

APPENDIX D: INVESTIGATION AND ANALYSIS

TABLE OF CONTENTS

Appendix D: Investigation and Analysis	i
Table of Contents	i
List of Tables	ii
List of Figures	iii
D 1. Introduction	5
D 2. Hydrologic Analysis	6
D 2.01 Existing Studies	6
D 2.02 Hydrologic Methodology	10
Watershed Delineations	10
Loss and Transform Methods	10
Routing and Storage	14
Meteorological Model - Precipitation	14
D 2.03 Model Calibration	15
Trouble Creek Dam	15
Maple Creek Bulletin 17C Analysis	15
Event Calibration	18
D 3. Hydraulic Analysis	20
D 3.01 Table 31 Existing Studies	20
D 3.02 Hydraulic Methodology	20
Existing Conditions Scenarios	25
D 3.03 Model Calibration	28
D 3.04 Baseline Hydraulic Results	30
D 3.05 Risk Assessment and Hydraulic Recommendations	31
Fremont	32
Inglewood	33
Ames	34
North Bend	34
Rogers	34
Other Areas	35
D 4. Preferred Alternative Analysis and Design	44
D 4.01 Site Identification	44
D 4.02 Site Prioritization	44
D 4.03 Site Specific Design Information	45
Site L1-1	45
Site L1-2	45
Site DC1-13A	45
D 4.04 Proposed Conditions Hydrology & Hydraulics	46
D 4.05 Dam Breach Analysis	50
Dam Breach Hydrology	50

	Dam Breach Hydraulics	50
D 4.06	Induced Flooding Evaluation	51
	Residual Risk.....	51
	Avoidance of Upstream Impacts	51
D 5.	Geology	54
D 6.	Economics.....	54
D 6.01	Introduction.....	54
D 6.02	Federal Guidelines of Benefit-Cost Analysis of Flood Mitigation Measures	55
	Guiding Principles	57
D 6.03	Ecosystem Services Evaluated	58
	Types of Services Impacted.....	58
	Ability to Characterize, Quantify, and Monetize Services	59
	Metrics to Evaluate Services.....	59
	Prioritizing Services	59
	Summary and Comparison of Ecosystem Service Changes	60
D 6.04	National Economic Efficiency Analysis Data and Methodology	62
	Reduced Property-Related Damage and Income Loss	63
	Building Repair and Replacement Cost	66
	Building Content Loss	66
	Business Inventory Damages	67
	Business Income and Wage Damages.....	68
	Agricultural Damage Reduction	70
	Wetland Habitat Creation.....	71
	Costs 73	
	Installation Costs	73
	Other Direct Costs & Adverse Effects.....	78
	Operations and Maintenance.....	78
D 6.05	Current Economic Damages	78
D 6.06	Economic Tables	79
D 7.	Cultural Resources	80
D 7.01	Post-Review Discovery procedures.....	80
	Human Remains	81

LIST OF TABLES

Table 1: Trouble Creek Dam Stage/Storage/Discharge.....	7
Table 2: Rainfall Depths.....	14
Table 3: Trouble Creek Dam Properties	15
Table 4: Maple and Rawhide Creek Characteristics	16
Table 5: Bulletin 17C Analysis	17
Table 6: NOAA Peaking Factors	17
Table 7: 100-year Peak Flows	18
Table 8: LiDAR Base Flow Condition.....	22

Table 9: Elkhorn River at Waterloo, Nebr. Duration Analysis	22
Table 10: Platte River near Leshara, Nebr. Duration Analysis.....	23
Table 11: Manning's n Values Used in HEC-RAS Model.....	23
Table 12: Manning's n Values Used for HEC-RAS Calibration Regions.....	24
Table 13: Joint Probability of Coincident Flood Events.....	30
Table 14: Ditch Capacity vs 100-year Flow and Overflows.....	31
Table 15: Design Rainfall Depths.....	46
Table 16: Hydrologic Performance of Detention Structures.....	47
Table 17: Proposed Breach Parameters.....	50
Table 18: Results of Upstream Property Analysis.....	52
Table 19: Ecosystem Services Framework Used to Evaluate Benefits and Costs	56
Table 20: Summary of Project Alternatives and Ecosystem Services (2024\$).....	61
Table 21: Count of Damaged Structures in the Rawhide Creek Watershed Under the Future Without Federal Investment (FWOFI) and the Preferred Alternative (PA)	65
Table 22: Replacement Cost Values for Buildings.....	66
Table 23: Building Content Loss as Percent of Building Replacement Value.....	67
Table 24: Business Inventory Losses as a Percent of Gross Sales per Square Foot.....	67
Table 25: Parameters Used to Calculate Business Income and Wage Loss.....	69
Table 26: Acres of Cropland Avoiding Flood Damages	70
Table 27: Agricultural Depth Damage Function	71
Table 28: Crop Values Used to Estimate Gross Crop Revenues	71
Table 29: National Average Benefit Value per Acre for Individual Wetland Ecosystem Services Produced by Wetland Mitigation (2024 \$).....	72
Table 30: Net Acres of Additional Wetland and Wetland Value of Preferred Alternative (2024 \$).....	72
Table 31: Estimated Installation Costs of DC1-13A (2024 \$).....	74
Table 32: Estimated Installation Costs of L1-1 & L1-2 (2024 \$).....	76
Table 33: Estimated Annual Operations and Maintenance Costs (2024 \$)	78
Table 34: Average Annualized Damages Under FWOFI (2024 \$).....	79

LIST OF FIGURES

Figure 1: Elkhorn Township Drainage Improvements Study Area	9
Figure 2: Hydrologic Model Curve Number Overview.....	12
Figure 3: Drainage Basins by Outlet Location.....	13
Figure 4: Maple and Rawhide Creek Watershed Overview	16
Figure 5: June 2016 Accumulated Precipitation (inches).....	18
Figure 6: Manning's n Calibration Regions	24
Figure 7: Hydraulic Model Geometry without New Highway 30	26
Figure 8: Hydraulic Model Geometry with New Highway 30.....	27
Figure 9: Map of Key Photo Locations in Fremont, NE.....	28
Figure 10: 10-year Coincident Event Existing Conditions.....	39
Figure 11: 25-year Coincident Event Existing Conditions.....	40
Figure 12: 50-year Coincident Event Existing Conditions	41
Figure 13: 100-year Coincident Event Existing Conditions.....	42
Figure 14: 500-year Coincident Event Existing Conditions	43



Figure 15: 100-year Coincident Event Proposed Conditions	48
Figure 16: 500-year Coincident Event Proposed Conditions	49
Figure 17: Anticipated Impacts on Ecosystem Services	59

D 1. INTRODUCTION

This appendix presents information that supports the formulation, evaluation, and conclusions of the Rawhide Creek Plan-EA. The outline is organized under major headings that allow the reader who is not familiar with the details of the watershed and the analysis leading to the conclusions to be able to form a conclusion and form an opinion on the adequacy of the Plan. The appendix follows USDA NRCS Watershed Program Manuals and guidance previously referenced in the Plan. The appendix is intended to supplement information contained in the Plan.

The appendix was written by the consultant in collaboration with the Nebraska NRCS Engineering team and in consultation with other federal, state, and local agencies, property owners, sub-consultants, Dodge County, and local community representatives. These stakeholders worked together to incrementally analyze a cost-effective alternative meeting social, political, and economic acceptability.

D 2. HYDROLOGIC ANALYSIS

Hydrologic analysis was conducted using various methods depending on the unique flow characteristics and potential solutions for the watershed. In general, modeling parameters were developed in accordance with appropriate engineering-based methods by professional engineers licensed in the State of Nebraska. Each of the models developed was calibrated using the best available scientific data including historical observations and historical gage information.

The following sections outline available background data, data sources, and other methods used in the development of the baseline hydrologic conditions within the study area.

D 2.01 EXISTING STUDIES

The alignment of Rawhide Creek and the ditch network within the watershed have been periodically modified and studied since the early 1900's. Data and studies that have been considered during the creation of this Hydrology model are as follows:

Trouble Creek Dam Design

The Trouble Creek Dam was designed and constructed in the early 1980's. The structure was designed as a significant hazard dam. Peak flows for the design storms were calculated using the SCS method for loss and transform. These design plans were used to model the Trouble Creek Dam for the Rawhide Creek hydrology modeling effort. Stage-storage data recorded in the dam as-built plans was copied to the model. A stage discharge curve was created based on the principal and auxiliary spillway details shown in the as-built plans and verified with the listed discharges in the plans. Key elevations and associated storage and discharge values of the reservoir are shown in Table 1.

Table 1: Trouble Creek Dam Stage/Storage/Discharge

	Elevation (ft)	Storage (acft)	Discharge (cfs)
	1,235.0	30	0
Low Level Inlet -	1,243.0	175	0
Permanent Pool -	1,248.5	447	0
	1,256.0	945	41
	1,258.0	1,185	47
Riser Crest -	1,260.1	1,500	52
	1,261.0	1,675	118
	1,262.0	1,875	178
Emergency Spillway -	1,262.5	1,987	179
	1,266.0	2,800	2,546
	1,268.0	3,340	4,837
Top of Dam -	1,270.0	4,000	7,593

Merlyn England Diversion and Ditch 8 Design

The design of this project was completed in the 1980's with construction completed in 1994. An Operations and Maintenance manual was created for the LPNNRD in 1994, and updated with clarifying language and maps in the 2000's. This study and design reroute part of Rawhide Creek flows into Ditch 8 instead of allowing it to flow uncontrolled into Fremont. High flows are still allowed to enter the old creek bed and flow towards the Merlyn England Diversion channel, which diverts flows from the ditch network and a branch of Rawhide Creek to Ditch 8. The Diversion structure consists of 3 large arch pipes moving most of the flow northeast to Ditch 8 and a weir with two 24" pipes allowing low flows to continue towards Fremont in Rawhide Creek. The design plans were used to gain an understanding of the changes made to the Rawhide Creek system in this area which was used to ensure the hydrology model was functioning correctly. Survey was taken at key points of this design to ensure flood model geometry is correct and the diversion is still functioning as intended.

NDOT Highway 30 Design

The design of the new Highway 30 alignment was completed in 2021 and is currently under construction. This highway alignment connects to the existing Highway 30 near Rogers then runs along the north side of North Bend and connects to the north stretch of Highway 275 north of Fremont. Design plans and surface models were used to add the new alignment, including culvert and bridge locations, into the terrain for the hydrologic and hydraulic models. These plans are available on request. This impacted the boundaries of drainage basins as it created a new major topographic feature in the watershed.

North Bend Cutoff Ditch Study

At the time of writing, this ongoing study and model analyze the effectiveness of the North Bend Cutoff Ditch and the flooding risks that the Rawhide Creek, Shell Creek and Platte River overflows pose to North Bend, NE. The study area includes the lower reach of Shell Creek and the western portion of the Rawhide Creek WFPO area, with the eastern boundary at the Central Cutoff Ditch. This model was referenced to gain an understanding of the impact it may have on the Rawhide WFPO Project and to begin to understand the impact the Shell Creek and Platte River have on this portion of the project area.

Elkhorn Township Drainage Study:

JEO completed a FEMA funded drainage study of the southeastern portion of the Rawhide Creek watershed in 2023. The study focused on the area south of Ditch 7 and east of Highway 77 until the Dodge County line to the south and Elkhorn River on the east (Figure 1). This Elkhorn Township study is focused on determining if flooding risk within Fremont is due to undersized storm drain infrastructure, restrictions within the urban ditch system or restrictions within the downstream, rural ditch system. HEC-RAS (USACE Hydrologic Engineering Center River Analysis System) was used to evaluate capacities for ditches in Fremont and east of Fremont. The modeling efforts for Rawhide Creek are being coordinated closely with the Elkhorn Township Study modeling effort in areas where they overlap.

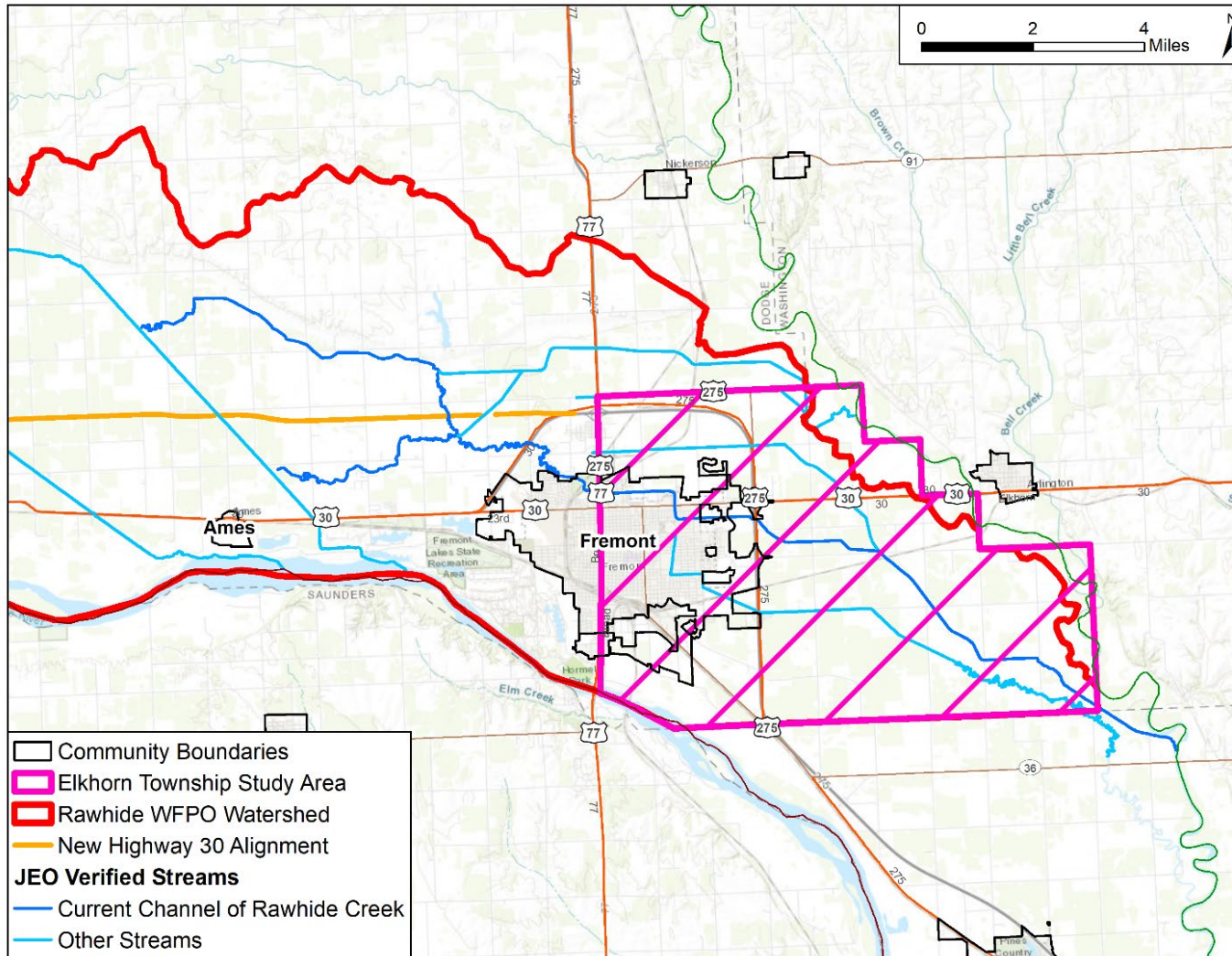


Figure 1: Elkhorn Township Drainage Improvements Study Area

D 2.02 HYDROLOGIC METHODOLOGY

WATERSHED DELINEATIONS

Rawhide Creek subbasins were initially delineated using HEC-GeoHMS (Hydrologic Engineering Center Geospatial Hydrologic Modeling Extension). Manual updates to basins were needed as the terrain in the watershed is flat and the ditch network and culvert crossings play a significant role in the hydrologic basin geometry. Key culvert locations were identified initially using aerial imagery and later surveyed. Culverts were used to determine where drainage would cross embankments that impact the border of the basin. Additionally, as the new alignment of Highway 30 is currently under construction it is not included in the most recent LiDAR data, thus this new major landmark in the terrain had to be added manually. Based on design plans, the new highway alignment was added as a new embankment with culverts which informed the drainage basin extents. Finally, manual basin edits were utilized to match the extents of the Fremont basins to the basin extents used for the current Elkhorn Township Drainage Study so that the model being utilized for that study could be used to cross check the results of the Rawhide WFPO modeling efforts. Terrain data was obtained from USGS Dodge, Saunders, Washington, Douglas and Colfax County LiDAR collected between 2016 and 2018. The terrain was then manually updated based off NDOT's Highway 30 plan set to include the new highway alignment. Basins were delineated to outflow locations that consist of major watershed landmarks. Basin outflow points were placed at tributary confluences, cutoff ditch locations, flow restrictions locations such as railroad and highway crossings, existing dams, and key culvert locations. In total, 108 subbasins ranging in size from 0.14 to 8.56 square miles were delineated (Figure 2).

LOSS AND TRANSFORM METHODS

The Rawhide Creek hydrologic model uses the SCS Curve Number loss method. The higher the curve number, the higher the percentage of precipitation will become runoff. The SCS Curve Number loss method classifies land based on both land use and hydrologic soil group (HSG) as indicated by the USDA NRCS Web Soil Survey. Land use was drawn from the 2016 National Land Cover Database. Because most of the watershed is the same hydrologic soil type and land use, the range of average curve numbers was relatively small (71.1 to 90.2) with the highest curve numbers primarily impacted by the amount of impervious cover. In general, the Rawhide Creek watershed has a high average curve number as the majority of the soils in the watershed are HSG C and D which have generally lower permeability and therefore lead to higher curve numbers. Subbasins along the current and historic Rawhide Creek channel have slightly lower curve numbers because of tree cover and the HSG of soils within the channel. An overview of basin delineations and calculated curve number is shown in Figure 2 and Figure 3.

The time of concentration for each basin was developed with Natural Resources Conservation Service (NRCS) TR-55 methodology. A mixture of Sheet Flow, Shallow Concentrated, and Channel Flow was used, depending on the subbasin. The maximum length of sheet flow was

assumed to be 100 feet. Shallow concentrated flow lengths were not allowed to exceed 5000 feet for rural basins as it is assumed that the flow would reach a ditch before leaving a square mile. For basins within Fremont the shallow concentrated flow was not allowed to exceed 1300 feet as it is assumed to reach storm sewer or a ditch within this length. The lag time was assumed to be 0.6 times the calculated time of concentration. Lag times were checked by comparing the Trouble Creek dam HMS basin to the Trouble Creek Dam design. The Trouble Creek Dam design plans used an area of 8.47 square miles and a curve number of 74. These are very similar to the numbers generated using HEC-GeoHMS of 8.56 square miles and curve number of 76.45. Similarities in basin characteristics lead to the assumption that the time of concentrations should be very similar. To adjust the time of concentrations to reasonably compare with the Trouble Creek Dam, the hydraulic radius was modified in basins with peaking factors of 300 or basins characterized by rural rolling hills, similar to the Trouble Creek dam basin.

