Preliminary Engineer's Report

Whitney Lake Subwatershed – Retention Site C

Flood Damage Reduction Project

Roseau River Watershed District

October 23, 2019

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Prepared for

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This Whitney Lake Subwatershed Retention Site C Flood Damage Reduction Project report was prepared for the Roseau River Watershed District.

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that, I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Jacob Rand Huwe, P.E.

License Number 56657

HDR

213 LaBree Avenue North, Suite 203

Thief River Falls, Minnesota

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ACRONYMS AND SHORT FORMS

ac-ft	Acre Feet
ASTM	American Society for Testing and Materials
Atlas 14	Atlas 14, Version 2, Chapter 8
BWSR	Board of Water and Soil Resources
CD	County Ditch
cfs	cubic feet per second
CR	County Road
CSAH	County State Aid Highway
EAW	Environmental Assessment Worksheet
EPA SWMM	Environmental Protection Agency Storm Water Management Model
ESH	Emergency Spillway Hydrograph
FBH	Freeboard Hydrograph
FDR	Flood Damage Reduction
GPS	Geographic Positioning System
HEC	USACE Hydrologic Engineering Center
HMS	HEC Hydrologic Modeling System
LAT	Lateral
LiDAR	Light Detection and Ranging
LLC	Limited Liability Company
LMGT	Lake Modified Glacial Till
LTFS	Long Term Flood Solutions
MGS	Minnesota Geological Survey
MnDNR	Minnesota Department of Natural Resources
MnDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
MSE	Midwest-Southeast
NAVD88	North American Vertical Datum of 1988
NEH	National Engineering Handbook
NRCS	Natural Resources Conservation Service, formally the SCS
NTI	Northern Technologies, LLC
NWI	National Wetland Inventory
R	Clark Storage Coefficient
RAS	HEC River Analysis System
RRWD	Roseau River Watershed District

RRWMB	Red River Watershed Management Board
SB	Soil Boring
SCS	Soil Conservation Service
SD	State Ditch
SWPPP	Storm Water Pollution Prevention Plan
T_c	Time of Concentration
TR-60	Technical Release 210-60
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
WCA	Wetland Conservation Act
WSE	Water Surface Elevation

1 Executive Summary

The purpose of the Whitney Lake Subwatershed Retention Site C Project (Retention Site C) is to reduce flood damages to agricultural lands during the 10-year, 24-hour storm (total 3.37 inches of rainfall) and reduce damages to roadways during the 25-year, 24-hour storm event (total 3.99 inches of rainfall) in the Whitney Lake Subwatershed.

Approximately 78 percent of the Whitney Lake Subwatershed land use is cropland with crop damage occurring in 8 of the last 10 years. Agricultural lands adjacent to ditches in the Whitney Lake Subwatershed frequently become inundated for 10 days or more destroying planted crops or delaying planting and harvesting.

The Roseau County Highway Department confirmed that County Road 115 and 270th Avenue overtop approximately once every 2 years requiring frequent maintenance with repair costs of major flooding sites resulting in over $340,000 in damages over the past 15 years.

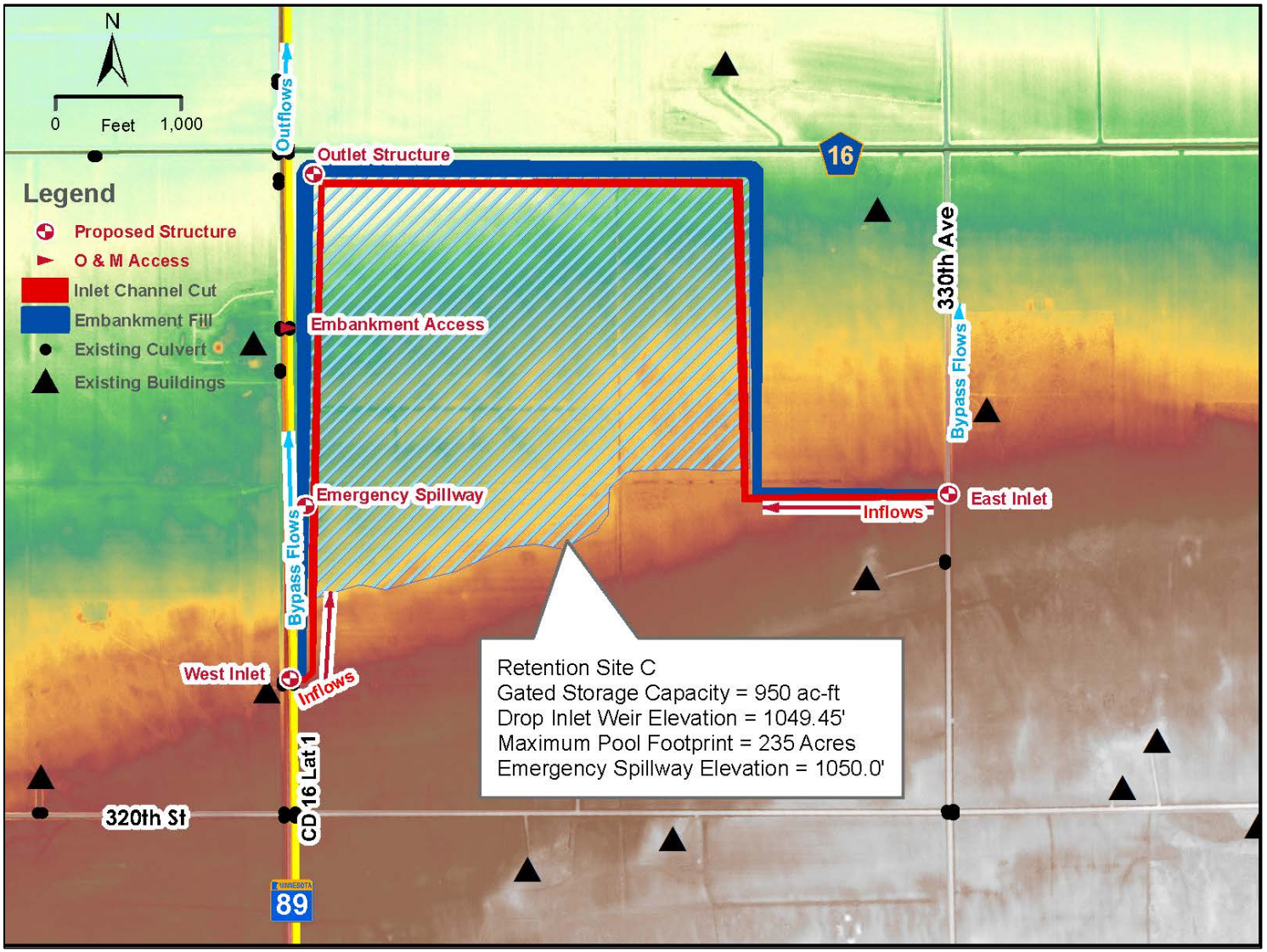
A Project Work Team, created in 2016, explored alternatives available to meet the purpose and need of this watershed and agreed that the primary alternatives to evaluate include retention, diversion, protection, and drainage. The Project Work Team gained consensus on a preferred alternative with the following components:

- Retention Site A,
- Retention Site C,
- increased conveyance along County Road 115,
- improvements to Roseau County Ditch 16 (CD 16),
- improvements to Roseau County Ditch 17 Branch 1.

The results presented in this report focus on Retention Site C, as shown in Figure 1, which consists of 235 acres and 950 acre-feet of storage. A gated outlet structure at the northwest corner of section 11 in Ross Township (Section 11) near CD 16 Lat 1 controls the dewatering of the impoundment. Two inlet channels convey flows into the impoundment.

Retention Site C will reduce peak flows and volumes in CD 16 Lat 1, CD 16, and reduce breakout flows that are causing flood damages in the Whitney Lake Subwatershed.

Figure 1. Retention Site C Project Layout



2 Introduction

2.1 Purpose and Need

The Roseau River Watershed District (RRWD) established a Whitney Lake Subwatershed Project Work Team to develop a Flood Damage Reduction Project with the following purpose and need statement:

> *The purpose of the Proposed Action is **Flood Damage Reduction:** Reduce damages to agricultural lands for a 10-year, 24-hour storm (total 3.37 inches of rainfall) and reduce damages to roadways for a 25-year, 24-hour storm event (total 3.99 inches of rainfall) in the Whitney Lake Subwatershed.*

The Proposed Action is needed for the following reasons:

- Roseau River levels cause flood damage to agricultural properties during frequent runoff events (i.e., a 2-year, 24-hour event or 2.26 inches of rainfall). The Roseau River will frequently back up into area drainage ditches for 2 miles or more, causing backwater effects in the drainage systems.

- The ditch systems in the Whitney Lake Subwatershed contain many culvert crossings, which have a lower capacity than a 2-year, 24-hour precipitation event. Additionally, the channels are undersized and not able to contain or convey the existing 2-year, 24-hour event in many places because the natural ground slope is too low to prevent flows from overtopping banks and flowing into adjacent lands. These adjacent lands become inundated for 10 days or more, which is long enough to destroy crops that have been planted or delay access to the land for planting and harvesting.

- In Roseau County, approximately 50 percent of land use is farmland and over $136 million of crops are sold annually (USDA 2012 Census of Agriculture). Within the Whitney Lake Subwatershed, 78 percent of land use is cropland. Review of crop information and insurance records of four willing landowners in the Whitney Lake Subwatershed over the past 10 years show a decrease in yields of up to 100 percent during wet years with precipitation data showing wet years for 8 out of the past 10 years.

- The Roseau County Highway department confirmed that during heavy rainfall, water overtops at CR 115 and 270th Avenue. Overtopping occurs approximately once every 2 years and requires frequent maintenance. While costs for minor road repairs due to flooding are not well documented, repair costs of major flooding sites are documented to have resulted in over $340,000 in damages over the past 15 years.

Secondary benefits from the project may include the following:

- temporary flood detention during high runoff
- contribution to a regional goal of reducing peak flow along the Red River by 20 percent during flooding

- reduction of erosion to improve water quality and for the benefit of wildlife and fish.

2.2 Background

The Whitney Lake Subwatershed has a long history of tense relations and disagreements between landowners due to the pattern of flooding. With a steep ridge in the upper (southeastern) portion of the subwatershed, the runoff moves quickly into the problem areas in the north and west. Many times high Roseau River water levels back up into the Whitney Lake Subwatershed ditches causing increased water surface elevations and forcing local runoff out of the ditch channel. Over time, these higher than normal water levels have created flow paths to the west, overtopping roads and inundating sections of agricultural land until reaching State Ditch 20.

Since 2016, the Whitney Lake Subwatershed Project Work Team has been meeting regularly and taking the necessary steps to address the flooding problem. Additional meetings were held with affected landowners, as well as public outreach and open informational sessions to address any concerns and solicit comments on proposed actions. Presentations of the background investigations validated by local knowledge and experiences helped to identify the actions that will meet the purpose and need. The Project Work Team process has resulted in a consensus-based set of alternatives (preferred alternative) for the watershed, which included early coordination with the USACE. Project Work Team meeting presentations and minutes are available on the RRWD website.

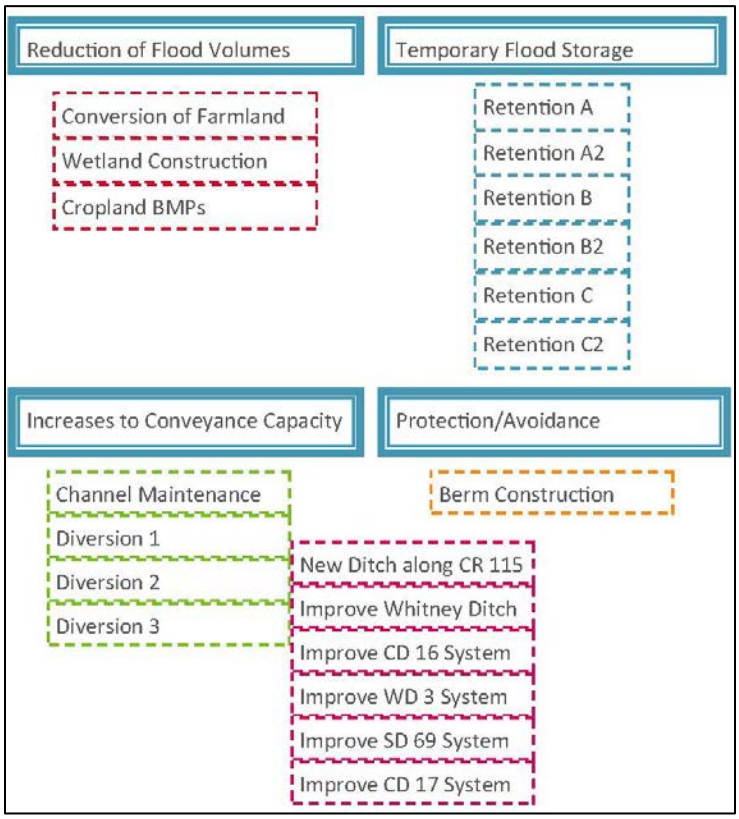
The RRWD is working to secure advanced funding for Retention Site C. In March 2019, Retention Site C received Step 1 recommendation for funding from the Red River Watershed Management Board. A Step 2 funding application, submitted by the RRWD on August 30, 2019, is scheduled for final review by the Red River Watershed Management Board on November 19, 2019.

2.3 Project Concept and Alternatives

The draft Whitney Lake Subwatershed Watershed Plan and Environmental Assessment (NRCS, Whitney Lake Subwatershed - Watershed Plan EA, 2019) describes the process used to identify and evaluate alternatives for further analysis. Figure 2 lists the complete set of identified alternatives, grouped into four strategies:

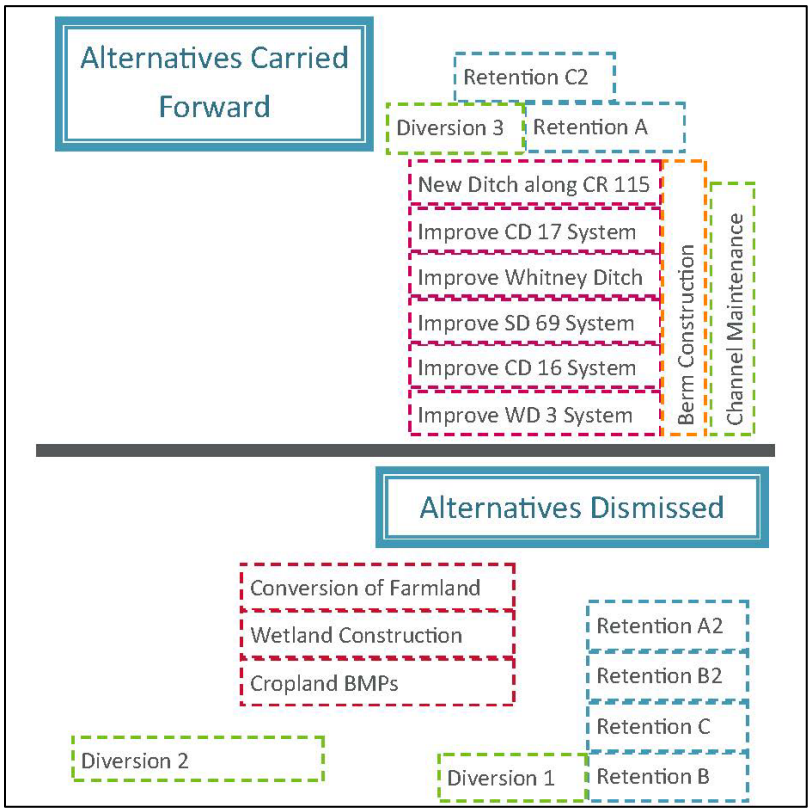
- reduction of flood volumes,
- temporary flood storage,
- increases to conveyance capacity, and
- protection and avoidance.

Figure 2. Identified Alternatives



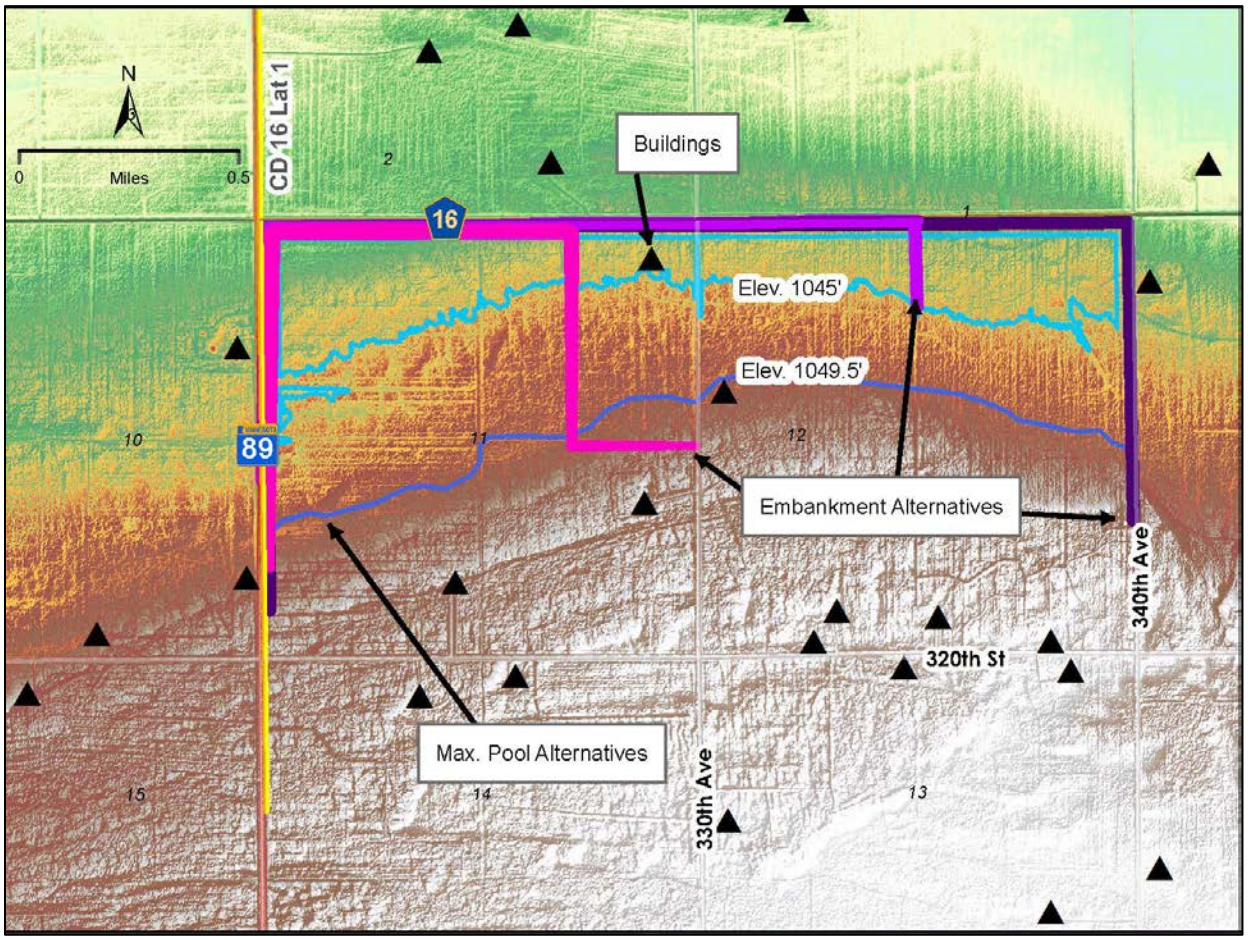
Some of these alternatives were dismissed while others were carried forward for analysis (Figure 3). Preliminary analyses and a feasibility study resulted in the following reasonable alternatives carried forward for further analysis:

Figure 3. Alternatives Carried Forward and Dismissed



This Preliminary Engineer's Report focuses on Retention Site C. The Retention C and C2 alternatives shown in Figures 1 and 2 are previous footprints that extended into the northeast quarter of Section 11. Figure 4 below shows the embankment and maximum pool elevation alternatives of the Retention C and C2 alternatives, as well as the current proposed embankment and maximum pool elevation of Retention Site C. The building identified in the northeast quarter of Section 11 is the primary consideration for the current embankment location.

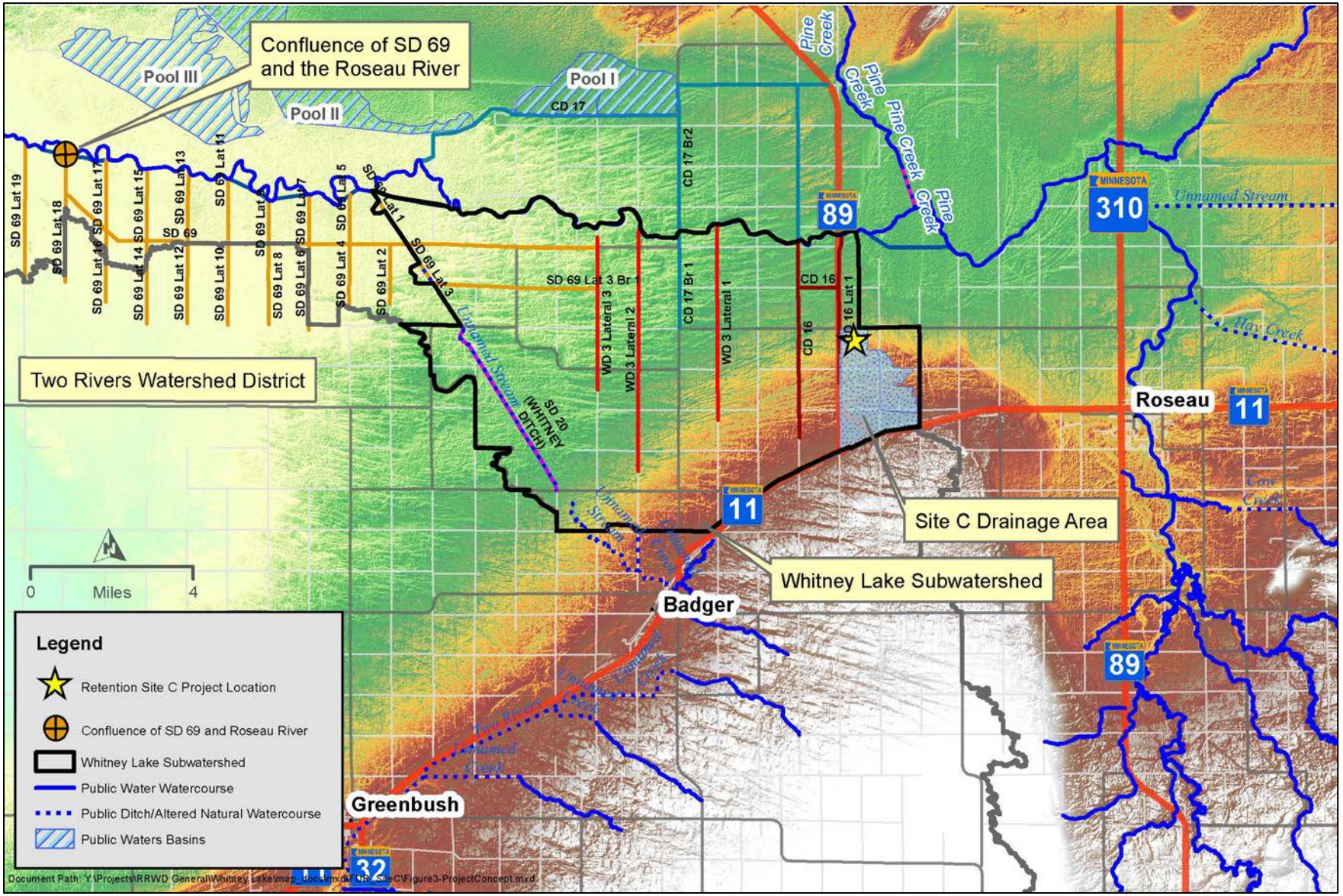
Figure 4. Retention Site C Alternatives



2.4 Location

Retention Site C is located in Section 11, Township 162 North, Range 41 West in Roseau County, 8.5 miles south of the Canadian border, 2.5 miles south of the Roseau River, and 6.5 miles west and 1.5 mile north of the City of Roseau. Figure 5 shows the controlled drainage area of 4.0 square miles contributing to Retention Site C.

Figure 5. Whitney Lake Subwatershed Ditch Systems and Topography



2.5 Goals

2.5.1 Local Flood Damage Reduction

The Whitney Lake Subwatershed Project Work Team agreed upon a set of preferred alternatives with the potential to reduce damages to adjacent agricultural lands during the 10-year 24-hour storm (total 3.37 inches of rainfall) and reduce damages to area roadways for a 25-year 24-hour storm event (total 3.99 inches of rainfall).

2.5.2 Red River Basin

There is a need to expect and prepare for flood events larger than the historic flood of 1997. (Red River Basin Commission, 2011) One specific goal has been set for the contributing watersheds in the basin to reduce peak flows to the Red River of the North mainstem by 20 percent during a flooding event similar to the 1997 spring flood. Retention Site C is compatible with the region-wide peak flow and volume reduction goals.

3 Criteria

The following design standards, plans, statues, and rules establish the criteria to design Retention Site C.

3.1 TR-60 Design Standards

TR 210-60 (TR-60) Earth Dams and Reservoirs (NRCS, 2019) provides design guidelines for spillway and freeboard design. A low hazard dam classification was used in determining the rainfall depths for each of the principal spillway, auxiliary spillway, and freeboard hydrographs. Retention Site C is classified as a low hazard dam because the product of storage (950 acre-feet) and effective height (10 feet) is less than 30,000 (950*10 = 9,500). TR-60 provides criteria for the hydrology, spillway design, outlet design, and embankment design as follows:

- primary outlet sized for the 25-year 10-day duration and 24-hour Emergency Spillway Hydrograph (ESH),
- emergency spillway sized using the 24-hour Free Board Hydrograph (FBH) and used to establish the maximum pool elevations and minimize the chance of embankment crest overtopping,
- outlet capacity designed to minimize damage on the downstream outlet channels with the impoundment set at the drop inlet crest elevation,

3.2 Roseau River Watershed District Overall Plan

The RRWD formed on June 17, 1963 under provisions of Minnesota Statute 103D with the District covering portions of Beltrami, Lake of the Woods, Marshall, Kittson, and Roseau Counties. It is the intention of the RRWD Board to manage the waters and related resources within the Watershed District in a reasonable and orderly manner to improve the general welfare

and public health of the residents of the Watershed District. The overall goals for the RRWD include:

3.2.1 Flood Damage Reduction Goals

- Provide 100-year flood protection for the City of Roseau and rural homesteads in the district,
- provide 10-year flood protection for agricultural lands,
- reduce flood damage to roads and crossings,
- reduce drought damages, and
- preserve ground water supply and recharge areas.

3.2.2 Natural Resource Enhancement Goals

- Protect, restore, enhance, and manage lakes and streams in the RRWD to support sustainable aquatic communities,
- manage wetland and upland habitats to support sustainable wildlife communities,
- preserve, protect, and restore unique natural resource communities and other features in the watershed,
- increase and promote outdoor recreational activities related to fish, wildlife, and other natural resources in the watershed,
- improve water quality in the RRWD.

3.3 Roseau County Local Water Management Plan

The purpose of the updated Local Water Management Plan for Roseau County is:

1. To actively work on the existing local priority concerns and to identify future potential priority concerns so that our water resources and related land resources are protected, managed and developed.
2. To update and continue the process of developing and applying an action plan to promote sound water and related land resource management in the county.
3. To continue working towards effective environmental protection and management in Roseau County through focusing on priority concerns and recognizing potential priority concerns.
4. This water plan is also recognized as the Roseau County Soil and Water Conservation District Comprehensive Plan.

Retention Site C contributes to the following goals of this water plan:

- Priority Concern 1: Erosion & Sedimentation of Surface Waters, Stormwater Runoff and Wetlands
- Priority Concern 2: Flood Control and Flood Damage Reduction
- Priority Concern 3: Surface Water Protection and Improvement
- Priority Concern 4: Managing Existing Ditch Systems

3.4 Minnesota Statutes and Rules

Section 103D of Minnesota Statutes (Minnesota Statutes, 2019) pertains to Watershed Districts with the following subdivisions particularly applicable to the Whitney Lake Retention project:

- Section 103D.335, Subd. 5 enables watershed districts to exercise the power to "…make necessary surveys or utilize other reliable surveys and data and develop projects to accomplish the purposes for which the district is organized."
- Section 103D.335, Subd. 8 gives the watershed district the power to "…construct, clean, repair, alter, abandon, consolidate, reclaim, or change the course or terminus of any public ditch, drain, sewer, river, watercourse, natural or artificial, within the district."
- Section 103D.335, Subd. 9 give the power to "…acquire, operate, construct, and maintain dams, levees, reservoirs, and appurtenant works."
- Section 103D.711 requires preparation of an "Engineer's Report" with the following requirements relative to the content of the report:
    - a scaled map of the area to be improved,
    - location of the proposed improvements,
    - location of respective outlets,
    - the watershed of the Project Area,
    - the location of existing highways, bridges and culverts,
    - all lands, highways, and utilities affected, together with the names of the owners thereof, so far as known
    - the outlines of any public lands and public bodies of water affected
    - potential benefiting lands
    - easement maps, and
    - principal Project features.

This preliminary engineer's report satisfies the requirements of 103D.605, 103D.701, and 103D.711. Additional statutory requirements include interaction with Statute 103E (Roseau County Ditch Authority). CD 16 Lat 1 will be impacted by Retention Site C. The RRWD will need the approval of the Roseau County Ditch Authority to proceed with any associated drainage system modifications and improvements.

3.5 State Environmental Review

Minnesota Rules Chapter 4410 requires the preparation of an Environmental Assessment Worksheet (EAW). The mandatory preparation of an EAW (Minnesota Rules 4410.4300, subpart 27) is necessary "for projects that will change or diminish the course, current, or cross-section of one acre or more of any public water or public waters wetland except for those to be drained without a permit pursuant to Minnesota Statutes, chapter 103G." With the construction of the new embankments and exterior drainage ditches, Retention Site C will disturb more than one acre of public water wetlands and requires preparation of an EAW.

3.6 USACE Section 404

A USACE Section 404 permit is required because excavation and fill will take place through wetlands. The USACE and RRWD have reached three checkpoints, or concurrence points, as outlined in Chapter 3 of the Project Team Handbook (FDRWG, 2007). These checkpoints include the purpose and need statement, alternatives to be carried forward, and the preferred alternative. The next step for Retention Site C is to apply for the section 404 permit and determine if any compensatory mitigation will be required. See Appendix A for the concurrence point documents.

3.7 Minnesota Department of Natural Resources

The MnDNR is required to review Retention Site C in accordance with Minnesota Rules 6115.0300. These rules regulate the construction and enlargement of dams, as well as the repair, alteration, maintenance, operation, and abandonment, in such a manner as to best provide for public health, safety, and welfare. A MnDNR Dam Safety permit is required because the Retention Site C embankment will likely be classified as a Class III low hazard dam. A MnDNR Public Waters Work Permit is required for work on channels draining to the Roseau River.

3.8 Board of Water and Soil Resources

The Board of Water and Soil Resources acts as the Wetland Conservation Act permitting authority. An individual wetland permit is required from the local government unit (LGU), which will include a review of operational parameters, such as wetland inundation, water level fluctuation, flood frequency, and water depth, in addition to wetland impacts from the construction footprint.

3.9 National Pollutant Discharge Elimination System Requirements

A storm water permit is required for construction, and the permittee will develop a Storm Water Pollution Prevention Plan (SWPPP) to address storm water discharges from the site. Each regulated party determines the appropriate pollution prevention practices, or best management practices, to minimize pollution for the specific site. The final engineering plans for Retention Site C will address the SWPPP for the site using seeding, mulch, fiber rolls, silt fence, filter fabric, and riprap.

4 Hydrologic Evaluation

The Expanded Distributed Detention Strategy Study (HDR Engineering, 2013) provides a HEC-HMS model of the Roseau River Watershed District. This model is used as the base condition for the Retention Site C hydrologic model. Modifications were incorporated into the HEC-HMS model for modeling at a smaller watershed scale including: subdividing subbasins into smaller drainage areas, updating with recommended precipitation values, and updating times of concentration to match adjusted basin sizes.

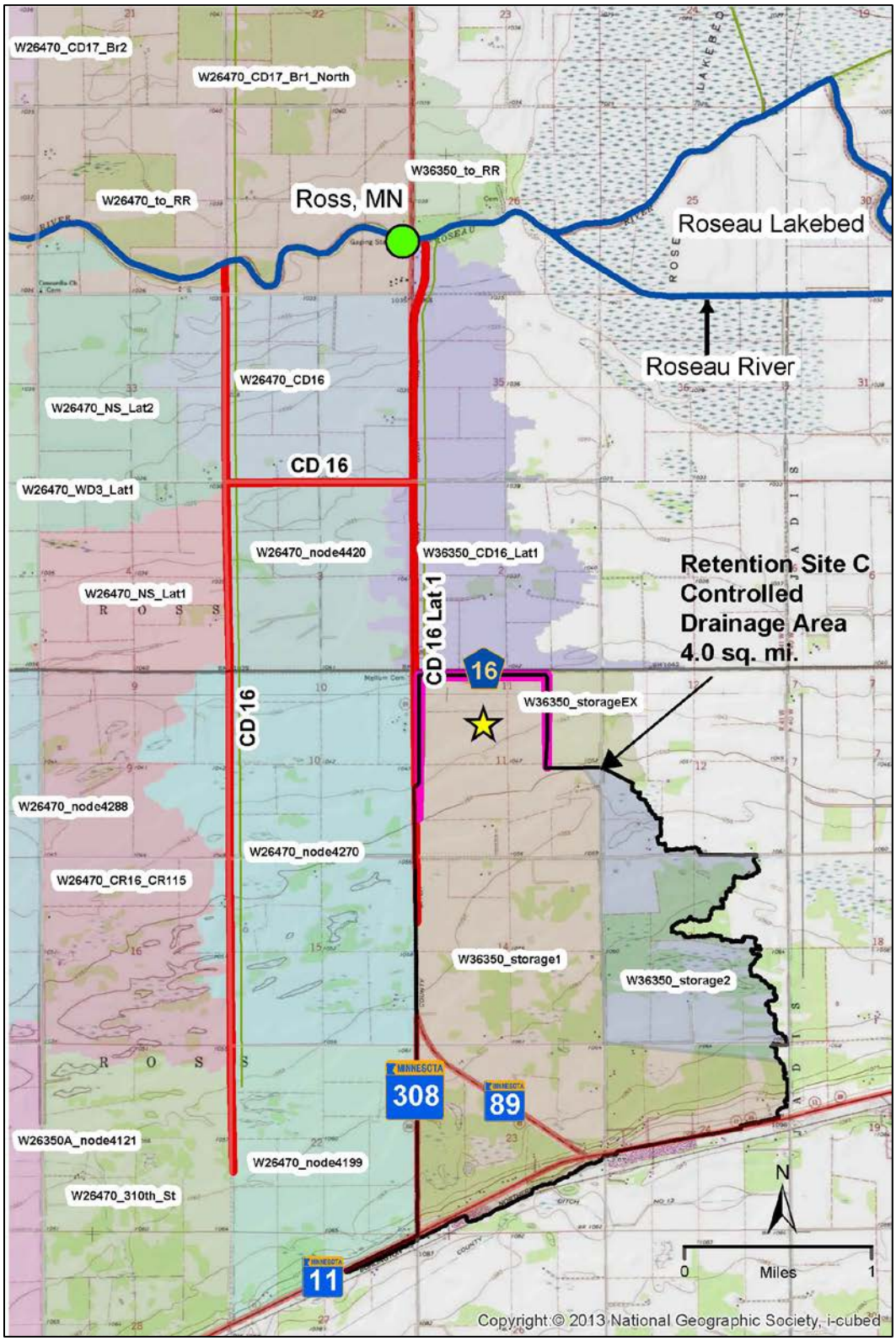
4.1 Subbasin Drainage Areas

The total drainage area of the Whitney Lake Subwatershed is 74 square miles. The proposed drainage area for Retention Area C is approximately 4.0 square miles or 5.4 percent of the Whitney Lake Subwatershed, see Table 1 and Figure 6 for subbasin areas and locations.

Table 1. HEC-HMS Drainage Areas at Ross, MN

Description	HMS ID	Drainage Area (square miles)
Roseau River	Reach-96	1079.2
CD 16 Lat 1 upstream of project inlet	W36350_storage1	3.1
330th Ave ditch upstream of project inlet	W36350_storage2	0.9
330th Ave ditch downstream of project inlet	W36350_storageEX	0.3
CD 16 Lat 1 downstream of project	W36350_CD16_Lat1	1.5
State Highway 89 ditch north of Roseau River	W36350_to_RR	0.4
TOTAL		**1085.4**

Figure 6. Retention Site C Drainage Area



4.2 Rainfall Depths

The RRWD HEC-HMS model utilizes the most current rainfall data available, National Oceanic and Atmospheric Administration Atlas 14, Version 2, Volume 8 (Atlas 14). The Minnesota NRCS field office published National Engineering Handbook supplement MN650.290, which specifies the use of Atlas 14 rainfall data as a replacement to the previous Technical Publication 40. (NRCS, MN650.290, 2015)

Embankment freeboard is calculated based on the hazard class and a site-specific value for probable maximum precipitation (PMP). The PMP comes from Hydrometeorological Report Number 51 (National Oceanic and Atmospheric Administration, 1978). Retention Site C has a drainage area of 4.0 square miles, so the PMP is 27.3 inches. The freeboard hydrograph depth is calculated below:

P100 + 0.12*(PMP – P100)

Where P100 is the 100-year, 24-hour precipitation depth. PMP is 27.3 and P100 is 5.72 for Retention Site C, therefore the 24-hour freeboard hydrograph depth is 8.3 inches.

The HEC-HMS model meterological events and their associated precipitation depths are shown in Table 2 below. The depth values are averages of all subbasins in the RRWD except the TR-60 referenced design events which are specific Retention Site C depths.

Table 2. HEC-HMS Precipitation Depths

Meterological Event	Precipitation Depth (inches)
2-Year, 24-Hour Summer Rainfall	2.26
10-Year, 24-Hour Summer Rainfall	3.37
25-Year, 24-Hour Summer Rainfall	3.99
25-Year, 10-Day Summer Rainfall	7.27
50-Year, 24-Hour Summer Rainfall	4.54
100-Year, 6-Hour Summer Rainfall	5.75
100-Year, 24-Hour Summer Rainfall	5.75
100-Year, 10-Day Spring Snowmelt	9.02
Freeboard Design Hydrograph (TR-60)	8.3
Probable Maximum Precipitation (TR-60)	27.3

4.3 Rainfall Distributions

National Engineering Handbook supplement MN650.290 specifies that the Midwest-Southeast (MSE) Distribution 3 is used for hyetographs of 24 hours or less. The MSE distributions are regionalized nested hyetographs developed from the Atlas 14 data. (Merkel & Moody, 2015) The recommended MSE 3 is more intense than the previously used SCS Type II distribution. In accordance with these recommendations, the MSE 3 distribution was applied to scenarios of 24

hours or less in the Retention Site C HEC-HMS model. The 10-day hyetographs from TR-60 are the standard practice for flood management studies in the Red River Basin.

4.4 Unit Hydrograph Shape

The District Model uses the Clark synthetic unit hydrograph transformation. This method requires time of concentration (T_c) and the storage coefficient (R) as inputs. Studies have found that R, divided by the sum of T_c and R, is reasonably consistent over a region. A USACE study of various gages in the Red River Basin use watershed ratios of $R/(R+T_c)$ (U.S. Army Corps of Engineers - St. Paul District, 1990).

4.5 Time of Concentration

T_c is the time it takes for a drop of water to travel from the hydraulically most remote point in the watershed to the outflow location. (Gupta, 2008) The travel times in the USACE HEC-HMS model data are derived from a MnDNR Geographic Information Systems application using land slope, land use, and degree of channelization with the results compared to several historic storm events. T_c of the Retention Site C subbasins varies from 1 to 12 hours, so the subbasins are fully contributing during the 24-hour events.

4.6 Runoff Losses

Surface runoff is the difference between total precipitation and total losses with losses attributed to initial abstraction, infiltration, evaporation, and groundwater and surface water storage. 10-day duration storms represent typical spring runoff events where most of the runoff is due to spring snow melt. Initial abstraction and constant loss rates were set to zero, because the ground is assumed to be fully saturated and frost still in the ground.

The SCS (Soil Conservation Science) Curve Number method used the 24-hour duration storm events to represent typical summer storms. The Retention Site C HEC-HMS model uses curve numbers ranging from 64.3 to 83.7 for 24-hour events, and the mean curve number across all subbasins is 74.7. Factors affecting curve number values include hydrologic soil group, hydrologic condition and antecedent moisture condition, land cover, and cropping practice (Gupta, 2008). The 10-day duration storm event curve numbers for the modeled subbasins were adjusted per TR-60.

4.7 Peak Inflows

Select upstream and downstream locations are summarized in Table 3. In each event modeled, the Retention Site C drainage areas contribute to the rising limb of the Roseau River at Ross, MN hydrograph. Retention Site C as proposed in this report will store up to 950 acre-feet of the rising limb for the Roseau River, equivalent to 74 percent of the 100-Year, 10-Day runoff volume in the controlled drainage area.

Table 3. HEC-HMS Results Summary

Hydrologic Event	Hydrologic Element*	Drainage Area (mi^2)	Peak Discharge (cfs)	Time of Peak (hours)	Total Volume (ac-ft)
Existing 2-Year, 24-Hour	W36350_storage1	3.08	27.0	23	77
	W36350_storage2	0.94	8.3	22	24
	Junction-144	6.00	49.5	24	141
	Reach-96	1079.18	1,509.6	210	39,555
	USGS05107500	1085.59	1,509.6	210	39,706
Existing 10-Year, 24-Hour	W36350_storage1	3.08	69.4	22	193
	W36350_storage2	0.94	21.4	21	59
	Junction-144	6.00	122.6	23	311
	Reach-96	1079.18	3,079.7	260	81,896
	USGS05107500	1085.59	3,079.7	260	82,231
Existing 25-Year, 24-Hour	W36350_storage1	3.08	102.4	22	282
	W36350_storage2	0.94	31.6	21	87
	Junction-144	6.00	195.0	23	462
	Reach-96	1079.18	3,817.7	279	107,224
	USGS05107500	1085.59	3,817.7	279	107,723
Existing 100-Year, 10-Day	W36350_storage1	3.08	163.9	130	986
	W36350_storage2	0.94	50.5	129	303
	Junction-144	6.00	322.1	130	1,625
	Reach-96	1079.18	9,868.9	355	386,607
	USGS05107500	1085.59	9,869.2	355	388,363

*W36350_storage1 is the CD 16 Lat 1 subbasin located upstream of the Project
W36350_storage2 is the 330th Ave ditch subbasin located upstream of the Project
Junction-144 is where CD 16 Lat 1 outlets into the Roseau River
Reach-96 is the portion of the Roseau River upstream of Ross, MN and CD 16 Lat 1
USGS05107500 is at the confluence of the Roseau River and CD 16 Lat 1

5 Hydraulic Evaluation

Hydraulic modeling was performed to accomplish the following objectives:

- evaluate peak flow rates, flood depth, and duration associated with existing conditions in the CD 16 system,
- evaluate peak flow rates, flood depth, and duration changes due to implementation of all planned alternatives in the CD 16 system, and
- design the proposed hydraulic structures.

EPA-SWMM 5.1 and HEC-RAS 5.0.7 models were created to complete the hydraulic modeling. The hydrologic inputs to these hydraulic models are described in the previous section.

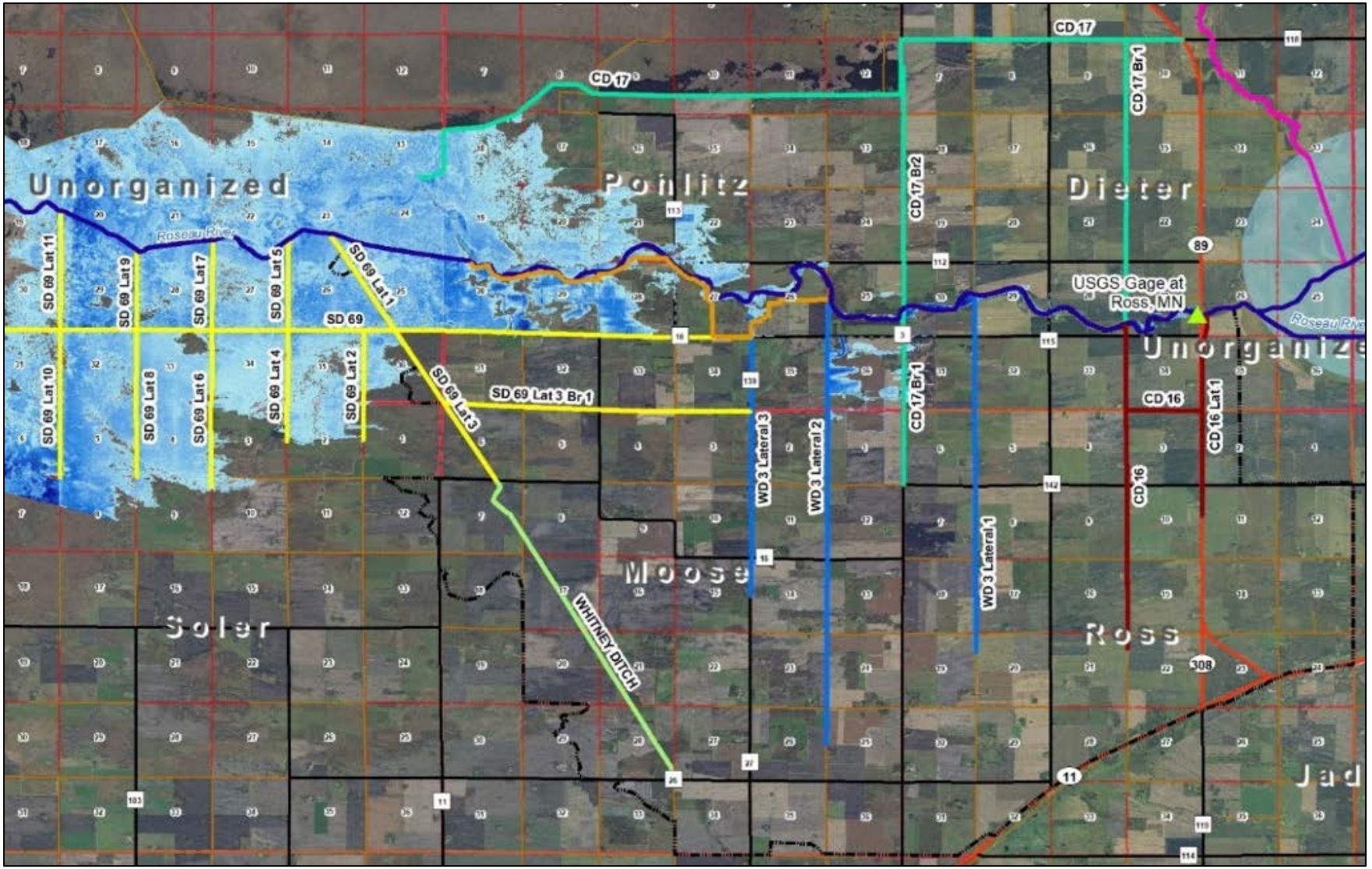
5.1 Elevations

A combination of topographic survey by HDR (HDR, 2018) and publically available light detection and ranging (LiDAR) elevation data (International Water Institute, 2010) provide the necessary elevations of the existing conditions models. All the elevations in this report reference the North American Vertical Datum of 1988. The following components were input in the hydraulic models: culverts, existing ground elevations, and channel cross-sections. The RRWD culvert inventory confirmed and supplemented the culvert inputs. HDR field survey data and LiDAR data were processed into a seamless terrain in HEC-RAS, and channel cross-sections were extracted for EPA SWMM and HEC-RAS reaches representing the existing CD 16 system.

