results

	1	2	3	4	5	6
WM + WS	10900.2	11201.2	11446.0	11365.2		
WM	6499.4	6499.4	6499.4	6499.4		
WW + T #1	1011.6	1042.1	991.3	1045.1		
WD + T #1	983.7	999.4	941.2	978.8		
TARE #1	246.2	244.0	246.6	247.5		
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	3.8	5.7	7.2	9.1		
DRY DENS.	124.6	130.8	135.6	131.1		

SIEVE TEST RESULTS
AASHTO T 27 AASHTO T 11

Opening Size	% Passing	Specs.
1.5"	95.6	
1"	84.5	
3/4"	78.5	
1/2"	68.3	
3/8"	59.7	
#4	43.9	
#8	34.4	
#10	31.8	
#16	27.1	
#30	22.3	
#40	20.3	
#50	18.4	
#100	15.0	
#200	12.0	

ROCK CORRECTED TEST RESULTS

Maximum dry density = 140.8 pcf

Optimum moisture = 6.2 %

Material Description

TP19 FC-03, Sample 2, 4-21'

Remarks:

Project No. 1804-224 **Client:** Sevier County

Project: Sevier County Watershed Plan & Flood Protection

○ **Location:** TP19 FC-03, S-2 **Sample Number:** 19-S-056

Checked by: Mark Rappleye

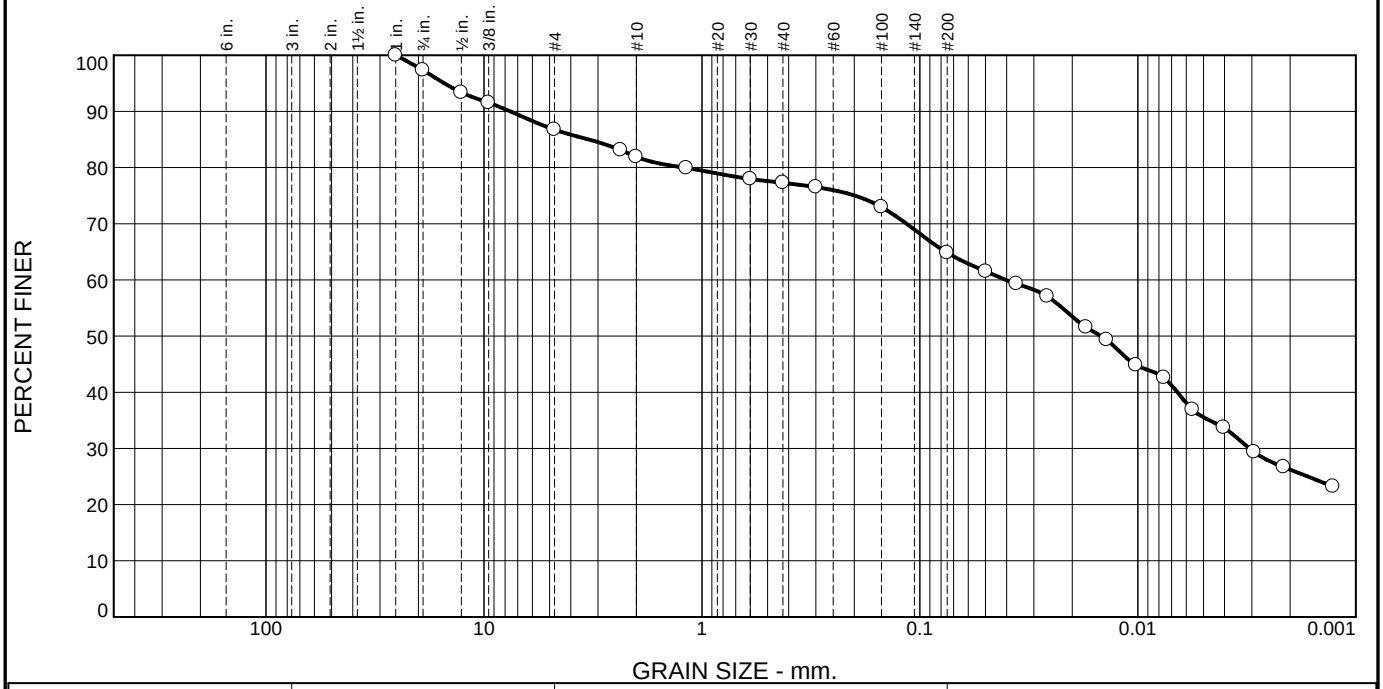
Title: Lab Manager

JONES & DEMILLE ENGINEERING INC.

Richfield, Utah

Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	2.7	10.6	4.8	4.6	12.5	29.3	35.5

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	97.3		
1/2"	93.4		
3/8"	91.6		
#4	86.7		
#8	83.1		
#10	81.9		
#16	79.9		
#30	78.0		
#40	77.3		
#50	76.5		
#100	73.0		
#200	64.8		
0.0498 mm.	61.5		
0.0360 mm.	59.3		
0.0260 mm.	57.1		
0.0173 mm.	51.6		
0.0139 mm.	49.3		
0.0102 mm.	44.8		
0.0076 mm.	42.6		
0.0056 mm.	36.9		
0.0040 mm.	33.7		
0.0029 mm.	29.3		
0.0021 mm.	26.7		
0.0013 mm.	23.2		

* (no specification provided)

Material Description

Native Red Clay

Atterberg Limits (ASTM D 4318)

PL= 13.4 **LL=** 27.2 **PI=** 13.8

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-6(6)

Coefficients

D_{90}= 7.5700 D_{85}= 3.3121 D_{60}= 0.0403
D_{50}= 0.0147 D_{30}= 0.0031 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 4/6/19 **Date Tested:** 4/22/19

Tested By: Matt Murphree

Checked By: Mark Rappleye

Title: Lab Manager

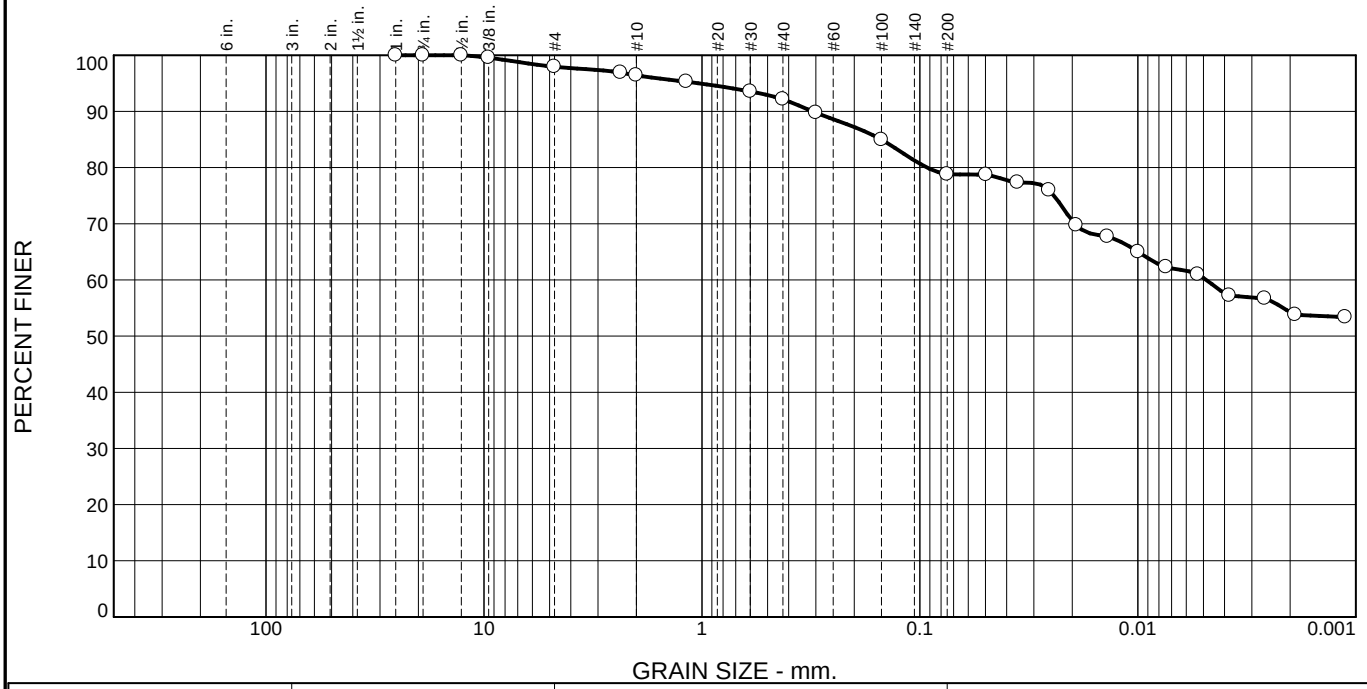
Location: Flat Canyon **Date Sampled:** 4/5/19
Sample Number: 19-S-166

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.0	1.6	4.3	13.3	18.4	60.4

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	100.0		
1/2"	100.0		
3/8"	99.6		
#4	98.0		
#8	96.9		
#10	96.4		
#16	95.3		
#30	93.5		
#40	92.1		
#50	89.8		
#100	85.0		
#200	78.8		
0.0497 mm.	78.7		
0.0356 mm.	77.4		
0.0255 mm.	76.0		
0.0192 mm.	69.7		
0.0138 mm.	67.7		
0.0100 mm.	65.0		
0.0074 mm.	62.3		
0.0053 mm.	61.0		
0.0038 mm.	57.2		
0.0026 mm.	56.7		
0.0019 mm.	53.8		
0.0011 mm.	53.4		

* (no specification provided)

Material Description

Native Clay Site - West of Elsinore

Atterberg Limits (ASTM D 4318)

PL= 18.0 **LL=** 67.5 **PI=** 49.5

Classification

USCS (D 2487)= CH **AASHTO (M 145)=** A-7-6(41)

Coefficients

D_{90}= 0.3102 D_{85}= 0.1506 D_{60}= 0.0049
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/27/19 **Date Tested:** 3/1/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: Flat Canyon (West of Elsinore)
Sample Number: 19-S-040

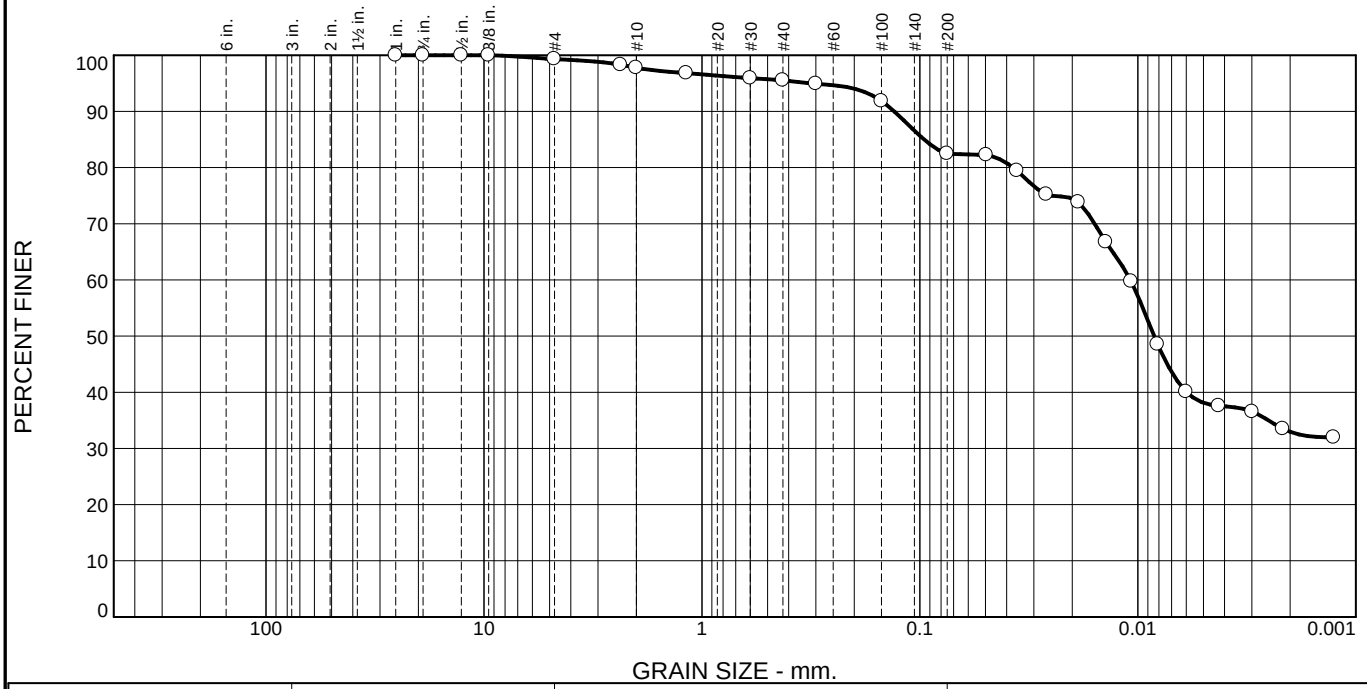
Date Sampled: 2/27/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.7	1.5	2.3	13.0	44.4	38.1

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	100.0		
1/2"	100.0		
3/8"	100.0		
#4	99.3		
#8	98.3		
#10	97.8		
#16	96.8		
#30	95.9		
#40	95.5		
#50	94.9		
#100	91.8		
#200	82.5		
0.0495 mm.	82.2		
0.0359 mm.	79.4		
0.0262 mm.	75.2		
0.0188 mm.	73.8		
0.0140 mm.	66.7		
0.0107 mm.	59.7		
0.0081 mm.	48.5		
0.0060 mm.	40.1		
0.0043 mm.	37.6		
0.0030 mm.	36.5		
0.0022 mm.	33.5		
0.0013 mm.	32.0		

* (no specification provided)

Material Description

Native Clay Site - West of Aurora

Atterberg Limits (ASTM D 4318)

PL= 13.5 **LL=** 45.6 **PI=** 32.1

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-7-6(26)

Coefficients

D_{90}= 0.1311 D_{85}= 0.0957 D_{60}= 0.0108
D_{50}= 0.0084 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/27/19 **Date Tested:** 3/1/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

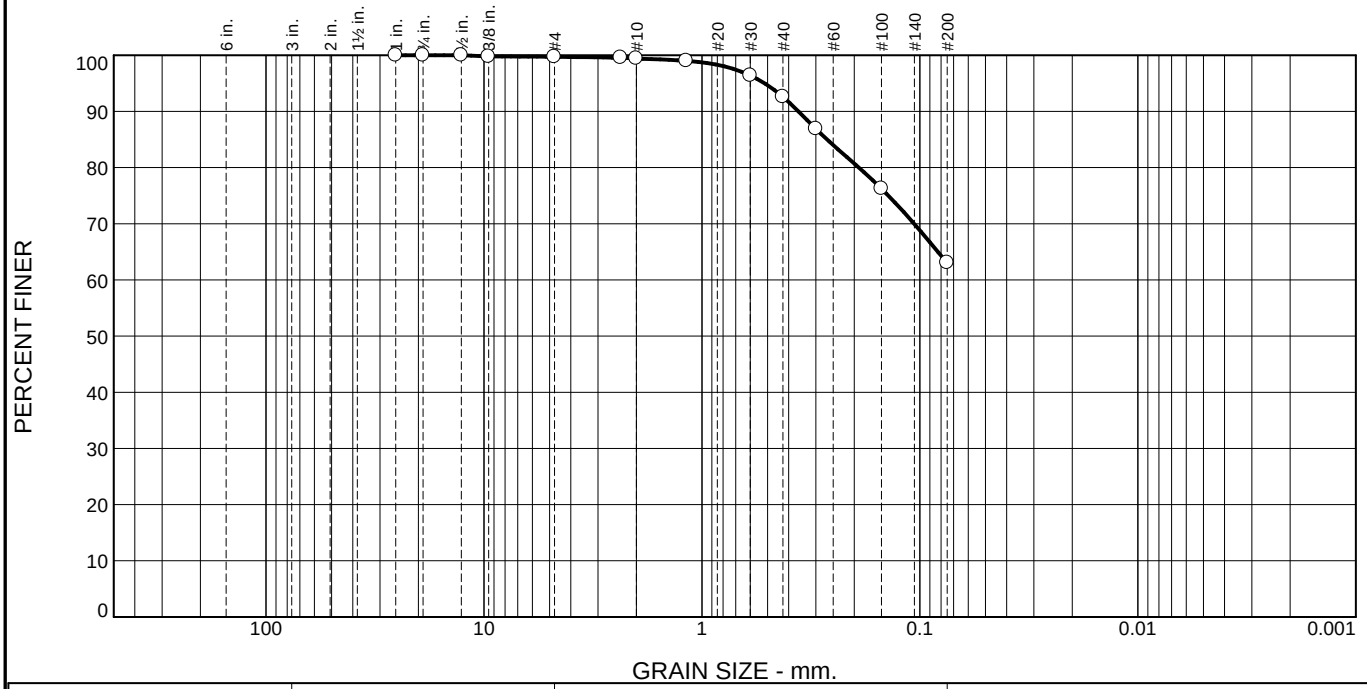
Location: West of Aurora (Above Water Tank) **Date Sampled:** 2/27/19
Sample Number: 19-S-041

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.3	0.3	6.8	29.6	63.0	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	100.0		
1/2"	100.0		
3/8"	99.8		
#4	99.7		
#8	99.6		
#10	99.4		
#16	99.0		
#30	96.4		
#40	92.6		
#50	86.9		
#100	76.2		
#200	63.0		

* (no specification provided)

Material Description

TP19 DC-01, Sample 1 (Combined with DC-02)

Atterberg Limits (ASTM D 4318)

PL= 20.2 **LL=** 24.0 **PI=** 3.8

Classification

USCS (D 2487)= CL-ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.3608 D_{85}= 0.2665 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/22/19 **Date Tested:** 3/5/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: TP19 DC-01, S-1 (Dairy Canyon) **Date Sampled:** 2/21/19

Sample Number: 19-S-046

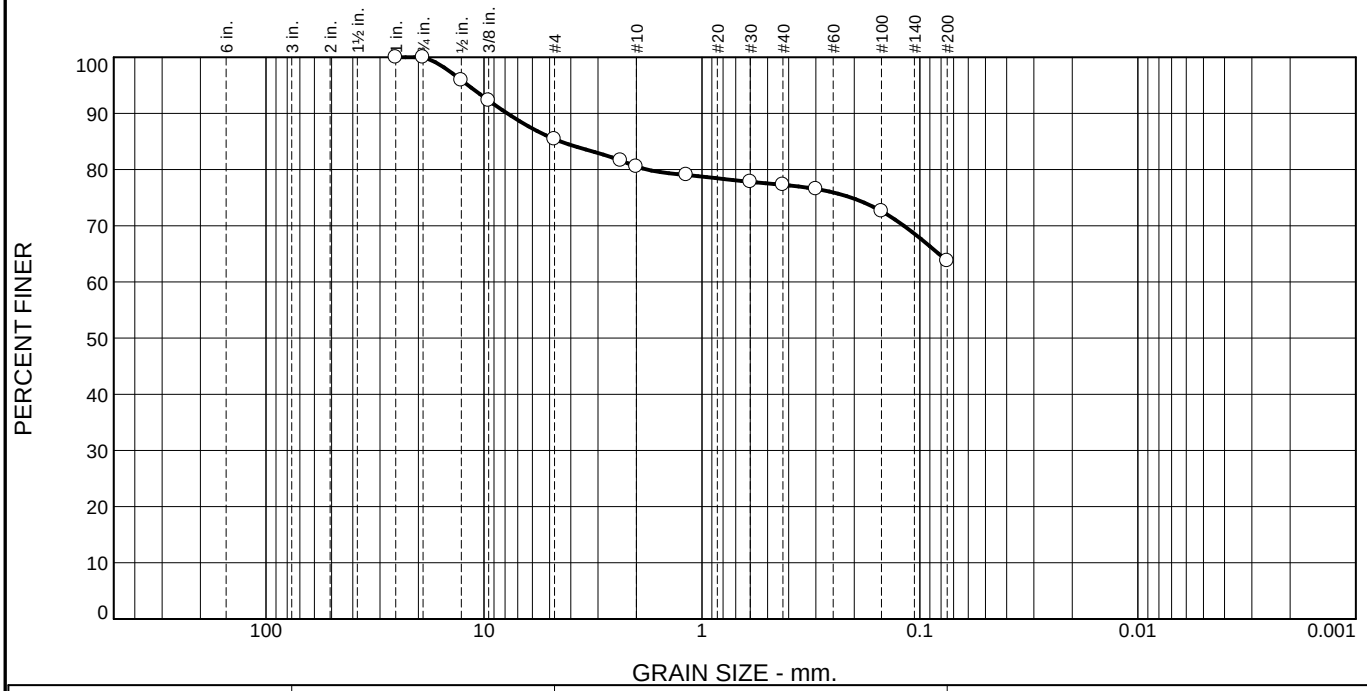
JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County

Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	14.6	4.8	3.3	13.6	63.7	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	100.0		
1/2"	95.9		
3/8"	92.3		
#4	85.4		
#8	81.6		
#10	80.6		
#16	79.0		
#30	77.8		
#40	77.3		
#50	76.6		
#100	72.6		
#200	63.7		

* (no specification provided)

Material Description

Red Native Silty/Clay

Atterberg Limits (ASTM D 4318)

PL= 12.8 **LL=** 25.7 **PI=** 12.9

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-6(5)

Coefficients

D_{90}= 7.8084 D_{85}= 4.4517 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 4/5/19 **Date Tested:** 4/10/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: Flat Canyon
Sample Number: 19-S-123

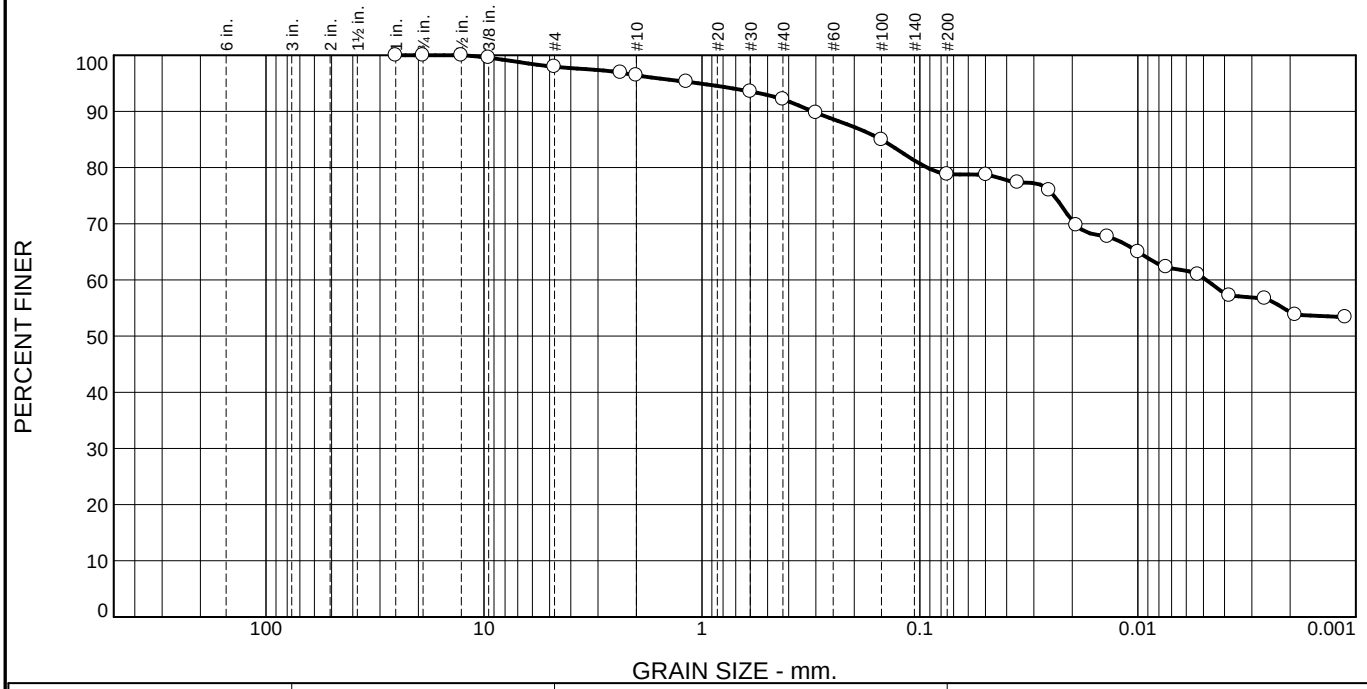
Date Sampled: 4/5/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.0	1.6	4.3	13.3	18.4	60.4

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	100.0		
1/2"	100.0		
3/8"	99.6		
#4	98.0		
#8	96.9		
#10	96.4		
#16	95.3		
#30	93.5		
#40	92.1		
#50	89.8		
#100	85.0		
#200	78.8		
0.0497 mm.	78.7		
0.0356 mm.	77.4		
0.0255 mm.	76.0		
0.0192 mm.	69.7		
0.0138 mm.	67.7		
0.0100 mm.	65.0		
0.0074 mm.	62.3		
0.0053 mm.	61.0		
0.0038 mm.	57.2		
0.0026 mm.	56.7		
0.0019 mm.	53.8		
0.0011 mm.	53.4		

* (no specification provided)

Material Description

Native Clay Site - West of Elsinore

Atterberg Limits (ASTM D 4318)

PL= 18.0 **LL=** 67.5 **PI=** 49.5

Classification

USCS (D 2487)= CH **AASHTO (M 145)=** A-7-6(41)

Coefficients

D_{90}= 0.3102 D_{85}= 0.1506 D_{60}= 0.0049
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/27/19 **Date Tested:** 3/1/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: Flat Canyon (West of Elsinore)
Sample Number: 19-S-040

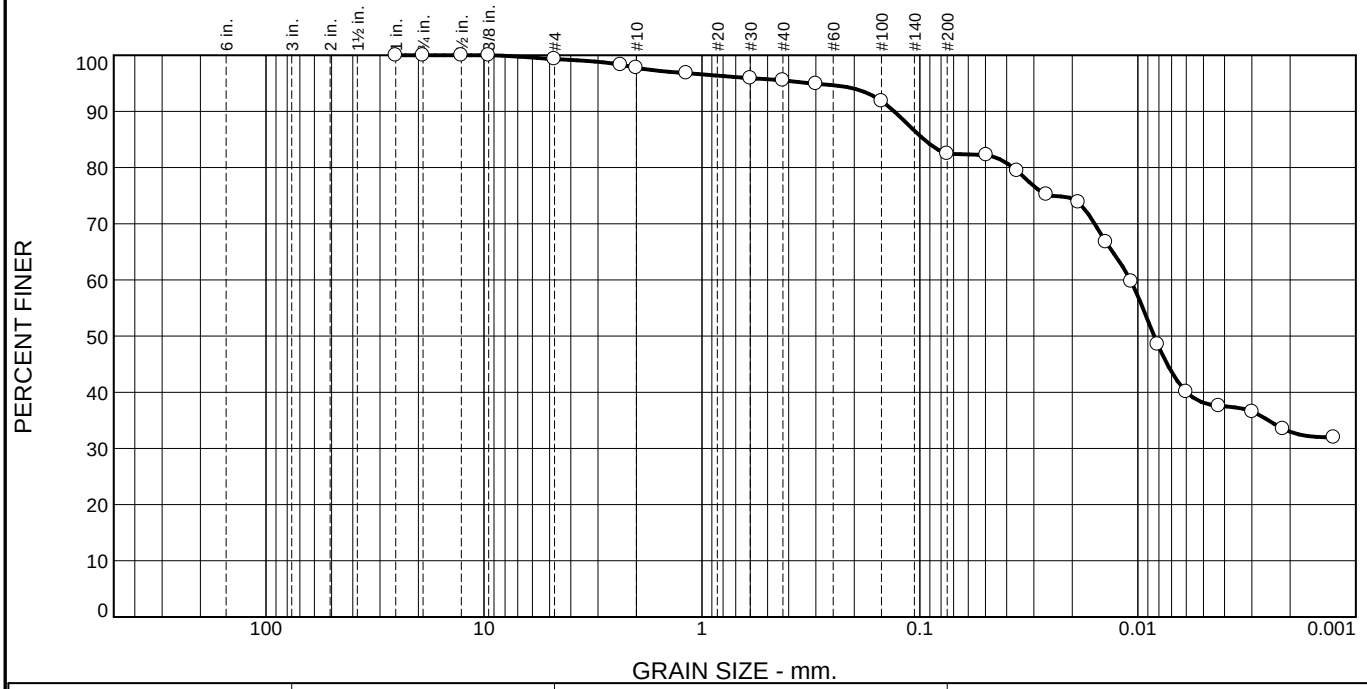
Date Sampled: 2/27/19

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.7	1.5	2.3	13.0	44.4	38.1

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	100.0		
1/2"	100.0		
3/8"	100.0		
#4	99.3		
#8	98.3		
#10	97.8		
#16	96.8		
#30	95.9		
#40	95.5		
#50	94.9		
#100	91.8		
#200	82.5		
0.0495 mm.	82.2		
0.0359 mm.	79.4		
0.0262 mm.	75.2		
0.0188 mm.	73.8		
0.0140 mm.	66.7		
0.0107 mm.	59.7		
0.0081 mm.	48.5		
0.0060 mm.	40.1		
0.0043 mm.	37.6		
0.0030 mm.	36.5		
0.0022 mm.	33.5		
0.0013 mm.	32.0		

* (no specification provided)

Material Description

Native Clay Site - West of Aurora

Atterberg Limits (ASTM D 4318)

PL= 13.5 **LL=** 45.6 **PI=** 32.1

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-7-6(26)

Coefficients

D_{90}= 0.1311 D_{85}= 0.0957 D_{60}= 0.0108
D_{50}= 0.0084 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/27/19 **Date Tested:** 3/1/19

Tested By: Mark Rappleye

Checked By: Mark Rappleye

Title: Lab Manager

Location: West of Aurora (Above Water Tank) **Date Sampled:** 2/27/19
Sample Number: 19-S-041

JONES & DEMILLE ENGINEERING INC.
Richfield, Utah

Client: Sevier County
Project: Sevier County Watershed Plan & Flood Protection

Project No: 1804-224 **Figure**

Attachment F. Seepage and Slope Stability Results

Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
02-Core [Drained]	Saturated / Unsaturated	Core	0.5	0	Core
03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

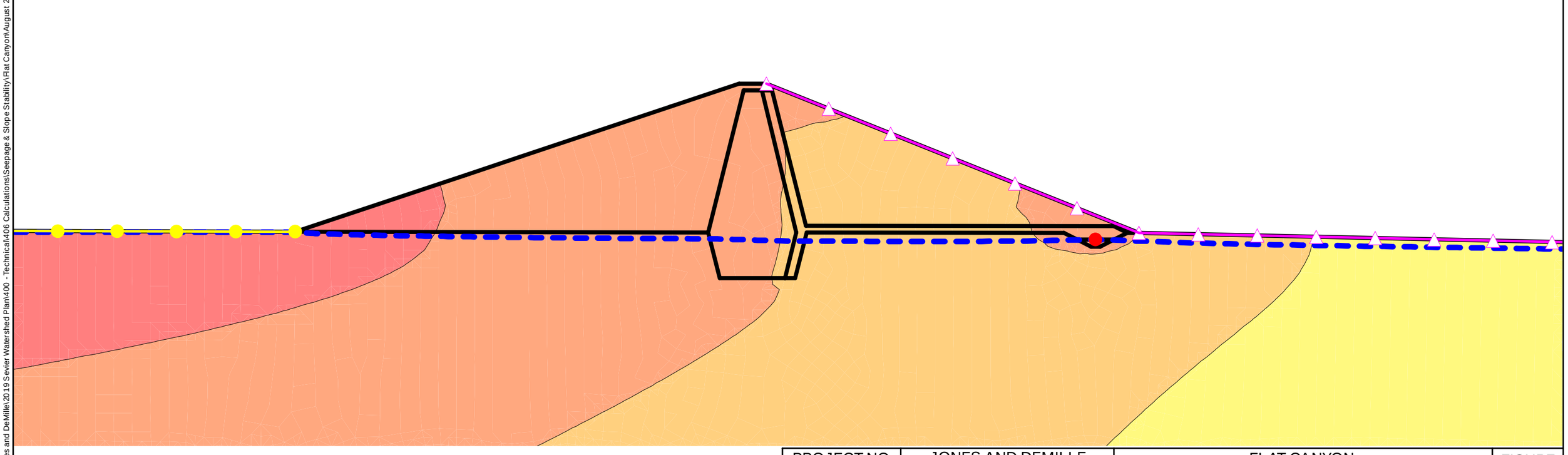
Name: Total Head

Contour parameter: Total Head ft

Starting Contour Value: 5,520 ft

Ending Contour Value: 5,544 ft

Increment by: 2 ft



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 1
AECOM	SEVIER COUNTY, UTAH	EMPTY SEEPAGE RESULTS	

Q:\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 4:58:56 PM

Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
02-Core [Drained]	Saturated / Unsaturated	Core	0.5	0	Core
03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