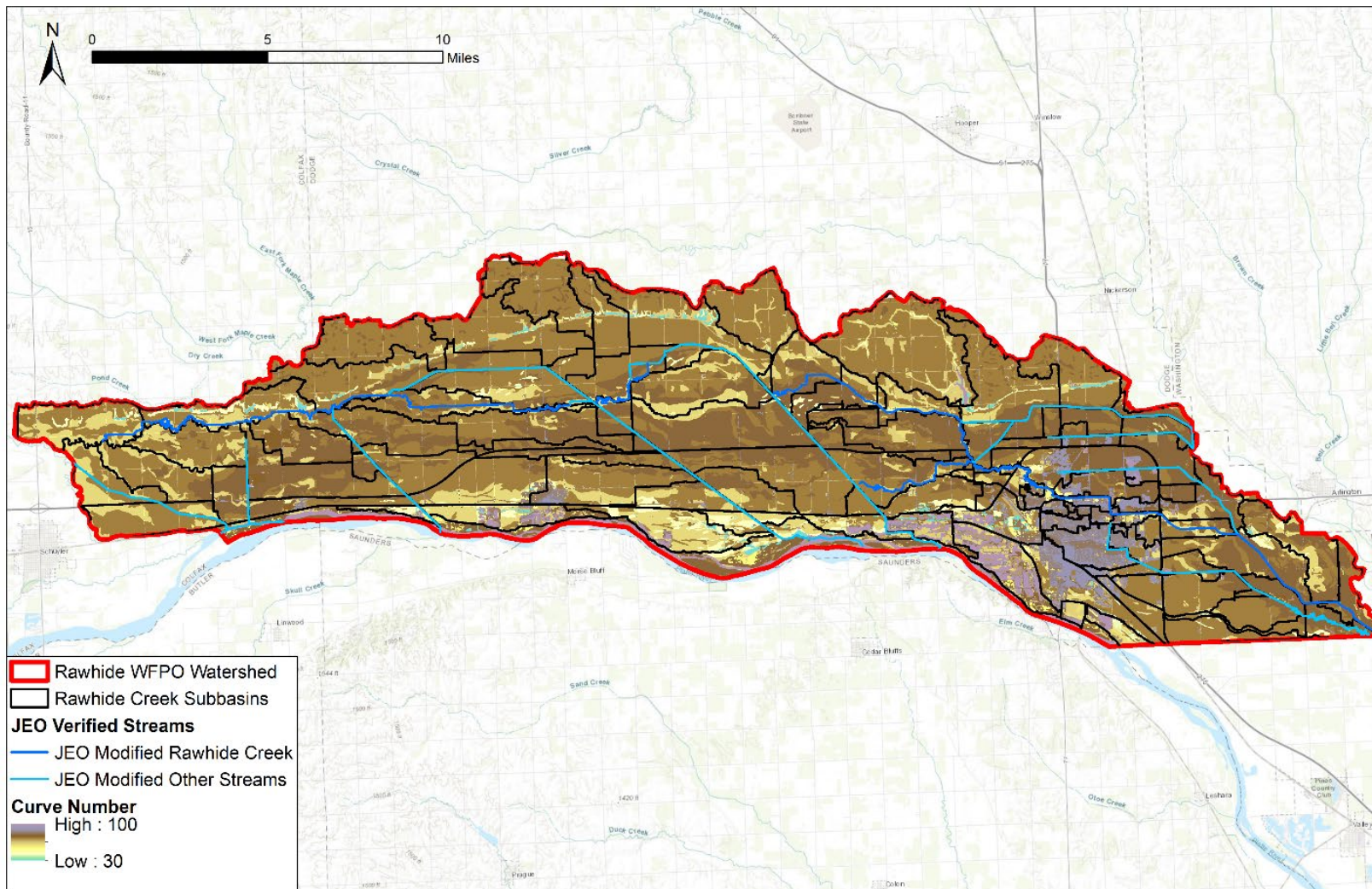


Figure 2: Hydrologic Model Curve Number Overview

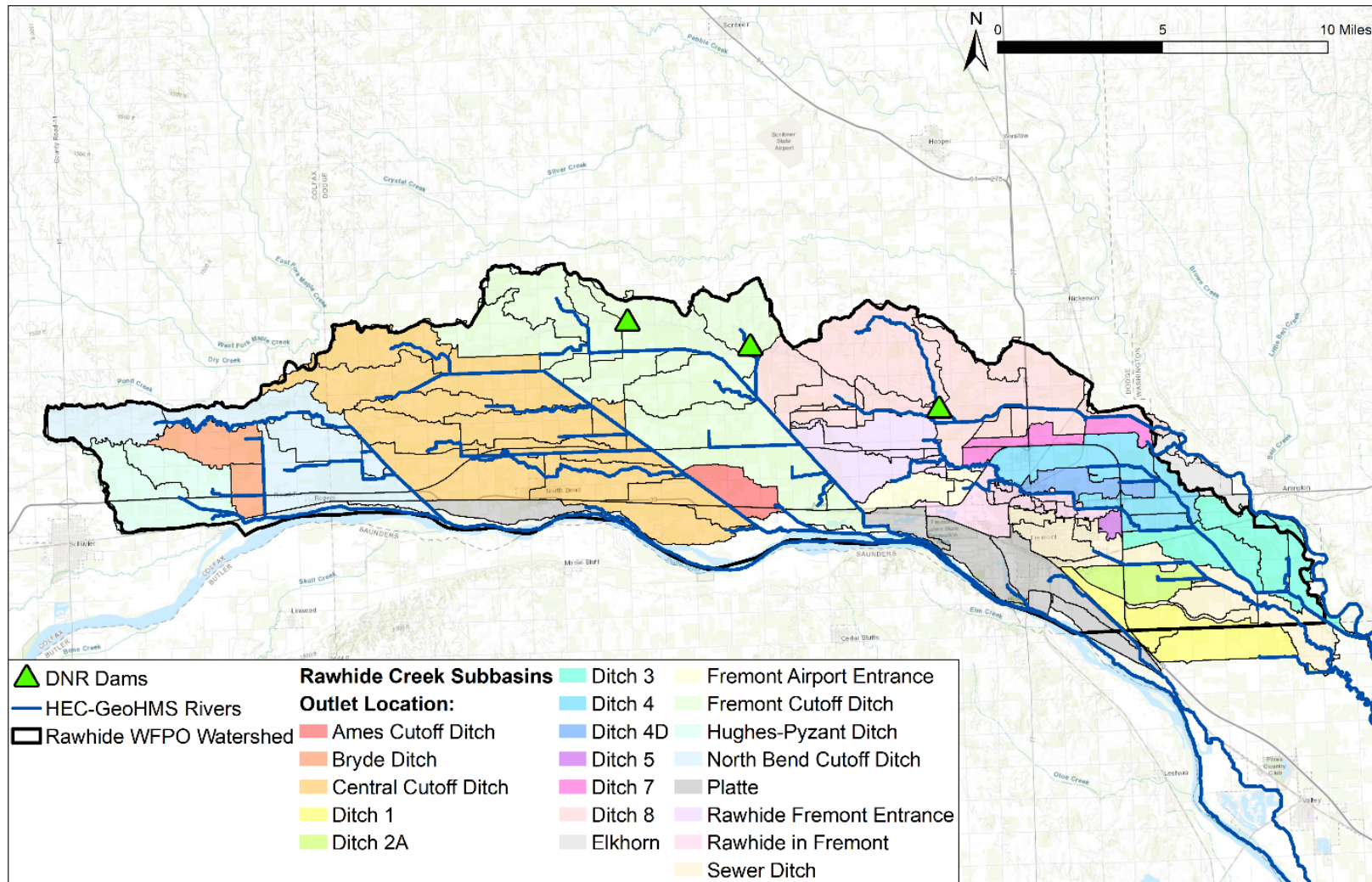


Figure 3: Drainage Basins by Outlet Location

ROUTING AND STORAGE

The Muskingum-Cunge eight-point cross section method was used to route flow through the stream reaches. Channel lengths and slopes were determined using HEC-GeoHMS and manually updated during basin edits. Channel slopes, ranging from 0.0002 ft/ft to 0.0082 ft/ft, sloped towards the confluence of Rawhide Creek, Elkhorn River and Platte River. The Rawhide Creek watershed has multiple paths water can take depending on the water surface elevation. For example, for a small event runoff typically stays within the Fremont Cutoff Ditch, however, during larger events the water may overtop Cutoff Road and flow towards Fremont. Due to the variability in where water may be routed, it was decided that Boundary Conditions within HEC-RAS would generally represent basin outflows, allowing the water to be routed over the 2D surface. Exceptions to this are a few basins along the Platte River which were grouped together at junctions, with routing included for short connecting channels.

The Trouble Creek Dam was included in the model. The other two dams, Brush Creek and Pollard, were not modeled as they are small, low hazard dams with low potential for hydrologic impact. Stage-storage and discharge data recorded in the dam as-built plans for Trouble Creek was used to incorporate the structure into the model.

METEOROLOGICAL MODEL - PRECIPITATION

Hypothetical storms created using the frequency storm methodology were used to model the 2-through 500-Year storm events. Precipitation data, illustrated in Table 2, was obtained from the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Data Server (PFDS). Point precipitation depths were reduced within HEC-HMS (Hydrologic Engineering Center Hydrologic Modeling System) using the program TP40 area reduction curves and a 223 square mile storm.

Table 2: Rainfall Depths

Design Storm	Rainfall Depth (In)
2-year, 24 hr	3.02
5-year, 24 hr	3.71
10-year, 24 hr	4.33
25-year, 24 hr	5.28
50-year, 24 hr	6.06
100-year, 24 hr	6.91
500-year, 24 hr	9.1

D 2.03 MODEL CALIBRATION

Calibration checks of the model focused on comparison to previous studies, event calibration, and a comparison of the results to the adjacent Maple Creek watershed. No stream gages are located in the Rawhide Creek watershed. The nearest stream gage is located on the Maple Creek Watershed, which is the next watershed to the north of Rawhide. This stream gage is located just upstream of the confluence with the Elkhorn River.

TROUBLE CREEK DAM

Calculated hydrologic parameters for the current analysis were compared to those reported in the Trouble Creek Dam As-Builts as an initial check on the validity of the existing model. As can be seen in Table 3, the model closely matches those parameters calculated as part of the Trouble Creek Dam design.

Table 3: Trouble Creek Dam Properties

	Dam As-Builts	Rawhide Creek Model	Percent Difference
Drainage Area (sqmi)	8.5	8.6	1.1%
Curve Number	74	76	3.2%
Time of Concentration (hrs)	6.3	5.9	-6.7%

MAPLE CREEK BULLETIN 17C ANALYSIS

The Maple Creek watershed is on the northern border of the Rawhide Creek watershed. While the land use is very similar to the Rawhide Creek watershed other characteristics vary. Both watersheds are primarily Class C soils, however, the Rawhide Creek watershed has a higher percentage of Class D soils. The relative relief (basin relief divided by the basin perimeter) of the watersheds is similar but it was also noted the majority of the Rawhide Creek watershed is located in the flat valley separating the Platte and Elkhorn Rivers. An overview of the watersheds and the hydrologic soils groups of each is shown in Figure 4. Watershed characteristics are highlighted in Table 4.

Table 4: Maple and Rawhide Creek Characteristics

	Maple Creek	Rawhide Creek
Contributing Drainage Area (sqmi)	368	225
Hydrologic Soil Group B%	20%	13%
Hydrologic Soil Group C%	79%	59%
Hydrologic Soil Group D%	1%	25%
Relative Relief (ft/mi)	4.1	4.5
Average Land Slope	1.8%	1.3%

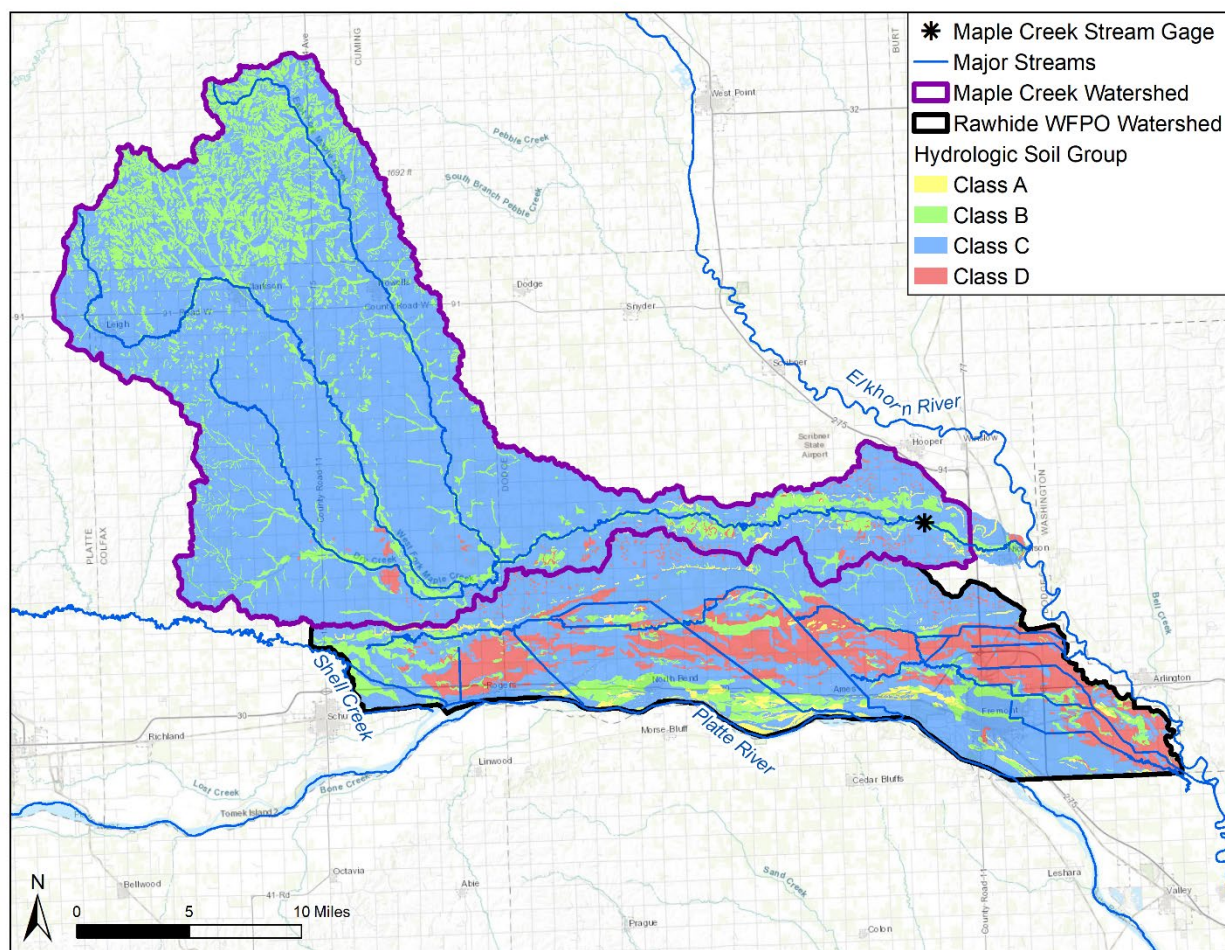


Figure 4: Maple and Rawhide Creek Watershed Overview

Given the hydrologic soil group and drainage area differences between the watersheds, it is not anticipated they would clearly result in similar discharges, however, with little other information to use for model calibration a review of the Maple Creek stream gage was completed as a high-level check of the validity of the Rawhide Creek model results. A Bulletin 17C analysis of the historical

USGS Stream Gage 06800000 Maple Creek near Nickerson was completed using the HEC-SSP (Hydrologic Engineering Center Statistical Software Package) software program Version 2.2. Annual peak discharges reported for the gage ranged from 480-cfs (1952) to 13,700-cfs (1996). A historical event was recorded on June 11, 1944, with a peak flow of 35,000 cfs and was treated as such in the analysis. Analysis was completed using the station skew and a weighted skew based on a regional skew value of -0.25. Results of the gage analysis are reported in Table 5.

Table 5: Bulletin 17C Analysis

	Station Skew	Weighted Skew
Computed 1% Chance Exceedance Discharge	21,594	19,871
Mean	3.510	
Standard Deviation	0.357	
Adopted Skew	-0.019	-0.162

The gage analysis results were compared to the peak flows produced from the Rawhide Creek HEC-HMS model for the 100-Year storm event. As can be seen in Table 7, the modeled peak flows were nearly double those estimated by the Bulletin 17C analysis for Maple Creek. Given the smaller contributing drainage area and flatter terrain, the peak flows produced by the model compared to the Maple Creek Bulletin 17C analysis appear to be high. The model was updated by adjusting the peaking factor from the default SCS value of 484. The unit hydrograph peaking factor was modified for all basins based on their topography per National Oceanic and Atmospheric Administration (NOAA) recommendations in the NOAA unit hydrograph technical manual as shown here: https://www.nohrsc.noaa.gov/technology/gis/uhg_manual.html. Table 6 outlines the peaking factor used based on basin topography. Specific basin peaking factors can be provided upon request.

Table 6: NOAA Peaking Factors

General Description	Peaking Factor
Urban areas; Steep Slopes	550
Typical SCS	484
Mixed Urban/Rural	400
Rural, Rolling Hills	300
Rural, Slight Slopes	200
Rural, Very Flat	100

The modeled results based on the updated peaking factors appeared more reasonable in comparison to the Maple Creek watershed, but still slightly high. Routing that occurs within the Rawhide Creek watershed is very complex, varying depending on the storm event. This is due to the flat nature of the watershed, which allows flows that exit the existing creek and ditch network

to flow overland, frequently ending up at a different outlet depending on the storm event. For this reason, the resulting subbasin hydrographs from the 100-Year storm event with the reduced peaking factors were applied to the HEC-RAS 2D model as inflow boundary conditions and the HEC-RAS model was run. The peak discharge from the downstream boundary of the HEC-RAS model is also reported in Table 7.

Table 7: 100-year Peak Flows

Maple Creek		Rawhide Creek		
Station Skew	Weighted Skew	Default Peaking Factor	Updated Peaking Factor	HEC-RAS Downstream Boundary
21,594	19,871	40,590	23,144	18,472

EVENT CALIBRATION

On June 17th, 2016, significant heavy rain fell on the Rawhide Creek watershed. The heaviest rainfall was centered over the City of Fremont where a cooperative observer for the National Weather Service reported receiving 7 inches. The western portion of the watershed received around one to two inches as shown in Figure 5. According to the NWS the event resulted in widespread urban flooding with many roads and properties flooded. Areas hardest hit were in the east part of town where the water took several days to subside.

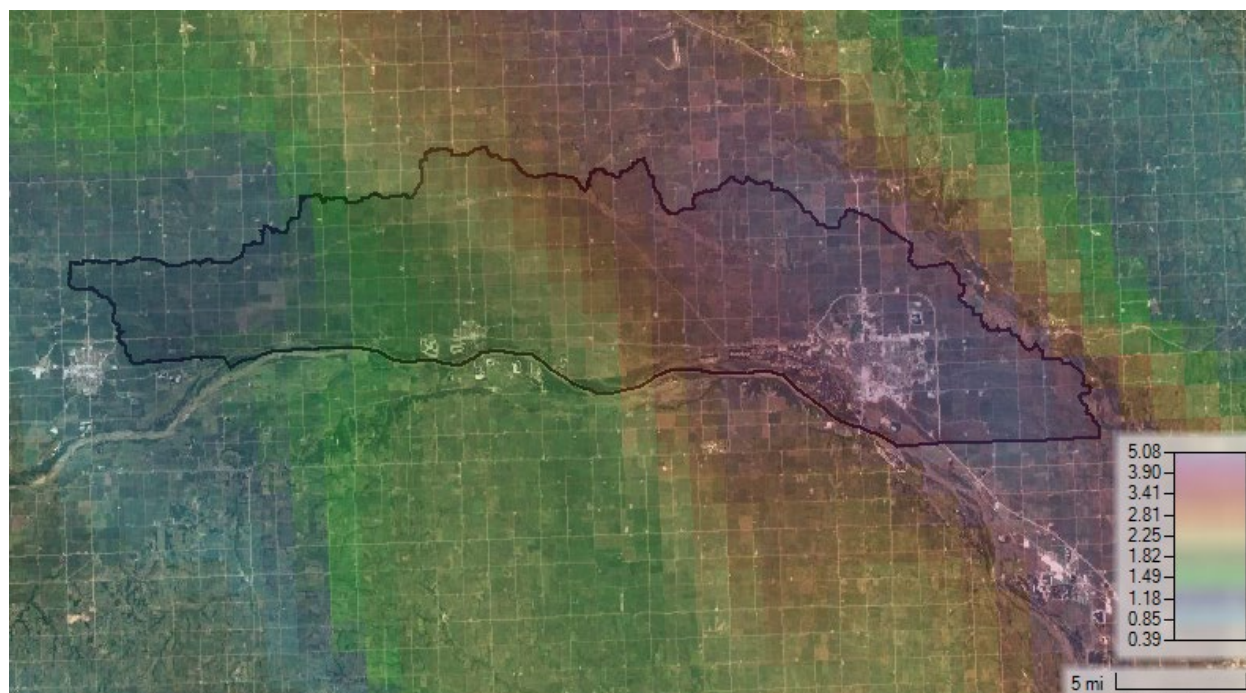


Figure 5: June 2016 Accumulated Precipitation (inches)

Event calibration of this event was conducted using the gridded precipitation method within HEC-HMS and comparing the modeled inundation depths and extents with pictures provided by stakeholders from the June 2016 flood event. Precipitation data was acquired from the National Weather Service, Advanced Hydrologic Prediction Service, Missouri River Basin Forecast Centers Analysis of Record for Calibration (AORC). The model used a structured discretization with a cell size of 2000-meters and a 30-minute time step. This event was chosen as it is the most recent flooding event reported based on rainfall on the watershed. The resulting subbasin hydrographs were then applied to the HEC-RAS 2D model as inflow boundary conditions and the HEC-RAS model was run. The resulting ponding depths and a selection of event pictures are shown in the Model Calibration section of this appendix. As can be seen, the model results appear to closely match the provided pictures. In some places the modeled results appear to show more flooding than the pictures indicate, however, it is not clear when the pictures were taken, and it is unlikely they would all have been taken at the time of the peak flooding. In other locations, such as the area around 17th and Main Street, the modeled results appear to show less flooding than the pictures indicate. This is likely due to the scale and detail of the current model efforts. Flooding at this location is likely due to local storm drainage deficiencies which were not included in the model.

D 3. HYDRAULIC ANALYSIS

D 3.01 TABLE 31 EXISTING STUDIES

In addition to the studies mentioned above in the Hydrologic Analysis Section the following study was referenced during the assembly of the hydraulic model.

USACE Section 205 and Silver Jackets Platte River Studies, 2020/2021

The USACE performed a Section 205 Flood Risk Management Feasibility Study for the Platte River at Fremont, Nebraska. The most recent draft project report was released in April 2022. A final report has not been released. This study considered structural and nonstructural/programmatic measures. Structural options included recommendations such as upstream diversion, levees/floodwalls, channelization, bridge removal/replacement, ice jam control and upstream dams. Nonstructural/programmatic options included: flood warning systems, dry floodproofing, wet floodproofing, elevations, filling in basements, and acquisitions/relocations. The recommendation of this study was to implement a nonstructural plan which would focus on flood mitigation to the structures within the floodplain starting with buildings within the 100-year floodplain. For cost-benefit reasons, the recommended plan focuses on buildings within the 25-year floodplain. Primary recommended mitigation actions were elevation, dry floodproofing, and wet floodproofing. The plan primarily focused on buildings that are in the Fremont Levee protected area, and a few in Platte Township that are not in the floodway. The 1D HEC-RAS model developed as part of this study was obtained from the USACE and has been used to inform the modeling of the Platte River as described in the Hydraulic Methodology Section.

D 3.02 HYDRAULIC METHODOLOGY

The hydraulic analysis for the Rawhide Creek Watershed was completed in HEC-RAS Version 6.3.1. A 2D HEC-RAS model was created for the Rawhide Creek basin. Due to the large size of the model, a grid cell size of 200 ft x 200 ft was used to provide a sufficient resolution of model outputs while also maintaining reasonable model run times. Break line cell spacing along key features such as 2D area connections, channels and roadways was also set at 150 ft to further refine the model. Further refinement was given to major ditches, with parallel break lines placed on their adjacent high ground with cells placed along the break lines in the channel, refining channel flow in ditches. Outflow boundary conditions for the model were assumed to be normal depth with energy slopes estimated from LiDAR. There is only one outflow boundary condition where flow can leave the model, which is just south of the Rawhide – Elkhorn Confluence and encompasses both the Platte and Elkhorn Rivers approximately 15.5 miles upstream of their confluence near Ashland, NE. There are 101 inflow boundaries used to model the different hydrographs from sub basins as modeled in HEC-HMS. These inflow boundary conditions were paired with flow hydrographs from the HMS output. Additionally, three inflow boundary conditions were included to model potential overflow hydrographs from the Platte River, Elkhorn River, and

Shell Creek under various flow conditions. The model was run for 3 days which was sufficient to pass the peak flow through Fremont.

Terrain data was obtained from USGS for Dodge, Saunders, Washington, Douglas, and Colfax County LiDAR collected between 2016 and 2018. For areas most impacted by the March 2019 flood event, LiDAR was collected in 2019 to reflect post-flood conditions. This updated data was reviewed for possible use to represent existing conditions; however, it was noted that most flood damaged areas at the time of the 2019 data collection have been restored during the recovery process to pre-damage condition. Therefore, it was deemed that overall, the pre-flood LiDAR more accurately reflects existing terrain. The terrain was then manually updated based off NDOT's Highway 30 plan sets and design surfaces to include the new highway alignment. NDOT Highway 30 plans along with survey information that was gathered by JEO were used to develop geometry for key bridge and culvert structures. Survey was also collected for the Cutoff Road Raise performed after the 2019 flood event, which raised approximately the south third of Cutoff Road along the east side of the Fremont Cutoff Ditch. Numerous break lines were incorporated within the model to enforce important topographic features (roadway embankments, berms, channel bottoms, etc.) into the 2D grid to align flows to natural topographic features.