5.2 Existing Conditions

To establish the existing conditions, a 1-dimensional (1D) steady-state HEC-RAS model of the CD 16 system was created with the following reaches: CD 16 Lat 1, CD 16 Main, and CD 16 East-West connection channel. Figure 7 shows the 2-year inundation from a steady state HEC-RAS model of the Roseau River. The 2-year, 24-hour event results in overland flooding downstream of the Whitney Lake Subwatershed and flows crossing into the Two Rivers Watershed District. Although the figure does not show overland flooding in the Whitney Lake Subwatershed, the local drainage in the watershed is slowed by the elevated Roseau River tailwater. To simulate a 2-year event on the Roseau River the downstream boundary conditions are set to a constant water surface elevation that represents the 2-year Roseau River peak. CD 16 Lat 1 downstream water surface elevation is 1031.6 feet, and CD 16 is 1031.5 feet. These elevations correspond to approximately 1,650 cubic feet per second (cfs) of discharge in the Roseau River at Ross, MN (USGS, 2019). Manning's roughness coefficients are 0.035 to 0.04 for the ditches and 0.035 to 0.1 for the overbank. The coefficient limits were adjusted based on field observations and aerial imagery.

Figure 7. Roseau River 2-Year Hydraulic Model Inundation



5.3 Proposed Conditions

The existing conditions model was used as the base condition model and modified to assess the impacts of Retention Area C and improvements to the outlet. EPA SWMM was used to model the proposed structures. The reservoir flood routing was modeled in HEC-HMS and EPA SWMM and the resulting peak flows were input in the HEC-RAS model.

5.3.1 Retention Site C Components

Retention Site C as shown in Figure 8 consists of 235 acres and 950 acre-feet of storage at elevation 1049.45 feet along CD 16 Lat 1 at a point north of CSAH 16 and east of Minnesota State Highway 89. The embankment adjacent to CSAH 16 extends east from CD 16 Lat 1 and turns south after approximately three-quarters of a mile in Section 11 until tying into natural ground at elevation 1053.0. A gated outlet structure at the northwest corner of Section 11 near CD 16 Lat 1 controls the dewatering of the impoundment. Two inlet channels convey flows into the impoundment.

5.3.1.1 EMBANKMENTS

Figure 9 depicts the proposed embankments. There are approximately 11,700 feet of embankment with a maximum height of 13 feet based on the lowest natural ground elevation of 1040.0 feet and a top of embankment elevation of 1053.0 feet.

5.3.1.2 INLET CHANNELS

The proposed Retention Site C has two inlet channels, one that conveys flows from CD 16 Lat 1 and another conveying flow from the east side of 330th Ave. The CD 16 Lat 1 inlet (West Inlet) has an upstream invert elevation of 1050.0. The 330th Ave inlet (East Inlet) has an upstream invert elevation of 1052.0. Both inlet channels have a bottom width of 8 feet and 4:1 side slopes. The grade of the channels vary but are stable during the bankfull event.

5.3.1.3 BYPASS STRUCTURES

Immediately downstream of the West Inlet, a crossing in CD 16 Lat 1 with a top elevation of 1052.5 and a 24-inch culvert with a gate provides a potential bypass location. At the East Inlet, an 18-inch culvert with aprons allows low flows to bypass the project. A reinforced concrete box culvert under 330th Ave conveys all inflows to the interior of the site. The proposed improvements to the ditches along the exterior embankments provide basic drainage and the ability to bypass flows around the project site. The side slopes of the exterior ditches are 3:1 (H:V). The bottom width of the exterior ditch depends on the amount of water being routed around the project. See Figure 8 for a plan view of the proposed bypass structures and exterior drainage patterns.

5.3.1.4 OUTLET STRUCTURES

The primary outlet structure is located in the northwest corner of Section 11 and can be remotely monitored and operated. Figure 12 shows the proposed structure in elevation view. The design of the outlet structure follows the guidelines in TR-60. The primary outlet structure consists of a gate, drop inlet (also known as the principal spillway), and conduit. The emergency spillway is located on the west embankment adjacent to CD 16 Lat 1. Table 4 summarizes the design sizes and elevations.

5.3.1.4.1 Gated Outlet

The gated outlet is a sluice gate mounted on an opening in the cast-in-place concrete outlet structure. The invert is set at the lowest elevation of the storage site and aligned with the interior channel so it can completely drain the impoundment when opened. The gate is operated by the actuator mounted to the outlet structure.

5.3.1.4.2 Drop Inlet

The drop inlet corresponds to the principal spillway in TR-60 and is the concrete riser which the gate is built onto (Figure 12). The drop inlet allows weir flow to enter the riser from all sides and flow out of the impoundment through the conduit. The top of the concrete riser is at elevation 1049.45.

5.3.1.4.3 Conduit

The outlet structure conduit is a 36-inch reinforced concrete pipe that conveys flows from both the gate and drop inlet to the outlet channel. The inlet invert is set at 1040.5 and outlet invert at 1040.0. As shown in Figure 12 the outlet of the conduit has a stilling basin that dissipates the energy before the flow reaches the outlet channel.

5.3.1.4.4 Emergency Spillway

The emergency spillway, also known as the auxiliary spillway, is an earthen weir that conveys excess inflows to the exterior ditch. The weir elevation is 1050.0, which is 3 feet lower than the top of the embankment, as required in TR-60. Emergency spillway length is calculated from the drainage area to Retention Site C. The minimum capacity of an emergency spillway from TR-60 is given by $237*DA^{0.493}$. For Retention Site C the drainage area is 4.0 square miles, so the minimum discharge capacity is 469 cubic feet per second. Assuming a headwater elevation of 1051.0 feet and a crest breadth of 39 feet, the minimum crest width required is 165.84 feet, which is rounded to 166 feet.

5.3.1.5 STORAGE CAPACITY

Table 4 provides pool area and storage volume for the various pool elevations. Figure 13 shows the storage-elevation curve of Retention Site C. The maximum gated storage of Retention Site C is 950 acre-feet. The storage capacity below the drop inlet elevation is considered gated storage, and the storage capacity above the drop inlet ungated storage. See Figure 10 for graphical representation of the storage definitions.

Figure 8. Retention Site C Project Layout

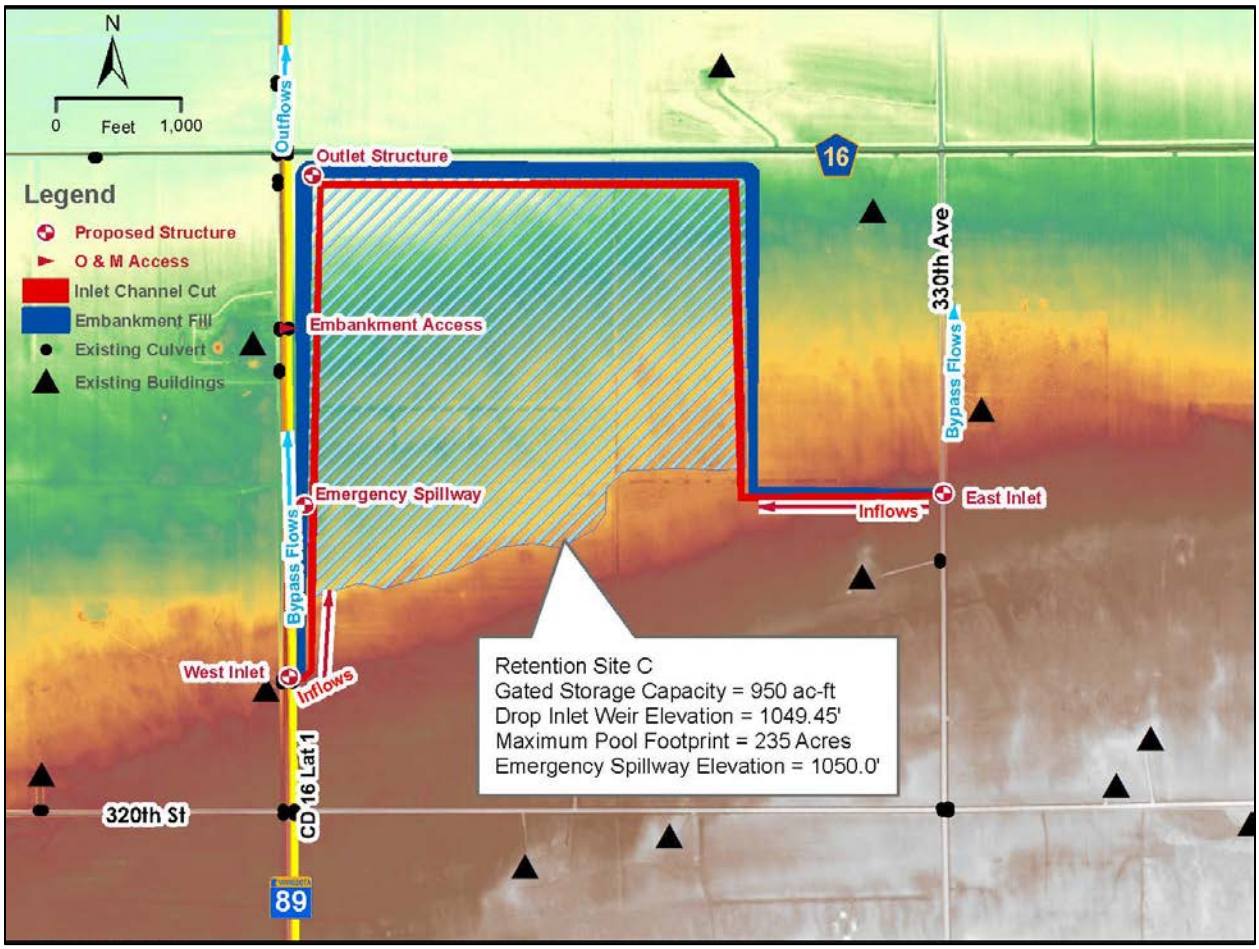


Figure 9. Typical Embankment Cross Section

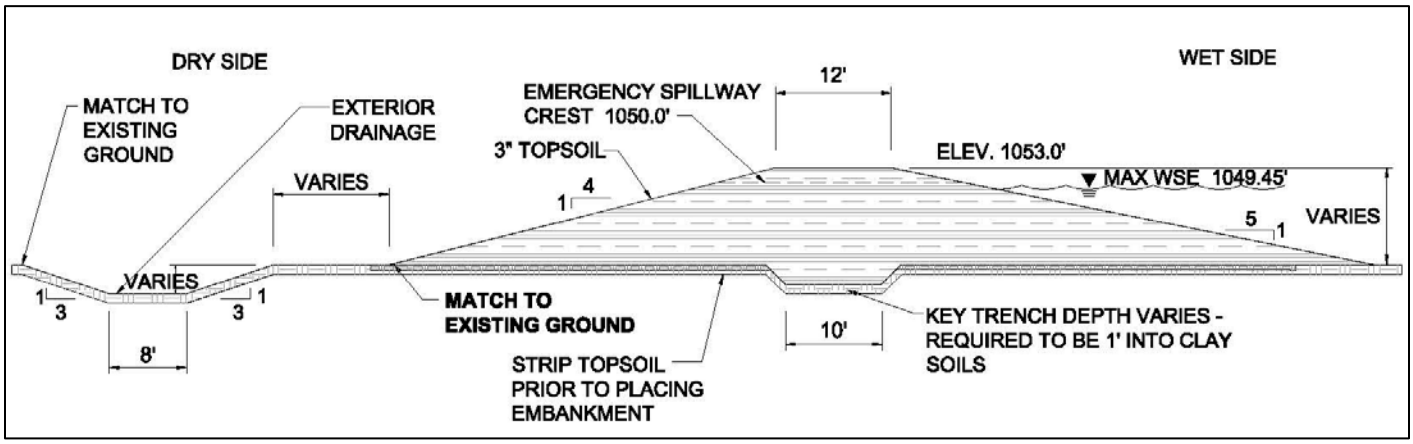


Figure 10. Storage Definitions

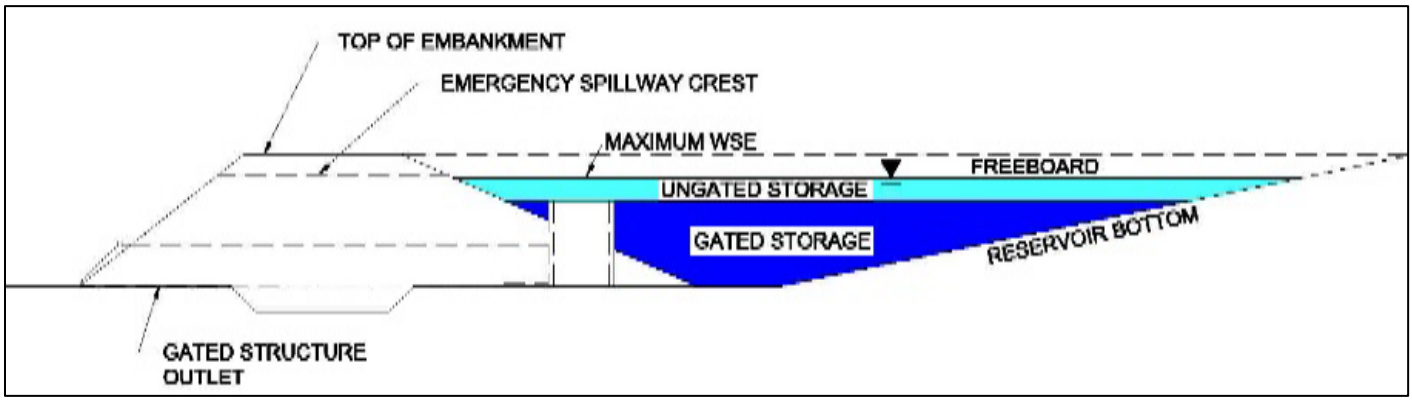


Figure 11. Inlet Channels & Bypass Structures

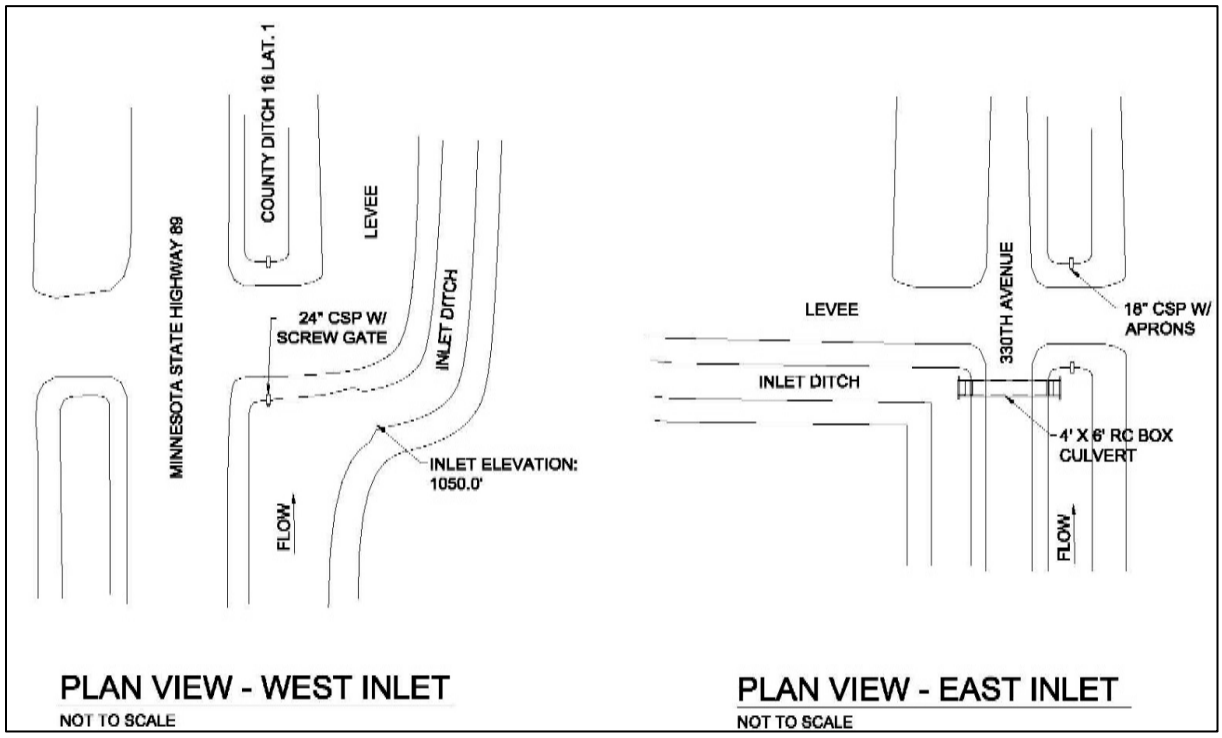


Figure 12. Outlet Structure

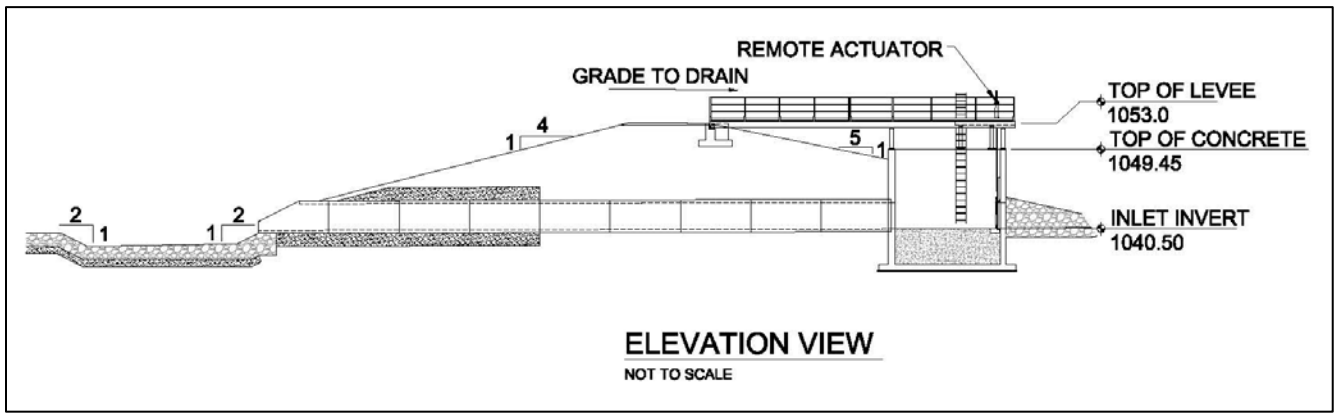


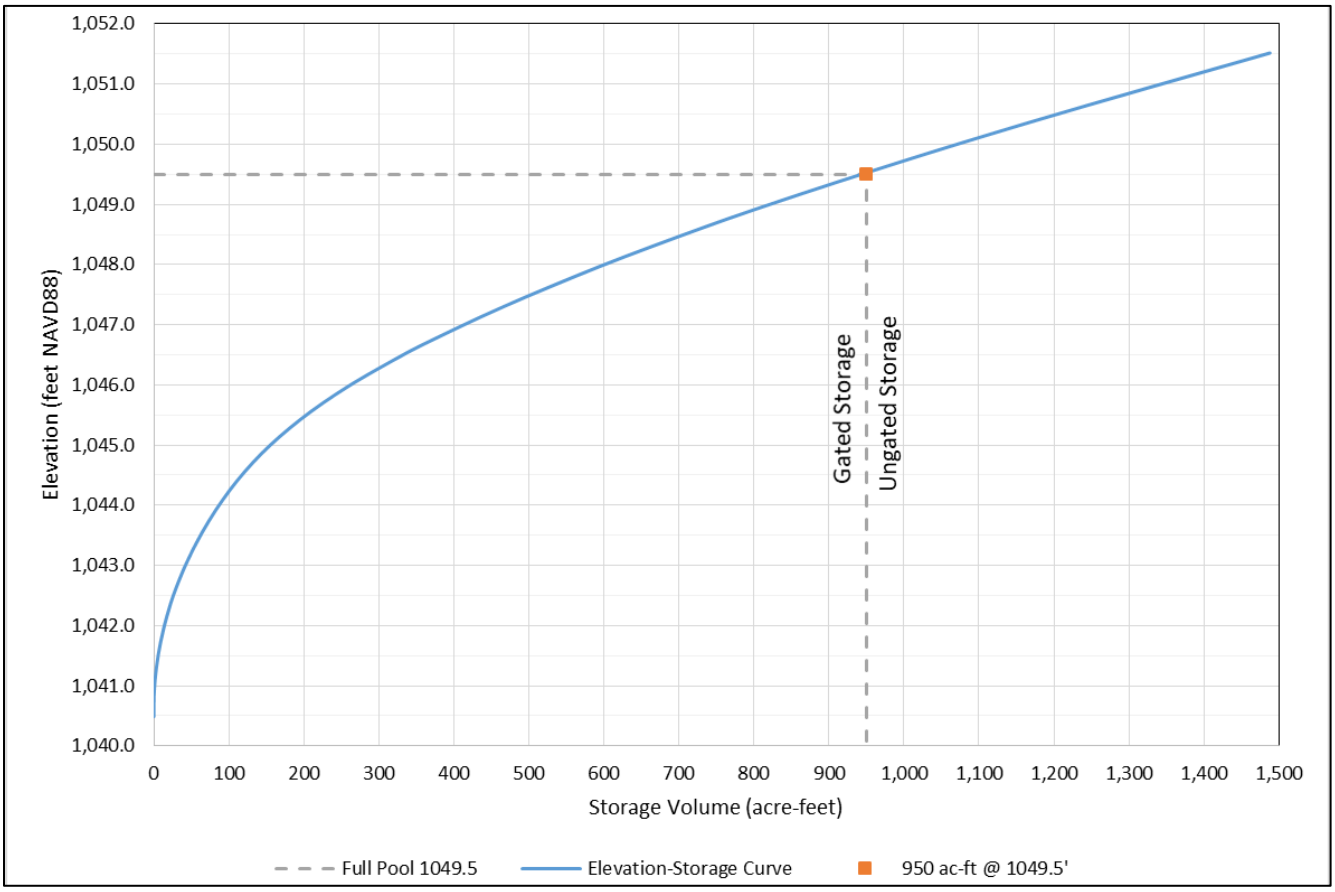
Table 4. Summary of Retention Site C Outlet Structures

Gate Invert Elevation	1040.5'
Gate Size [WxH]	2’ X 3’
Drop Inlet Elevation	1049.45'
Drop Inlet Size	5’ X 15’
Conduit Size	36” Concrete Pipe
Emergency Spillway Elevation	1050.0'
Emergency Spillway Length	166

Table 5. Retention Site C – Pool Elevation, Pool Area, and Storage Volume

Pool Elevation (feet NAVD88)	Pool Area (acres)	Storage Volume (acre-feet)
1051.0	279	1,350
1050.5	270	1,213
1050.0	259	1,081
1049.5	246	954
1049.0	235	834
1048.5	218	721
1048.0	203	616
1047.5	189	518
1047.0	174	427
1046.5	154	345
1046.0	135	273
1045.5	113	211
1045.0	92	160

Figure 13. Retention Site C Storage Curve



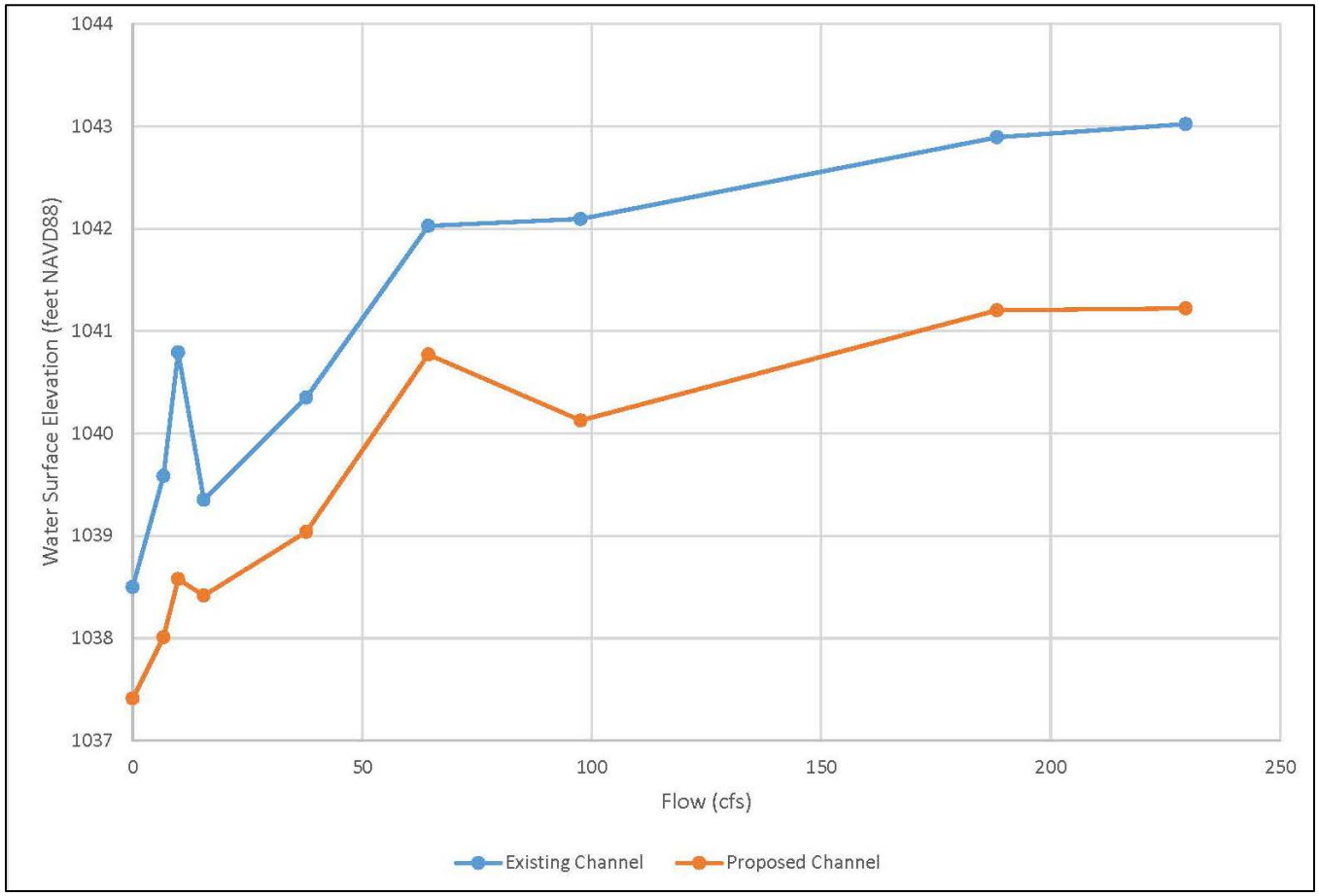
5.3.1.6 ROADWAYS, FIELD ENTRANCES, AND EMBANKMENT ACCESS

The Retention C embankment and pool footprints do not impact roadways. Two existing field entrances on the east side of Minnesota State Highway 89 are impacted. For maintenance, the primary outlet structure can be accessed from Minnesota State Highway 89 via a crossing over CD 16 Lat 1 and travelling along the embankment. The embankment will be constructed at an elevation above Minnesota State Highway 89, so the site can be accessed as long as Minnesota State Highway 89 is not overtopped.

5.3.2 Outlet Improvements

The RRWD received a petition for improvement of the CD 16 system under Minnesota Statutes 103E and prepared a preliminary survey report (HDR Engineering, Inc., 2019). The petitioned project will improve the CD 16 system to convey up to a 10-year, 24-hour rainfall event. Specific measures include improving the ditch grade, ditch geometry, and properly sizing culverts. Other proposed drainage improvements are located immediately downstream of the Retention Site C bypass structures and are designed to convey limited flows along the exterior of Retention Site C. The rating curves of the existing and proposed CD 16 Lat 1 are shown in Figure 14 below.

Figure 14. CD 16 Lat 1 Rating Curves



6 Hydrologic & Hydraulic Modeling Results

The results of the hydrologic and hydraulic evaluations show that Retention Site C will reduce peak flows and volumes in CD 16 Lat 1, CD 16, Roseau River, and reduce breakout flows that are causing flood damages in the Whitney Lake Subwatershed, the Roseau River, and the Red River of the North. This section will also address the adequacy of the outlet for Retention Site C, which is the CD 16 system and the Roseau River.

6.1 Downstream FDR Benefits

6.1.1 Roseau River

The HEC-HMS model shows flow reductions on the Roseau River at Ross and downstream of the Whitney Lake Subwatershed. Figure 16 and Figure 17 are the hydrographs of existing and proposed conditions on the Roseau River at the confluence of State Ditch 69 (SD 69) and at the confluence of CD 16 Lat 1 (Ross). The differences between the Roseau River at Ross and at SD 69 confluence are due to the Roseau River's gentle grade and limited capacity in the SD 69 area, also known as the Big Swamp. This is shown in the attenuation of the peak flow from Ross (9,870 cfs on day 17) to the SD 69 confluence (5,473 cfs on day 30). Downstream of Ross, flows up to 900 cfs are confined to the channel, but at 1,400 cfs the Roseau River begins to enter the floodplain. Figure 15 shows the inundated areas downstream of Ross at three flows: 900, 1,400, and 2,000 cfs.

Additionally, when flows exceed 2,000 cfs, water crosses into the Two Rivers Watershed District through the southern laterals of SD 69. This crossover flow is included in Figure 16. The downstream benefits are not obvious in the hydrographs below, but the volume reductions provided by Retention Site C and where the reduction occurs (center of mass) is shown. At the SD 69 confluence, there is a 5 cfs reduction at the peak. At Ross, the peak flow is the same, but Figure 17 shows flow reductions on the rising limb of the Roseau River hydrograph between 1,000 and 3,500 cfs. That early portion of the hydrograph is exactly when the Roseau River begins to enter the floodplain and cause damages, so the Retention Site C drainage area is positioned perfectly to reduce those damaging flows by storing early Roseau River water. Any drainage improvements in the CD 16 system will similarly affect the rising limb of the Roseau River hydrograph. Improvements up to a 10-year event are going to shift the CD 16 peak flows earlier and away from the peak of the Roseau River. Events greater than a 10-year event are temporarily stored upstream of culverts and roads at each intersection and will not increase peak flows on the Roseau River.

Figure 15. Roseau River Inundated Areas Downstream of Ross, MN

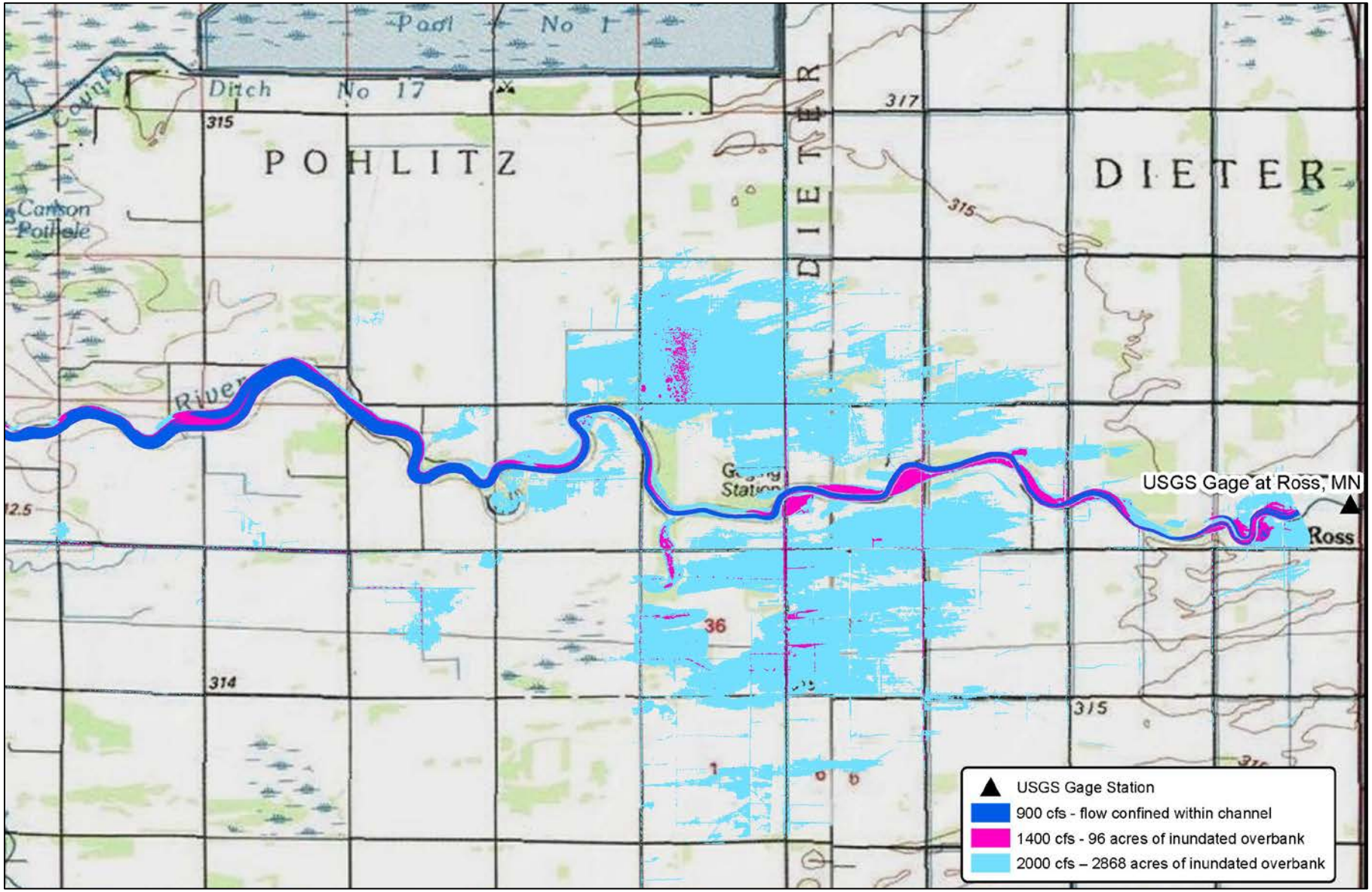


Figure 16. 10-Day, 100-Year Hydrographs of Roseau River at SD 69 Confluence

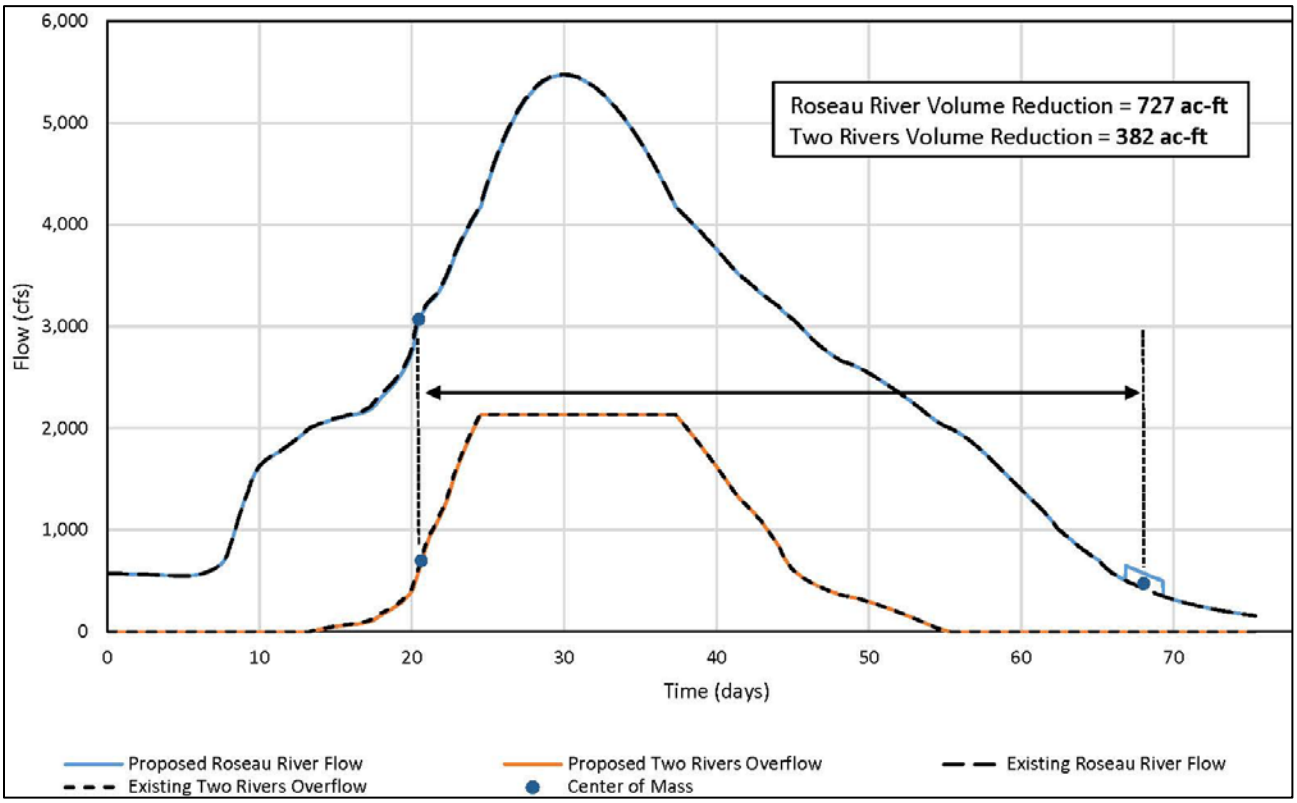
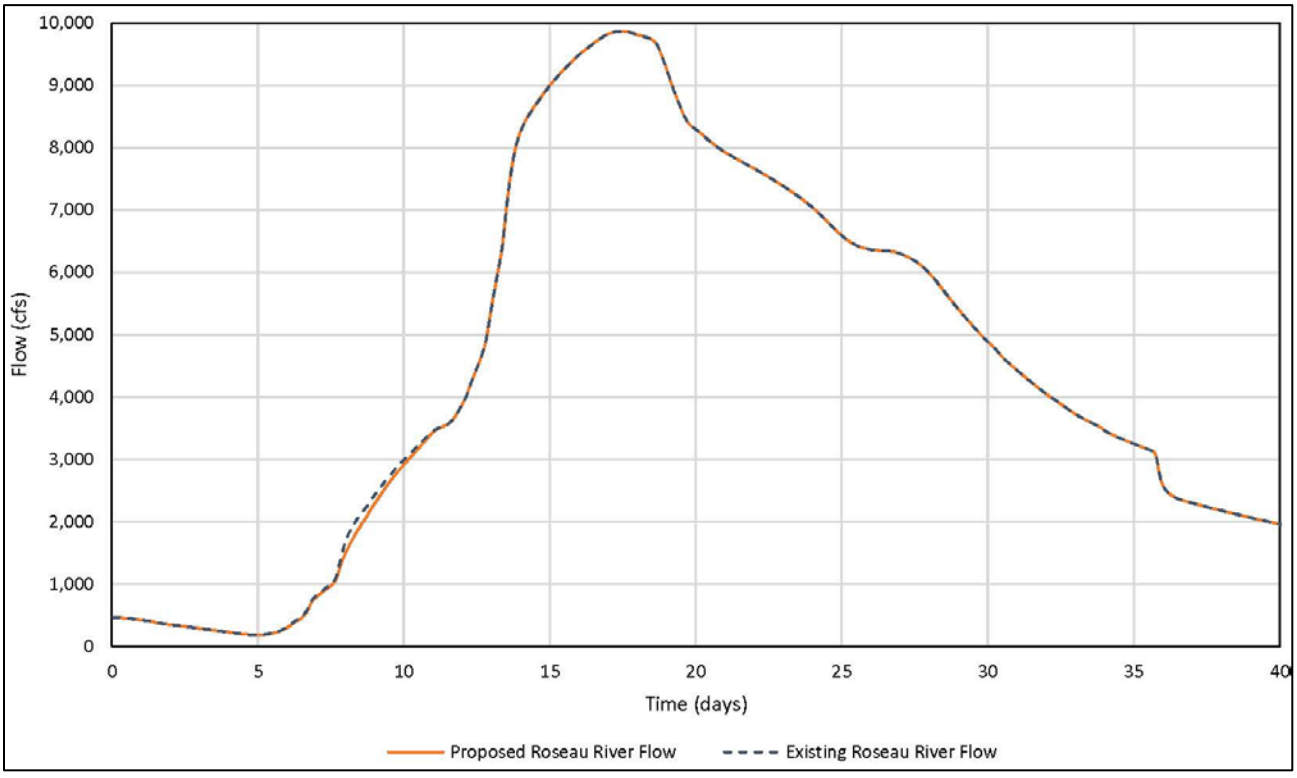


Figure 17. 10-Day, 100-Year Hydrographs of Roseau River at Ross



6.1.2 CD 16

The CD 16 system conveys the outflows from Retention Site C to the Roseau River. CD 16 Lat1 enters the Roseau River directly upstream of the bridge at Ross, MN. Figure 18 shows the reduction in the downstream water surface profile of CD 16 Lat 1. There is a 1 to 2 foot reduction in the profile from the Retention Site C outlet to the Roseau River. CD 16 Lat 1 also connects to CD 16 through a one-mile long channel that flows east and west, further benefits in CD 16 Lat 1 will translate to benefits throughout the CD 16 system. Figure 20 shows the maximum flooded extents of the existing and proposed 10-year, 24-hour event in the CD 16 system. The existing inundated area is 2,170 acres and proposed inundated area is 1,750 acres. Retention Site C stores 273 ac-ft during the 10-year, 24-hour event, inundating 235 acres within the embankments.