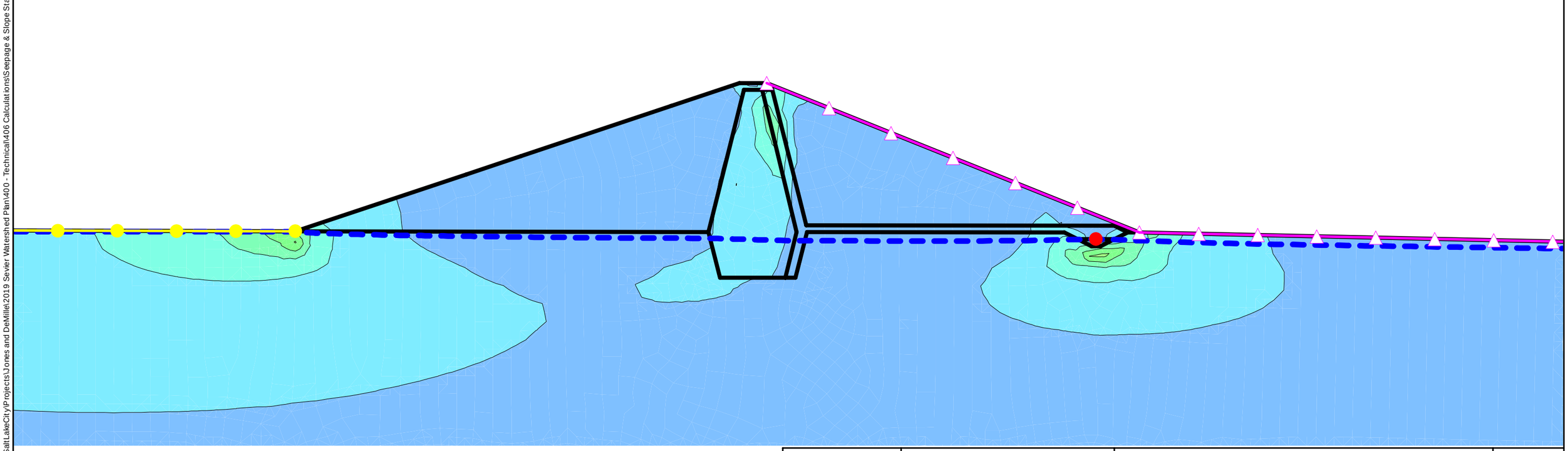
Name: Gradients

Contour parameter: XY-Gradient

Starting Contour Value: 0

Ending Contour Value: 0.22

Increment by: 0.02



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 2
AECOM	SEVIER COUNTY, UTAH	EMPTY SEEPAGE GRADIENTS	

\\urssaltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 4:58:56 PM

Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
02-Core [Drained]	Saturated / Unsaturated	Core	0.5	0	Core
03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

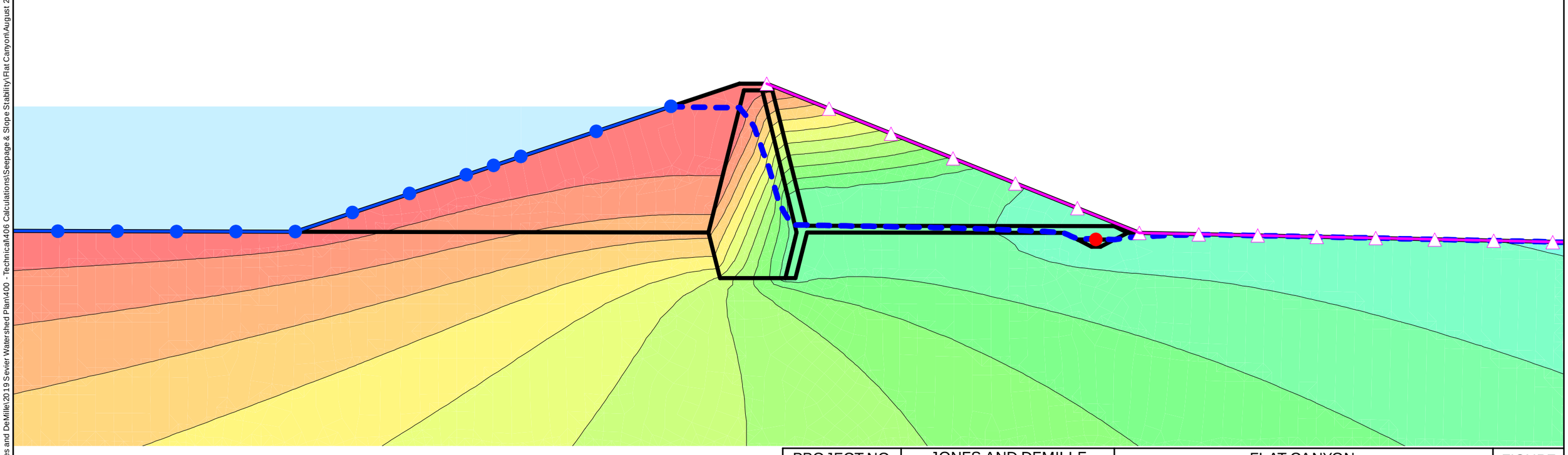
Name: Total Head

Contour parameter: Total Head ft

Starting Contour Value: 5,520 ft

Ending Contour Value: 5,600 ft

Increment by: 5 ft



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 3
AECOM	SEVIER COUNTY, UTAH	FULL SEEPAGE RESULTS	

Q:\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 4:58:56 PM

Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
02-Core [Drained]	Saturated / Unsaturated	Core	0.5	0	Core
03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

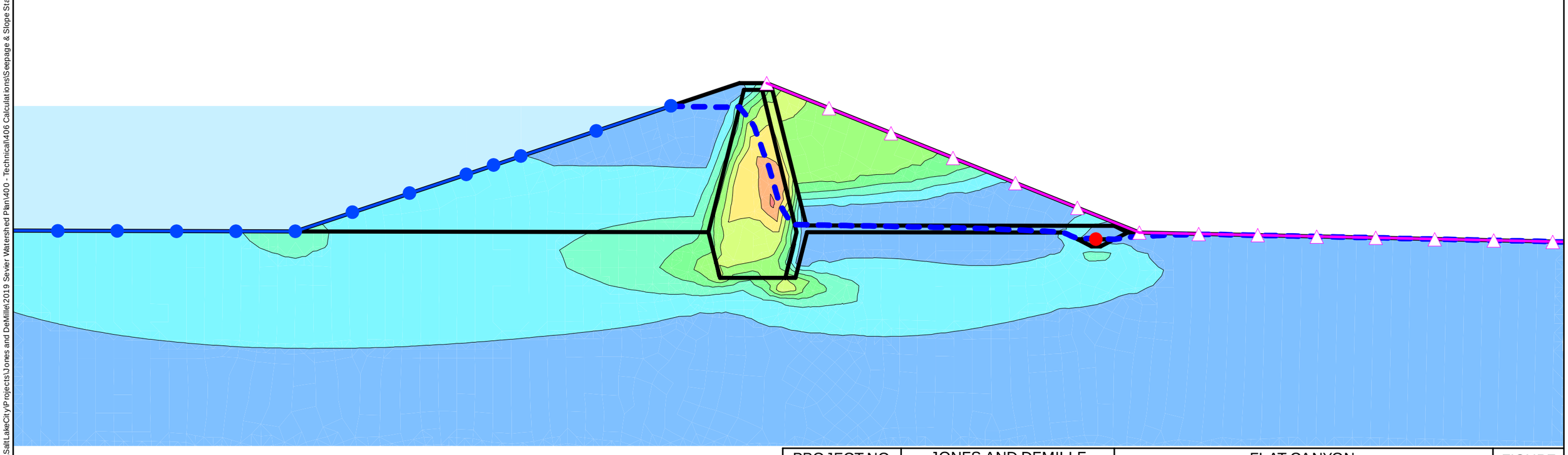
Name: Gradients

Contour parameter: XY-Gradient

Starting Contour Value: 0

Ending Contour Value: 1.8

Increment by: 0.2



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 4
AECOM	SEVIER COUNTY, UTAH	FULL SEEPAGE GRADIENTS	

\\urssaltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 4:58:56 PM

Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
02-Core [Drained]	Saturated / Unsaturated	Core	0.5	0	Core
03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
04-Basin Sediment [Drained]	Saturated / Unsaturated	Sediment	0.1	0	Sediment
05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

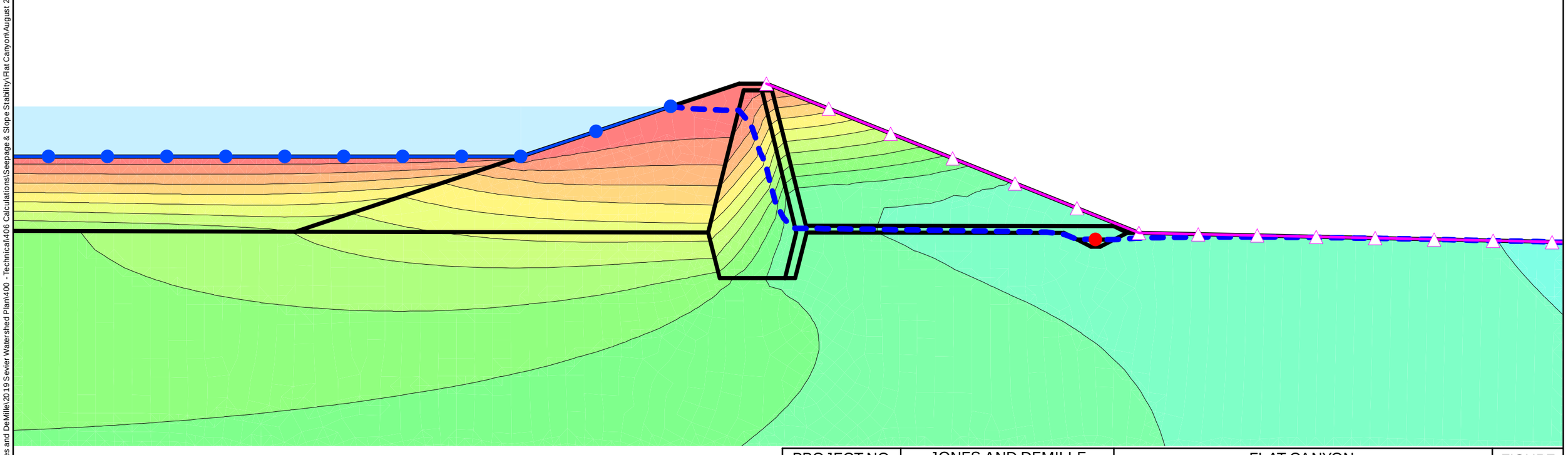
Name: Total Head

Contour parameter: Total Head ft

Starting Contour Value: 5,520 ft

Ending Contour Value: 5,600 ft

Increment by: 5 ft



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 5
AECOM	SEVIER COUNTY, UTAH	SEDIMENT FILLED SEEPAGE RESULTS	

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Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
02-Core [Drained]	Saturated / Unsaturated	Core	0.5	0	Core
03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
04-Basin Sediment [Drained]	Saturated / Unsaturated	Sediment	0.1	0	Sediment
05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

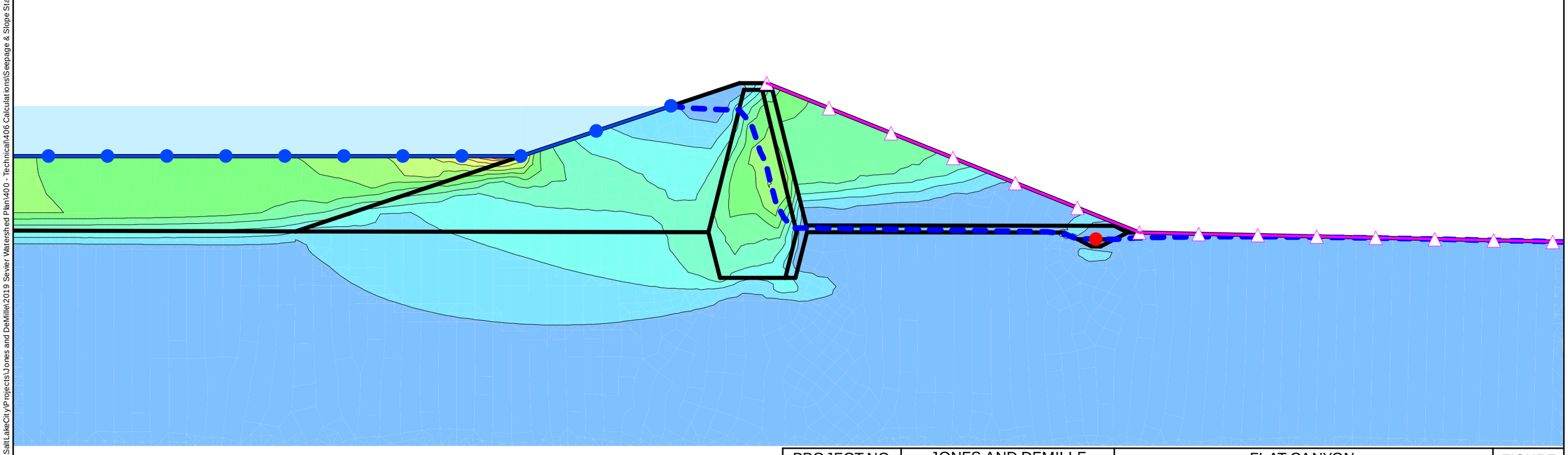
Name: Gradients

Contour parameter: XY-Gradient

Starting Contour Value: 0

Ending Contour Value: 2.6

Increment by: 0.2

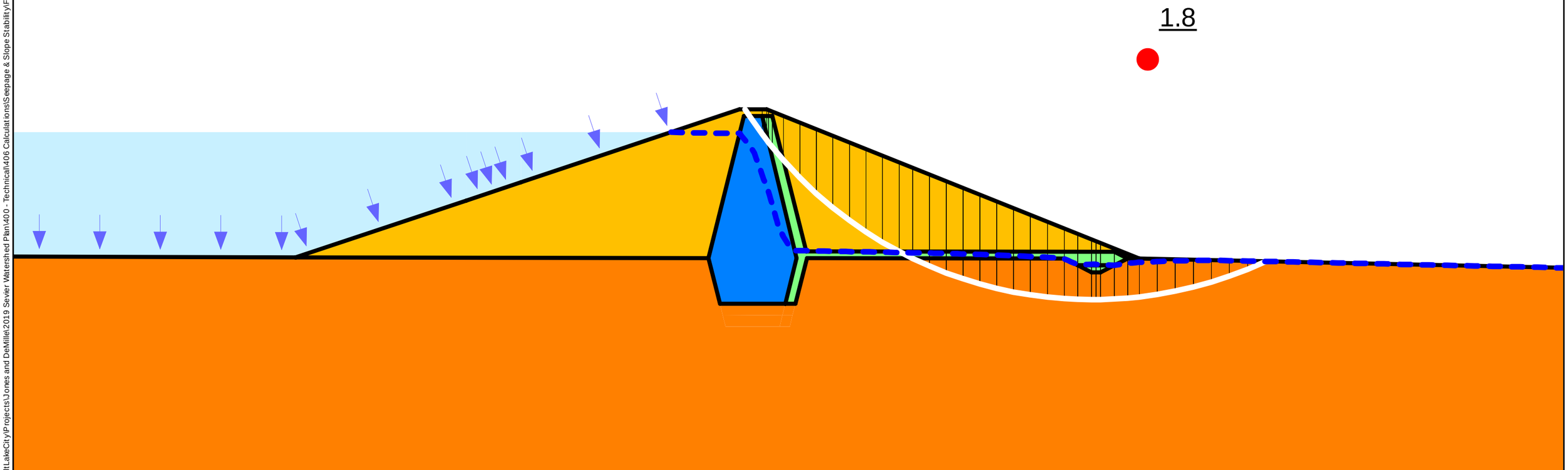


SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 6
AECOM	SEVIER COUNTY, UTAH	SEDIMENT FILLED SEEPAGE GRADIENT	

\\urssaltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 4:58:56 PM

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	130	0	33	0
	02-Core [Drained]	Mohr-Coulomb	125	0	28	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	130	0	34	0

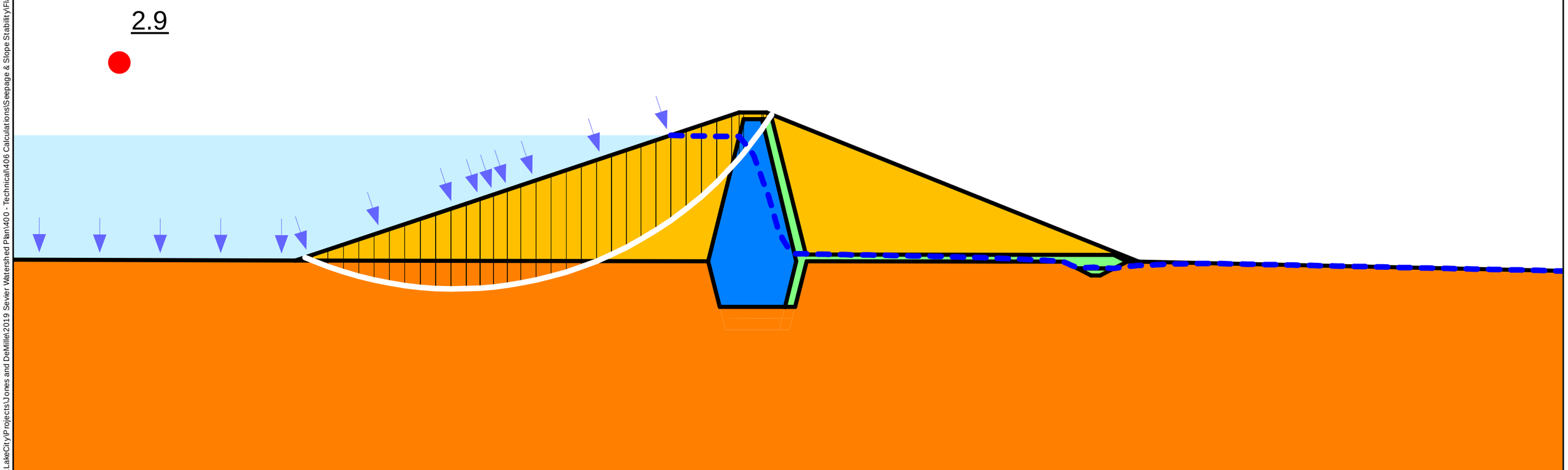


SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 7
AECOM	SEVIER COUNTY, UTAH	DOWNSTREAM - DRAINED	

\\urssaltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 5:36:31 PM

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	130	0	33	0
	02-Core [Drained]	Mohr-Coulomb	125	0	28	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	130	0	34	0

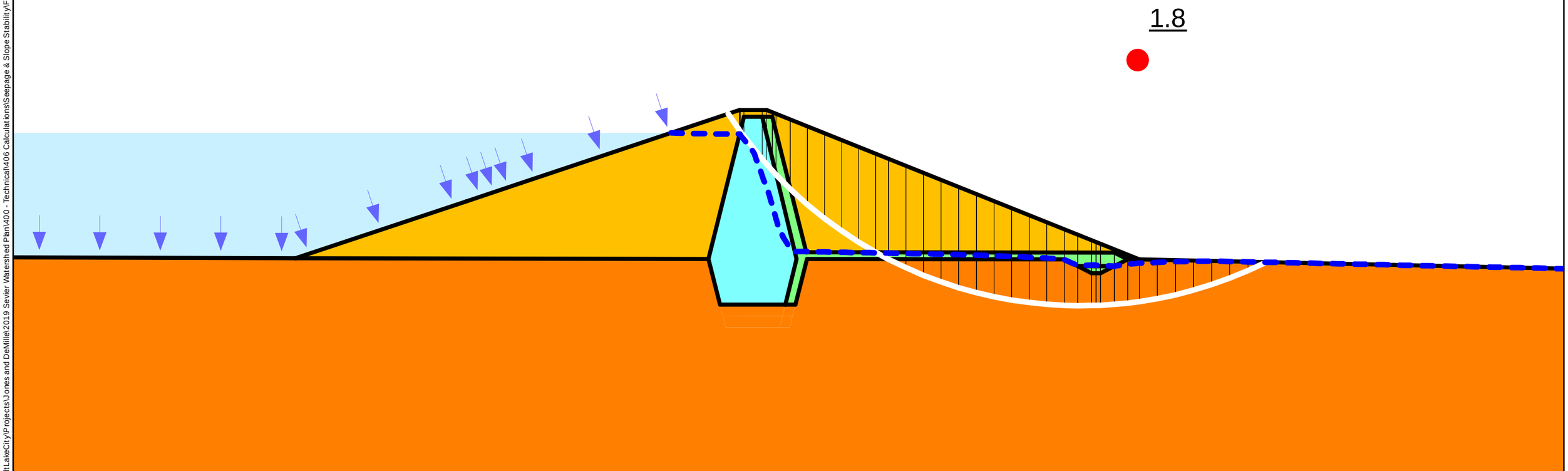


SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 8
AECOM	SEVIER COUNTY, UTAH	UPSTREAM - DRAINED	

\\urssaltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 5:36:31 PM

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	130	0	33	0
	02-Core [Undrained]	Mohr-Coulomb	125	0	21.8	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	130	0	34	0

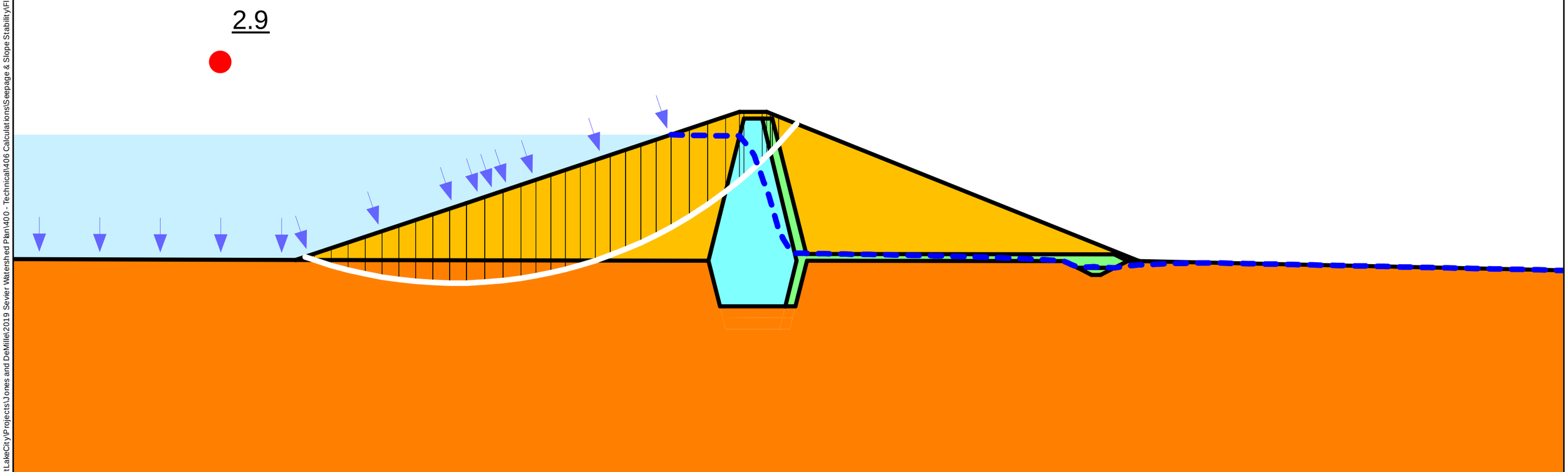


SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 9
AECOM	SEVIER COUNTY, UTAH	DOWNSTREAM - UNDRAINED	

\\urssaltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 5:36:31 PM

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	130	0	33	0
	02-Core [Undrained]	Mohr-Coulomb	125	0	21.8	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	130	0	34	0



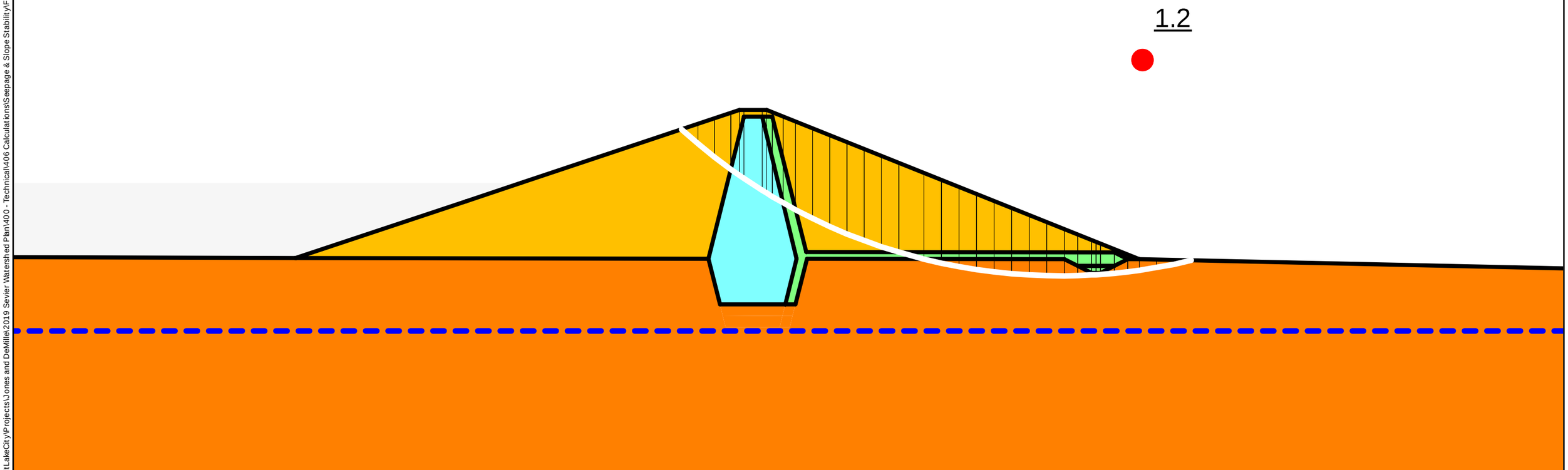
SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 10
AECOM	SEVIER COUNTY, UTAH	UPSTREAM - UNDRAINED	

\\urssaltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 5:36:31 PM

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	01-SM with Gravel [All]	Mohr-Coulomb	130	0	33	0	1
	02-Core [Undrained]	Mohr-Coulomb	125	0	21.8	0	1
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0	1
	05-Embankment Shell [All]	Mohr-Coulomb	130	0	34	0	1

Horz Seismic Coef.: 0.245



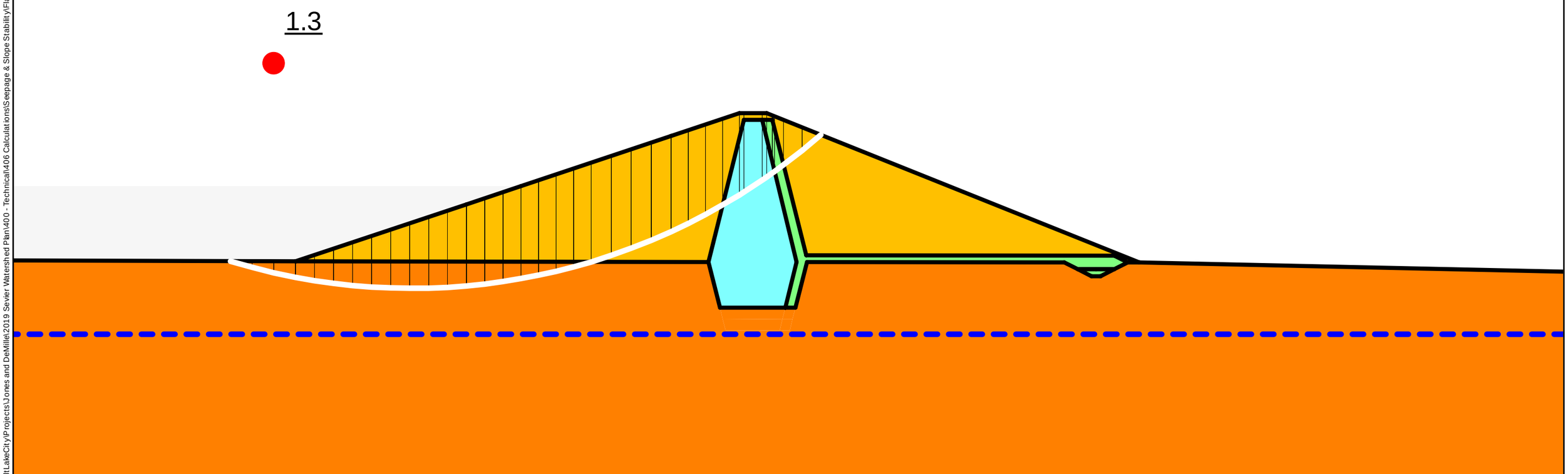
SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 11
AECOM	SEVIER COUNTY, UTAH	DOWNSTREAM - PSEUDOSTATIC	

\\urssaltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/8/2019 5:01:28 PM

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	130	0	33	0
	02-Core [Undrained]	Mohr-Coulomb	125	0	21.8	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	130	0	34	0

Horz Seismic Coef.: 0.245

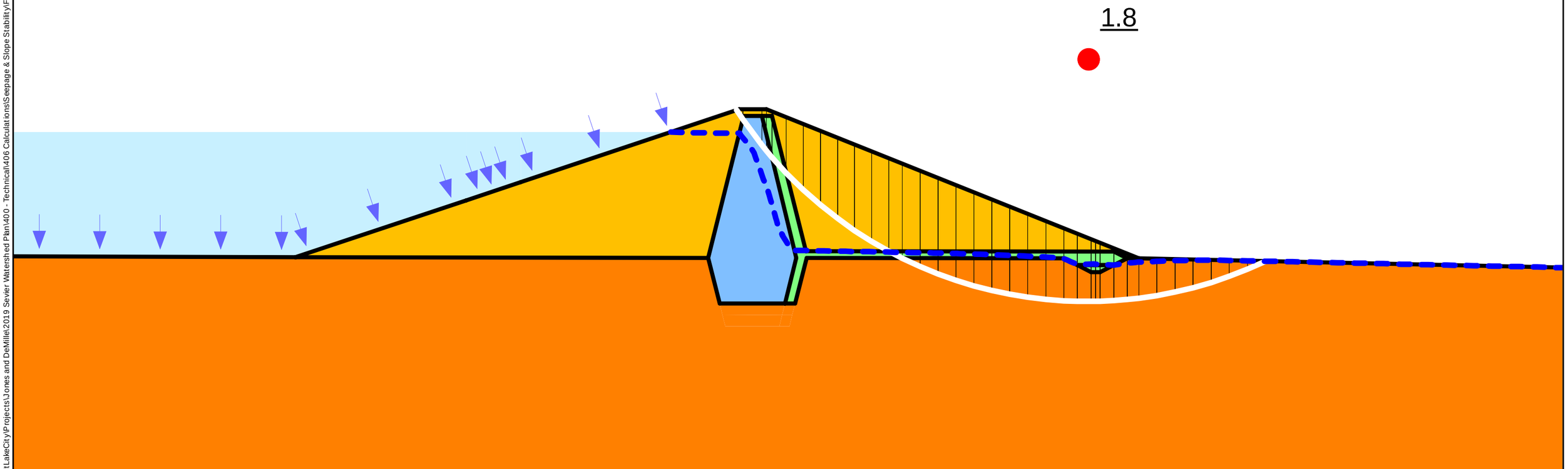


SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 12
AECOM	SEVIER COUNTY, UTAH	UPSTREAM - PSEUDOSTATIC	

8/8/2019 4:56:37 PM
\\urssaltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	130	0	33	0
	02-Core [Post-Earthquake]	Mohr-Coulomb	125	0	17.4	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	130	0	34	0