The Rawhide Creek, Shell Creek, Elkhorn River, and Platte River, along with many of the major ditches in the watershed, typically have water flowing within them. This baseline condition is assumed to be accounted for by the LiDAR surface which records the water surface elevation on the day the data was gathered. As this system seems likely to be sensitive to the water surface elevation at the Elkhorn and Platte Rivers the date of the LiDAR collection was compared to the USGS stream gage records downstream of the Rawhide watershed during the same period. Table 8 outlines the dates listed for the data collection of the LiDAR used for the 2D model along with the average discharge and stage that the LiDAR data accounts for. This data was then compared to a duration analysis completed in HEC-SSP Version 2.2 for both the Platte and Elkhorn Rivers (Table 9 & Table 10) for each stream gage since January 1, 1990. Based on this analysis the base flow condition that is being evaluated with the 2D model is likely to be observed 16% of the time on the Elkhorn River (60 days a year) and 5% of the time on the Platte River (18 days a year). LiDAR was not changed due to this analysis. This analysis was done to understand the baseflow condition that the terrain provides. These values provide a conservative base flow condition.

Table 8: LiDAR Base Flow Condition

County	Collection Date	Gage	Average Discharge (cfs)	Average Gage Depth (ft)
Douglas County	2/20/20 - 2/21/20	Elkhorn River at Waterloo, Nebr. USGS 06800500	2722	3.5
Dodge County	4/23/18 – 5/7/18	Elkhorn River at Waterloo, Nebr. USGS 06800500	3735.17	5.3
Dodge County	4/23/18 – 5/7/18	Platte River near Leshara, Nebr. USGS 06796500	6000	4.5
Colfax County	12/8/16 – 2/3/17	Platte River near Leshara, Nebr. USGS 06796500	4000	5.5

Table 9: Elkhorn River at Waterloo, Nebr. Duration Analysis

% of Time Exceeded	Annual Flow
99	269
95	476.8
90	597
80	845
50	1440
25	2500
15	3400
16.23 (LiDAR)	3200
10	4210
5	5844
2	8934.8
1	12700
0.1	33822.4

Table 10: Platte River near Leshara, Nebr. Duration Analysis

% of Time Exceeded	Annual Flow
99	269
95	476.8
90	597
80	845
50	1440
25	2500
15	3400
10	4210
5	5844
4.85 (LiDAR)	6000
2	8934.8
1	12700
0.1	33822.4

Manning's roughness coefficients of the channel and floodplains were based off land use data obtained from the National Land Cover Dataset (NLCD). Table 11 shows the different land uses and associated Manning's n values used in the model.

Table 11: Manning's n Values Used in HEC-RAS Model

Land Use	Manning's n-value	Land Use	Manning's n-value
All Other	0.04	Evergreen Forest	0.15
Barren	0.03	Grassland	0.04
Cultivated Crops	0.04	Herbaceous Wetlands	0.045
Deciduous Forest	0.10	Mixed Forest	0.12
Developed - Low	0.08	Open Water	0.035
Developed - Medium	0.12	Pasture	0.04
Developed - High	0.15	Shrub	0.05
Developed - Open	0.035	Woody Wetlands	0.07

Manning's n calibration regions were added to refine stream channels. Major cutoff or diversion ditch channel calibration regions were added to ensure that key ditch sections have uniform Manning's n values in the model. Ditch channel calibration regions were applied in all model geometries. Figure 6 shows the extents of the calibration regions and Table 12 details the calibration region values.

Table 12: Manning's n Values Used for HEC-RAS Calibration Regions

Calibration Region Name	Manning's n values
Central Cutoff	0.035
Ditch 8	0.035
Ditch 8 South	0.035
Fremont Cut/off	0.035
Hughes-Payzant	0.035
North Bend Cutoff	0.035

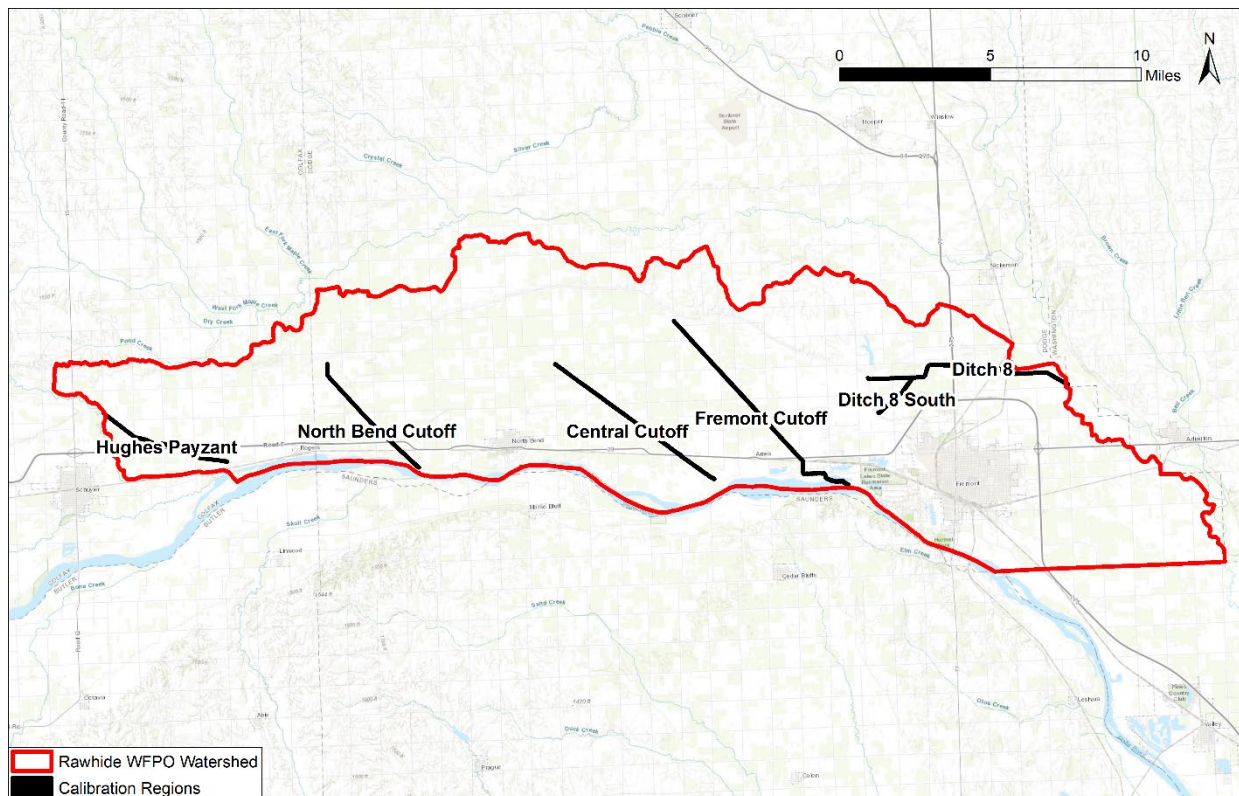


Figure 6: Manning's n Calibration Regions

EXISTING CONDITIONS SCENARIOS

Multiple geometry and flow scenarios were created to capture the existing conditions and potential flood risk scenarios within the Rawhide Creek Watershed. Figure 7 shows the model geometry which does not include the new Highway 30 alignment and represents the geometry that was in place before the 2019 flood event. This geometry was created for the calibration of the model with local input related to a flood event in June 2016. A second geometry was created that included the Cutoff Road Raise added after the 2019 flood which raised approximately the south third of Cutoff Road along the east side of the Fremont Cutoff Ditch. This geometry is meant to capture the existing conditions in place for events prior to the 2019 flood and to understand the differences due to the new Highway 30 alignment. Figure 8 shows the third geometry created to capture revised existing conditions which includes the Cutoff Road raise and new Highway 30 alignment and structures. This geometry captures the current conditions within the watershed following the completion of construction of the new Highway 30. The geometry shown in Figure 8 is what has been used for the existing conditions modeling runs. This geometry includes a reduction in the total number of subbasins, increases in the number of break lines, and increases in the number of modeled culverts.

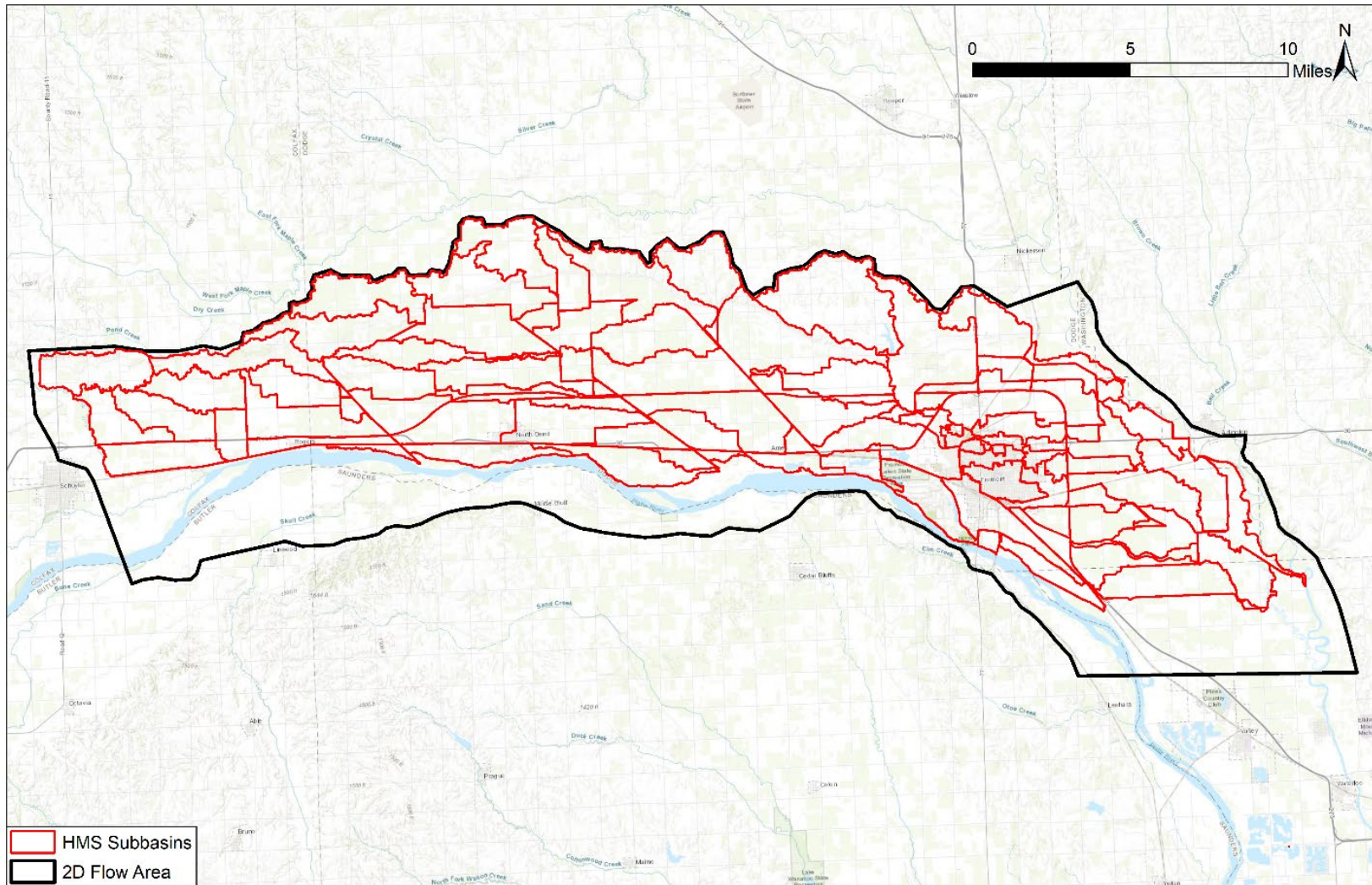


Figure 7: Hydraulic Model Geometry without New Highway 30

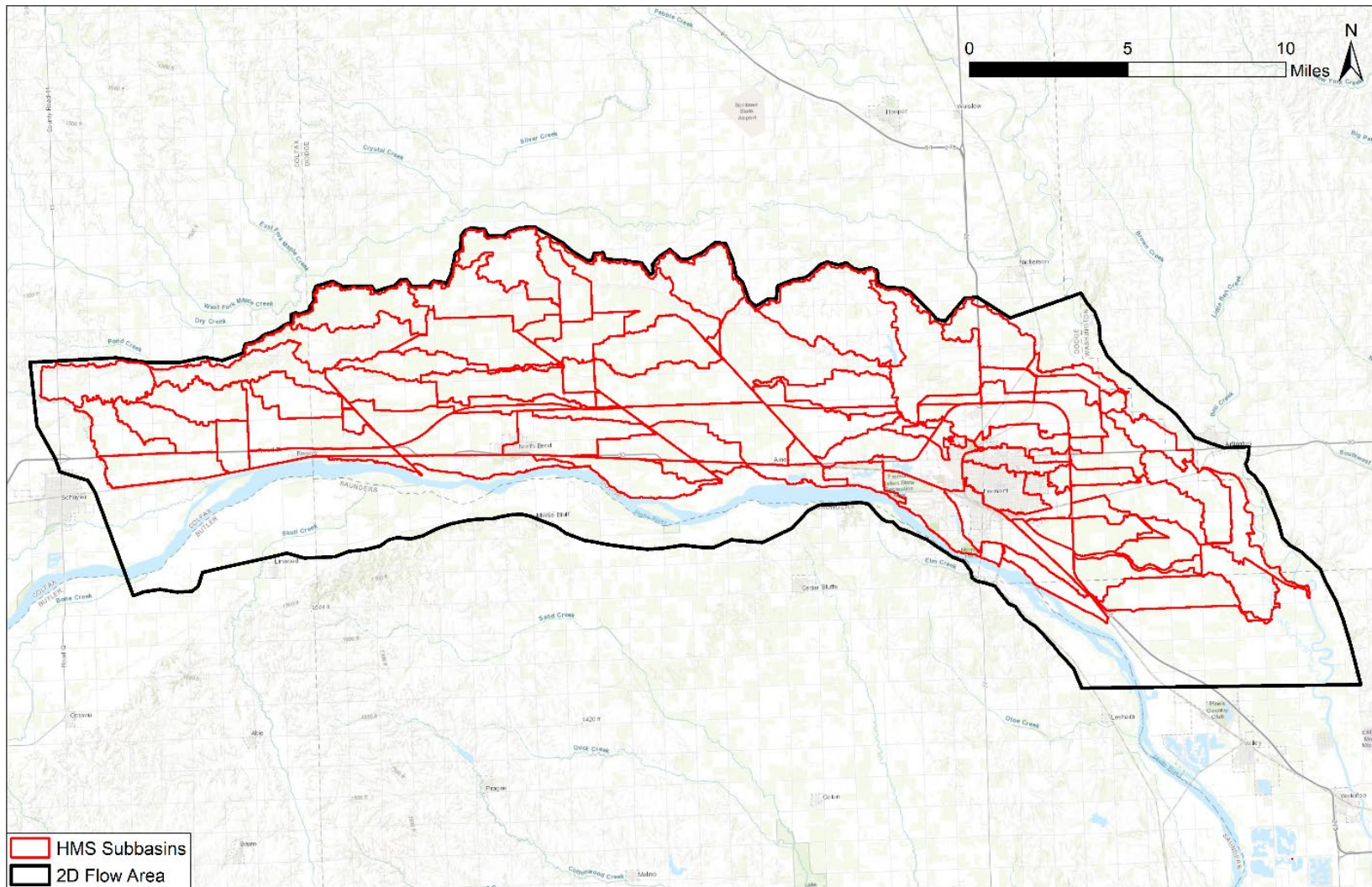


Figure 8: Hydraulic Model Geometry with New Highway 30

D 3.03 MODEL CALIBRATION

On June 17th, 2016, significant heavy rain fell on the Rawhide Creek watershed. Flooding observations from this event were used to calibrate both the HEC-HMS and HEC-RAS models. Precipitation data was acquired from the National Weather Service, Advanced Hydrologic Prediction Service, Missouri River Basin Forecast Centers Analysis of Record for Calibration (AORC). The HEC-HMS model used a structured discretization with a cell size of 2000-meters and a 30-minute time step. This event was chosen as it is the most recent flooding event reported based on rainfall on the Rawhide Creek watershed. The resulting subbasin hydrographs were then applied to the HEC-RAS 2D model as inflow boundary conditions and the HEC-RAS model was run. The resulting ponding depths and key event pictures are shown in Figure 9 and Photos 2, 5, 10, 12, 19 and 45. As can be seen, the model results appear to closely match the provided pictures. In some places the modeled results appear to show more flooding than the pictures indicate, however, it is not clear when the pictures were taken, and it is unlikely they would all have been taken at the time of the peak flooding. Additional photos are available upon request.

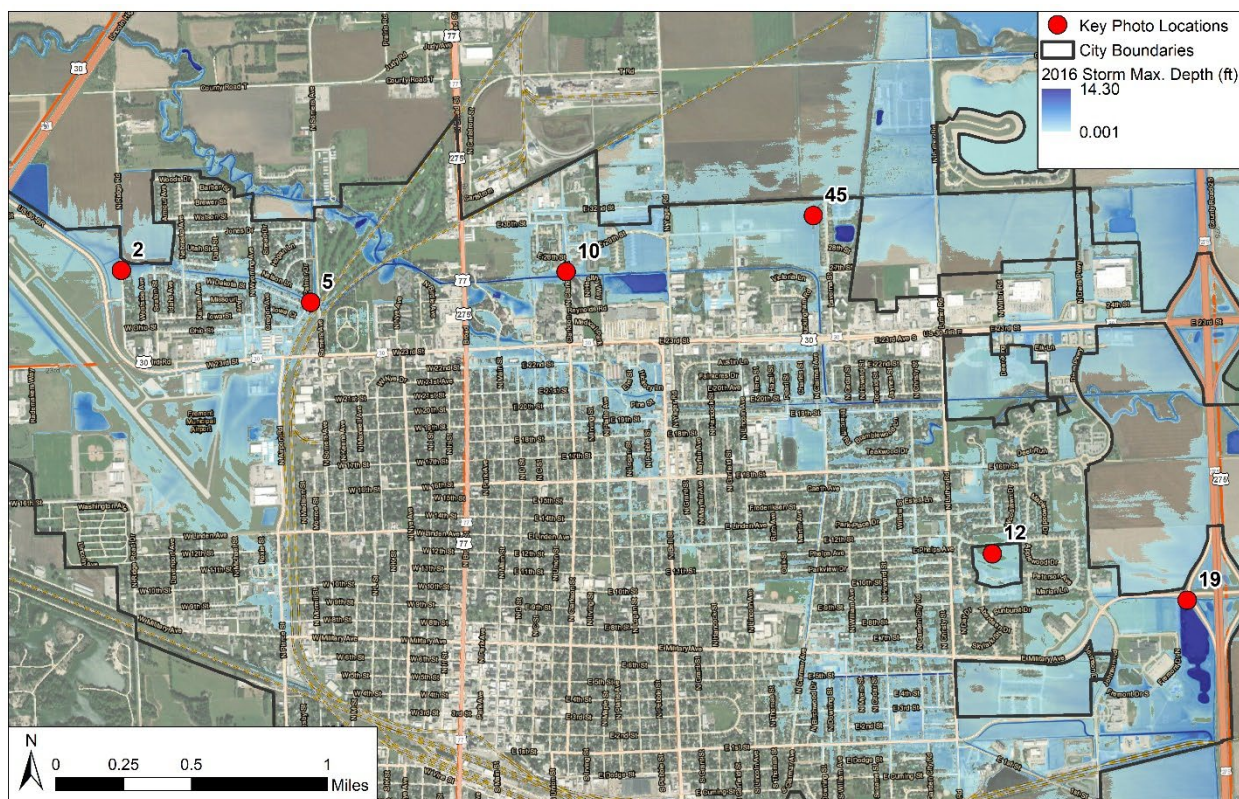


Figure 9: Map of Key Photo Locations in Fremont, NE



Photo 2



Photo 5



Photo 10



Photo 12



Photo 19



Photo 45

D 3.04 BASELINE HYDRAULIC RESULTS

The 2D hydraulic model begins east of Schuyler and runs southeast until Rawhide Creek joins with the Elkhorn River. Rawhide Creek flows through the City of Fremont, while the other communities within the watershed lie along the watershed boundary shared with the Platte River. The flow characteristics of Rawhide Creek are influenced by the topography, cutoff and diversion ditches, major roadway embankments, local roadway bridges/culverts, the Union Pacific Railroad Company Railroad (RR), and local topography features within Fremont. Culverts greatly impact the hydrology and hydraulics of this watershed, and although it was not feasible to add all culverts to the 2D model, key culverts with the most potential to impact flooding extents were added to the model based on survey data or NDOT plan sheets.

In the Rawhide Creek WFPO hydraulic model, the Shell Creek, Elkhorn River, and Platte River were modeled using the National Cooperative Highway Research Program NCHRP Report 15-36 technique for estimating joint probabilities of coincident flows developed for the AASHTO Model Drainage Manual. The drainage area ratios of the other contributing waterways and Rawhide Creek were used to determine the flood flow frequency used in the model for the Shell Creek, Elkhorn River, and Platte River according to the size of event modeled on Rawhide Creek. Peak flows for the Elkhorn River were taken from the USACE November 2021 report “Peak Flow Frequency Improvement with Mixed Population Hydrology and Subject Matter Expert Elicitation” while the peak flows for the Platte River were taken from the USACE October 2020 report “Lower Platte River Flood Frequency Update”. A bulletin 17C analysis was completed on the USGS stream gage 06795500 Shell Creek near Columbus, Nebraska to determine the coincident peak flows for Shell Creek. Table 13 below shows the coincident events with Rawhide Creek and the other contributing flood risk sources used for this study.

Table 13: Joint Probability of Coincident Flood Events

Stream	Frequency for Coincidental Occurrence (years)						
Joint Return Period	2	5	10	25	50	100	500
Rawhide Creek	2	5	10	25	50	100	500
Shell Creek	0	0	5	10	25	25	50
Shell Creek Flow Rate (cfs)	0	0	3,126	4,544	6,794	6,794	8,826
Elkhorn River	0	0	2	2	2	2	5
Elkhorn River Flow Rate (cfs)	0	0	14,700	14,700	14,700	14,700	26,500
Platte River (Rainfall Season)	0	0	2	2	2	2	5
Platte River (Rainfall Season) Flow Rate (cfs)	0	0	28,300	28,300	28,300	28,300	44,000

D 3.05 RISK ASSESSMENT AND HYDRAULIC RECOMMENDATIONS

Risk assessment and hydraulic recommendations described below are based on the existing conditions model results from the hydraulic model described above. These existing conditions are based on a Rawhide Creek driven coincident flood event based on the joint probability of coincidence described in Table 13. This risk assessment and recommendations do not consider the impact of flood events whose major source is the Platte River, Elkhorn River or Shell Creek. Existing conditions maps for the 10, 25, 50, 100 and 500-year storm events are attached in Figure 10 through Figure 14. The results of these model results are discussed below, with key flow locations displayed in Table 14.