Figure 18. CD 16 Lat 1 10-year, 24-hour Water Surface Elevation Profiles

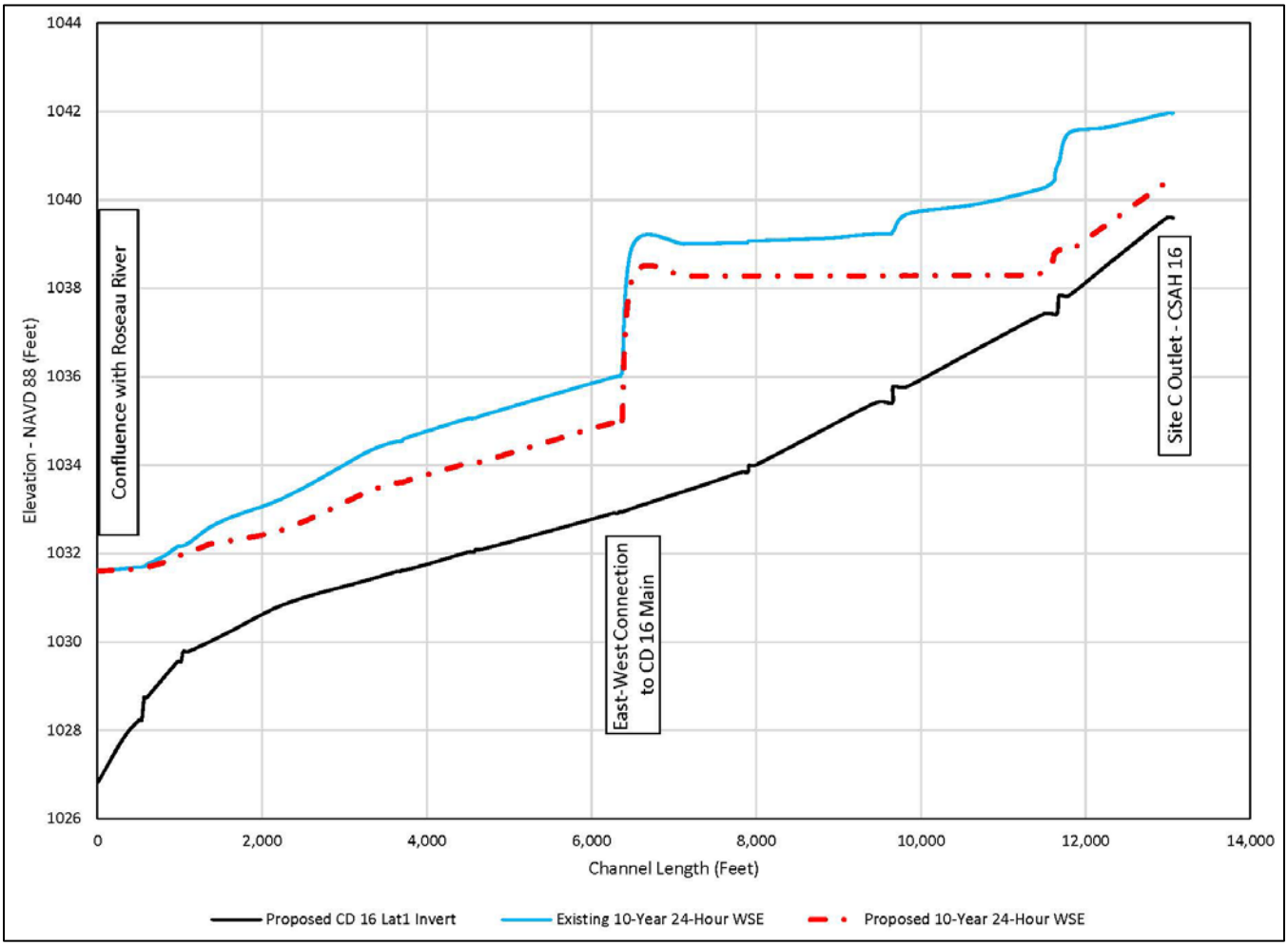


Figure 19. CD 16 10-year, 24-hour Water Surface Elevation Profiles

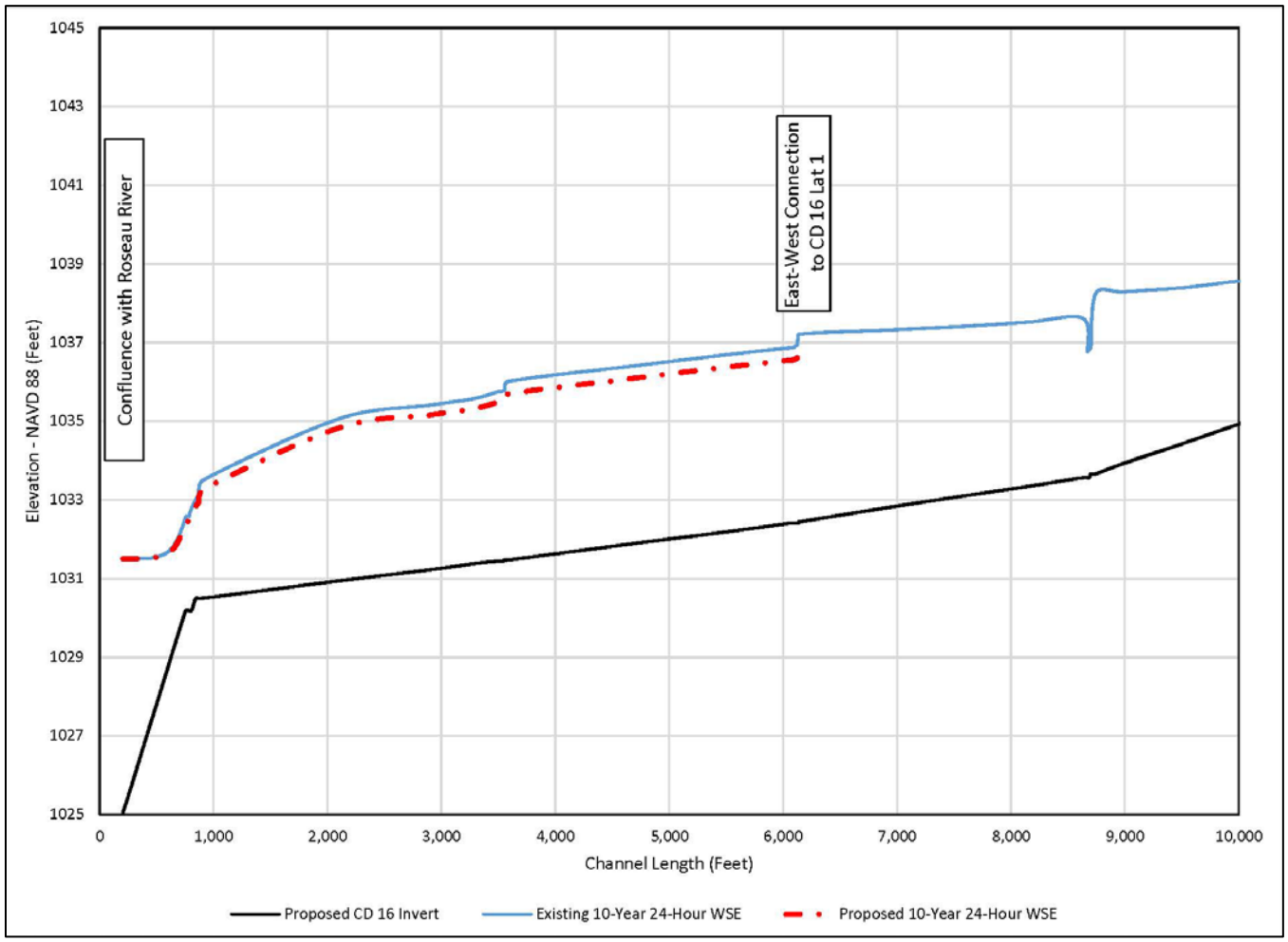
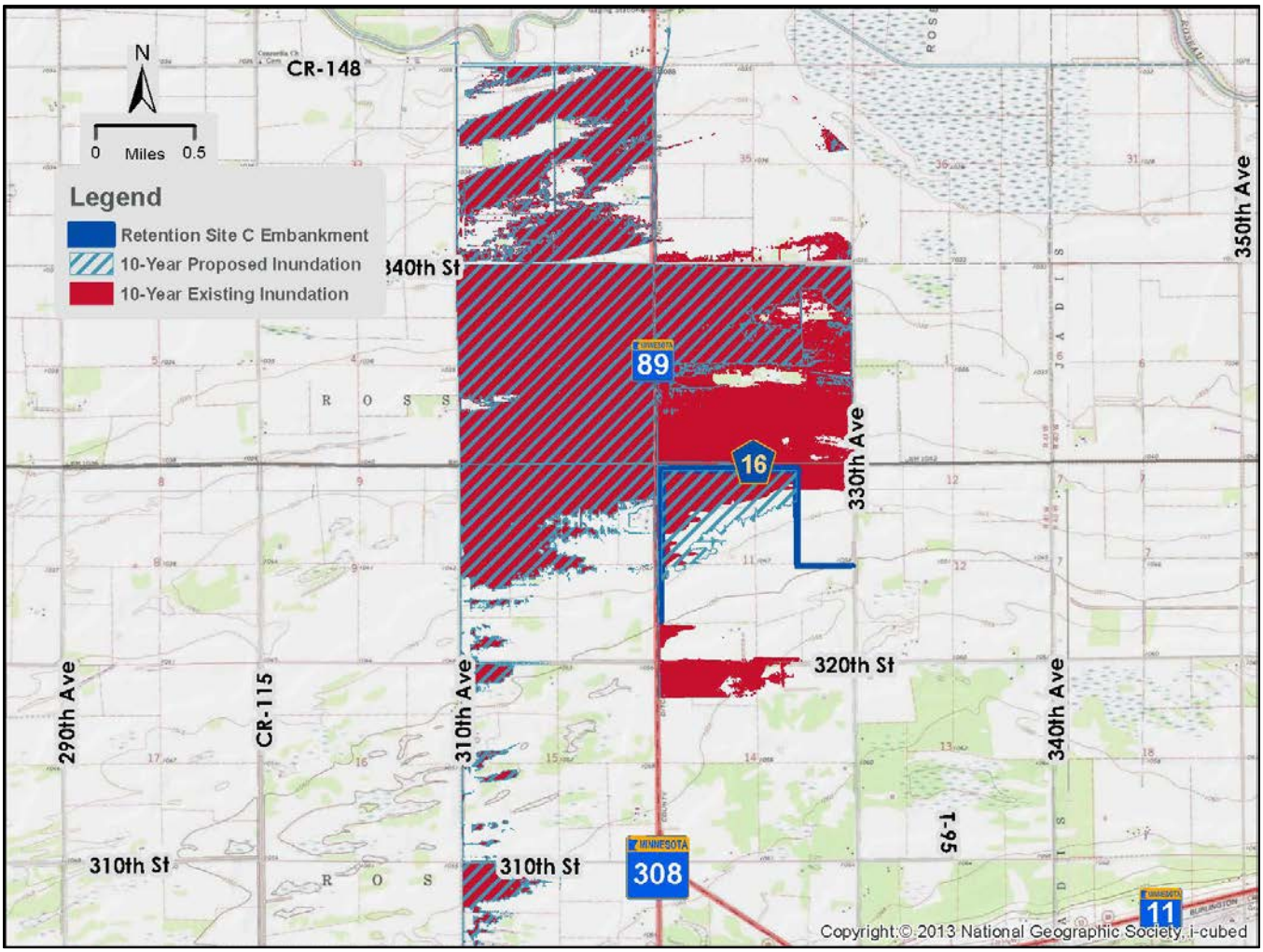


Figure 20. 10-Year, 24-Hour Existing and Proposed Inundation



6.2 Retention Site C Performance

The 2-, 10-, 25-year, 24-hour summer rainfall events are stored without reaching the maximum gated storage capacity of Retention Site C. The 100-year, 10-day spring snowmelt event reaches a maximum water surface elevation of 1049.9 in Retention Site C. Figure 21 shows the extents of the Retention Site C pools for four design events listed above. Figure 22 is the water surface elevation, drop inlet outflow, and bypass flow of Retention Site C during a 100-year, 10-day spring snowmelt.

Figure 21. Retention Site C Pools

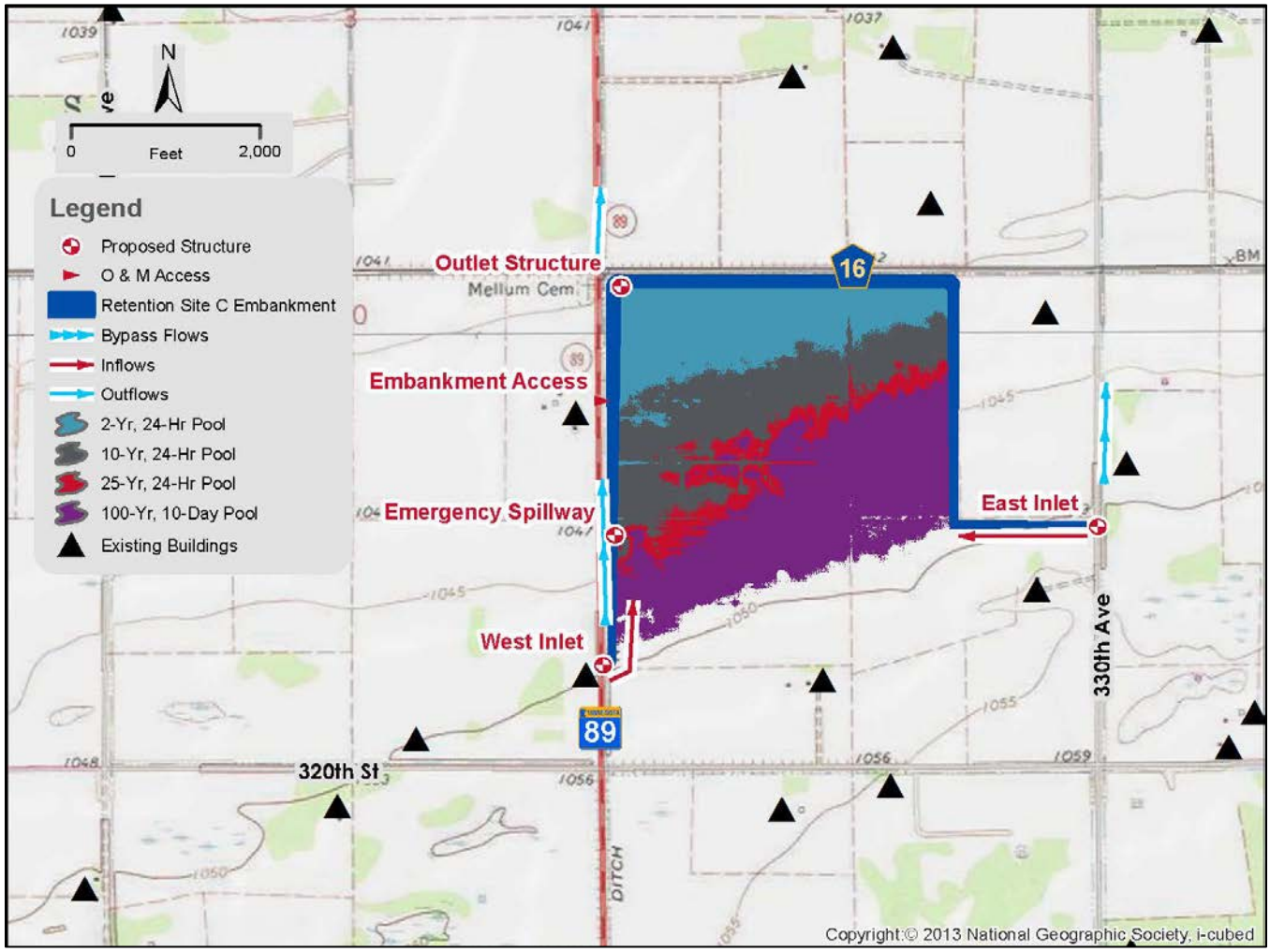
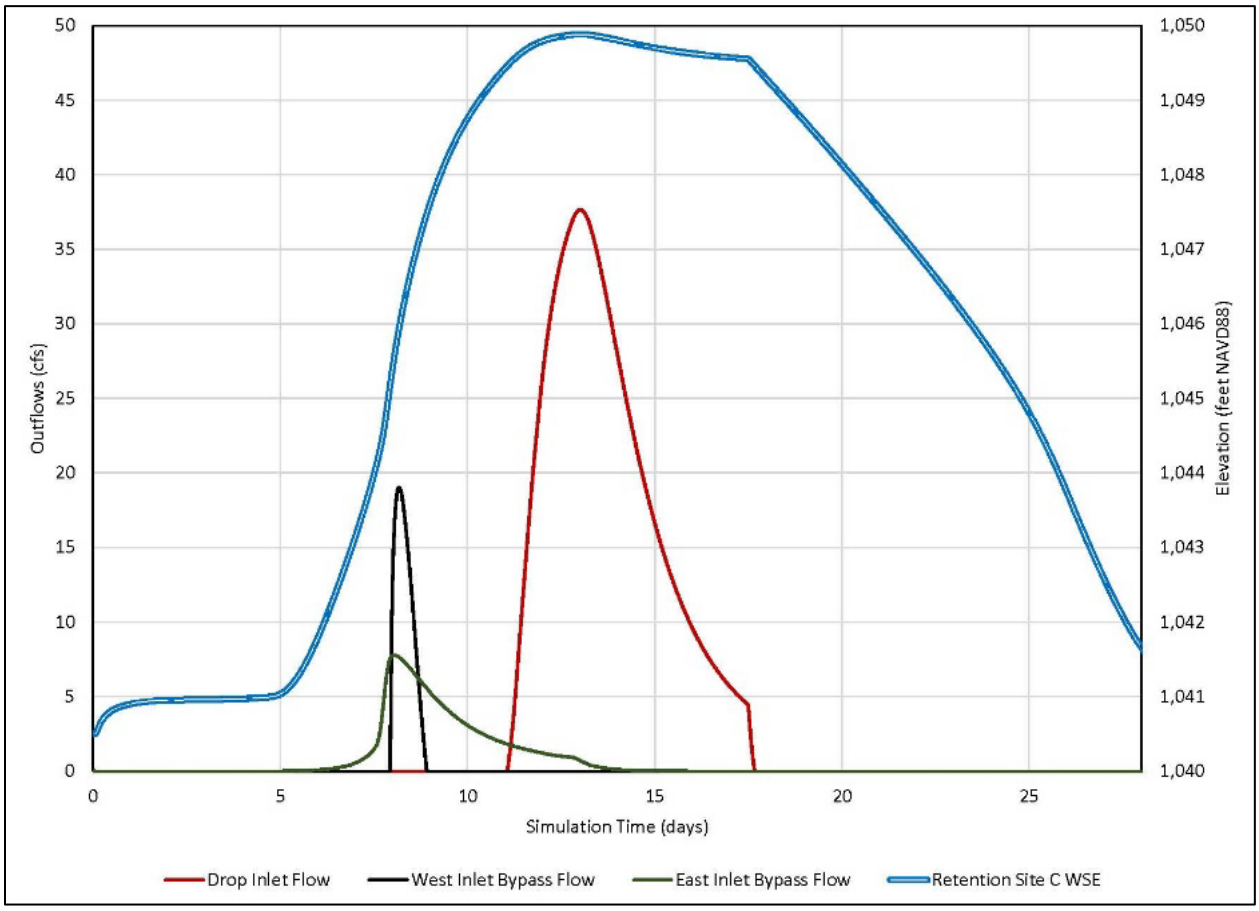


Figure 22. Retention Site C 100-Year, 10-Day Performance



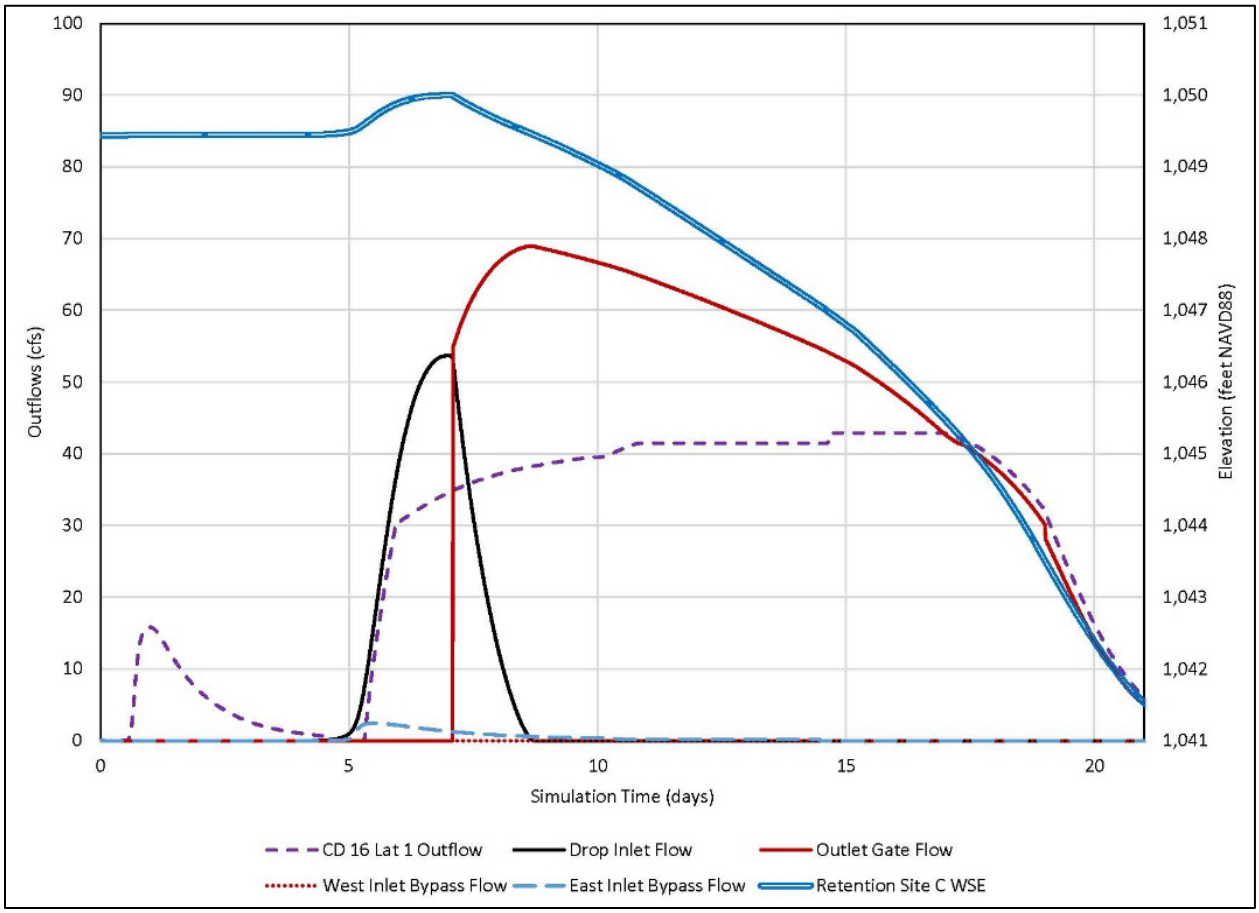
6.2.1 Principal Spillway Hydrograph

The principal spillway hydrograph (PSH) was developed from the 10-day, 25-year rainfall event, which has a precipitation depth of 7.27 inches. Table 6 below summarizes the results. The PSH model has a starting water surface elevation equal to the drop inlet elevation. The maximum water surface elevation is computed from the PSH, and it must not reach the emergency spillway. The gate is opened after the maximum water surface elevation is reached, and after 10 days the impoundment must have less than 15 percent of the maximum storage remaining.

Table 6. PSH Results

Maximum Water Surface Elevation	1049.99'
Peak Volume	1,081 acre-feet
10-day Drawdown Volume	150 acre-feet (13.9%)
Peak Outflow	70 ft^3/s

Figure 23. PSH & Drawdown Results



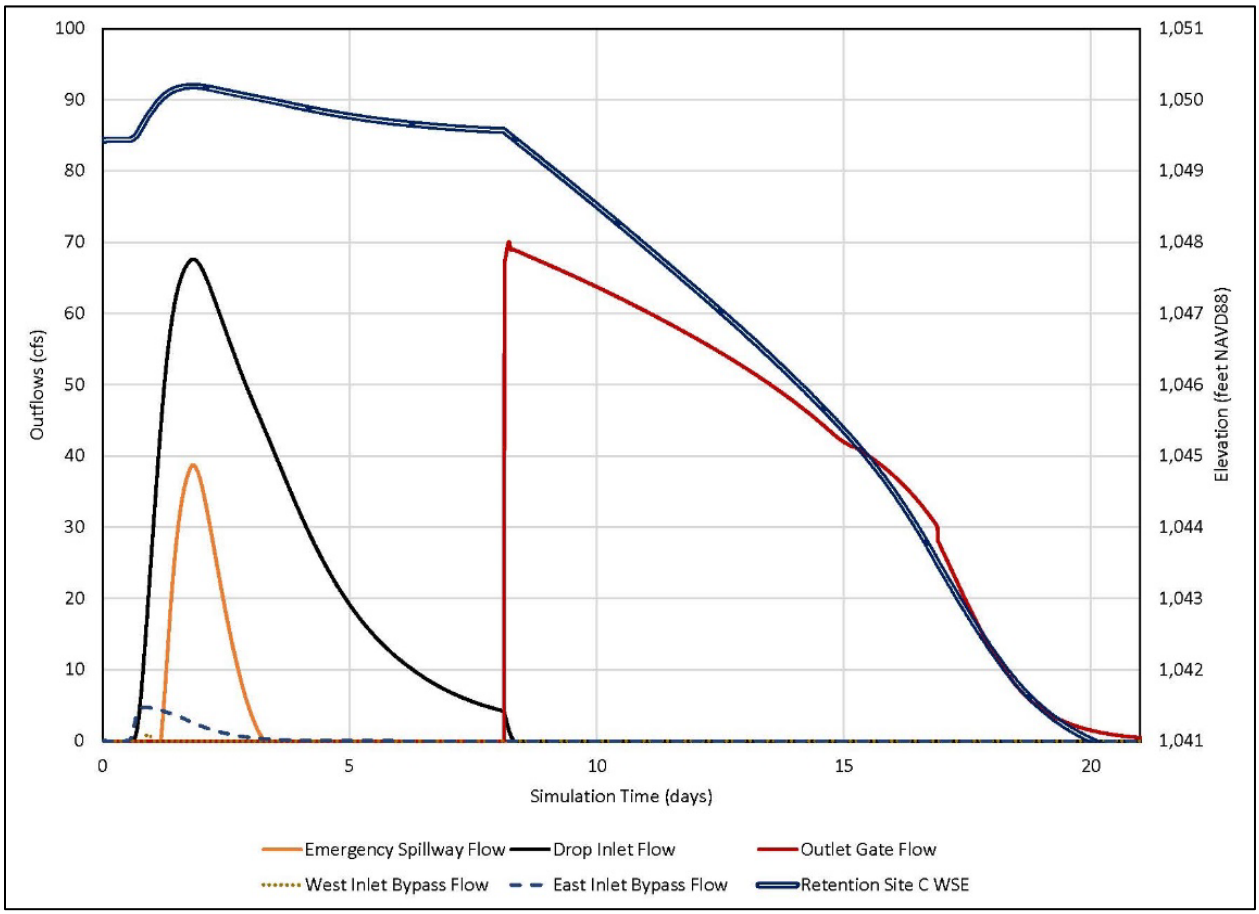
6.2.2 Auxiliary Spillway Hydrograph

The auxiliary spillway hydrograph (ASH), also known as the stability design or emergency spillway hydrograph, is the 100-year, 24-hour rainfall event. This event has a precipitation depth of 5.72". Similar to the PSH, the ASH model has a starting water surface elevation equal to the drop inlet elevation. Retention Site C achieves a maximum water surface elevation of 1050.09 and a maximum flow in the emergency spillway of 12 cubic feet per second. The depth in the emergency spillway reaches a maximum of 1 inch.

Table 7. ASH Results

Maximum Water Surface Elevation	1050.09'
Peak Volume	1,104 acre-feet
Peak Outflow	70 ft^3/s

Figure 24. ASH Results



6.2.3 Freeboard Hydrograph

The freeboard hydrograph (FBH) has a precipitation depth of 8.3 inches. Similar to the PSH and the ASH, the FBH model has a starting water surface elevation equal to the drop inlet elevation. The FBH maximum water surface elevation of Retention Site C is 1050.14 feet, and so the Retention Site C freeboard from the maximum water surface elevation is 2.86 feet. Results are shown in Table 8.

Table 8. FBH Results

Maximum Water Surface Elevation	1050.14'
Peak Volume	1,118 acre-feet
Peak Outflow	75 ft^3/s

6.3 CD 16 Improvements

The outlet for Retention Site C is CD 16 Lat 1 and CD 16. The existing CD 16 system does not have the capacity to convey the runoff from a 10-year, 24-hour event without damaging the adjacent agricultural areas. Improving the CD 16 system will help to meet the Whitney Lake Subwatershed purpose and need. Results of the Retention Site C proposed storage and CD 16 drainage improvements are shown in the tables below. Figure 25 shows the results of a 10-year, 24-hour event in CD 16 before and after the Retention Site C and CD 16 improvements. The existing inundation is 2,170 acres and proposed inundation is 135 acres.

For events up to a 10-year, 24-hour rainfall, the improvements to CD 16 will increase peak flows to the Roseau River. However, the CD 16 drainage area affects the early portion of the Roseau River hydrograph and increases to those flows will benefit that downstream system by moving that volume away from the Roseau River peak. The combination of Retention Site C and CD 16 improvements provides better overall benefits because it stores a portion of the early flow and releases it after the peak of the Roseau River.

Table 9. CD 16 Lat 1 Peak Flow and Water Surface Elevations at Retention Site C Outlet

Event	Existing Peak Flow Rate (cfs)	Existing Peak Water Surface Elevation (feet)	Retention Site C Peak Flow Rate (cfs)	Retention Site C Peak Water Surface Elevation (feet)	Flow Change from Existing (cfs)
2-Year, 24-Hour	37.8	1040.35	2.6	1037.53	35.2
10-Year, 24-Hour	96.8	1042.04	6.7	1038.04	90.1
25-Year 24-Hour	142.8	1042.4	9.9	1038.39	132.9
100-Year, 10-Day	229.4	1042.9	64.4	1040.46	165

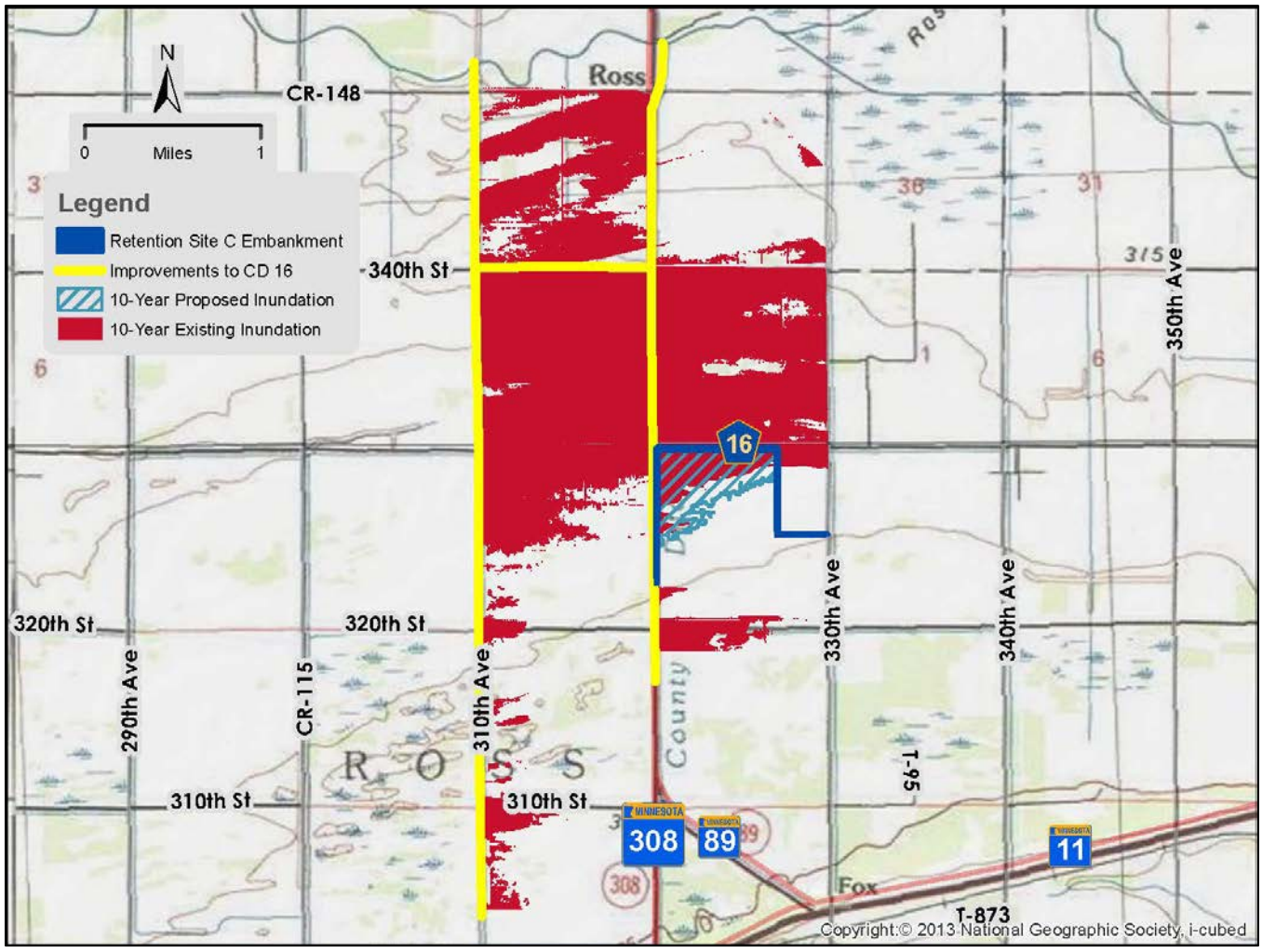
Table 10. CD 16 Lat 1 Peak Flow and Water Surface Elevations at Roseau River Confluence

Event	Existing Peak Flow Rate (cfs)	Existing Peak Water Surface Elevation (feet)	Retention Site C Peak Flow Rate (cfs)	Retention Site C Peak Water Surface Elevation (feet)	Flow Change from Existing (cfs)
2-Year, 24-Hour	49.5	1031.6	26.1	1031.6	23.4
10-Year, 24-Hour	122.6	1031.6	62.7	1031.6	59.9
25-Year 24-Hour	195	1031.6	85.6	1031.6	109.4
100-Year, 10-Day	322.1	1031.6	118	1031.6	204.1

Table 11. CD 16 Peak Flow and Water Surface Elevations at Roseau River Confluence

Event	Existing Peak Flow Rate (cfs)	Existing Peak Water Surface Elevation (feet)	Retention Site C Peak Flow Rate (cfs)	Retention Site C Peak Water Surface Elevation (feet)	Flow Change from Existing (cfs)
2-Year, 24-Hour	81.1	1031.5	77.8	1031.5	3.3
10-Year, 24-Hour	212.7	1031.52	186.3	1031.5	26.4
25-Year 24-Hour	292	1031.54	276.5	1031.5	15.5
100-Year, 10-Day	415.6	1031.6	412.9	1031.5	2.7

Figure 25. Existing vs. Proposed 10-Year, 24-Hour Inundation with Retention Site C and CD 16 Improvements



7 Operating Plan & Maintenance

Retention Site C provides flood control benefits by storing flood runoff until CD 16 Lat 1 ditch flows are no longer out of bank and after the Roseau River has peaked. The RRWD will operate the outlet structure. Risk to public safety will be the primary consideration in the operation.

7.1 Operation Goals

The operating goal is to reduce flooding to the maximum extent possible. Discharge of water from Retention Site C will be managed to reduce flooding on agricultural lands downstream of the project.

7.2 Gate Operation

Flow into Retention Site C is via two passive inlet channels. Flow out of Retention Site C will be by gated operation. The outlet structure will be remotely monitored and operated. Figure 12 shows the proposed structure in elevation view. The structure operation is as follows:

- Outlet closed when CD 16 Lat 1 is at capacity and remains closed until CD 16 Lat 1 drops below a to-be-determined stage and Roseau River drops below flood stage at Ross.
- Once conditions are below these points then the outlet gate is opened until downstream CD 16 Lat 1 stage triggers closure.
- A remotely operated gate actuator paired with water level sensors will enhance the ease of operation for this structure, also reducing travel and staff hours during flood events.

The intent is to operate the outlet gates so flow from Retention Site C does not exceed the downstream channel capacity during the falling limb of the hydrograph. Flows will be released until the impoundment is sufficiently dry and storage is available for FDR operation. Operation may need to be adjusted due to the following:

- Public safety threats due to localized flooding;
- potential for damage to public infrastructure and property damage,
- extreme weather events,
- potential for damage to project infrastructure,
- multiple events where the crest of one flood has not passed or has only recently passed Ross, and
- unintended accumulation of water along stretches of the exterior ditches

7.3 Flood Forecast Information

The Roseau River gage at Ross and upstream gages will be used to determine when the Roseau River has peaked. The variables that will help flood management planning is the snowpack water equivalent, forecasted temperature to judge melt rate, and storage/ground infiltration. The National Oceanic and Atmospheric Administration (NOAA) provides snowpack information (depth and water equivalent) for the Midwest at the following website: https://www.nohrsc.noaa.gov/interactive/html/map.html. The following gages are publically available to inform the operation of the project.

- Roseau River at Ross, MN maintained by USGS – near project outlet, contributing drainage area 1,090 square miles.
- Roseau River near Caribou, MN maintained by USGS – downstream of project, contributing drainage area 1,420 square miles.

7.4 Maintenance

Annual maintenance will be the responsibility of the RRWD. Activities will include mowing or spraying the embankments and channels and inspecting all components for damage after flooding events or as needed. Embankment access and sufficient space for maintenance vehicles will be provided for maintenance at the outlet structure.

8 Geotechnical

Published information from the Minnesota Geological Survey (Hobbs & Geobel, 1982) indicates peat deposits and lake-modified till of the Erskine Moraine associated with the Des Moines Lobe. The topography of the site dips gently in elevation from the southeast to the northwest. The maximum embankment height of Retention Site C is 13 feet.

The NRCS Web Soil Survey (NRCS, 2017) was used to evaluate soil information at Retention Site C. As displayed in Table 12, 82% of the soil within Retention Site C is NRCS Map Unit I84A described as Percy loam, 0 to 1 percent slopes, very cobbly. The remaining 18% of the soil within the Retention Site C is NRCS Map Unit I117A described as Skagen loam, dense till, 0 to 2 percent slopes, very cobbly. Soil types found within and near the project area are displayed in Figure 27.

Table 12. Soil Map Unit Descriptions

Map Unit	Map Unit Description	Area in Retention Site C (acres)	Percent of Total Area
I84A	Percy loam, 0 to 1 percent slopes, very cobbly	208.0	82
I117A	Skagen loam, dense till, 0 to 2 percent slopes, very cobbly	45.5	18

RRWD contracted Northern Technologies, LLC (NTI) of Fargo, North Dakota to perform a geotechnical exploration at Retention Site C that consisted of 2 soil boring (SB) locations, SB-12 at 45 feet deep and SB-13 at 20 feet deep. Figure 26 shows the locations of the completed borings. Samples were analyzed by NTI for several key engineering properties including:

- Water content (ASTM D2216),
- dry density (ASTM D7263-09 Method B),
- atterberg limits (ASTM D4318),
- standard proctor test (ASTM D698 Method A),
- hydraulic conductivity (ASTM D5084), and
- UU Triaxial (ASTM D2850).

Detailed geotechnical information on the borehole logs and laboratory test results can be found in the *Geotechnical Exploration and Engineering Review* report provided by NTI (Appendix B). Based on the borehole logs and laboratory testing, the overall subsurface soil profile at borings SB-12 and SB-13 consist of approximately 0.7 to 1 feet of topsoil underlain by soft to stiff (blow counts ranging from 4 to 21) Lake Modified Glacial Till (LMGT) which extends to the termination depth of the borings (maximum 46 feet). The LMGT soils are comprised of lean clay with trace amounts of sand and gravel. The soils have varying color, moisture contents ranging from 11 to 22%, and wet unit weights ranging from 149 to 159 lb/ft^3.

As described by the borehole logs, poor foundation materials are present consisting of 0.7 to 1.0 feet of black topsoil composed of organic clay with silt. Existing topsoil, organics, and non-native fill within the embankment footprint must be removed prior to construction. Figure 9 shows the typical embankment cross section. Analysis of seepage, slope stability, and settlement of the embankments will be completed during final design.

Figure 26. Borrow and Borehole Locations

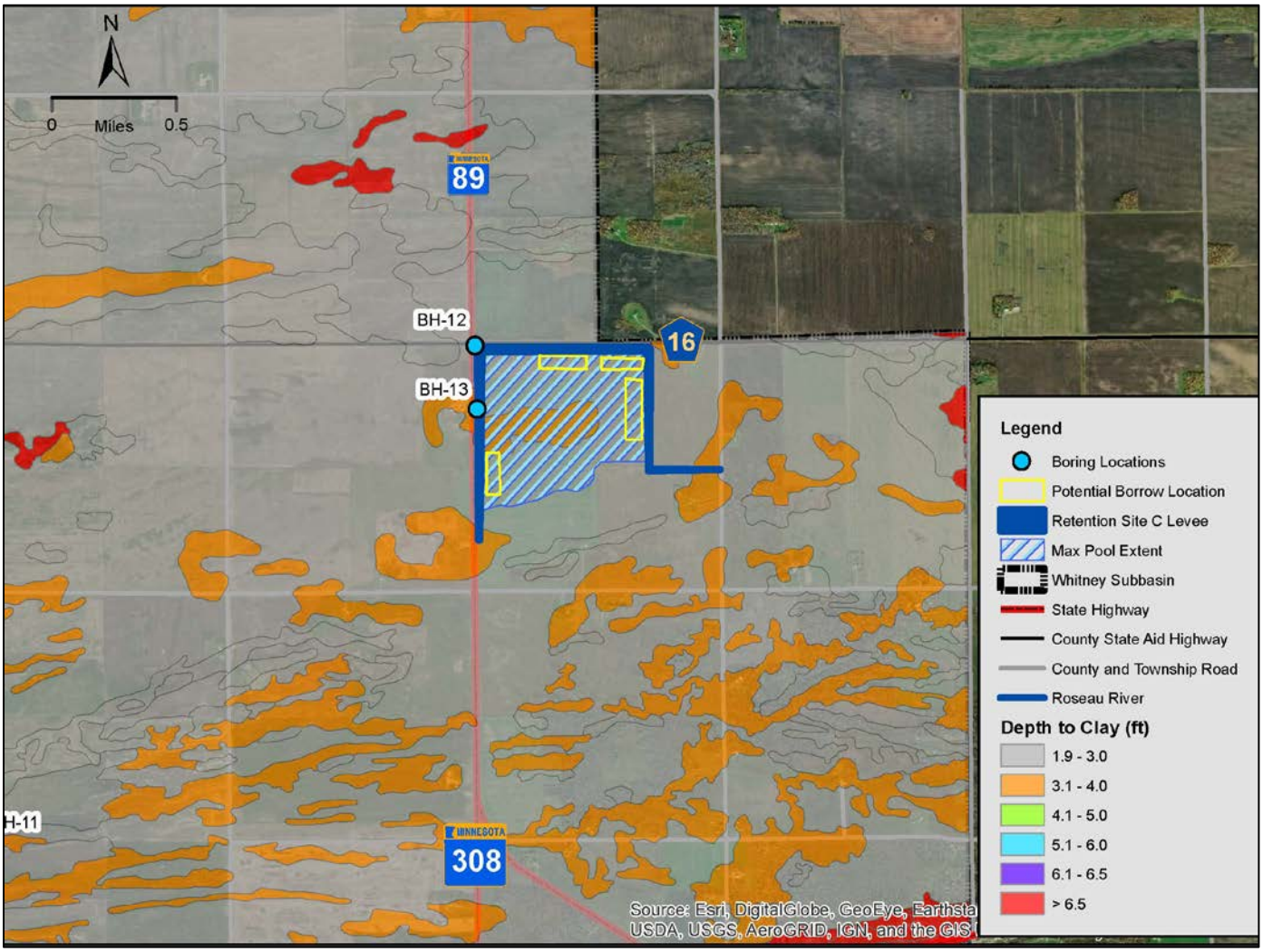
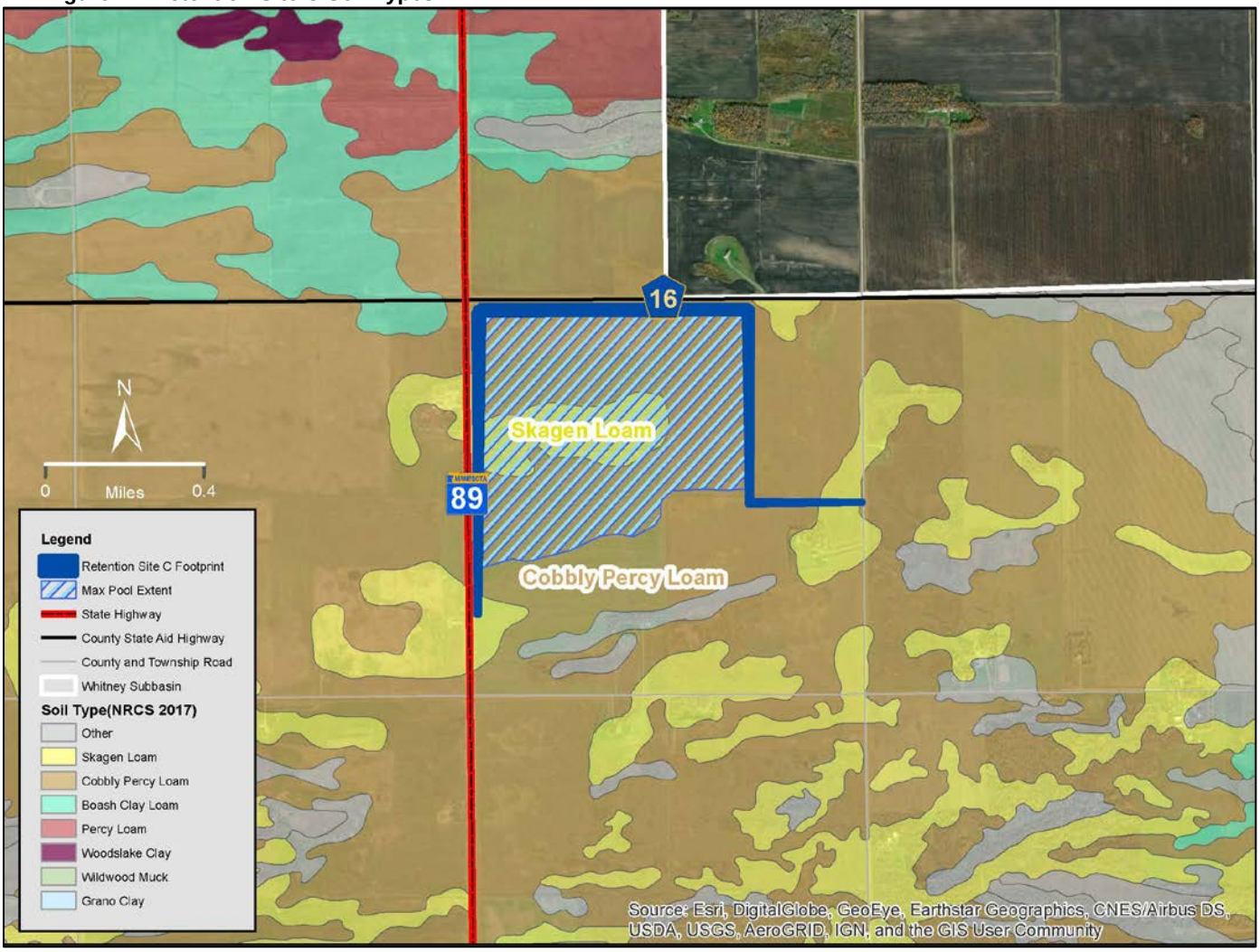


Figure 27. Retention Site C Soil Types



8.1 Potential Groundwater Impacts

Groundwater levels were inconsistent during the geotechnical drilling. In SB-12, groundwater was encountered at 2 feet below ground surface. The summary of groundwater conditions provided in the *Geotechnical Exploration and Engineering Review* report provided by NTI (Appendix B), it states: "*We anticipate the shallow groundwater (2 feet) is due to recent rainfall and is a temporary perched condition."* In SB-13, groundwater was not observed during the borehole drilling. This does not indicate SB-13 was terminated above the groundwater level and long-term groundwater observations are required to better define groundwater levels. Groundwater levels fluctuate seasonally and in response to climatic conditions.

Lab permeability results show a coefficient of permeability of 9.5×10^{-9} ft/min for the lean clay at 10 feet below ground surface in SB-12. Due to the low permeability of the clay soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole in these materials. Long-term water level readings in piezometers or observation wells sealed from the influence of surface water are used to define groundwater levels.

There is no indication of an aquifer at Retention Site C.

8.2 Potential Borrow Sources

In order to make Retention Site C embankments as economical as possible, the potential borrow sources are located in close proximity to the embankments. The combination of NRCS Soil Survey maps and soil information from the geotechnical investigation were used to determine locations of suitable borrow source (Figure 27). Ultimately, borrow sources will be chosen by the RRWD and willing landowners.

9 Environmental Considerations

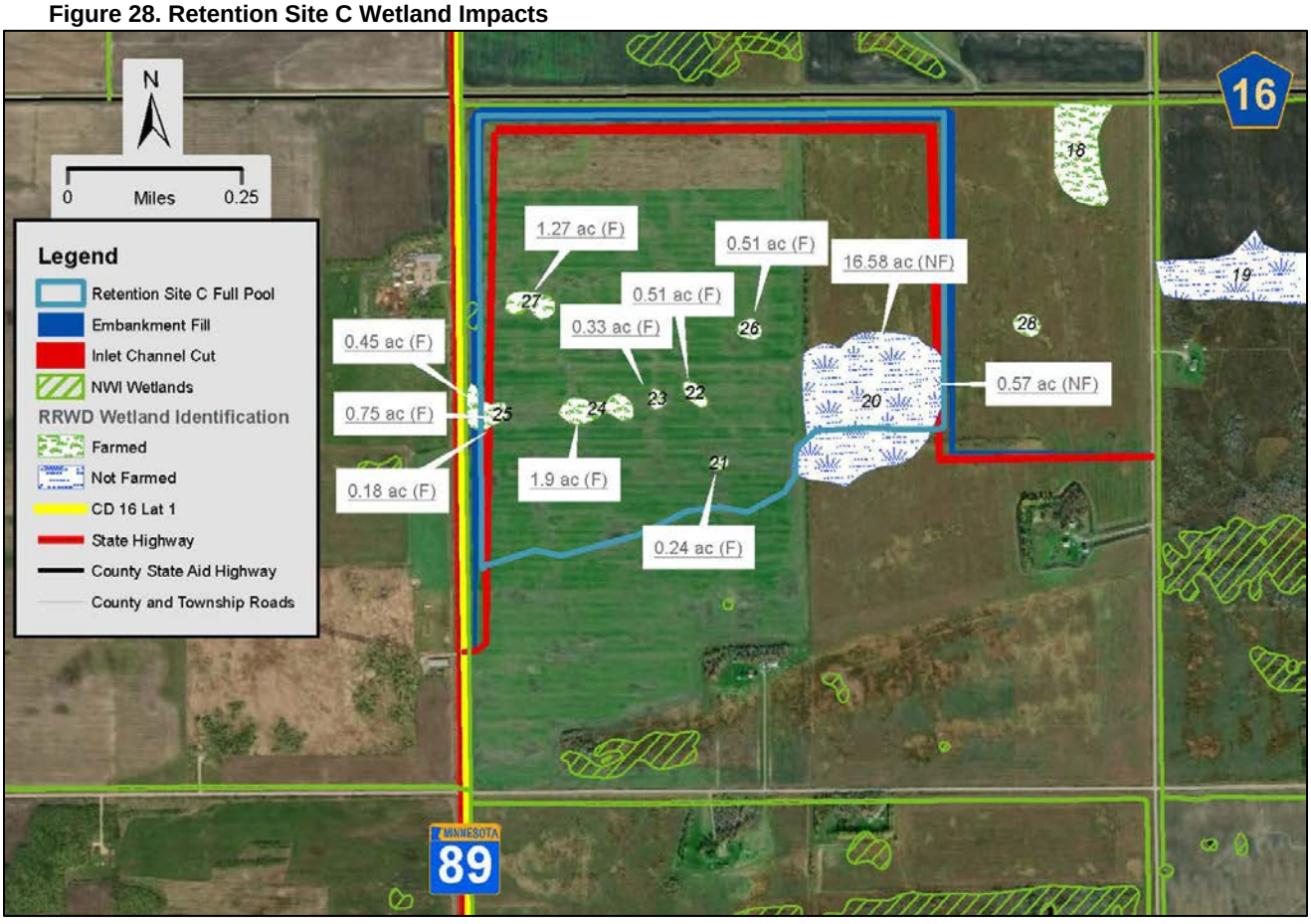
9.1 Wetland Mitigation

A wetland delineation, permit application, and mitigation plan will be developed prior to construction for any wetland disturbed by construction equipment, excavation, or fill material. RRWD performed a preliminary wetland investigation at Retention Site C. This provided locations of potential wetlands and classified them as "farmed" or "not farmed." Retention Site C embankments, inlet channels, and full pool cause impacts in the form of fill for embankments, excavation for inlet channels, and inundation for the full retention pool. The impacts are summarized in Table 13. Figure 28 shows the locations of each wetland with respect to Retention Site C project features.