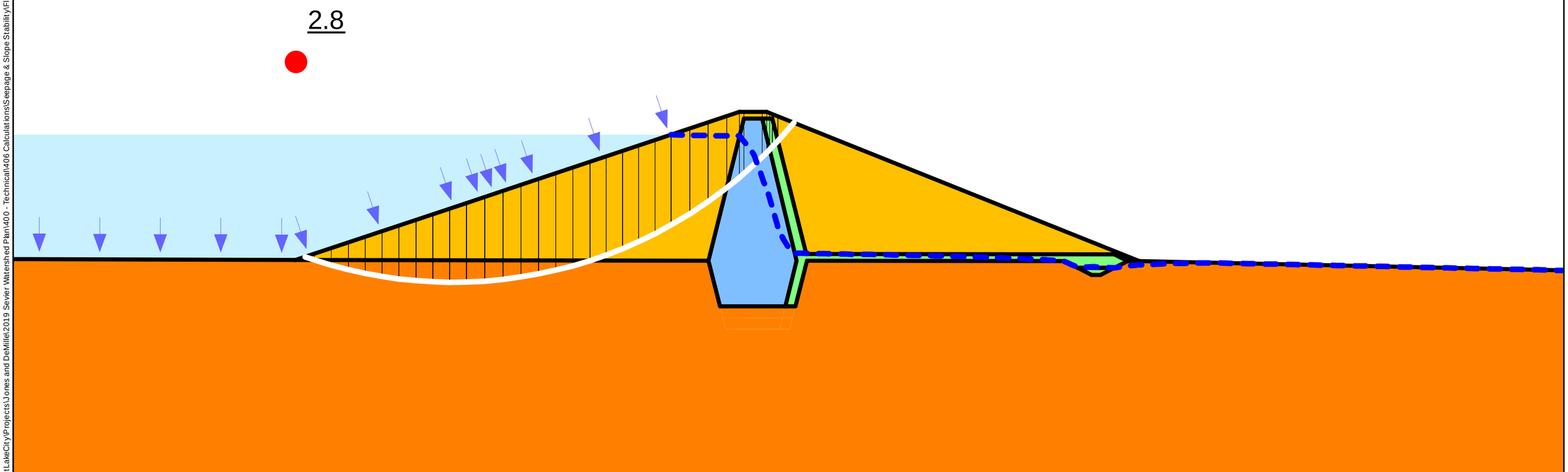


SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 13
AECOM	SEVIER COUNTY, UTAH	DOWNSTREAM - POST-EARTHQUAKE	

\\urssaltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 5:36:31 PM

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	130	0	33	0
	02-Core [Post-Earthquake]	Mohr-Coulomb	125	0	17.4	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	130	0	34	0

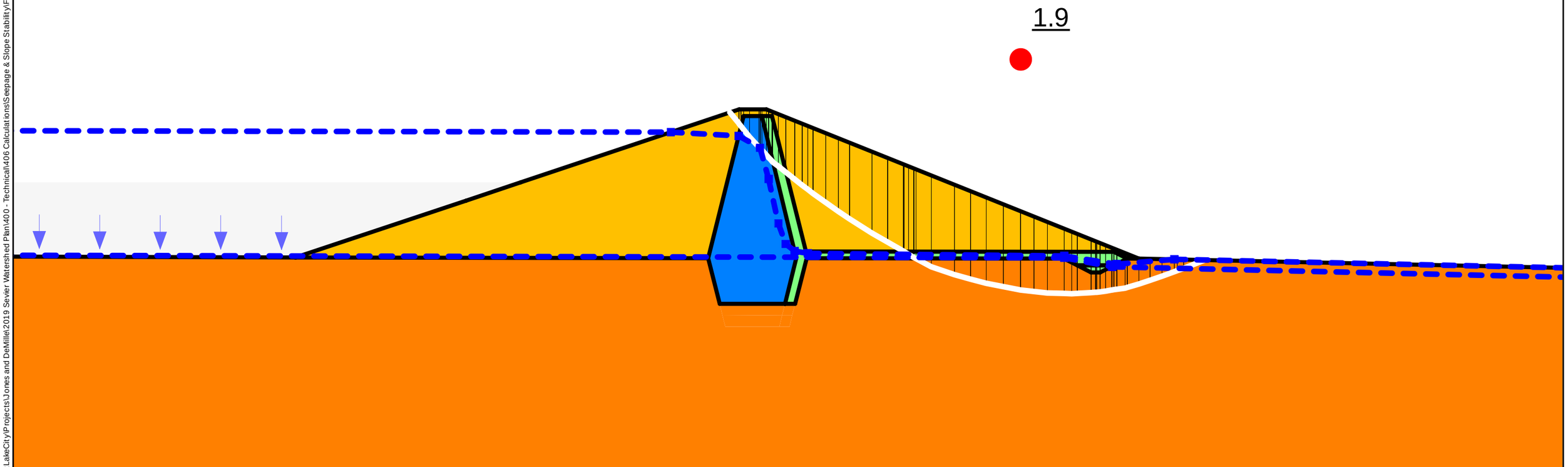


SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 14
AECOM	SEVIER COUNTY, UTAH	UPSTREAM - POST-EARTHQUAKE	

\\urssaltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 5:36:31 PM

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	01-SM with Gravel [All]	Mohr-Coulomb	130	0	33	0	0	0	1	2
	02-Core [Drained]	Mohr-Coulomb	125	0	28	0	400	16	1	2
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0	0	0	1	2
	05-Embankment Shell [All]	Mohr-Coulomb	130	0	34	0	0	0	1	2

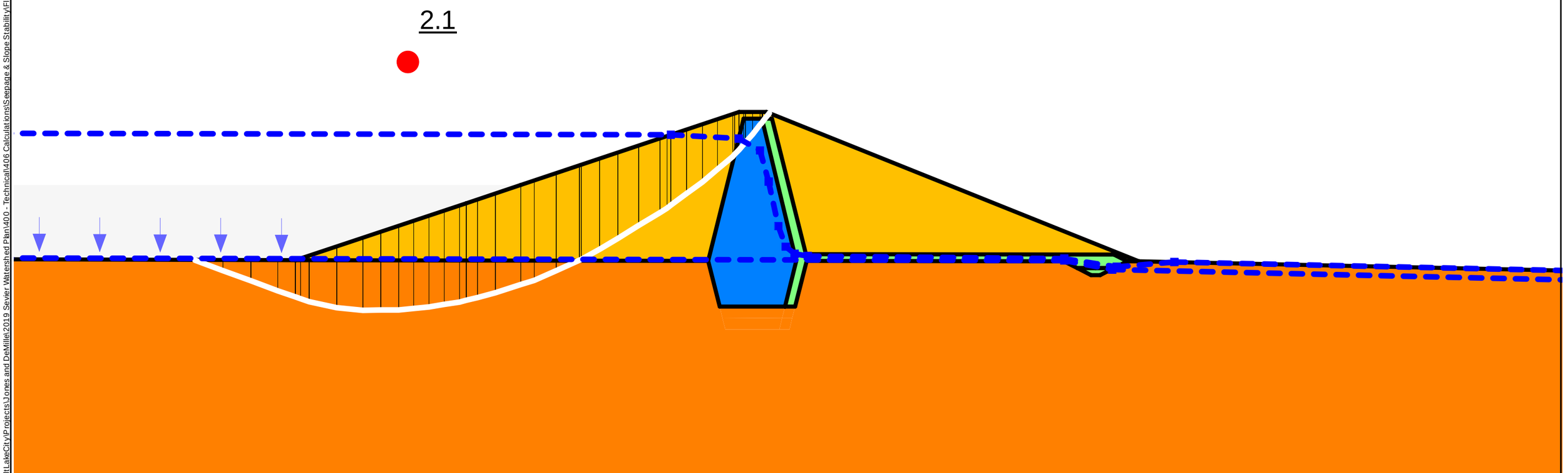


SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 15
AECOM	SEVIER COUNTY, UTAH	DOWNSTREAM - RAPID DRAWDOWN	

\\urssaltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 8:33:39 AM

Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
01-SM with Gravel [All]	Mohr-Coulomb	130	0	33	0	0	0	1	2
02-Core [Drained]	Mohr-Coulomb	125	0	28	0	400	16	1	2
03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0	0	0	1	2
05-Embankment Shell [All]	Mohr-Coulomb	130	0	34	0	0	0	1	2



SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:500.71685

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	FLAT CANYON MAXIMUM SECTION	FIGURE 16
AECOM	SEVIER COUNTY, UTAH	UPSTREAM - RAPID DRAWDOWN	

\\rrs\saltlakecity\SaltLakeCity\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Flat Canyon\August 2019 Rev\Flat Canyon.gsz 8/9/2019 8:43:25 AM

Color	Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
	01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
	02-Core [Drained]	Saturated / Unsaturated	Core	0.5	0	Core
	03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
	05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

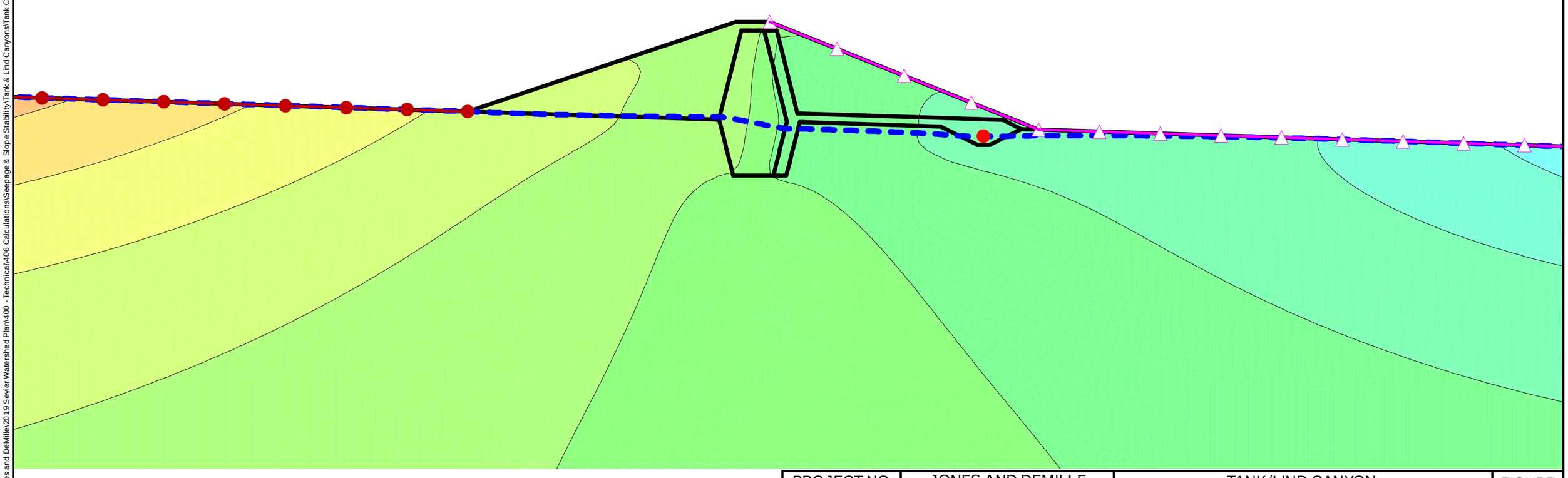
Name: Total Head

Contour parameter: Total Head ft

Starting Contour Value: 5,408 ft

Ending Contour Value: 5,436 ft

Increment by: 2 ft



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 17
AECOM	SEVIER COUNTY, UTAH	EMPTY SEEPAGE RESULTS	

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Color	Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
	01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
	02-Core [Drained]	Saturated / Unsaturated	Core	0.5	0	Core
	03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
	05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

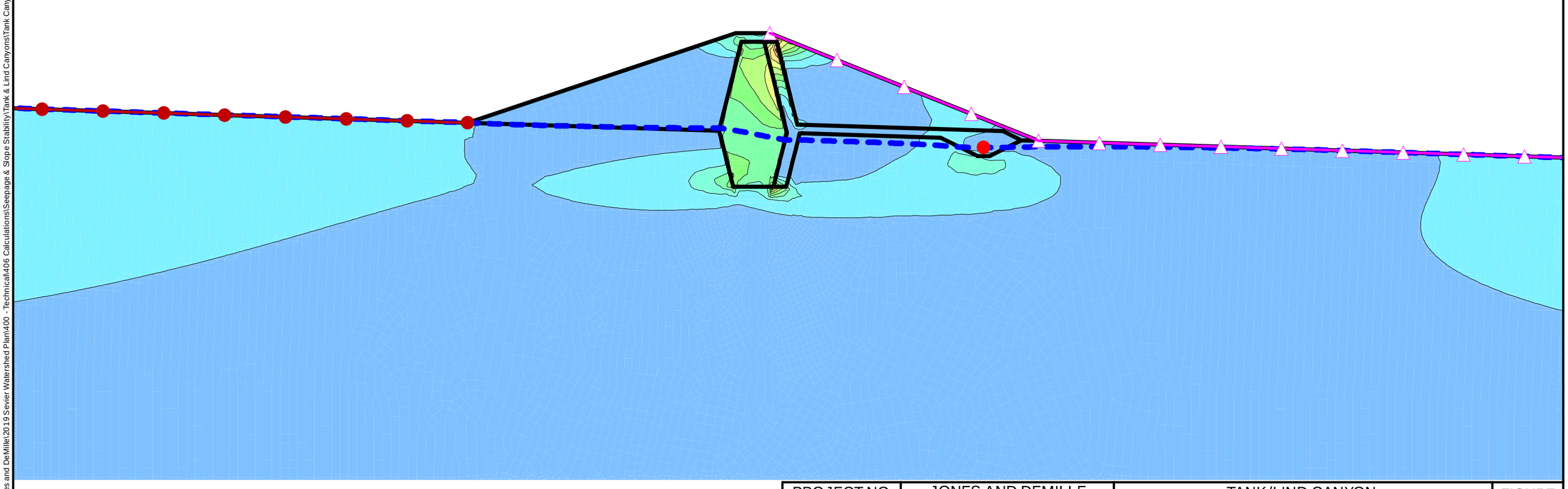
Name: Gradients

Contour parameter: XY-Gradient

Starting Contour Value: 0

Ending Contour Value: 0.5

Increment by: 0.05



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 18
AECOM	SEVIER COUNTY, UTAH	EMPTY SEEPAGE GRADIENT	

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Color	Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
	01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
	02-Core [Drained]	Saturated / Unsaturated	Core	0.5	0	Core
	03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
	05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

Name: Total Head

Contour parameter: Total Head ft

Starting Contour Value: 5,405 ft

Ending Contour Value: 5,450 ft

Increment by: 5 ft

SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 19
AECOM	SEVIER COUNTY, UTAH	FULL SEEPAGE RESULTS	

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Color	Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
	01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
	02-Core [Drained]	Saturated / Unsaturated	Core	0.5	0	Core
	03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
	05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

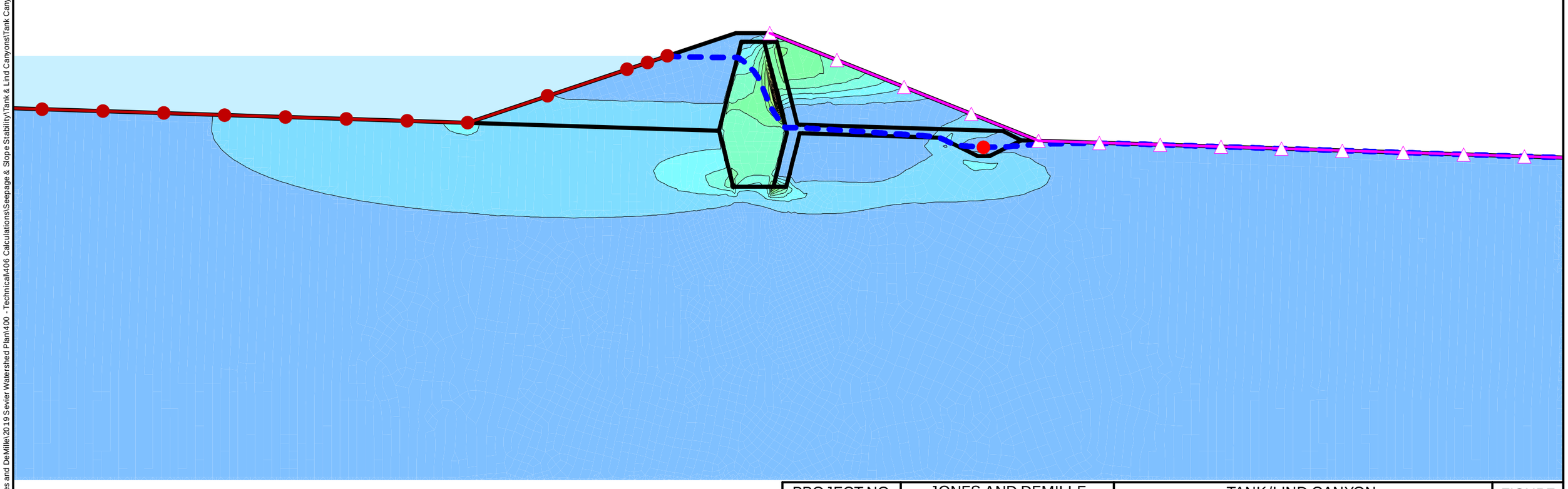
Name: Gradients

Contour parameter: XY-Gradient

Starting Contour Value: 0

Ending Contour Value: 3.2

Increment by: 0.2



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 20
AECOM	SEVIER COUNTY, UTAH	FULL SEEPAGE GRADIENT	

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Color	Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
	01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
	02-Core [Drained]	Saturated / Unsaturated	Core	0.5	0	Core
	03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
	04-Basin Sediment [Drained]	Saturated / Unsaturated	Sediment	0.1	0	Sediment
	05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

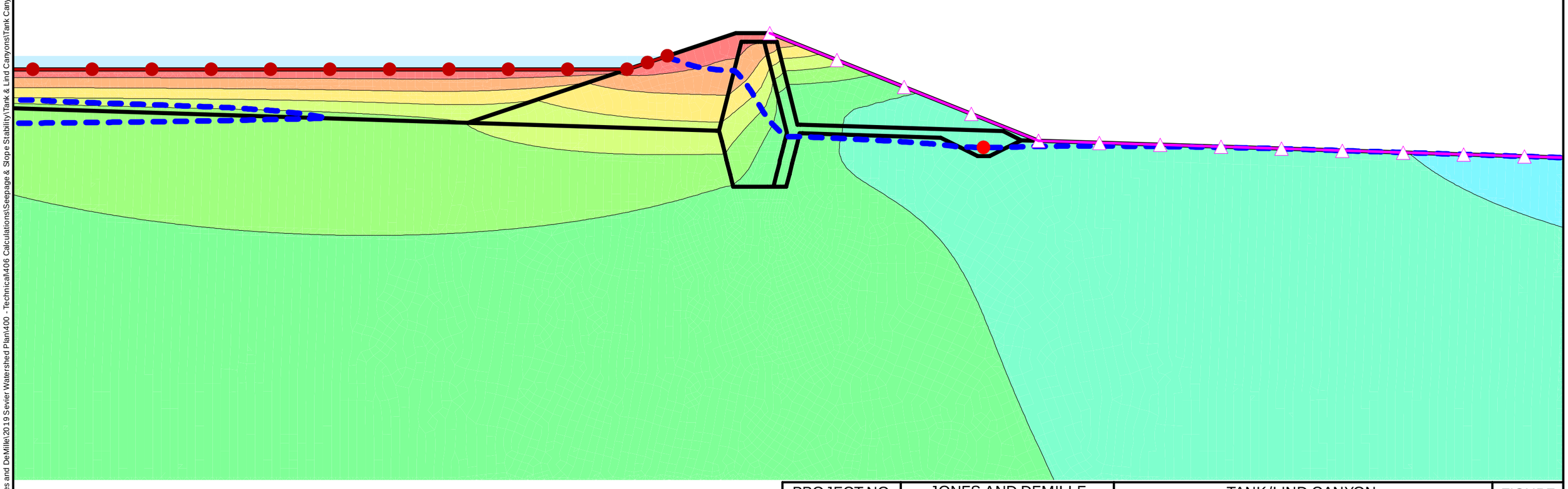
Name: Total Head

Contour parameter: Total Head ft

Starting Contour Value: 5,405 ft

Ending Contour Value: 5,450 ft

Increment by: 5 ft



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 21
AECOM	SEVIER COUNTY, UTAH	SEDIMENT FILLED SEEPAGE RESULTS	

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Color	Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
	01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
	02-Core [Drained]	Saturated / Unsaturated	Core	0.5	0	Core
	03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
	04-Basin Sediment [Drained]	Saturated / Unsaturated	Sediment	0.1	0	Sediment
	05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

Name: Gradients

Contour parameter: XY-Gradient

Starting Contour Value: 0

Ending Contour Value: 3.4

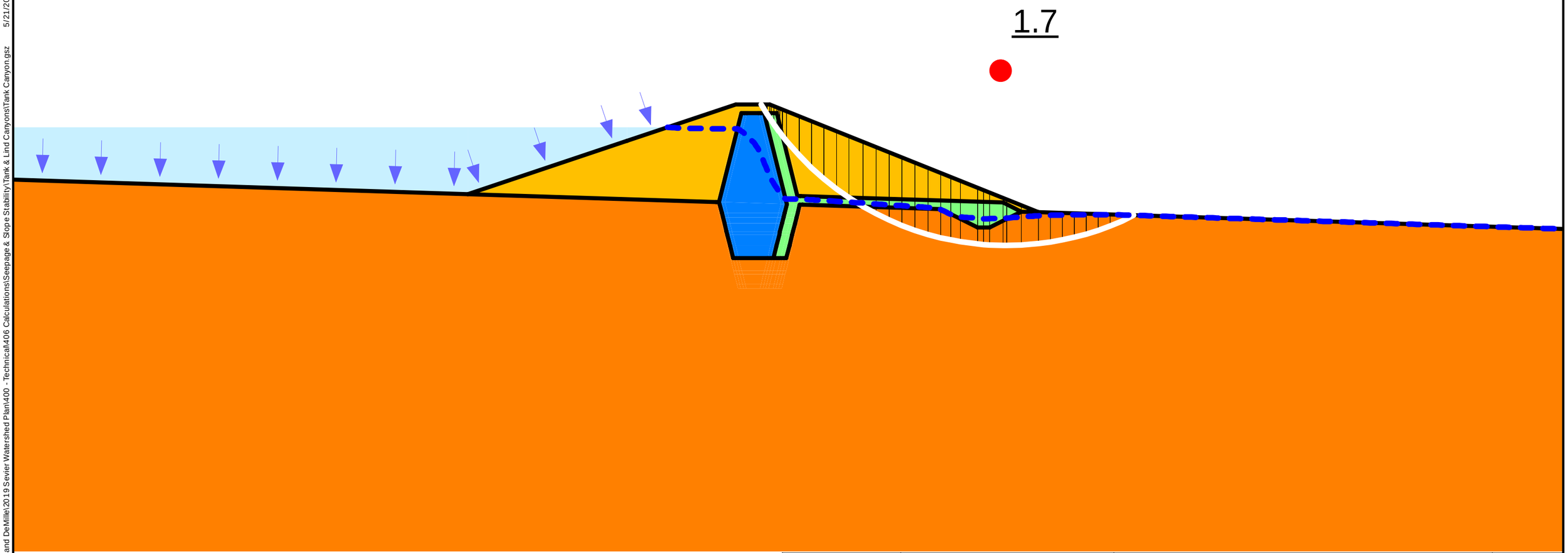
Increment by: 0.2

SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 22
AECOM	SEVIER COUNTY, UTAH	SEDIMENT FILLED SEEPAGE GRADIENT	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0
	02-Core [Drained]	Mohr-Coulomb	125	0	28	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0

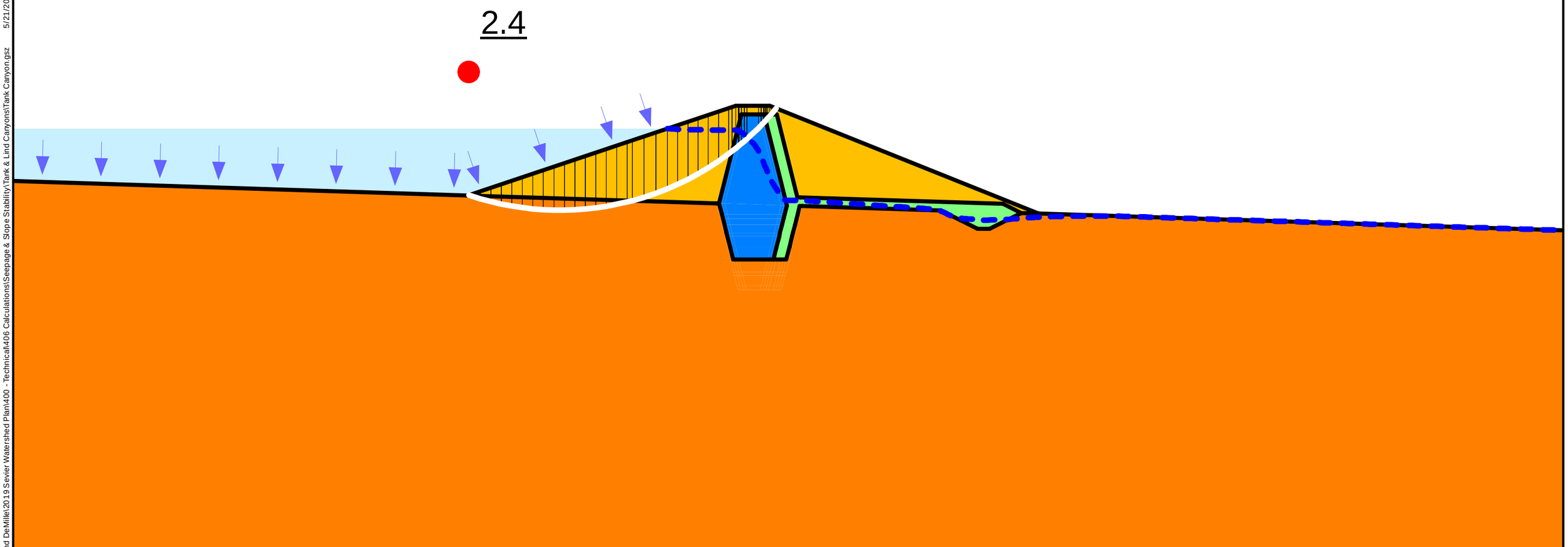


SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 23
AECOM	SEVIER COUNTY, UTAH	DOWNSTREAM - DRAINED	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0
	02-Core [Drained]	Mohr-Coulomb	125	0	28	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0

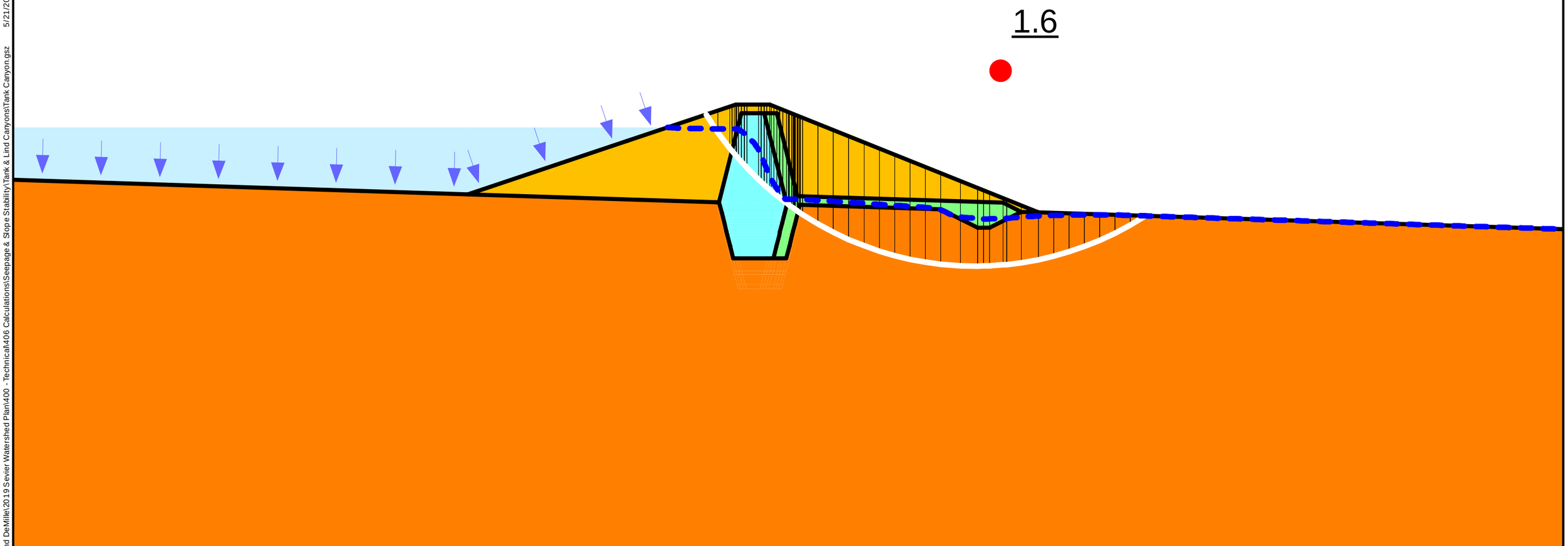


SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 24
AECOM	SEVIER COUNTY, UTAH	UPSTREAM - DRAINED	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0
	02-Core [Undrained]	Mohr-Coulomb	125	0	21.8	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0



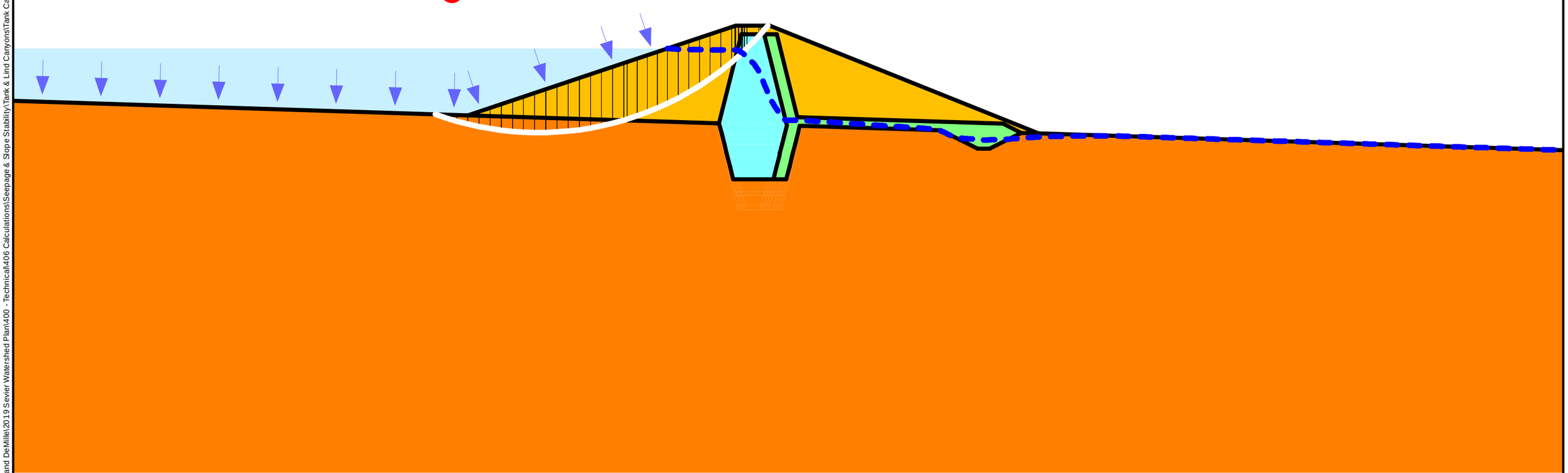
SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE
AECOM	SEVIER COUNTY, UTAH	DOWNSTREAM - UNDRAINED	25

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0
	02-Core [Undrained]	Mohr-Coulomb	125	0	21.8	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0