Table 14: Ditch Capacity vs 100-year Flow and Overflows

Outlet	Ditch Capacity Coincident Event (cfs)	Ditch Capacity Rawhide Only Event (cfs)	100-year Coincident Results Peak Flow (cfs)
**Hughes-Payzant Ditch	6.5	328.1	1,860.7
Byrne Ditch	23.5	23.5	1,226.7
**North Bend Cutoff Ditch	-354.4	403.8	1,223.1
**Central Cutoff Ditch	720.9	764.2	2,204.3
Fremont Cutoff Ditch	481.7	481.1	3,141.4
Ditch 8	686.6	685.6	1,398.7
Rawhide Entering Fremont	172.1	174.9	385.5
Airport Entrance to Fremont	37.8	37.8	153.9
Rawhide Leaving Fremont	146.9	146.7	327.1
Model Outlet (Platte and Elkhorn combined)	N/A	N/A	66,482.5

**Note: Ditches which show less capacity for a coincident event than a Rawhide only event are impacted by back water from the Platte or Elkhorn Rivers which is the cause of coincident event ditch capacities less than Rawhide only ditch capacities. 100-year coincident peak flow results are derived from the model at areas of high ground near the outlet of each ditch, for example, at the current Highway 30 and Railroad embankments along the south of the watershed.

FREMONT

Fremont is located within the southeastern portion of the watershed. Fremont is meant to be compartmentalized from the rest of the Rawhide Creek watershed by the Fremont Cutoff Ditch and Cutoff Road. Additionally, the Merlyn England Diversion and Ditch 8 improvements are meant to direct flow north away from the Rawhide entrance to Fremont. Two entrances for flow exist on the western side of Fremont under Highway 275, one at the Rawhide Creek inflow and one near the Fremont Municipal Airport. A small detention area lies just inside of Highway 275 to detain water entering at this location. Generally, Fremont development abuts the top of the current ditch and creek banks. Starting within Fremont a ditch system gathers drainage and carries it southeast to the Rawhide Creek confluence with the Elkhorn River. Further improvements to detention west of Fremont, ditches to move flow more efficiently through and/or out of town, as well as improvements to the Fremont Cutoff Ditch and Cutoff Road Embankment are recommended to reduce flooding impacts from the Rawhide Creek watershed in the Fremont Region.

Major Findings for Rawhide Creek Flood Risk:

- Culvert without flapgate causing flooding at Co Rd 16 and Cutoff Rd.
- Culvert without flapgate causing flooding at Co Rd 15 Blvd and Cutoff Rd.
- Culvert without flapgate causing flooding just north of Co Rd S and Cutoff Rd.
- Cutoff Rd over topping just north of Co Rd S. At 100 yr coincident event approximately 2 inches of depth is overtopping allowing a volume of 239 ac-ft to cross the embankment. Overtopping begins at the 50-year coincident event. This flow then stays along the north side of Highway 30 until the Rawhide Crossing near the Merlyn England project.
- Significant ponding occurs behind the Fremont Cutoff Ditch and Cutoff Rd.
- Discharge ditch for Brush Creek Dam is over topping and causing flooding within the area southeast of the berms.
- A significant amount of flow exits Rawhide Creek between Co Rd 16 and Co Rd 19 which is then intercepted by the ditch along the north of Co Rd S until it is overtopped and is then intercepted by the ditch along the north side of the new Highway 30.
- Merlyn England Detention locations are functioning generally as planned.
- Overtopping occurs along Ditch 8 at the abandoned railroad crossing near Luther Rd with an approximate depth of 2 inches allowing a volume of 102 ac-ft to cross the north embankment. Overtopping begins at the 50-year coincident event.

- Detention near Highway 275 and Fremont Municipal Airport is undersized beginning at the 10-year coincident event.
- Significant ponding occurs on the west side of Highway 275 near the Airport impacting the neighborhood located at Co Rd 20 Ave and T Blvd.
- The ditch that runs near Milliken Park Elementary School is undersized from Ridge Road to North Somers Avenue causing significant ponding throughout this neighborhood.
- Rawhide Creek is undersized through Fremont with overtopping beginning at the 25-year coincident event causing significant ponding north of E 23rd St between N Somers Ave and the east leg of Highway 275.
- The ditch that runs from the Masonic Park to connect to its confluence with the Rawhide Creek near E 20th St and N Clarmar Ave is undersized with flooding starting at the 2-year event. Overflow from this ditch inundates the immediate area around the ditch as well as areas to the south and east.
- Ditch 4D and 4B are undersized for their drainage areas beginning at the 2-year storm and receive additional flow from overtopping in the Rawhide Creek between N Broad St and Laverna St beginning at the 25-year storm.
- Sewer Ditch is undersized with ponding at the powerplant of approximately 2.67 feet for the 100-year coincident event. Significant ponding begins at the 2-year event.
- Drainage east of Fremont generally flows southeast along Ditch 4 to its confluence with the Elkhorn River.
- Areas along the Elkhorn River are sensitive to Elkhorn River overtopping. Particularly near the northeast corner of Fremont including Ditch 4B and Ditch 4D.

INGLEWOOD

Inglewood is located south of Fremont between Fremont and the Platte River. Internal drainage seems to be a likely problem within this area during a Rawhide watershed driven storm, however a more detailed model would be needed to determine specific concerns. The highest risk of flooding is from the Platte River.

Major Findings for Rawhide Creek Flood Risk:

- Internal drainage seems to be a factor within this area.

AMES

Ames is located just west of Fremont along the current Highway 30. This area is at risk of flooding from Platte River overflow but does seem to be impacted by Rawhide Creek watershed flooding.

Major Findings for Rawhide Creek Flood Risk:

- A ditch runs along the north side of Ames. This does not seem to impact any buildings within Ames for the 100-year coincident event.

NORTH BEND

North Bend is located on the south boundary of the watershed on Highway 30 near the Platte River. Rawhide Creek does not pose a flood risk to this community; however, some internal drainage may cause damages and a more detailed model should be created to identify specific concerns. Most risk to this community is posed by the Platte River and Shell Creek overflows. Improvements to the North Bend Cutoff Ditch and embankment is recommended to reduce risk from these sources and are being currently considered by a separate study.

Major Findings for Rawhide Creek Flood Risk:

- Flow generally is routed around the north side of North Bend.
- Some flow enters town via a ditch along the north side of the current Highway 30 which seems to cause some drainage concerns within town as the flow moves east through town.
- Some structural damage is seen within town.

ROGERS

Rogers is the most western community within the Rawhide Creek watershed and is located along Highway 30 and the Platte River. Rawhide Creek drainage does not appear to pose a threat to Rogers, however, some localized drainage concerns do seem to be present, and a detailed model should be created for this area to identify these specific concerns. Platte River overflows and overflows from large events on the Shell Creek are the primary major flooding risk factors for this community.

Major Finding for Rawhide Creek Flood Risks:

- Many ditches within the community are showing ponding, however, no structures appear to be impacted for the 100-year coincident event.

OTHER AREAS

Large amounts of the rural area in this watershed are impacted by Rawhide Creek drainage. The Rawhide Creek and ditch system throughout the watershed seems to be consistently undersized. A unified plan regarding overall flow paths and increased sizing should be explored to improve the function of this system to reduce the damages to crops, livestock, the rural road network, and buildings. Specifically, the North Bend, Central, and Fremont Cutoff Ditches should be examined to determine the capacity and embankment height necessary to achieve flood risk reduction goals. Additionally, Shell Creek overflows should be managed with either additional ditches to carry this flow or improvements to the Hughes Payzant ditch.

Major Findings for Rawhide Creek Flood Risk:

Central Cutoff Ditch

- Significant ponding occurs behind the Central Cutoff Ditch and Embankment.
- A culvert near current Highway 30 and Co Rd 13 lacks a flapgate which allows flooding within this area. Additionally, some overtopping is at this same location with approximately 9 inches of depth for the 100-year coincident event. Cumulatively, the culvert and overtopping allow a volume of 143 ac-ft to cross the embankment. Overtopping begins at the 50-year coincident event.
- A culvert near the Co Rd T and Co Rd 12 intersection is causing ponding in the area.
- Overtopping occurs just north of the new Highway 30 with approximately 2 inches of depth for the 100-year coincident event, allowing 430 ac-ft to cross the embankment. This overtopping begins at the 100-year coincident event.
- A field ditch between Co Rd 10 and Co Rd 11 is causing ponding in this area.
- A culvert and roadside ditch at the Co Rd 10 crossing are causing ponding east of the embankment in this area.
- A culvert near the Co Rd R crossing is causing ponding in this area.
- Overtopping occurs between Co Rd Q and Co Rd 9 with approximately 2 inches of depth, allowing a volume of 87 ac-ft to cross the embankment for the 100-year coincident event. Overtopping begins at the 50-year coincident event.
- The west roadside ditch of Co Rd 8 is causing ponding in this area.

North Bend Cutoff Ditch

- Significant ponding occurs behind the North Bend Cutoff Ditch and Embankment. (This impact is being considered in a separate study.)
- Overtopping occurs at the Co Rd R crossing with approximately 5 inches depth over the embankment, allowing a volume of 104 ac-ft to cross the embankment for the 100-year coincident event. Overtopping begins at the 10-year coincident event. (This impact is being considered in a separate study.)

Byrne Ditch

- Significant ponding occurs behind the Byrne Ditch and Co Rd 17 Embankment.
- Multiple locations overtop between Co Rd H and Co Rd G with the deepest at approximately 5 inches, allowing a cumulative volume of 842 ac-ft across Co Rd 17 for the 100-year coincident event. Overtopping begins at the 2-year coincident event. Flow that overtops generally flows along Co Rd G to the North Bend Cutoff Ditch.

Hughes-Payzant Ditch

- During the 100-year coincident event the Hughes-Payzant Ditch receives 402 cfs of flow from Shell Creek, and a cumulative volume of 1280 ac-ft enters the Rawhide Creek watershed.
- The Hughes-Payzant Ditch does not appear to have overtopping locations once flow enters the ditch, instead flooding observed along the north and south sides of the ditch appears to be flow that has overtopped from Shell Creek and local drainage that is not able to enter the ditch due to Shell Creek occupying the ditches capacity. Ponding then occurs at the Railroad crossing as these flows merge.

Shell Creek Overtopping

- West of Highway 15 approximately 130 cfs overtops the north Shell Creek bank and allows 60 ac-ft to enter the Rawhide Creek watershed. This flow is forced back into the Shell Creek by the Highway 15 embankment.
- Just east of Highway 15 approximately 71 cfs overtops the north bank of the Shell Creek into the Rawhide Creek channel and allows 20 ac-ft to enter the Rawhide Creek watershed. Overtopping begins at the 100-year coincident event.
- Just north of the Hughes-Payzant Ditch entrance approximately 417 cfs overtops the north bank of the Shell Creek into the Rawhide Creek channel and allows 550 ac-ft enter the Rawhide Creek watershed. Overtopping begins at the 25-year coincident event.

- During the 100-year coincident event the Hughes-Payzant Ditch receives 402 cfs of flow from the Shell Creek, and a cumulative volume of 1280 ac-ft enters the Rawhide Creek watershed.
- Just north of the Highway 30 crossing approximately 132 cfs overtops the north bank of the Shell Creek into the Rawhide Creek channel and allows 154 ac-ft enter the Rawhide Creek watershed. Overtopping begins at the 50-year coincident event.
- Within the section of Shell Creek which runs along the north side of the Railroad to its crossing approximately 1792 cfs overtops the north bank of the Shell Creek into the Rawhide Creek channel and allows 4056 ac-ft enter the Rawhide Creek watershed. Overtopping begins at the 10-year coincident event.

Rawhide Creek – Rural Areas

- Just east of Highway 15 approximately 71 cfs overtops the north bank of Shell Creek into the Rawhide Creek channel and allows 20 ac-ft enter the Rawhide Creek watershed. Overtopping begins at the 100-year coincident event.
- Rawhide Creek between Shell Creek and the North Bend Cutoff Ditch is poorly defined with multiple sections being farmed through. As a result, many locations overtop the banks and generally flow south where is it intercepted by Co Rd H and Co Rd G.
- Rawhide Creek between the North Bend and Central Cutoff Ditches has been mostly straightened into what is now called the Scott Ditch. Scott Ditch appears to be undersized with multiple locations of overtopping. Flow that leaves the ditch flows south and east along portions of smaller ditch systems and the historic Rawhide Creek channel.
- Rawhide Creek between the Central and Fremont Cutoff Ditches has been mostly straightened into roadside ditches along the north sides of Co Rd P and Co Rd Q. The roadside ditches appear to be undersized with multiple locations of overtopping. Flow that leaves the channels flows alongside the existing ditches to the Fremont Cutoff Ditch.
- Rawhide Creek between the Fremont Cutoff Ditch and the Merlyn England Diversion Structure has been mostly straightened and connected to Ditch 8. This section of Rawhide Creek is generally undersized, with multiple locations where the south bank is overtopped. These flows move southeast where they are intercepted by the Co Rd S ditch and the new Highway 30 embankment. High flows are still allowed to overtop Ditch 8 into the old channel that turns to the south and enters the Merlyn England Diversion. The flow within the Co Rd S and Highway 30 ditches enters the disconnected Rawhide channels which flows south to the Merlyn England Diversion.

Other Observations

- Results and topography show what appears to be a continuation of a South Branch of Rawhide Creek which runs from just north of North Bend to the Merlyn England Diversion but is cutoff by the Fremont and Central Cutoff Ditches. This flow path is less defined than the Rawhide Creek and is generally farmed through for its entire length.