Table 13. Retention Site C Wetland Impacts

RRWD Wetland FID	Total Size (acres)	Land Use F = farmed NF = not farmed	Type of Impact	Area of Impact (acres)
20	23.49	NF	Inundation	16.58
20	23.49	NF	Excavation	0.57
21	0.24	F	Inundation	0.24
22	0.51	F	Inundation	0.51
23	0.33	F	Inundation	0.33
24	1.90	F	Inundation	1.90
25	1.45	F	Inundation	0.75
25	1.45	F	Excavation	0.18
25	1.45	F	Fill	0.45
26	0.51	F	Inundation	0.51
27	1.27	F	Inundation	1.27

Figure 28. Retention Site C Wetland Impacts



9.2 Invasive Species

The designated Weed Inspector for Roseau County is the Roseau County Soil and Water Conservation District. The County Weed Inspector administers the Minnesota Noxious Weed Law, seed testing and inspection, and commercial applicator testing for Roseau County. According to Roseau County's Cooperative Weed Management Program grant reporting (Roseau County SWCD, 2018), their target invasive species are spotted knapweed, purple loosestrife, and common tansy. Secondary target species are Canada thistle, leafy spurge, and wild parsnip. Permanent impacts from Retention Site C construction are possible through the construction equipment movement. If invasive species are identified in Retention Site C or in the surrounding area, best management practices will be developed to prohibit the spread of them. Further analyses will be completed as a part of the final construction specifications, but are not included in this report.

9.3 Water Quality

The MPCA has deemed the section of the Roseau River from Hay Creek to the Minnesota/Canada border to be in good overall condition. The MPCA has one impairment (Mercury in fish tissue) listed in this section of the Roseau River. For the Roseau River watershed, the MPCA completed intensive water quality monitoring in 2015 and 2016 and both a Stressor Identification Report and a Monitoring and Assessment Report were completed in 2018. The MPCA has a water quality monitoring station located on the Roseau River at Minnesota State Highway 89. Retention Site C has potential to benefit water quality in the CD 16 system, the Roseau River, and downstream. The table below describes what benefits are anticipated.

Table 14. Retention Site C Effects on Water Quality

Pollutant or Parameter	Anticipated Trend
Turbidity and TSS	Decrease in turbidity and TSS during all storm events.
DO	Increase in DO during all storm events.
TN/TP/OP (Nutrients)	Decrease in TN/TP/OP (nutrients) during all storm events.
Chlorophyll-*a*	Decrease in chlorophyll-*a* during all storm events.
E. coli	No significant change.
Flow Rate	Decrease in the subwatershed's peak flow rate.

9.4 Erosion Control

9.4.1 Erosion Control During Construction

A Storm Water Pollution Prevention Plan (SWPPP) will be implemented to reduce erosion and soil loss during construction. Best management practices such as: buffer strips, sheet pile, cofferdams, temporary cover, silt fences, floating silt curtains, etc. will be considered during final design.

9.4.2 Prevention of Embankment Erosion

In order to prevent erosion from occurring during project operation the embankments will be lined with turf reinforcement matting along emergency spillway crest. Armorflex and riprap will be used at the inlet and outlet of hydraulic structures, if necessary.

9.4.3 Vegetation

Newly constructed channels and embankments will be vegetated with appropriate seed mixes in accordance with Native Vegetation Establishment Guidelines (MN Board of Water and Soil Resources, 2019). Upland areas of disturbance will be seeded with native construction mix (32-241), while channel bottom, wetland and transitional areas will be seeded with emergent wetland mix (34-181).

10 Other Site Considerations

10.1 Land Ownership

The land in Retention Site C is privately owned. Throughout the development of the Whitney Lake Subwatershed Project, the public has supported Retention Site C because the land has a history of flooding problems and the current landowners are in favor of pursuing solutions for the Whitney Lake Subwatershed. Figure 29 illustrates the land ownership in and around Retention Site C. Right-of-way to construct embankments and inlet channels is expected to be purchased by RRWD and the maximum inundated extents are expected to have flowage easements purchased by RRWD. These areas are summarized Table 15.

Table 15. Right-of-way Required for Embankments and Ditches

Retention Site C Component	Right-of-Way Required (Acres)
Embankments	18.21
West Inlet Channel	3.56
East Inlet Channel	8.47
Maximum Pool	235.31
10-Yr, 24-Hr Pool	135.19

10.2 Land Cover

A map of Retention Site C with the National Land Cover Database (USGS, 2016) is shown in Figure 30. Inside the maximum pool of Retention Site C, the land cover types are cultivated crops, emergent herbaceous wetlands, and pasture/hay. This data is consistent with the other investigations in this report.

10.3 Utilities

The approximate locations of known public utilities are shown in Figure 31. The existing overhead electric power lines will be buried during construction and the poles will be removed. There is approximately 1,750 linear feet of overhead line that can be buried adjacent to the Retention Site C embankment, and also be used to power the gate actuator on the outlet structure.

Figure 29. Land Ownership

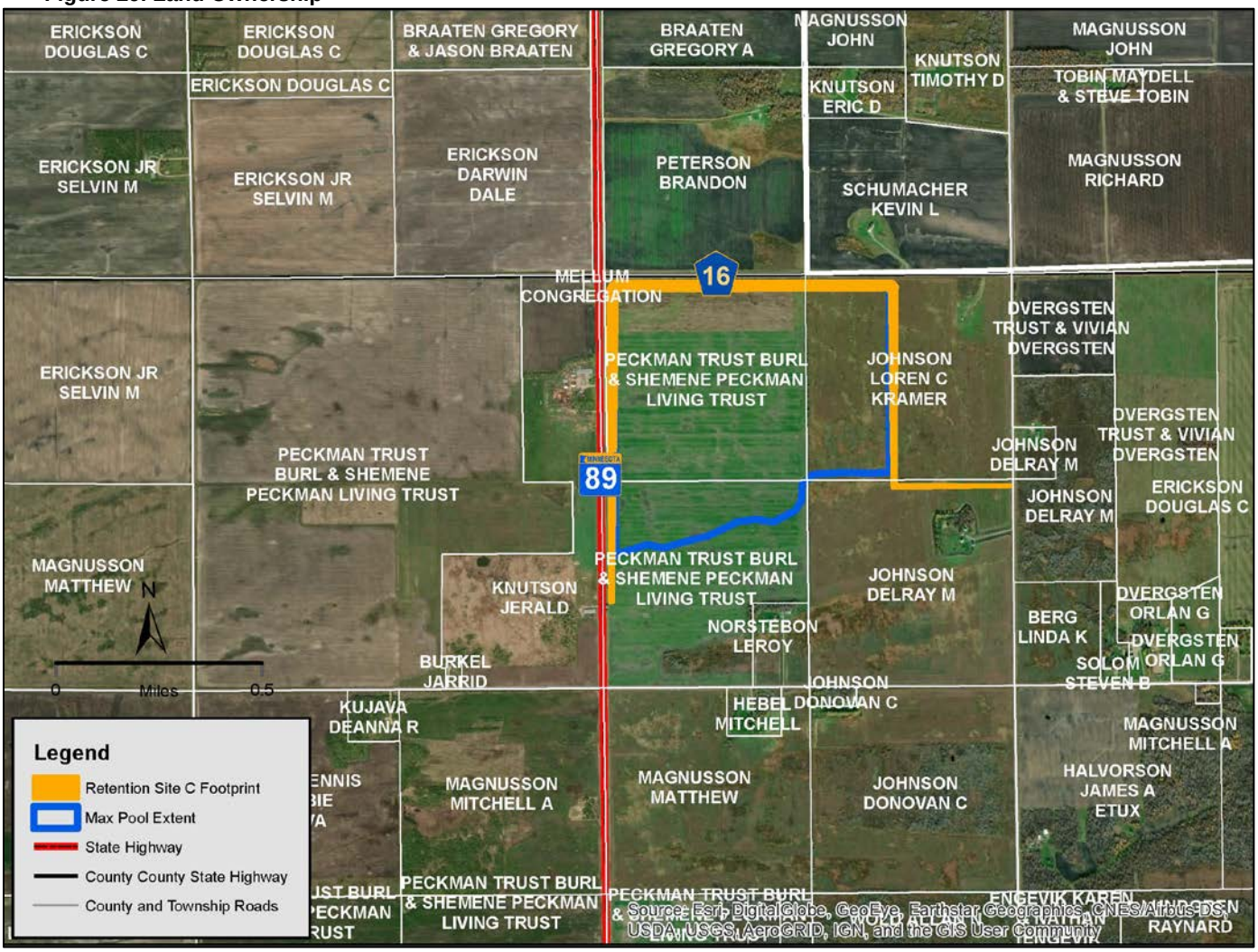


Figure 30. NLCD 2016 Land Cover

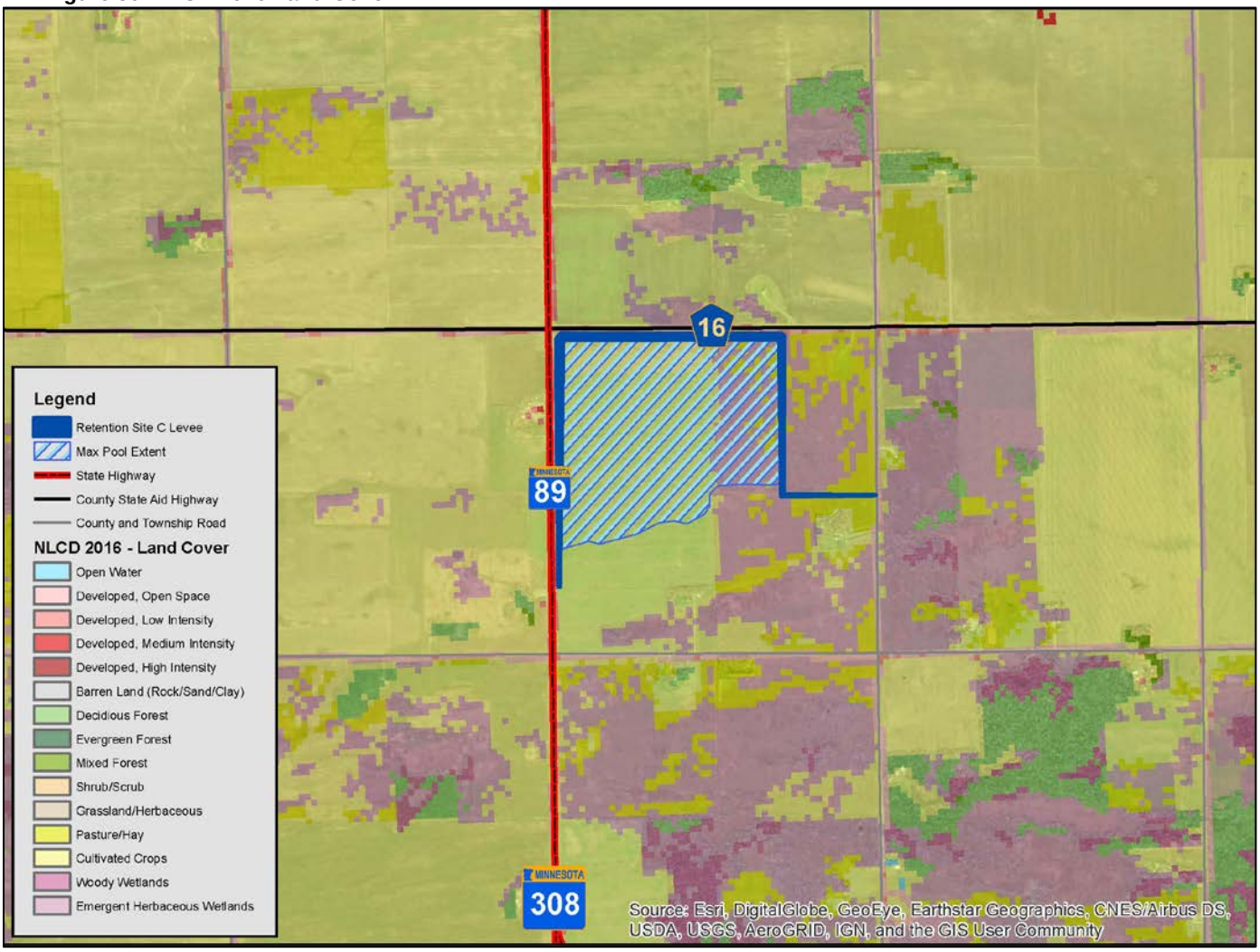
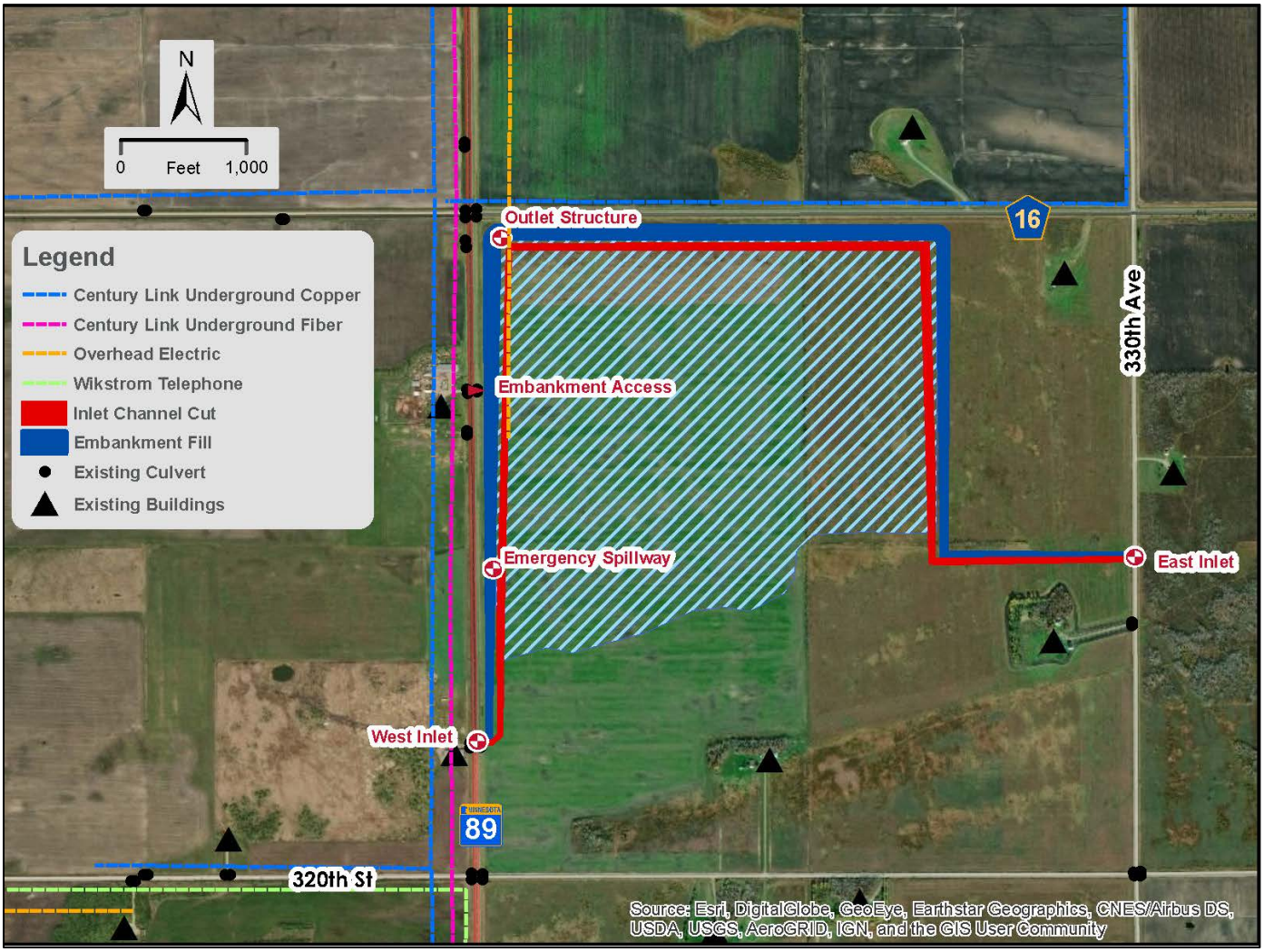


Figure 31. Retention Site C Existing Utilities



11 Engineer's Opinion of Probable Construction Costs

Table 16 summarizes the preliminary cost estimate for Retention Site C.

Table 16. Retention Site C Cost Estimate

Item Description	Unit	Quantity	Unit Cost	Cost
Mobilization	lump sum (LS)	1	$30,000	$30,000
Clearing and Grubbing	LS	1	$5,000	$5,000
Common Excavation	cubic yard (CY)	48,701	$2.75	$133,928
Common Borrow	CY	226,728	$4.50	$1,020,276
Aggregate Surfacing, Class 5	CY	175	$20	$3,500
Outlet Structure	each (EA)	1	$200,000	$200,000
Structure Excavation	CY	500	$5.50	$2,750
Granular Bedding	CY	24	$14	$336
18" Corrugated Steel Pipe Culvert	linear foot (LF)	80	$40	$3,200
18" Culvert Apron	EA	2	$250	$500
24" Corrugated Steel Pipe Culvert	LF	80	$45	$3,600
24" Culvert Screw Gate	EA	1	$1,500	$1,500
24" Culvert Apron	EA	1	$350	$350
4' X 6' Reinforced Concrete Box Culvert	LF	45	$725	$32,625
4' X 6' Reinforced Concrete End Section	EA	2	$6,000	$12,000
Traffic Control	LS	1	$3,000	$3,000
Erosion Control	LS	1	$30,000	$30,000
Construction Subtotal				**$1,482,565**
Engineering and Administration	25% of construction subtotal			$370,650
Materials Testing	2% of earthwork			$23,085
Utility Relocation	LF	1,750	$3.00	$5,250
Right-of-Way Acquisition				$106,442
Contingencies	10% of construction subtotal			$148,257
Total Cost				**$2,136,249**

12 Recommendations

The hydrologic and hydraulic data indicates that Retention Site C will contribute to flood damage reduction along CD 16 Lat 1 to help address the severe and repeated damage that currently occurs to private property, agricultural lands, and public infrastructure. Retention Site C will use embankments, exterior drainage ditches, and gate operation to reduce peak flows and volumes in CD 16 Lat1, CD 16, the Roseau River, the Two Rivers, and finally the Red River of the North. The following characteristics were reviewed for Retention Site C:

- hydraulic results,
- compatibility with the project goals, and
- overall project cost.

Retention Site C provides benefits for a reasonable cost, is compatible with the stated project goals, and has potential to positively impact the environment. HDR recommends further development of Retention Site C. This includes meeting with affected landowners, holding a public hearing, developing permit applications and necessary documentation, and developing a final engineer's report with plans and specifications for construction.

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Appendix A

Concurrence Point Documents

Purpose of and Need for Action

The purpose of the proposed action is ***Flood Damage Reduction*****:** Reduce damages to agricultural lands for a 10 year 24 hour storm (total 3.3 inches of precipitation) and reduce damages to roadways for a 25 year 24 hour storm event (total 3.9 inches of rainfall) in the Whitney Lake Watershed.

The need for the proposed action is:

- Roseau River levels cause flood damage to agricultural properties during frequent runoff events (i.e. a 2-year, 24-hour event or 2.1 inches of rainfall). The Roseau River will frequently backup into area drainage ditches as much as two miles or more causing backwater effects in the drainage systems.

- The ditch systems in the Whitney Lake Watershed contain many culvert crossings, which have a lower capacity than a 2-year, 24-hour precipitation event. Additionally, the channels are undersized and not able to contain or convey the existing 2-year, 24-hour event in many places because the natural ground slope is too low to prevent flows from overtopping banks and flowing into adjacent lands. These adjacent lands become inundated for up to ten or more days, which is long enough to destroy crops that have been planted or delay access to the land for planting and harvesting.

- In Roseau County approximately 50% of landuse is farmland and an average of over 136 million dollars of crops are sold annually (USDA 2012 Census of Agriculture). Within the Whitney Lake watershed, 78% of landuse is cropland. Review of crop information and insurance records of four landowners in the Whitney Lake watershed over the past 10 years show a decrease in yields of up to 100% during wet years (precipitation data shows that 8 out of the past 10 years were wet years).

- The Roseau County Highway department confirmed that during heavy rainfall events water overtops at County Road 115 and 270th Ave. Overtopping occurs approximately once every two years and requires frequent maintenance. While costs for minor road repairs due to flooding are not well documented, repair costs of major flooding sites are documented and over the past 15 years have resulted in over $340,000 in damages.

Secondary benefits from the project may include:

- Temporary flood detention during high runoff events;

- Contribution to a regional goal of reducing peak flow along the Red River by 20 percent during flooding events;

- Reduction of erosion to improve water quality and for the benefit of wildlife and fish.

Event (inches of rainfall)	Flooded Area (24-hour duration)
10-year (3.3")	3,166 Acres
25-year (3.9")	4,705 Acres
100-year (4.9")	6,874 Acres

Roseau River Watershed District

0 0.5 1 Miles

State Highway
County Road
Township Roads
DuxbyLevee
County Ditch 16
State Ditch 51
State Ditch 87
State Ditch 69
County Ditch 17
Watershed Ditch 3
State Ditch 20
Existing 10-Yr Flood
Existing 25-Yr Flood
Existing 100-Yr Flood
Whitney Lake Study Area

EXISTING FLOODED AREAS
WHITNEY LAKE SUBWATERSHED

Whitney Lake Subwatershed Concurrence Point #2 (June 4, 2018)

INTRODUCTION

The Roseau River Watershed District (RRWD) has established a Project Team to develop a project to reduce flood damages in the Whitney Lake Subwatershed. The Project Team has established the following purpose and need statement:

> *The purpose of the proposed action is **Flood Damage Reduction:** Reduce damages to agricultural lands for a 10 year 24 hour storm (total 3.3 inches of rainfall) and reduce damages to roadways for a 25 year 24 hour storm event (total 3.9 inches of rainfall) in the Whitney Lake Subwatershed.*

The U.S. Army Corps of Engineers concurred with this purpose and need statement on November 16, 2017.

As outlined in Chapter 3 of the Project Team Handbook the next step in the Points of Concurrence process is to establish Concurrence Point 2: Array of Alternatives and Alternatives Carried Forward.

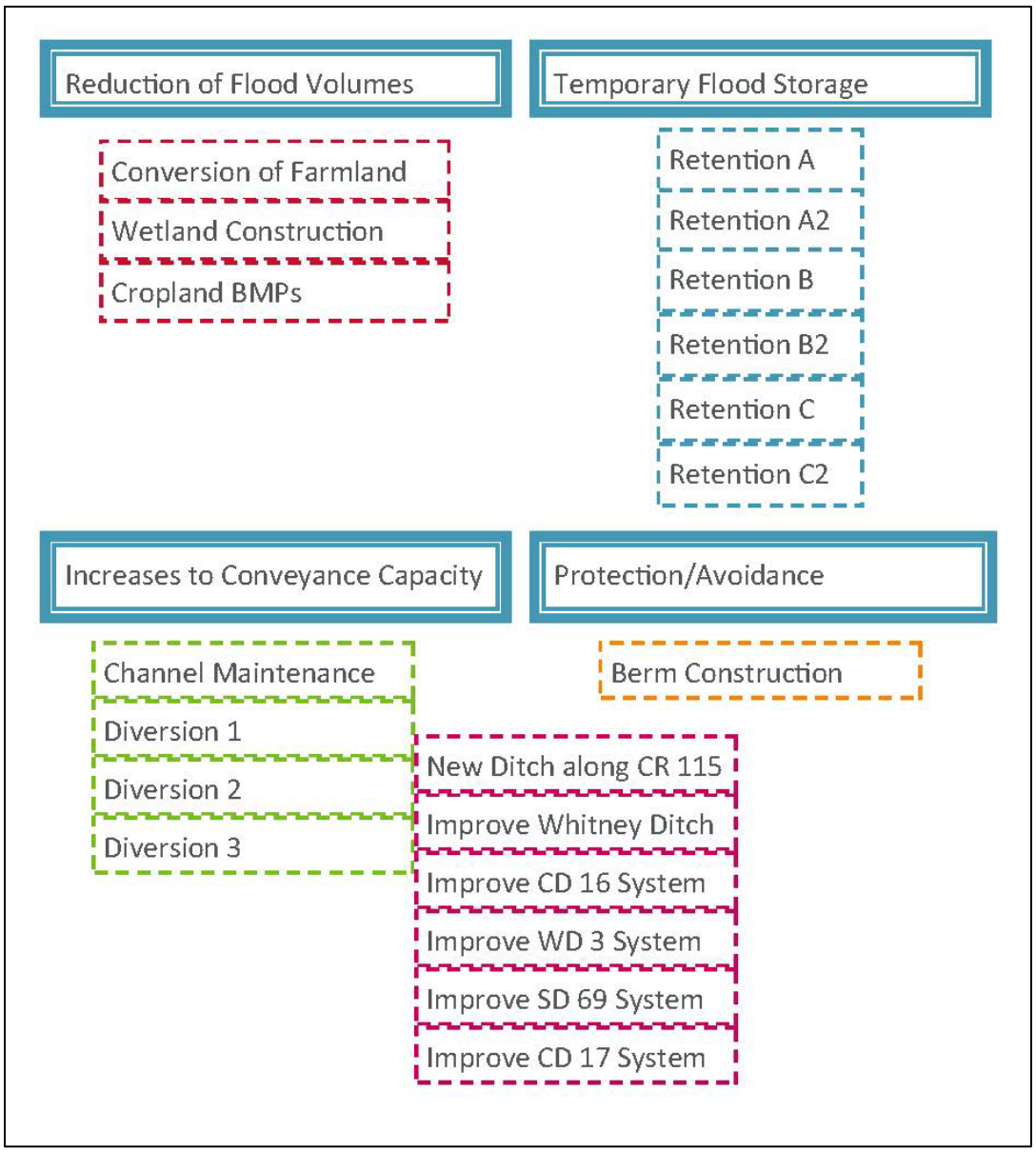
The full range of alternatives was developed from the strategies found in TP11, landowner meetings, and Project Team meetings. Members of the Whitney Lake Subwatershed Project Work Team are listed in Table 1.

The chart in Figure 1 lists the complete set of identified alternatives separated into the four strategies from TP 11.

Table 1. Whitney Lake Subwatershed Project Work Team

Name	Organization/Landowner
Jason Braaten	Roseau River Watershed District (RRWD)
Matt Fischer	Board of Water & Soil Resources (BWSR)
Brian Dwight	Board of Water & Soil Resources (BWSR)
Kristina Quaempts	Cheyenne Nation
Nate Dalager	HDR Engineering
Douglas Erickson	Landowner
Mark Foldesi	Landowner
Brent Haugen	Landowner
Jimmy Johnson	Landowner
Kevin Johnson	Landowner
Kasey Solberg	Landowner
Daryl Wicklund	Landowner
Natalie Weyaus	Mille Lacs Band of Ojibwe
Cary Hernandez	Minnesota Pollution Control Agency (MPCA)
Henry Van Offelen	MN Department of Natural Resources (DNR)
Stephanie Klamm	MN Department of Natural Resources (DNR)
Phil Talmage	MN Department of Natural Resources (DNR)
Dave Jones	Natural Resources Conservation Service (NRCS)
Roger Falk	Roseau County Commission
Russell Walker	Roseau County Commission
Brian Ketring	Roseau County Highway Department (RCHD)
Tracy Halstensgard	Roseau River Watershed District (RRWD)
LeRoy Carriere	Roseau River Watershed District (RRWD)
Scott Johnson	Soil & Water Conservation District (SWCD) Roseau Co.
Craig Jarnot	U.S. Army Corps of Engineers (USACOE)

Figure 1. Full Range of Alternatives Identified



INITIAL SCREENING OF ALTERNATIVES

The purpose of this document is to report the results of the Project Team's initial screening of types of alternatives that could meet the purpose and need and the selection of specific project options to be carried forward for further review. The first screening evaluates a "no permit" alternative and the four flood damage reduction "measures" described in Technical Paper 11 (TP11). In this first screening, each measure was evaluated in the context of the purpose and need. No other alternatives were identified by any member of the Project Team during the screening process.

No Permit: No-Action/Future Without Project (FWoP)

Decision: This scenario was considered and eliminated because it will not meet the purpose and need.

Rationale: Under the No Permit scenario, flood damages would continue to occur in the subwatershed during wet years. Breakout flows would continue to damage roads and repeatedly inundate farmland.

Measure 1: Reduce Runoff Volume

Decision: This flood damage reduction (FDR) measure was considered and eliminated because it will not meet the purpose and need.

Rationale: The primary land use in the Whitney Lake Subwatershed is agricultural (pasture, cultivated crop) and covers 82% of the watershed. The majority of the remaining land use (13.5%, 6,400 acres) is undeveloped while approximately 4.5% is developed. The undeveloped lands consist mostly of forested areas, and some open water and wetlands.

Taking land use in the Whitney Lake Subwatershed into consideration as well as the recommendations in TP11 the following reduction of flow volume strategies were evaluated:

- Converting crop land and pasture to wetlands
- Converting crop land and pasture to forested land
- Construction of wetlands
- Cropland best management practices (BMPs)

For reference, the pre-settlement vegetation based on Marschner's analysis of Public Land Survey notes is shown on Figure 2 (MN DNR).[1] A 12,844 acre wet prairie is located in the western portion of the pre-settlement subwatershed. The RRWD HEC-HMS hydrologic model was utilized to evaluate the effects of converting cropland and pasture to wetlands in the Whitney Lake Subwatershed. The assumption was made that the converted wetlands would fall under land cover type "Woody Wetlands." Figure 3 shows the land cover values after all cropland and pastures were reclassified as woody wetlands. Combining the reclassified land cover with the existing hydrologic soil types gives new runoff curve numbers representing a 100% conversion rate. The curve numbers increased slightly with this new land classification (Table 2). Running the hydrologic model with higher curve numbers results in slightly higher runoff volumes, due to less infiltration loses in the individual subwatersheds. The results are shown below in Table 3. In this case, converting cropland and pasture to wetlands

[1] ftp://ftp.gisdata.mn.gov/pub/gdrs/data/pub/us_mn_state_dnr/biota_marschner_presettle_veg/metadata/metadata.html

results in an increase in runoff volume and peak flows. Any lesser conversion rates would yield similarly small changes.

Table 2. Hydrologic Model Curve Numbers

Model Subbasin	Size (mi^2)	Existing Curve Number	Adjusted Curve Number
W26910	34.8	77	79
W26350A	25.1	77	78
W26470	31.7	76	78

Table 3. Hydrologic Model Results for 100% Conversion of Cropland and Pasture to Wetland

Modeled Rainfall Event	Change in Whitney Lake Subwatershed Peak Flow	Change in Whitney Lake Subwatershed Runoff Volume
10-Year 24-Hour Rainfall (3.3")	0%	1%
100-Year 24-Hour Rainfall (4.9")	0%	1%

The Whitney Lake Subwatershed hydraulic model was utilized to evaluate the impacts of converting all cropland and pasture to forested lands (Figure 4). This model utilizes a rain-on-grid input to represent excess precipitation, and HDR developed land cover regions based on NLCD data and aerial imagery. Each land cover region is assigned a manning's "n" value for flow calculations. In this case, manning's "n" values for all areas of cropland and pasture increased from 0.05 (pasture) or 0.06 (cropland) to 0.1 (trees). Results are shown in Table 4 below. Runoff volume in the subwatershed is minimally affected by converting to forested lands, so this measure to reduce runoff volume does not meet the purpose and need for the Whitney Lake Subwatershed. Creation of wetlands and/or cropland BMPs are also assumed to have minimal effects on the runoff peak flow and volume in this subwatershed.

Table 4. Hydraulic Model Results for 100% Conversion of Cropland and Pasture to Forested Land

Modeled Rainfall Event	Change in Whitney Lake Subwatershed Peak Flows	Change in Whitney Lake Subwatershed Runoff Volume
10-Year 24-Hour Rainfall (3.3")	6%	1%
100 Year 24 Hour Rainfall (4.9")	12%	3%

Figure 2. Existing Land Cover and Pre-settlement Vegetation in the Whitney Lake Subwatershed

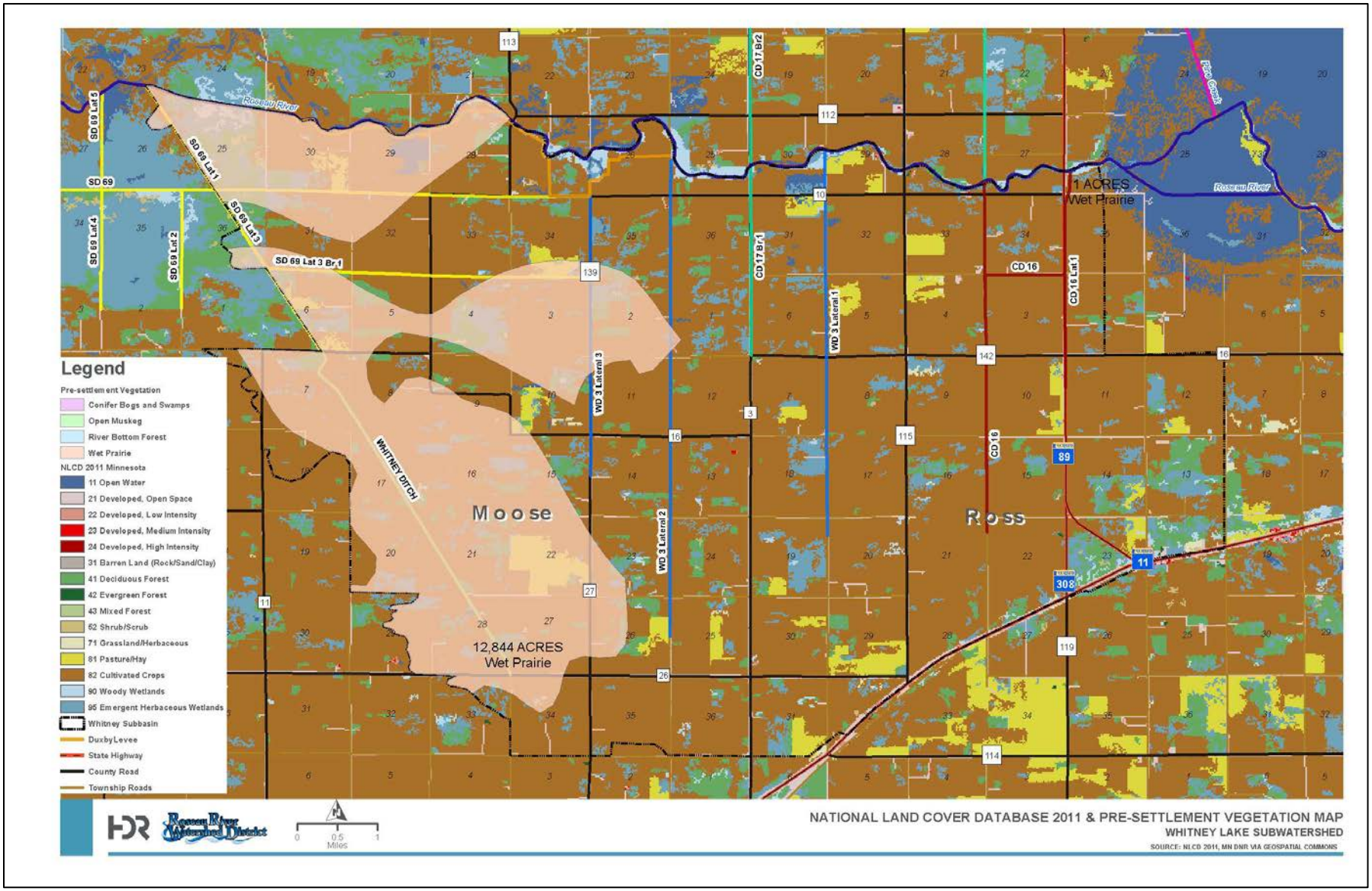


Figure 3. Reclassified Land Cover from Pasture/Hay and Cultivated Crops to Woody Wetlands

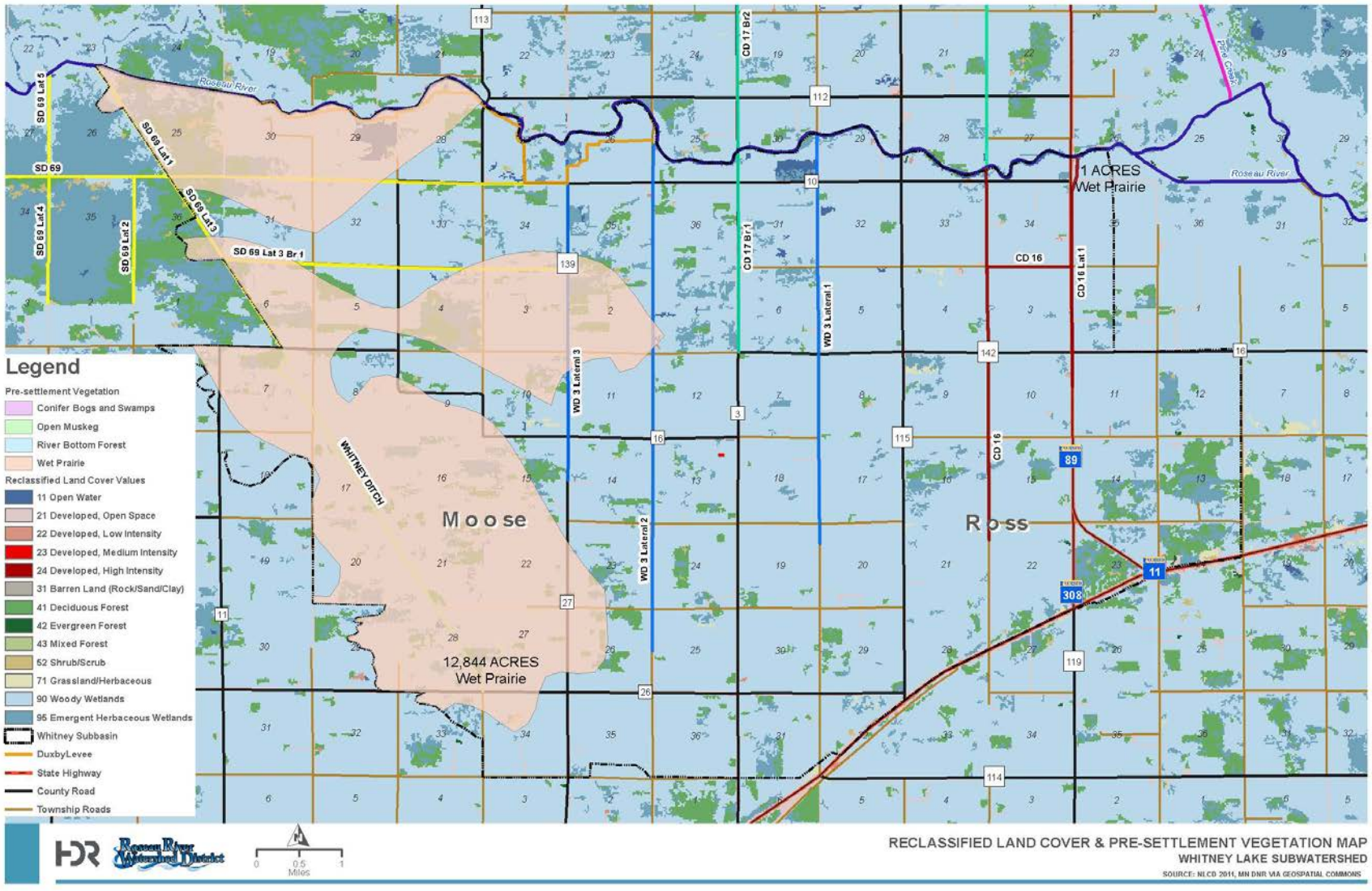
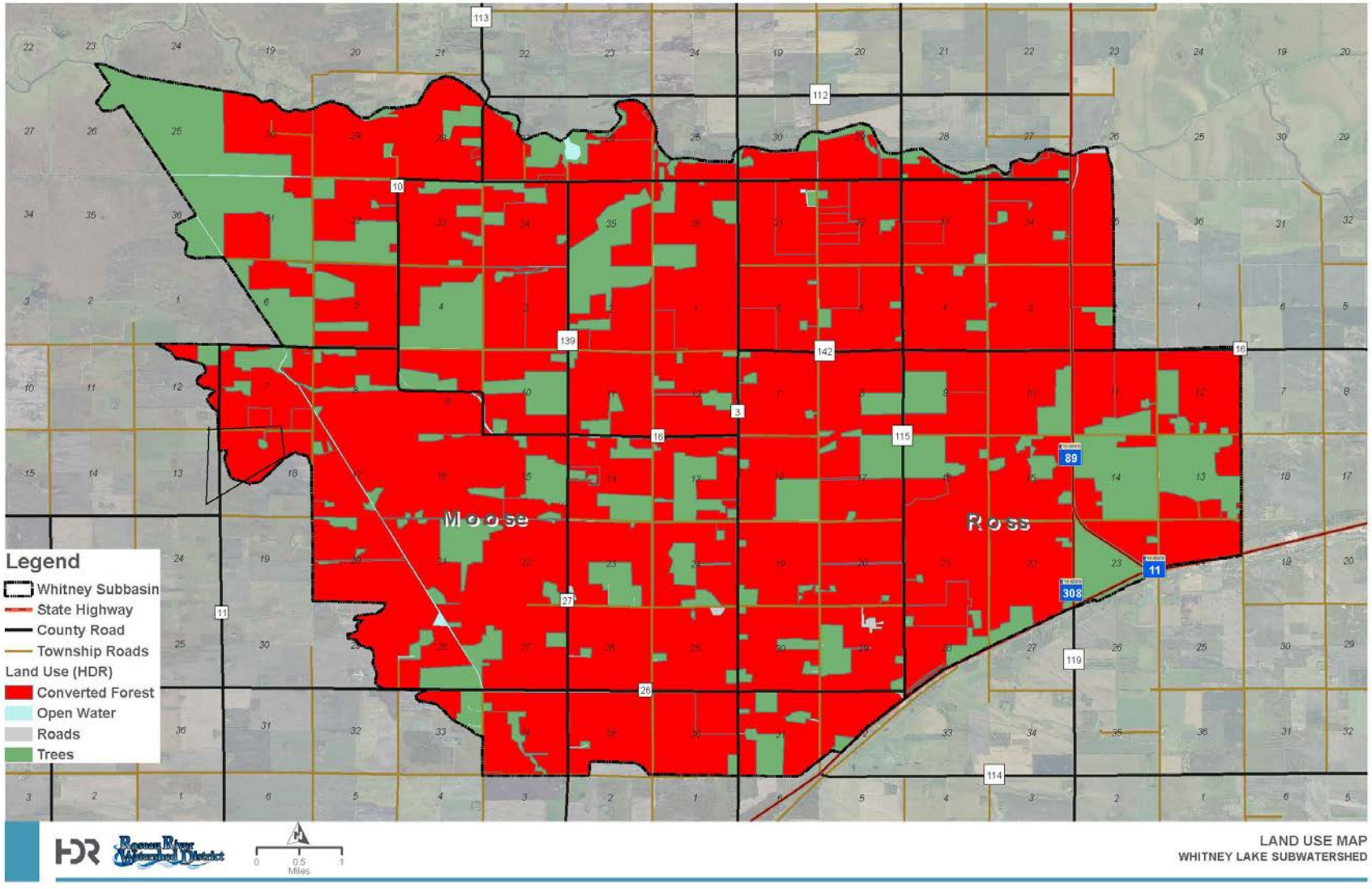


Figure 4. Conversion to Forest Areas (Increasing Manning's 'n' Values)



Measure 2: Increase Temporary Flood Storage

Decision: This FDR measure was considered and determined to have the potential to meet the purpose and need.

Rationale: Temporary flood storage would provide flow reduction benefits within the Whitney Lake Subwatershed including reducing inundation areas along the downstream legal ditches or reducing the duration of flooding during a local rainfall event in the subwatershed. In the selection of the retention basin locations, the *Preliminary feasibility analyses and the Roseau River Watershed District Expanded Distributed Detention Strategy* (HDR, 2013) report vetted strategic locations for flood storage within the Roseau River watershed. Three temporary storage options within the Whitney Lake Subwatershed were identified:

- Retention A – along State Ditch 69 (Whitney Ditch)
- Retention B – along County Ditch 17 Branch 1 and Watershed Ditch 3 Lateral 1
- Retention C – along County Ditch 16 Lateral 1

Figure 5 shows the three locations within the Whitney Lake Subwatershed. Also shown on the figure is the Roseau River 100-year floodplain (FEMA) and locations of buildings with a 500-foot radius around them. Technical Paper 11 suggests that this subwatershed, due to its location in the middle zone of the Roseau River Watershed, will effectively reduce peak flows downstream (near the Red River) through temporary flood storage. In other words, the Whitney Lake Subwatershed contributes to the middle of the hydrograph and has a strong effect on the peak of the Roseau River. Figure 6 shows that the Whitney Lake Subwatershed is located in the highest potential hydrological impact zone for the Roseau River. By definition, the 100-year floodplain is already storing flood waters from the Roseau River. The result of placing additional temporary flood storage in the 100-year floodplain could have two results. First, the storage could be used by early runoff from the Whitney Lake Subwatershed, but only after it flows through the upper portions of the subwatershed. This would cause the Roseau River to lose some of its potential floodplain storage which naturally occurs in the middle of the hydrograph and creates the most damaging flows downstream. The second possibility is that Roseau River water is temporarily stored in this area, and the Whitney Lake Subwatershed continues to experience flooding from local runoff. For these reasons, the 100-year floodplain is not being considered for temporary flood storage. Figure 7 shows the 100-year Roseau River flood model results along with the FEMA 100-year floodplain.

The Roseau County Environmental Services department develops, maintains, and enforces the Roseau County Floodplain Management Ordinance provisions in coordination with the MN DNR and the Roseau River Watershed District. The ordnance regulates the development in the flood hazard areas of Roseau County. A permit and engineering analysis would be required to build a retention site in this area.

Taking into account the areas that are not in the 100-year floodplain, or directly impacting buildings, the three retention areas become apparent (Figure 5). The exact locations were determined by storage potential and ability to direct flow into the storage area. Results of several meetings with the Project Team and landowners have helped develop some modifications to the preliminary retention concepts: Retention A2, B2, and C2; although the footprints of these sites are preliminary and will be evaluated in more detail in future phases of the Project.