2.4

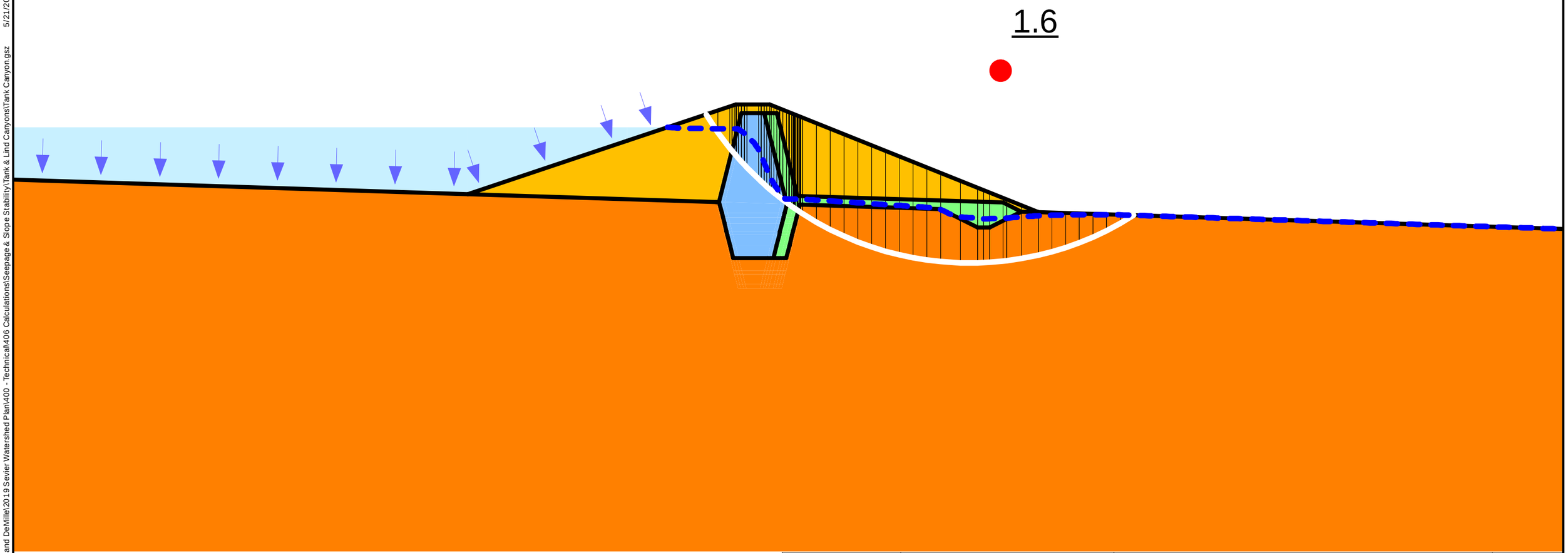


SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 26
AECOM	SEVIER COUNTY, UTAH	UPSTREAM - UNDRAINED	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0
	02-Core [Post-Earthquake]	Mohr-Coulomb	125	0	17.4	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0



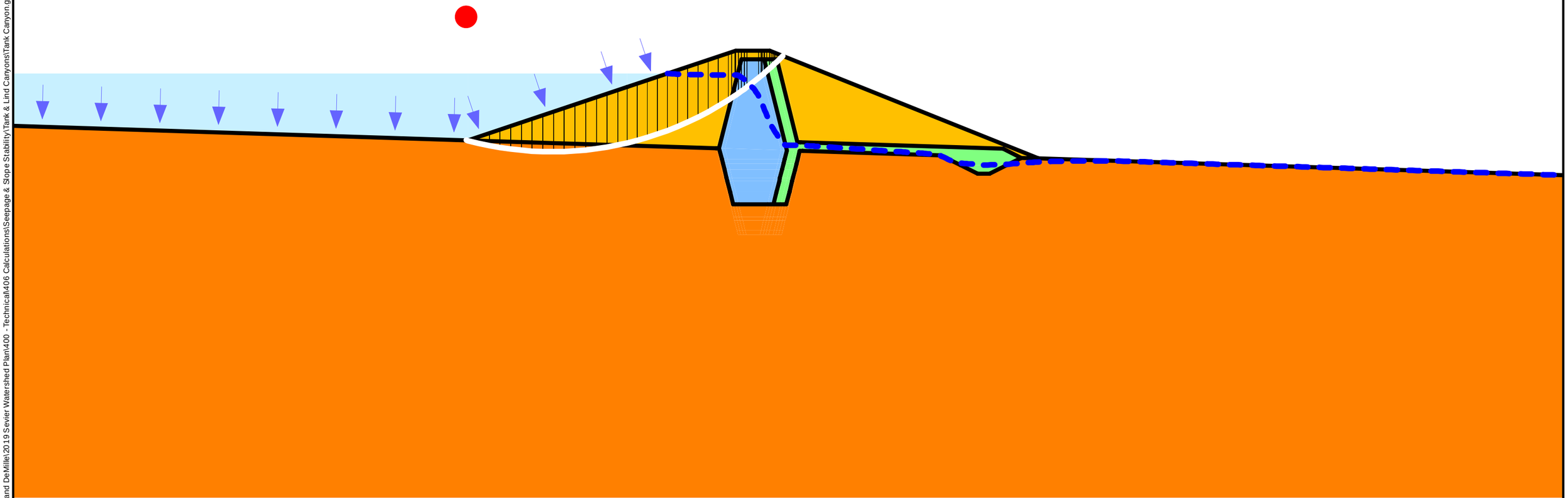
SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 27
AECOM	SEVIER COUNTY, UTAH	DOWNSTREAM - POST-EARTHQUAKE	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0
	02-Core [Post-Earthquake]	Mohr-Coulomb	125	0	17.4	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0

2.3



SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

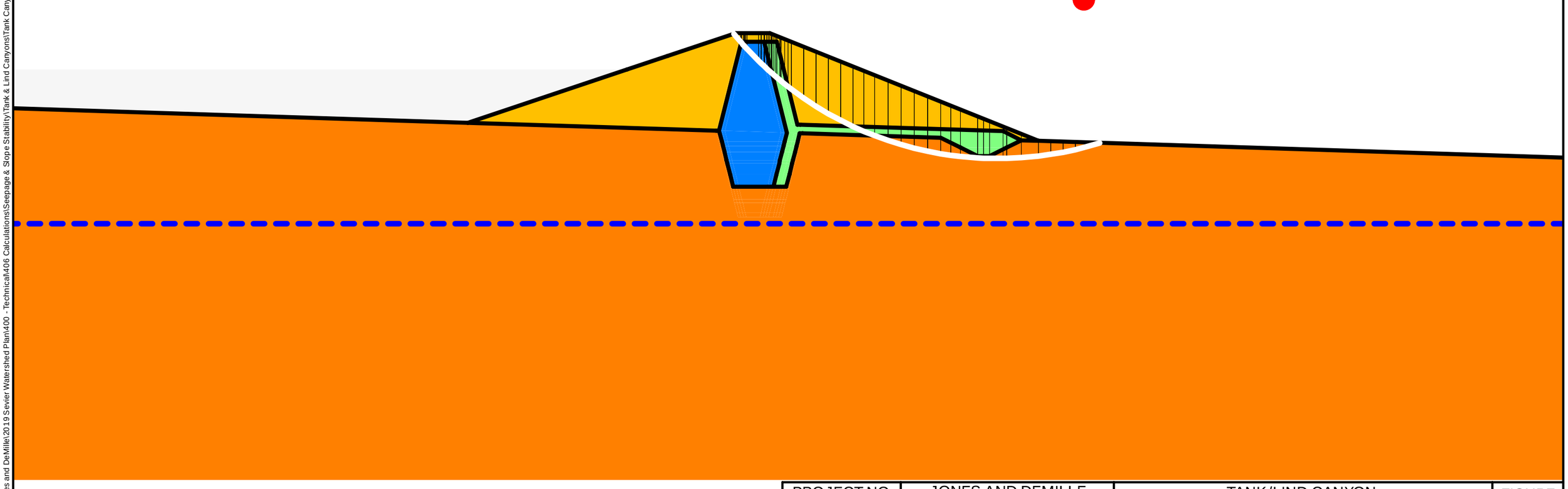
PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 28
AECOM	SEVIER COUNTY, UTAH	UPSTREAM - POST-EARTHQUAKE	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0	1
	02-Core [Drained]	Mohr-Coulomb	125	0	28	0	1
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0	1
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0	1

Horz Seismic Coef.: 0.245

1.1



SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

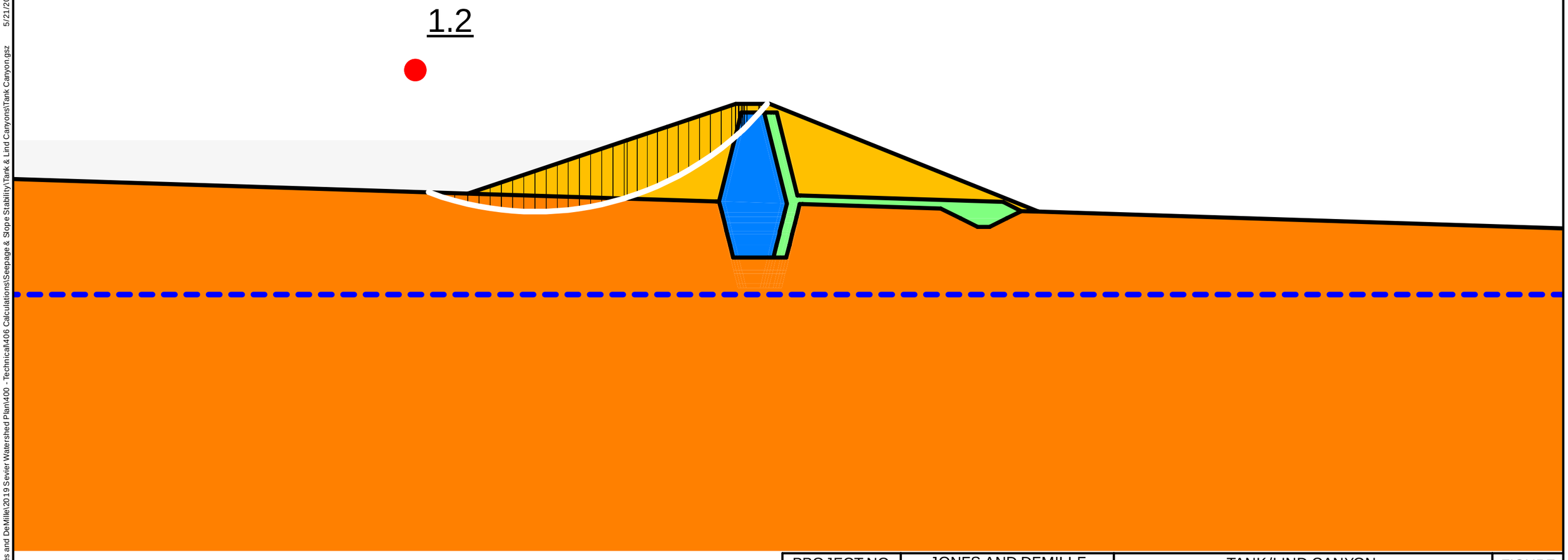
PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 29
AECOM	SEVIER COUNTY, UTAH	DOWNSTREAM - PSEUDOSTATIC	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0	1
	02-Core [Drained]	Mohr-Coulomb	125	0	28	0	1
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0	1
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0	1

Horz Seismic Coef.: 0.245

1.2



SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 30
AECOM	SEVIER COUNTY, UTAH	UPSTREAM - PSEUDOSTATIC	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0	0	0	1	2
	02-Core [Drained]	Mohr-Coulomb	125	0	28	0	400	16	1	2
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0	0	0	1	2
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0	0	0	1	2

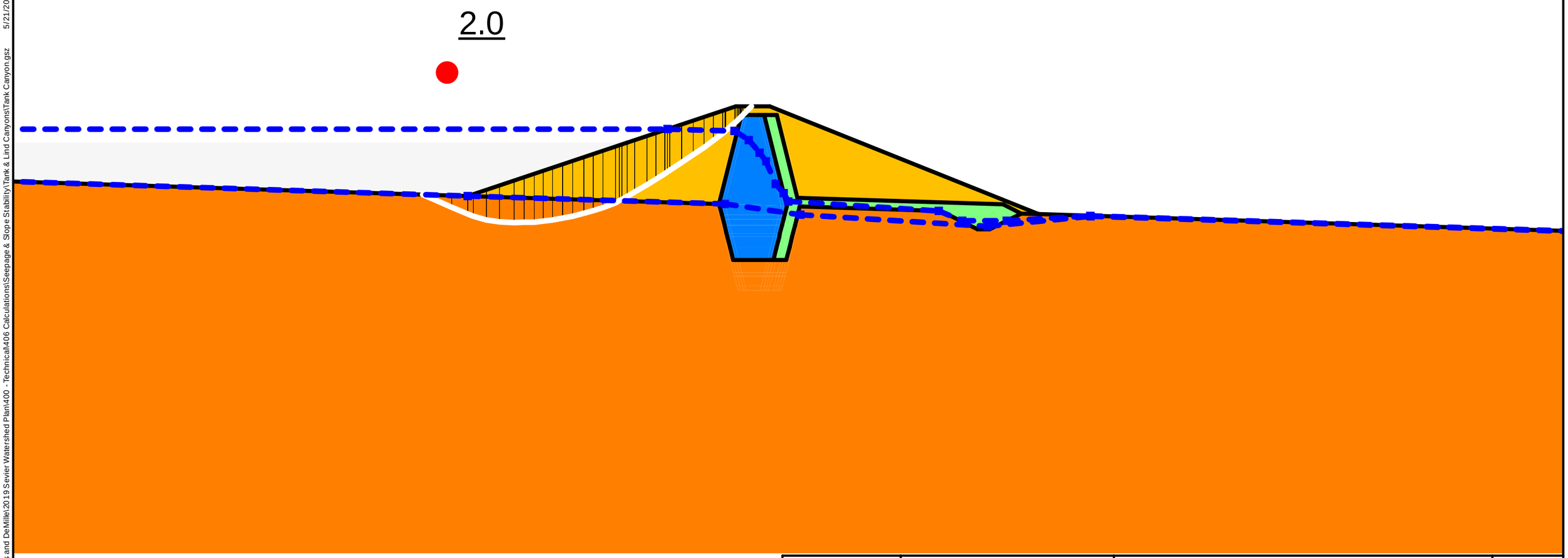
1.8

SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 31
AECOM	SEVIER COUNTY, UTAH	DOWNSTREAM - RAPID DRAWDOWN	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0	0	0	1	2
	02-Core [Drained]	Mohr-Coulomb	125	0	28	0	400	16	1	2
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0	0	0	1	2
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0	0	0	1	2



SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 32
AECOM	SEVIER COUNTY, UTAH	UPSTREAM - RAPID DRAWDOWN	

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Color	Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
	01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
	03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
	03-Gravel Drain [All]	Saturated / Unsaturated	Gravel Drain	1	0	Gravel Drain
	05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

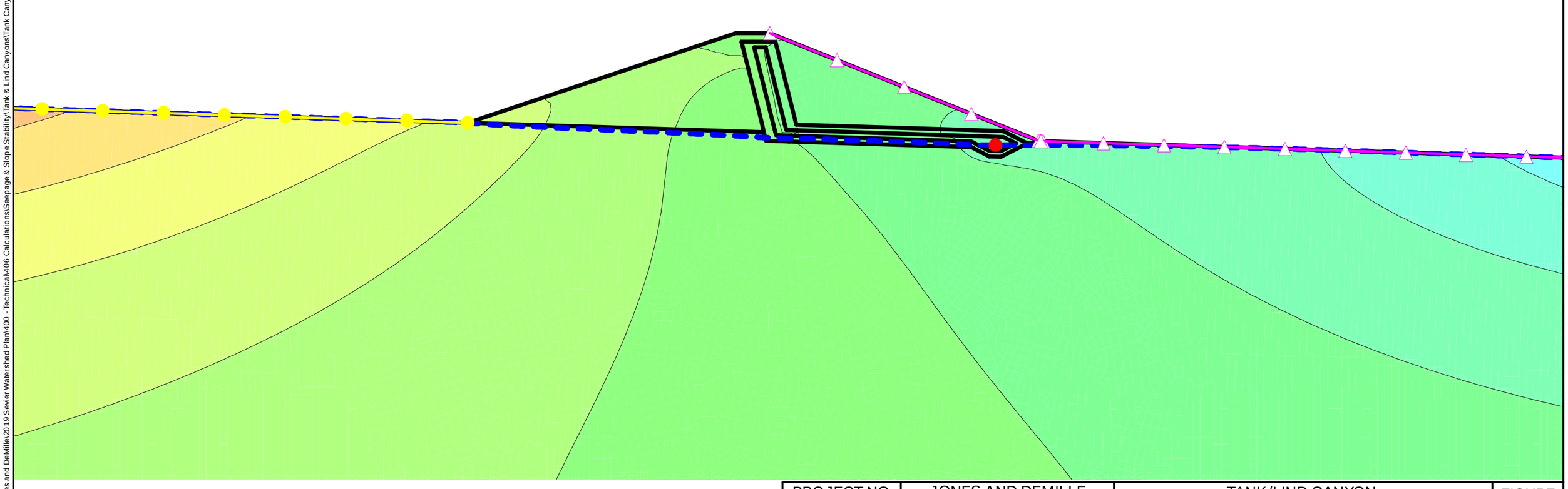
Name: Total Head

Contour parameter: Total Head ft

Starting Contour Value: 5,408 ft

Ending Contour Value: 5,436 ft

Increment by: 2 ft



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 33
AECOM	SEVIER COUNTY, UTAH	EMPTY SEEPAGE RESULTS	

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Color	Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
	01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
	03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
	03-Gravel Drain [All]	Saturated / Unsaturated	Gravel Drain	1	0	Gravel Drain
	05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

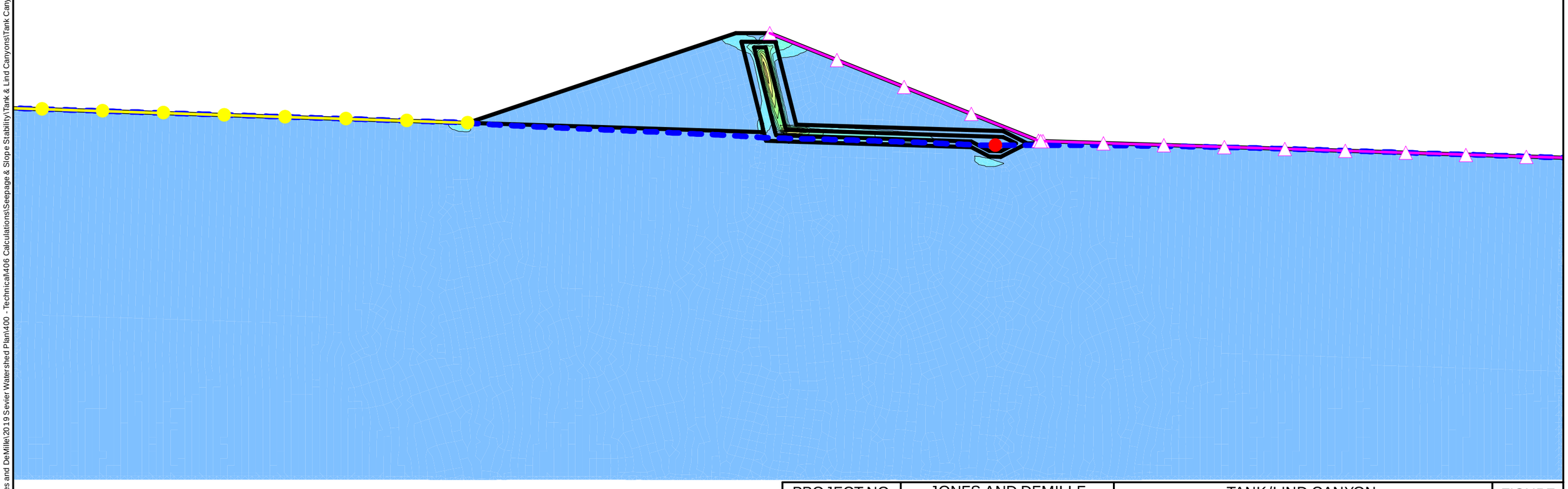
Name: Gradients

Contour parameter: XY-Gradient

Starting Contour Value: 0

Ending Contour Value: 1.1

Increment by: 0.1



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 34
AECOM	SEVIER COUNTY, UTAH	EMPTY SEEPAGE GRADIENT	

Q:\Projects\Jones and DeMille\2019 Sevier Watershed Plan\400 - Technical\406 Calculations\Seepage & Slope Stability\Tank & Lind Canyons\Tank Canyon_Drain.gsz 5/20/2019 2:11:21 PM

Color	Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
	01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
	03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
	03-Gravel Drain [All]	Saturated / Unsaturated	Gravel Drain	1	0	Gravel Drain
	05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

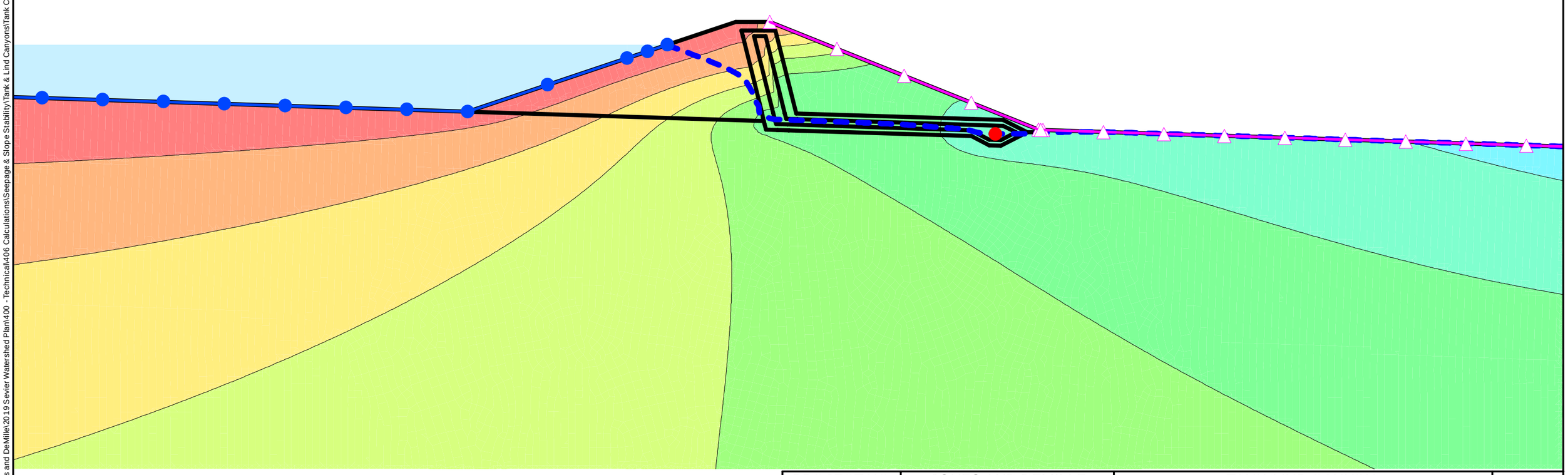
Name: Total Head

Contour parameter: Total Head ft

Starting Contour Value: 5,405 ft

Ending Contour Value: 5,450 ft

Increment by: 5 ft



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 35
AECOM	SEVIER COUNTY, UTAH	FULL SEEPAGE RESULTS	

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Color	Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
	01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
	03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
	03-Gravel Drain [All]	Saturated / Unsaturated	Gravel Drain	1	0	Gravel Drain
	05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

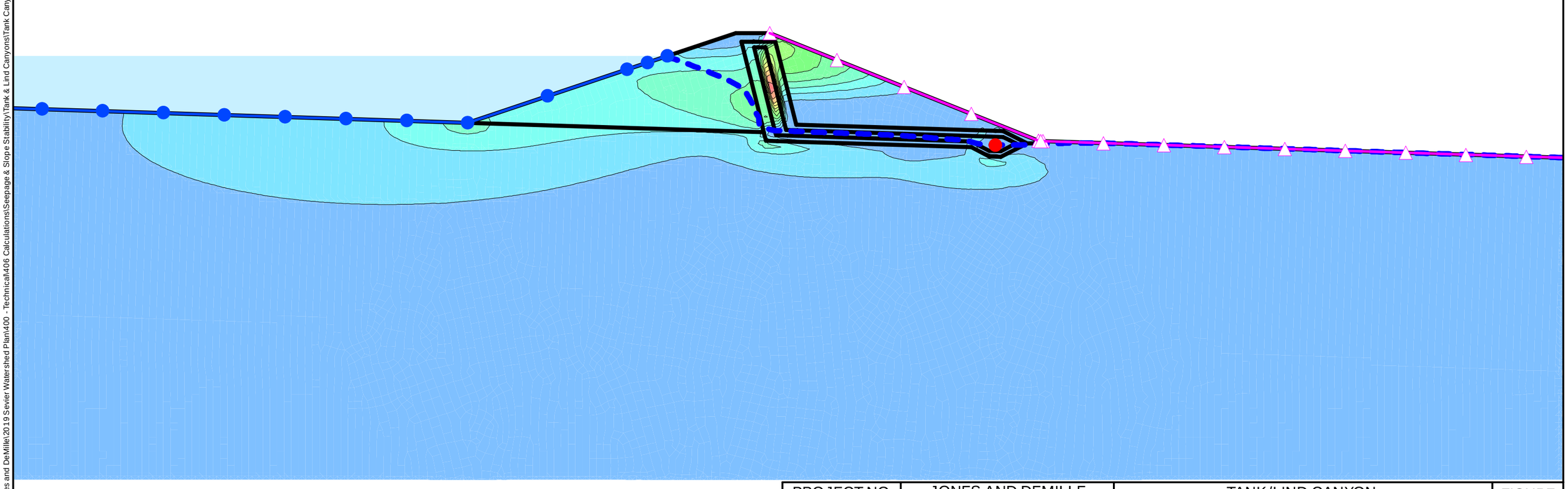
Name: Gradients

Contour parameter: XY-Gradient

Starting Contour Value: 0

Ending Contour Value: 2.6

Increment by: 0.2



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 36
AECOM	SEVIER COUNTY, UTAH	FULL SEEPAGE GRADIENT	

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Color	Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
	01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
	03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
	03-Gravel Drain [All]	Saturated / Unsaturated	Gravel Drain	1	0	Gravel Drain
	04-Basin Sediment [Drained]	Saturated / Unsaturated	Sediment	0.1	0	Sediment
	05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

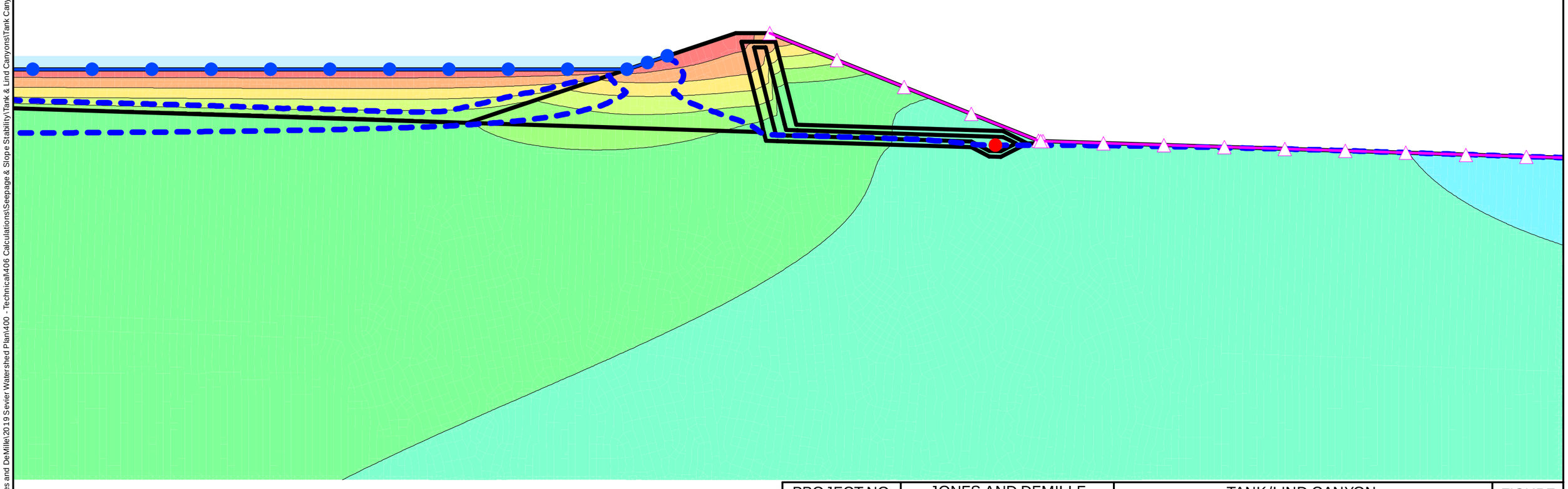
Name: Total Head

Contour parameter: Total Head ft

Starting Contour Value: 5,405 ft

Ending Contour Value: 5,450 ft

Increment by: 5 ft



SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 37
AECOM	SEVIER COUNTY, UTAH	SEDIMENT FILLED SEEPAGE RESULTS	

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Color	Name	Model	K-Function	Ky'/Kx' Ratio	Rotation (°)	Vol. WC. Function
	01-SM with Gravel [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel
	03-Filter Drain [All]	Saturated / Unsaturated	Filter Drain	1	0	Filter Drain
	03-Gravel Drain [All]	Saturated / Unsaturated	Gravel Drain	1	0	Gravel Drain
	04-Basin Sediment [Drained]	Saturated / Unsaturated	Sediment	0.1	0	Sediment
	05-Embankment Shell [All]	Saturated / Unsaturated	SM with Gravel	0.1	0	SM with Gravel

Name: Gradients

Contour parameter: XY-Gradient

Starting Contour Value: 0

Ending Contour Value: 4.5

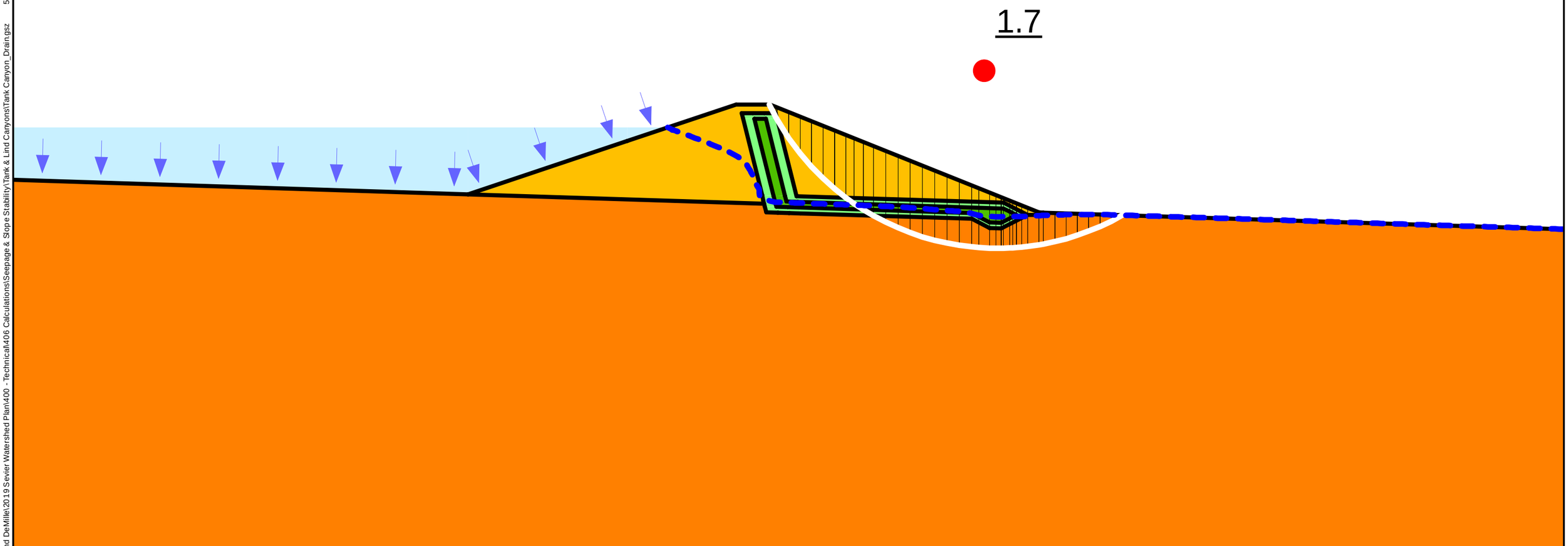
Increment by: 0.5

SOFTWARE VERSION: SEEP/W v. 8.16.2.14053
METHOD: Steady-State
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 38
AECOM	SEVIER COUNTY, UTAH	SEDIMENT FILLED SEEPAGE GRADIENT	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	03-Gravel Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0