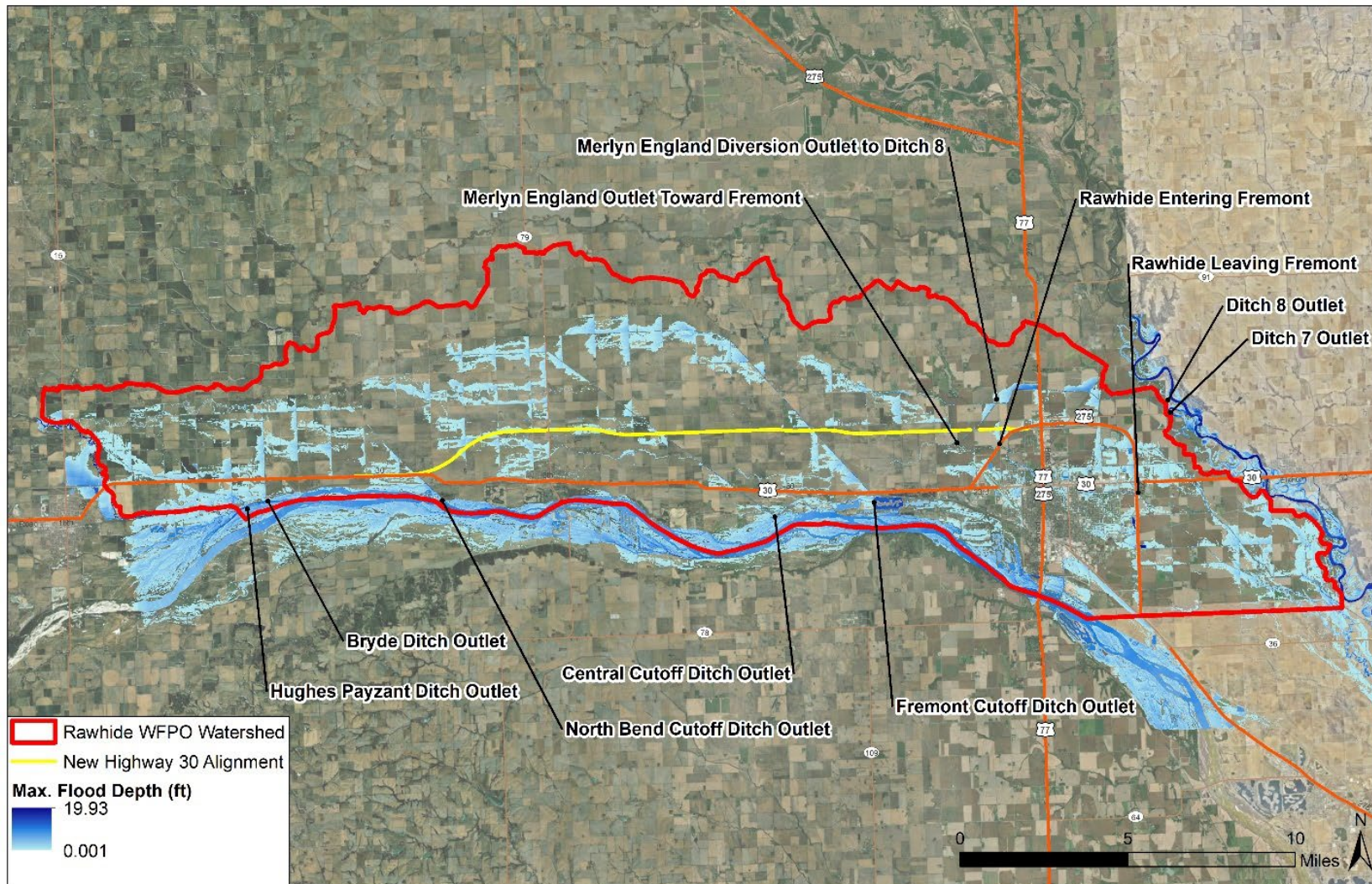


Figure 10: 10-year Coincident Event Existing Conditions

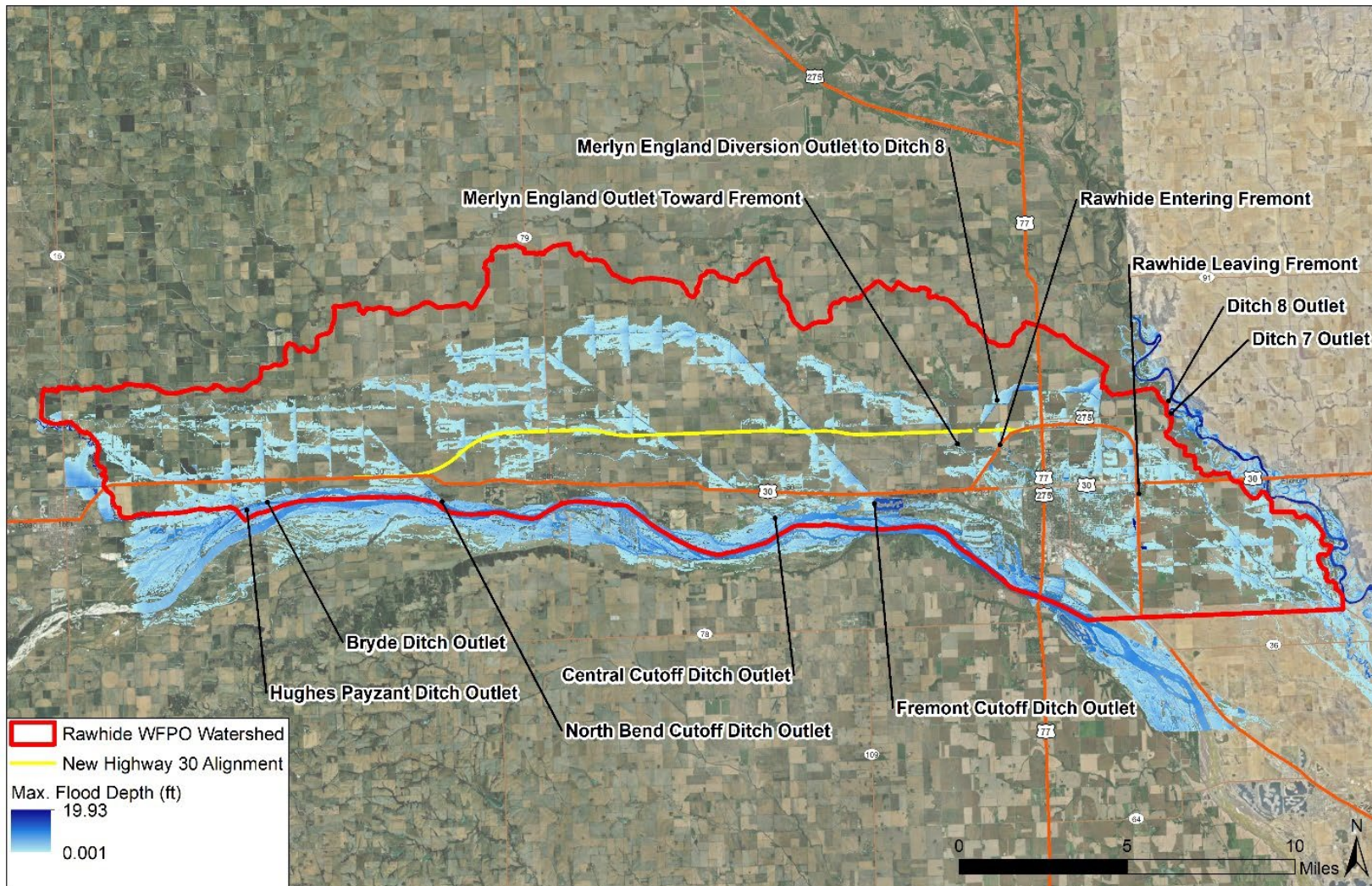


Figure 11: 25-year Coincident Event Existing Conditions

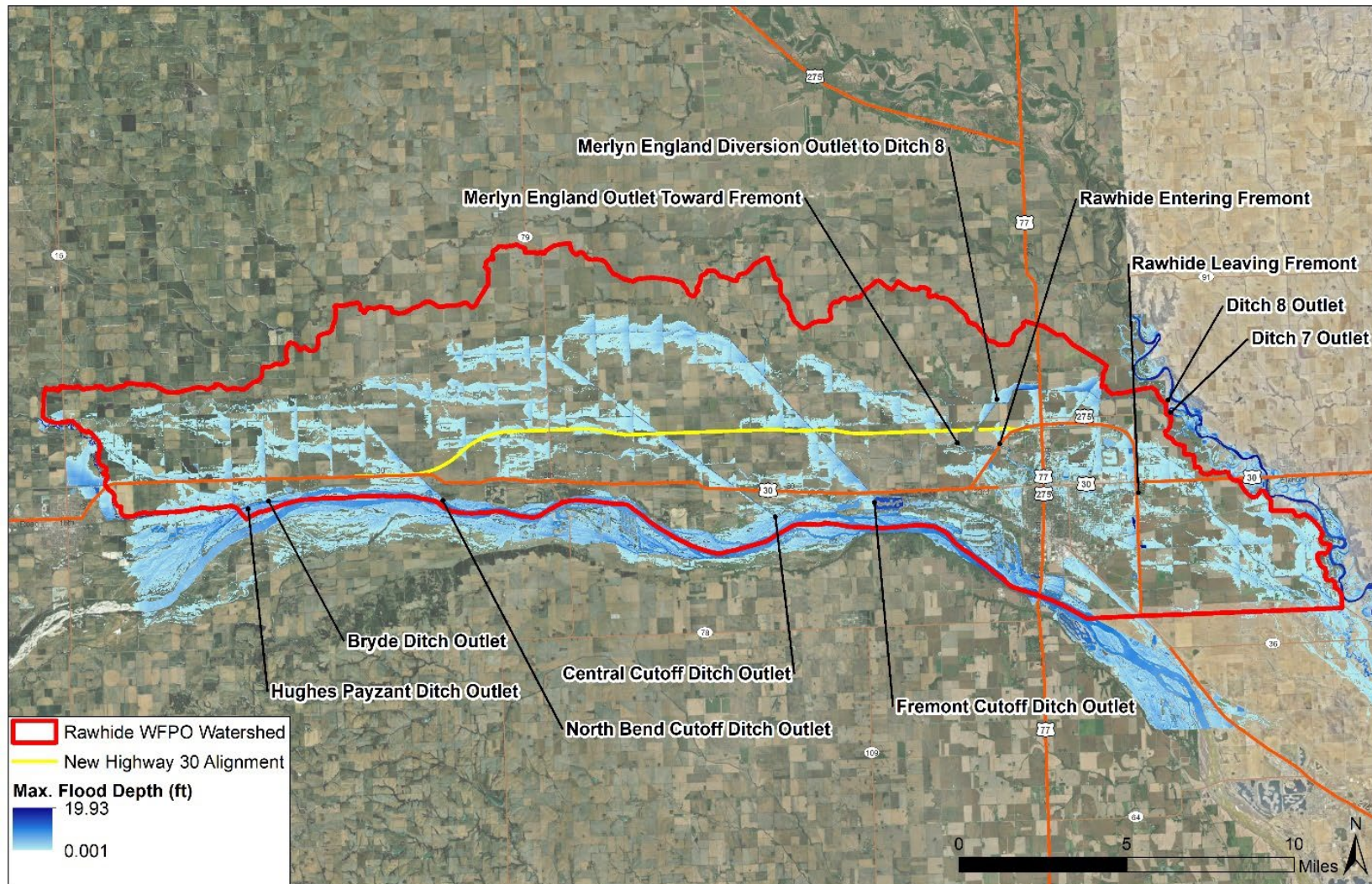


Figure 12: 50-year Coincident Event Existing Conditions

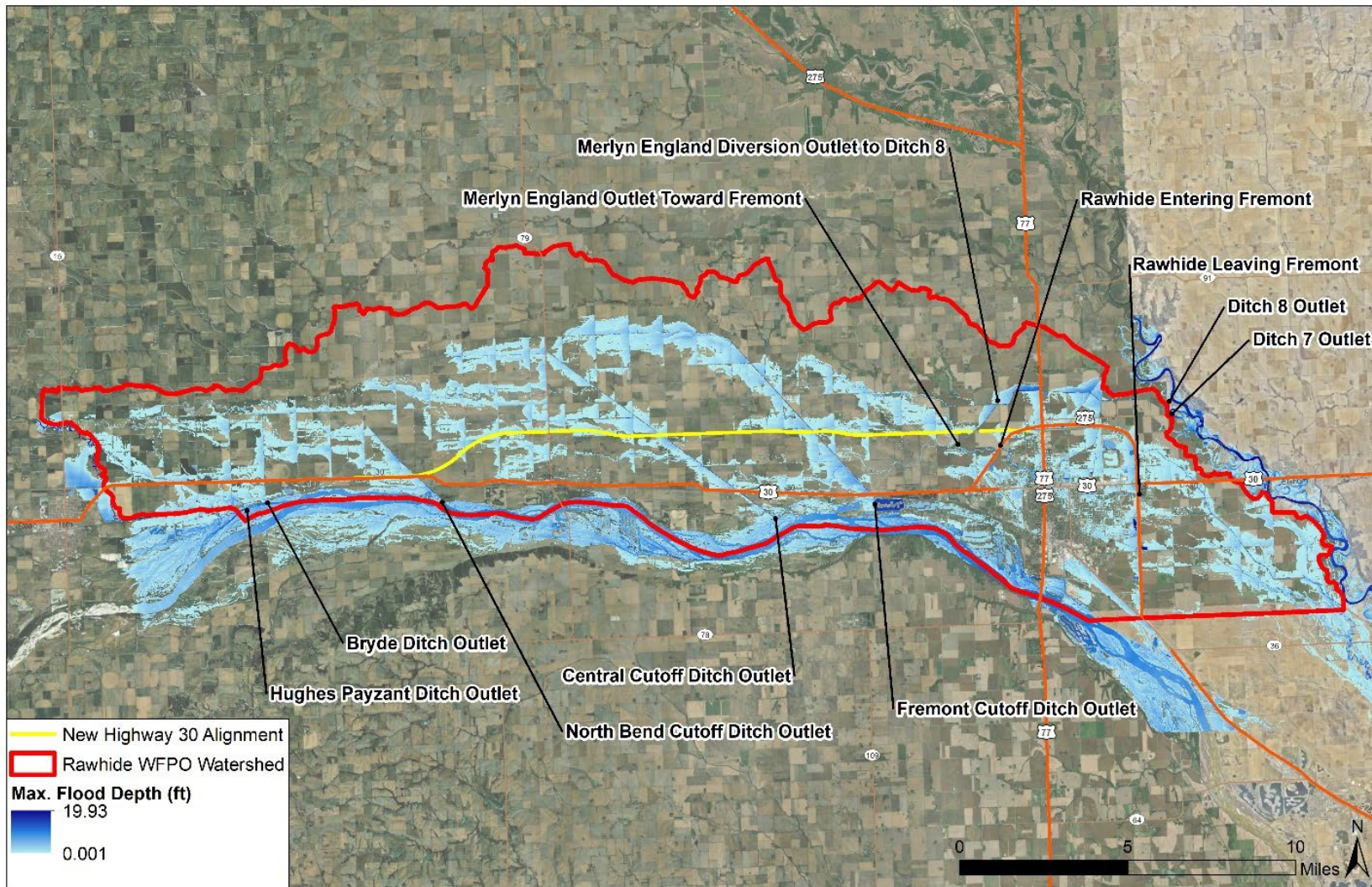


Figure 13: 100-year Coincident Event Existing Conditions

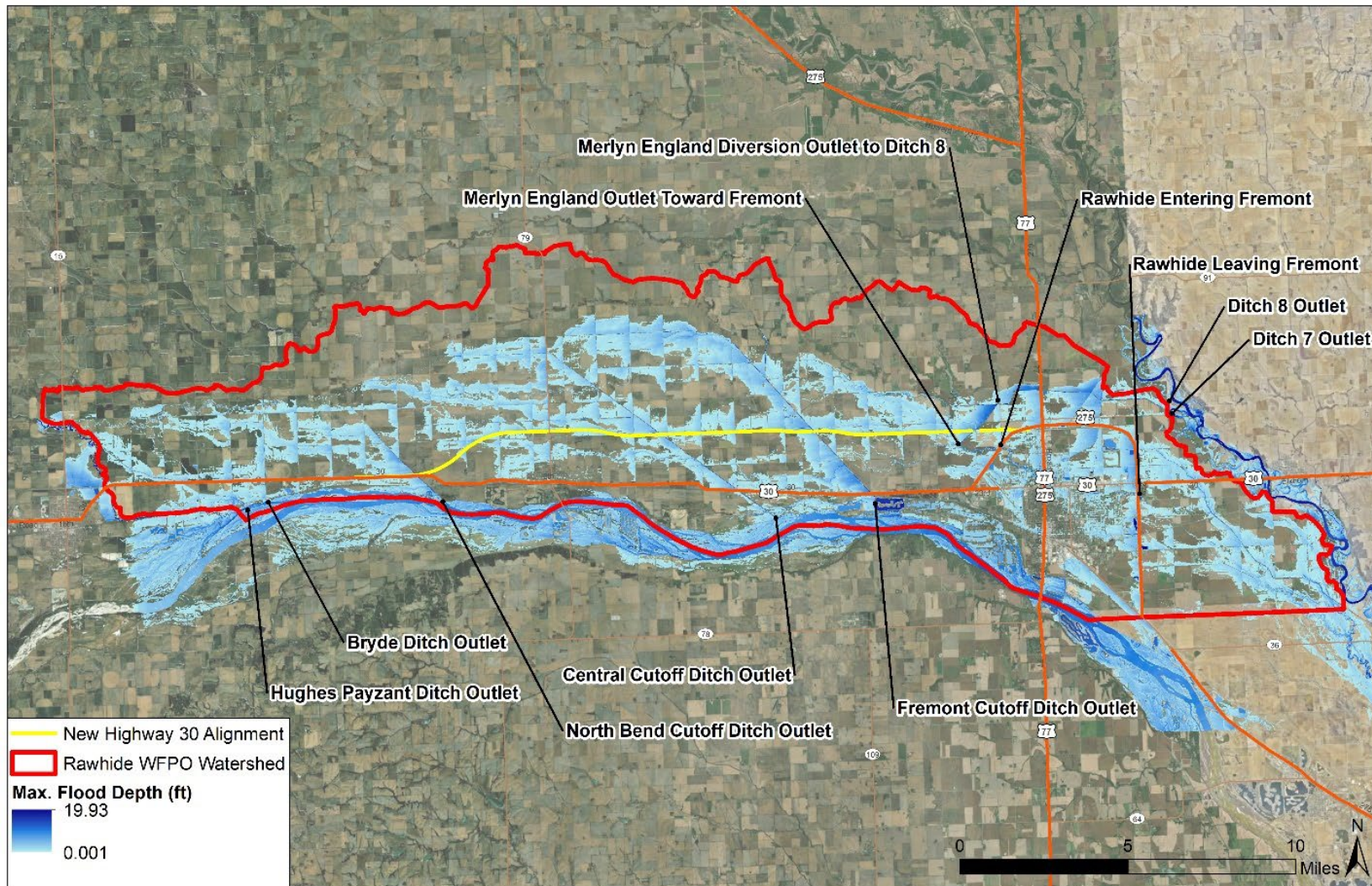


Figure 14: 500-year Coincident Event Existing Conditions

D 4. PREFERRED ALTERNATIVE ANALYSIS AND DESIGN

The results of the baseline hydraulic analysis and risk assessment provided recommended solutions which were evaluated as alternatives. Through this alternative evaluation process, a combination of berm improvements and detention cells was identified for inclusion in the Final Array of Alternatives. As discussed in Chapter 4 of the Plan-EA, this alternative is both the NRCS preferred alternative and the NEPA proposed alternative and will be referred to as the preferred alternative throughout this document. The NRCS preferred alternative is the option and course of action that the SLO and NRCS agree best addresses the stated purpose and need. The NEPA proposed alternative must be technically and economically feasible and meet the purpose and need. A justification for these determinations is included in the narrative below. The intent of this project is to reduce peak flows entering Fremont through the two structures under Highway 275. Selected results from a preliminary geotechnical investigation were used in planning this project and are available upon request. Additional geotechnical investigation will take place during the design phase.

D 4.01 SITE IDENTIFICATION

Potential project sites were identified and analyzed using several factors including aerial imagery, publicly available GIS data, topographic data, field investigations, previous studies, and stakeholder and public involvement. The location of existing infrastructure, including roadways, railroads, utilities, homes, and buildings were all considered to initially select low-impact locations. Alignments were then adjusted to compensate for infrastructure, residences, and other buildings within the project area and areas of impact. An effort was made to identify potential projects which would leverage the current infrastructure that exists in the watershed, like the Merlyn England diversion channel and the cutoff ditches. Additional consideration was given to protecting the new Highway 30 alignment, which is currently under construction at the time of this writing. Existing sensitive resources were also considered when choosing potential site locations. Stream and woodland corridors, potential wetlands, and habitat for threatened and endangered species were identified and used in conjunction with the other data collected.

D 4.02 SITE PRIORITIZATION

Sites that were deemed feasible were evaluated for the quantity of potential flow reduction provided at each entrance to Fremont, the target location. The combination of improvements to two berms, the creation of two detention cells and an overflow channel between the two cells provide significant flood damage risk reduction to Fremont along with reduction to the flood risk to the agricultural areas around Fremont, thus meeting the Plan's purpose and need.

D 4.03 SITE SPECIFIC DESIGN INFORMATION

The detention cells include reinforced concrete boxes or pipes (RCB or RCP), a connecting channel between the detention cells to allow for storage to equalize as needed between the cells and include earthen auxiliary spillways. Levees are aligned along existing roadway and berm to reduce the impact of the footprint to adjacent ag land. Site specific design considerations are described below, and additional details are provided in Structural Tables 3 and 3a located in Chapter 7 of the Plan-EA.

SITE L1-1

Site L1-1 is located on the east side of Cutoff Ditch Road lying between County Road P Blvd on the north and Cutoff Ditch Road on the south. The berm is designed to tie in the Cutoff Ditch Road berm improvements into the higher ground near County Road P Blvd to prevent the 100-year storm from flanking the Cutoff Ditch Road berm. The embankment expands upon an existing berm, with only part of the footprint expanding into the farm ground to the east. This site features a 10-foot wide top and 3:1 (h:v) side slopes. The average height of the berm is 6.5-feet, and the total length of the berm is 5153.5-feet. Site L1-1 is designed to have 2 ft of freeboard for the 100-year event. Structural details are included in Structural Table 3A in Chapter 7 of the Plan-EA and supporting drawings are included in Appendix C. The berm is designed per the Conservation Practice Standard Dike and Levee (Code 356) Class III.

SITE L1-2

Site L1-2 is located along the existing Cutoff Ditch Road alignment from the tie in with Site L1-1 southeast to County Road 15 Blvd. The berm is designed to the 100-year storm. The embankment expands upon the existing roadway, with only part of the footprint expanding into the farm ground to the east. The project footprint does not impact the left bank of the Cutoff Road Ditch and includes the closure of any culverts along the alignment. This site features a 25-foot wide top and 3:1 (h:v) side slopes. The average height of the berm is 3.8-feet, and the total length of the berm is 12265.82-feet. Site L1-2 is designed to have 2 ft of freeboard for the 100-year event, except at the downstream end to allow for tying into existing ground. Structural details are included in Structural Table 3A in Chapter 7 of the Plan-EA and supporting drawings are included in Appendix C. The berm is designed per the Conservation Practice Standard Dike and Levee (Code 356) Class III.

SITE DC1-13A

Site DC1-13A is a detention cell complex consisting of two detention cells connected by a channel. These structures are both located south of the new Highway 30 alignment and west of County Road 20 Ave. At the existing Merlyn England diversion structure, the north detention cell will be

added to control a 7.84 square mile drainage area. The north detention cell expands upon the existing diversion by increasing the berm height. This detention cell is sized to hold the 100-year without use of the auxiliary spillway, set at Elev. 1206.9, and to pass the 500-year. Two outfall structures convey flows either to the Merlyn England Diversion Channel (2 RCB at 6-ft x 6 ft and 6 ft x 7 ft) set at Elev. 1199.55 or to the Rawhide Creek (2 RCP @ 24-inch) set at 1198.3. The detention cell includes 118.3 acre-ft for sediment storage. Site DC1-13A North is connected to Site DC1-13A South via a 10-foot-wide channel and 10-foot top width berm set at Elev. 1212.9, which allows the structures to hold a greater volume of water from variable sources. The South detention cell is located south of County Road T Ave and controls a 2.07 square mile drainage area. This detention cell collects drainage from the ditch which crosses Highway 275 near the Fremont Municipal Airport. This detention cell is sized in conjunction to hold the 100-year and to pass the 500-year and freeboard event, including 45.5 acre-ft for sediment storage. The outfall structures convey flows towards the airport in the existing ditch through an 18-inch RCP set at 1201.0. These detention cells will be dry most of the time. Together the detention cells store a total flood retarding volume of 1454.1 acre-ft. Sediment storage needs were calculated using RUSLE methodology. It was estimated that approximately 1.05 tons/acre would be delivered annually to the detention cell. Estimated trap rates of 30% were then used to develop the required 100-yr sediment storage of 118.3 acre-ft and 45.5 acre-ft, for the two detention cell holding areas, respectively. Structural details are included in Structural Table 3A in Chapter 7 of the Plan-EA and supporting drawings are included in Appendix C. This detention cell is designed per the Conservation Practice Standard - Dams (Code 402), NRCS National Engineering Manual (NEM) (Title 210), Part 520, Subpart C, "Dams"; and NRCS Technical Release (TR) (Title 210) 60, "Earth Dams and Reservoirs".

D 4.04 PROPOSED CONDITIONS HYDROLOGY & HYDRAULICS

Hydrology and hydraulics for the proposed conditions were analyzed using a combination of HEC-HMS and HEC-RAS using the same hydrology and hydraulic models as the existing conditions. The model terrain was updated to include the geometry of the proposed berm improvements and detention cells. Subbasin extents were updated to reflect the values reported from the proposed hydrology, and the hydraulics were updated for the 10, 25, 50, 100, and 500-year rainfall events. Figure 15 and Figure 16 show the 100 and 500 year proposed flooding extents.

Additionally, since both structures were designed to High Hazard Standards, the determination of the appropriate hydrographs used for design were determined as described in Table 15. Determinations were selected as the product of storage (acre-ft) x effective height (ft) was less than 30,000 acre-ft². PMP storm for this area is 23.7 inches.

Table 15: Design Rainfall Depths

Design Hydrograph	Requirement	Rainfall Depth
-------------------	-------------	----------------

Principal Spillway (24-hr)	P25	5.28
Auxiliary Spillway (24-hr)	P100	6.91
Freeboard (24-hr)	PMP	23.7

Performance of the proposed detention cells were evaluated using an iterative process in HEC-RAS to determine the storage needs, berm height and outlet configurations which would meet the requirements outlined in TR-210-60. This information is presented in Table 16.

It is important to note that the detention cells work in cooperation with each other once water surface elevations within the cells are greater than 1203.00 for this reason the analysis of the cells was performed with both cells at the same time.

Table 16: Hydrologic Performance of Detention Structures

Design Storm	10-year	25-year	50-year	100-year	500-year
DC1-13A North					
Existing Inflow (cfs)	326	585	755	1064	1490
Proposed Outflow (cfs)	255	391	515	601	627
Percent Reduction	22	33	32	43	58
DC1-13A South					
Existing Inflow (cfs)	287	417	530	654	985
Proposed Outflow (cfs)	2	6	10	15	35
Percent Reduction	99	98	98	98	96
DC1-13A Combined					
Existing Inflow (cfs)	613	1002	1285	1718	2475
Proposed Outflow (cfs)	257	397	525	616	662
Percent Reduction	58	60	59	64	73

** Flow Rates are rounded to the nearest 5 cfs.*

The proposed berms and detention cell improvements work in combination to reduce the flood damage experienced by the Fremont area. For all rainfall events the implementation of this project was able to eliminate the overtopping of Cutoff Ditch Road and significantly reduce the inflow into the City of Fremont.