Figure 5. Strategic Retention Locations

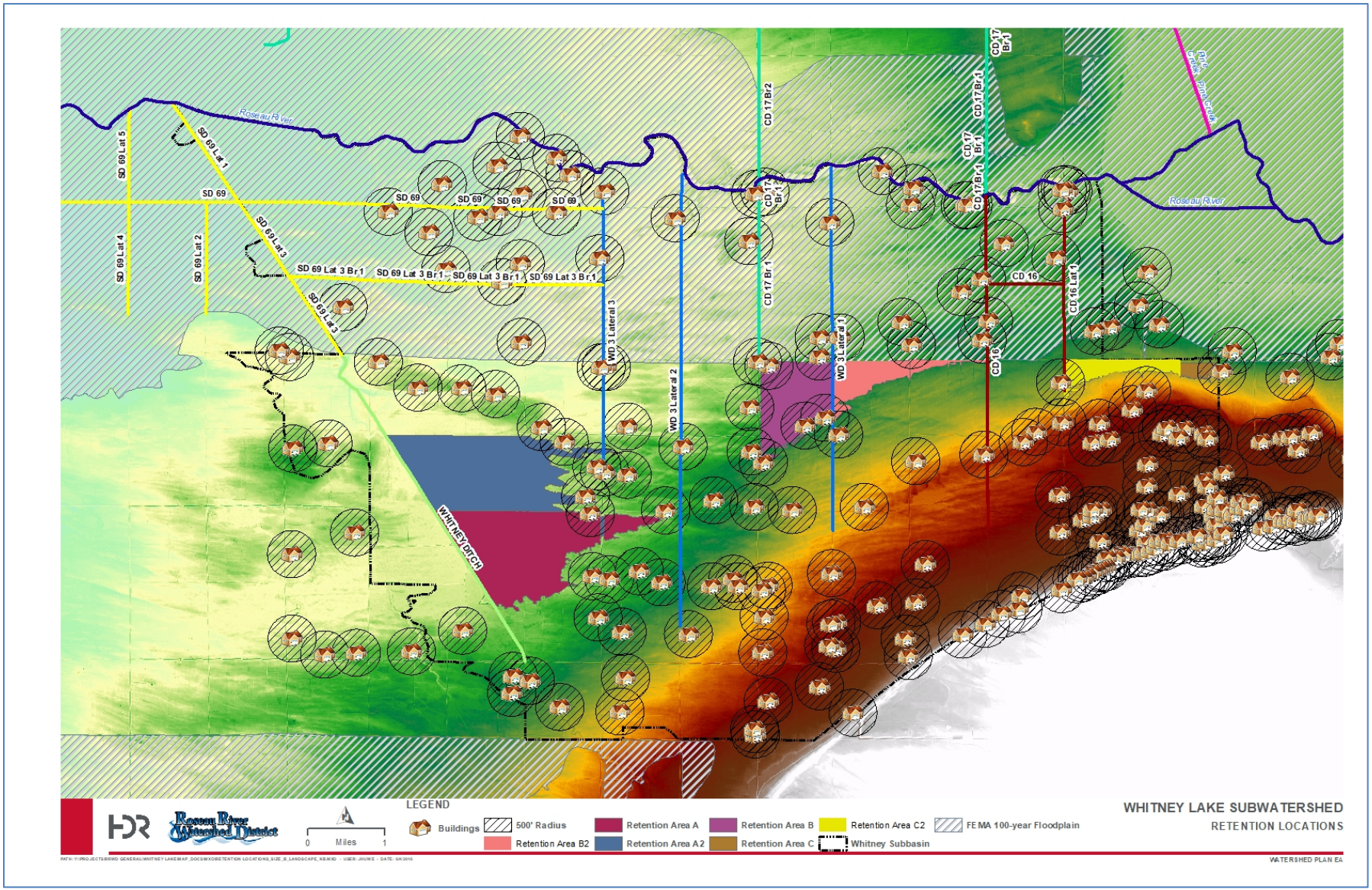


Figure 6. Hydrologic Impact Zones of the Roseau River

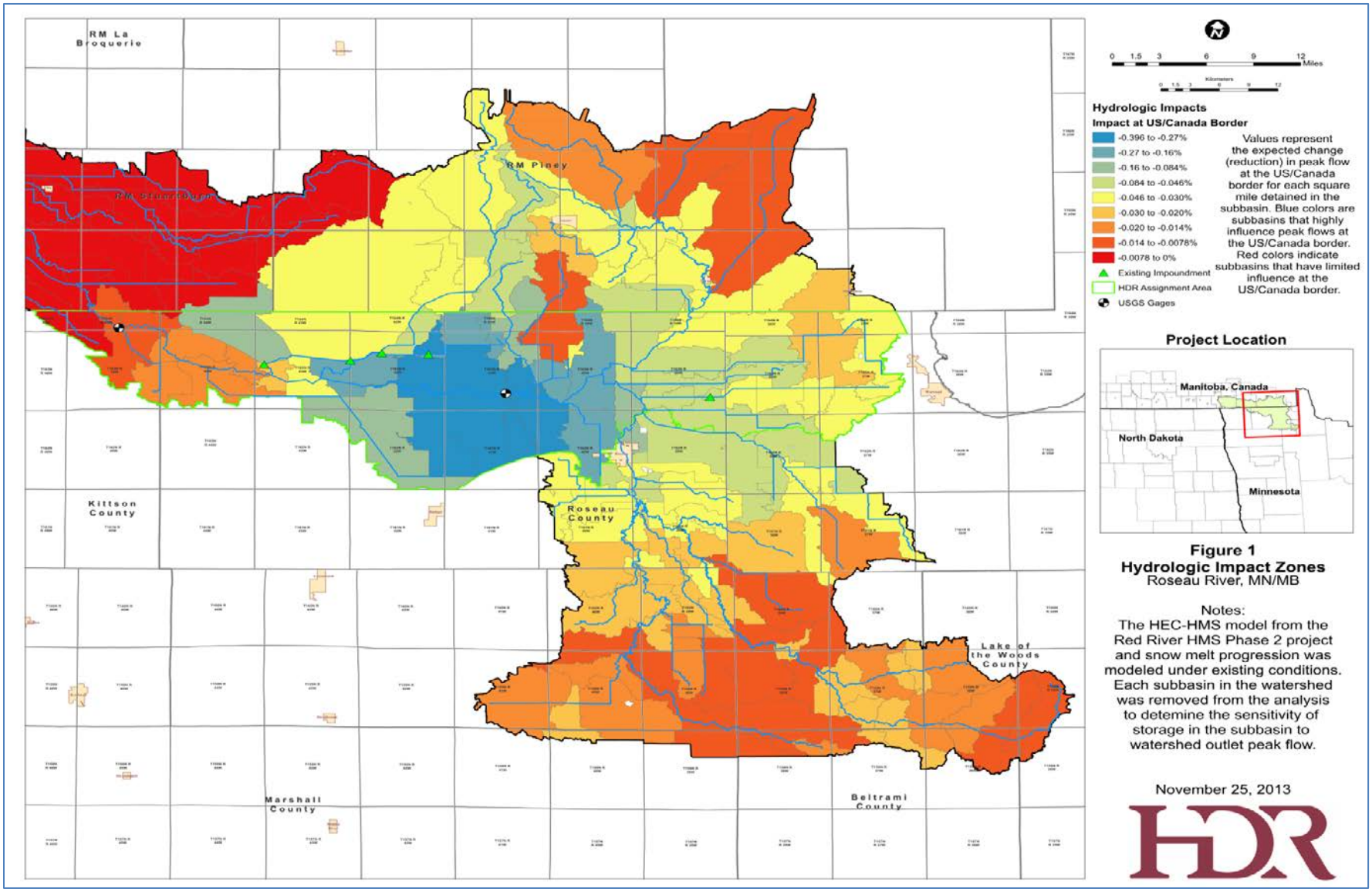
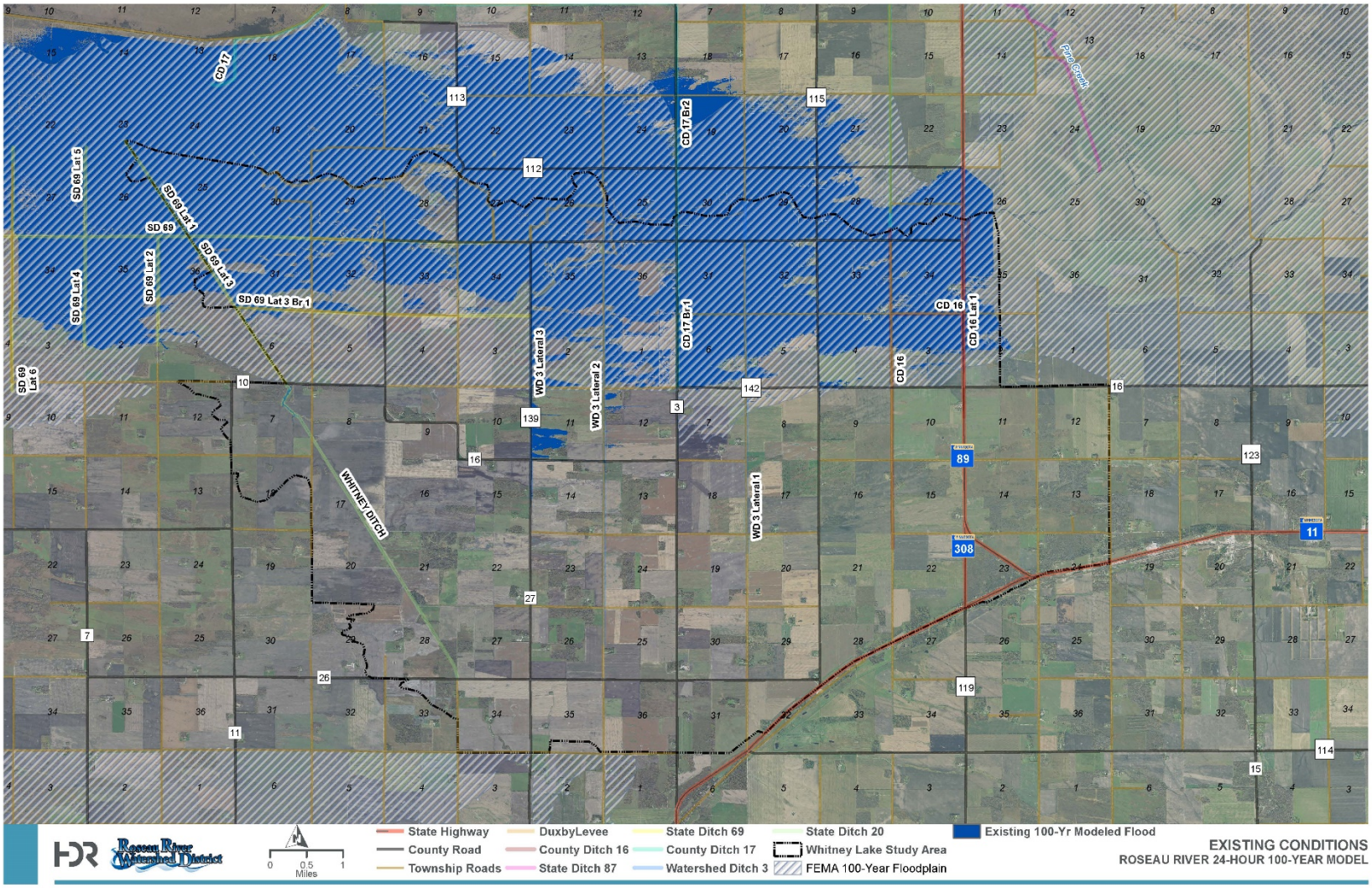


Figure 7. Roseau River 24-Hour, 100-Year Flood Model



Measure 3: Increase Conveyance

Decision: This FDR measure was considered and determined to have the potential to meet the purpose and need.

Rationale: Increases to legal ditch channel capacity were evaluated in the Whitney Lake Subwatershed. Potential means for increasing capacity could include:

- Channel maintenance such as clearing and grubbing, planting, and vegetation management within the downstream channel banks to reduce resistance to flow (reduce manning's "n" values within the channel)
- Increasing the size of road and field access culverts in order to allow water to flow more freely in the channel without backing up at crossing locations
- Channel widening to allow increased flows into the Roseau River
- Diversions from one or more legal ditch systems

According to the zoned mapping in Technical Paper 11, there would be "likely negative impacts to downstream flooding" in the Red River as a result of increasing conveyance capacities in the Whitney Lake Subwatershed. This strategy may not be able to stand alone as an alternative, but could be part of a comprehensive plan for the subwatershed. Modeling results show that channel maintenance and vegetation management may cause downstream impacts due to an increase to peak flow rates. Channel widening would also increase downstream peak flow rates and would likely require some upstream storage to mitigate the effects on the downstream systems. A diversion channel connecting one or more legal ditch systems would also increase flows at the location of its outlet and would require some temporary flood storage.

Based on existing flood problem locations in the watershed, existing infrastructure, and storage capacity of the retention basins, three diversion options were selected (Diversions 1, 2, and 3). These diversions were selected to connect to Retentions A and B (Retention C does not need a diversion, water would flow into it from existing ditches). Diversions 1, 2, and 3 will be discussed in detail in the Secondary Screening section of this report.

Measure 4: Avoidance and Protection

Decision: This FDR measure was considered and determined to have the potential to meet the purpose and need.

Rationale: The approach of protection or avoidance relies on removing assets from harm's way, building barriers to floodwaters in order to protect assets, or protecting structures and other assets from floodwaters through elevation or providing protective measures. The structures in the Whitney Lake Subwatershed are mostly protected by ring dikes or already built out of harm's way.

The alternative to protect agricultural lands in the Whitney Lake Subwatershed consists of constructing berms along drainage channels and installing side water inlet culverts. Berm construction would be in conjunction with the alternatives listed in the increased conveyance section.

SECONDARY SCREENING OF ALTERNATIVES

The alternatives discussed below fit under the Measure 2 (Increase Temporary Flood Storage), 3 (Increase Conveyance), and 4 (Avoidance and Protection) categories above. These scenarios have the potential to meet the project purpose and need but additional screening is needed to determine whether they should be carried forward for consideration in concurrence point 3.

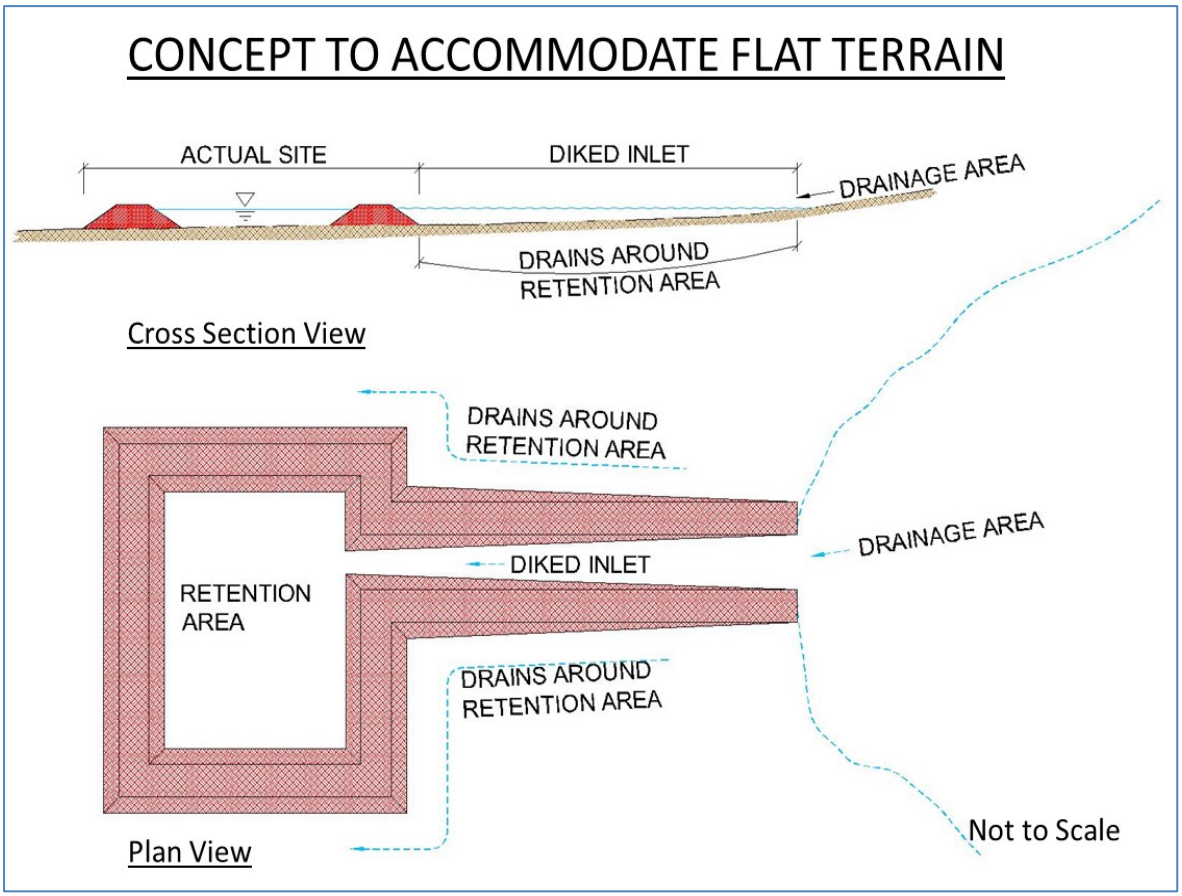
Alternatives Dismissed During Project Team Discussions

Three alternatives were discussed and dismissed during project team meetings:

Alternative 1: Retention Areas within 2 miles of the Roseau River.

This was dismissed because the topography in the area is so flat that storage is not a feasible option. Retention sites that are too flat (i.e. slopes less than 0.05%) require extensive work to build inlets that can fill and hold water up to a few feet above natural ground. Figure 8 depicts a concept designed to create retention area on very flat terrain. While this design can accommodate a flat terrain, the area within 2 miles of the Roseau River is part of the natural floodplain of the River and is not suitable for common retention sites (refer to initial screening section *Measure 2: Increase Temporary Flood Storage* for details).

Figure 8. Diked Inlet Concept Drawing



Alternative 2: Diversions within 2 miles of the Roseau River

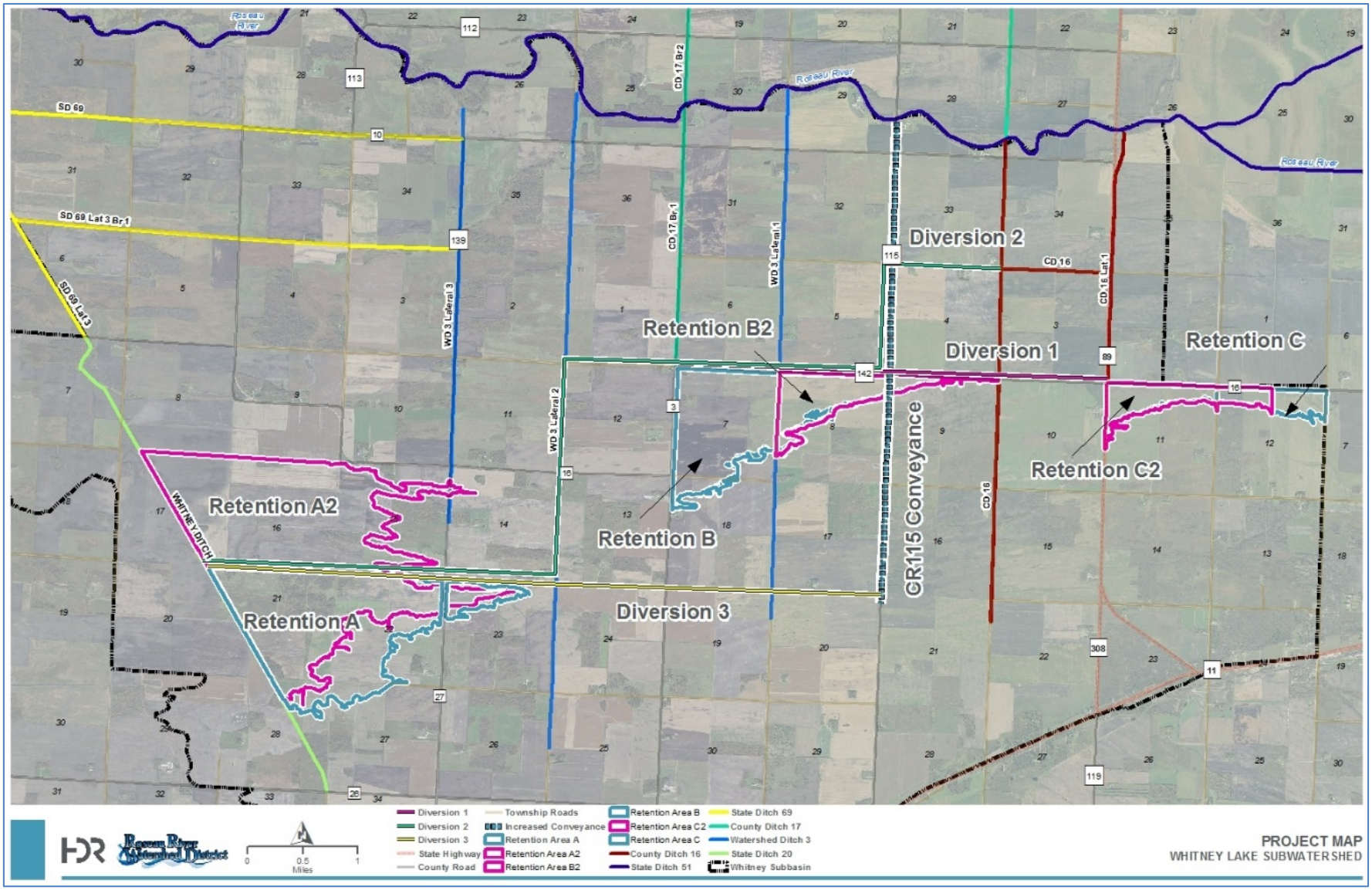
These were dismissed because the Roseau River would back up into the diversions and would have another path into the subwatershed.

Alternative 3: Outlet traps on ditches flowing into the Roseau River.

The purpose of this alternative was to prevent water in the Roseau River from backing up into existing ditches (a problem that currently occurs). This option was dismissed because it was determined that it would cause a slight increase in water surface elevation in the Roseau River. This alternative also depends on 100% installation and operation in order to effectively prevent Roseau River breakouts, which has proven to be difficult to maintain.

The following review includes an array of further alternatives. Figure 9 shows all of the alternatives evaluated in this section.

Figure 9. Alternatives Carried Forward for Secondary Screening



Alternatives: Increase Temporary Flood Storage

Alternatives 4 and 5: Retention Sites A or A2

Decision: Retention Site A carried forward, Retention Site A2 carried forward.

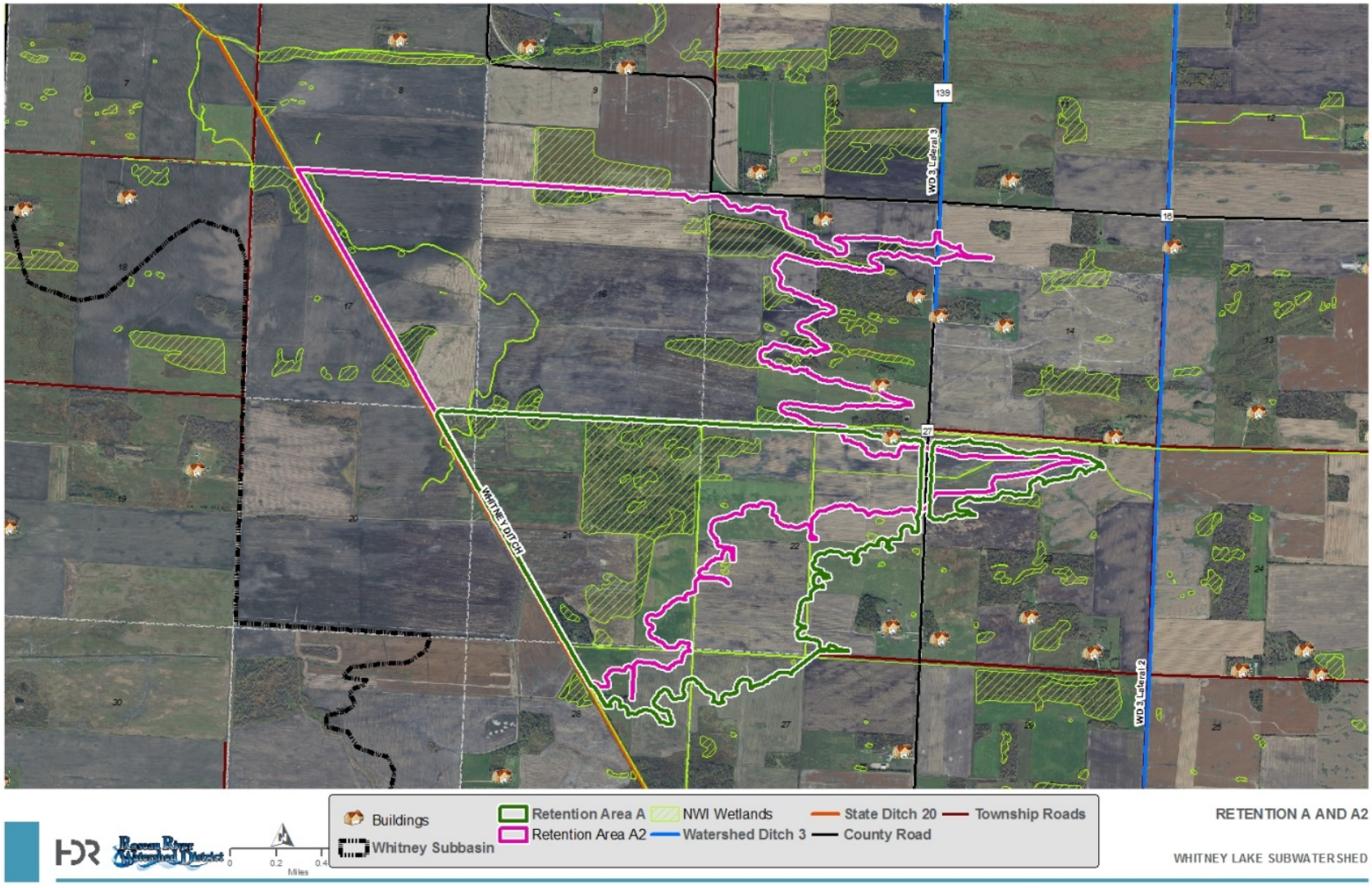
Rationale*:* Both Retentions Sites A and A2 have the potential to meet the purpose and need by providing temporary flood storage within the Whitney Lake Subwatershed and would have potential to provide flow reduction benefits to the Red River. Retention A and A2 are located along SD 69 as shown in Figure 10 below and have positive support of the current landowners in the area. At this point the impacts of Retention A2 appear to be higher than Retention A. Table 5 below shows direct (excavation and fill area for retention dikes) and indirect (pool footprint) National Wetland Inventory impacts for retention sites A and A2. Both sites are carried forward for more detailed analysis.

Table 5. Direct and Indirect National Wetland Inventory (NWI) Impacts for Retention A and A2

	Wetland Type	Retention A	Retention A2
NWI Indirect Impacts (Acres)	Freshwater Emergent	37.78	44.85
	Freshwater Forested/Shrub Wetland	185.96	259.19
	Freshwater Pond	0.3	0.45
	Lake	0	0
	Riverine	7.53	12.05
	TOTAL	**231.57**	**316.54**
NWI Direct Impacts (Acres)	Freshwater Emergent	0	1.38
	Freshwater Forested/Shrub Wetland	14.38	22.35
	Freshwater Pond	0.14	0.14
	Lake	0	0
	Riverine	7.75	6.94
	TOTAL	**22.27**	**30.81**

Details of flood storage, location, additional features, drainage areas, footprints, and embankment heights of Retention sites A and A2 are provided below.

Figure 10. Retention Site A and A2 footprints.



Retention A

This alternative consists of creating approximately 2,000 acre-feet of storage along the Whitney Ditch (aka SD 69). The full pool elevation of 1034.5 feet covers approximately 1,200 acres. Figure 11 shows the extent of various pool elevations.

Table 6 provides pool footprint and storage volume data for the various pool elevations. The pool elevation of 1034.5 was chosen as a balance between pool footprint, storage volume, and proximity to buildings.

The retention area would be constructed with earthen dikes located adjacent to and on the east side of the Whitney Ditch starting in Section 28 of Moose Township and running north and west to the north edge of Section 20 of Moose Township. The dikes would continue east from that point following the northern edge of Sections 20 – 22 of Moose Township aligned just to the south of the existing drainage ditch. An outlet structure would be constructed at the downstream point the dike comes to in Section 20 near the Whitney Ditch with gates to control the dewatering of the impoundment. Inlet structures will be needed to divert flows from the Whitney Ditch into the impoundment and promote filling of the impoundment. A pilot channel may be needed to direct runoff through the impoundment to the outlet at the northwest corner. The exact locations of the inlet structures and pilot channel will be determined in a future, detailed design phase.

The proposed drainage area for Retention A is approximately 9.7 square miles (approximately 13% of the Whitney Lake Subwatershed) (Figure 12). The protected area for Retention A is approximately 25.5 square miles (Figure 13, Table 7).

Figure 11. Retention A - Storage

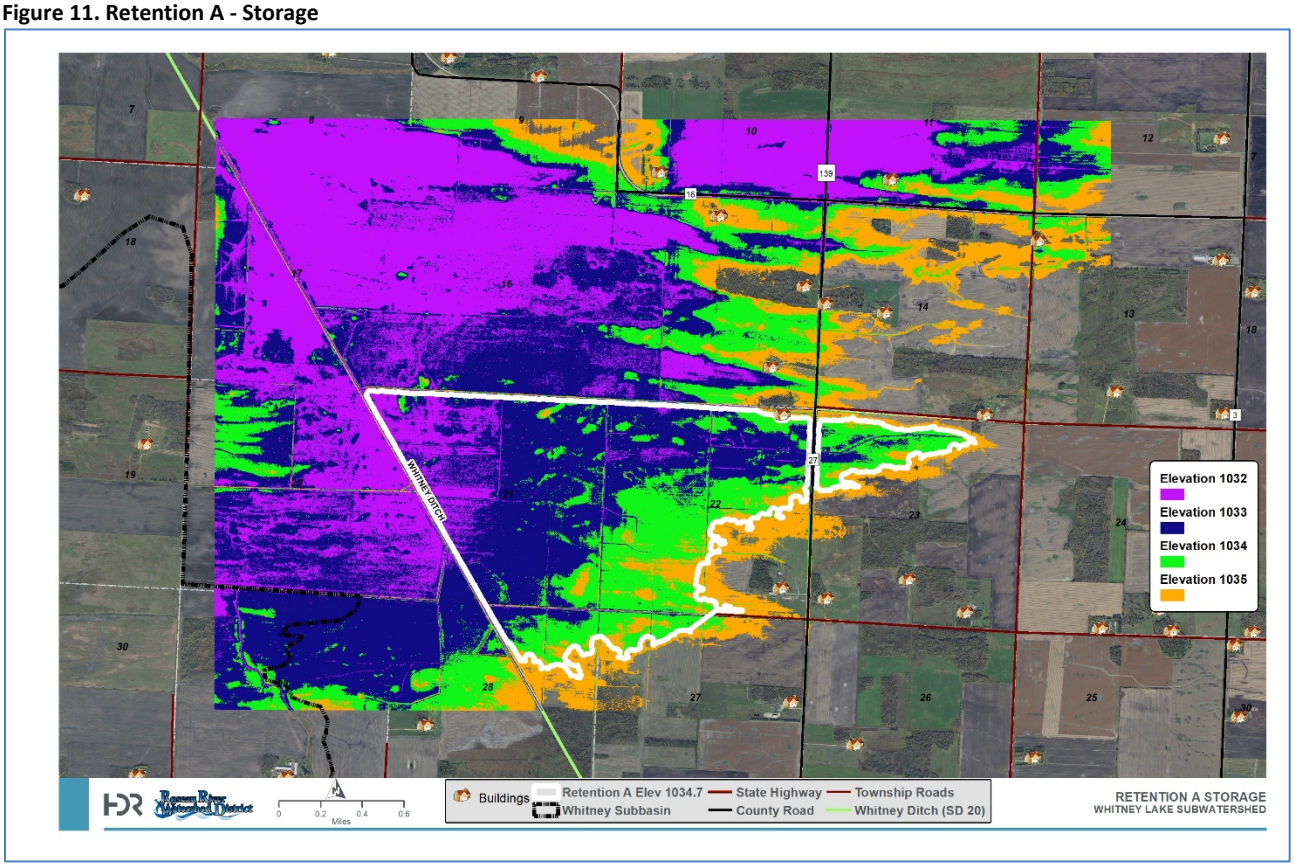


Table 6. Retention A - Pool Elevation, Pool Footprint, and Storage Volume Data

Max Pool Elevation (ft)	Pool Footprint (Acres)	Storage Volume (Acre-ft)
1035.0	1,206	2,561
1034.5	**1,197**	**1,959**
1034.0	1,118	1,375

Figure 12. Retention A and A2 Drainage Areas

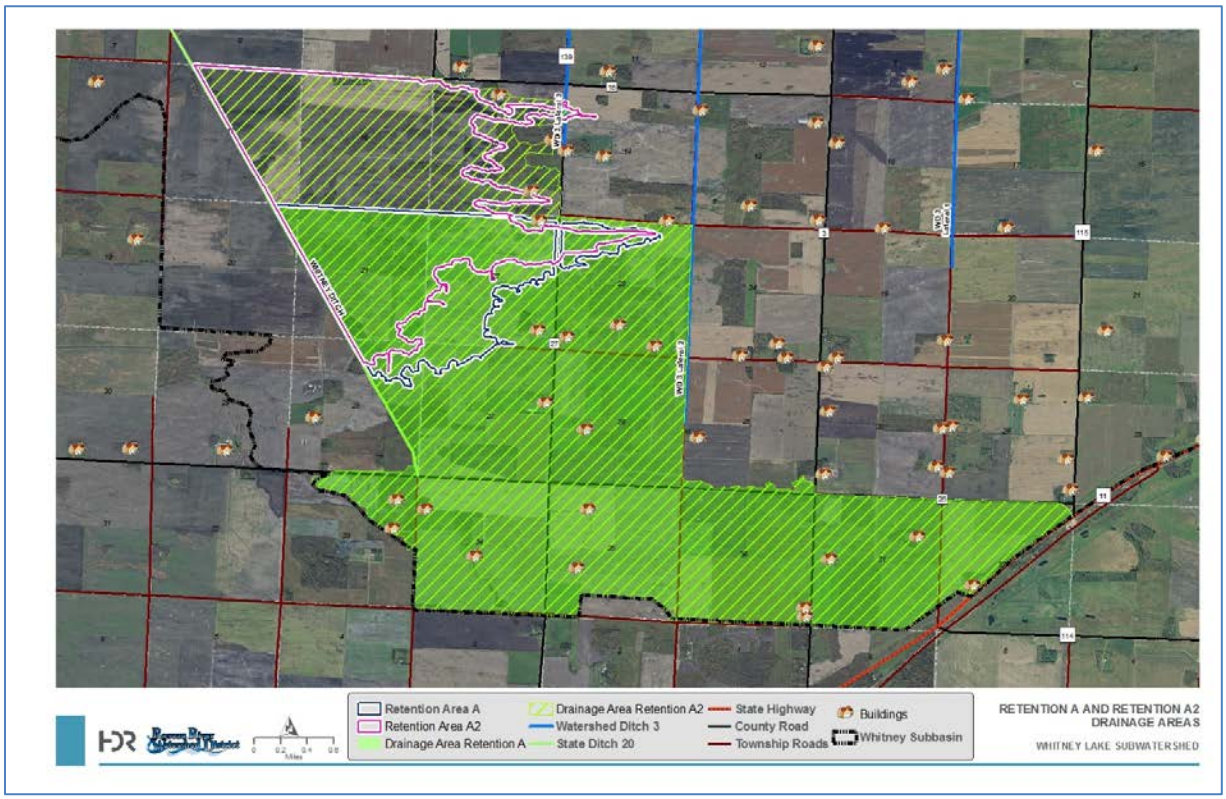


Figure 13. Retention A and A2 Drainage Areas and Benefitted Areas

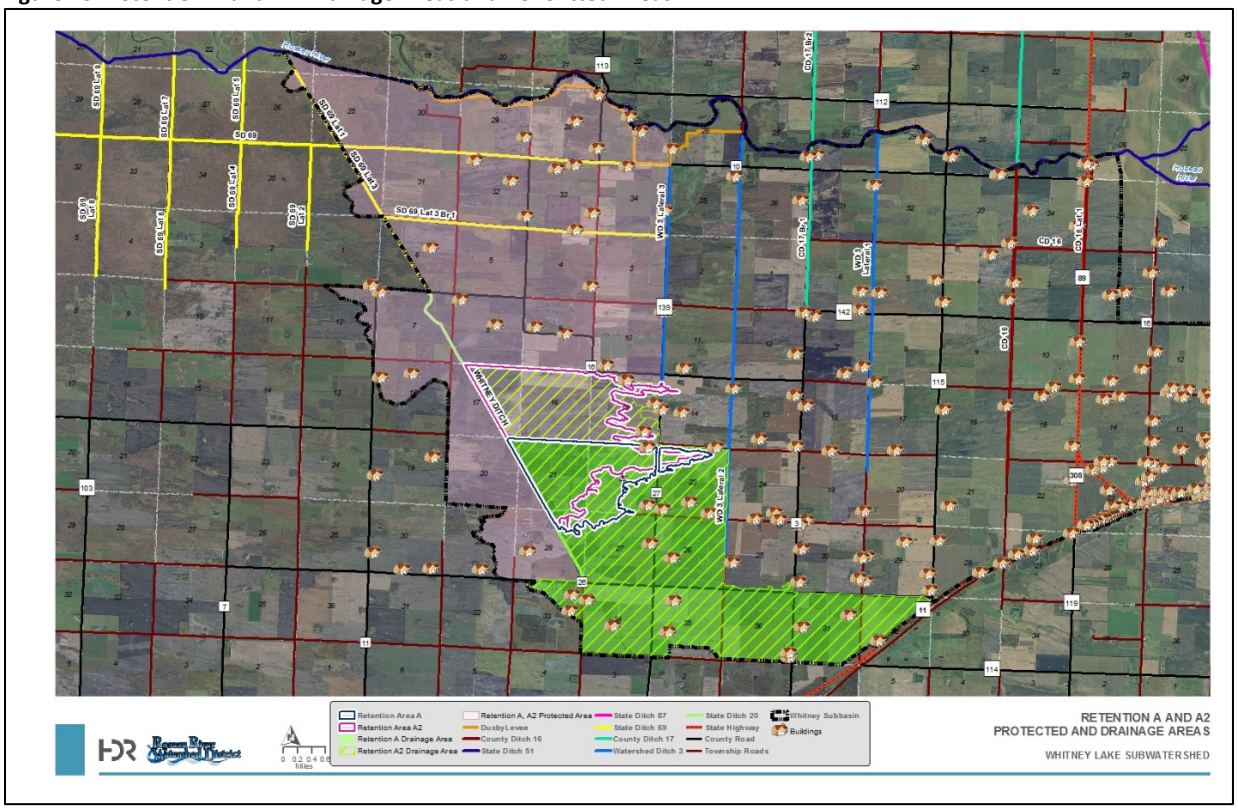


Table 7. Retention A and A2 – Drainage Area and Protected Area

	Retention A	Retention A2
Drainage Area (miles^2)	9.69	12.35
Protected Area (miles^2)	25.50	22.84

Retention A2

This alternative consists of creating approximately 1,800 acre-feet of storage along the Whitney Ditch. The full pool elevation of 1033.0 feet covers approximately 1,900 acres. Figure 14 shows the extent of various pool elevations. Table 8 provides pool footprint and storage volume data for the various pool elevations. The pool elevation of 1033.0 was chosen as a balance between pool footprint, storage volume, and proximity to buildings.

The retention area would be constructed as Retention A1 was described above, but the levee along the Whitney Ditch would start in Section 21 of Moose Township and continue north and west to the north edge of Section 17 of Moose Township. The dikes would continue east along the northern edge of Section 17 until the natural ground becomes high enough to tie into the top of the dike, which occurs near the northeast corner of Section 16 of Moose Township. An outlet structure would be constructed at the downstream point in Section 17 near the Whitney Ditch with gates to control the dewatering of the impoundment. Inlet structures will be needed to divert flows from the Whitney Ditch into the impoundment and promote filling of the impoundment. A pilot channel may be needed to direct runoff through the impoundment to the outlet at the northwest corner. The exact locations of the inlet structures and pilot channel will be determined upon detailed design.

The proposed drainage area for Retention A2 is approximately 12.4 square miles (approximately 17% of

the Whitney Lake Subwatershed) (Figure 12). The protected area for Retention A2 is approximately 22.8 square miles (Figure 13, Table 7).

Figure 14. Retention A2 - Storage

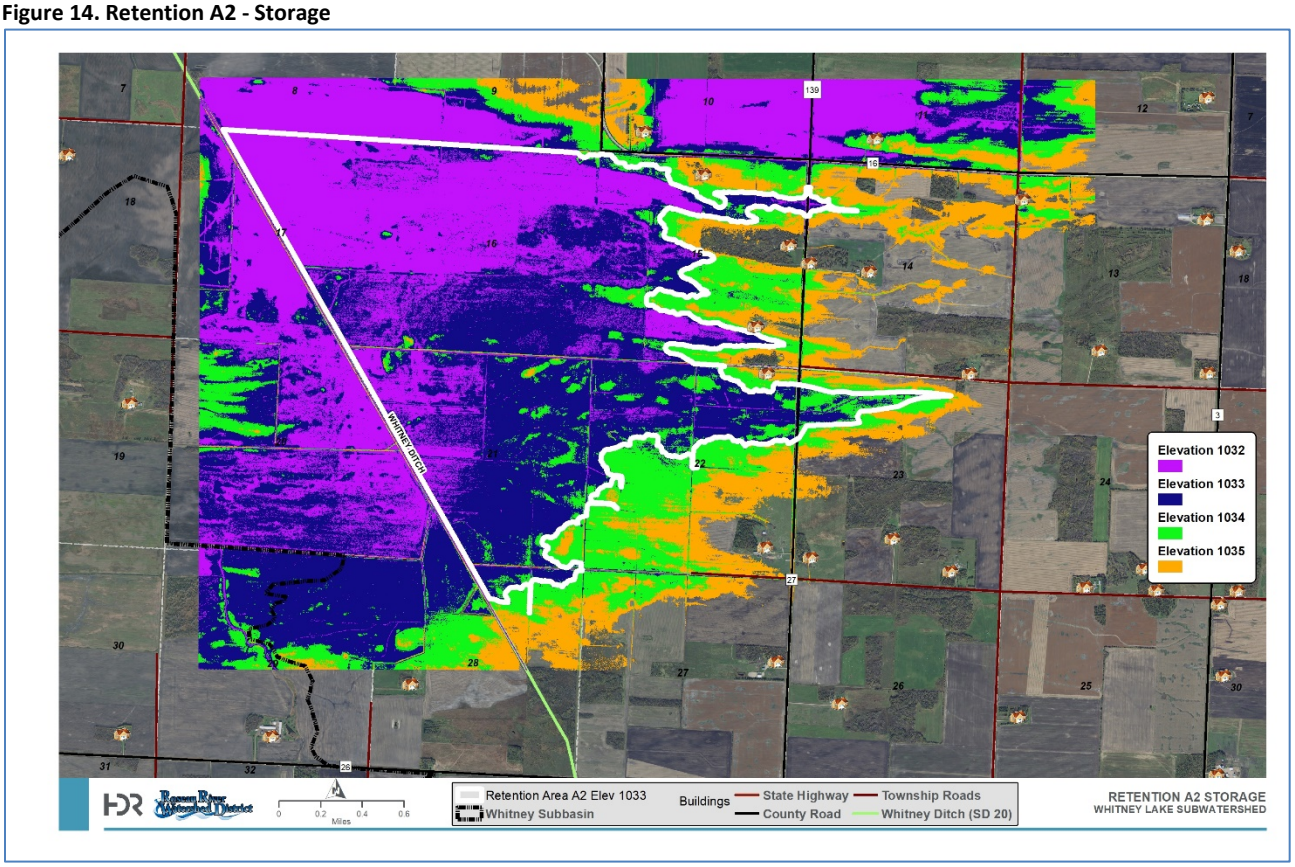


Table 8. Retention A2 - Pool Elevation, Pool Footprint, and Storage Volume Data

Max Pool Elevation (ft)	Pool Footprint (Acres)	Storage Volume (Acre-ft)
1034.0	2,077	3,834
1033.5	2,052	2,800
1033.0	**1,922**	**1,797**
1032.5	1,542	921
1032.0	869	304

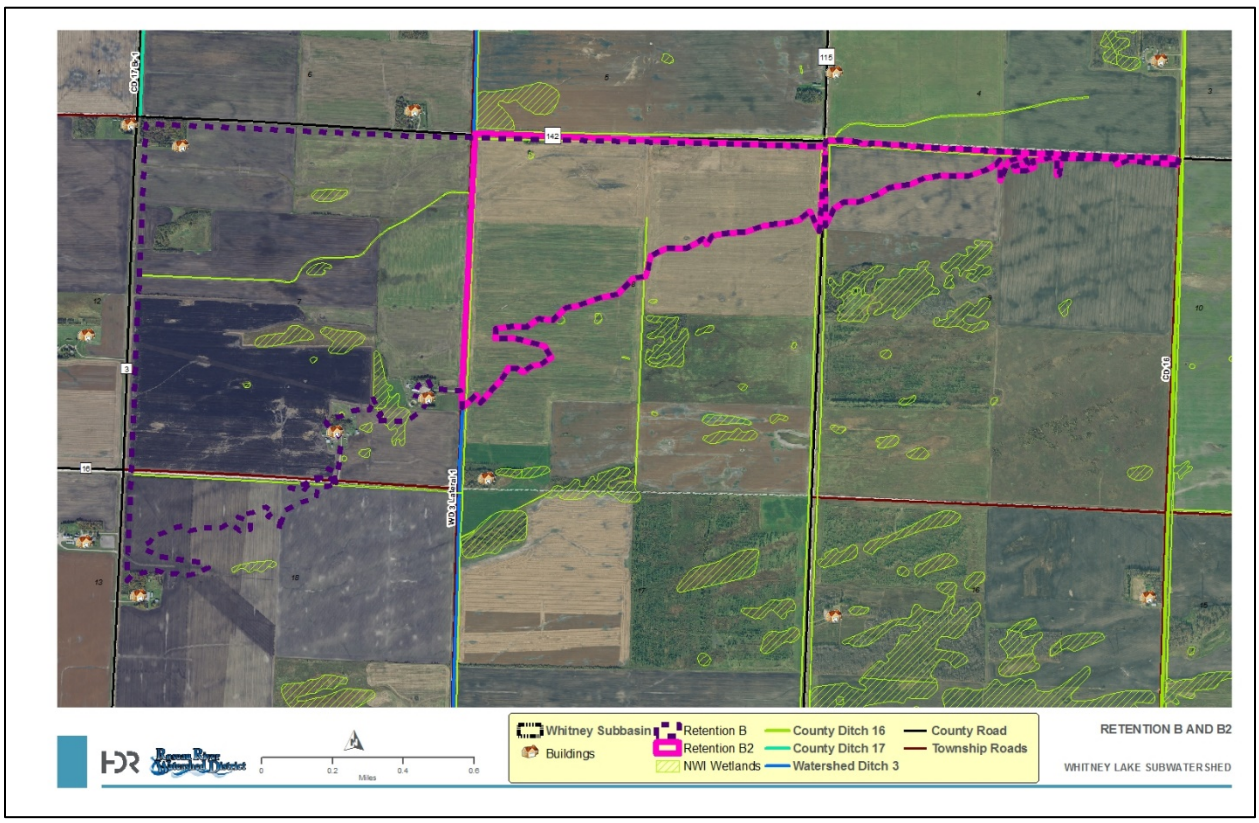
Alternatives 6 and 7: Retention Site B and B2

Decision: Dismissed.

Rationale: Retention Site B and B2 have the potential to meet the purpose and need by providing temporary flood storage within the Whitney Lake Subwatershed and would have potential to provide flow reduction benefits to the Red River. Retention B is located along CD 17 BR 1 as shown in Figure 15 below. National Wetland Inventory data shows 20.8 acres of wetland within the footprint of Retention B and 4.7 acres of wetland within the Retention B2 footprint (see Figure 15). However, both Retention sites were dismissed due to adamant opposition by landowners. Landowners within the site footprints and others within the Whitney Lake Subwatershed have expressed their displeasure with retention sites B and B2. Reasons for their dismissal include but are not limited to: the location of a home in the northwest corner of Retention Site B (Figure 15) and the current agricultural production that occurs in these sections of land. The RRWD Board of Managers is not willing to pursue condemnation of this property for the Project at this time, and for these reasons Retention B and B2 are dismissed from further consideration.