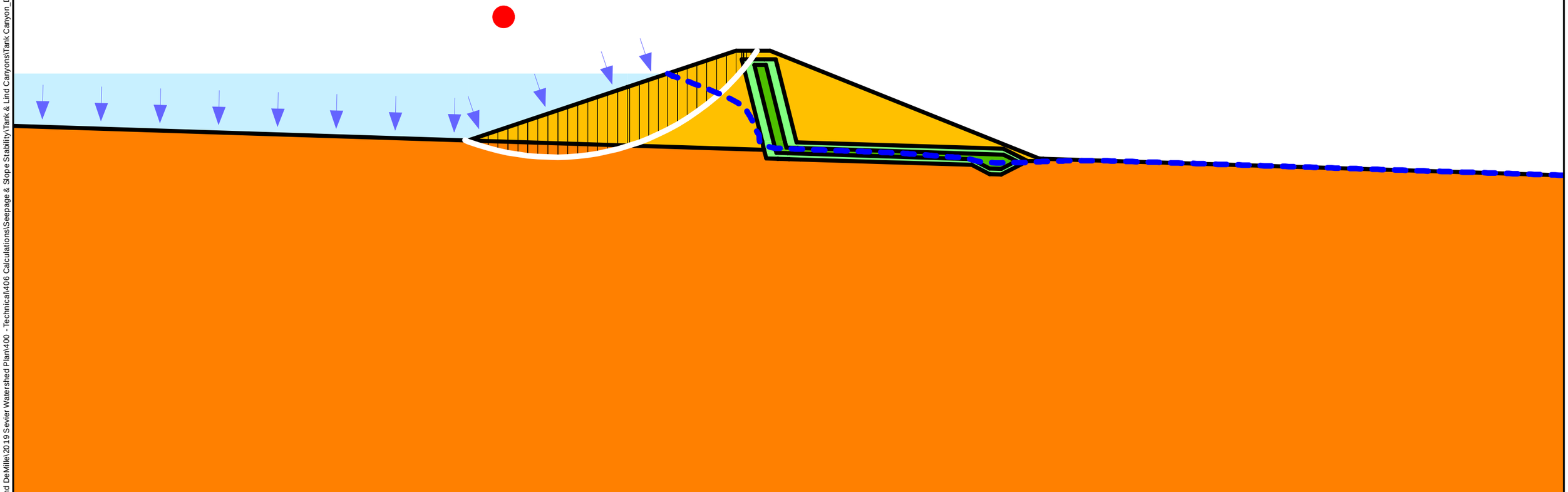
SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 39
AECOM	SEVIER COUNTY, UTAH	DRAINED - DOWNSTREAM	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0
	03-Gravel Drain [All]	Mohr-Coulomb	120	0	36	0
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0

3.1



SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

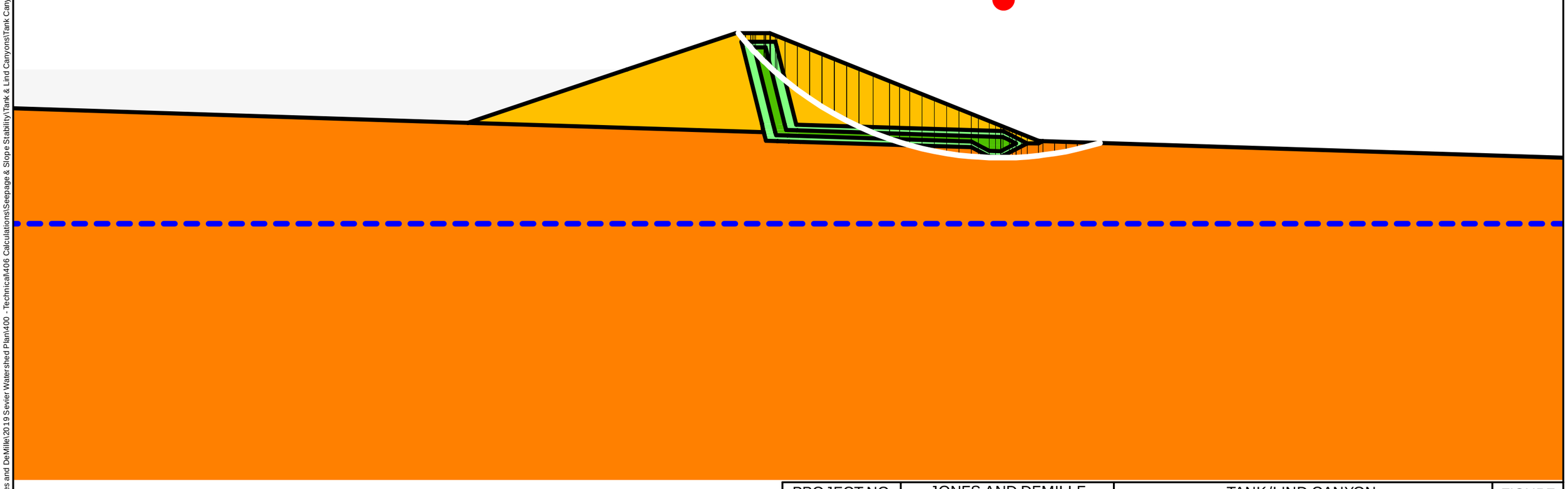
PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 40
AECOM	SEVIER COUNTY, UTAH	DRAINED - UPSTREAM	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0	1
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0	1
	03-Gravel Drain [All]	Mohr-Coulomb	120	0	36	0	1
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0	1

Horz Seismic Coef.: 0.245

1.1



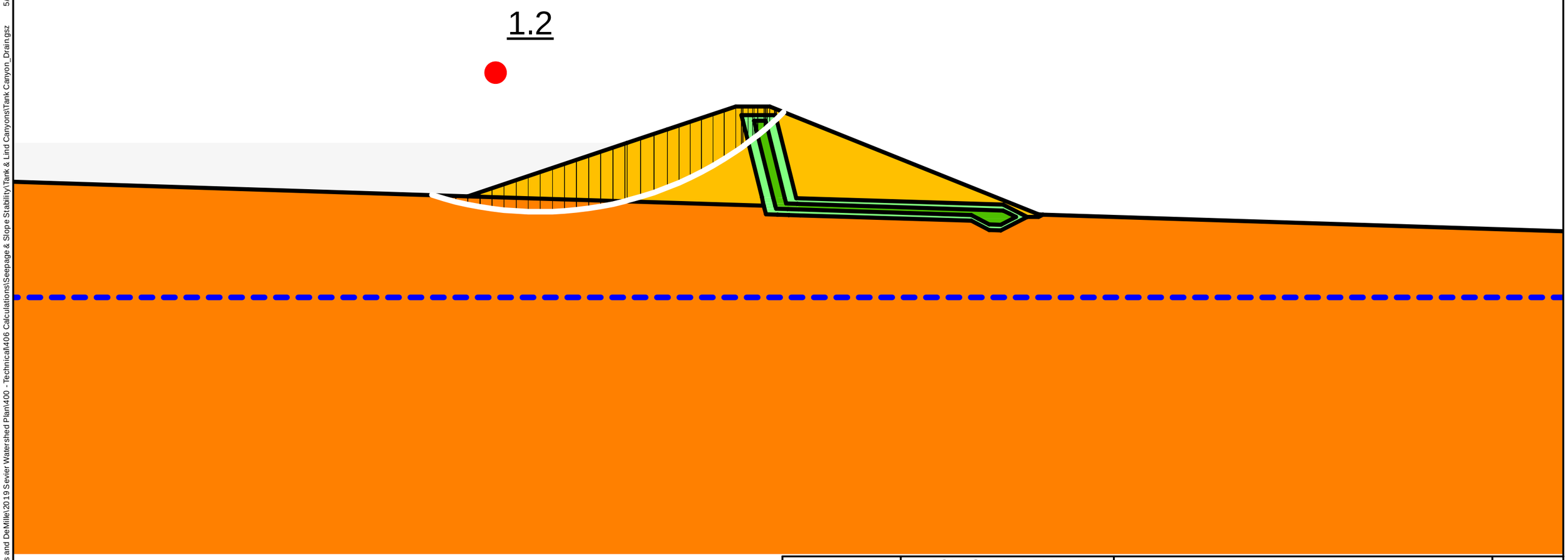
SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 41
AECOM	SEVIER COUNTY, UTAH	PSEUDOSTATIC - DOWNSTREAM	

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Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	01-SM with Gravel [All]	Mohr-Coulomb	125	0	30	0	1
	03-Filter Drain [All]	Mohr-Coulomb	120	0	36	0	1
	03-Gravel Drain [All]	Mohr-Coulomb	120	0	36	0	1
	05-Embankment Shell [All]	Mohr-Coulomb	125	0	34	0	1

Horz Seismic Coef.: 0.245

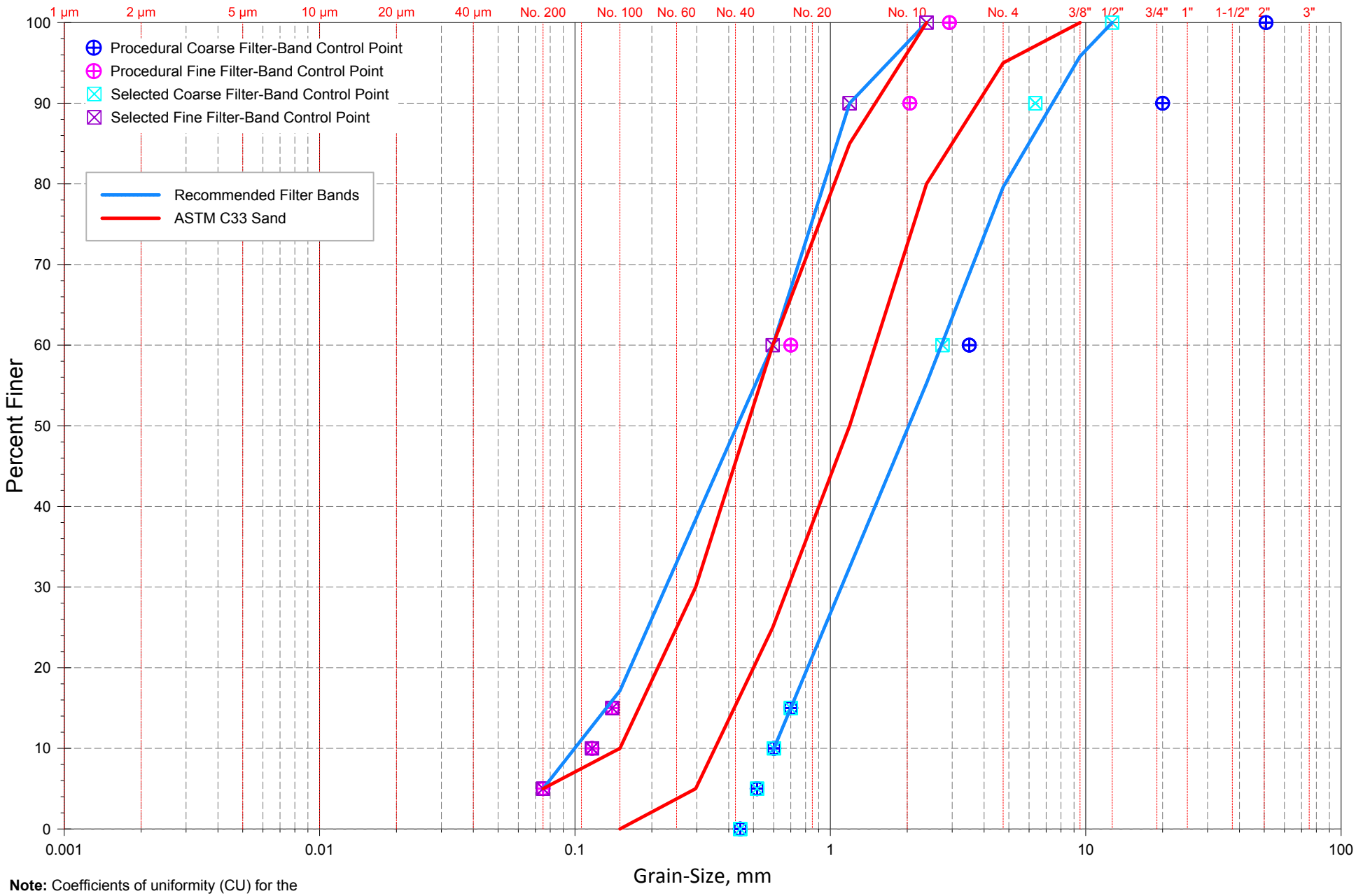


SOFTWARE VERSION: SLOPE/W v. 8.16.2.14053
METHOD: Spencer
Scale: 1:400.57348

PROJECT NO. 60598028	JONES AND DEMILLE ENGINEERING	TANK/LIND CANYON MAXIMUM SECTION	FIGURE 42
AECOM	SEVIER COUNTY, UTAH	PSEUDOSTATIC - UPSTREAM	

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Attachment G. Recommended Filter Bands



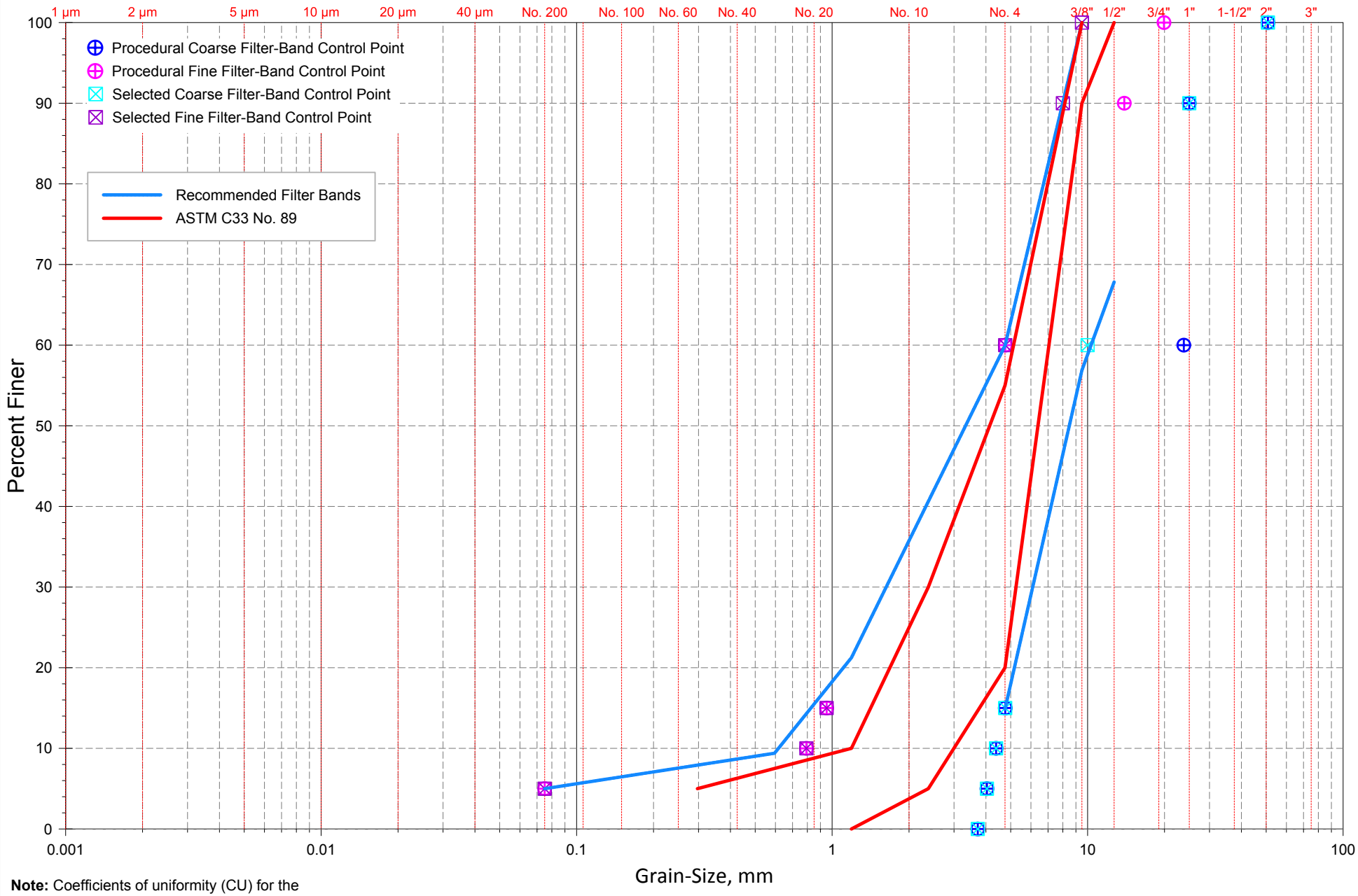
Note: Coefficients of uniformity (CU) for the recommended fine and coarse filter bands are 5.96 and 4.53, respectively.

Method: Natural Resources Conservation Service [NRCS]. (2017). "Gradation Design of Sand and Gravel Filters." *National Engineering Handbook, Part 633 - Soil Engineering*, United States Department of Agriculture, Washington, D.C., 62.

PROJECT NO. 60598028	JONES & DEMILLE ENGINEERING	ZONE 1 FILTER RECOMMENDED FILTER BAND SHOWING ASTM C33 Sand	FIGURE 1
AECOM	SEVIER COUNTY, UTAH		

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Note: Coefficients of uniformity (CU) for the recommended fine and coarse filter bands are 7.71 and #VALUE!, respectively.

Method: Natural Resources Convervation Service [NRCS]. (2017). "Gradation Design of Sand and Gravel Filters." *National Engineering Handbook, Part 633 - Soil Engineering*, United States Department of Agriculture, Washington, D.C., 62.

PROJECT NO. 60598028	JONES & DEMILLE ENGINEERING	ZONE 2 FILTER RECOMMENDED FILTER BAND SHOWING ASTM C33 No. 89	FIGURE 2
AECOM	SEVIER COUNTY, UTAH		

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TM006 – Economic Analysis

Table of Contents

1.0 Overview 1
2.0 Economic Evaluation Procedures, Assumptions, and Methods 2
2.1 Structure-Related Damages 2
2.2 Agriculture-Related Damages 9
2.3 Economic Analysis Benefits, Costs, and Results 16
3.0 References 20

Tables

Table 1-1. Description of the With-Project Alternative 1
Table 1-2. Benefit-Cost Analysis Summary 1
Table 2-1. Structures Inventoried 4
Table 2-2. Assumed Foundation Heights 4
Table 2-3. RS Means Replacement Values and Depreciation Rates 5
Table 2-4. Contents Value as a Percent of Structure Value 7
Table 2-5. Summary of Residential Debris Costs 9
Table 2-6. Crops in Study Area 10
Table 2-7. Crop Progress 10
Table 2-8. HEC-FIA Assumptions 12
Table 2-9. Crop Plant Data Assumptions 12
Table 2-10. Crop Damages from 1 to 3 days of Inundation 15
Table 2-11. Planting and Production Costs per Acre 15
Table 2-12. Average Crop Yield and Average Production Value 16
Table 2-13. Likelihood of Flooding by Month 16
Table 2-14. Number of Buildings Protected for the 0.2-percent-annual-probability Flood Event 17
Table 2-15. Structure-Related Benefits by Flood Event and Structure Type (in thousands) 17
Table 2-16. Average Annual Structure-Related Benefits 18
Table 2-17. Breakdown of Agricultural Land Inundated by Crop (acres) 18
Table 2-20. Cost Breakdown 19
Table 2-21. Benefit-Cost Analysis Summary 19

1.0 Overview

AECOM Technical Services, Inc. (AECOM) conducted economic analyses for the identified alternative of the Richfield-West Sevier Watershed Plan. This technical memorandum presents National Economic Development (NED) benefits that were developed following guidance in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (U.S. Water Resources Council 1983). The primary benefit categories evaluated were agricultural benefits and community (residential and non-residential structures, roads and bridges, other infrastructure) flood risk management benefits.

This memorandum describes the methods used to quantify damages avoided for the identified alternative (hereafter with-project alternative). Table 1-1 describes the with-project alternative.

Table 1-1. Description of the With-Project Alternative

Component	Description
Flat Canyon Debris Basin	Construct a debris basin near the mouth of Flat Canyon
South Flood Channel	Construct a channel to divert floodwaters from Flat Canyon
North Flood Channel	Construct a channel to divert floodwaters from Flat Canyon

Economic feasibility for a with-project alternative is determined by comparing the average annual benefits to the average annual costs. If the average annual benefits for a with-project alternative exceed the average annual costs, then the alternative is considered economically feasible. The economic analysis considers the no-action scenario (hereafter without-project alternative) as the baseline condition, which does not have any benefits or costs associated with it. Changes resulting from implementation of a with-project alternative in relation to the without-project alternative would be measured as a benefit or a dis-benefit.

The analyses of benefits associated for the with-project alternative include damage reduction to residential and nonresidential structures (e.g., residential, commercial, religious facility, government), contents, automobiles, agriculture, and debris removal.

The benefit categories represent damage reduction from future flooding and are evaluated in average annual terms. The flood damage reduction analysis uses inundation models for eight flood recurrence intervals, which are the 50-percent- (2-year), 20-percent- (5-year), 10-percent- (10-year), 4-percent- (25-year), 2-percent- (50-year), 1-percent- (100-year), 0.5-percent- (200-year), and 0.2-percent- (500-year) annual-probability flood events, to estimate future damages from flooding within the study area.

Benefits and costs over the period of analysis were annualized to allow for a direct comparison of average annual benefits to average annual costs. The benefits and costs were evaluated using a 2025 price level over a 102-year period of analysis (2 years of construction and 100-year evaluation period). The costs and benefits were annualized over the 100-year evaluation period using a 3.0 percent discount rate. Table 1-2 outlines the average annual benefits and costs for the with-project alternative and summarizes the analysis results.

Table 1-2. Benefit-Cost Analysis Summary

Alternative	Average Annual Benefits	Average Annual Costs	Benefit-Cost Ratio	Net Benefits
With-Project Alternative	$1,757,000	$685,000	2.6:1.0	$1,072,000

Notes: 2025 price level, annualized over the 100-year evaluation period using a 3.0% discount rate.

The following sections discuss the types of evaluations and methods used in the economic analysis.

2.0 Economic Evaluation Procedures, Assumptions, and Methods

The analyses of damages associated with the alternatives include damages or costs incurred for a range of benefit categories. The benefits evaluated include damage reductions to residential and nonresidential structures and contents, automobiles and agriculture, and debris removal. Damages to structures and contents typically account for the most damages that result from a flood event, and therefore, form the foundation of the economic analyses. Damages were estimated using custom-built economic models.

2.1 Structure-Related Damages

Knowledge of existing residential and nonresidential development located in a floodplain is essential when evaluating a flood-risk-management project. Structure-related damages assessed include damages to residential and nonresidential structures, contents, and automobiles, and debris removal. The methods used to assess structure damages are described in this section.

2.1.1 Structure Inventory

A structure inventory was undertaken to estimate the residential and nonresidential structures located in the study area, which serves as the base data for the economic analysis. The structure inventory comprises residential (with and without basements) and nonresidential structures that are within the area of inundation based on the hydrologic and hydraulic (H&H) models. Data from the Sevier County Assessor's Office were utilized as the basis for the structure inventory.

In addition, a 50-foot buffer was used in calculating relative flood depths from the flood inundation models. This was done to ensure the analysis captures the flooding that would affect structures that are partially flooded (i.e., partial building flooding that does not cover the address point near the center of the building) as well as to better represent the two-dimensional (2D) modeling result (i.e., the 2D model accounts for the hydraulics of water moving around building obstructions, and therefore reported water surface elevations vary between the middle and outer boundary of a structure footprint).

Structures that could be inundated during the 0.2-percent-annual probability flood event (the maximum flood extent assessed) were inventoried. A summary of the structures included in the inventory is provided in

Table 2-1, which provides a breakdown of the number of structures potentially vulnerable to the 0.2-percent-annual-probability flood event by structure type.

Table 2-1. Structures Inventoried

Structure Type	Count
Apartments	86
Convenience Store	1
Fast Food	1
Grocery Store	6
Industrial - Light	14
Manufactured	27
Medical Office	8
Non-Fast Food	11
Office - One Story	70
Recreation	2
Religious Facility	10
Residential – One Story, Basement	113
Residential – One Story, No Basement	487
Residential – Two Story, Basement	5
Residential – Two Story, No Basement	13
Retail - Clothing	28
Retail - Electronics	16
Schools	4
Service Station	21
Split Level – Basement	4
Split Level – No Basement	5
Warehouse – Non-Refrigerated	15
Total	**947**

The analysis estimated the mean adjacent ground elevation of each residential and nonresidential structure by overlaying the 50-foot-buffered centroid of each address point, which was found to generally be near the center of the structure footprints on LiDAR data. The first-floor elevation (FFE) of each structure was estimated based on adding the ground elevation and an assumed foundation height. Table 2-2 lists the foundation height assumptions used to estimate the FFE (ground elevation plus foundation height) of each structure.

Table 2-2. Assumed Foundation Heights

Structure Type	Foundation Height (Feet Above Ground Level)
Nonresidential	0.5
Residential, no basement	1
Residential, basement	1.5

Detailed data from the Sevier County Assessor's Office were used to determine structure characteristics. The tax assessor listed multiple valuation components (e.g., land, improvement) for each parcel. To avoid including land values when accounting for damages to residential and nonresidential structures,

the value listed under the improvement component in the tax assessor data was used as a proxy for the depreciated replacement value of each structure. For the structures in the analysis that did not have tax appraisal information available (e.g., schools), depreciated replacement values were estimated by multiplying the value per square foot assigned to each building type, as estimated using RS Means data, by the square footage of the total main area of the building. Depreciation rates were obtained from the Federal Emergency Management Agency (FEMA) Final Methodology Evaluation and Recommendations guidance (FEMA 2012). Table 2-3 lists the RS Means replacement values and the associated depreciation rates for each building type.

Table 2-3. RS Means Replacement Values and Depreciation Rates

Building Type	Replacement Value ($/sq. ft.)	Depreciation Rate
Apartments	$187	33.2%
Office – One Story	$214	31.9%
Fast Food	$199	31.9%
Non-Fast Food	$203	31.9%
Recreation	$177	31.9%
Religious Facility	$167	31.8%
Schools	$175	32.0%
Convenience Store	$121	31.9%
Grocery Store	$145	30.3%
Service Station	$200	31.3%
Medical Office	$240	34.7%
Warehouse – Non-Refrigerated	$133	31.3%
Retail – Electronics	$148	31.9%
Retail – Clothing	$148	31.9%
Protective Services	$189	31.9%
Industrial – Light	$116	31.3%
Residential – One Story, No Basement	$100	38.8%

The content value for each structure was estimated based on the structure's depreciated replacement value and the content-to-structure value ratio (CSVR) for the assigned building class.

Table 2-4 quantifies contents value as a percent of the building depreciated replacement value for each building class.

Table 2-4. Contents Value as a Percent of Structure Value

Building Class	CSVR (percent of structure's depreciated replacement value)
Apartments	12%
Convenience Store	38%
Fast Food	30%
Grocery Store	79%
Industrial – Light	44%
Medical Office	66%
Non-Fast Food	25%
Office – One Story	20%
Recreation	28%
Religious Facility	7%
Residential – One Story, No Basement	100%
Residential – One Story, Basement	100%
Residential – Two Story, No Basement	100%
Residential – Two Story, Basement	100%
Retail – Clothing	51%
Retail – Electronics	74%
Manufactured	100%
Schools	8%
Service Station	77%
Split Level – No Basement	100%
Split Level – Basement	100%
Warehouse – Non-Refrigerated	43%

Source: USACE 2019
Note: Split the difference between pre-engineered and engineered contents to building ratio values.

The methods used to calculate structure, contents, automobile, and debris removal damages are described in the following sections.

2.1.2 Structure and Content Damages

Each structure was assigned a depth-damage function (DDF) that estimates an economic loss as a percentage of the value of the structure based on the building class and depth of flooding. DDFs were sourced from the U.S. Army Corps of Engineers (USACE) Economic Guidance Memorandum (EGM) 04-01 (USACE 2003). DDFs for nonresidential buildings were sourced from FEMA's Benefit-Cost Analysis Toolkit (FEMA 2019). Because the DDFs estimate damages at 1-foot intervals, straight-line interpolation was used to estimate damages in 0.1-foot intervals.

Within each DDF, the ratios of damage for the building and its contents are provided in 1-foot increments. The analysis uses the depth of inundation to calculate the percent damage to each building per flood recurrence interval, which was then multiplied by the building depreciated replacement value to estimate the building damages. Similarly, the analysis uses the depth of inundation to calculate the percent damage to contents per flood recurrence interval, which was then then multiplied by the contents value to estimate the content damages.

2.1.3 Automobiles

The damages to automobiles were determined using the USACE EGM 09-04 (USACE 2009). In accordance with the guidance, the elevation of each automobile was assumed to be the mean ground elevation estimated at each building. The damages to vehicles at residences depends on the following: the average number of vehicles per household and the percentage of vehicles that are likely to be at the residence at the time the flood waters reach the property.

In 2016, the median number of vehicles per household in Sevier County, Utah, was two (Data USA 2019). As suggested by the guidance, the average vehicle value was obtained from Edmunds. According to the Edmunds Used Car Market Report (Edmunds 2018), the average retail value for used vehicles was $24,400 (adjusted to 2025 dollars using GDP deflator).

The length of potential warning time and the access to a safe evacuation route to a flood-free location were considered to estimate the percentage of vehicles that would likely remain in the flood-prone location. For Sevier County, the analysis assumes that the warning time would be less than 6 hours; therefore, 50.5 percent of the vehicles in the flood area would be evacuated according to USACE EGM 09-04 and 49.5 percent would remain.

Because only those vehicles not used for evacuation can be included in the damage calculations, an adjusted average vehicle value of $24,200 ($24,400 x 2 x 0.495) was assigned to each individual residential building record. The analysis calculates automobile damages for each flood recurrence interval.

2.1.4 Debris Removal

Debris can accumulate from flood damage, requiring effort to bring damaged materials to the street for pickup and removal. The costs associated with debris removal were estimated based on guidance from the USACE (2018). Costs associated with debris removal were assumed to be incurred based on building damages for the purposes of this analysis.

The debris removal costs were monetized for each residential building inundated in the analysis. Debris removal costs were estimated for residential structures with and without a basement. The debris cost per residential structure includes the hauling cost, tipping fee, and labor to remove debris and break it into pieces that could be hauled to the street for pickup.

FEMA has estimated 25 to 30 cubic yards of debris for a home without a basement and 45 to 50 cubic yards for a home with a basement. Assuming 1 ton of mixed debris has a volume of 4 cubic yards, the average volume for each building type equates to about 6.9 tons for a home without a basement and 11.9 tons for a home with a basement (FEMA 2010). Thus, 5 tons of debris is estimated for the basement level of a home.

The cost to load and haul away debris was estimated using the average labor cost per cubic yard of $31.30 ($125 per ton) from the Homewyse Debris Removal Cost Calculator (Homewyse, 2019, updated to 2025 dollars). The tipping fee of $31 per ton for the Sevier County Landfill was used in place of the disposal cost. The analysis assumes a debris removal cost of $156 per ton (2025 dollars).

Using the Homewyse Debris Removal Cost Calculator (2019), the number of labor hours to break down debris and move it from the building site to the street was estimated to be 1.4 hours for every cubic yard of debris. Because homeowners are forgoing other activities to clean up debris, including work and leisure, the opportunity cost was used to value this time. The value of time was estimated using the 2017 median household income for Sevier County from the Census and updating to 2025 dollars using

the GDP Deflator before dividing by 2,080 hours to get $31.28 per hour per household, which represents the hourly opportunity cost of work per household (White House OMB). For leisure time, an opportunity cost of $20.85 was assigned based on the common practice used in economics literature to value recreation time as a fraction of the wage. In literature, this fraction ranges from one-third of the wage to the full wage; therefore, a fraction of two-thirds was used to estimate the opportunity cost of leisure. Finally, during the flood aftermath, owners were assumed to forego recreation time two-thirds of the time and forego work one-third of the time, for an average value of time of $24.33 per hour (2025 dollars). Table 2-5 presents the average cost of debris removal from a flooded residential building.