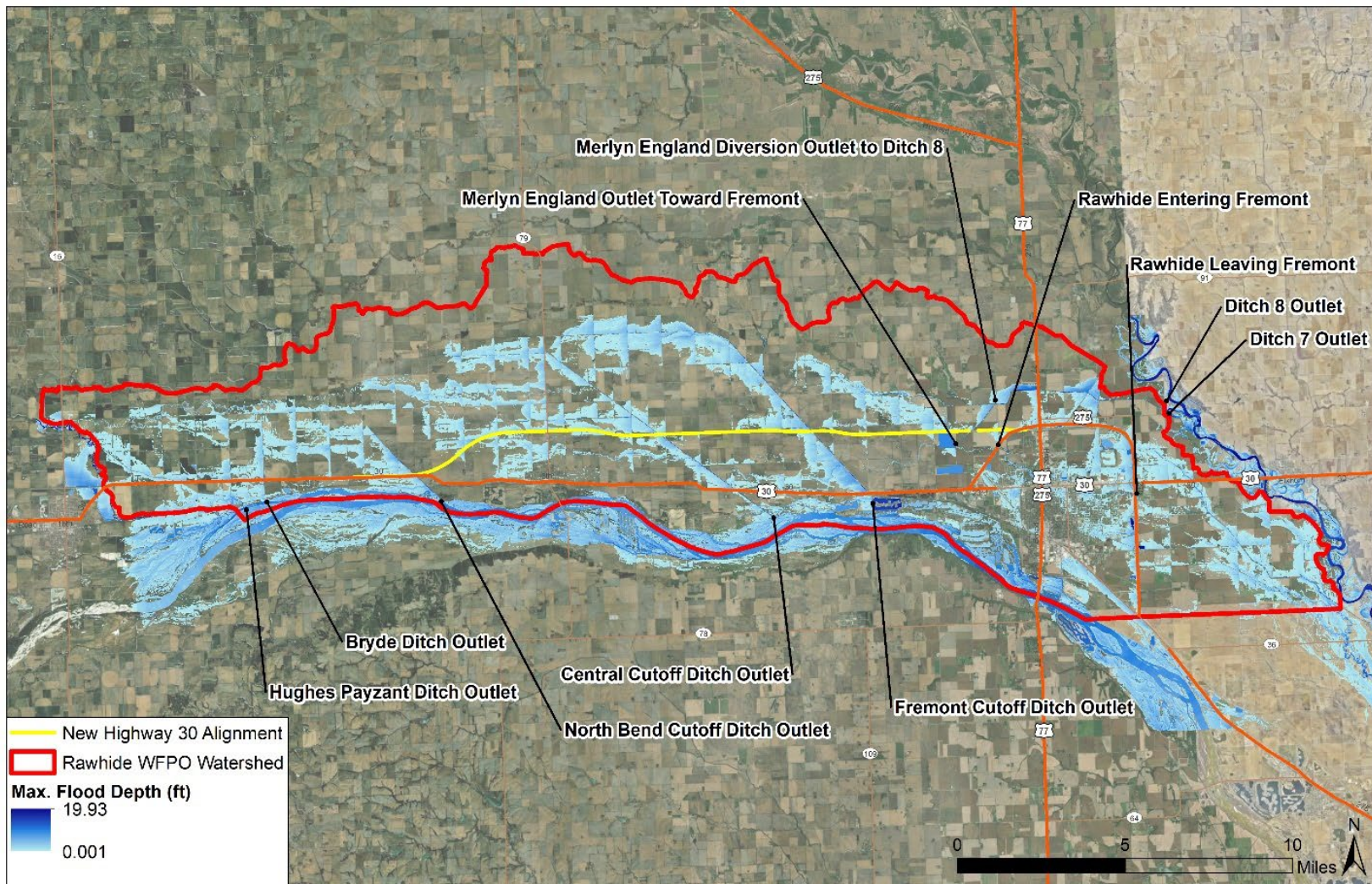


Figure 15: 100-year Coincident Event Proposed Conditions

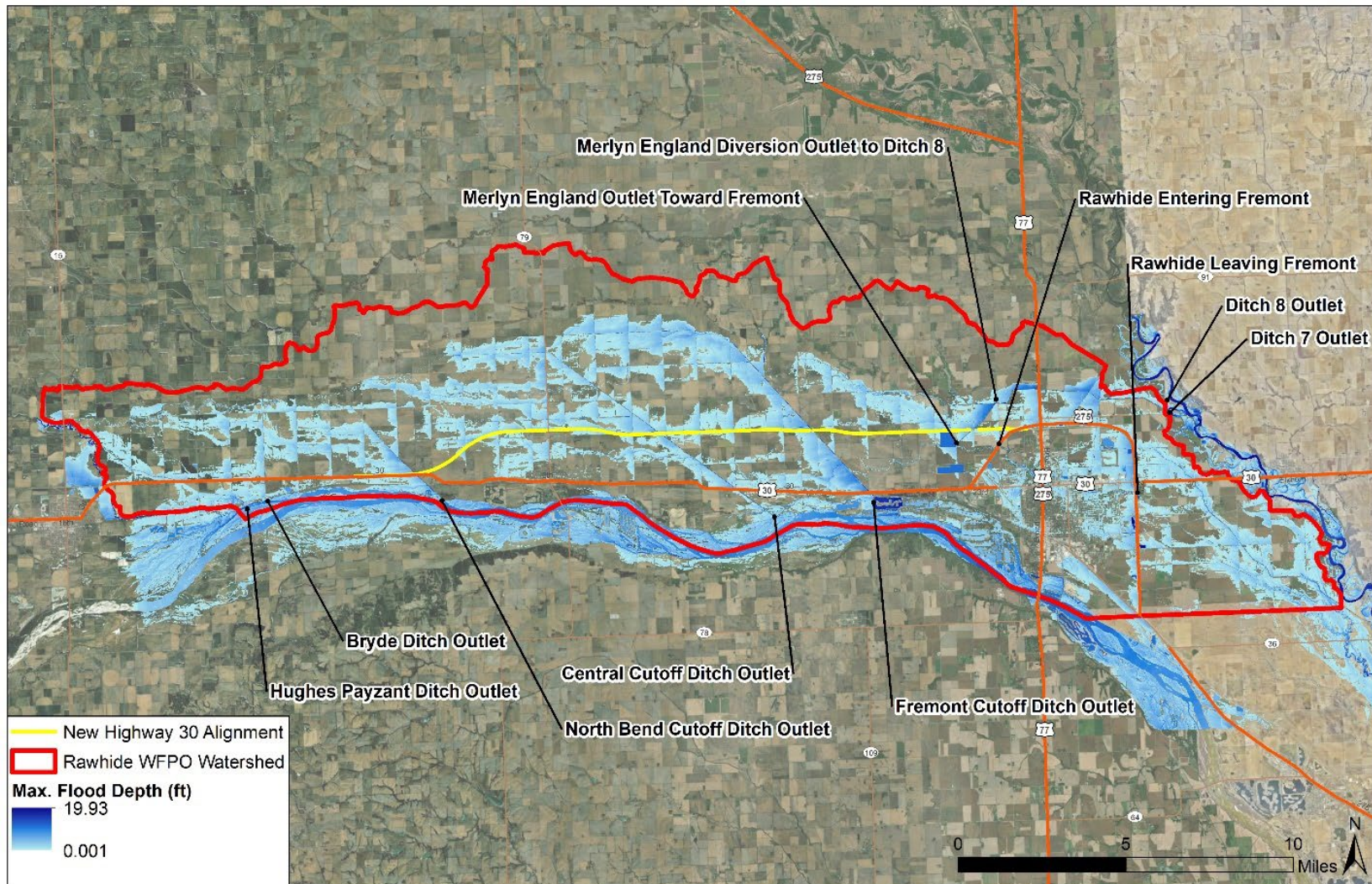


Figure 16: 500-year Coincident Event Proposed Conditions

D 4.05 DAM BREACH ANALYSIS

DAM BREACH HYDROLOGY

Peak breach discharge for each of the structures was estimated using the methodology outlined in Part 1 of TR 210-60 Earth Dams and Reservoirs. The geometry for the proposed dam was based on the cross-sections and elevations noted within the proposed plans. These peak discharges were combined with the storage volume of the reservoir at the time of failure which was used to determine a breach hydrograph in accordance with TR-66. In all cases, the breach elevation was assumed to be at the maximum berm elevation for the detention cell for the freeboard event. A summary of breach flows and breach conditions is provided in Table 17.

Table 17: Proposed Breach Parameters

Parameter	DC1-13A
Minimum Top of Dam Elevation	1211.8
Auxiliary #1 Spillway Elevation	1206.9
Breach Elevation*	1212.9
Volume at Breach (Acre-Ft)	2,144
Tailwater Elevation	1198.20
Peak Breach Discharge (cfs)	9,400

*Note: Breach elevation is maximum detention berm elevation.

DAM BREACH HYDRAULICS

Breach routings were completed in HEC-RAS version 6.5 using the same 2D mesh and geometry used for the proposed conditions hydraulics. Breach hydrographs were developed in accordance with applicable Nebraska Dam Safety standards and in accordance with methodology outlined in *NRCS Technical Release 210-60 – Earth Dams and Reservoirs*.

To understand the maximum impact on the City of Fremont multiple breach scenarios were run. Breach hydrographs were also developed assuming that the water surface elevation at the time of the breach was set at the elevation of the pool at a freeboard event, resulting in a peak flow rate of 9,400 cfs. Three breach scenarios were considered, one scenario at each outfall location. The resulting hydrograph was introduced to the 2D mesh immediately downstream of the dam at each outfall location and routed through the 2D model to provide an estimation of flooding extent and severity should sudden dam failure occur.

The most severe result map for the dam is included in Appendix C.

D 4.06 INDUCED FLOODING EVALUATION

RESIDUAL RISK

Though significant improvement exists for all design storms under the preferred alternative, Fremont still has pluvial drainage problems and Platte River, Elkhorn River and Shell Creek overflow flooding are still major concerns for all communities within the Rawhide Creek watershed. For those buildings for which flood risk remains following implementation of the preferred alternative, additional nonstructural floodproofing could be implemented to further reduce flooding damages in conjunction with other ongoing flood risk reduction projects in Fremont and the surrounding region. Additionally, the current regulatory floodplain is outdated compared to the existing conditions that were modeled during this study effort. One major discrepancy between the existing regulatory Platte River floodplain and the model developed for this assessment is the addition of the new alignment for Highway 30. Additionally, there are a multitude of newly built structures in Fremont that are not in the regulatory floodplain, but still regularly experience inundation. The best available floodplain information for this region is the model developed for this study. Based on this, it has been recommended to the City of Fremont to adopt this study for local floodplain management purposes; that action is under consideration by the City.

AVOIDANCE OF UPSTREAM IMPACTS

Since a berm is designed to prevent water from entering an area, it has the potential to increase the water surface elevation over areas upstream of the berm. For this reason, an analysis of the water surface elevation upstream of the Site L1-1 and L1-2 berms was conducted to ensure that proper action was taken if upstream buildings were impacted by the berm improvements. This analysis found that four farmsteads are potentially impacted by the increased water surface elevations, with increases in flood elevation ranging from approximately 0.5 to 4.4 inches. Of the four potentially impacted farmsteads flagged during preliminary investigations using LiDAR, only two farmsteads showed potential impacts to the home while the other two farmsteads showed potential impacts to outbuildings only. All four farmsteads showing potential impacts during the preliminary investigation were then surveyed to better understand the flood risk prior to implementation of the preferred alternative along with changes to flood risk due to implementation of the preferred alternative. Survey showed that the homes on all four properties have a first-floor elevation or lowest opening above the proposed (with preferred alternative) water surface elevation, so no flood risk mitigation activities are required for homes. Table 18 outlines the findings of this analysis. These findings show that as all buildings are below the regulatory base flood elevation and homes are still well above the proposed (with preferred alternative) water surface elevation. Additionally, the flood zone the properties are in is Zone AE without floodway which allows up to a foot of rise due to the improvements under the current ordinance. Considering both of these items, no flood easements are required for this project. The County may decide to work to provide a one-time compensation for property owners based on the incremental depth increase over the property and value of the buildings and agricultural land.

Table 18: Results of Upstream Property Analysis

	Property #1	Property #2	Property #3 (First Floor)	Property #3 (Windowsill)	Property #4 (First Floor)	Property #4 (Windowsill)
Basement	None	Crawl	Full	Full	Full	Full
Regulatory BFE (ft)	1228.50	1228.50	1231.00	1231.00	1232.50	1232.50
Platte Model Max. Existing WSE (ft)	1227.78	1227.08	1227.98	1227.98	0.00	0.00
Platte Model Max. Proposed WSE (ft)	1227.78	1227.78	1227.98	1227.98	0.00	0.00
Platte Model Depth Increase	0.00	.000	0.00	0.00	0.00	0.00
Rawhide Model Max. Existing WSE (ft)	1224.74	1224.71	1227.99	1227.99	1231.12	1231.12
Rawhide Model Max. Proposed WSE (ft)	1225.08	1225.08	1228.05	1228.05	1231.23	1231.23
Rawhide Model Depth Increase (ft)	0.34	0.37	0.06	0.06	0.11	0.11
Surveyed Home First Floor Elevation (ft)	1227.36	1227.81	1232.33	1229.28	1236.37	1232.36
Surveyed Ground at Home Foundation (ft)	1224.50	1226.01	1227.88	1227.88	1232.78	1232.78
First Floor Height Above Existing WSE (ft)	2.62	3.10	4.34	1.29	5.25	1.24
First Floor Height Above Proposed WSE (ft)	2.28	2.73	4.28	1.23	5.14	1.13
Ground Height Above Existing WSE (ft)	-0.24	1.30	-0.11	-0.11	1.66	1.66
Ground Height Above Proposed WSE (ft)	-0.58	0.93	-0.17	-0.17	1.55	1.55

First Floor Height Above Regulatory (ft)	-1.14	-0.69	1.33	-1.72	3.87	-0.143
Ground Height Above Regulatory (ft)	-4.00	-2.49	-3.12	-3.12	0.28	0.28

Note: Negative values in the table above denote locations where the proposed water surface elevation is greater than the surveyed ground surface.

D 5. GEOLOGY

A preliminary geological investigation, including subsurface sampling, was performed to support the design of the preferred alternative. The purpose was to identify any geologic conditions or hazards to address in the design, construction, or operation of the preferred alternative. Field investigations were completed by Thiele Geotech Inc. between August 24, 2023, and January 22, 2024. A summary is included below. The full report is included in Appendix E. A detailed geological investigation would be completed during the design phase and has been included in the project cost estimates. Soil boring was conducted at 18 locations in total:

- Cutoff Ditch Rd – 6 borings
- Brush Creek Dam Outfall – 2 borings
- Detention Cell – 10 borings

Soils encountered generally consisted of man-placed fill underlain by alluvial and Pre-Illinoian-aged glacial till deposits. Weathered sandstone was encountered below the glacial till. As expected for an alluvial setting, soil conditions vary due to their mode of deposition. The existing soils encountered primarily consisted of alluvial deposits ranging in moisture content, consistency, and plasticity. Excavated site soils will generally be suitable for reuse as structural fill, however, moderate to significant moisture conditioning should be anticipated. The soils encountered in test borings are compressible, and the addition of fill to raise grades will cause these soils to consolidate and settle. Groundwater was encountered in 11 out of 18 test borings with depths ranging from 6.5 to 17.3 feet below existing grades. These soil conditions appear generally suitable for support of the proposed projects.

Preliminary seismic hazard evaluation for the preferred alternative was performed by locating the region as denoted within the 2018 USGS Long-term National Seismic Hazard Map. As seen within the map, the project area is located within a low hazard region. Additionally, the project area is not located over any active faults, as confirmed by the USGS Quaternary Fault Database. A full seismic evaluation as determined necessary by NRCS guidelines will be performed within the design phase of the project.

D 6. ECONOMICS

D 6.01 INTRODUCTION

This report estimates the benefits and costs of proposed flood mitigation measures proposed as part of the Rawhide Creek Watershed Improvement Project in eastern Nebraska. The Rawhide Creek watershed lies within Dodge and Colfax counties and comprises a total area of 142,528 acres. Beginning in Colfax County to the west, Rawhide Creek flows from the City of North Bend (population of 1,269) to the east, through Fremont, a city of approximately 27,400 people. The southern edge of the watershed also contains sections of the Platte River, and the western edge

contains a section of Shell Creek. The Elkhorn River lies just north of the eastern edge of the watershed.

The watershed is prone to frequent, and occasionally severe flooding. Storms occurring both in and outside of the watershed cause Shell Creek, the Platte River, and the Elkhorn River to overflow. In 2010, two flood events caused significant damage to North Bend. In March of that year, an ice-blockage caused approximately \$75,000 of damage to buildings and led to the rescue of several people. That summer, a storm event caused the South Platte River to flood, causing an estimated \$20 million in damages to public property in and around North Bend.¹ During the most recent flood event in 2019, extensive flooding and damage occurred in Fremont, cutting the city off from public-access for more than a week. The 2019 floods damaged approximately 1,500 homes and buildings in the city.² Total public damages from the 2019 floods, which did not account for damages to private property or transportation infrastructure, amounted to more than \$34 million in Dodge County.

Dodge County responded by starting the Rawhide Creek Watershed Flood Risk Reduction Plan – Environmental Assessment (Plan-EA) to identify projects to reduce flood risk to homes, businesses, agricultural property, and infrastructure within the watershed in order to protect the diverse economic benefits created within the project area. This report considers the benefits and costs of flood mitigation measures proposed to limit flood damage in the watersheds by addressing the challenges cited above. Specifically, this report considers the benefits and costs of the Action Alternative, which consists of constructing two detention structures as well as a road raise and berms. The benefits and costs of the alternative are compared against a baseline of no action, which is also referred to as the Future Without Federal Investment (FWOFI).

This report is structured into the following sections:

- Federal Guidelines of Benefit-Cost Analysis of Flood Mitigation Measures
- Alternatives and Ecosystem Services Evaluated
- National Economic Efficiency Analysis Data and Methodology
- Current Economic Damages
- Economic and Structural Tables

D 6.02 FEDERAL GUIDELINES OF BENEFIT-COST ANALYSIS OF FLOOD MITIGATION MEASURES

¹ <https://storymaps.arcgis.com/stories/9cb7e97dd8fe42e8bb3d27c2a05298a6>

² Channel 3 News. 2020. Following the Floods: Fremont. Available at: <https://www.3newsnow.com/news/following-the-floods/following-the-floods-fremont#:~:text=In%202019%2C%20Fremont%20had%201500,magnitude%20was%2040%20years%20ago.%22>

The benefit-cost analysis (BCA) conducted as part of this report uses federal water resource project and NRCS guidelines for the evaluation of benefits and costs of the no action and action alternatives, relying primarily on the Principles, Requirements and Guidelines (PR&G)(NRCS, 2014a), the NRCS Natural Resources Economics Handbook (NRCS 1998), and the National Watershed Program Manual (NRCS 2014b).

With the federal Law passage of the 2007 Water Resources Development Act, Congress directed the federal government to update and consolidate its past guidance on evaluating the costs and benefits of federal investments. The original Principles and Guidelines (P&G) was replaced by Principles, Requirements and Guidelines (PR&G) as of April 2019. The PR&G allow for:

... maximizing public benefits (of all types) relative to costs, the use of quantified and unquantified information in the tradeoff analysis, flexibility in decision making to promote localized solutions, ability to rely on the best available science and objectivity, and advance transparency for Federal investments in water resources.

The PR&G further state:

Federal investments in water resources as a whole should strive to maximize public benefits, with appropriate consideration of costs. Public benefits encompass environmental, economic and social goals; include monetary and non-monetary effects; and allow for the consideration of both quantified and unquantified measures.

The PR&G also requires benefits and costs to be evaluated in an ecosystem service framework. An ecosystem is a natural unit of living and non-living things that function together to create goods and services valued by people (Olander et al., 2016). Ecosystem services is a broad term used to describe the benefits humanity receives from ecosystems as a byproduct of their functioning.

By putting nature at the center, ecosystem services frameworks give economic, social, and environmental costs and benefits equal standing in decision-making processes and therefore help to accomplish the federal objective of maximizing national economic efficiency, ensuring federal investments protect and restore ecosystem functions and values and avoid irreversible impacts (NRCS, 2014a). Economic efficiency requires that resources are used in their highest valued use. Projects that create more benefits than costs utilize resources more efficiently than baseline conditions and therefore increasing societal value.

The four-category ecosystem framework adopted in the PR&G, and utilized in this report, is shown in Table 19.

Table 19: Ecosystem Services Framework Used to Evaluate Benefits and Costs

Service Type	Examples
Provisioning	The supply of food, fuel, fiber, water, timber, and genetic resources

Regulating	The regulation of air, climate, natural hazards, water quality, pests, and disease
Cultural	Services that enhance cultural values, like aesthetics, recreation, tourism, and spiritual or religious values
Supporting	Nutrient cycling, soil formation, and primary production

Source: USDA, 2014b

As Table 19 shows, ecosystem services can be placed into one of four categories. Provisioning services supply goods that directly benefit people. The production of crops, fuel, water, timber, and other raw materials are all provisioning services. Regulating services describe the benefits people receive from an ecosystem's ability to regulate things like air quality, climate, and hazards, both natural and manmade. Cultural services describe the benefits people derive from an ecosystem's ability to provide a good view, a recreation opportunity, a place to travel and visit, or spiritual or religious values.

GUIDING PRINCIPLES

In addition to requiring projects to be evaluated using an ecosystem service framework, the PR&G also seeks to promote projects that fulfill guiding principles related to federal investments in water resources. These include:

- **Healthy and Resilient Ecosystems** – Federal investments in water resources should protect and restore functions of ecosystems and mitigate any unavoidable damage to these natural systems.
- **Sustainable Economic Development** – Federal investments in water resources should encourage sustainable economic development that improve the economic well-being of the Nation for present and future generations through the sustainable use and management of water resources.
- **Floodplains** – Federal investments in water resources should avoid the unwise use of flood prone-areas and avoid and minimize adverse impacts and vulnerabilities in any case in which a flood-prone area must be used. Federal investments should seek to reduce the Nation's vulnerability to floods and storms.
- **Public Safety** – Federal investments in water resources should avoid, reduce, or mitigate risks to people, including both loss of life and injury, from natural events.
- **Environmental Justice** – Federal investments in water resources should ensure that and disproportionately high and adverse public safety, human health, or environmental burdens of projects on tribal, minority, or low-income populations are identified, mitigated, or eliminated.
- **Watershed Approach** - Federal investments in water resources should use a watershed approach that properly frames a problem by evaluating it on a systems level that identifies root causes and interconnectedness of watershed problems that enables the design of solutions that considers the benefits of water resources for a wide range of stakeholders within and around the watershed.

The Rawhide Creek Watershed Plan-EA considered these principles in the characterization of flood risks and water management challenges faced by stakeholders in the watershed and the formulation of solutions as defined in the Action Alternative.

D 6.03 ECOSYSTEM SERVICES EVALUATED

To reduce the risk of flooding in the Rawhide Creek watershed, the project team met with interested parties to answer questions, provide additional information, and learn more about properties that may be impacted by proposed flood risk reduction alternatives. Following these meetings JEO Consulting Group, Inc., the planning consultant, developed an Action Alternative that was evaluated alongside a No Action Alternative as part of the NEE BCA analysis. The No Action Alternative, also known as the Future Without Federal Investment (FWOFI), describes the most likely future if no federal investment is made in the watershed. The Action Alternative describes the proposed actions to be taken to reduce future flood damage in the Rawhide Creek Watershed.

TYPES OF SERVICES IMPACTED

Public scoping comments, planning documents, watershed plans from surrounding areas, and discussions with the project proponent suggest that the project's primary benefits will result from regulating flood risk so that the associated damages to properties, incomes, and farmland in and surrounding population centers in the Rawhide Creek watershed are smaller under the Action Alternative than under the FWOFI.

Figure 17 shows the causal chain describing how the Action Alternative would create social benefits and costs as part of the Rawhide Creek Watershed Flood Risk Reduction Plan. Causal chains are models describing how changes to the structure of an ecosystem affect its functioning and the goods and services it provides to society (Olander et al., 2016). When used as part of a NEE analysis, a causal chain assessment of ecosystem services impacts traces changes in ecosystem composition all the way through to effects on social outcomes and human well-being.

As Figure 17 shows, the Action Alternative would change the ecological structure of the watershed through the construction of the works of improvement described in Table 19.

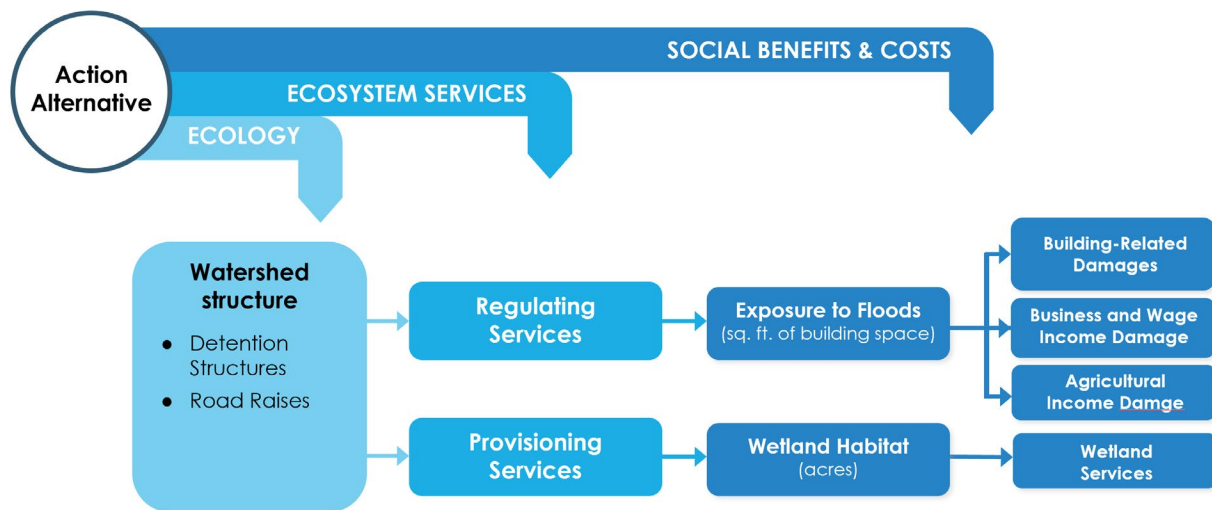


Figure 17: Anticipated Impacts on Ecosystem Services

The change in watershed structure would regulate flooding affecting property-related damages, including damage to buildings as well as their contents and inventory, business and wage income, and agriculture income. In addition, the change would also increase the provisioning of wetland habitat and its associated ecosystem services.