Details of flood storage, location, additional features, drainage areas, footprints, and embankment heights of Retention sites B and B2 are provided below.

Figure 15. Retention Site B and B2 footprints.



Retention B

This proposed retention site covers approximately 850 acres in sections 7 – 9 and 18 of Ross Township. The full pool elevation of 1039.5 feet provides 2,200 acre-feet of storage from a 9.1 mi^2 drainage area (12.4% of the Whitney Lake Subwatershed).

Figure 16 shows the extent of various pool elevations. Table 9 provides pool footprint and storage volume data for the various pool elevations. The pool elevation of 1039.5 was chosen for evaluation as a balance between pool footprint, storage volume, and proximity to buildings.

The proposed drainage area for Retention B is shown in Figure 17. The protected area for Retention B is approximately 9.3 square miles (Figure 18, Table 10).

The retention area has 4.1 miles of earthen dikes adjacent to County Road 3 on the west edge and County Road 142 on the north. The dike along County Road 3 begins in the north west ¼ of section 18 and continues north for 1.1 miles through the western ½ of section 7 before turning and going east along the northern ½ of section 7, continuing across section 8 and into section 9. The outlet structure is located in the northwest corner of section 7 and outlets into CD 17 Br 1. Inflows to the retention area are from the south along County Road 3, the southern 2 miles of WD 3 Lat 1, and along County Road 115. A diversion (Diversion 1) also brings flow from the CD 16 system into this retention area from the east.

Figure 16. Retention B - Storage

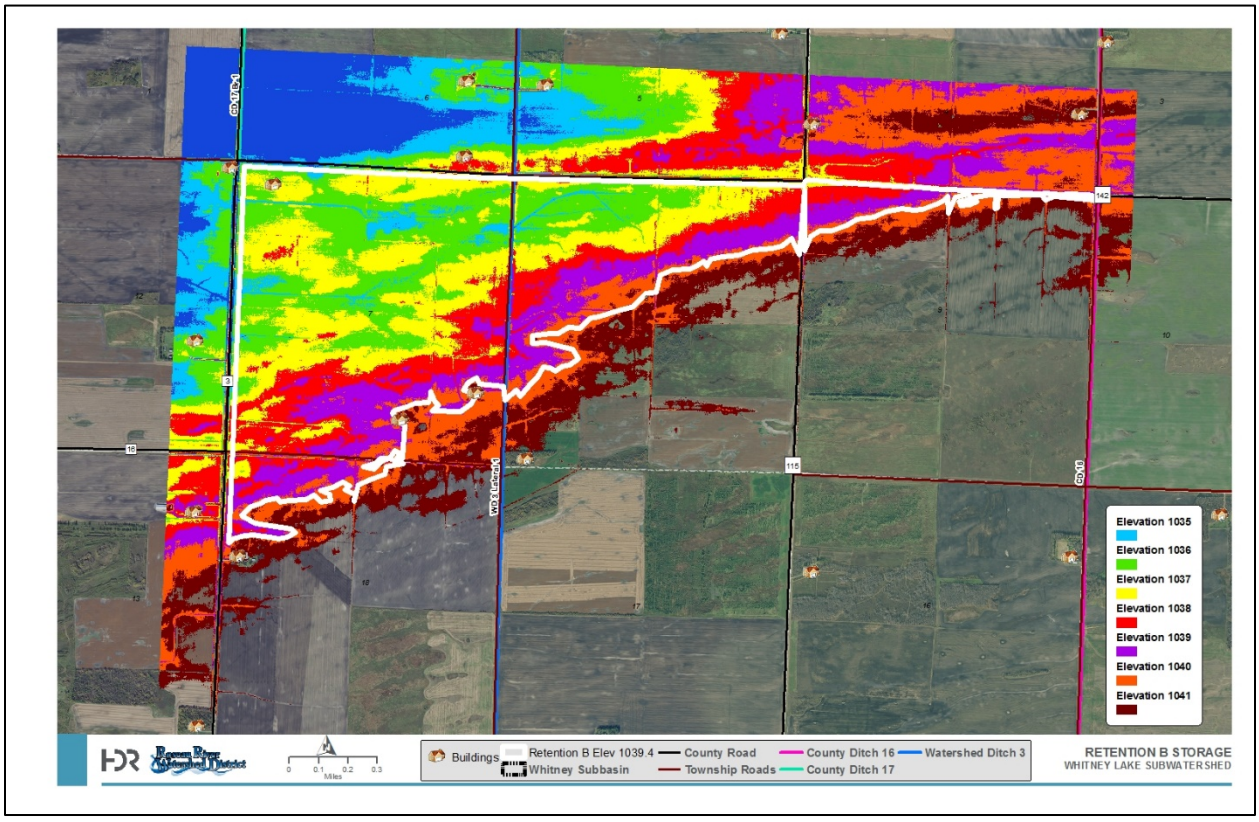


Table 9. Retention B - Pool Elevation, Pool Footprint, and Storage Volume Data

Max Pool Elevation (ft)	Pool Footprint (Acres)	Storage Volume (Acre-ft)
1041	871	3,530
1040.5	870	3,095
1040	868	2,660
1039.5	**859**	**2,227**
1039	805	1,808
1038.5	724	1,426
1038	646	1,083

Figure 17. Retention B and B2 Drainage Areas

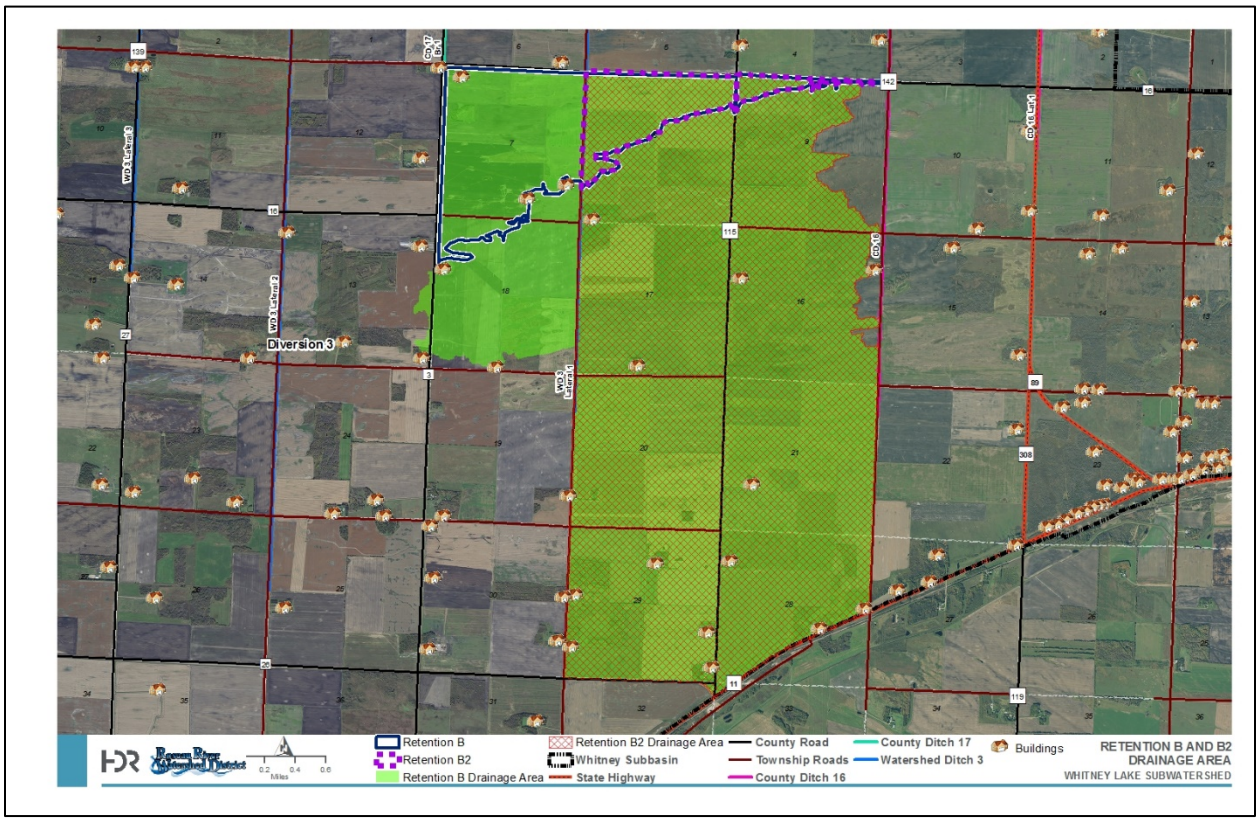


Figure 18. Retention B and B2 Drainage Areas and Benefitted Areas

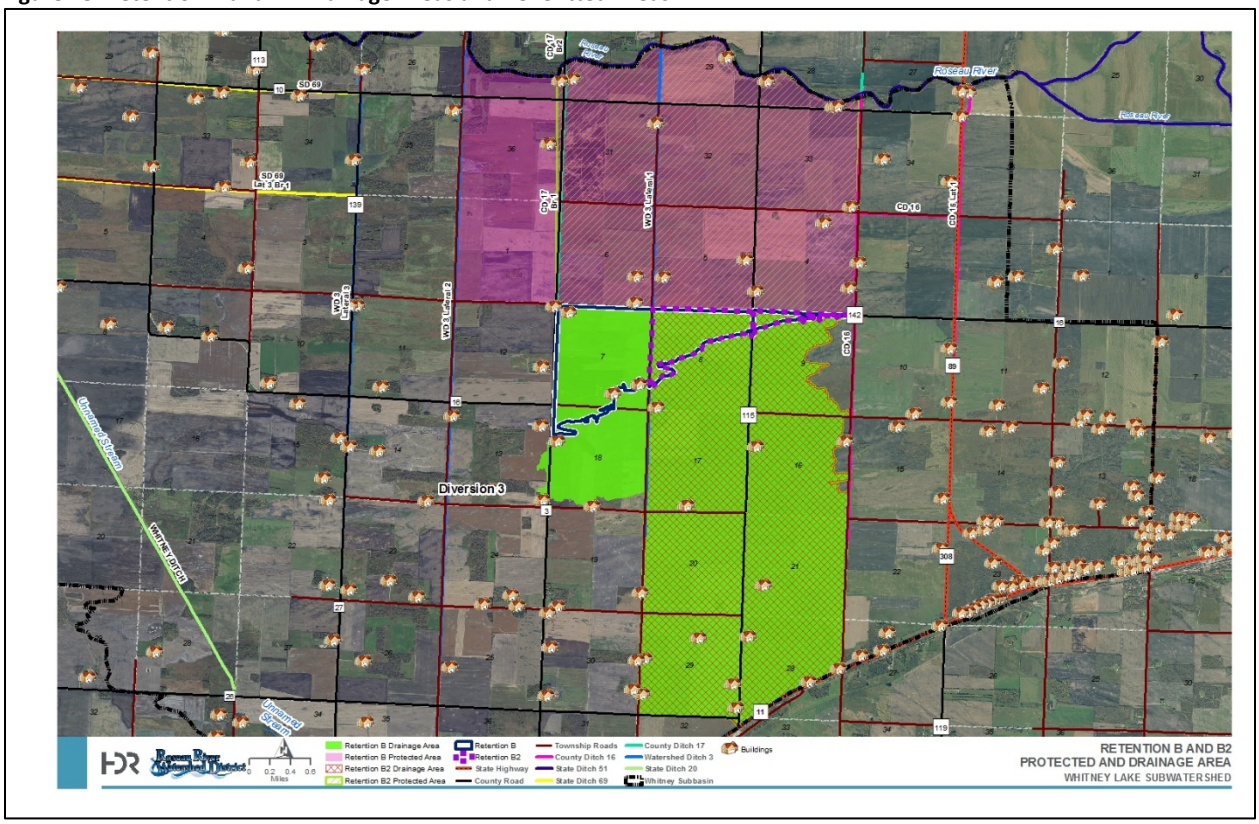


Table 10. Retention B and B2 – Drainage Area and Protected Area

	Retention B	Retention B2
Drainage Area (miles^2)	9.16	7.36
Protected Area (miles^2)	9.29	7.09

Retention B2

This proposed alternative to Retention B has a smaller footprint and storage potential. It simply removes the part of Retention B that covered section 7 and 18 of Ross Township. This retention site covers approximately 300 acres in sections 8 and 9 of Ross Township. The full pool elevation of 1041 feet provides 1000 acre-feet of storage from a 7.4 mi^2 drainage area (9.9% of the Whitney Lake Subwatershed).

Figure 19 shows the extent of various pool elevations. Table 11 provides pool footprint and storage volume data for the various pool elevations. The pool elevation of 1041.0 was chosen for evaluation as a balance between pool footprint, storage volume, and proximity to buildings.

The drainage area for Retention B2 is shown in Figure 17. The protected area for Retention B2 is approximately 7.1 square miles (Figure 18, Table 10).

The retention area has 2.4 miles of earthen dikes adjacent to WD 3 Lat 1 on the west edge and County Road 142 on the north. The dike along WD 3 Lat 1 begins in the south west ¼ of section 8 and continues north for 0.4 miles through the western ½ of section 8 before turning and going east along the northern ½ of section 8 and into section 9. The outlet structure is located in the northwest corner of section 8 and outlets into WD 3 Lat 1. Inflows to the retention area are from the southern 2 miles of WD 3 Lat 1, and

flow along County Road 115. A diversion (Diversion 1) also brings flow from the CD 16 system into this retention area from the east.

Figure 19. Retention B2 - Storage

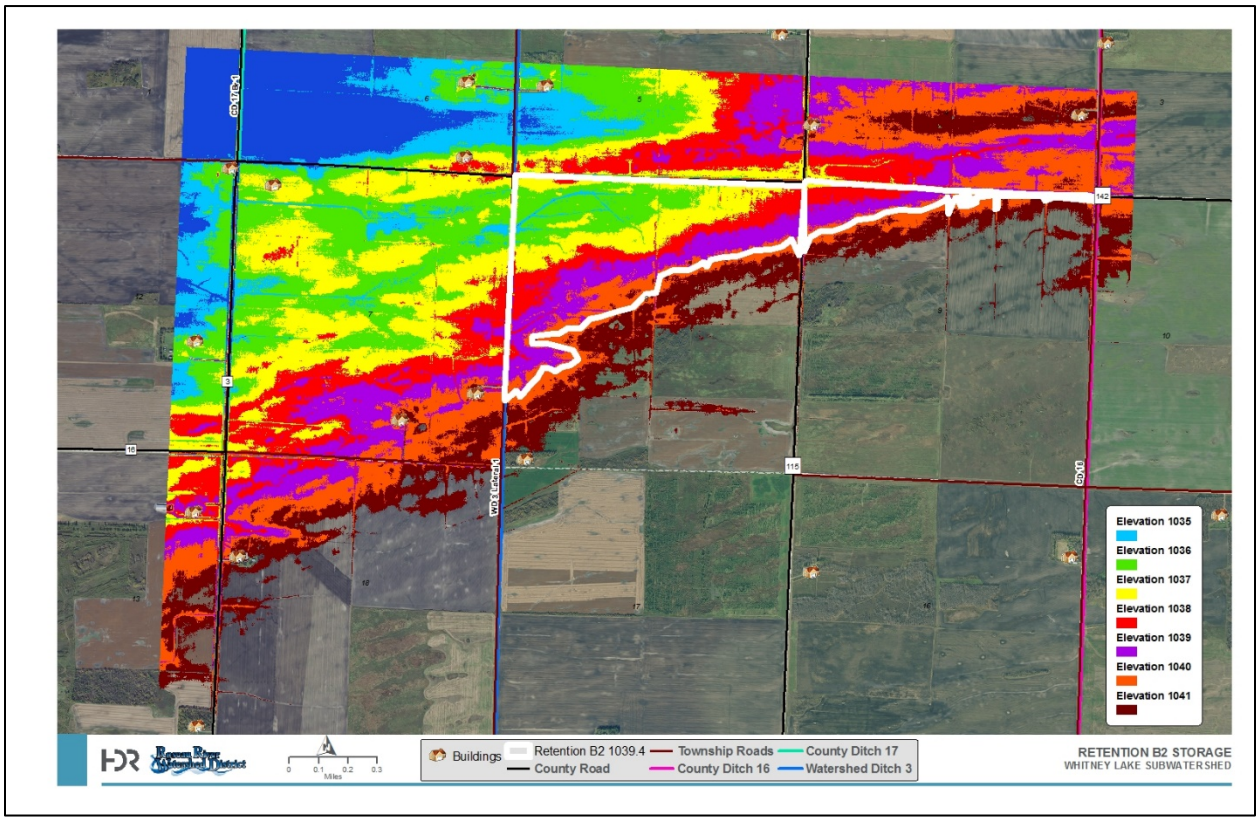


Table 11. Retention B2 - Pool Elevation, Pool Footprint, and Storage Volume Data

Max Pool Elevation (ft)	Pool Footprint (Acres)	Storage Volume (Acre-ft)
1041	**295**	**1,054**
1040.5	294	907
1040	293	760
1039.5	286	615
1039	254	478
1038.5	210	362
1038	174.9	266.7

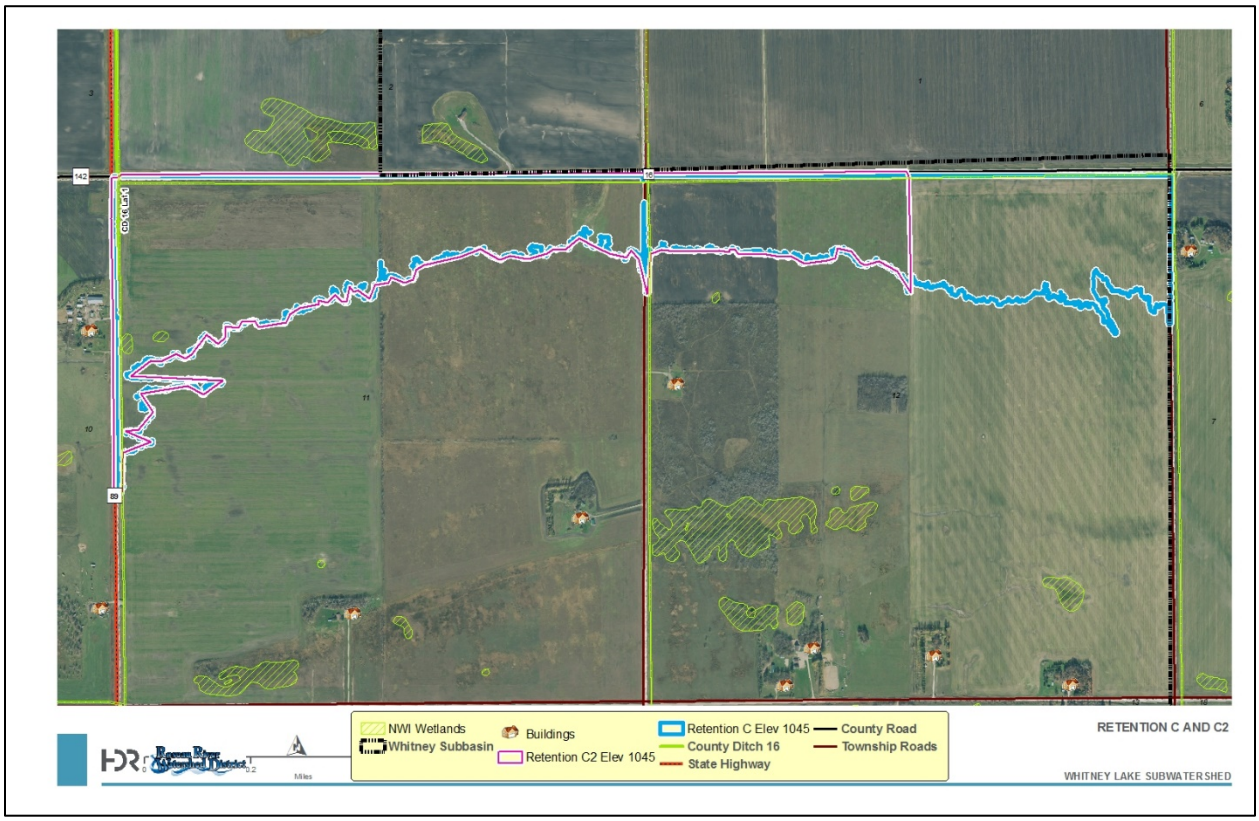
Alternatives 8 and 9: Retention Sites C or C2

***Decision**:* Retention Site C2 carried forward, Retention Basin C dismissed.

Rationale: Both Retentions Sites C and C2 have the potential to meet the purpose and need by providing temporary flood storage within the Whitney Lake Subwatershed and would have potential to provide flow reduction benefits to the Red River. Retention C and C2 are located along CD 16 LAT 1 as shown in Figure 20 below. National Wetland Inventory data shows 0.5 acres of wetlands within the footprint of Retention C and 0.5 acres of wetland within the Retention C2 footprint (see Figure 20). After further analysis of the sites, Retention Site C2 will be carried forward. In Retention Site C, the land in the eastern half of section 12 is profitable cropland that drains to Roseau Lake and not into the Whitney Lake Subwatershed. In addition, Retention C2 will still be able to contain the 25 year storm event, and has a smaller footprint than Retention C. In summary, Retention Site C2 functions more effectively than Retention C.

Details of flood storage, location, additional features, drainage areas, footprints, and embankment heights of Retention sites C and C2 are provided below.

Figure 20. Retention C and C2 Site Footprints



Retention C

This alternative has approximately 2,200 acre-feet of storage along CD 16 Lat 1. The full pool elevation of 1049.5 feet covers approximately 580 acres.

The retention area has earthen dikes located adjacent to and on the east side of MN Highway 89 starting

in section 11 of Ross Township and continues north to the north edge of Section 11. The dikes continue east adjacent to County Road 16 on the south side for two miles and then turn south along the east edge of section 12 of Ross Township. The dikes continue south along the west side of the township road until natural ground ties into the top of the dike, which occurs about one-half mile south of CR 16. An outlet structure is located in the northwest corner of section 11 near CD Lat 1 with gates to control the dewatering of the impoundment. Inlet structures divert flows from CD 16 Lat 1 into the impoundment and promote filling of the impoundment.

The drainage area for Retention C is approximately 5.0 square miles (approximately 6.8% of the Whitney Lake Subwatershed). Due to this relatively small drainage area, this alternative has smaller levees and controls the same drainage area up to a 25-year event. A full pool elevation of 1045.0 covers 235 acres and provides up to 350 acre-feet of storage. There are significant cost savings from reducing the height of the levees.

Figure 21 shows the extent of various pool elevations. Table 12 provides pool footprint and storage volume data for the various pool elevations.

The proposed drainage area for Retention C with a full pool elevation of 1045.0 is shown in Figure 22. The protected area for Retention C with a full pool elevation of 1045.0 is approximately 6.0 square miles (Figure 23, Table 13).

Figure 21. Retention C - Storage

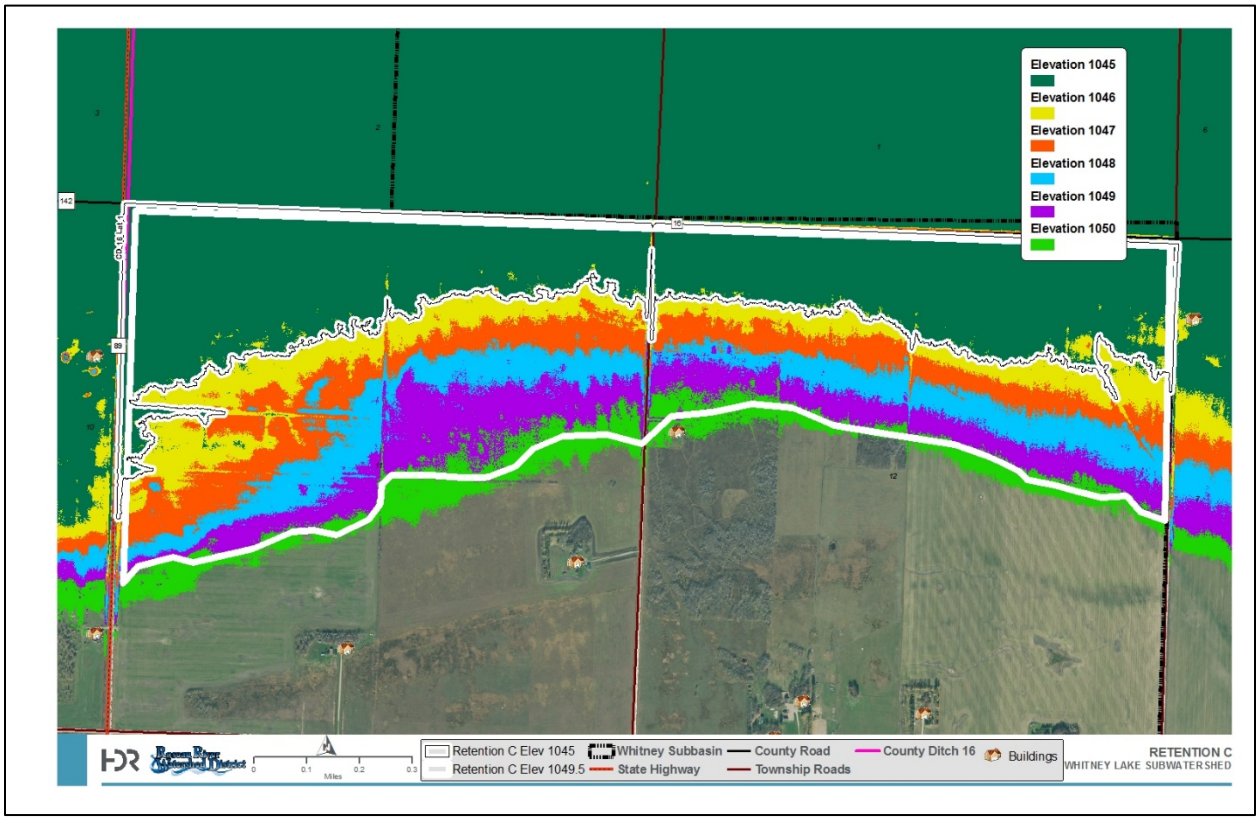


Table 12. Retention C - Pool Elevation, Pool Footprint, and Storage Volume Data

Max Pool Elevation (ft)	Pool Footprint (Acres)	Storage Volume (Acre-ft)
1050.0	581	2,513
1049.5	578	2,223
1049.0	554	1,938
1048.5	514	1,671
1048.0	475	1,424
1047.5	438	1,196
1047.0	402	986
1046.5	362	795
1046.0	321	624
1045.5	279	474
1045.0	**235**	**346**

Figure 22. Retention C and C2 Drainage Areas

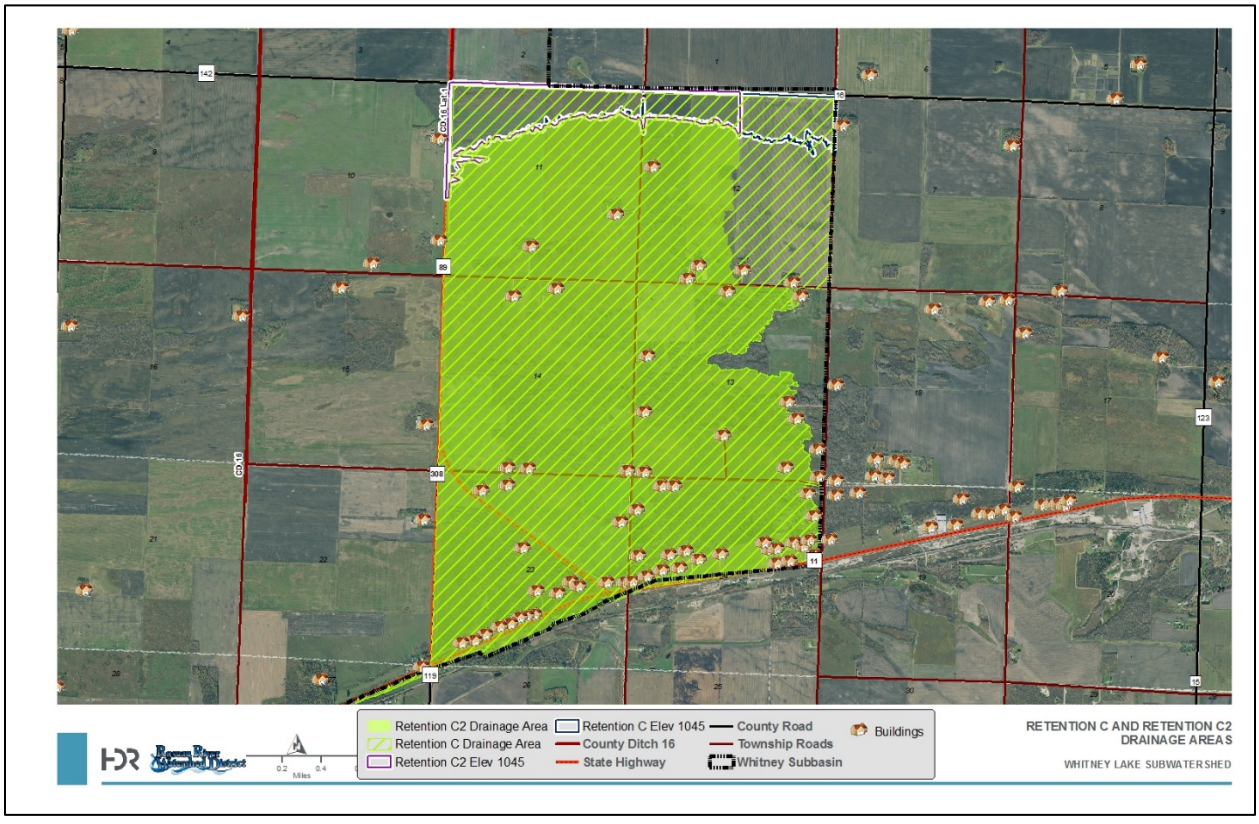


Figure 23. Retention C and C2 Drainage Areas and Benefitted Areas

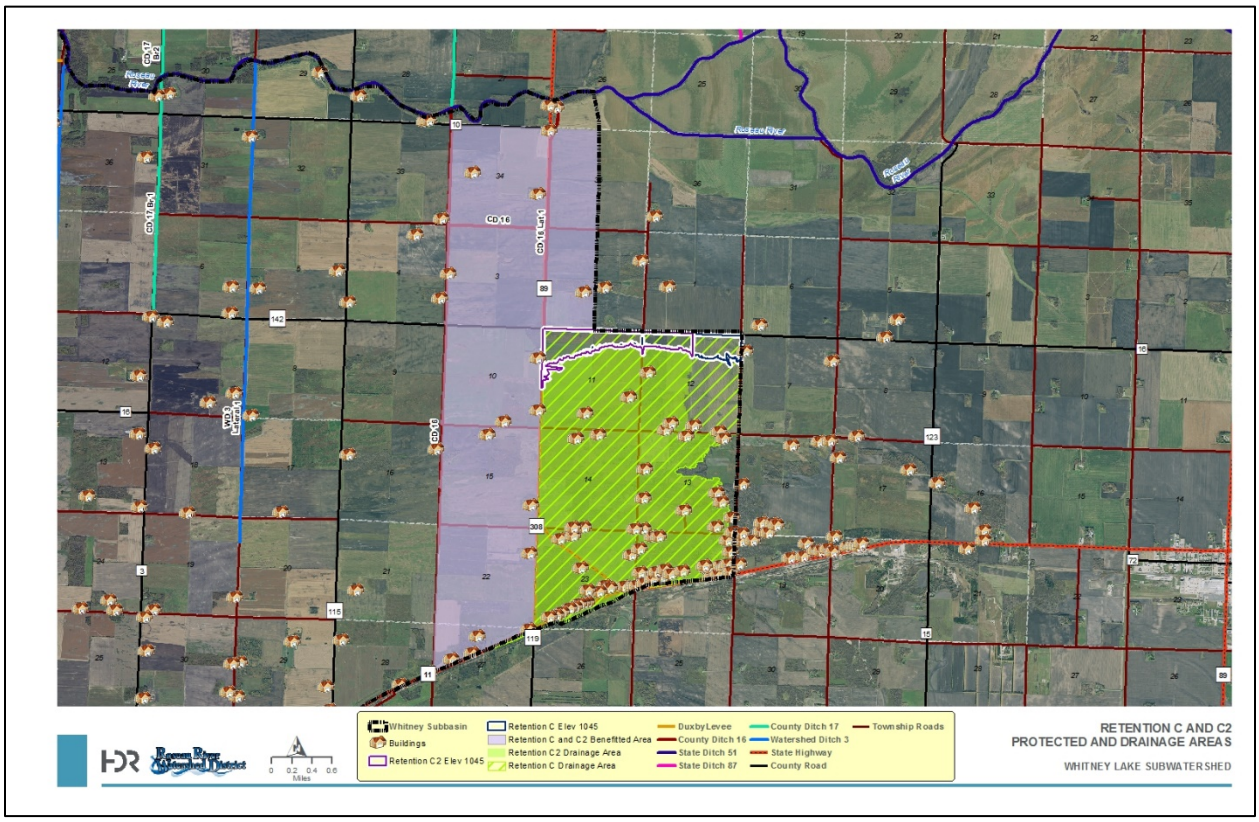


Table 13. Retention C and C2 – Drainage Area and Protected Area

	Retention C	Retention C2
Drainage Area (miles^2)	5.02	4.58
Protected Area (miles^2)	5.97	

Retention C2

This alternative consists of creating approximately 1,700 acre-feet of storage along CD 16 Lat 1. The full pool elevation of 1049.5 feet covers approximately 450 acres. The retention area is similar to Retention C above, but the levee adjacent to CR 16 extends east from CD 16 Lat 1 and turns south at the middle of section 12, leaving the eastern half of section 12 outside of the retention area. The dike continues south through the middle of section 12 until the natural ground becomes ties into the top of the dike. An outlet structure at the northwest corner of section 11 near CD Lat 1 has gates to control the dewatering of the impoundment. Inlet structures divert flows from CD 16 Lat 1 into the impoundment and promote filling of the impoundment.

The proposed drainage area for Retention C2 is approximately 4.6 square miles (approximately 6.2% of the Whitney Lake Subwatershed). As with Retention C, designing Retention C2 at a lower elevation still controls the drainage area up to a 25-year event. The elevation of 1045.0 feet covers 170 acres and has 270 acre-feet of storage potential.

Figure 24 shows the extent of various pool elevations. Table 14 provides pool footprint and storage volume data for the various pool elevations.

The drainage area for Retention C2 with a full pool elevation of 1045.0 is shown in Figure 22. The protected area for Retention C2 with a full pool elevation of 1045.0 is approximately 6.0 square miles (Figure 23, Table 13).

Figure 24. Retention C2 - Storage

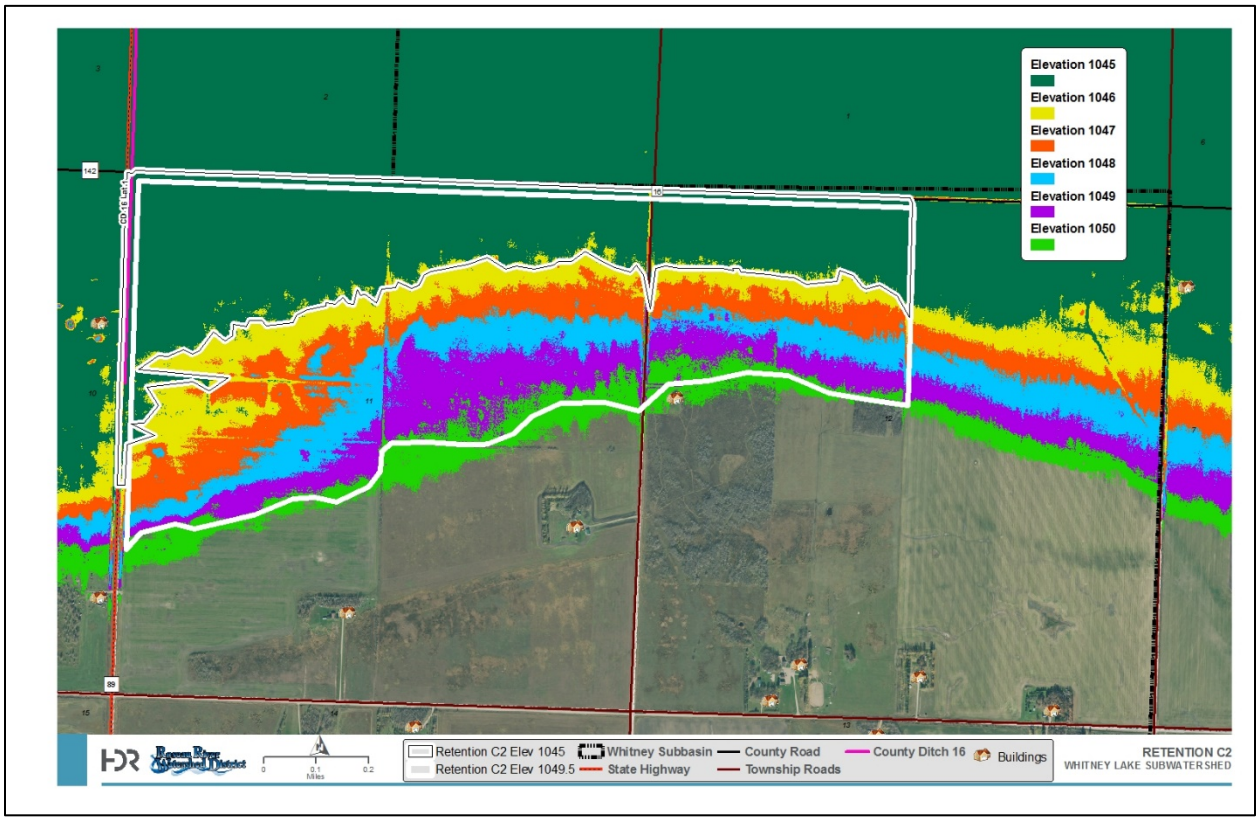


Table 14. Retention C2 - Pool Elevation, Pool Footprint, and Storage Volume Data

Max Pool Elevation (ft)	Pool Footprint (Acres)	Storage Volume (Acre-ft)
1050.0	446	1,913
1049.5	**444**	**1,690**
1049.0	424	1,472
1048.5	390	1,268
1048.0	359	1,081
1047.5	332	909
1047.0	305	749
1046.5	272	605
1046.0	238	477
1045.5	204	367
1045.0	**172**	**273**

Alternatives: Increased Conveyance

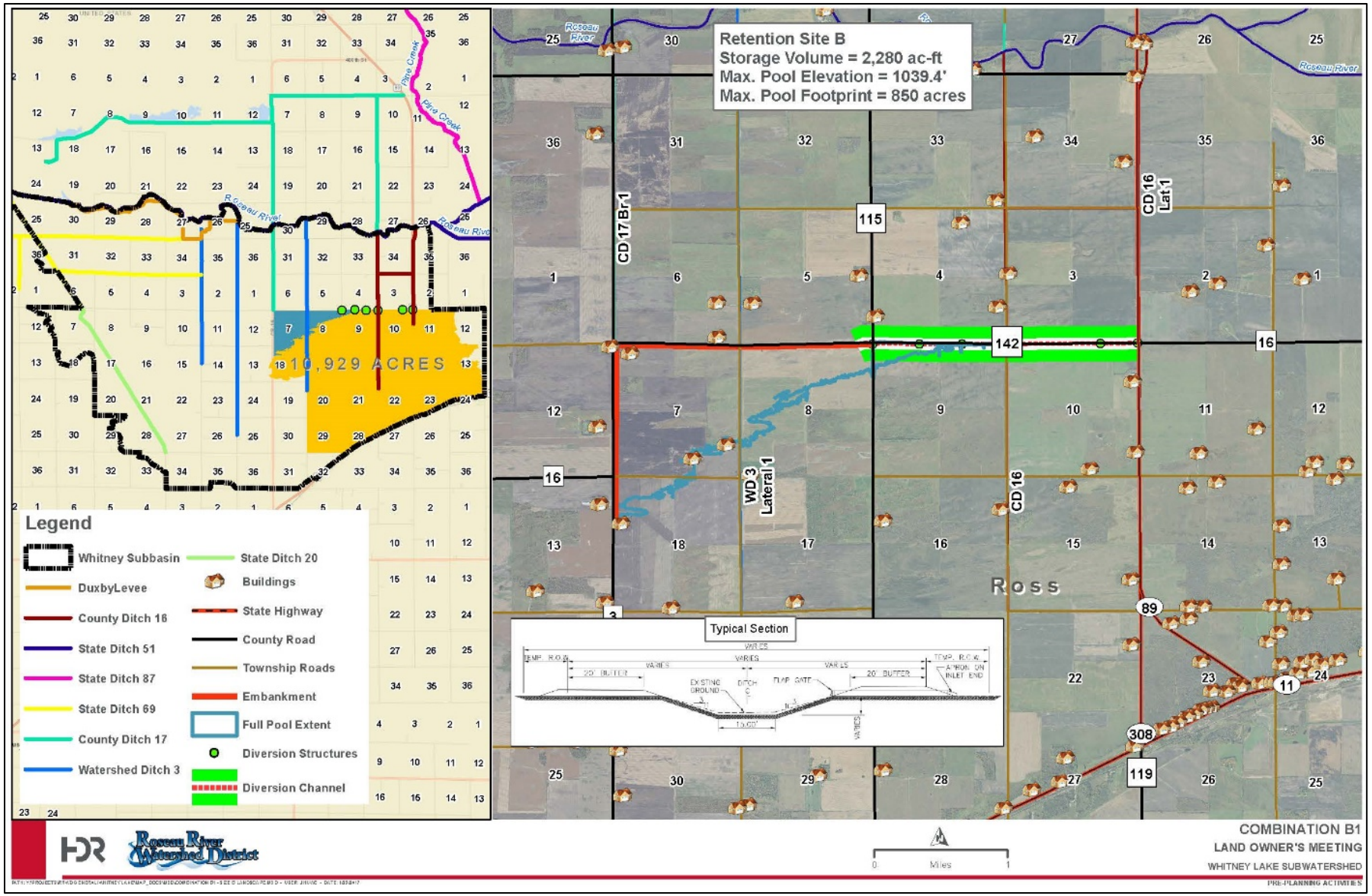
Alternative 10: *Diversion 1*

Decision: Dismissed

Rationale*:* Creating Diversion 1 was evaluated for the ability to reduce flood damage in the Whitney Lake Subwatershed. Diversion 1 is located 2 miles south of the Roseau River and connects CD 16 Lat 1 to SD 69 (Figure 9).

A diversion transfers flows from one drainage system to another system. There are inherent consequences in doing this because of the increased flow in the downstream receiving system. Therefore, a diversion would likely need to be paired with a retention site in order to justify the increased volume of water downstream of the project. Since a retention site is not a reasonable alternative in the vicinity of Diversion 1, this alternative has been dismissed. This alternative was evaluated with Retentions B or B2 serving as the downstream outlet of Diversion 1. Retentions B and B2 are explained above. This combination of Retention B and Diversion 1 is shown in Figure 25 below. Diversion 1 receives flow from CD 16 Lat 1 and CD 16 and outlets into Retention B. The channel is 2 miles long starting in the northeast corner of section 10 of Ross Township and continuing west along the north edge of section 10 and across section 9 to County Road 115. Diversion 1 has a bottom width of 15 feet and 4:1 (Horizontal:Vertical) side slopes. The channel is located on the south side of County Road 16/142 for two miles and crosses under one township road and County Road 115. Structures consist of large box culverts conveying flows from the 7.9 mi^2 drainage area.

Figure 25. Diversion 1 and Retention B Alternative



Alternative 11: *Diversion 2*

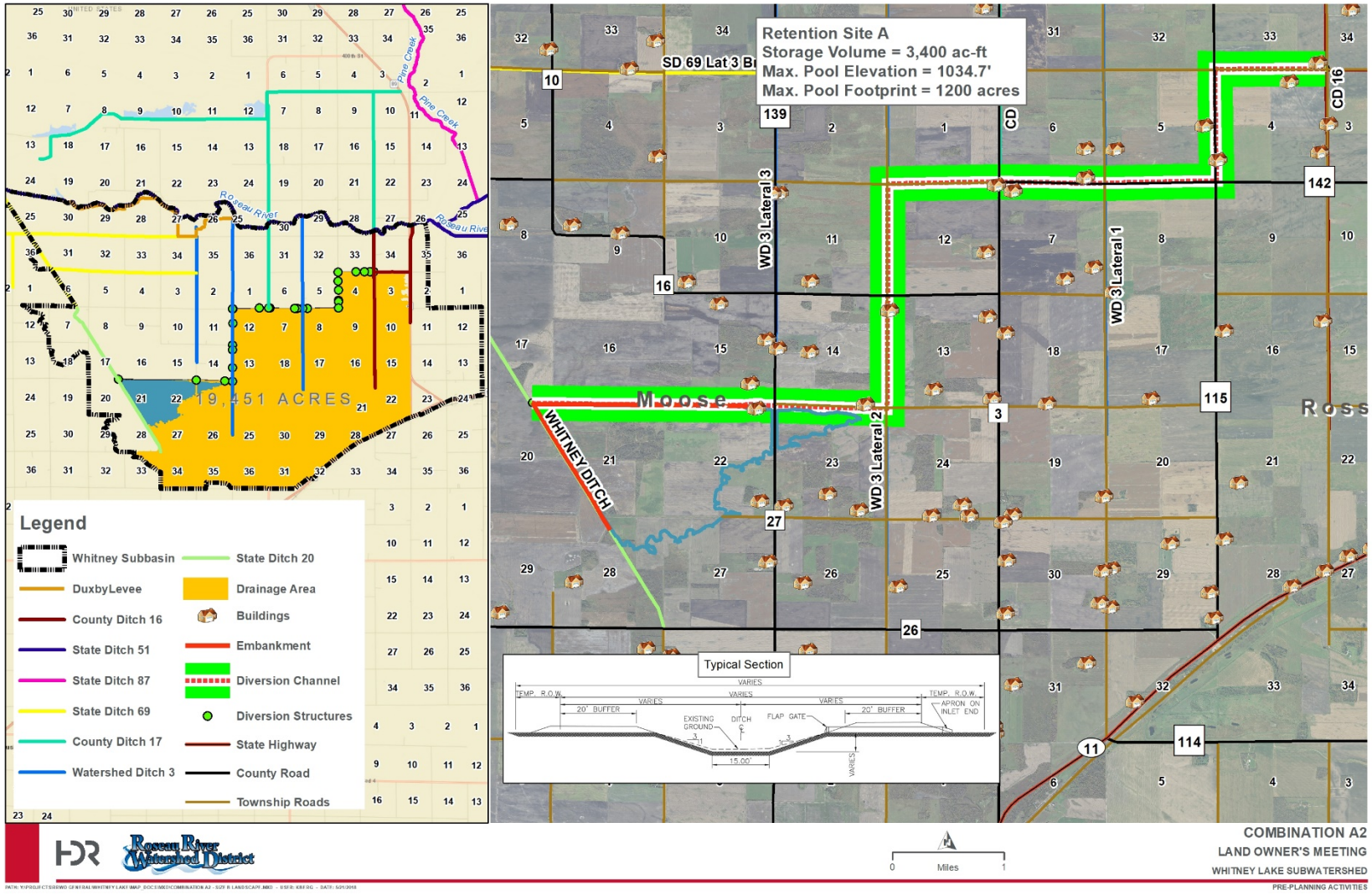
***Decision**:* Not carried forward.