Table 2-5. Summary of Residential Debris Costs

Building Description	Cubic Yards of Debris	Average Tons of Debris	Debris Removal – Labor and Tipping	Labor Value	Total Debris Costs
Residential – No Basement	25 to 30	6.9	$1,000	$900	$2,000
Residential – Basement	45 to 50	11.9	$1,800	$1,600	$3,400
Basement Level Only	20	5	$700	$700	$1,400

Notes: 2025 price level, monetary values rounded to the nearest hundred.

2.2 Agriculture-Related Damages

Knowledge of existing agricultural land located in a floodplain is essential when evaluating flood-risk-management measures. Part of the analysis includes estimating the benefits of the with-project alternative based on a reduction in agricultural damages. Agricultural impacts assessed include economic losses due to crop damage and canal maintenance. The analysis is based on the timing, duration, and extent of flooding. This section describes the methods used to estimate agricultural damages in the analysis.

2.2.1 Flood Impacts

Flood damage to crops can result in replanting, fertilizing, additional spraying, and reduced crop yields. A flood occurring prior to the start of field preparation may cause damages (e.g., reduced yields) from delay of seeding. However, due to uncertainty, these damages were not captured in the model. Following a damaging flood that occurs near the beginning of the growing season, a farmer would likely rework the land and replant the same or a substitute crop to minimize loss. Variable production costs for a replanted crop are usually higher than those without a flood because additional fertilizer must be applied to offset loss of soil fertility, herbicides are often required to combat weed infestation, and additional preparation of seed beds is required. For a flood occurring too late in the season to replant, the damages are represented as the reduction of gross crop revenue from crop damage. The analysis assumes that damages to turfgrass (sod farms located in the area) were entirely from sedimentation, because turfgrass cannot be harvested after sediment has been deposited on it. Other crops were assumed to not experience damages from sedimentation because the agricultural land in the study area is far enough from the canyons that any sediment deposited would likely be fine materials that would not result in crop damages.

Seasonal crop damage curves were developed to calculate weighted average damage per acre of flooded agricultural land. Current normalized prices were used when available to counteract the

frequent short-term fluctuations of crop prices (Utah State University 2019).[1] Total crop damages per acre amount to the difference between the expected net income without a flood and the net income with a flood as well as additional planting and production costs incurred. Damages to pastures were limited to the replacement costs of the damaged fencing.

2.2.2 Crops in Study Area

Utah Department of Water Resources (UDWR) Water Related Land Use (2019) data were obtained for the region to identify the percentage of inundated land that is used for agriculture at each flood recurrence interval. The data were also used to identify which crops are grown in the study area and the percent of agricultural land they account for. Table 2-6 identifies the crops grown in the study area and the percent each crop makes up compared to total acres harvested.

Table 2-6. Crops in Study Area

Crop	Percent of Acres Planted
Alfalfa	53%
Corn (Silage)	9%
Pasture	35%
Turfgrass	3%

2.2.3 Crop Progress for Utah Crops

Prior to estimating crop damages associated with a flood occurring in each month, crop progress was estimated for crops grown in Sevier County. USDA's National Agricultural Statistics Service (NASS) information was obtained to determine the months in which crops were planted and harvested. Table 2-7 identifies the months in which corn is planted and harvested. Pastures were not accounted for because the damages to pastures included in the analysis are limited to damages to fencing that encloses the pasture. Damages to pastures do not include a loss in production value.

Table 2-7. Crop Progress

Crop	Progress	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Corn	Planted				20%	70%	10%						
	Harvested										50%	50%	

2.2.4 Crop Damage Analysis

The crop progress data for Utah crops identified in Table 2-7 were used to extract crop DDFs from the USACE Hydrologic Engineering Center – Flood Impact Analysis software (HEC-FIA). Necessary inputs to obtain DDFs include first plant date, full yield date, last planting date, and end of harvest date.

[1] Corn – silage price estimates were sourced from the silage price calculator for Box Elder County, which were provided in 2013 dollars and adjusted to 2025 dollars using the GDP deflator. 2006 Corn – silage prices for Sevier County, the most recent year available, were compared to 2006 corn – silage prices for Box Elder County to demonstrate prices were consistent statewide. Turfgrass unit prices were not used in the analysis.

Table 2-8 provides definitions for each input as defined in the HEC-FIA User's Manual (USACE 2012) and the respective assumption used in the analysis.

Table 2-8. HEC-FIA Assumptions

Date/Days	HEC-FIA Definition	Assumption
First Plant Date	First date that the crop can be planted.	First day of the earliest month in which crops were planted in Utah.
Full Yield Date	Latest date that the crop can be planted and still reach full maturity.	One month prior to the Last Planting date.
Last Planting Date	Latest date that the crop can be planted with a reduction in yield.	Last day of latest month in which crops were planted in Utah.
End of Harvest Date	Last date that the crop is harvested, after which little damage can be incurred.	Last day of final month in which crops are harvested.
Dryout Period (days)	Number of days after a flood has receded before the soil is sufficiently dry so replanting can begin. FIA automatically adds 7 days on to the dryout period to allow for re-cultivation of the fields.	The default value in HEC-FIA. Default includes a period of 3 days for dryout and 7 days for recultivation for a 10-day period following inundation before crops can be replanted.

The data in Table 2-7 were used to make the crop planting and harvesting date assumptions shown in Table 2-9, which were then used to extract the appropriate DDFs from HEC-FIA.[2]

Table 2-9. Crop Plant Data Assumptions

Crop	First Plant Date	Full Yield Date	Last Planting Date	End of Harvest Date
Corn	April 1	May 31	June 30	November 30

HEC-FIA provided damage estimates in “Initial % Crop Loss” values, which represent an estimate of the percentage of the mature crop value that is expected to be reported as damaged if the crop was planted on the First Plant Date. Initial % Crop Loss values depend on the date on which a flood event occurs and factors crop plant data into its estimates. HEC-FIA also categorizes crop damages as a percentage of crop yield for flood events lasting 0, 3, 7, and 14 days based on the vulnerability of the crop to flood damage. Straight-line interpolation was used to estimate total crop damages as a percent of crop yield for flood events lasting 1 and 2 days. Figure 2-1 is a screenshot of corn’s crop loss function during the month of April as generated by HEC-FIA.

[2] Crop progress assumptions for turfgrass farms were obtained from a phone conversation with Sevier County turfgrass farm owner. Consequently, crop progress data for turfgrass farms were not entered into HEC-FIA.

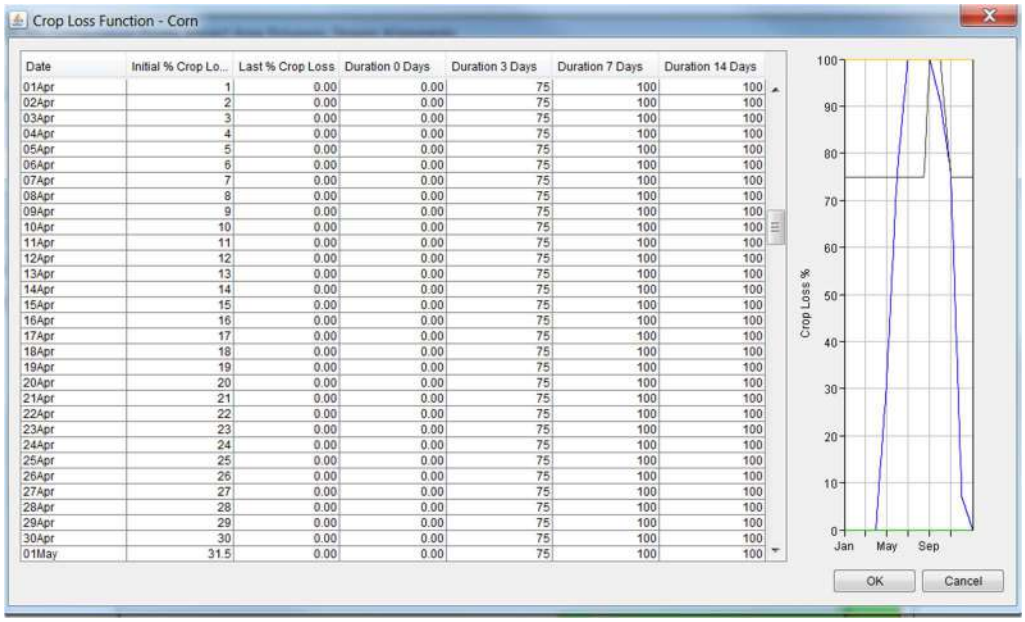


Figure 2-1. Crop Loss Function – Corn

Finally, the Initial % Crop Loss estimates were multiplied by expected damages from flood events lasting 0, 1, 2, and 3 days. The analysis also multiplied the Initial % Crop Loss and the Last % Crop Loss estimates by the estimated damages from flood events lasting 1 and 2 days, which were calculated using straight-line interpolation. Initial % Crop Loss estimates were multiplied by expected damages by flood duration to estimate the crop damages from flooding each day of the calendar year. Then, DDFs from HEC-FIA were averaged over each month to estimate crop damages by month.

Crop damages for alfalfa, one of the primary crops grown in the study area, were estimated using a different method. Alfalfa is a perennial crop that is typically replanted every three to five years. In the study area, it is common to cut and harvest alfalfa three times per year (June, July, and September), with each cutting providing about a third of the total harvest for the year.

While alfalfa is not considered to be tolerant of flooding, it can withstand short periods of flooding (i.e., a couple of days) without major damage. However, due to the sediment and velocity of the floodwater in the study area, it is estimated that 50 percent of the flooded acres would need to be replanted following a flood event with no harvestable crop until the following year for all of the inundated area.[3] The remaining acreage of flooded crop that was not severely impacted by flooding would not need to be replanted but would not be harvestable for the remainder of the year. This would allow the plant roots time to recover, to grow through any sediment, and to wash the sediment from the plants themselves. It is assumed that full production would resume the following year.

[3] Alfalfa analysis based on discussions with project engineers who have experience farming in the region.

Table 2-10 provides the crop damage assumptions for 1 to 3 days of inundation.

Table 2-10. Crop Damages from 1 to 3 days of Inundation

Crop (Duration of Inundation)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alfalfa (1 day)	0%	0%	0%	100%	100%	100%	67%	33%	33%	0%	0%	0%
Alfalfa (2 days)	0%	0%	0%	100%	100%	100%	67%	33%	33%	0%	0%	0%
Alfalfa (3 days)	0%	0%	0%	100%	100%	100%	67%	33%	33%	0%	0%	0%
Corn silage (1 day)	0%	0%	0%	4%	13%	22%	25%	27%	32%	24%	10%	0%
Corn silage (2 days)	0%	0%	0%	8%	27%	44%	50%	55%	64%	48%	20%	0%
Corn silage (3 days)	0%	0%	0%	12%	40%	66%	75%	82%	95%	72%	29%	0%
Pasture* (1 day)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Pasture* (2 days)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Pasture* (3 days)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Turfgrass** (1 day)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Turfgrass** (2 days)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Turfgrass** (3 days)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

*For pasture, the analysis assumes that the entire portion of a fence that has been inundated must be replaced. Consequently, flood damages are 100% per acre inundated.

**Crop damage assumptions for turfgrass farms are based on a phone conversation with a Sevier County turfgrass farm owner and were not obtained using HEC-FDA. The analysis assumes that damages to turfgrass are a result of sedimentation, and any flood event at any time of the year will require complete replanting regardless of the crop's progress. Any flood event will result in 100% damages and 100% replant for all inundated land, as the turf cannot be harvested after sediment has been deposited on it following a flood event.

2.2.5 Crop Planting and Production Prices

To monetize crop damages, the analysis estimated direct (variable) costs and indirect (fixed) costs for alfalfa and corn, estimated by acre, using data on budgets by commodity sourced from Utah State University's Crop and Livestock Budgets (2019) based on estimates for Sevier County. Direct costs include items such as fertilizer, herbicides, seed, equipment operations, labor, and crop insurance. Indirect costs include items such as equipment, management, cash rent, and liability insurance. Additional planting costs per acre were seed, fertilizer, equipment operating expenses, and crop insurance. Also, during the growing season three additional sprays of herbicide would be required after flooding. Replanting costs for pasture account for the costs to replace the damaged fencing, rather than costs associated with replanting a crop. Replanting cost for turfgrass farms was estimated based on a phone conversation with a Sevier County turfgrass farm owner. Table 2-11 lists estimates for crop replanting and production costs per acre for all crops in the study area.

Table 2-11. Planting and Production Costs per Acre

Item	Crop (2025$)			
	Alfalfa	Corn	Pasture	Turfgrass**
Seed	$28	$66	N/A	N/A
Herbicides	$80	$187	N/A	N/A
Fertilizer	$31	$97	N/A	N/A
Trucking	$17	$45	N/A	N/A
Crop Insurance	$19	$22	N/A	N/A
Replanting Cost (per acre)	**$95**	**$229**	**$30***	**$4,278**
Additional Production Cost (per acre)	**$80**	**$187**	**$0**	**$0**

* Account for the costs to replace the damaged fencing, rather than costs associated with replanting a crop.

** Replanting cost for turfgrass farms was estimated based on a phone conversation with a Sevier County turfgrass farm owner.

The analysis assumes replanting would occur following any flood event that occurred in a month in which the damaged crop could be replanted (i.e., before the last plant date). Acres replanted were assumed to equal acres damaged in the flood event.

2.2.6 Crop Production Value

To complete the assessment of agricultural flood damages, production values of each crop per acre were estimated by multiplying the average yield by the normalized price per unit. Yields per acre were obtained from the Utah State University Crop Budgets (2019). Normalized prices for alfalfa were sourced from NASS (2018) and Utah Department of Agriculture and Food (2018). Normalized prices for corn were obtained from the Utah State University Corn Silage Price Calculator. The average production value of turfgrass per acre was estimated by a Sevier County turfgrass farm owner. The production value of pasture per acre was not considered in the analysis. Agricultural prices were standardized to be the value per bushel. Table 2-12 displays the average crop yield and average production value per acre for all crops in the analysis.

Table 2-12. Average Crop Yield and Average Production Value

Item	Crop (2025$)			
	Alfalfa	Corn – Silage	Pasture	Turfgrass*
Average yield (bushel/acre)	130	196	N/A	N/A
Normalized prices (per bushel)	$6.53	$9.97	N/A	N/A
Average production value per acre	$850	$1,950	N/A	$8,020

*Average production value of turfgrass farms ranges from $0.04 to $0.31 per square foot based on a phone conversation with a local turfgrass farm owner. The analysis assumes the production value of turfgrass farms is $0.16 per square foot.

2.2.7 Likelihood of Flooding by Month

The next step was to determine the likelihood of a flood occurring each month. The probability that a flood event would occur in a month was estimated from monthly precipitation data for Sevier County between 1987 and 2017 from the National Oceanic and Atmospheric Administration (NOAA 2019). Average monthly precipitation values were divided by the total average annual precipitation to calculate the percentage of precipitation that occurs each month. The percentage of precipitation per month was used as a proxy for the likelihood of a flood event occurring (see Table 2-13).

Table 2-13. Likelihood of Flooding by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
8%	8%	10%	10%	8%	4%	8%	9%	8%	10%	7%	9%

An Excel-based model was developed to estimate the average annual agricultural damages for the with- and without-project scenarios. The model incorporates the factors presented above and H&H data that estimates the agricultural acres flooded by duration for eight flood recurrence intervals (50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent-annual-probability flood events).

2.3 Economic Analysis Benefits, Costs, and Results

The following sections summarize benefits quantified in the analysis.

2.3.1 Structure-Related Benefits

The with-project would result in structure-related benefits that result from a reduction in inundation. Table 2-14 lists the number of structures protected.

Table 2-14. Number of Buildings Protected for the 0.2-percent-annual-probability Flood Event

Alternative	Buildings Inundated under Without-Project Scenario	Buildings Inundated under With-Project Scenario	Buildings Protected
With-Project Alternative	947	0	947

Structure-related benefits include damage reductions to structures, contents, automobiles, and debris removal. Structure-related benefits evaluated are summarized by recurrence interval and structure type in Table 2-15.

Table 2-15. Structure-Related Benefits by Flood Event and Structure Type (in thousands)

Structure Type	Annual Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
Apartments	$0	$0	$0	$0	$0	$15,358	$15,672	$15,767
Convenience Store	$0	$0	$0	$0	$0	$211	$216	$216
Fast Food	$0	$0	$0	$0	$0	$54	$54	$54
Grocery Store	$0	$458	$458	$475	$492	$3,392	$3,463	$3,480
Industrial - Light	$0	$0	$0	$5	$11	$771	$782	$791
Manufactured	$0	$0	$0	$0	$10	$1,570	$1,593	$1,616
Medical Office	$0	$0	$0	$0	$0	$412	$415	$418
Non-Fast Food	$0	$0	$0	$0	$0	$3,986	$3,993	$3,993
Office - One Story	$0	$131	$131	$141	$151	$4,775	$4,818	$4,826
Recreation	$0	$0	$0	$0	$0	$717	$776	$776
Religious Facility	$0	$0	$0	$0	$0	$4,331	$4,343	$4,343
Residential – One Story, Basement	$0	$246	$260	$466	$559	$9,972	$10,026	$10,061
Residential – One Story, No Basement	$0	$0	$19	$72	$127	$28,689	$28,929	$29,017
Residential – Two Story, Basement	$0	$0	$0	$0	$0	$375	$375	$379
Residential – Two Story, No Basement	$0	$0	$0	$0	$0	$615	$619	$622
Retail - Clothing	$0	$0	$0	$0	$0	$472	$477	$477
Retail - Electronics	$0	$0	$0	$0	$0	$444	$453	$454
Schools	$0	$0	$0	$0	$0	$3,609	$3,615	$3,615
Service Station	$0	$79	$79	$82	$85	$1,490	$1,499	$1,508
Split Level – Basement	$0	$0	$0	$0	$0	$221	$222	$222
Split Level – No Basement	$0	$0	$0	$12	$15	$129	$130	$131
Warehouse - Non-Refrigerated	$0	$243	$243	$264	$286	$905	$938	$965
Total	**$0**	**$1,158**	**$1,190**	**$1,517**	**$1,736**	**$82,497**	**$83,409**	**$83,731**

Average annual structure-related benefits are summarized in Table 2-166.

Table 2-166. Average Annual Structure-Related Benefits

Alternative	Structure Related Benefits
With-Project Alternative	$1,492,000

Note: 2025 price level.

2.3.2 Agriculture-Related Benefits

To estimate agricultural losses, H&H data estimated agricultural land inundated for each flood recurrence interval. Each with-project scenario would result in a reduction in inundation of agricultural lands. Table 2-177 summarizes total agricultural land inundated for the 1-percent-annual-probability flood event and the 0.2-percent-annual-probability flood event by crop.

Table 2-177. Breakdown of Agricultural Land Inundated by Crop (acres)

Crop	1-Percent-Annual Probability	0.2-Percent-Annual Probability
Alfalfa	1,340	1,480
Corn (Silage)	240	270
Pasture	880	980
Turfgrass	80	90
Total	**2,540**	**2,820**

A summary of agricultural land protected from the 1-percent- and 0.2-percent-annual probability flood events is provided in

Table 2-118.

Table 2-18. Area of Agricultural Land Protected (acres)

Alternative	1-Percent-Annual Probability			0.2-Percent-Annual Probability		
	Agricultural land inundated - without-project	Agricultural land inundated – with-project	Agricultural land protected	Agricultural land inundated - without-project	Agricultural land inundated – with-project	Agricultural land protected
With-Project Alternative	2,540	0	2,540	2,820	0	2,820

Note: Acreage inundated is rounded to the nearest ten.

Table 19 summarizes the average annual agriculture-related benefits, which include damage reductions to crops and sediment reductions.

Table 2-19. Average Annual Agriculture-Related Benefits

Alternative	Agriculture-Related Benefits
With-Project Alternative	$265,000

2.3.3 Cost Analysis

Average annual NED costs associated with with-project alternative include costs for design and construction and operations and maintenance (O&M). Interest during construction was included in the average annual cost calculation. Table 2-180 shows the cost breakdown.

Table 2-180. Cost Breakdown

Alternative	Total Implementation Costs	Average Annual O&M	Average Annual Costs
With-Project Alternative	$20,629,000	$12,000	$685,000

Notes: 2025 price level, annualized over the 100-year evaluation period using a 3.0% discount rate, average annual cost includes interest during construction, costs are rounded to the nearest thousand.

2.3.4 Results of Economic Analysis

The NED plan is the federally assisted project measures that provide for the greatest net economic benefits. Table 2-191 summarizes the average annual benefits, average annual costs, and the benefit-cost ratio.

Table 2-191. Benefit-Cost Analysis Summary

Alternative	Average Annual Benefits	Average Annual Costs	Benefit-Cost Ratio	Net Benefits
With-Project Alternative	$1,757,000	$685,000	2.6:1.0	$1,072,000

Notes: 2025 price level, annualized over the 100-year evaluation period using a 3.0% discount rate, values may not sum due to rounding.

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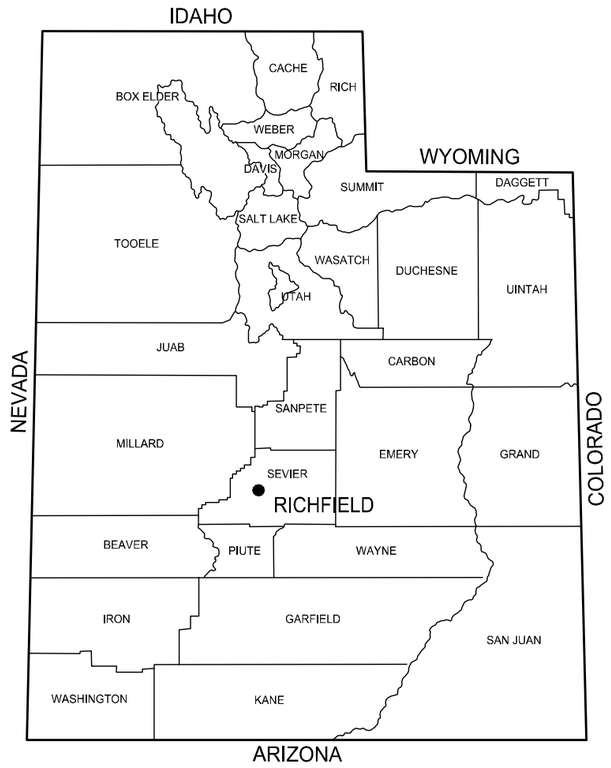
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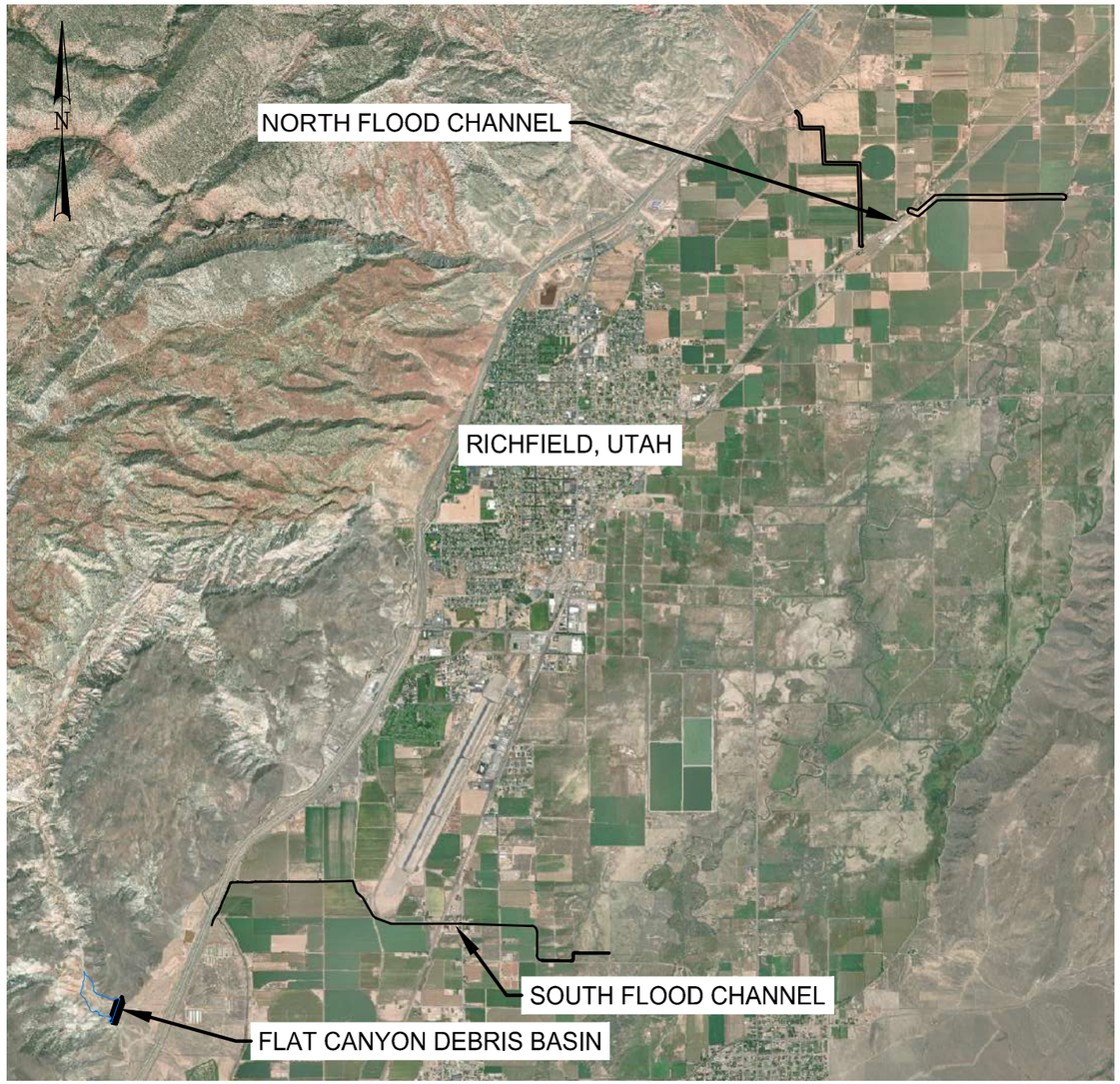
TM007 – Conceptual Design Drawings

SEVIER COUNTY NRCS WATERSHED PLAN

SEVIER COUNTY, UTAH

2025

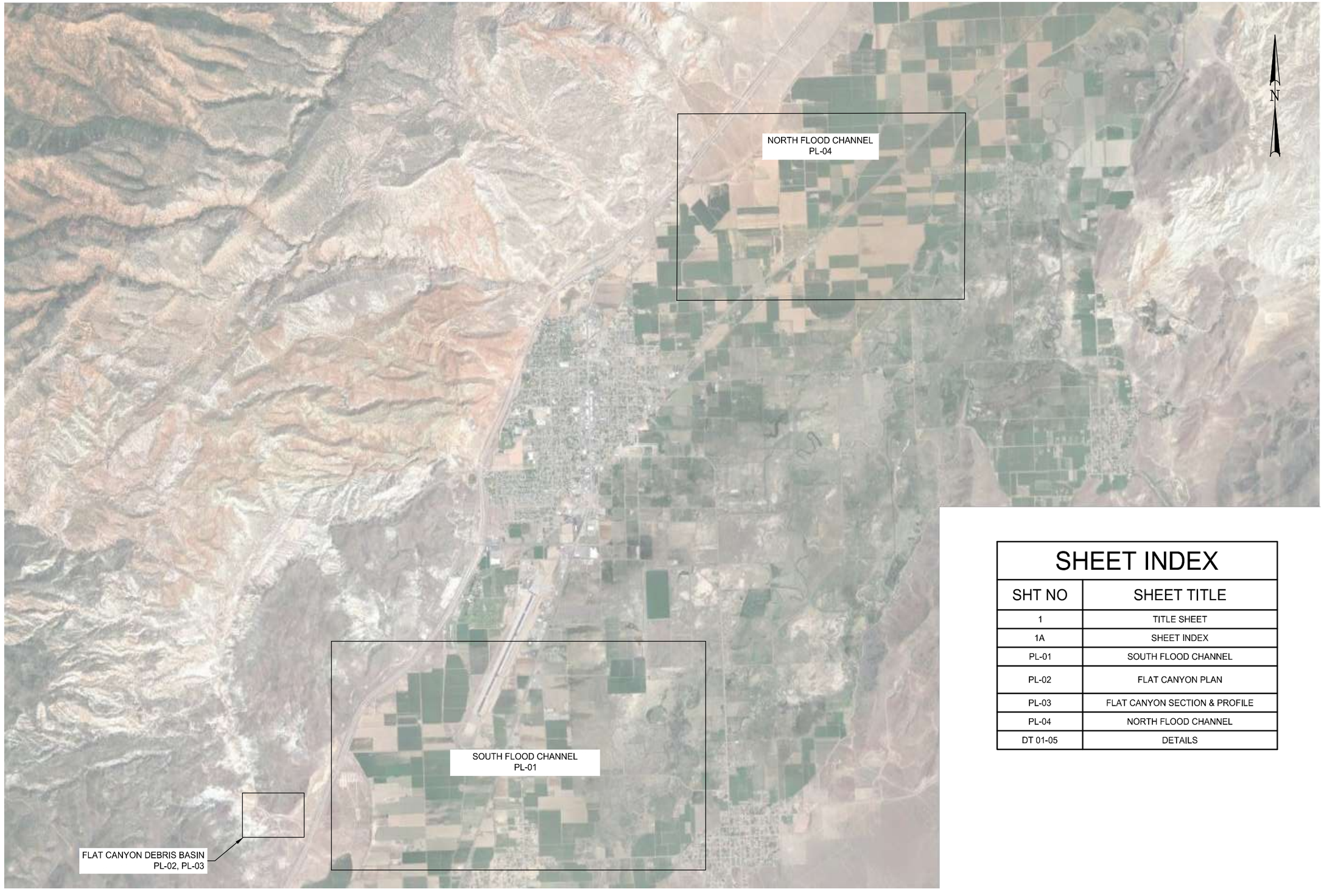




VICINITY MAP

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SHEET INDEX

SHT NO	SHEET TITLE
1	TITLE SHEET
1A	SHEET INDEX
PL-01	SOUTH FLOOD CHANNEL
PL-02	FLAT CANYON PLAN
PL-03	FLAT CANYON SECTION & PROFILE
PL-04	NORTH FLOOD CHANNEL
DT 01-05	DETAILS

REVISIONS

NO.	DATE	REMARKS

SCALE: NONE

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UPDATED: 5/14/2025
PLOTTED: 5/14/2025

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APPROVED QUALITY MANAGEMENT REVIEW DATE

SEVIER COUNTY

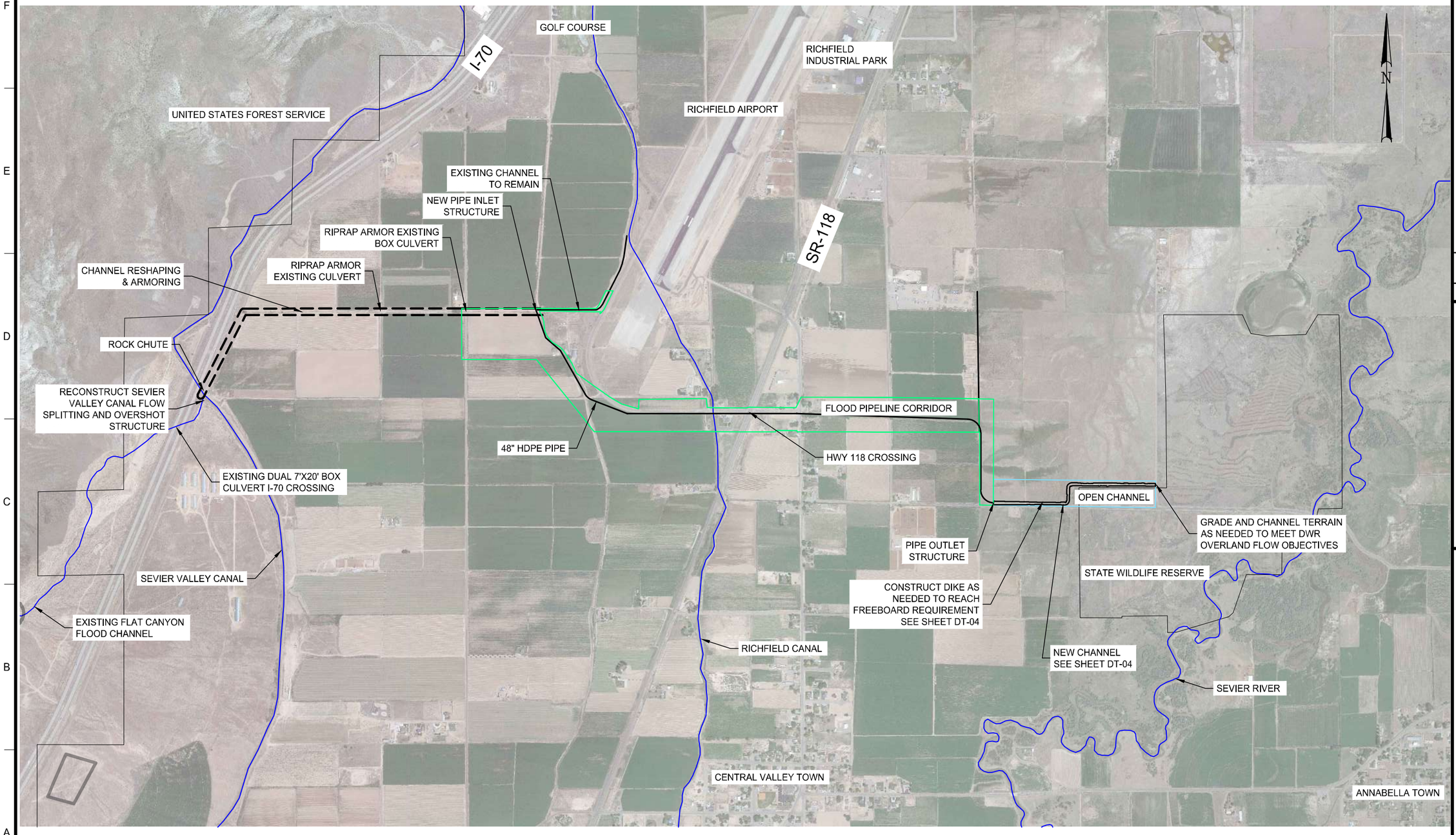
SEVIER COUNTY NRCS WATERSHED PLAN

SHEET INDEX

PROJECT NUMBER: 1804-224

SEVIER COUNTY

SHEET NO. 1A



REVISIONS

NO.	DATE	REMARKS

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UPDATED: 5/14/2025

PLOTTED: 5/14/2025

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PROJECT DESIGN ENGINEER DATE

QUALITY MANAGEMENT REVIEW DATE

APPROVAL RECOMM.