ABILITY TO CHARACTERIZE, QUANTIFY, AND MONETIZE SERVICES

The ecosystem services described in Figure 17 can all be characterized, quantified, and monetized using publicly available information and accepted methodologies that relate biophysical values to economic values. The methods to quantify and value each ecosystem service evaluated as part of this analysis are described in more detail in section D 6.04.

METRICS TO EVALUATE SERVICES

The metrics used to evaluate the change in ecosystem service values under the Action Alternative are shown in Figure 17. Regulating services are evaluated by quantifying and valuing changes to the square footage of buildings affected by flooding of different depths. Provisioning services are evaluated by the change in wetland acres.

PRIORITIZING SERVICES

Services were prioritized based on their expected contribution to the project's primary purposes of reducing damages from floods and enhancing ecosystem service production in the watershed. As a result, the regulating and provisioning services shown in Figure 17 were prioritized for analysis as part of the evaluation of the Action Alternative's impact on National Economic Efficiency (NEE). The project may also result in smaller, secondary changes to other ecosystem services. For example, many residents of rural towns have lived there for many years or multiple

generations and have a strong sense of place. Knowing that the community is at lower risk of flooding, and is therefore more secure, could create cultural benefits for the city's residents (Fabbri et al., 2020).

SUMMARY AND COMPARISON OF ECOSYSTEM SERVICE CHANGES

A summary of the Action Alternative's impact on ecosystem services in the Rawhide Creek Watershed and fulfillment of federal investment principles in water resources are shown in Table 20.

The Action Alternative was created and supported through a local stakeholder process. As part of this process, stakeholders were invited to provide public comment and input into the design and evaluation of the Action Alternative. As a result of this input, the Action Alternative is the locally preferred alternative. The FWOFI is the non-structural alternative in that, without federal investment, there would be no change in the structure of the watershed. The Action Alternative is the alternative that increase National Economic Efficiency by reducing flood damages, infrastructure damages, conserving municipal water, enhancing the provision of farm income, and enhancing recreation values, thereby increasing the value of ecosystem services produced by the watershed. The Action Alternative is also the environmentally preferred alternative as defined in Section 101 of the National Environmental Policy Act.³

³ Section 101 of NEPA states that "...It is the continuing responsibility of the Federal Government to (1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations; (2) assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings; (3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences; (4) preserve important historic, cultural, and natural aspects of our national heritage, and maintain wherever possible an environment which supports diversity and variety of individual choice; (5) achieve balance between population and resource use which will permit high standards of living and wide sharing of life's amenities; and (6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources."

Table 20: Summary of Project Alternatives and Ecosystem Services (2024\$)

	Alternatives	
	FWOFI	Action Alternative ¹
Alternatives		
Locally Preferred		X
Non-structural		
National Economic Efficiency		X
Environmentally Preferable		X
Guiding Principles		
Healthy and Resilient Ecosystems		X
Sustainable Economic Development		X
Watershed Approach		X
Environmental Justice		X
Public Safety		X
Floodplains		X
Total Project Investment (Annualized Average)²	\$-	\$1,146,600
Monetized Net Benefits (Annualized Average)³	-\$8,545,605	\$1,315,800
Regulating Services (Annualized Average)		
Reduced building-related damages	-\$2,152,800	\$339,400
Reduced business income and wage loss	-\$6,265,000	\$860,000
Reduced agricultural damages	-\$127,200	\$2,800
Provisioning Services (Annualized Average)		
Increased Wetland Habitat	\$-	\$113,600

Notes: (1) Note that all costs and benefits for Action Alternative are compared to the Future Without Federal Investment (FWOFI) here and elsewhere in this document. Benefits and costs were calculated over a 103 year analysis period starting two years after construction begins using a discount rate of 2.75 percent. All values reported in 2024 dollars.

(2) Annualized costs for the Action Alternative include design, engineering, administration, permitting, construction, and operations and maintenance.

(3) The net benefits of the FWOFI are negative to reflect the annualized damages and expenses in the study area due to flood events and monetary expenditures.

The Action Alternative, which used a watershed approach to characterize problems and solutions in the watershed, meets the federal principles for investments in water resources. The Action Alternative would restore the watershed's ability to regulate flood damage impacting the population centers in the Rawhide Creek watershed, thereby increasing the health and resiliency of the ecosystem. By reducing flood damages, the Action Alternative improves sustainable economic development by improving the economic well-being of present and future generations

living within the watershed. The Action Alternative also avoids the unwise use of flood-prone areas by reducing the watershed's vulnerability to future flood events. Public safety is also enhanced by the Action Alternative because it would result in lower rates of injury and death related to flooding. The Action Alternative would not adversely affect environmental justice communities.

In terms of benefits and costs, the Action Alternative's investment in the watershed would generate economic returns in excess of the upfront installation and ongoing management costs of the flood control structures as compared to the FWOI. Under the FWOI, average annual economic damages and expenses are approximately \$8.5 million. These damages are the result of expenses residents of the watershed face to repair property-related damages as well as damages to farmland. The Action Alternative would invest an average annual amount of \$1.1 million in built infrastructure to regulate flooding in the watershed, thereby avoiding many of these damages and expenses. The annualized discounted value of the enhanced regulating service benefits generated by the project amount to \$1.3 million, outweighing the Action Alternative's annualized expense.⁴

D 6.04 NATIONAL ECONOMIC EFFICIENCY ANALYSIS DATA AND METHODOLOGY

To evaluate the extent to which the Action Alternative would maximize public benefits relative to costs, the expected effects of the Action Alternative were quantified, valued, and compared against the FWOI or No Action Alternative. The NEE BCA analysis evaluated the costs of the Action Alternative based on cost estimates from JEO Consulting Group, Inc., which included costs for property, permitting, engineering, construction, and operations and maintenance. These were compared against benefits received by regulating losses associated with flood damage in the Rawhide Creek Watershed.

Effects of the Action Alternative were evaluated over a 103-year time horizon, beginning two years after the start of construction to account for the total period of analysis of 105 years. This equates to a 100-year operational life for the structures, which is equal to the length of time over which the structures are expected to have significant beneficial effects. Benefits are expected to begin accruing in full the year after the structures included in the Action Alternative are installed and continue to accrue until the end of the 103-year time horizon. Since all the project elements have design lives of 100 years, replacement costs were not included in the analysis as the project time horizon does not exceed the life of the measures (PR&G Section 9, NWPM 501.37.B and the Economics Handbook, Part 611, 1.12.).

⁴ Benefits and costs were calculated over a 103 year analysis period starting two years after construction begins using a discount rate of 2.75 percent. All values reported in 2024 dollars.

To assess the economic benefits and costs of the Action Alternative, GIS-based hydrologic and hydraulic (H&H) projections were developed to assess flood extent and depth in the watershed for 5-, 10-, 25-, 50-, 100-, and 500-year events under the Action and No Action Alternatives. The NEE analysis used this information to quantify and value the benefits and costs associated with the Action Alternative as discussed in more detail below.

Projected benefits and costs are based on a full employment economy and assume no change in relative prices during the period of analysis. Benefits and costs are discounted using the discount rate for federal projects of 2.75 percent for 2024 (NRCS, 2023). Results are reported in both net present values and average annual values in 2024 dollars.

The unit of analysis in this study is the system of projects combined under the Action Alternative. For this study, costs and benefits are estimated jointly for all components of the Action Alternative. Section D.6 considers the impact of each component separately, beginning with the most beneficial component and ending with the least beneficial component, as part of the incremental analysis (390-NWPH, Part 606, Subpart B, Section 606.20).

REDUCED PROPERTY-RELATED DAMAGE AND INCOME LOSS

Reduced property losses were estimated with the HAZUS model. The HAZUS model, endorsed by the NRCS for watershed planning and developed by FEMA, serves as a robust tool for estimating flood damage across various scenarios⁵. The model's primary strength lies in its ability to quickly produce estimates using user-defined H&H modeling and pre-packaged building data, making it well-suited for widespread and integrated flood risk assessments. However, this convenience comes with a tradeoff in precision; HAZUS may not provide the same level of detail for building-specific flood depth damages as models like HEC-FDA. On the other hand, models like HEC-FDA are specifically designed for detailed flood risk analysis but demand more time, specialized expertise, and detailed data, which can limit their accessibility for large flood inundation areas with diverse building inventories. Peer-reviewed comparisons of the HAZUS and HEC-FDA models, which applied the models to several different study areas, found the outputs from HAZUS are similar and consistent with those from HEC-FDA, while requiring a fraction of the time and effort to produce⁶. Based on these reviews and to best utilize the limited resources available in preparing the watershed plan, the project team chose to utilize HAZUS.

The HAZUS model, developed by FEMA based on records of previous flood events and expert judgement, was created as a tool for flood plain managers and others to use in flood mitigation planning (HAZUS Technical Manual 2.1 pg. 2-2). Its primary goal is to provide quantifiable

⁵ USDA, NRCS. 2017. Departmental Manual 9500-013. U.S. Department of Agriculture, Washington, D.C.

⁶ Ding, A., White, J. F., Ullman, P. W., & Fashokun, A. O. (2008). "Evaluation of hazus-mh flood model with local data and other program." Nat. Hazards Rev., 10.1061/(ASCE)1527-6988(2008)9:1(20), 1527-6996.

information on the damage caused by flood events in support of disaster relief and watershed planning efforts.

The spatially explicit model runs on standard GIS software and addresses damages associated with almost all parts of the built environment. The model can estimate the value of a wide range of different types of flood loss. The model contains different loss modules, which the user has the option of including in their total damage calculation. The modules for reduced property loss, which are time-independent, include:

- Building repair and replacement cost;
- Building content loss; and
- Building inventory loss.

The sum of these losses constitutes building and content losses in the benefit-cost analysis.

The modules for reduced income loss, which measures flood-events impact on business activity, include:

- Capital related income loss; and
- Wage loss.

Regardless of which module is being run, HAZUS works in a two-step process, which includes a flood risk projection step and a flood loss estimation step. In the flood risk projection step, the user defines flood risk in terms of parameters like flood frequency, discharge, and ground elevation in the study area. In the second step, damages are calculated based on the flood risk projections developed in the first step and using default functions relating depth to damage (depth-damage functions) from the U.S. Army Corps of Engineers (USACE) and building inventory and valuation data from the U.S. Census (HAZUS, 2022). The model combines this information to produce spatial and tabular data describing flood losses in monetary terms.

An important part of estimating reduced flood damage is identifying the number, value, type, and other characteristics of at-risk building stock. The HAZUS model's General Building Stock data (GBS) includes information on residential, commercial, industrial, agricultural, religious, government, and education buildings for each Census block in the impacted communities. For modeling simplicity, HAZUS assumes building inventory is evenly distributed across a census block, such that building damage estimates represent averages across their respective block. The model associated each building type with one of seven corresponding occupancy classifications:

- Residential
- Commercial
- Industrial
- Agricultural
- Religion
- Government
- Education

The occupation classification allows the model to analyze losses for buildings with similar uses, valuations, and damages using building type-specific depth-damage curves. Table 21, below, shows the number of structures damaged by flooding under each storm event frequency.

Table 21: Count of Damaged Structures in the Rawhide Creek Watershed Under the Future Without Federal Investment (FWOFI) and the Preferred Alternative (PA)

Occupancy Type	500-Year		100-Year		50-Year		25-Year		10-Year	
	FWOFI	PA	FWOFI	PA	FWOFI	PA	FWOFI	PA	FWOFI	PA
Residential	749	693	536	487	445	405	352	317	224	210
Commercial	4	3	1	1	1	1	1	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0
Agricultural	0	0	0	0	0	0	0	0	0	0
Religious	0	0	0	0	0	0	0	0	0	0
Government	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0
Total	753	696	537	488	446	406	353	317	224	210

Source: HAZUS v5.1

The data in Table 21 were combined in the HAZUS model with flood extent and depth projections for the FWOFI and Preferred Alternative. Flood extent and depth data was input into the HAZUS model using depth grids from five return periods (10%, 4%, 2%, 1%, and 0.2% annual chance floods, or 10-, 25-, 50-, 100-, and 500-year return periods) developed as outputs from the hydrology and hydraulic analysis (H&H) for the FWOFI or existing conditions.

The model combined the general building stock data from Table 21 with the H&H data to estimate the count and square feet of different building types flooded at different depths for different flood frequencies under the FWOFI and Preferred Alternative.

The HAZUS model used the data in Table 21 to estimate the losses for the study area's general building stock under the FOWFI and Preferred Alternative. In total, annual building-related damages, including structures and contents, equate to an average annualized damage of about \$2,152,000 per year under the FWOFI, compared to \$1,813,000 under the Preferred Alternative, for a net damage reduction of \$339,400 per year. The HAZUS model's methods for calculating each type of loss are discussed below.

BUILDING REPAIR AND REPLACEMENT COST

Damage to buildings under the FWOPI and Preferred Alternative were calculated by estimating the cost to repair or replace flood-damaged structures and their contents. Building repair and replacement cost estimates are based on the full replacement cost less depreciation model, whereby losses from flood-damaged buildings are calculated assuming the full value of damages, less depreciation, are restored.

Replacement cost data is stored in the HAZUS model at the Census Block level for each building type. The replacement cost values used by the HAZUS model were depreciated based on the median age and assumptions regarding the typical condition of structures in the watershed. According to the U.S. Census' American Community Survey, the median home in Dodge County, which contains the Rawhide Creek Watershed, was built in 1964 and is approximately 60 years old. A visual survey of residential neighborhoods in impacted communities showed that homes are generally maintained in average to above-average condition.

This information was cross-referenced with the Swift Estimator, which provides a depreciation curve for structures of various ages. Based on the median age and assumed condition of buildings in the watershed, the swift estimator recommended using a depreciation rate of 15 percent, which was applied to the replacement cost values provided by HAZUS as shown in Table 22.

Table 22: Replacement Cost Values for Buildings

Occupancy Type	Cost per Sq. Ft.	Depreciation Factor	Depreciated Cost per Sq. Ft.
Residential	\$135	15%	\$115
Commercial	\$198	15%	\$168
Industrial	\$97	15%	\$78
Agricultural	\$191	15%	\$162
Religious	\$114	15%	\$87
Government	\$135	15%	\$115
Education	\$103	15%	\$88

Note: Replacement costs are reported in costs per square foot for multiple occupancy type sub-categories based on the weighted average of values used in the analysis of building damages.

Source: HAZUS v.5.1.

The replacement cost values used by the HAZUS model were validated using market prices to represent depreciated values since the market takes into account the age and condition of structures.

BUILDING CONTENT LOSS

The HAZUS model estimates the loss value of building contents as a percentage of the structure replacement value as shown in Table 23. Contents in the model include furniture, equipment, computers, appliances, clothing, and personal possessions. Contents do not include things like

light fixtures, ceiling lamps, or other mechanical or electronic components that are integral to the structure of a building.

Table 23: Building Content Loss as Percent of Building Replacement Value

Occupancy Type	Content Values as % of Building Replacement Value
Residential	50%
Commercial	105%
Industrial	140%
Agricultural	100%
Religious	-
Government	125%
Education	125%

Source: HAZUS v.5.1.

The HAZUS model uses an internal damage function library that includes 144 inventory-depth-damage functions from the U.S. Army Corps of Engineers for buildings with different occupancy types.

BUSINESS INVENTORY DAMAGES

Many occupancy types have more than one inventory-depth-damage curve associated with them. In these cases, the HAZUS model averages the relevant functions to form a single average function for the entire building occupancy class. The HAZUS model uses this information along with information on total damaged floor area, annual gross sales per square foot, and business inventory as a percent of annual gross sales, to calculate the total inventory damage for each building type. The gross revenue per square foot and business inventory as a percentage of gross revenue are shown in Table 24.

Table 24: Business Inventory Losses as a Percent of Gross Sales per Square Foot

Occupancy Type	Gross Revenue per Sq. Ft.	Business Inventory as % of Gross Revenue
Residential	-	-
Commercial	\$68	12%
Industrial	\$613	4%
Agricultural	\$156	8%
Religious	-	-
Government	-	-
Education	-	-

Source: HAZUS v.5.1.

BUSINESS INCOME AND WAGE DAMAGES

HAZUS calculates business interruption costs, including proprietor income loss and employee wage loss by building type. In the model, business income and wage losses depend on the amount of time it takes to restore the building where the business resides in addition to restocking its inventory. Restoration time accounts for physical restoration, clean-up, inspections, permits, and contractor availability. Restoration times increase with flood depth and also vary based on building type. Restoration times range from a low of a few months for structures with minimal flooding to a high of several years. For many commercial businesses, restoring lost inventory and equipment accounts for the largest share of restoration time.

The equations below show how HAZUS calculates business income and wage losses following flood events:

- **Income Loss_i** = $\sum (1-IRF_i) \times FA_{i,j} \times Inc_j \times RT_{i,j}$
- **Wage Loss_i** = $\sum (1-WRF_i) \times FA_{i,j} \times WA_j \times RT_{i,j}$

The parameters of the above equations are defined as:

- i is the building type of the impact structure
- IRF_i is the income recapture factor for building type i
- WRF_i is the wage recapture factor for building type i
- FA_i is the income per day (per sq. ft.) for building type i
- INC_i is the business income per day (per sq. ft.) for building type i
- WA_i is the wage per day (per sq. ft.) for building type i
- $RT_{i,j}$ is the restoration time, measured in days, for building type i and flood depth j .

The equations represent income and wage loss as a function of the length of time needed to restore business operations as well as the ability of businesses and employees to recapture their respective incomes and wages. For example, according to the wage loss equation, employees who are able to recover their full wage following a flood event would have a recapture rate of one, which would mean they would not lose any wages as a result of the flood. Lower recapture rates would lead to high damages, all else equal. The income and wage recapture rates used by the HAZUS model ensure that estimates of income and wage loss only include actual losses rather than deferred economic activity. The equations also reflect the productivity of the business as measured by income generated per square foot.

The parameters used to calculate reduced business income and wage losses under the Preferred Alternative and FWOPI are shown in Table 25. The restoration times shown in the table are based on expert opinion and account for various factors like physical restoration, clean-up, inspections, permits, approval processes, and delays due to contractor availability. Table 25 also displays the income recapture rates, annual business income generation rates, and daily wage rates per square foot used in the analysis.

Table 25: Parameters Used to Calculate Business Income and Wage Loss

Occupancy Type	Restoration Time (Days)	Income Recapture Rate	Daily Business Income per Sq. Ft per Year	Daily Wage per Sq. Ft.
Residential	180 – 720	0%	\$0	\$0
Commercial	180 – 900	68%	\$0.20	\$0.48
Industrial	0 – 900	80%	\$0.10	\$0.42
Agricultural	0 -210	67%	\$0.05	\$0.17
Religious	180 – 900	80%	\$0.16	\$2.46
Government	360 – 900	80%	\$0.10	\$0.14
Education	360 - 900	83%	\$0.10	\$0.67

Source: HAZUS v.5.1.

NREH Part 611.0403 states that the benefit of reducing business income losses from flood risk reduction can be included as part of National Economic Efficiency benefit-cost ratio when interview data are collected to verify that losses are not compensated for by postponement of an activity or transfer of the economic activity to other establishments.

To validate the nature of business income and wage related losses estimated by HAZUS, a survey of business owners was conducted by the Lower Loup Natural Resource District (LLNRD) to estimate the impact of a 100-year flood event on their business revenue and employee wages. LLNRD approached a sample of businesses to participate in the interviews utilizing NRCS Form ECN-003 (NREH Part 611, Appendix 4A, Form NRCS-ECN-003). The LLNRD engaged in structured dialogues with each business to ensure uniformity in questioning and responses. Confidentiality was assured to encourage participation and information sharing. In total, 11 businesses completed the questionnaires.

The businesses surveyed represented a range of sectors, including retail trade, professional and business services, financial services, and information services. These businesses employed between one and 15 people, with an average of about four employees per enterprise. All respondents indicated that flooding would cause irreversible harm to their operations. This aligns with FEMA data, which shows that 43 percent of small businesses do not reopen after a disaster, and an additional 29 percent close within two years.⁷ Furthermore, the limited economic development in rural areas means there may be few alternative businesses to meet the needs of customers impacted by flooding. Even when other businesses are available, demand for goods

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[https://emilms.fema.gov/is_0111a/groups/23.html#:~:text=Almost%20half%20\(43%20percent\)%20of,facilitate%20the%20restoration%20of%20businesses.](https://emilms.fema.gov/is_0111a/groups/23.html#:~:text=Almost%20half%20(43%20percent)%20of,facilitate%20the%20restoration%20of%20businesses.)

and services may decrease as affected residents experience financial hardship during the post-flood recovery period.

For many rural retail businesses, lost sales are unlikely to be recovered. For instance, restaurant patrons will not order additional meals to compensate for missed purchases during flood-induced closures, and gas station customers cannot fill their tanks twice to make up for unpurchased fuel. These flood-related losses in transactions cannot be recovered and reflect real and lasting losses of business income and employee wages.

The comparison of income losses estimated with the survey results and the HAZUS model showed that HAZUS produced conservative estimates. On this basis, the HAZUS estimates of income losses are carried forward as national effects in the benefit-cost analysis following guidance in NREH Part 611.0403.

AGRICULTURAL DAMAGE REDUCTION

The H&H projections developed for the HAZUS model were also used to estimate the number of acres of farmland impacted by flooding under the FWOFI and Preferred Alternative. The projections were combined with data from the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) Cropscape database. The web-based database, which shows crop cover in the United States, was used to classify the land cover of impacted acres in the Rawhide Creek watershed.