Rationale: Diversion 2 starts 2 miles south of the Roseau River and zigzags south and west to end 4.5 miles south of the Roseau River (Figure 9).

Similar to Diversion 1, the downstream impacts of a diversion would require some flood storage to be practical. This alternative was evaluated with Retentions A and A2. Retentions A and A2 are explained above. Diversion 2 is approximately 10 miles long. Dimensions of the proposed channel are 10-20 feet wide at the bottom with 4:1 (Horizontal:Vertical) side slopes. A shown in Figure 26 the channel is located along the south side of the existing township road (340th St) starting at CD 16 in the northeast corner of Section 4 of Ross Township. The channel continues west from that point along the north edge of Section 4 until County Road 115 where it continues south along CR 115 for one mile. At CR 142, the diversion crosses under the county roads and continues along the south side of CR 142 in section 8 of Ross Township. The channel crosses section 8 and 7 on the north edge and section 12 of Moose Township along the township road (330th St) until it reaches WD 3 Lat 2. WD 3 Lat 2 is re-graded to the south and widened to a 20-foot bottom for 2 miles, continuing west along 310th St on the north part of section 23. From there it outlets into the impoundment created by Retention A dikes. Structures consist of culverts with aprons at the upstream inlet of the diversion channel and where county roads or township roads cross over the diversion channel. This alternative connects existing legal ditch systems to Retentions A or A2 and existing culverts are removed and re-installed in order to provide improved drainage and optimal operation of the alternatives.

The proposed drainage area for Diversion 2 as described in this section is approximately 23.1 square miles (approximately 31% of the Whitney Lake subwatershed). Preliminary hydraulic modeling of this alternative shows increased flooding along WD 3 Lat 2. Although the terrain allows for re-grading of the channel, there is limited elevation change, which causes the adjacent land to become inundated while the diversion is in operation. The water surface elevations in WD 3 Lat 2 are increased up to 1 foot as a result. Due to these reasons, Diversion 2 is being dismissed from further consideration.

Figure 26. Diversion 2 Alternative



Alternative 12: *Diversion 3*

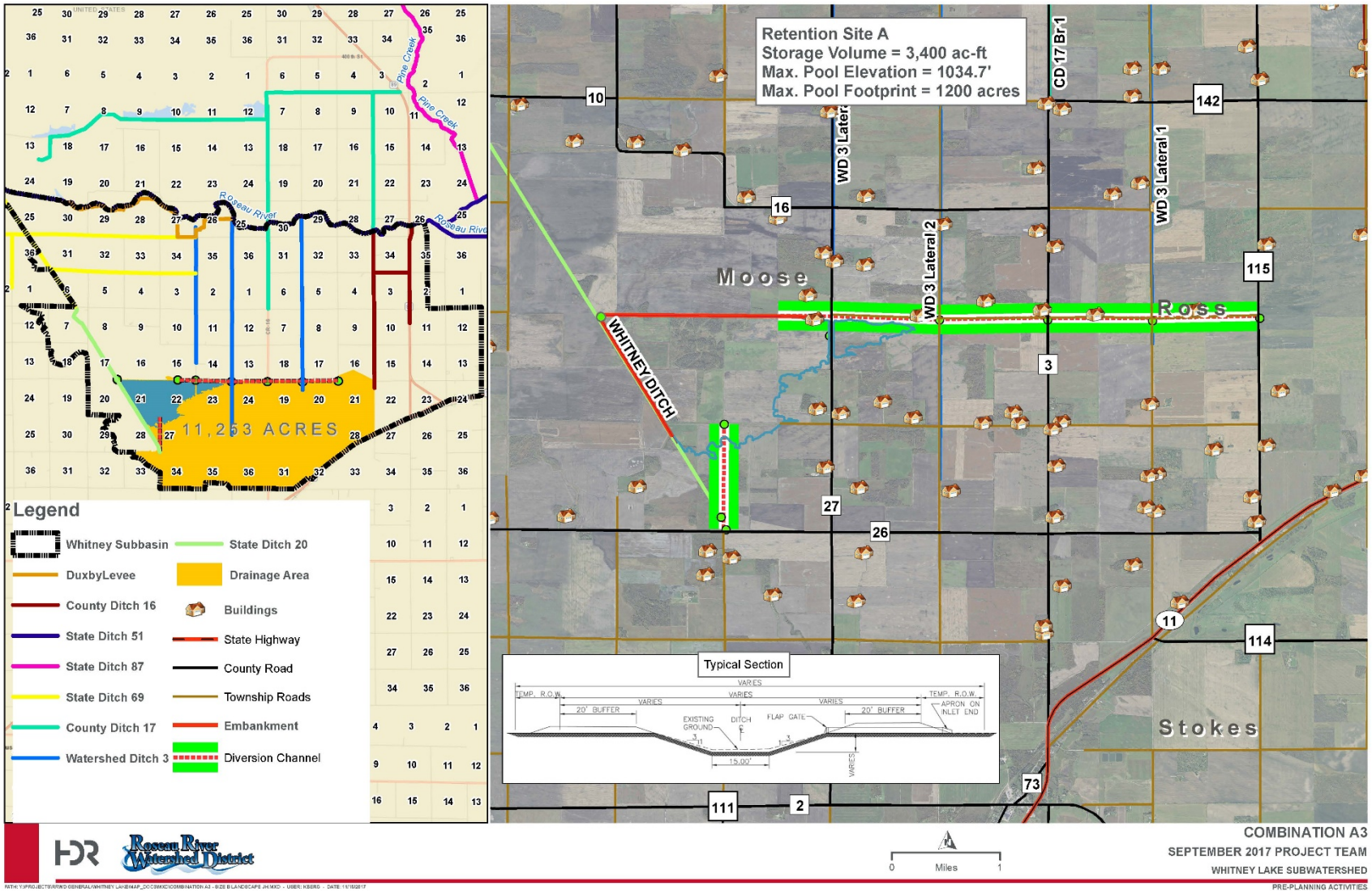
***Decision*:** Carried forward.

Rationale: Creating Diversion 3 was evaluated for the ability to reduce flood damage in the Whitney Lake Subwatershed and is located 4 miles south of the Roseau River (Figure 9).

Due to potential downstream impacts with a diversion, this alternative was evaluated in combination with Retentions A and A2. Figure 27 shows the combination of Retention A and Diversion 3. This map also shows an inlet channel from the south of Retention A which is a preliminary design element and may change upon detailed design. Diversion 3 is approximately 4.3 miles long. Dimensions of the proposed channel are 15 feet wide at the bottom with 4:1 (Horizontal:Vertical) side slopes. As shown in Figure 27 the channel is along the south side of the existing township road (310th St) starting at County Road 115 in the northeast corner of Section 20 of Ross Township. The channel continues west from that point along the north edges of Sections 19 and 20 of Ross Township and Sections 22 – 24 of Moose Township and outlets into Retention A. Structures consist of culverts with aprons at the upstream inlet of the diversion channel and where county roads or township roads cross over the diversion channel. This alternative connects existing legal ditch systems to Retention A and existing culverts are removed and re-installed in order to provide improved drainage and optimal operation of the alternatives.

The proposed drainage area for Diversion 3 as described in this section is approximately 8.0 square miles (approximately 11% of the Whitney Lake Subwatershed).

Figure 27. Diversion 3 and Retention A Alternative



Alternative 13: Increased Conveyance – New Ditch along CR 115

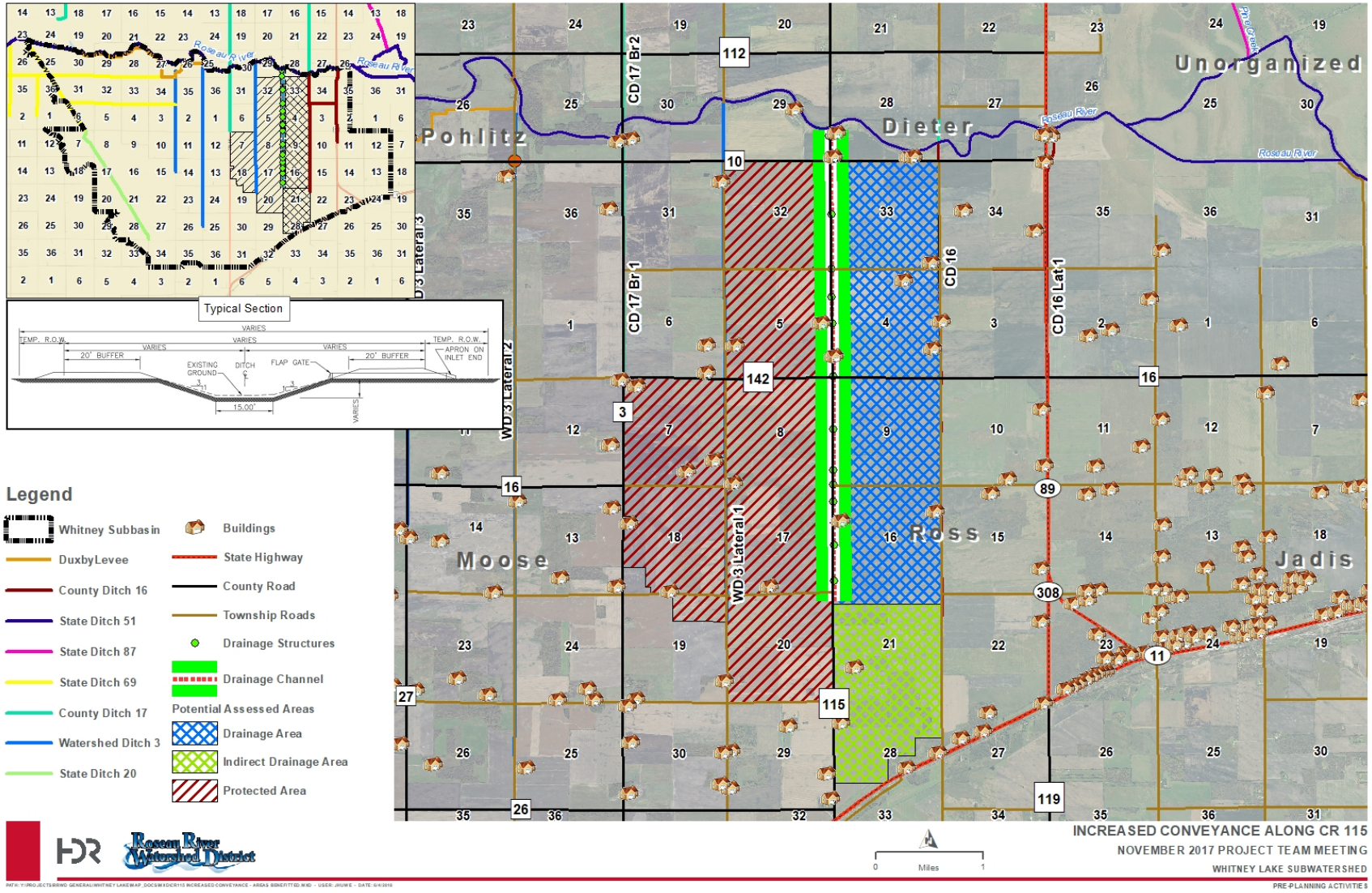
Decision: Carried forward.

Rationale: The subwatershed was assessed for locations to construct new legal ditch alternatives. Constructing a new ditch along County Road 115 was identified as an alternative. Existing drainage along County Road 115 is not a legal ditch, and has not been properly designed to convey the amount of runoff that the drainage area provides. Modeling of a 10-year 24-hour event (3.3" rainfall) shows that each section along the east side of County Road 115 experiences flooding, and both County Road 115 and 142 are overtopped.

Figure 28 shows the location and benefitted area of a new ditch along County Road 115. This alternative consists of a new channel approximately 4.3 miles long.

Dimensions of the proposed channel are 10 feet wide at the bottom with 4:1 (Horizontal:Vertical) side slopes. This new ditch will reduce flooding and damages to the roads in this area. The new ditch will increase the downstream peak flow rates, and will be considered as part of a comprehensive plan in order to minimize any impacts downstream.

Figure 28. New Ditch along County Road 115

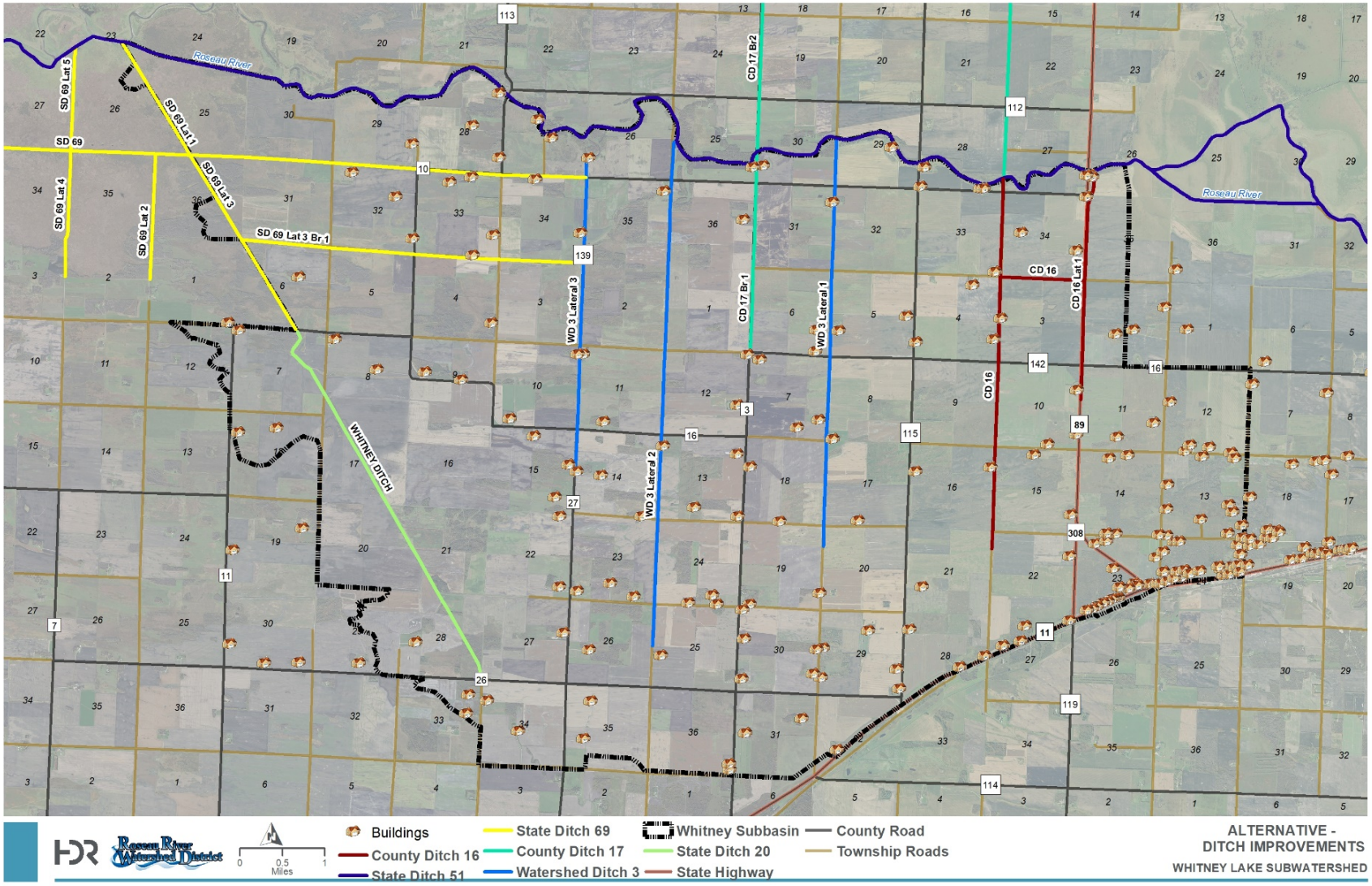


Alternative 14: Improvements to Existing Legal Ditches

Decision: *Carried forward*.

Rationale: Existing legal ditch systems in the Whitney Lake Subwatershed include: County Ditch 16, County Ditch 17, Watershed Ditch 3, State Ditch 20 (Whitney Ditch), and State Ditch 69 (Figure 29). Preliminary modeling showed the limited capacity of these systems is a cause of flooding in the subwatershed. Many of the structures and channels are only able to convey a 2-year 24-hour rainfall event (2.1" within 24 hours). Improvements include widening or deepening the channel, increasing the size of culverts, and channel maintenance. Improving the existing ditches increases downstream impacts by increasing peak flow rates and volumes. Widening a channel requires additional right-of-way and impacts the adjacent landowners. Improvements are favorable to landowners in the area, because improved drainage benefits their agricultural production. Downstream impacts must be evaluated before the selected alternatives can be finalized.

Figure 29. Existing Whitney Lake Subwatershed Legal Ditch Systems



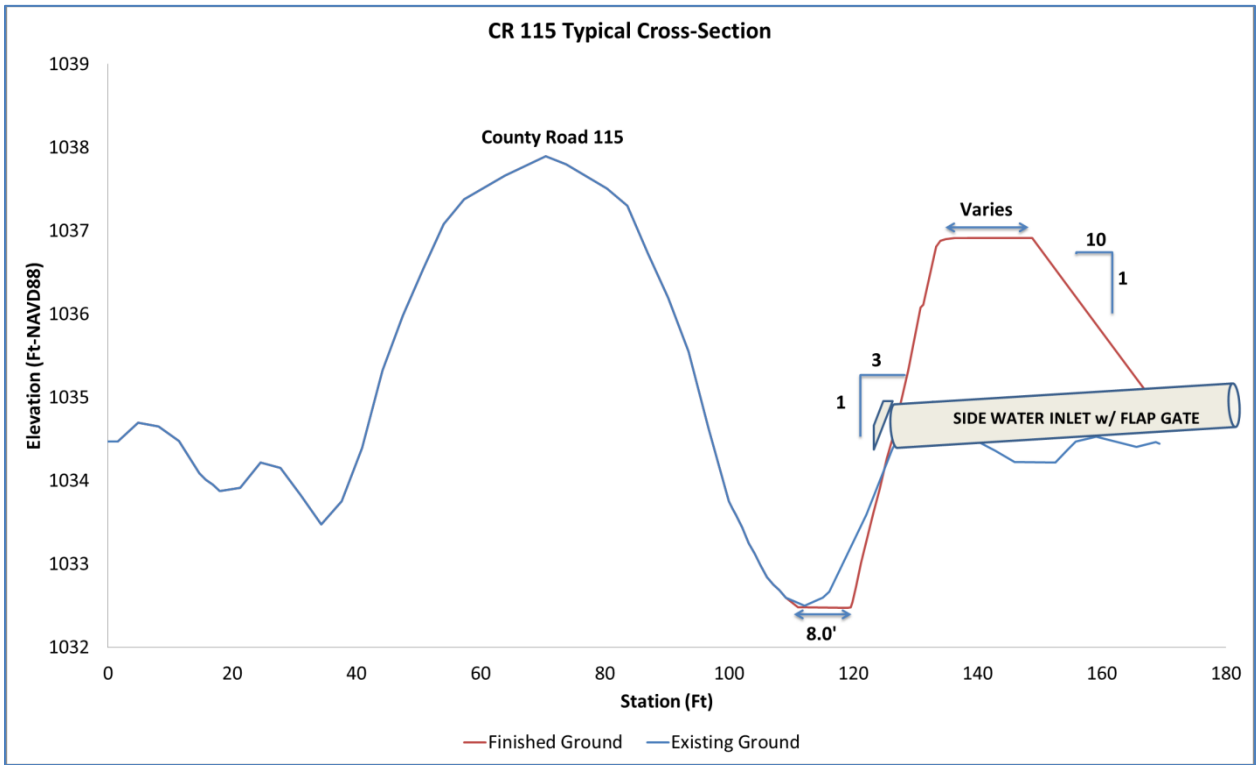
Alternatives: Avoidance and Protection

Alternative 15: Field Berms and Side Water Inlets

***Decision**: Carried forward*.

***Rationale**:* Berm construction would be carried forward in conjunction with any of the increased conveyance alternatives. The construction of field berms (Figure 30) would protect the adjacent farmland from breakouts occurring up to a ten-year event (3.3" of rainfall). Side water inlet culverts promote sedimentation and reduce erosion while potentially being an alternative practice to buffer strips. As stated, improving drainage also increases peak flows and volume to the Roseau River, but will be mitigated by another practice such as temporary flood storage.

Figure 30. Example of Berm Construction and Side Water Inlet



SUMMARY OF ALTERNATIVES MOVING FORWARD

Table 15 provides a summary and explanation of which alternatives are being dismissed and which are being carried forward. The chart in Figure 31 and the map in Figure 32 also show the alternatives being carried forward.

Table 15. Summary of Alternatives Moving Forward

Alternative	Carried forward (Y/N)	Explanation
Retention A	Y	Provides flood damage reduction in the subwatershed
Retention A2	Y	Provides flood damage reduction in the subwatershed
Retention B	N	Dismissed due to community disruption (adamant opposition)
Retention B2	N	Dismissed due to community disruption (adamant opposition).
Retention C	N	The land in the eastern half of section 12 drains to Roseau Lake and not into the Whitney Lake Subwatershed.
Retention C2	Y	Provides flow reduction benefits up to a 25-year rainfall event
Diversion 1	N	Negative impacts downstream result in dismissal. Not considered reasonable without Retention B or B2.
Diversion 2	N	Modeling results proved that Diversion 2 was unable to effectively reduce flood damage in the subwatershed. This was mainly due to the existing topography and limitations on channel size and slope
Diversion 3	Y	Provides flood damage reduction in the subwatershed and is able to be paired with Retention A or A2 to minimize downstream impacts
New Ditch along CR 115	Y	Provides flood damage reduction in the subwatershed
Improve CD 16	Y	Provides flood damage reduction in the subwatershed
Improve WD 3	Y	Provides flood damage reduction in the subwatershed
Improve SD 69	Y	Provides flood damage reduction in the subwatershed
Improve CD 17	Y	Provides flood damage reduction in the subwatershed
Improve Whitney Ditch (SD 20)	Y	Provides flood damage reduction in the subwatershed
Conversion of Farmland to wetlands or native vegetation.	N	Analysis shows that widespread conversion of farmland to wetlands or native vegetation would have minimal effects on the runoff peak volume in this subwatershed.
Cropland BMPs	N	Does not provide reduction in flood damages
Channel Maintenance (Vegetation)	Y	Channel maintenance will increase downstream impacts through increased flow rates and volumes. This measure is being considered with improvements to the legal ditch systems

Figure 31. Alternatives Dismissed and Alternatives Carried Forward

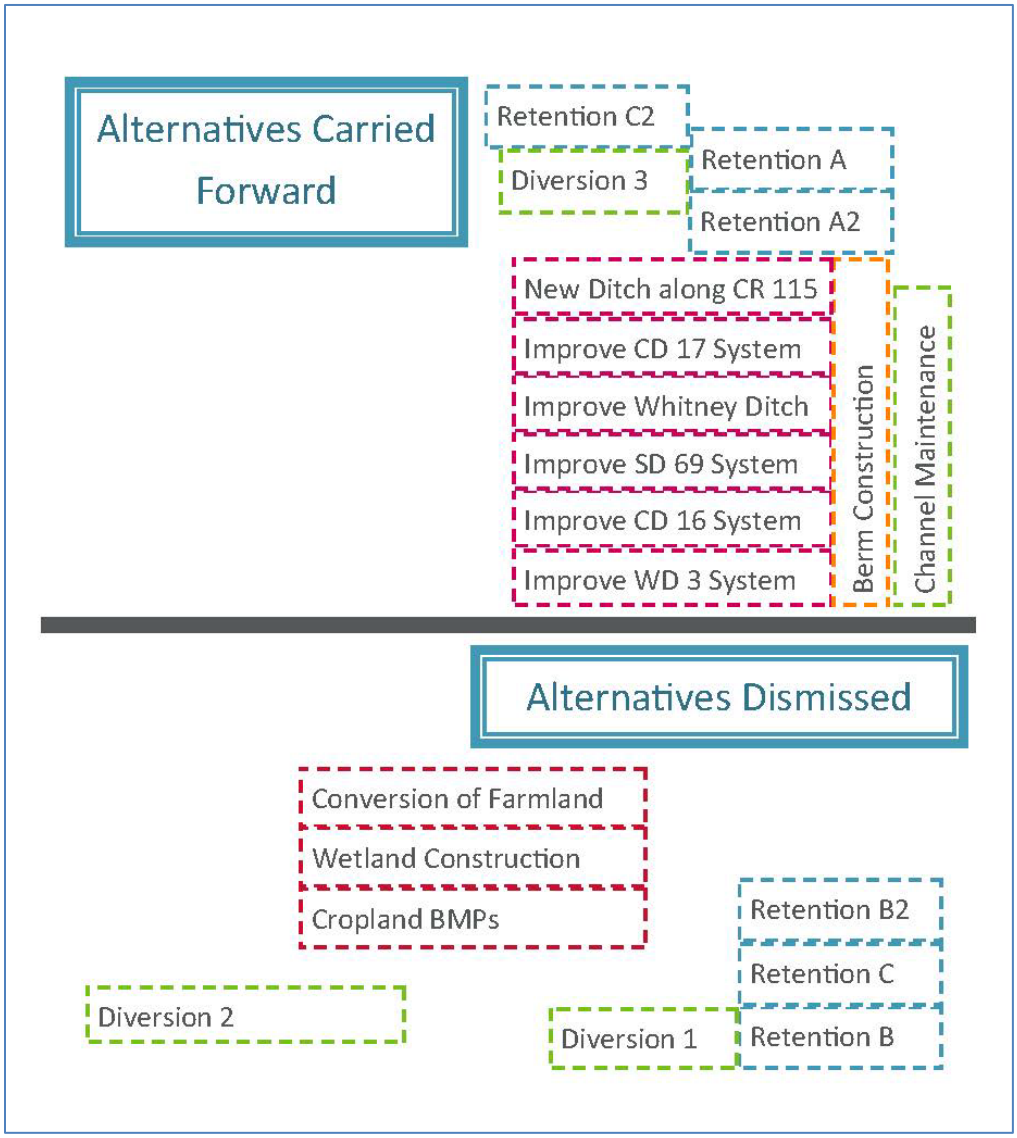
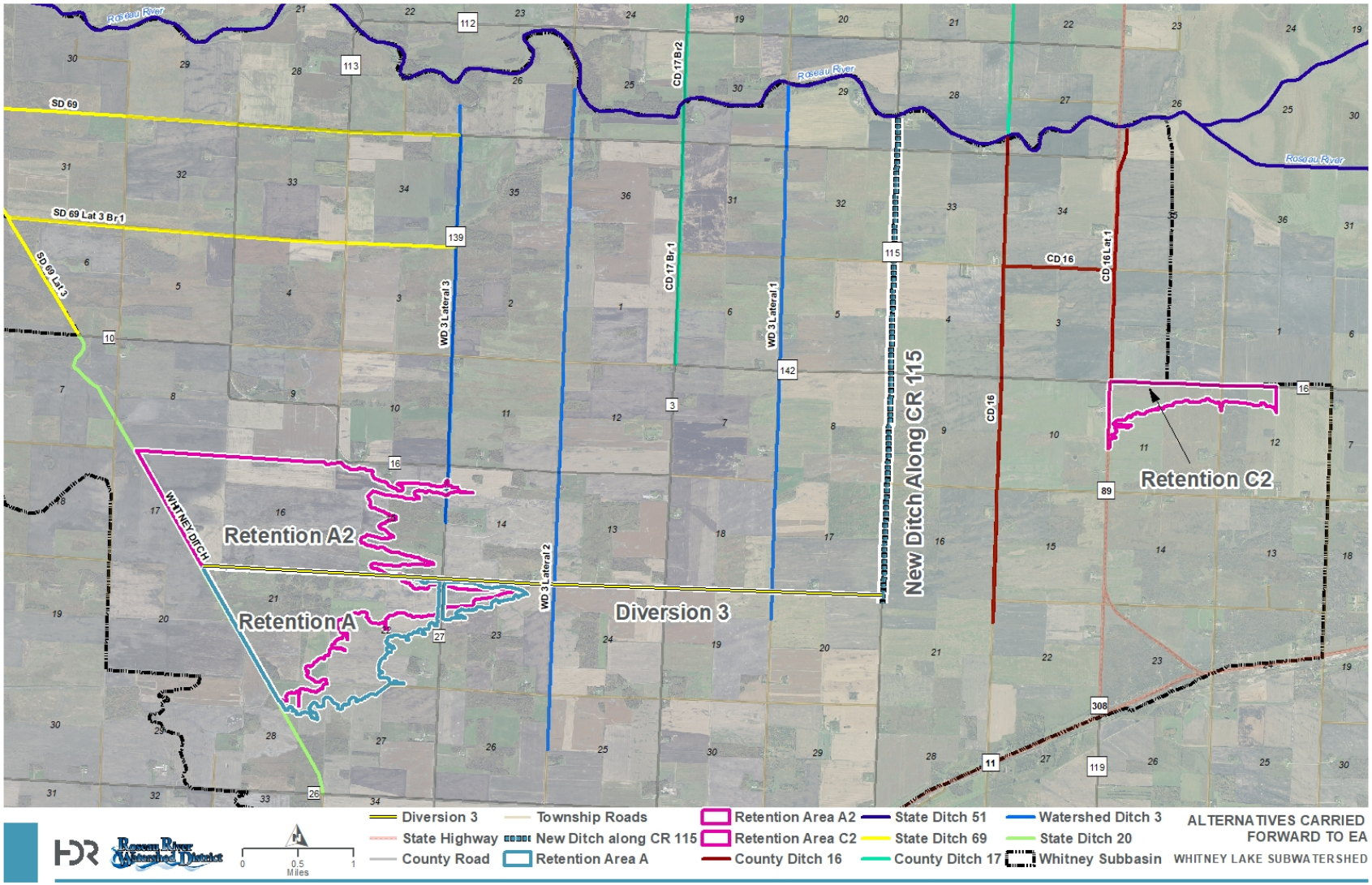


Figure 32. Alternatives Carried Forward



Whitney Lake Subwatershed Concurrence Point #3 (August 2019)

Introduction

The Roseau River Watershed District (RRWD) has established a Project Team to develop a project to reduce flood damages in the Whitney Lake Subwatershed.

The Whitney Lake Subwatershed Project Team is developing a watershed plan for the Whitney Lake Subwatershed under the terms and conditions of the Cooperative Agreement (CA) with the Natural Resource Conservation Service (NRCS). NRCS PL83-566 Planning Review Points are being aligned with the U.S. Army Corps of Engineers Section 404 (b) (1) Concurrence Points Guidance which was developed to increase the efficiency and likelihood of project execution by aligning the watershed's project planning process with the 404 review process.

This report and the previous documentation provided to the US Corps of Engineers St. Paul District Regulatory Branch (Concurrence Point #1 - Purpose and need, and Concurrence Point #2 – Alternatives Carried Forward) is intended to describe and document Concurrence Point #3. Concurrence Point #3 identifies potential options associated with the alternatives carried forward from Concurrence Point #2, further analysis and refinement of those options, and the selection of a preferred option for recommendation to the Roseau River Watershed Board of Directors.

The Whitney Lake Subwatershed Project Team selected the preferred option based on its potential to meet the project purpose and need (Concurrence Point #1), its practicability or availability, and its known environmental effects.

Previously Defined Purpose and Need (Concurrence Point #1 Received: November 16, 2017)

The Project Team has established the following purpose and need statement:

> *The purpose of the proposed action is **Flood Damage Reduction:** Reduce damages to agricultural lands for a 10-year 24-hour storm (total 3.3 inches of rainfall) and reduce damages to roadways for a 25-year 24-hour storm event (total 3.9 inches of rainfall) in the Whitney Lake Subwatershed.*

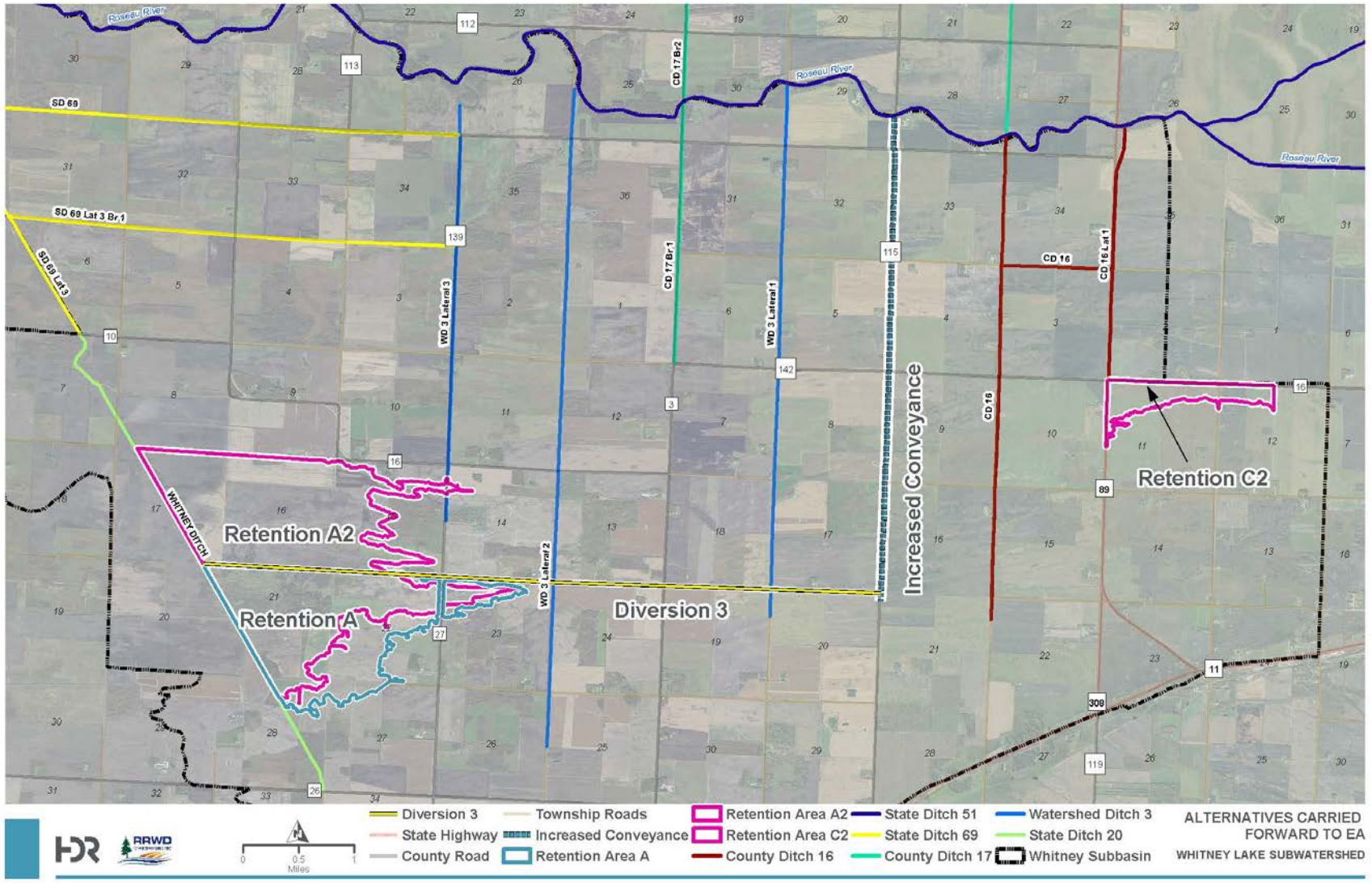
Alternatives Carried Forward (Concurrence Point #2 Received: June 21, 2018).

Table 1 below provides a summary and explanation of which alternatives were dismissed and which were carried forward. The map in Figure 1 shows the alternatives being carried forward.

Table 1. Summary of Alternatives Moving Forward

Alternative	Carried forward (Y/N)	Explanation
Retention A	Y	Provides flood damage reduction in the subwatershed
Retention A2	Y	Provides flood damage reduction in the subwatershed
Retention B	N	Dismissed due to community disruption (adamant opposition)
Retention B2	N	Dismissed due to community disruption (adamant opposition)
Retention C	N	The land in the eastern half of section 12 drains to Roseau Lake and not into the Whitney Lake Subwatershed.
Retention C2	Y	Provides flow reduction benefits up to a 25-year rainfall event
Diversion 1	N	Negative impacts downstream result in dismissal. Not considered reasonable without Retention B or B2.
Diversion 2	N	Modeling results proved that Diversion 2 was unable to effectively reduce flood damage in the subwatershed. This was mainly due to the existing topography and limitations on channel size and slope
Diversion 3	Y	Provides flood damage reduction in the subwatershed and is able to be paired with Retention A or A2 to minimize downstream impacts
New Conveyance along CR 115	Y	Provides flood damage reduction in the subwatershed
Improve CD 16	Y	Provides flood damage reduction in the subwatershed
Improve WD 3	Y	Provides flood damage reduction in the subwatershed
Improve SD 69	Y	Provides flood damage reduction in the subwatershed
Improve CD 17	Y	Provides flood damage reduction in the subwatershed
Improve Whitney Ditch (SD 20)	Y	Provides flood damage reduction in the subwatershed
Conversion of Farmland to wetlands or native vegetation.	N	Analysis shows that widespread conversion of farmland to wetlands or native vegetation would have minimal effects on the runoff peak volume in this subwatershed.
Cropland BMPs	N	Does not provide reduction in flood damages
Channel Maintenance (Vegetation)	Y	Channel maintenance will increase downstream impacts through increased flow rates and volumes. This measure is being considered with improvements to the legal ditch systems

Figure 1. Alternatives Carried Forward



Basis for Determination of the Preferred Alternative Plan (Concurrence Point #3)

The ten individual alternatives established in concurrence point 2 were systematically assessed to establish concurrence point 3. The goal is to come up with an alternative plan (combination of individual alternatives) that provides the least environmental damage while being practicable and meeting the project purpose. To come up with the preferred alternative plan, alternatives were evaluated based on their environmental effects, practicability, and their ability to meet the project purpose.

1. **Assessment Based on Environmental Effects**

An assessment of the 10 individual alternatives effect on natural resources was carried out. Direct and indirect impacts were assessed. Direct impacts were assessed by locating the natural resources compared to the construction footprint. Indirect impacts were assessed by analyzing the changes to inundation areas pre- and post-project during 2- and 10-year rainfall events. The 2- and 10-year events were selected for analysis based on the projects purpose and need. For potential effects to resources of concern that cannot be quantified, the discussion is qualitative. It should be noted that Diversion 3 was modeled with Retention A to calculate indirect impacts for the 2- and 10-year rainfall events. Diversion 3 is an inlet channel to Retention A or A2.

Prime Farmland

Direct Effects

Permanent farmland impacts would be limited to areas directly impacted by construction of retention basins. The two new conveyances and five ditch improvements are not anticipated to cause permanent farmland impacts due to their location along existing roads and minimal construction footprint. Table 2 quantifies the farmland directly impacted by the two new conveyances, five ditch improvements, and three retention basins.

Table 2 Direct Impacts to Farmland

Farmland Type	Retention A	Retention A2	Retention C2	New Conveyance along CR 115	Diversion 3	Improvements to WD 3	Improvements to CD 16	Improvements to CD 17 Br 1	Improvements to SD 69	Improvements to Whitney Ditch (SD 20)
	Embankment Footprint	Embankment Footprint	Embankment Footprint	Conveyance and Berm Footprint	Conveyance and Berm Footprint	Conveyance Width Improvement and Berm Footprint	Conveyance Width Improvement and Berm Footprint	Conveyance Width Improvement and Berm Footprint	Conveyance Width Improvement and Berm Footprint	Conveyance Width Improvement and Berm Footprint
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
All prime farmland	0.0	0.0	0.0	1.4	0.0	0.7	6.1	0.0	0.0	0.0
Farmland if drained	19.9	25.0	9.9	7.0	24.5	80.2	33.3	24.2	74.2	22.0
Farmland of statewide importance	0.0	0.0	0.0	1.4	0.1	0.0	2.5	0.0	16.4	0.0
Not Prime Farmland	121.2	130.1	91.4	42.4	74.6	101.2	56.3	27.4	98.6	94.8
Total	**141.2**	**155.0**	**101.4**	**52.2**	**99.2**	**182.0**	**98.3**	**51.6**	**189.2**	**116.7**

Indirect Effects

No-Action Alternative

Under the no-action alternative farmland would continue to be inundated under high rainfall events. Inundation of farmland could cause sediment and phosphorus to be introduced into waterways.

Construction Alternatives

The no-action alternative and ten alternatives were analyzed under the 2- and 10-year rainfall events. The three retention basins would experience increased inundation, therefore, flowage easements are included in the probable construction costs of these alternatives. Alternative *Retention A* and *Diversion 3 with Retention A* show an increase in flooding of *Prime Farmland if Drained*. This is because an area of *Prime Farmland if Drained* soil is located within the Retention A basin footprint. The effect of these alternatives will show a reduction in damage to other lands in the Whitney Lake Subwatershed, including other *Prime Farmland if Drained*.

Table 3 identifies the potential acres of farmland inundated under 2- and 10-year rainfall events for each alternative.

Table 3-1 Indirect Impacts of Retentions Basins to Farmland

Farmland Type	Retention Basin A					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
All prime farmland	5.6	5.5	0.0	11.9	11.0	0.9
Farmland if drained	708.9	724.2	-15.3	1873.0	1950.0	-77.1
Farmland of statewide importance	18.6	17.4	1.2	34.7	34.1	0.6
Total	**733.0**	**747.1**	**-14.1***	**1919.6**	**1995.2**	**-75.6***

Farmland Type	Retention Basin A2					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
All prime farmland	5.6	4.8	0.8	11.9	10.7	1.2
Farmland if drained	708.9	598.9	109.9	1873.0	1835.1	37.9
Farmland of statewide importance	18.6	16.3	2.3	34.7	32.9	1.8
Total	**733.0**	**620.0**	**113.0**	**1919.6**	**1878.6**	**41.0**

Farmland Type	Retention Basin C2					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
All prime farmland	5.6	5.7	-0.1	11.9	12.0	-0.1
Farmland if drained	708.9	703.6	5.3	1873.0	783.8	1089.2
Farmland of statewide importance	18.6	17.1	1.5	34.7	33.9	0.8
Total	**733.0**	**726.4**	**6.6**	**1919.6**	**829.7**	**1089.9**

*The negative numbers in the "change" column in the table above represent a greater proposed impact than the existing conditions

Table 3-2 Indirect Impacts of Ditch Improvements to Farmland

Farmland Type	Improvements to WD 3					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
All prime farmland	5.6	5.7	-0.2	11.9	11.9	0.0
Farmland if drained	708.9	679.2	29.7	1873.0	1772.7	100.3
Farmland of statewide importance	18.6	16.1	2.5	34.7	33.9	0.8
Total	**733.0**	**701.0**	**32.0**	**1919.6**	**1818.6**	**101.0**

Farmland Type	Improvements to CD 16					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
All prime farmland	5.6	6.1	-0.6	11.9	12.9	-1.0
Farmland if drained	708.9	696.3	12.6	1873.0	1872.6	0.4
Farmland of statewide importance	18.6	18.5	0.1	34.7	34.9	-0.1
Total	**733.0**	**720.9**	**12.1**	**1919.6**	**1920.4**	**-0.8**

Farmland Type	Improvements to CD 17 Br 1					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
All prime farmland	5.6	5.7	-0.1	11.9	12.0	-0.1
Farmland if drained	708.9	677.6	31.3	1873.0	1813.7	59.3
Farmland of statewide importance	18.6	18.7	0.0	34.7	34.7	0.0
Total	**733.0**	**701.9**	**31.1**	**1919.6**	**1860.4**	**59.2**

Farmland Type	Improvements to SD 69					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
All prime farmland	5.6	5.6	-0.1	11.9	12.0	-0.1
Farmland if drained	708.9	679.8	29.1	1873.0	1799.3	73.7
Farmland of statewide importance	18.6	18.7	-0.1	34.7	34.7	0.0
Total	**733.0**	**704.1**	**29.0**	**1919.6**	**1846.0**	**73.6**

Farmland Type	Improvements to Whitney Ditch (SD 20)					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
All prime farmland	5.6	5.4	0.2	11.9	11.4	0.5
Farmland if drained	708.9	612.8	96.1	1873.0	1713.1	159.8
Farmland of statewide importance	18.6	18.6	0.0	34.7	34.4	0.3
Total	**733.0**	**636.7**	**96.3**	**1919.6**	**1758.9**	**160.6**

*The negative numbers in the "change" column in the table above represent a greater proposed impact than the existing conditions

Table 3-3 Indirect Impacts of New Conveyances to Farmland

Farmland Type	Diversion 3 with Retention A						Farmland Type	New Conveyance along CR 115					
	2 Year			10 Year				2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change		No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres				Acres			Acres		
All prime farmland	5.6	4.8	0.7	11.9	10.7	1.2	All prime farmland	5.6	5.8	-0.3	11.9	12.1	-0.2
Farmland if drained	708.9	707.6	1.3	1873.0	2043.1	-170.1	Farmland if drained	708.9	689.1	19.8	1873.0	1849.1	23.9
Farmland of statewide importance	18.6	15.0	3.6	34.7	33.2	1.5	Farmland of statewide importance	18.6	18.5	0.1	34.7	34.4	0.3
Total	**733.0**	**727.4**	**5.6**	**1919.6**	**2087.0**	**-167.4***	**Total**	**733.0**	**713.4**	**19.6**	**1919.6**	**1895.6**	**24.0**

*The negative numbers in the "change" column in the table above represent a greater proposed impact than the existing conditions

Temporary Impacts

Construction of the three retention basins, two new conveyances, and improvements of five ditches would require heavy earth-moving operations. Vegetation will be removed, topsoil will be stripped and stockpiled, and unsuitable soils removed and stockpiled on site.

Summary of Impacts

Direct impacts to prime farmland due to construction for Retention A (141.2 acres) are less than Retention A2 (155.0 acres). New Conveyance Along CR 115, Diversion 3, and Improvements to CD 17 Br 1 and CD 16 show the lowest direct impacts. For indirect impacts, all alternatives reduce prime farmland inundation with the exception of Retention A. As mentioned above, this is because an area of *Prime Farmland if Drained* soil is located within the Retention A basin footprint.

Highly Erodible Cropland

Direct Effects

Permanent Highly Erodible Cropland (HELC) impacts would be limited to areas directly impacted by the construction of retention basins. The two new conveyances and five ditch improvements are not anticipated to cause permanent HELC impacts due to their location and minimal construction footprint. Table 4 quantifies the Highly Erodible Land (HEL) directly impacted by construction of the two new conveyances, five ditch improvements, and three retention basins.

Table 4 Direct Impacts to HEL

HEL Type	Retention A	Retention A2	Retention C2	New Conveyance along CR 115	Diversion 3	Improvements to WD 3	Improvements to CD 16	Improvements to CD 17 Br 1	Improvements to SD 69	Improvements to Whitney Ditch (SD 20)
	Embankment Footprint	Embankment Footprint	Embankment Footprint	Conveyance and Berm Footprint	Conveyance and Berm Footprint	Conveyance Width Improvement and Berm	Conveyance Width Improvement and Berm	Conveyance Width Improvement and Berm	Conveyance Width Improvement and Berm	Conveyance Width Improvement and Berm
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
HELC	48.0	52.6	0.0	0.0	0.2	1.6	0.0	0.0	33.7	34.2
Potential HELC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**48.0**	**52.6**	**0.0**	**0.0**	**0.2**	**1.6**	**0.0**	**0.0**	**33.7**	**34.2**

Indirect Effects

No-Action Alternative

HELC would continue to become inundated under existing conditions. Farming practices and increases in flow rates have the potential to cause more erosion to existing HELC which would expose sediment and phosphorus to the watershed from adjacent agricultural fields.