APPROVED

SEVIER COUNTY

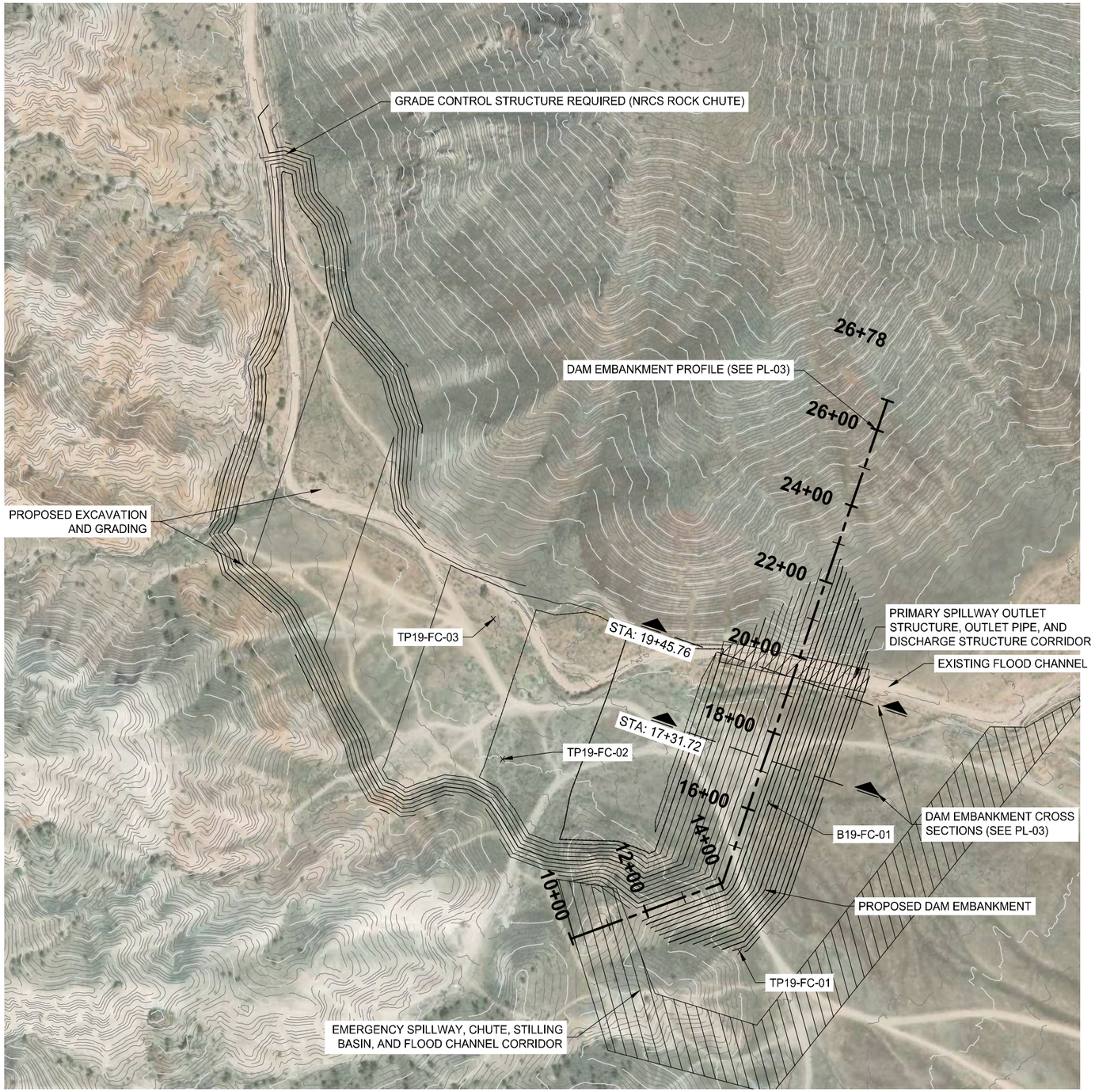
SEVIER COUNTY NRCS WATERSHED PLAN

SOUTH FLOOD CHANNEL

PROJECT NUMBER: 1804-224

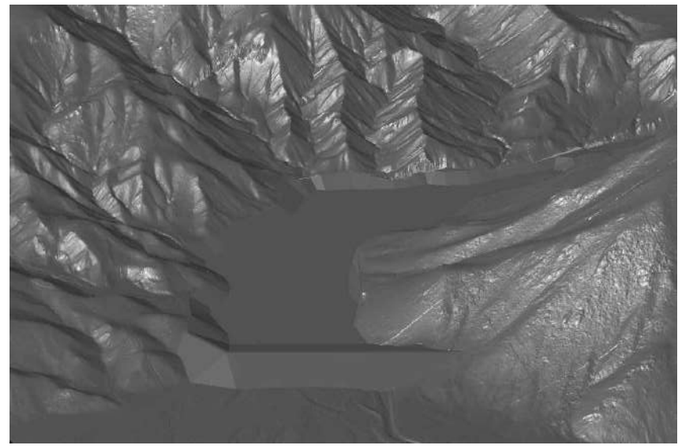
SEVIER
COUNTY

SHEET NO. PL-01



5 FOOT CONTOUR INTERVAL
SCALE: 1" = 300'

DAM CREST ELEVATION = 5,609.0
EMERGENCY SPILLWAY CREST ELEVATION = 5,599.0
STORAGE AT EMERGENCY SPILLWAY CREST = 826.9 AC.FT.
100-YEAR SEDIMENT ELEVATION =
100-YEAR SEDIMENT STORAGE = 359.0 AC. FT.
EMBANKMENT EARTHWORK VOLUME = 313723 CY
TOTAL APPROXIMATE EMBANKMENT HEIGHT = 73.0



REVISIONS

NO.	DATE	REMARKS

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UPDATED: 5/14/2025
PLOTTED: 5/14/2025

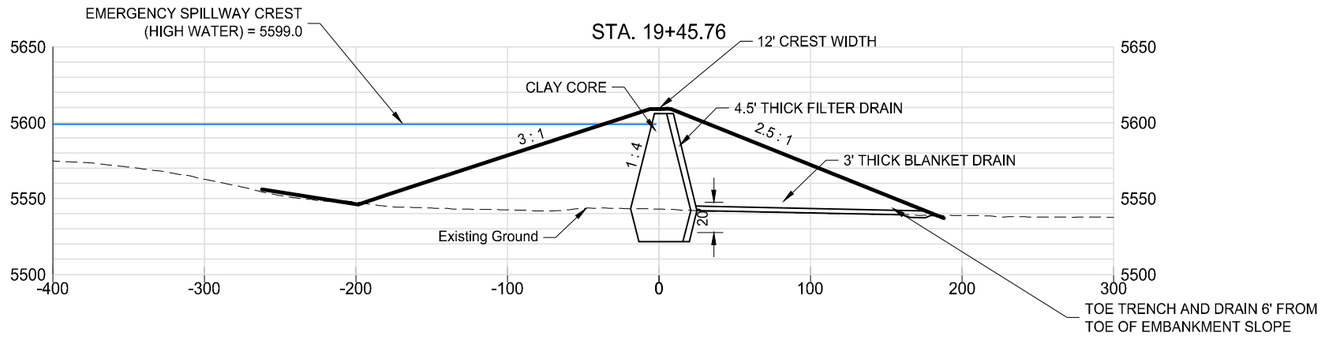
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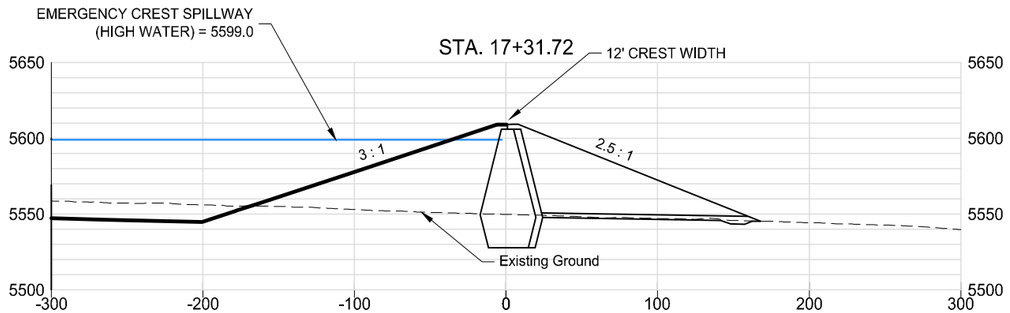
APPROVAL RECOMM. PROJECT DESIGN ENGINEER DATE
APPROVED QUALITY MANAGEMENT REVIEW DATE

SEVIER COUNTY WATERSHED PLAN
FLAT CANYON
PLAN
PROJECT NUMBER: 1804-224

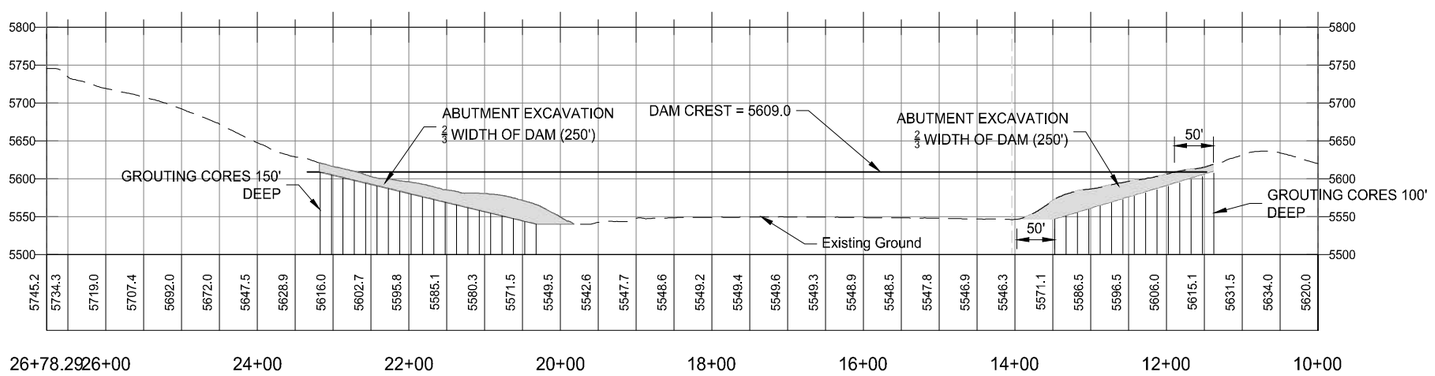
SEVIER COUNTY
SHEET NO. PL-04

FLAT CANYON CROSS SECTIONS





FLAT CANYON DAM PROFILE



REVISIONS

NO.	DATE	REMARKS

UPDATED: 5/14/2025
PLOTTED: 5/14/2025
DWG NAME: H:\JD\Proj\1804-224\dwg\FlatCynLower.dwg
SCALE: NTS

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SEVIER COUNTY WATERSHED PLAN
FLAT CANYON
CROSS SECTIONS AND PROFILE
PROJECT NUMBER: 1804-224

SEVIER
COUNTY
SHEET NO. PL-05



REVISIONS

NO.	DATE	REMARKS

UPDATED: 5/14/2025
PLOTTED: 5/14/2025

DWG NAME: H:\JD\Proj\1804-224\dwg\WoodCyn\Civil

SCALE: 1" = 1000'

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SEVIER COUNTY

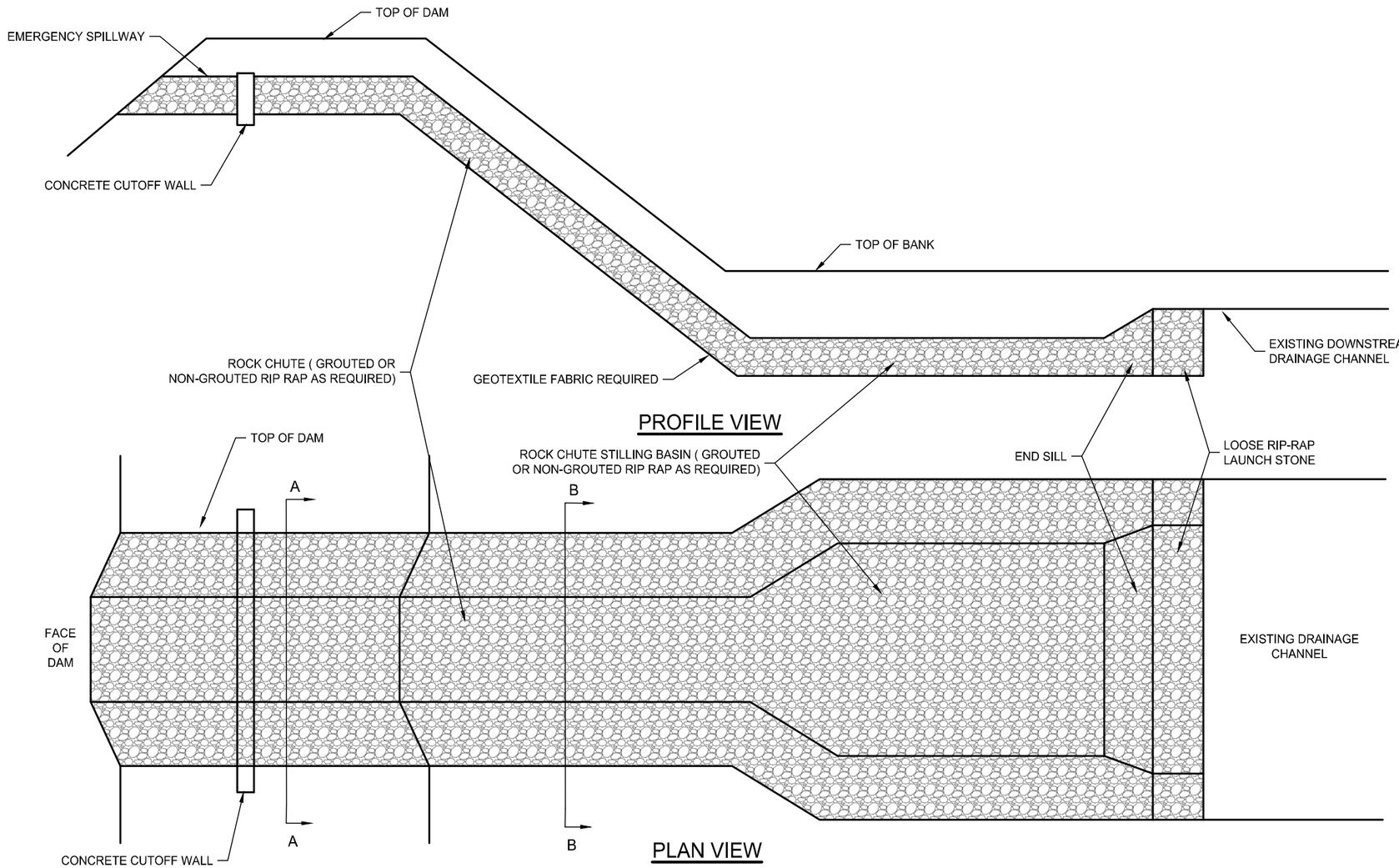
SEVIER COUNTY WATERSHED PLAN

NORTH FLOOD CHANNEL

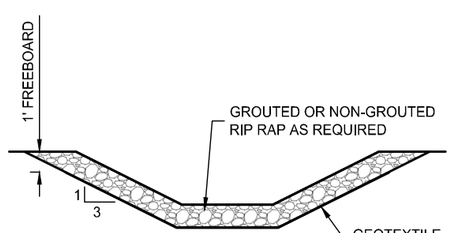
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SEVIER
COUNTY

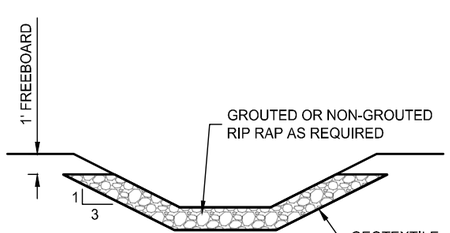
SHEET NO. PL-04



TYPICAL DAM SPILLWAY ROCK CHUTE DETAIL



A-A
ROCK CHUTE
CROSS SECTION



B-B
ROCK CHUTE
CROSS SECTION

REVISIONS

NO.	DATE	REMARKS

UPDATED: 5/14/2025
PLOTTED: 5/14/2025

DWG NAME: H:\JD\Proj\1804-224\dwg\details.dwg

SCALE: NTS

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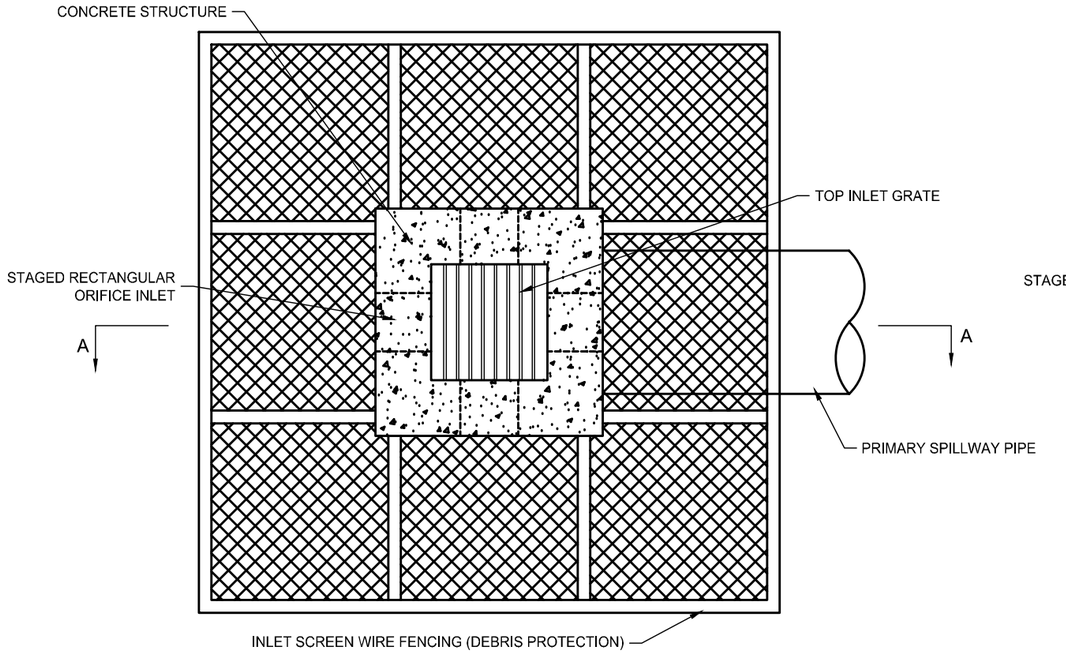
APPROVED QUALITY MANAGEMENT REVIEW DATE

TYPICAL ROCK CHUTE
SEVIER COUNTY NRCS WATERSHED PLAN
DETAIL

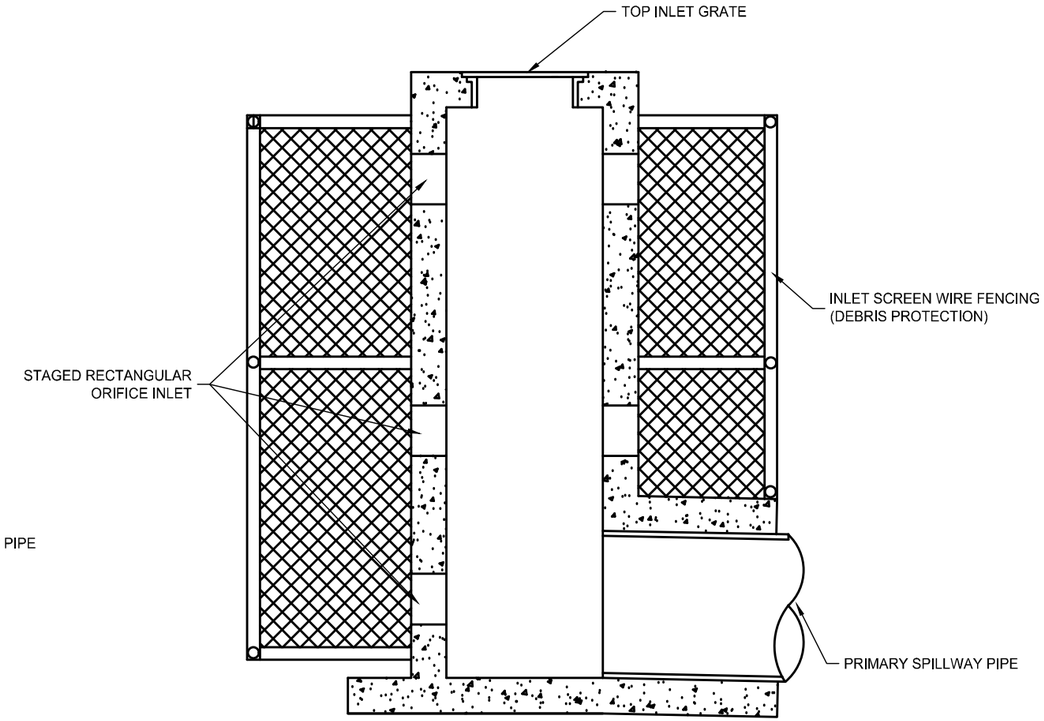
PROJECT NUMBER: 1804-224

SEVIER
COUNTY

SHEET NO. DT-01



PLAN



SECTION A-A

TYPICAL PRIMARY SPILLWAY RISER OUTLET DETAIL

REVISIONS

NO.	DATE	REMARKS

SCALE: NTS

DWG NAME: H:\JD\Proj\1804-224\dwg\details.dwg

UPDATED: 5/14/2025

PLOTTED: 5/14/2025

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PROJECT DESIGN ENGINEER DATE

QUALITY MANAGEMENT REVIEW DATE

APPROVAL RECOMM.

APPROVED

TYPICAL PRIMARY SPILLWAY RISER OUTLET

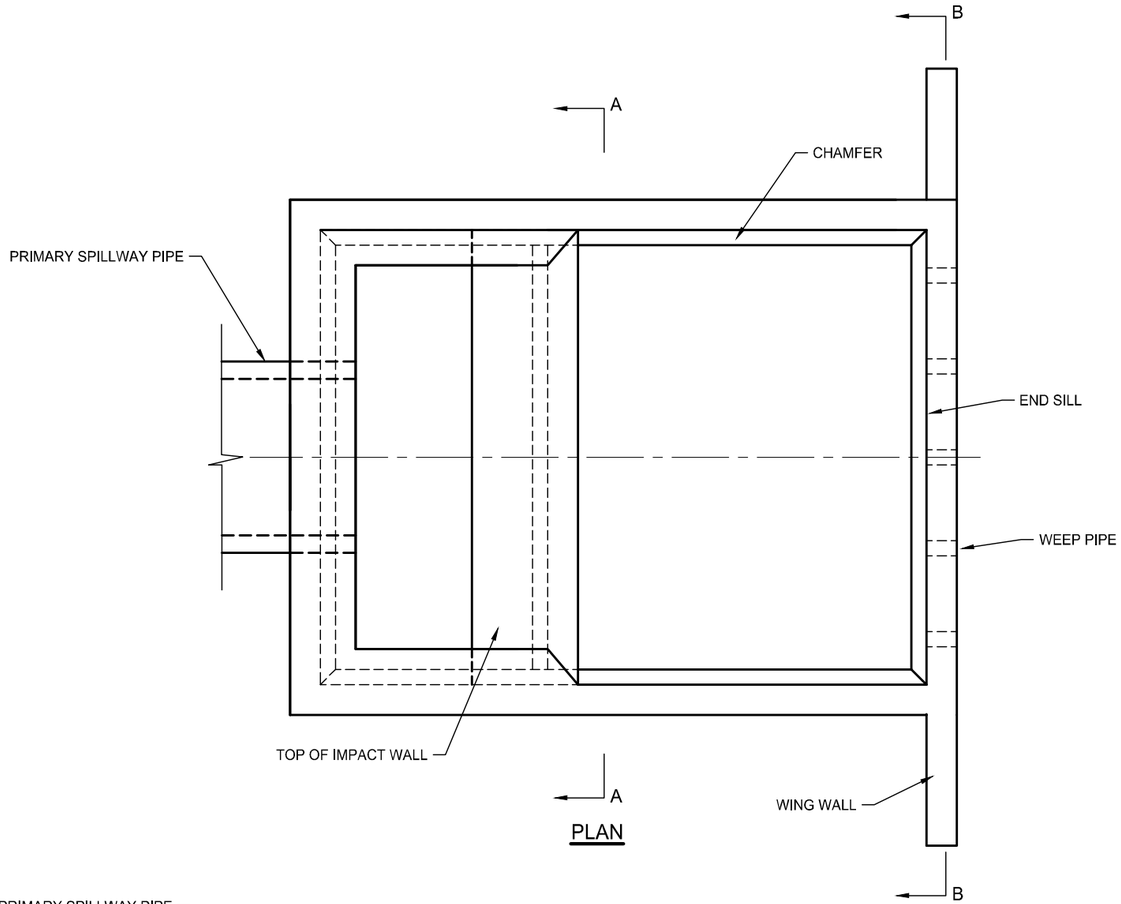
SEVIER COUNTY NRCS WATERSHED PLAN

DETAIL

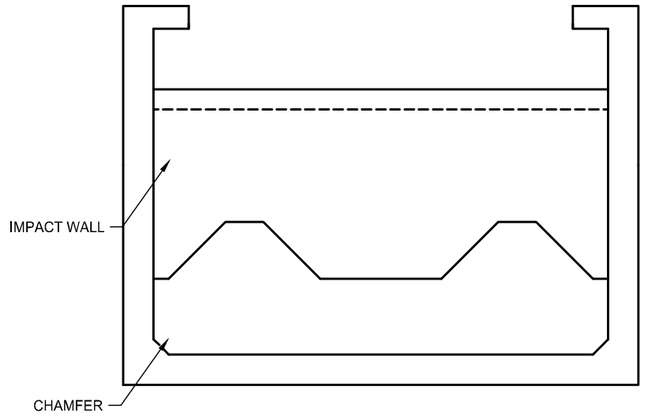
PROJECT NUMBER: 1804-224

SEVIER COUNTY

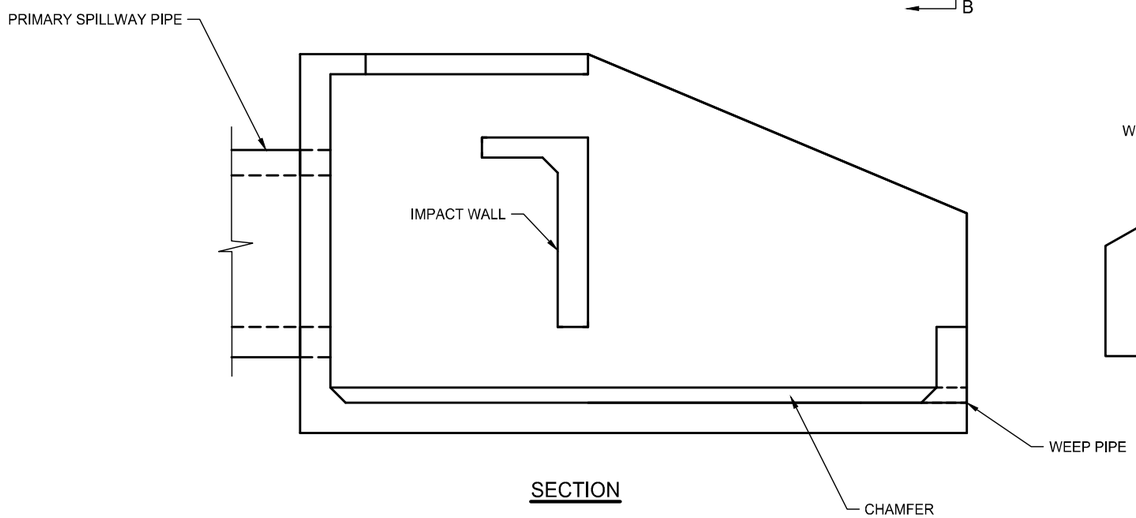
SHEET NO. DT-02



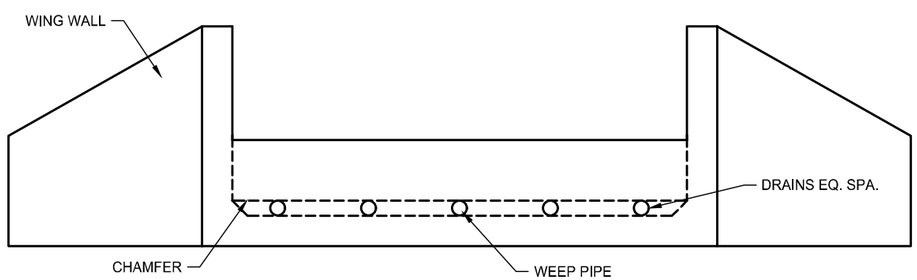
PLAN



SECTION A-A



SECTION



SECTION B-B

TYPICAL PRIMARY SPILLWAY OUTLET IMPACT BASIN DETAIL

REVISIONS

NO.	DATE	REMARKS

SCALE: NTS

DWG NAME: H:\JD\Proj\1804-224\dwg\details.dwg

UPDATED: 5/14/2025

PLOTTED: 5/14/2025

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TYPICAL PRIMARY SPILLWAY OUTLET IMPACT BASIN

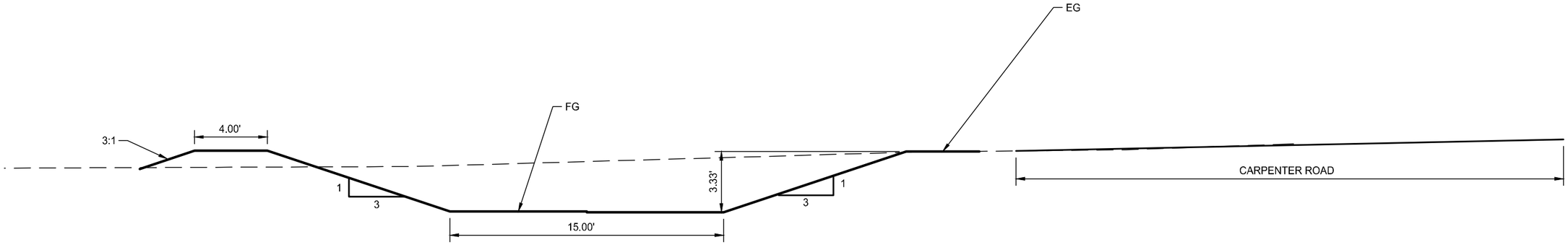
SEVIER COUNTY NRCS WATERSHED PLAN

DETAIL

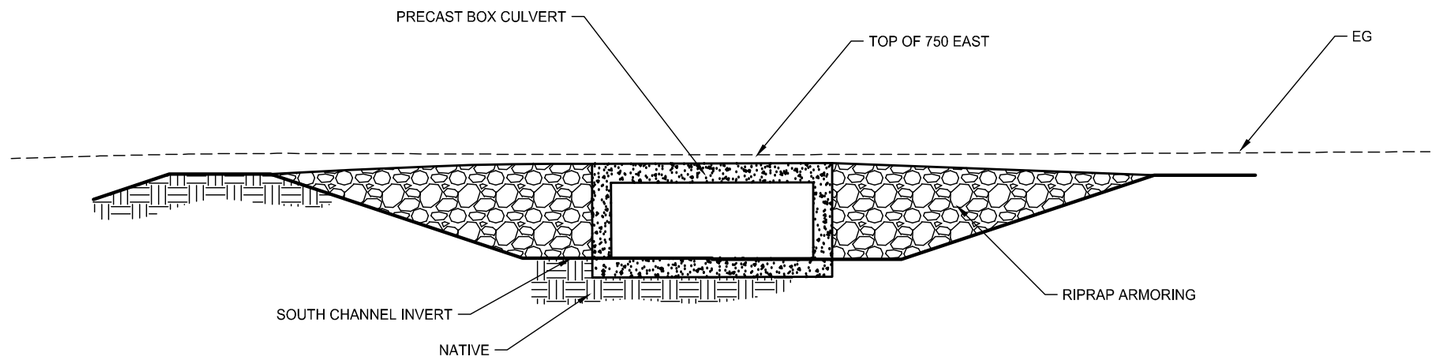
PROJECT NUMBER: 1804-224

SEVIER COUNTY

SHEET NO. DT-03



NEW SOUTH CHANNEL AND DIKE DETAIL



NEW SOUTH CHANNEL BOX CULVERT DETAIL

NO.	DATE	REMARKS

REVISIONS

SCALE: 1" = 6'

DWG NAME: H:\JD\Proj\1804-224\dwg\WoodCynChnl.dwg

UPDATED: 5/14/2025

PLOTTED: 5/14/2025

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APPROVED QUALITY MANAGEMENT REVIEW DATE

SEVIER COUNTY WATERSHED PLAN

WOOD CANYON FLOOD CHANNEL

DETAIL

PROJECT NUMBER: 1804-224

SEVIER COUNTY

SHEET NO. DT-04

TM008 – Costs

1.0 Introduction

There are significant flooding issues in Sevier County in and around the Richfield City area. The proposed solutions to mitigate these issues involve the construction of several detention/debris basins, flood channels, and overflow structures. The feasibility of constructing debris basins at Flat Canyon, Lind Canyon, Tank Canyon, and Wood Canyon were evaluated. A smaller sediment/debris trap structure was also considered at the mouth of Wood Canyon. The final alternative only includes the construction of a debris basin at Flat Canyon. The project would also require existing flood channels to be improved and extended, as the channels would receive attenuated flood waters from other hydraulic structures.