Land cover data for alfalfa, corn, and soybeans were carried forward for analysis as they represent the predominant crops grown in the watershed (USDA NASS Cropscape Database, 2021). Table 26 shows the total number of acres that would avoid damages of flooding at different depths under the Preferred Alternative for all flood frequencies. For example, 10 acres of alfalfa that flooded at a depth of 0-1 feet under the FWOFI would avoid damage under the Preferred Alternative. As Table 26 shows, the Preferred Alternative would remove approximately 1,900 acres of agricultural land from flood risk.

Table 26: Acres of Cropland Avoiding Flood Damages

Crop	Flood Depth			Total
	0 to 1 ft.	1 to 3 ft.	3+ ft.	
Alfalfa	10	9	0	20
Corn	599	334	-45	887
Soybeans	726	294	-138	882
Pasture	77	53	1	131
Total	1,412	689	-181	1,920

To estimate the value of reducing crop damage, the impacted acres of alfalfa, corn, soybeans, and pasture in Table 26 were categorized based on the depth of flooding experienced under different flood frequencies. Flood depth categories were defined as 0 –to 1 foot, 1 –to 3 feet, and

more than 3 feet so that they correspond to the depth-damage function used to assess flood losses.

The depth-damage function was used to relate the depth of flooding to corresponding percent reduction in gross revenue as shown in Table 27. For example, an alfalfa field flooded with more than three feet of water would be expected to lose approximately 38.8 percent of its gross value.

Table 27: Agricultural Depth Damage Function

Crop	Loss of Gross Revenue (ac)		
	0 to 1 ft.	1 to 3 ft.	3+ ft.
Alfalfa	18.9%	31.9%	38.8%
Corn	24.6%	50.5%	63.3%
Soybeans	21.2%	43.0%	52.7%
Pasture	13.3%	21.5%	26.5%

Source: Nebraska Resources Development Fund, 2000. Guidelines Including Regulations and Nebraska Statutes.

The gross value of each crop was estimated using state and county-level yield and price data from the USDA's NASS as shown in Table 28. Price information was taken from the NRCS USDA data series on annual normalized prices for the state of Nebraska for alfalfa, corn, and soybeans for the period from 2011 through 2020 (NRCS, 2021). Prices for each crop were estimated using the NRCS normalized price data series. Price information for pasture was collected from the University of Nebraska's 2019 Farm Real Estate Report, which estimated the statewide average annual cash rent for pastures (UNL, 2019). Data on crop yields was gathered from the USDA NASS (USDA NASS, 2021a/b).

Table 28: Crop Values Used to Estimate Gross Crop Revenues

Crop	Units	Normalized Price (2023)	Yield per Acre	Gross Value per Acre
Alfalfa	TON	\$164.00	4	\$623
Corn	BU	\$4.21	180	\$758
Soybeans	BU	\$10.10	58	\$586
Pasture	AC	\$34.00	1	\$34

Source: USDA NASS, 2021a/b.

The data in Table 26 through Table 28 were combined to calculate the reduced agricultural damages under the Preferred Alternative.

WETLAND HABITAT CREATION

Wetlands are extremely productive ecosystems, capable of producing a variety of public benefits. Previous studies of wetland values have shown that wetlands provide recreational opportunities, including fishing, bird watching, hunting, and boating. Wetlands also provide important habitat for aquatic and avian species, in addition to regulating water flows and improving water quality.

The wetlands included in the Preferred Alternative would be created as part of the project and would therefore have a different value than existing wetlands. Still, created wetlands can produce ecosystem service values. A 2015 study of wetlands created for mitigation compliance with Section 404 of the Clean Water Act found that mitigation wetlands create similar values to original wetlands when they are properly constructed.

The study used data from 33 independent valuation studies from across the U.S. found that wetlands created for mitigation create approximately \$8,000 to \$60,000 per acre in annual ecosystem service benefits (Table 29). The study also used the data to estimate state-specific wetland value transfer functions, which accounted for several ecosystem services. The study controlled for regional variability of wetland values by including variables characterizing the geographic locations of wetlands included in the meta-analysis. The study used the function to estimate that wetlands in Nebraska produce an average of \$8,700 in ecosystem services each year.

Table 29: National Average Benefit Value per Acre for Individual Wetland Ecosystem Services Produced by Wetland Mitigation (2024 \$)

Ecosystem Service	Annual Average Benefit Per Acre	Annual Average Benefit Per Acre (Lower Bound)
Recreational Fishing	\$3,865	\$537
Bird Hunting	\$3,984	\$554
Bird Watching	\$18,865	\$2,623
Water Quality Protection	\$13,494	\$1,877
Water Supply Protection	\$9,938	\$1,382
Commercial Fishing	\$11,477	\$1,595
Flood Control	\$2,436	\$382
National Average	\$64,057	\$8,949
State of Nebraska	\$8,720	\$3,783

Source: Adusumilli, N. 2015. *Valuation of Ecosystem Services From Wetlands Mitigation in the United States*. *Land*, 4(1).

Table 30 shows the acres of wetland that would be created by each proposed structure. The acres were multiplied by a value of \$8,720 to reflect the average value. In total, the Preferred Alternative will create approximately 22 acres of wetland, resulting in a net increase of approximately 15 acres of wetland in the watershed when accounting for areas impacted due to construction. This will result in an annual total of approximately \$130,800 in ecosystem service benefits. Note that the value of \$130,800 calculated today, when discounted and amortized over the project lifespan and reported as an average annualized figure, becomes \$113,600 as reported in Table 20.

Table 30: Net Acres of Additional Wetland and Wetland Value of Preferred Alternative (2024 \$)

Preferred Alternative Component	Net Acres of Additional Wetland	Annual Value of Ecosystem Services
L1-1 & L1-2	0	-

DC1-13A	15	\$130,800
Total	15	\$130,800

COSTS

Project costs include all expenses incurred as part of the development, installation, operation, and maintenance of a project. Preliminary engineering work was completed by JEO Consulting Group, Inc., who was hired by the Sponsoring Local Organization to lead design and planning work on the project. JEO is the lead engineer on the project. Based on this work, JEO provided cost estimates for the Action Alternative. The cost estimates were allocated to categories, which included:

- Permitting;
- Administration;
- Engineering and Design;
- Construction; and
- Operations and Maintenance.

Each cost was allocated to federal sources or the project sponsor.

INSTALLATION COSTS

Installation costs were estimated using the bottom-up approach. This method breaks projects and structures into lower-level components and then costs those components for their direct costs, including labor, materials, and professional services. In addition, installation cost estimates include cost contingencies of 20 percent of construction costs.

Table 31 and Table 32 show the estimated installation costs for the structures included in the Action Alternative.

Table 31: Estimated Installation Costs of DC1-13A (2024 \$)

ESTIMATE OF QUANTITIES					
Item #	Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
1.	Mobilization	LS	1.00	1,076,000.00	1,076,000.00
2.	Bonding and Insurance	LS	1.00	359,000.00	359,000.00
3.	Clearing and Grubbing	LS	1.00	200,000.00	200,000.00
4.	Temporary Traffic Control Measures	LS	0.00	0.00	0.00
5.	North Excavation, Established Quantity	CY	1,055,550.00	5.00	5,277,750.00
6.	North Earthwork Measured in Embankment (Established Quantity)	CY	7,200.00	20.00	144,000.00
7.	South Excavation, Established Quantity	CY	1,318,375.00	5.00	6,591,875.00
8.	South Earthwork Measured in Embankment (Established Quantity)	CY	8,295.00	20.00	165,900.00
9.	Bridge Removal and Replacement	SF	0.00	500.00	0.00
10.	18" RCP, Class III	LF	40.00	250.00	10,000.00
11.	18" RCP Flared End Section	EA	1.00	1,700.00	1,700.00
12.	24" RCP, Class III	LF	140.00	300.00	42,000.00
13.	24" RCP Flared End Section	EA	2.00	2,000.00	4,000.00
14.	Twin 7'x6' Box Culvert	LS	1.00	150,000.00	150,000.00
15.	48" RCP Flared End Section	EA	0.00	3,000.00	0.00
16.	Concrete Headwall	EA	2.00	15,000.00	30,000.00
17.	Automatic Flap Gate	EA	0.00	10,000.00	0.00
18.	Crushed Rock Base Course	TONS	0.00	75.00	0.00
19.	Gravel Surface Course	TONS	0.00	90.00	0.00
20.	Rock Riprap	TONS	1,300.00	110.00	143,000.00
21.	Remove Pavement	SY	0.00	25.00	0.00
22.	7" Concrete Pavement	SY	0.00	100.00	0.00
23.	Silt Fence, Low Porosity	LF	16,000.00	4.00	64,000.00
24.	Seeding, Fertilizer and Mulch	ACRE	570.00	3,000.00	1,710,000.00
Subtotal of Construction					\$15,969,300.00
Contingency 15%					\$3,193,900.00
Total - Construction					\$19,163,200.00
Local Items					
1.	Mobilization	LS	1.00	15,000.00	15,000.00
2.	Bonding and Insurance	LS	1.00	5,000.00	5,000.00
3.	Clearing and Grubbing	LS	1.00	5,000.00	5,000.00
4.	Temporary Traffic Control Measures	LS	0.00	0.00	0.00
5.	Excavation, Established Quantity	CY	0.00	5.00	0.00
6.	Earthwork Measured in Embankment (Established Quantity)	CY	0.00	20.00	0.00
7.	Triple 8'x4' Box Culvert	LS	1.00	200,000.00	200,000.00
8.	Bridge Removal and Replacement	SF	0.00	500.00	0.00

9.	24" RCP, Class III	LF	0.00	300.00	0.00
10.	24" RCP Flared End Section	EA	0.00	2,000.00	0.00
11.	48" RCP Class III	LF	0.00	500.00	0.00
12.	48" RCP Flared End Section	EA	0.00	3,000.00	0.00
13.	Concrete Headwall	EA	0.00	7,500.00	0.00
14.	Automatic Flap Gate	EA	0.00	10,000.00	0.00
15.	Crushed Rock Base Course	TONS	0.00	75.00	0.00
16.	Gravel Surface Course	TONS	0.00	90.00	0.00
17.	Rock Riprap	TONS	0.00	110.00	0.00
18.	Remove Pavement	SY	0.00	25.00	0.00
19.	7" Concrete Pavement	SY	0.00	100.00	0.00
20.	Silt Fence, Low Porosity	LF	0.00	4.00	0.00
Subtotal of Construction					\$225,000.00
Contingency 15%					\$45,000
Total Construction					\$270,000
Land Acquisition					
1.	Permanent Land	ACRE	340.00	15,000.00	5,100,000.00
2.	Temporary Easement	ACRE	230.00	5,000.00	1,150,000.00
3.	Home Buyout	EA	0.00	100,000.00	0.00
4.	Hold	LS	0.00	0.00	0.00
Land Acquisition Subtotal					\$6,250,000.00
Legal Fees, Appraisals, Etc					\$625,000.00
Total Land Rights					\$6,875,000.00
Engineering					
1.	Design, Geotech, & Bidding	LS	1	3,109,400.00	3,109,400.00
2.	Permitting	LS	1	777,400.00	777,400.00
3	Construction Engineering & Material Testing	LS	1	1,943,400.00	1,943,400.00
ENGINEERING SUBTOTAL					\$5,830,200
Professional Services					
Subtotal Project Cost					\$32,138,400.00
Sponsor Administration and Other Fees					\$485,900.00
NRCS Administration Fees					\$75,000.00
Total Project Cost					\$32,699,300.00

Table 32: Estimated Installation Costs of L1-1 & L1-2 (2024 \$)

ESTIMATE OF QUANTITIES					
Item #	Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
1.	Mobilization	LS	1	\$151,000.00	\$151,000.00
2.	Bonding and Insurance	LS	1	\$51,000.00	\$51,000.00
3.	Clearing and Grubbing	LS	1	\$30,000.00	\$30,000.00
4.	Temporary Traffic Control Measures	LS	1	\$30,000.00	\$30,000.00
5.	Excavation, Established Quantity	CY	570	\$10.00	\$5,700.00
6.	Earthwork Measured in Embankment (Established Quantity)	CY	93,025	\$20.00	\$1,860,500.00
7.	Bridge Removal and Replacement	SF	0	\$500.00	\$0.00
8.	48" RCP Class III	LF	0	\$500.00	\$0.00
9.	48" RCP Flared End Section	EA	0	\$3,000.00	\$0.00
10.	Concrete Headwall	EA	0	\$7,500.00	\$0.00
11.	Automatic Flap Gate	EA	0	\$10,000.00	\$0.00
12.	Crushed Rock Base Course	TONS	0	\$75.00	\$0.00
13.	Gravel Surface Course	TONS	0	\$90.00	\$0.00
14.	Rock Riprap	TONS	0	\$110.00	\$0.00
15.	Remove Pavement	SY	0	\$25.00	\$0.00
16.	7" Concrete Pavement	SY	0	\$100.00	\$0.00
17.	Silt Fence, Low Porosity	LF	14,000	\$4.00	\$56,000.00
18.	Seeding, Fertilizer and Mulch	ACRE	6	\$10,000.00	\$60,000.00
Subtotal of Construction					\$2,244,200.00
Contingency 15%					\$448,900.00
Total - Construction					\$2,693,100.00
Local Items					
1.	Mobilization	LS	1	\$41,000.00	\$41,000.00
2.	Bonding and Insurance	LS	1	\$14,000.00	\$14,000.00
3.	Clearing and Grubbing	LS	0	\$30,000.00	\$0.00
4.	Temporary Traffic Control Measures	LS	0	\$0.00	\$0.00
5.	Excavation, Established Quantity	CY	0	\$10.00	\$0.00
6.	Earthwork Measured in Embankment (Established Quantity)	CY	0	\$20.00	\$0.00
7.	Bridge Removal and Replacement	SF	0	\$500.00	\$0.00
8.	48" RCP Class III	LF	160	\$500.00	\$80,000.00
9.	48" RCP Flared End Section	EA	4	\$3,000.00	\$12,000.00
10.	Concrete Headwall	EA	4	\$7,500.00	\$30,000.00
11.	Automatic Flap Gate	EA	4	\$10,000.00	\$40,000.00
12.	Crushed Rock Base Course	TONS	3,000	\$75.00	\$225,000.00
13.	Gravel Surface Course	TONS	1,500	\$90.00	\$135,000.00
14.	Rock Riprap	TONS	192	\$110.00	\$21,120.00
15.	Remove Pavement	SY	0	\$25.00	\$0.00
16.	7" Concrete Pavement	SY	0	\$100.00	\$0.00
17.	Silt Fence, Low Porosity	LF	0	\$4.00	\$0.00
18.	Seeding, Fertilizer and Mulch	ACRE	0	\$10,000.00	\$0.00

Subtotal of Construction					\$589,200.00
Contingency 15%					\$119,700
Total Construction					\$717,900
Land Acquisition					
1.	Permanent Land	ACRE	26	\$15,000.00	\$390,000.00
2.	Temporary Easement	ACRE	12	\$5,000.00	\$60,000.00
3.	Home Buyout	EA	0	\$100,000.00	\$0.00
4.	Hold	LS	0	\$0.00	\$0.00
Land Acquisition Subtotal					\$450,000.00
Legal Fees, Appraisals, Etc					\$135,000.00
Total Land Rights					\$585,000.00
Engineering					
1.	Design, Geotech, & Bidding	LS	1	\$545,800.00	\$545,800.00
2.	Permitting	LS	1	\$136,500.00	\$136,500.00
3	Construction Engineering & Material Testing	LS	1	\$341,100.00	\$341,100.00
ENGINEERING SUBTOTAL					\$1,023,400.00
Professional Services					
Subtotal Project Cost					\$5,019,400.00
Sponsor Administration and Other Fees					\$85,300.00
NRCS Administration Fees					\$25,000.00
Total Project Cost					\$5,129,700.00

OTHER DIRECT COSTS & ADVERSE EFFECTS

According to the NRCS PR&G:

Other direct costs and adverse effects include uncompensated losses caused by the installation, operation, maintenance, and replacement of a project or group of projects. These other direct costs and adverse impacts can include costs caused by downstream flood damages cause by channel modifications, levies, dikes, and other structures, erosion of land along streambanks created by dams that prevent sediment export downstream, and through lost use value of the land where flood mitigation structures are cited (NRCS, 2014).

The Action Alternative has only one primary category of other direct costs. The nature of and methods used to calculate these other direct costs are discussed in more detail below.

OPERATIONS AND MAINTENANCE

Once the works of improvement are built, overheads for operations and maintenance will be required for the works of improvement to continue generating the benefits for which they were designed. Operations and maintenance costs were estimated to be 0.75 percent of each work of improvement's construction costs. Estimated annual operations and maintenance costs for each work of improvement are shown in Table 33, below.

Table 33: Estimated Annual Operations and Maintenance Costs (2024 \$)

Work of Improvement	Construction Cost	Annual O&M Costs
L1-1 & L1-2	\$3,411,000	\$25,600
DC1-13A	\$19,433,200	\$145,700
Total	\$22,844,200	\$171,300

Annual operations and maintenance (O&M) costs are assumed to equal 0.75 percent of structure construction costs, which do not include costs for engineering, permitting, and administration.

D 6.05 CURRENT ECONOMIC DAMAGES

Average annual flood losses under the FWOFI were estimated to serve as a benchmark of comparison with the Action Alternative and are shown in Table 34, below (NWPM 501.36). In total, average annual flood losses under the FWOFI are approximately \$8,545,000 per year, including \$2,152,800 of building repair and replacement damages, \$6,265,000 of business income and wage losses and \$127,200 of crop damages.

Table 34: Average Annualized Damages Under FWOFI (2024 \$)

Work of Improvement	Building Related Damages	Business Income and Wage Losses	Crop Losses	Total Annual Damages
FWOFI	\$2,152,800	\$6,265,000	\$127,200	\$8,545,000
Total	\$2,152,800	\$6,265,000	\$127,200	\$8,545,000

Totals may not sum due to rounding. Prepared: January 2024.

Price base: 2024 dollars; amortized over 103 years at a discount rate of 2.75 percent starting two years after construction begins.

D 6.06 ECONOMIC TABLES

The results of the NEE analysis for the Action Alternative are compared against the FWOFI or No Action Alternative and serve as the best estimate of the additional economic value that would be created under the Action Alternative. Results are presented using the Economic and Structural Tables (NWPM Part 506, NRCS 2014b) as provided in Chapter 7 of the Plan-EA.

D 7. CULTURAL RESOURCES

The cultural resource inventory report (Buried Past Consulting, LLC 2024) that details the methods and results of the cultural resource inventories of the area of potential effect (APE) for the alternatives outlined in the Rawhide Creek watershed plan-EA can be found in Appendix E. Information regarding the location of specific cultural resources has been removed from the report in accordance with Section 304 of the National Historic Preservation Act (54 U.S.C. §307103) and Nebraska Revised Statute 84-712.05. Complete copies of the cultural resource inventory reports may be available from History Nebraska (hn.hp@nebraska.gov) upon request.

D 7.01 POST-REVIEW DISCOVERY PROCEDURES

Once NHPA Section 106 consultation is complete for this project, there is still potential for ground disturbance to expose cultural materials that were not identified by the cultural resources inventory. If any evidence of cultural resources is encountered during construction, all activities will be halted immediately and NRCS will proceed in accordance with the regulation on post-review discoveries (36 CFR § 800.13) by following the procedures outlined in the NRCS Cultural Resources Handbook (Title 190 Part 601.29). Those procedures are described below.

Where construction has not yet begun and a cultural resource is discovered after Section 106 review is complete, the NRCS shall seek avoidance or minimization strategies and/or resolution of adverse effects in accordance with 36 CFR Part 800.6 in consultation with the SHPO and consulting Tribes.

The NRCS shall ensure that every contract for this project includes provisions for halting work/construction in the area when potential historic properties are discovered or when unanticipated effects to historic properties are found after implementation, installation, or construction has begun. When such a discovery occurs, Dodge County or their contractor shall immediately notify the NRCS State Conservationist's Office, Cultural Resource Specialist (CRS), supervisory NRCS personnel for the area, and the landowner.

The NRCS CRS shall inspect the discovery within 24 hours if weather permits. The CRS shall establish a protective buffer zone surrounding the discovery in consultation with the local NRCS official (field office supervisor or District or Area Conservationist), concerned Indian tribes, the SHPO, the NRCS State engineering or program supervisor, as appropriate), and Dodge County. This action may require inspection by Tribal cultural resources experts in addition to the CRS.

All NRCS contact with media shall occur only under the direction of the NRCS Public Affairs Officer, as appropriate, and the State Conservationist. Security shall be established to protect the resources/historic properties, workers, and private property. Local law enforcement authorities will be notified in accordance with applicable State law and NRCS policy in order to protect the resources. Construction and/or work may resume outside the buffer only when the State Conservationist determines it is appropriate and safe for the resources and workers.

The NRCS CRS shall notify the SHPO, concerned Indian Tribes, and the Advisory Council on Historic Preservation no later than 48 hours after the discovery. The NRCS CRS will describe NRCS's assessment of the National Register eligibility of the property, as feasible, and the proposed actions to resolve any adverse effects to historic properties. The eligibility determination may require the assessment and advice of concerned Indian Tribes, the SHPO, and technical experts (such as historic landscape architects) not employed by NRCS. NRCS shall take any comments provided into account and carry out appropriate actions to resolve any adverse effects. NRCS shall provide a report to the SHPO, Tribes, and the ACHP of the actions when they are completed.

HUMAN REMAINS

When human remains are discovered, the NRCS shall follow all applicable federal, tribal, and state burial laws and ordinances, and related human rights and health statutes, where appropriate. NRCS shall refer to the ACHP's Policy Statement regarding Treatment of Burial Sites, Human Remains and Funerary Objects and the ACHP's Section 106 Archaeology Guidance. NRCS shall also follow USDA and NRCS policy on treatment of human remains and consultation.

All the measures proposed in the Rawhide Creek Watershed Plan will be installed on non-federal, non-Tribal land. Therefore, any human remains discovered during construction will be subject to protection under the Unmarked Human Burial Sites and Skeletal Remains Protection Act (Nebraska Revised Statutes 12-1201 to 12-1212). Per Nebraska Revised Statute 12-1205, all ground disturbing activities in the area shall stop immediately. The remains shall be covered and/or protected in place in such a manner that minimizes further exposure of and damage to the remains. Dodge County or its contractor shall contact local law enforcement within 48 hours of the discovery. Per Nebraska Revised Statute 12-1207 and 12-1208, disposition of the human remains shall be the responsibility of the county attorney and/or History Nebraska. Construction may resume once all human remains and/or burial goods have been removed from the project area, and the State Conservationist determines it is appropriate and safe for the resources and workers.