2.0 Project Costs

Project costs were estimated from similar, local projects. A 30% construction contingency factor was applied to the total construction estimate to account for unknown or unforeseen costs and to account for price increases. The total costs are shown in Table 1. Detailed costs for each alternative are included in Attachment A.

Table 1. Total Costs for Project Components

Component	Total Project Cost Estimate
Flat Canyon Detention Basin	$14,504,000
South Flood Channel	$3,231,000
North Flood Channel	$2,894,000
TOTAL	**$20,629,000**

3.0 O&M Costs

3.1 Flat Canyon and North and South Flood Channels

The need for maintenance of the debris basins would be identified in regular detailed inspections (required by Utah Dam Safety) and during cleaning of the principal outlet trash racks after every storm event that activates the principal outlet. The condition of fences, spillways, inlet and outlet works, and other major elements would also be addressed after each inspection. If identified during inspections, deep-rooted vegetation would be removed from the embankment.

The flood channel and inlet and outlet structures would be inspected at the same interval as the debris basins. Flood debris or rooted invasive vegetation that affects channel capacity would be removed, and erosion damage would be repaired when identified. Trash racks would be cleaned after flood flow events. Stormwater pipeline maintenance would include inspection and cleaning of pipeline inlet trash racks during and after every flood-flow event. Access manholes would be accessed annually to quantify sediment deposition; where necessary, sediment would be removed from pipeline segments with sewer vacuum truck equipment. Manhole covers would be repaired, replaced, or re-installed on an as-needed basis. The combined post-project conditions annual O&M costs were estimated for Flat Canyon and the North and South Flood Channel to be approximately $12,000. All annual O&M cost estimates are shown in Table 2.

Table 2. O&M Cost Estimates for the Project Components

Component	Existing Annual O&M Estimate	Post-Project Annual O&M Estimate
Flat Canyon and North and South Flood Channels	-	$12,000

Attachment A. Alternatives 30% Design Cost Estimates

Owner: Sevier County
Project: Sevier County Watershed Plan-EA
Date: 05-30-2025
PM: Darin Robinson, PE

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ENGINEER'S OPINION OF PROBABLE COST: FLAT CANYON DETENTION BASIN

Item Description	Unit	Estimated Units	Unit Price	Price
Contractor Mobilization	L.S.	1	$ 1,050,000.00	$ 1,050,000
Traffic Control	L.S.	1	$ 15,000.00	$ 15,000
Storm Water Controls & SWPPP	L.S.	1	$ 20,000.00	$ 20,000
Compacted Embankment (Fill)	C.Y.	366,123	$ 7.00	$ 2,562,861
Basin Material Removal (Cut)	CY	539,926	$ 2.00	$ 1,079,852
Import Material for Embankment	CY	28,000	$ 10.00	$ 280,000
Basin Excess Material Hauling & Disposal	CY	100,578	$ 5.00	$ 502,892
Detention Basin Clay Core	C.Y.	64,000	$ 15.00	$ 960,000
Foundation Cutoff Trench/Keyway Excavation	C.Y.	23,200	$ 12.00	$ 278,400
Abutment Excavation (Earth)	CY	57,000	$ 6.00	$ 342,000
Abutment Excavation (Rock Ex)	CY	40,000	$ 20.00	$ 800,000
Grouting Abutment Treatment (150' Depth)	FT	225	$ 1,860.00	$ 418,500
Grouting Abutment Treatment (100' Depth)	FT	294	$ 1,240.00	$ 364,560
Clearing and Grubbing	Acre	30	$ 1,000.00	$ 30,000
Existing Construction Access Road Improvements	L.F.	1,500	$ 24.00	$ 36,000
Primary Outlet Structure	L.S	1	$ 150,000.00	$ 150,000
Secondary Spillway Concrete Cutoff Wall	Each	1	$ 30,000.00	$ 30,000
Secondary Spillway & Chute Grouted Riprap	C.Y.	5,000	$ 40.00	$ 200,000
Grout for Riprap	C.Y.	1,500	$ 300.00	$ 450,000
Primary Outlet Discharge Structure	Each	1	$ 20,000.00	$ 20,000
Secondary Energy Dissipation Structure	Each	1	$ 50,000.00	$ 50,000
Onsite Riprap Screening, Sorting and Stockpiling	C.Y.	1,500	$ 15.00	$ 22,500
Offsite Riprap Mining, Screening, Sorting and Hauling	C.Y.	3,500	$ 25.00	$ 87,500
Embankment Field Fence	L.F.	1,200	$ 10.00	$ 12,000
Gate	Each	2	$ 500.00	$ 1,000
Seeding	Acre	30	$ 700.00	$ 21,000
Outlet Pipe Sand Filter with Drain	L.F.	73	$ 210.00	$ 15,330
Chimney and Toe Drain	C.Y.	31,000	$ 50.00	$ 1,550,000
Outlet Pipe	L.F.	400	$ 180.00	$ 72,000
Concrete Encasement	L.F.	400	$ 250.00	$ 100,000
OHV Bypass Trail	L.S.	1,000	$ 20.00	$ 20,000
			Construction Subtotal	**$ 11,541,395**
Contingency 12.25%	L.S.	1	$ 1,413,000.00	$ 1,413,000
			TOTAL PROBABLE CONSTRUCTION COST	**$ 12,954,000**
ENGINEERING AND PROFESSIONAL SERVICES				
Design Engineering	L.S.	1	$ 808,000.00	$ 808,000
Construction Engineering	L.S.	1	$ 578,000.00	$ 578,000
Design survey, investigation, and technical coordination	L.S.	1	$ 30,000.00	$ 30,000
			Engineering and Professional Services Subtotal	**$ 1,416,000**
Administration	L.S.	1	$ 129,540.00	$ 129,540
Real Property Rights	L.S.	0	$ -	$ -
Final Environmental Permitting	L.S.	1	$ 4,000.00	$ 4,000
			TOTAL PROBABLE PROJECT COST	**$ 14,504,000**

Owner: Sevier County
Project: Sevier County Watershed Plan-EA
Date: 05-30-2025
PM: Darin Robinson, PE

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ENGINEER'S OPINION OF PROBABLE COST: NORTH FLOOD CHANNEL

Item Description	Unit	Estimated Units	Unit Price	Price
Mobilization	L.S.	1	$ 207,000.00	$ 207,000
Traffic Control	L.S.	1	$ 12,000.00	$ 12,000
SWPPP	L.S.	1	$ 1,500.00	$ 1,500
Sevier Valley Flood Overflow Structure	L.S.	1	$ 130,000.00	$ 130,000
Sevier Valley Canal Flood Control Gate and Appurtenances	Each	1	$ 210,000.00	$ 210,000
Flood Channel Upgrade Type 1 (to Richfield Canal)	C.Y.	7,100	$ 5.00	$ 35,500
Grouted Riprap Protection (Rock Only)	C.Y.	400	$ 50.00	$ 20,000
Grout for Riprap	C.Y.	280	$ 300.00	$ 84,000
Richfield Canal Flood Overflow and Flood Pipe Inlet Structure	L.S.	1	$ 200,000.00	$ 200,000
Hwy 118 Crossing (ADS Culvert)	L.F.	200	$ 200.00	$ 40,000
Flood Water Pipe (48" ADS Smooth Culvert)	L.F.	6,700	$ 175.00	$ 1,172,500
84" Flood Pipe Access Manhole	Each	7	$ 8,000.00	$ 56,000
Flood Pipe Outlet Headwall Structure	Each	1	$ 25,000.00	$ 25,000
Hwy 118 Crossing (Road repairs & associated work	L.F.	150	$ 250.00	$ 37,500
Canal Crossing Structure (Vermillion Canal)	L.S.	1	$ 10,000.00	$ 10,000
Cultural Mitigation	L.S.	1	$ 20,000.00	$ 20,000
Existing Irrigation Facility Relocation	L.S.	1	$ 15,000.00	$ 15,000
			Construction Subtotal	**$ 2,276,000**
Contingency 12.25%	L.S.	1	$ 279,000.00	$ 279,000
			TOTAL PROBABLE CONSTRUCTION COST	**$ 2,555,000**
ENGINEERING AND PROFESSIONAL SERVICES				
Design Engineering	L.S.	1	$ 160,000.00	$ 160,000
Construction Engineering	L.S.	1	$ 114,000.00	$ 114,000
Design survey, investigation, and technical coordination	L.S.	1	$ 23,000.00	$ 23,000
			Engineering and Professional Services Subtotal	**$ 297,000**
Administration	L.S.	1	$ 25,550.00	$ 25,550
Real Property Rights - Utility Relocations	L.S.	1	$ 15,000.00	$ 15,000
Final Environmental Permitting	L.S.	1	$ 1,000.00	$ 1,000

TOTAL PROBABLE CONSTRUCTION COST $ 2,894,000

Owner: Sevier County
Project: Sevier County Watershed Plan-EA
Date: 05-30-2025
PM: Darin Robinson, PE

Jones & DeMille Engineering
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ENGINEER'S OPINION OF PROBABLE COST: SOUTH FLOOD CHANNEL

Item Description	Unit	Estimated Units	Unit Price	Price
Mobilization	L.S.	1	$ 229,000.00	$ 229,000
Traffic Control	L.S.	1	$ 10,000.00	$ 10,000
SWPPP	L.S.	1	$ 1,500.00	$ 1,500
Canal Overshot Flood Structure	L.S.	1	$ 130,000.00	$ 130,000
Stilling Basin/Rock Chute	L.S.	1	$ 30,000.00	$ 30,000
Existing Channel Reshaping and Armoring	C.Y.	7,900	$ 5.00	$ 39,500
48" HDPE - DR26 (80 psi) Pipe (1X 7680' Segment)	L.F.	7,680	$ 200.00	$ 1,536,000
New Channel Excavation	CY	10,815	$ 13.00	$ 140,595
Levee	CY	100	$ 35.00	$ 3,500
Utility and Drainage Obstacle	LS	1	$ 50,000.00	$ 50,000
Removal of Channel Spoil	C.Y.	11,000	$ 5.00	$ 55,000
84" Storm Drain Manhole	Each	8	$ 8,000.00	$ 64,000
8'x3' Precast Box Culvert	LF	30	$ 2,000.00	$ 60,000
Culvert Riprap Armoring	CY	50	$ 100.00	$ 5,000
Pipe inlet and flow splitter (near airport)	L.S.	1	$ 90,000.00	$ 90,000
Hwy 118 Crossing (Road repairs & associated work)	L.F.	125	$ 250.00	$ 31,250
Cultural Mitigation	L.S.	1	$ 20,000.00	$ 20,000
Existing Irrigation Facility Relocation	L.S.	1	$ 18,000.00	$ 18,000
			Construction Subtotal	**$ 2,513,345**
Contingency 12.25%	L.S.	1	$ 308,000.00	$ 308,000
			TOTAL PROBABLE CONSTRUCTION COST	**$ 2,821,000**
ENGINEERING AND PROFESSIONAL SERVICES				
Design Engineering	L.S.	1	$ 198,000.00	$ 198,000
Construction Engineering	L.S.	1	$ 142,000.00	$ 142,000
Design survey, investigation, and technical coordination	L.S.	1	$ 26,000.00	$ 26,000
			Engineering and Professional Services Subtotal	**$ 366,000**
Administration	L.S.	1	$ 28,210.00	$ 28,210
Real Property Rights - Utility Relocations	L.S.	1	$ 15,000.00	$ 15,000
Final Environmental Permitting	L.S.	1	$ 1,000.00	$ 1,000
			TOTAL PROBABLE PROJECT COST	**$ 3,231,000**

TM009 – Hazard Classifications

Table of Contents

1.0 Introduction 1
2.0 Dam Breach Analysis 1
2.1 Dam Breach Parameters 1
2.2 Hydraulic Modeling (HEC-RAS 2D) 1
3.0 Dam Breach Analysis Results 2
3.1 Flat Canyon 2
4.0 References 3

Attachments

Attachment A. TR-60 Dam Breach Parameters
Attachment B. Inundation Maps

Tables

Table 1-1. Hazard Classifications 1
Table 2-1. Peak Breach Flows 1
Table 2-2. Manning's n Values by Land Cover Type 2

1.0 Introduction

NRCS Technical Release 210-60 (TR-60; 2019) and Utah Code 73-5a-106 (1996) outline the criteria for dam hazard classifications in the watershed area. The criteria are summarized in Table 1-1.

Table 1-1. Hazard Classifications

Hazard Classification	NRCS TR-60 (2019)	Utah Dam Safety (1996)
Low	Dams in rural or agricultural areas where failure may damage farm buildings, agricultural land, or township and country roads.	Those dams which, if they fail, would cause minimal threat to human life, and economic losses would be minor or limited to damage sustained by the owner of the structure.
Significant/Moderate	Dams in predominantly rural or agricultural areas where failure may damage isolated homes, main highways or minor railroads, or interrupt service of relatively important public utilities.	Those dams which, if they fail, have a low probability of causing loss of human life, but would cause appreciable property damage, including damage to public utilities.
High	Dams where failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads.	Those dams which, if they fail, have a high probability of causing loss of human life or extensive economic loss, including damage to critical public utilities.

2.0 Dam Breach Analysis

2.1 Dam Breach Parameters

Per Utah Administrative Code R655-10 (2016), the hazard classification for a dam shall be determined using a dam breach analysis with the reservoir level at the spillway crest. This scenario is also known as a sunny-day breach condition. For this analysis, the sunny-day condition is considered to be when the reservoir level is equal to the auxiliary spillway crest. For TR-60, this is also known as the static failure mode.

The peak breach flows and dam breach hydrographs for Flat Canyon (see Attachment A) were developed using TR-60 and Soil Conservation Service TR-66 (1985) guidelines. The peak breach flows for the Flat Canyon detention basin is shown in Table 2-1.

Table 2-1. Peak Breach Flows

Debris Basin Name	Peak Breach Flow (cfs)
Flat Canyon	71,789

2.2 Hydraulic Modeling (HEC-RAS 2D)

The U.S. Army Corps of Engineers (USACE) River Analysis System (HEC-RAS 5.0.7) software was used to complete the hydraulic modeling (USACE 2019). HEC-RAS was used to create a 2D model simulating the dam breach hydrographs and inundated flood areas. This section outlines the development and parameters of the 2D model.

2.2.1 Terrain Data

The best available elevation surface data for the area was obtained from the Utah Automated Geographic Reference Center (AGRC 2019). The terrain is a 1-meter resolution LiDAR surface from 2018, and the datum is NAVD 88.

2.2.2 Surface Roughness

Land cover types were based on aerial imagery to determine the surface roughness of the terrain data. The land cover types and corresponding Manning's n values that were used in the HEC-RAS model are shown in Table 2-2.

Table 2-2. Manning's n Values by Land Cover Type

Land Cover Type	Value
Agricultural Field	0.06
None - Vegetated Soil	0.025
Parks and Recreational Areas	0.04
Residential Areas	0.075
Roads	0.025

2.2.3 2D Mesh Parameters

A computational grid, or mesh, was created for the HEC-RAS 2D model. The cells of the grid measured 50 feet by 50 feet. Break lines were also used to capture important terrain features such as channel centerlines and major roads.

Time steps for the model were selected to maintain a Courant number of approximately 1.0. Several time steps were considered for a sensitivity analysis to ensure stable, accurate results.

2.2.4 Culverts

Several Utah Department of Transportation (UDOT) culverts with diameters ranging from 24 to 60 inches cross beneath I-70 downstream of Flat Canyon (UDOT 2017). It was important to model the culverts into the HEC-RAS geometry to accurately model how the breach flows would distribute beyond I-70. Culverts with 36-inch diameters were assumed to be clogged with debris and sediment and were therefore excluded from the model. An existing UDOT underpass on I-70 downstream of Flat Canyon was modeled as a large box culvert since it was missing from the 2018 LiDAR surface. The location of the culverts and underpass included in the model are shown in the inundation maps found in Attachment B.

2.2.5 Boundary Conditions

The dam breach hydrographs (see Attachment B) were used for the unsteady flow data boundary conditions at the proposed detention basin locations. Downstream boundary conditions were located on the Sevier River and were modeled using a normal depth approach.

3.0 Dam Breach Analysis Results

An inundation map from the dam breach analysis for the Flat Canyon detention basin is provided in Attachment B. The inundation map includes approximate arrival times of the flood wave for several major roads.

3.1 Flat Canyon

Due to the large alluvial fan at the mouth of Flat Canyon, the dam breach analysis resulted in breach flows going north, east, and south of the canyon. To the north, the breach flows cross under I-70 through existing UDOT culverts and flow toward the Richfield Municipal Airport. The breach flows continue

northeast until they are impounded by Annabella Road. To the east, the breach flows cross under I-70 through the existing underpass and flood across agricultural fields and Central Valley before entering the Sevier River floodplain. To the south, the model shows breach flows overtop I-70 (at depths of approximately 1-2 feet) and flow across Elsinore before reaching the Sevier River floodplain.

Several residential homes and other infrastructure (including Elsinore's fire station) within Elsinore, Central Valley, and surrounding communities are within the dam breach inundation boundary of the Flat Canyon debris basin. Based on the modeling results, it is recommended the Flat Canyon debris basin receive a hazard rating of **high hazard** for both NRCS and Utah Dam Safety criteria as shown in Table 1-1.

4.0 References

Automated Geographic Reference Center (AGRC). 2019. Utah Automated Geographic Reference Center. https://gis.utah.gov/data/. Accessed 6-5-2019.

Natural Resources Conservation Service (NRCS). 2019. Technical Release 210-60: Earth Dams and Reservoirs (TR-60).

Soil Conservation Service. 1985. Technical Release 210-66: Simplified Dam-Breach Routing Procedure (TR-66).

U.S. Army Corps of Engineers. 2019. River Analysis System (HEC-RAS), Version 5.0.7. Hydrologic Engineering Center. March 2019.

Utah Administrative Code (UAC). 2016a. R655-10: Dam Safety Classifications, Approval Procedures and Independent Reviews.

Utah Department of Transportation (UDOT). 2017. UDOT Data Portal. https://data-uplan.opendata.arcgis.com/. Accessed 4-12-2017.

Utah Code. 1996. 73-5a-106 – Dams classified according to hazard and use.

Attachment A. TR-60 Dam Breach Parameters

Dambreach Hydrographs via TRs 60 & 66 NRCS guidance

version 3, July 2018

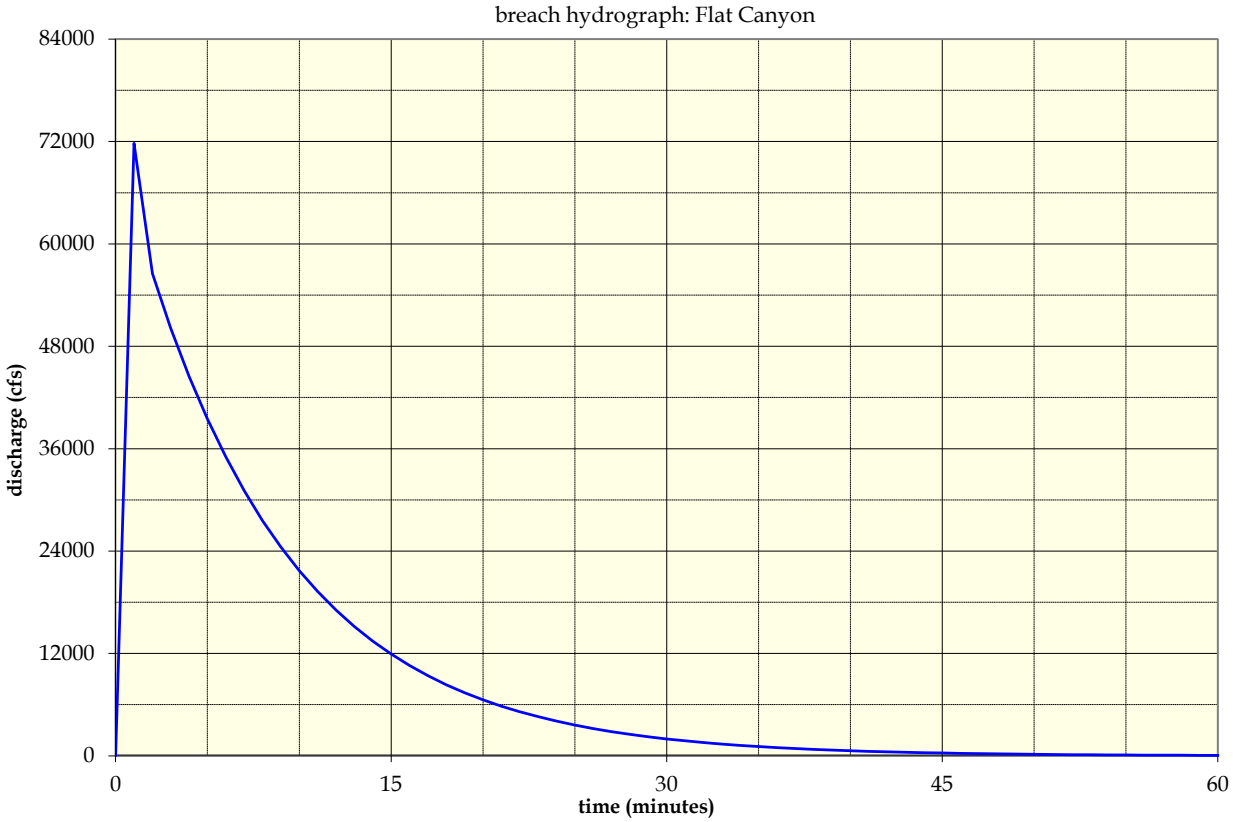
Failure Mode: Static

Input data required:

Dam: Flat Canyon

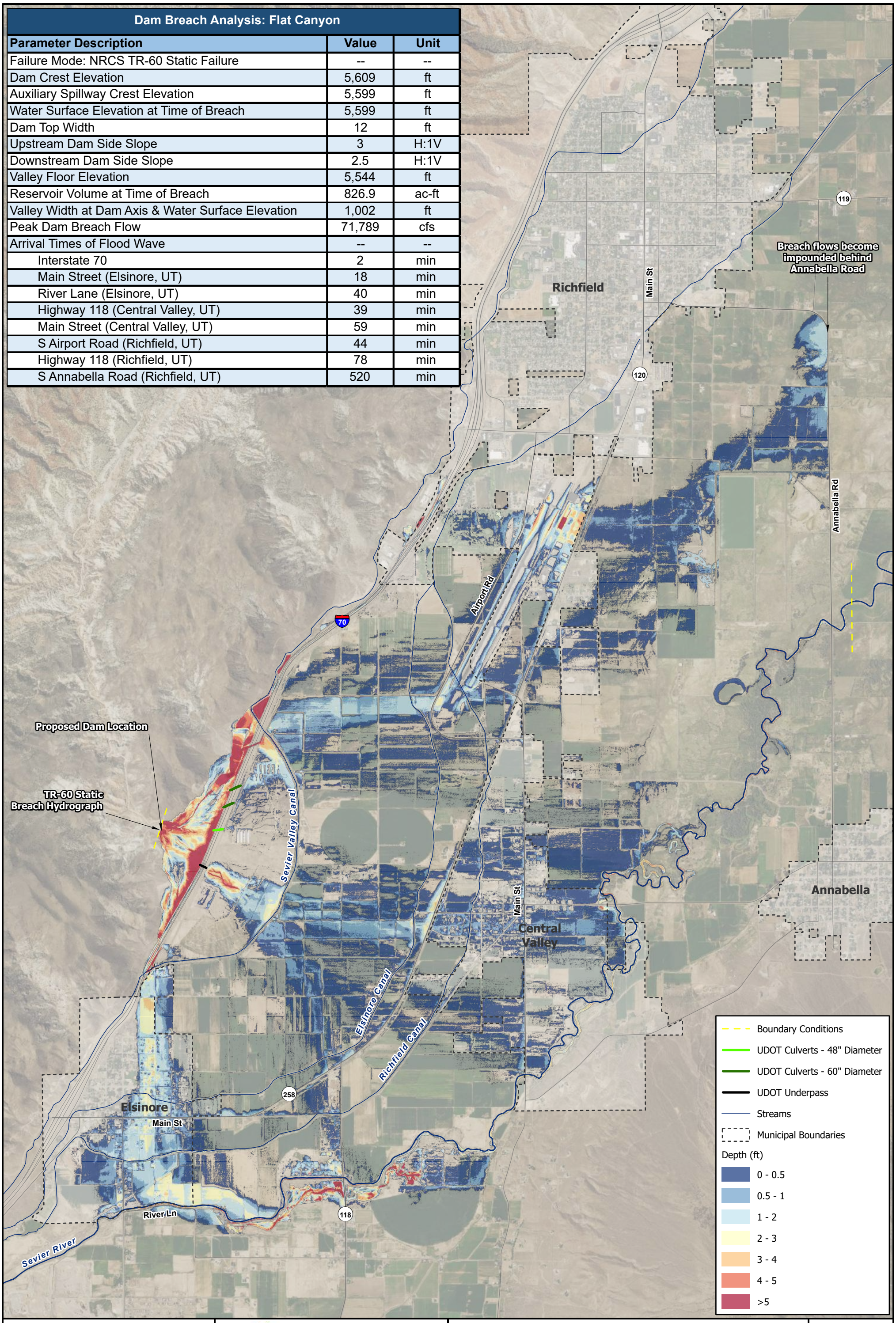
data	variable	explanation
5609	crestEL	dam crest elevation
5599	wsEL	w.s. elev at time of breach
12	TW	dam top width (feet)
3	SSup	dam side slope (upstream, SSup:1)
2.5	SSdn	dam side slope (downstream, SSdn:1)
5544	floorEL	valley floor elev (see note)
826.9	Vs	resv vol at time of breach (acre-feet)
1002	L	valley width at dam axis & w.s. elev (feet)
	ELwave	top of wave berm elevation
	Wwave	width of top of wave berm feet
	SSwave	wave berm side slope (SSwave:1)
	ELstab	top of stability berm elevation
	Wstab	width of top of stability berm (feet)
	SSstab	stability berm side slope (SSstab:1)
1	ts	timestep (minutes) for breach hydrograph

output		**breach hydrograph**	
variable	**results**	**time (min)**	**Q (cfs)**
T	635	0	0
(L < T)?	N	1	**71789**
H_w	55	2	56518
Q_1	107791	3	50148
(H_w < 103)?	Y	4	44496
Awave	0	5	39481
Astab	0	6	35031
A	12399	7	31083
Br	4	8	27579
Q_2	6359	9	24471
Q_{min}	71789	10	21713
(Q_2 < Q_{min})?	Y	11	19266
(Q_2 > Q_1)?	N	12	17094
(Q_1 < Q_{min})?	N	13	15168
Q_{max}	**71789**	14	13458


breach hydrograph: Flat Canyon
84000
72000
60000
48000
36000
24000
12000
0
discharge (cfs)
0
15
30
45
60
time (minutes)

Attachment B. Inundation Maps

Dam Breach Analysis: Flat Canyon		
Parameter Description	**Value**	**Unit**
Failure Mode: NRCS TR-60 Static Failure	--	--
Dam Crest Elevation	5,609	ft
Auxiliary Spillway Crest Elevation	5,599	ft
Water Surface Elevation at Time of Breach	5,599	ft
Dam Top Width	12	ft
Upstream Dam Side Slope	3	H:1V
Downstream Dam Side Slope	2.5	H:1V
Valley Floor Elevation	5,544	ft
Reservoir Volume at Time of Breach	826.9	ac-ft
Valley Width at Dam Axis & Water Surface Elevation	1,002	ft
Peak Dam Breach Flow	71,789	cfs
Arrival Times of Flood Wave	--	--
Interstate 70	2	min
Main Street (Elsinore, UT)	18	min
River Lane (Elsinore, UT)	40	min
Highway 118 (Central Valley, UT)	39	min
Main Street (Central Valley, UT)	59	min
S Airport Road (Richfield, UT)	44	min
Highway 118 (Richfield, UT)	78	min
S Annabella Road (Richfield, UT)	520	min



N

0 1,500 3,000 Feet

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Sevier County

Sevier County Watershed Plan
Dam Breach Analysis: Flat Canyon

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_HH\1804-224_HH.aprx - EXH_Dam_Breach_01_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/30/2021

Sevier County

Scale: 1" = 3,000'

1