Construction Alternatives

Table 5 identifies the potential acres of HEL inundated under 2- and 10-year rainfall events for each alternative. The no-action alternative and ten alternatives were analyzed under the 2- and 10-year

rainfall events. Table 5 shows that the three retention basins would experience increased flooding in HELC within the retention basin areas, therefore, flowage easements are included in the probable construction costs of these alternatives. It is assumed that the inundation could be long enough to have an impact to HEL within the retention basins. The retention basins would prevent soil from the HEL within the retention basin from flowing downstream into ditches, and eventually the Roseau River.

Table 5 – 1 Indirect Impacts of Retention Basins to HEL

HEL Type	Retention Basin A					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
HELC	78.4	134.7	-56.3	236.8	353.3	-116.6
Potential HELC	0.0	0.0	0.0	0.0	0.0	0.0
Total	**78.4**	**134.7**	**-56.3***	**236.8**	**353.3**	**-116.6***

HEL Type	Retention Basin A2					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
HELC	78.4	196.0	-117.6	236.8	654.7	-417.9
Potential HELC	0.0	0.0	0.0	0.0	0.0	0.0
Total	**78.4**	**196.0**	**-117.6***	**236.8**	**654.7**	**-417.9***

HEL Type	Retention Basin C2					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
HELC	78.4	78.4	-0.1	236.8	236.8	0.0
Potential HELC	0.0	0.0	0.0	0.0	0.0	0.0
Total	**78.4**	**78.4**	**-0.1***	**236.8**	**236.8**	**0.0**

*The negative numbers in the "change" column in the table above represent a greater proposed impact than the existing conditions

Table 5-2 Indirect Impacts of Ditch Improvements to HEL

HEL Type	Improvements to WD 3					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
HELC	78.4	75.8	2.6	236.8	229.6	7.2
Potential HELC	0.0	0.0	0.0	0.0	0.0	0.0
Total	**78.4**	**75.8**	**2.6**	**236.8**	**229.6**	**7.2**

HEL Type	Improvements to CD 16					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
HELC	78.4	78.6	-0.2	236.8	236.6	0.2
Potential HELC	0.0	0.0	0.0	0.0	0.0	0.0
Total	**78.4**	**78.6**	**-0.2***	**236.8**	**236.6**	**0.2**

HEL Type	Improvements to CD 17 Br 1					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
HELC	78.4	78.4	0.0	236.8	238.0	-1.2
Potential HELC	0.0	0.0	0.0	0.0	0.0	0.0
Total	**78.4**	**78.4**	**0.0**	**236.8**	**238.0**	**-1.2***

HEL Type	Improvements to SD 69					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
HELC	78.4	74.8	3.6	236.8	216.7	20.1
Potential HELC	0.0	0.0	0.0	0.0	0.0	0.0
Total	**78.4**	**74.8**	**3.6**	**236.8**	**216.7**	**20.1**

HEL Type	Improvements to Whitney Ditch (SD 20)					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
HELC	78.4	69.8	8.6	236.8	202.4	34.4
Potential HELC	0.0	0.0	0.0	0.0	0.0	0.0
Total	**78.4**	**69.8**	**8.6**	**236.8**	**202.4**	**34.4**

*The negative numbers in the "change" column in the table above represent a greater proposed impact than the existing conditions

Table 5-3 Indirect Impacts of Conveyances to HEL

HEL Type	Diversion 3 with Retention A						HEL Type	New Conveyance along CR 115					
	2 Year			10 Year				2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change		No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres				Acres			Acres		
HELC	78.4	217.8	-139.4	236.8	407.3	-170.5	HELC	78.4	78.4	-0.1	236.8	238.2	-1.4
Potential HELC	0.0	0.0	0.0	0.0	0.0	0.0	Potential HELC	0.0	0.0	0.0	0.0	0.0	0.0
Total	**78.4**	**217.8**	**-139.4**	**236.8**	**407.3**	**-170.5***	**Total**	78.4	78.4	-0.1*	236.8	238.2	-1.4*

*The negative numbers in the "change" column in the table above represent a greater proposed impact than the existing conditions

Temporary Impacts

Construction of the three retention basins, two new conveyances, and improvements to five ditches would require heavy earth-moving operations. Vegetation will be removed, topsoil will be stripped and stockpiled, and unsuitable soils removed and stockpiled on site.

Summary of Impacts

Direct impacts to HEL due to construction for Retention A (40 acres) are less than Retention A2 (52 acres). New Conveyance Along CR 115, Diversion 3, and Improvements to CD 17 Br 1 and CD 16 show the lowest direct impacts. As mentioned above, for indirect impacts, the three retention basin alternatives would experience increased flooding in HELC within the retention basin areas, therefore, flowage easements are included in the probable construction costs of these alternatives. The retention basins would prevent soil from the HEL within the retention basin from flowing downstream into ditches, and eventually the Roseau River.

Surface Water Quality

Direct Effects

Construction of all alternatives would only result in temporary direct impacts to surface water quality, due to the potential for discharge of construction-related pollutants. Temporary impacts to surface water quality are described later in this section. There are no water quality features located within areas impacted by construction of the alternatives.

Indirect Effects

Detailed watershed and water quality modeling is beyond the scope of this assessment and has not been performed, however the anticipated impacts to surface water quality will be generally described in this section. Detailed water quality modeling may be performed during design of the selected alternative.

No-Action Alternative

Surface water quality would continue to be negatively impacted during inundation of farmland that occurs during high rainfall events. Flooding of agricultural land can cause pollutants such as nutrients (nitrogen and phosphorus) and sediment to be introduced into waterways.

Construction Alternatives

The five ditch improvements and two new conveyances are not anticipated to cause significant impacts to surface water quality, because flooding due to the 2- and 10-year rainfall events would occur infrequently and for short durations. For the three retention basin alternatives, surface water quality would improve. The retention basin alternatives provide the greatest flooding relief, which minimizes the inundation of agricultural land and highly erodible land. Retention basins can also function as water quality best management practices when rainfall occurs, regardless of whether or not flooding conditions convey nutrients (nitrogen and phosphorus) and sediment to the retention basins during storm events would have an opportunity to settle to the bottom of the basin, reducing the pollutant load downstream to ditches and the Roseau River. Alternatives for Retention A and A2 have higher potential to improve water quality than Retention C2, due to the larger contributing drainage areas and the larger sizes of the retention basins. Anticipated surface water quality trends in the sub-watershed are described qualitatively in Table 6 below.

Table 6. Potential Anticipated Surface Water Quality Trends

Pollutant or Parameter	No-Action Alternative	Conveyance Alternatives	Retention Basin Alternatives
Turbidity and TSS	No significant change	Potential minor decrease in turbidity and TSS during the 2- and 10-year rainfall events.	Decrease in turbidity and TSS during all storm events.
DO	No significant change	Potential minor increase in DO during the 2- and 10-year rainfall events.	Increase in DO during all storm events.
TN/TP/OP (Nutrients)	No significant change	Potential minor decrease in TN/TP/OP (nutrients) during the 2- and 10-year rainfall events.	Decrease in TN/TP/OP (nutrients) during all storm events.
Chl-a	No significant change	Potential minor decrease in Chl-a during the 2- and 10-year rainfall events.	Decrease in Chl-a during all storm events.
E. coli	No significant change.	No significant change.	No significant change.
Flow Rate	No significant change	Increase in downstream peak flow rate.	Decrease in the sub-watershed's peak flow rate.

Temporary Impacts

Construction of the three retention basins, two new conveyances, and improvements of five ditches would require heavy earth-moving operations. Vegetation will be removed, topsoil will be stripped and stockpiled, and unsuitable soils removed and stockpiled on site.

Exposed sediments and the temporary potential for discharge of construction-related pollutants would potentially result in additional temporary pollutant loading to the ditch network within the Whitney Lake Sub-watershed. The pollutants would be controlled through use of best management practices as required by the National Pollutant Discharge Elimination System program.

Summary of Impacts

The Retention area alternatives will improve surface water quality. The retention basins with the larger contributing drainage areas and larger capacity have a higher potential to improve water quality.

Wetlands

Direct Effects

National Wetland Inventory (NWI) data shows that construction of all alternatives would cause wetland impacts due to placement of fill within wetland areas. The runoff that enters retention sites likely contains sediment that will be deposited within the site. Technically, this sedimentation can be classified as "fill" and is regulated under the WCA (BWSR).

Wetland and/or stream impacts would be replaced as applicable per the requirements of Section 404 of the Clean Water Act. Any final mitigation requirements would be determined by the U.S. Army Corps of Engineers (USACE) through the Section 404 Permit process.

Table 7 quantifies the wetlands directly impacted by the two new conveyances, five ditch improvements, and three retention basins. Section 2 of this document also continues to assess wetland effects.

Table 7 Direct Impacts to Wetlands Based on National Wetland Inventory (NWI) Data

Wetland Type	Retention A	Retention A2	Retention C2	New Conveyance along CR 115	Diversion 3	Improvements to WD 3	Improvements to CD 16	Improvements to CD 17 Br 1	Improvements to SD 69	Improvements to Whitney Ditch (SD 20)
	Embankment Footprint	Embankment Footprint	Embankment Footprint	Conveyance and Berm Footprint	Conveyance and Berm Footprint	Conveyance Width Improvement and Berm Footprint	Conveyance Width Improvement and Berm Footprint	Conveyance Width Improvement and Berm Footprint	Conveyance Width Improvement and Berm Footprint	Conveyance Width Improvement and Berm Footprint
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Freshwater Emergent	0.0	1.4	0.4	0.6	4.4	1.0	1.2	0.0	24.4	6.7
Freshwater Forested/Shrub Wetland	14.4	22.3	0.0	0.1	0.0	3.4	0.0	0.0	58.9	2.5
Freshwater Pond	0.1	0.1	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.1
Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riverine	7.8	4.5	4.0	5.5	5.2	7.9	11.4	2.0	10.5	8.4
Total	**22.3**	**28.3**	**4.4**	**6.4**	**9.5**	**12.3**	**12.6**	**2.0**	**93.8**	**17.7**

Indirect Effects

No-Action Alternative

Approximately 20 percent of land within the watershed has been classified as wetlands, including ponds, lakes and riverine as shown on U.S. Fish and Wildlife Service's (USFWS) National Wetland Inventory (NWI). The largest areas of wetlands are located throughout depressions in agricultural land and along ditches, streams and public water basins. Wetland degradation will likely continue due to runoff of sediment and nitrogen and phosphorus from agricultural fields in the watershed.

Construction Alternatives

The no-action alternative and 10 alternatives were analyzed under the 2- and 10-year rainfall events. The three retention sites were modeled to impound all drainage area flows for these events, and the

indirect (inundation) impacts shown in the following tables include the lands in both the drainage area and downstream protected areas. This analysis leads to variations in inundation totals, which are due to the different inundation levels in the impoundment and effectiveness in reducing downstream flooding for each event. Table 8 shows that the three retention basins would experience increased flooding in NWI wetland areas within the retention basin areas. Impacts that are sufficient to assert WCA jurisdiction include significant sedimentation, long-term inundation greater than 2 meters (6.56 feet) and elimination or degradation of wetland plant community (BWSR). Depth and duration of inundation will vary greatly, but to illustrate the worst-case scenario (100-year event), several figures are included in Section 2 below. The data in the tables below show small increases (1.4 to 1.9 acres) in impacts to NWI wetlands for the *Improvements to CD16, CD17, and SD69* alternatives. These impacts are negligible and can likely be avoided if the alternative is selected for final design. Furthermore, any new conveyances or ditch improvements have the potential to alter the hydrology of wetland basins, and these impacts will be avoided in final design or minimized. For example, if a ditch improvement is adjacent to a wetland and the protective berm that would be constructed along the field side will negatively impact the wetland, then the ditch and berm system would be designed differently in that specific location. A specific example of this would be a requirement to haul spoil material and place it outside of any delineated wetlands. This can avoid or minimize any negative effects of the project.

Table 8-1 Indirect Impacts of Retention Basins to Wetlands

Wetland Type	Retention Basin A						Wetland Type	Retention Basin A2					
	2 Year			10 Year				2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change		No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres				Acres			Acres		
Freshwater Emergent	132.9	151.3	-18.4	294.3	286.2	8.1	Freshwater Emergent	132.9	142.1	-9.2	294.3	323.4	-29.1
Freshwater Forested/ Shrub Wetland	112.6	118.1	-5.4	273.3	265.0	8.3	Freshwater Forested/ Shrub Wetland	112.6	110.3	2.3	273.3	375.3	-102.0
Freshwater Pond	1.2	1.2	0.0	2.5	2.4	0.1	Freshwater Pond	1.2	1.1	0.1	2.5	2.6	-0.1
Lake	0.0	0.0	0.0	0.0	0.0	0.0	Lake	0.0	0.0	0.0	0.0	0.0	0.0
Riverine	46.2	48.9	-2.7	70.2	71.6	-1.5	Riverine	46.2	44.0	2.2	70.2	59.2	11.0
Total	**292.9**	**319.5**	**-26.6***	**640.3**	**625.2**	**15.0**	**Total**	**292.9**	**297.4**	**-4.5***	**640.3**	**760.5**	**-120.3***

Wetland Type	Retention Basin C2					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
Freshwater Emergent	132.9	147.8	-14.9	294.3	294.1	0.2
Freshwater Forested/ Shrub Wetland	112.6	112.4	0.2	273.3	273.2	0.1
Freshwater Pond	1.2	1.2	0.0	2.5	2.5	0.0
Lake	0.0	0.0	0.0	0.0	0.0	0.0
Riverine	46.2	44.6	1.6	70.2	68.1	2.1
Total	**292.9**	**306.0**	**-13.1***	**640.3**	**637.8**	**2.5**

*The negative numbers in the "change" column in the table above represent a greater proposed impact than the existing conditions

Table 8-2 Indirect Impacts of Ditch Improvements to NWI Wetlands

Wetland Type	Improvements to WD 3					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
Freshwater Emergent	132.9	133.1	-0.3	294.3	291.1	3.2
Freshwater Forested/Shrub Wetland	112.6	109.7	3.0	273.3	269.1	4.2
Freshwater Pond	1.2	1.2	0.0	2.5	2.5	0.0
Lake	0.0	0.0	0.0	0.0	0.0	0.0
Riverine	46.2	46.2	0.0	70.2	69.3	0.9
Total	**292.9**	**290.2**	**2.7**	**640.3**	**632.0**	**8.3**

Wetland Type	Improvements to CD 16					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
Freshwater Emergent	132.9	125.5	7.4	294.3	295.2	-0.9
Freshwater Forested/Shrub Wetland	112.6	112.6	0.0	273.3	273.2	0.1
Freshwater Pond	1.2	1.2	0.0	2.5	2.5	0.0
Lake	0.0	0.0	0.0	0.0	0.0	0.0
Riverine	46.2	45.9	0.3	70.2	70.7	-0.6
Total	**292.9**	**285.2**	**7.6**	**640.3**	**641.7**	**-1.4***

Wetland Type	Improvements to CD 17 Br 1					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
Freshwater Emergent	132.9	132.9	0.0	294.3	294.7	-0.4
Freshwater Forested/Shrub Wetland	112.6	55.0	57.6	273.3	275.6	-2.3
Freshwater Pond	1.2	1.2	0.0	2.5	2.5	0.0
Lake	0.0	0.0	0.0	0.0	0.0	0.0
Riverine	46.2	45.8	0.4	70.2	69.4	0.8
Total	**292.9**	**234.9**	**58.0**	**640.3**	**642.2**	**-1.9***

Wetland Type	Improvements to SD 69					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
Freshwater Emergent	132.9	130.7	2.1	294.3	285.1	-0.9
Freshwater Forested/Shrub Wetland	112.6	103.8	8.8	273.3	233.1	0.1
Freshwater Pond	1.2	1.2	0.0	2.5	2.5	0.0
Lake	0.0	0.0	0.0	0.0	0.0	0.0
Riverine	46.2	45.3	0.8	70.2	69.5	-0.6
Total	**292.9**	**281.0**	**11.8**	**640.3**	**641.7**	**-1.4***

Wetland Type	Improvements to Whitney Ditch (SD 20)					
	2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres		
Freshwater Emergent	132.9	132.0	0.9	294.3	285.9	8.4
Freshwater Forested/Shrub Wetland	112.6	103.2	9.5	273.3	238.8	34.5
Freshwater Pond	1.2	1.1	0.1	2.5	2.4	0.1
Lake	0.0	0.0	0.0	0.0	0.0	0.0
Riverine	46.2	45.5	0.6	70.2	69.0	1.2
Total	**292.9**	**281.8**	**11.1**	**640.3**	**596.1**	**44.2**

*The negative numbers in the "change" column in the table above represent a greater proposed impact than the existing conditions

Table 8-3 Indirect Impacts of Conveyances to NWI Wetlands

Wetland Type	Diversion 3 with Retention A						Wetland Type	New Conveyance along CR 115					
	2 Year			10 Year				2 Year			10 Year		
	No-action	Proposed	Change	No-action	Proposed	Change		No-action	Proposed	Change	No-action	Proposed	Change
	Acres			Acres				Acres			Acres		
Freshwater Emergent	132.9	112.9	20.0	294.3	301.4	-7.0	Freshwater Emergent	132.9	122.0	10.9	294.3	290.7	3.6
Freshwater Forested/Shrub Wetland	112.6	169.0	-56.4	273.3	435.3	-162.0	Freshwater Forested/Shrub Wetland	112.6	112.7	-0.1	273.3	275.7	-2.4
Freshwater Pond	1.2	1.2	0.1	2.5	2.4	0.1	Freshwater Pond	1.2	1.2	0.0	2.5	2.5	0.0
Lake	0.0	0.0	0.0	0.0	0.0	0.0	Lake	0.0	0.0	0.0	0.0	0.0	0.0
Riverine	46.2	44.1	2.0	70.2	70.6	-0.4	Riverine	46.2	46.0	0.2	70.2	70.7	-0.5
Total	**292.9**	**327.2**	**-34.3***	**640.3**	**809.6**	**-169.3***	**Total**	**292.9**	**281.9**	**11.0**	**640.3**	**639.5**	**0.8**

*The negative numbers in the "change" column in the table above represent a greater proposed impact than the existing conditions

Temporary Impacts

Construction of the three retention basins, two new conveyances, and improvements to five ditches would require heavy earth-moving operations. The Wetland Conservation Act calls for no net loss in the quantity, quality and biological diversity of wetlands (M.S. 103A.201, Subd.2). Wetland and/or stream impacts would be replaced as applicable per the requirements of Section 404 of the Clean Water Act. Any final mitigation requirements would be determined by the U.S. Army Corps of Engineers (USACE) through the Section 404 Permit process.

RRWD (Roseau River Watershed District) Desktop Study of Wetlands

In addition to reviewing NWI wetland data, RRWD staff completed a desktop study reviewing aerial photos to locate wetland signatures in the retention basin areas. The wetland signatures determined based on aerial photos were similar to NWI data near the location of the retention areas. See section 2, updated wetland review, for more details on this study.

Summary of Impacts

Direct impacts to NWI wetlands (impacts due to construction) for Retention A (22.3 acres) are less than Retention A2 (28.3 acres). New Conveyance Along CR 115, Diversion 3, and Improvements to WD3, CD 17 Br 1, and CD 16 show the lowest direct impacts. As mentioned above, for indirect impacts, the three retention basin alternatives would experience increased inundation in NWI wetland areas within the retention basin areas, and potentially less inundation in downstream protected areas. The data shows small increases (1.4 to 1.9 acres) in indirect impacts to NWI wetlands for the *Improvements to CD16, CD17, and SD69* alternatives. These impacts are negligible and can likely be avoided if the alternatives are selected for final design.

Riparian Areas

Direct Effects

Permanent impacts to PWI listed rivers and streams would be limited to the SD 20 and SD 69 ditch improvement alternatives as well as the construction of Retention A and A2. The construction of retention basin C2, the new conveyances, and the remaining ditch improvements are not in proximity to any other PWI listed rivers and streams.

Indirect Effects

No-Action Alternative

The majority of waterways within the Whitney Lake Subwatershed are a network of drainage ditches. The use of drain tile and ditches in agriculture quicken water movement across land and into waterways. This quick movement, along with greater volume of water due to flooding, increases streambank erosion and the flow of harmful pollutants into rivers and streams[1]. Riparian degradation will likely continue due to runoff of sediment and phosphorus from agricultural fields in the watershed.

Construction Alternatives

It is anticipated that the new conveyances and ditch improvement alternatives will not cause significant impacts to rivers and streams within the subwatershed as a result of the 2- and 10-year rainfall events since these events would be of short duration. The retention basin alternatives have the potential to lower runoff flow and volume and decrease streambank erosion to the Roseau River and/or SD 20 and SD 69.

Temporary Impacts

Construction of the three retention basins, two new conveyances, and improvements to five ditches would require heavy earth-moving operations. Vegetation will be removed, topsoil will be stripped and stockpiled, and unsuitable soils removed and stockpiled on site.

Summary of Impacts

The retention basin alternatives have the potential to lower runoff flow and volume and decrease streambank erosion to the Roseau River and/or SD 20 and SD 69.

Wildlife Habitat

Direct Effects

Permanent impacts to wildlife habitat would be limited to areas directly impacted by the construction of the retention basin embankments, the five ditch improvements, and two new conveyances. These construction activities will clear any trees necessary for construction and future maintenance. Inundation in the retention areas could potentially impact the existing forested areas, depending on the depth and duration of inundation. Section 2 contains figures of the 100-year depth in each retention area. Construction alignments that intersect forested areas will impact more habitat than alignments that only intersect agricultural lands. Therefore, the final design of each alternative will consider these effects in order to avoid or minimize habitat losses.

[1] https://www.pca.state.mn.us/water/threats-minnesotas-rivers-and-streams. Accessed 8/28/2018

Indirect Effects

No-action Alternative

The no-action alternative would not include construction of flood retention structures and current habitat would remain the same.

Construction Alternatives

Roseau Lake, four Minnesota Department of Natural Resources (MNDNR) Wildlife Management Areas (WMA) (Roseau River WMA, Ondatra WMA, Moose Marsh WMA, and Roseau Lake WMA), and an Important Bird Area are located within one mile of the Whitney Lake Subwatershed.

Wildlife Management Areas within the subwatershed are managed for watchable wildlife and game species such as deer, black bear, a variety of small game, and sharptail grouse.

Roseau Lake is located in NW Minnesota between the town of Roseau and the Canadian Border. The lake was drained in the early 1900's for agricultural purposes. Attempts to farm the lake basin have been abandoned due to frequent flooding. This frequent flooding leads to lost crops or greatly reduced yields and lost waterfowl production[2]. The DNR has identified Roseau Lake as a Lake of Moderate Biological Significance. Lakes of Moderate Biological Significance contain occurrences of rare species, moderately disturbed native plant communities, and/or landscapes that have strong potential for recovery[3]. The significance of Roseau Lake is based on it being an important waterfowl lake.

The Kittson-Roseau Aspen Parkland Important Bird Area (IBA), designated by the National Audubon Society, is located in the northwest corner of the Whitney Lake Subwatershed. The goal of the IBA program is to ensure the survival of wild bird populations through the identification and protection of their most important habitats. The semi-natural state of these intervening areas provide important connections between many of the large blocks of aspen parkland vegetation. This IBA lies within the Aspen Parkland Physiographic Area (Partners In Flight Area 30), which harbors the highest number of breeding birds of any physiographic area on the continent. The complex interspersion of habitats in this IBA are particularly important because high priority habitats (sedge wetland, native prairie, oak savanna, in particular) comprise vast expanses of native vegetation[4].

It is anticipated that the new conveyances and ditch improvement alternatives will not cause significant impacts to the wildlife habitat as a result of the 2- and 10-year rainfall events since these events would be infrequent and of short duration.

Temporary Impacts

Construction of the three retention basins, two new conveyances, and improvements of five ditches would require heavy earth-moving operations. Vegetation will be removed, topsoil will be stripped and stockpiled, and unsuitable soils removed and stockpiled on site.

Summary of Impacts

No long-term or permanent changes to the amount wildlife habitat are expected to change due to impacts from any of the alternatives.

Threatened and Endangered Species

Section 7 of the Endangered Species Act of 1973 requires that actions authorized, funded, or carried out by Federal agencies not jeopardize federally threatened or endangered species or adversely modify

[2] http://www.roseauriverwd.com/Project_Roseau_Lake_Bottom.html. Accessed 8/29/2018.

[3] https://files.dnr.state.mn.us/eco/mcbs/biodiversity_significance_ranking.pdf. Accesses 8/30/2018.

[4] https://www.audubon.org/important-bird-areas/kittson-roseau-aspen-parkland-iba. Accessed 8/27/2018.

designated critical habitat. To fulfill this mandate, Federal agencies (or their designated non-federal representatives) must consult with the U.S. Fish and Wildlife Service if they determine their project may affect listed species or critical habitat. Agencies must confer under section 7(a)(4) if any proposed action is likely to jeopardize species proposed for listing as endangered or threatened or likely to adversely modify any proposed critical habitat.

Direct Effects

Permanent impacts to threatened and endangered species are not anticipated because habitat for Federal and State Listed Threatened and Endangered Species (TES) within the subwatershed are not located in areas directly impacted by construction of retention basins, the five ditch improvements, or the two new conveyances.

Indirect Effects

No-action Alternative

The no-action alternative would not include construction of flood retention structure. Habitat for TES would remain in the current state.

Construction Alternatives

A review for Federally Listed TES within one mile of the Whitney Lake Subwatershed boundary was completed using the USFW IPAC database on August 17, 2018, and three occurrences were found (see the FT species listed in Table 9). The IPAC list identifies any federally threatened, endangered, proposed and candidate species that may occur within the action area (one mile buffer around the Whitney Lake Subwatershed boundary) or the area that is likely to be affected by your proposed project.

State protected TES were identified using the Natural Heritage Inventory System (NHIS) database under license agreement LA-647. The database was used to identify known occurrences of state protected TES species within one mile of the Whitney Lake Subwatershed. Additionally, a letter requesting concurrence with these findings was sent to the MNDNR on November 6, 2018. Table 9 shows federal and state listed TES species located within one mile of the Whitney Lake Subwatershed.

Table 9. Federal and State Listed Threatened and Endangered Species

Category	Common Name	Scientific Name	Status
Vertebrate Animal	**Canada Lynx**	***Lynx canadensis***	**FT**
Vertebrate Animal	**Gray Wolf**	***Canis lupus***	**FT**
Vertebrate Animal	**Northern Long-eared Bat**	***Myotis septentrionalis***	**FT**
Vertebrate Animal	**Burrowing Owl**	***Athene cunicularia***	**SE**
Vertebrate Animal	**Sprague's Pipit**	***Anthus spragueii***	**SE**
Vascular Plant	Few-flowered Spikerush	*Eleocharis quinqueflora*	SPC
Vascular Plant	Twig Rush	*Cladium mariscoides*	SPC
Vertebrate Animal	Marbled Godwit	*Limosa fedoa*	SPC
Invertebrate Animal	Black Sandshell	*Ligumia recta*	SPC

Vertebrate Animal	Eastern Spotted Skunk	*Spilogale putorius*	ST
Vertebrate Animal	Sandhill Crane	*Grus canadensis*	SW
Vertebrate Animal	Upland Sandpiper	*Bartramia longicauda*	SW

FT= Federal Threatened, SW=State Watchlist, ST= State Threatened, SE = State Endangered, SPC= State Special Concern

There are no regulatory restrictions limiting actions affecting special concern or watchlist species. As defined by the MNDNR, a species of special concern is a species that is not threatened or endangered but is extremely uncommon in Minnesota or has "unique or highly specific habitat requirements and deserves careful monitoring of its status" (MNDNR). The federal species in Table 9 identifies any federally threatened, endangered, proposed and candidate species that may occur within the action area that is likely to be affected by the proposed project.

No USFW Designated Critical Habitat for Canada Lynx and Gray Wolf occur within the one-mile buffer of the Project area. Critical Habitat for Northern Long-eared Bat has not been designated by the USFW. Suitable summer habitat for the northern long-eared bat consists of a wide variety of forested and wooded habitats where they roost, forage, and travel. They do not depend on certain species of trees for roosts, instead they use many tree species that form suitable cavities or retain bark. Suitable winter habitat includes caves and cave-like structures (e.g., abandoned or active mines, railroad).[5]

Two state listed threatened species and one state listed endangered species have known occurrences within one mile of the Project area. Burrowing owl habitat includes grazed pastures or native, mixed-grass prairies. Eastern spotted skunks are generally found in open lands with sufficient cover, such as thickets, brush, and riparian woodlands. In agricultural areas they use buildings, corncribs, trash piles, rock piles, and haystacks for cover and den sites. Sprague's pipits prefer native mixed or tall-grass upland prairies, particularly tracts that have light to moderate levels of grazing.[6]

The 2- and 10-year rainfall events would occur for short durations. However, the frequency of these events may cause changes to the understory or canopy of wooded areas within the retention basins or along the impacted area. Depending on the duration, habitat may be altered. If trees are removed during construction, potential habitat for the Northern Long-eared Bat is reduced, but these habitat changes would be local and are located far enough from known populations of TES that no impacts would occur to these species.

Temporary Impacts

Construction of the three retention basins, two new conveyances, and improvements of five ditches would require heavy earth-moving operations. Vegetation will be removed, topsoil will be stripped and stockpiled, and unsuitable soils removed and stockpiled on site.

Earth moving and heavy civil construction activities would likely cause noise and vibration. However, noise and vibration are temporary and would not result in long-term changes to habitat or use by Federal and State TES. Construction activities are far enough from known occurrences of TES that no alterations to occupied habitat is anticipated.

Summary of Impacts

No impacts are anticipated to TES from any of the alternatives.

[5] https://ecos.fws.gov/ecp0/profile/speciesProfile?sId=9045#crithab. Accessed 8/27/2018.

[6] https://www.dnr.state.mn.us/rsg/a-z_search.html?action=a-zSearch&letter=S&column=common_name. Accessed 8/27/2018.

Migratory Birds

The MBTA is a statute that protects 1,006 bird species within the United States, making it unlawful to "pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatsoever, receive for shipment, transportation or carriage, or export, at any time, or in any manner, and migratory bird, included in the terms of this Convention,…for the protection of migratory birds…or any part, nest, or egg of any such bird, (16 USC703), unless these activities are permitted by regulatory means." Most birds (outside of introduced species and non-migratory game birds) within the US are protected under the MBTA.

The MBTA was enacted in 1918 as a means of protecting migratory bird populations from over-harvesting. The USFWS oversees and enforces the MBTA. The USFWS issues depredation permits for destruction of active nests of species covered under the MBTA. A depredation permit is not needed for destruction of nests that are not active. The Minnesota DNR also has permit authority over destruction of active bird nests.

A 1988 amendment to the Fish and Wildlife Conservation Act requires the U.S. Fish and Wildlife Service (USFWS) to identify species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act (ESA) of 1973. Bird species considered for the Birds of Conservation Concern (BCC) include nongame birds, gamebirds without hunting seasons and ESA candidate, proposed or recently delisted species.

Direct Effects

Permanent impacts to migratory bird habitat would be limited to areas directly impacted by construction. The three retention basin sites, five ditch improvements, and two new conveyances are not anticipated to cause permanent impacts to migratory bird habitat due to their minimal construction footprint.

Indirect Effects

No-action Alternative

The no-action alternative would not include construction of flood retention structures. Habitat for migratory birds would remain in the current state.

Construction Alternatives

The five ditch improvements and two new conveyances are not anticipated to cause any indirect impacts to migratory bird habitat. Water impounded within the retention areas during the 2- and 10-year rainfall events could have a temporary impact to migratory bird habitat. Habitat changes could be beneficial to species who utilize wetland or transitional habitats and detrimental to those using more terrestrial habitats. The dynamic nature of habitat changes caused by weather, fire, wind and floods causes species to move in and out of new areas each year. These fluctuations in habitat availability would be consistent to those currently experienced by annual migrants and resident species that occur in this region of the state. It is thought that the annual changes to habitats associated with this project would not cause widespread displacement and that species using these habitats would remain and no permanent changes to species use are anticipated.

The following species are known to occur within one mile of the project area based on a query of IPAC[7] on August 27, 2017. Table 10 identifies the federally listed migratory birds of conservation concern

[7] https://ecos.fws.gov/ipac/project/SLHJ3MXGCVDUTF4V6QLHFHCMLM/review. Accessed 8/27/2018/

located within 1 mile around the 2- and 10-year rainfall events.

Table 10. Birds of Conservation Concern

Common Name	Scientific Name
American Bittern	*Botaurus lentiginosus*
Bald Eagle	*Haliaeetus leucocephalus*
Black Tern	*Chlidonias niger*
Black-billed Cuckoo	*Coccyzus erythropthalmus*
Bobolink	*Dolichonyx oryzivorus*
Canada Warbler	*Cardellina canadensis*
Cape May Warbler	*Setophaga tigrina*
Eastern Whip-poor-will	*Antrostomus vociferus*
Franklin's Gull	*Leucophaeus pipixcan*
Harris's Sparrow	*Zonotrichia querula*
Least Bittern	*Ixobrychus exilis*
Lesser Yellowlegs	*Tringa flavipes*
Long-eared Owl	*asio otus*
Marbled Godwit	*Limosa fedoa*
Olive-sided Flycatcher	*Contopus cooperi*

Temporary Impacts

Construction of the three retention basins, two new conveyances, and improvements of five ditches would require heavy earth-moving operations. Vegetation will be removed, topsoil will be stripped and stockpiled, and unsuitable soils removed and stockpiled on site. Temporary construction activities in the vicinity of the retention basins, the ditch improvements, or the new conveyances are not anticipated to impact migratory birds. To the extent possible, vegetation that may need to be cleared during construction would be completed outside of the nesting period (March 1 – September 30) to avoid or minimize adverse effects on migratory birds.

Summary of Impacts

No impacts are anticipated to migratory birds from any of the alternatives. As mentioned above, vegetation that may need to be cleared during construction would be completed outside of the nesting period (March 1 – September 30) to avoid or minimize adverse effects on migratory birds.

Invasive Species

The designated Weed Inspector for Roseau County is the Roseau County Soil and Water Conservation District. The County Weed Inspector is responsible for administering the Minnesota Noxious Weed Law, seed testing and inspection, and commercial applicator testing for Roseau County.

Direct Effects

The potential spread of invasive species would be limited to areas directly impacted by construction of retention basins or from construction equipment moving from one construction area to another. If invasive species are located in the study area, BMPs would be developed to prohibit the spread of invasive species.

Indirect Effects

No-action Alternative

The Roseau County Soil and Water Conservation District is the Weed Inspector for the County and administers the Minnesota Noxious Weed Law. The no-action alternative would not include construction so the spread of invasive species is not anticipated.

Construction Alternatives

According to Roseau County's Cooperative Weed Management Program grant reporting[8], their target invasive species are spotted knapweed, purple loosestrife, and common tansy. Secondary target species are Canada thistle, leafy spurge, and wild parsnip. During construction, contractors and project managers will follow Best Management Practices (BMPs) for preventing the spread of invasive species. Examples of BMPs include avoiding unnecessary ground disturbances and using erosion control measures that are free of weeds and weed seeds.

Temporary Impacts

Construction of the three retention basins, two new conveyances, and improvements of five ditches would require heavy earth-moving operations. Vegetation will be removed, topsoil will be stripped and stockpiled, and unsuitable soils removed and stockpiled on site. During construction, contractors and project managers will follow Best Management Practices (BMPs) for preventing the spread of invasive species.

Summary of Impacts

As mentioned above, during construction, contractors and project managers should follow Best Management Practices (BMPs) to prevent the spread of invasive species.

Environmental Assessment Conclusions

Retention areas provide more environmental benefit (improvement of surface water quality) than conveyance alternatives. New Conveyance Along CR 115, Diversion 3, and Improvements to CD 17 Br 1, CD 16, and WD 3 show the lowest direct impacts. No permanent impacts to riparian areas, wildlife habitat, TES, or migratory birds are anticipated.

2. Updated Wetland Review

RRWD completed an aerial wetland review in the area of Retentions A, A2, and C2. Figure 2 below shows the aerial wetland review areas identified. For comparison purposes, NWI wetlands are shown in Figure 3. Since concurrence point 2 was submitted, a new residency has been constructed within the proposed Retention C2 footprint. This affected the site layout which is shown in Figure 2 below and has been used for this updated wetland review.

[8] Roseau County SWCD, Cooperative Weed Management Program, https://www.roseauswcd.org/county-weed-inspector (Accessed September 26, 2018).

The wetlands in Figure 2 are based on guidance metrics for aerial review (Guidance for Offsite Hydrology/Wetland Determinations, July 2016, BWSR and USACE), meaning they may not exhibit the three wetland criteria in the field. Field drains that met aerial criteria were included as many of them were in shallow swales. In the field, these drains may delineate as non-wetland.

In attempt to differentiate wetland function and value, the wetlands were categorized as follows:

- **F -** Farmed Wetland. Designates wetlands that were actively row cropped or shown signatures of being modified/developed
- **NF** – Non-farmed Wetland. Wetlands that are either used for recreation/hunting land, located in pastures or otherwise show little/no signs of ongoing disturbance.

Figure 2. Aerial Wetland Review in Retention Basin Areas

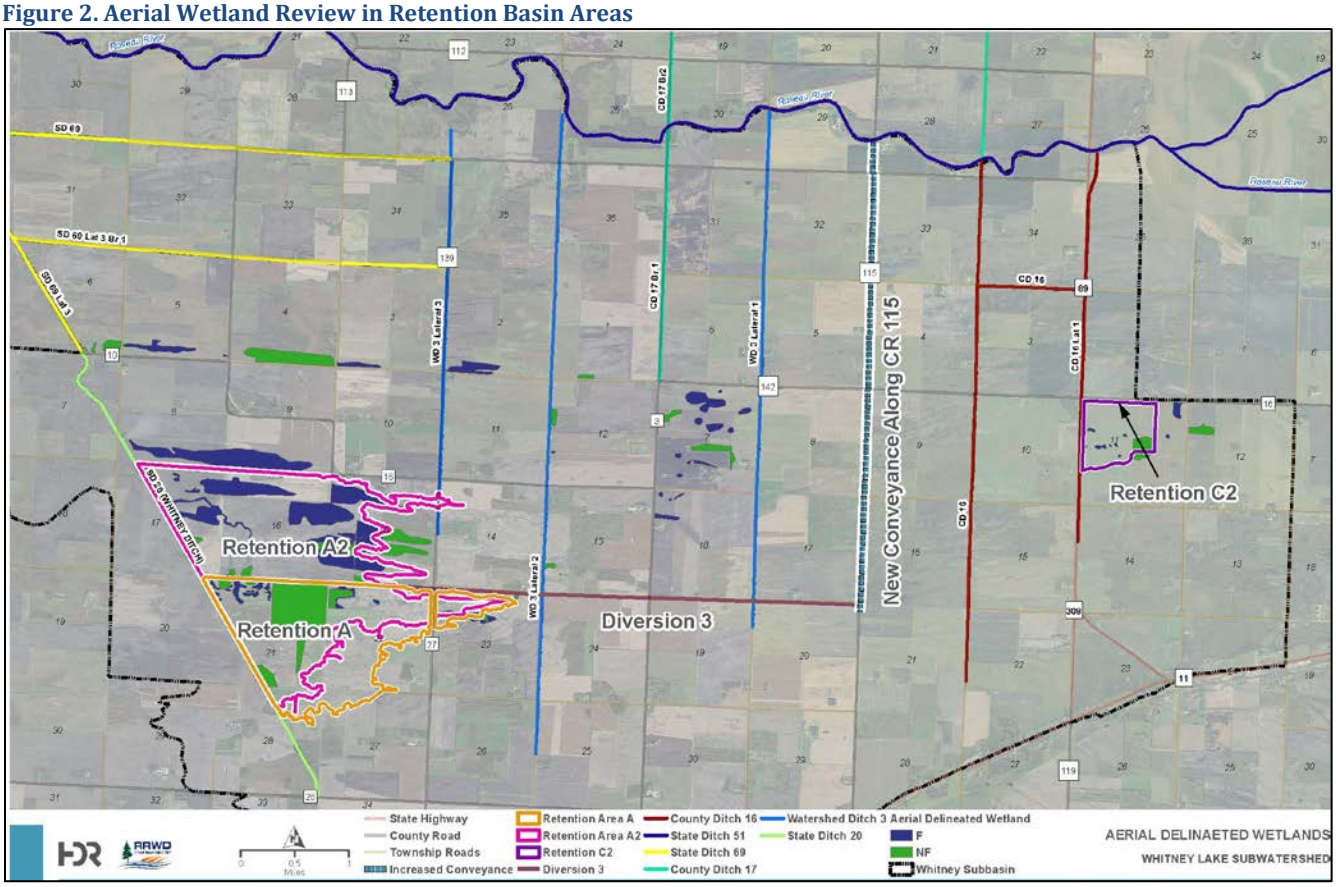


Figure 3. NWI Wetlands

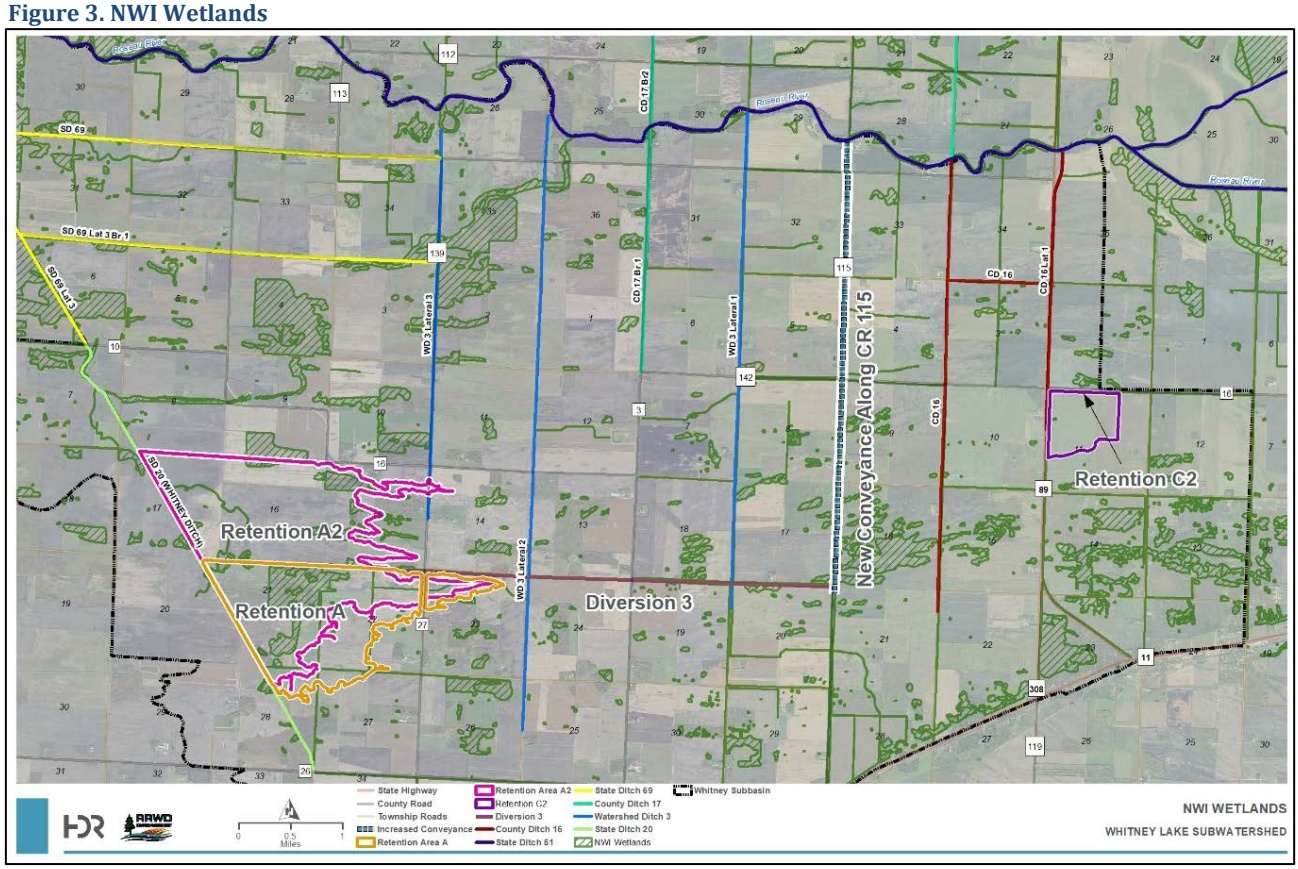


Table 11 shows the direct impacts of the retention basins on the wetlands delineated by the aerial review. For the retention basins, direct impacts are the embankment footprint (impacts caused by construction). Results show that Retention A2 has less total direct impacts to wetlands than Retention A. In addition, Retention A2 shows less direct impacts to non-farmed wetlands than Retention A. Retention C2 shows minimal direct wetland impacts.

Table 12 provides the direct impacts of the conveyance and ditch improvement alternatives on the wetlands delineated by the aerial review. For the conveyance and ditch improvement alternatives, direct impacts are the conveyance and berm footprint (impacts caused by construction).

Table 11. Direct Impacts of Retention Basins to Aerial Review Wetlands

Aerial Review Wetland Type	Retention A	Retention A2	Retention C2
	Embankment Footprint	Embankment Footprint	Embankment Footprint
	Acres	Acres	Acres
F - Farmed Wetland	8.7	22.7	0.4
NF – Non-farmed Wetland	23.1	7.9	0.0
Total	**31.8**	**30.6**	**0.4**

Table 12. Direct Impacts of Conveyances and Ditch Improvements to Aerial Review Wetlands

Aerial Review Wetland Type	New Conveyance along CR 115	Diversion 3	Improvements to WD 3	Improvements to CD 16	Improvements to CD 17 Br 1	Improvements to SD 69	Improvements to Whitney Ditch (SD 20)
	Conveyance and Berm Footprint	Conveyance and Berm Footprint	Conveyance Width Improvement and Berm Footprint	Conveyance Width Improvement and Berm Footprint	Conveyance Width Improvement and Berm Footprint	Conveyance Width Improvement and Berm Footprint	Conveyance Width Improvement and Berm Footprint
	Acres	Acres	Acres	Acres	Acres	Acres	Acres
F - Farmed Wetland	1.0	0.2	6.4	3.6	0.7	3.1	4.0
M - Modified vegetation	0.4	1.9	4.8	0.4	0.0	42.0	13.9
Total	**1.4**	**2.1**	**11.2**	**4.0**	**0.7**	**45.1**	**17.9**

Table 13 shows the indirect impacts of the retention basins on the wetlands delineated by the aerial review. The values for the indirect impacts shown in the table are the aerial review wetlands that would be inundated if the retention basin was full (100-year rainfall event). Results show that Retention A2 has more total indirect impacts to wetlands than Retention A. In addition, Retention A2 shows more indirect impacts to non-farmed wetlands than Retention A. Compared to Retention sites A

and A2, C2 shows minimal indirect wetland impacts.

Table 13. Indirect Impacts of Retention Basins to Aerial Review Wetlands (Full Pool, 100-Yr Rainfall Event)

Aerial Review Wetland Type	Retention A	Retention A2	Retention C2
	Acres	Acres	Acres
F - Farmed Wetland	45.1	391.1	5.5
NF - Not Farmed	217.0	263.2	16.6
Total	**262.1**	**654.3**	**22.1**

Figure 4 through Figure 6 show the flooding depths for Retention Basin A, A2, and C2 respectively when the basins are full (100-year event). The wetlands delineated by the aerial review are also shown in the figures. Duration of each flood event will depend on a prescribed operation plan for each retention site, but a general assumption is that the gated storage will be held for a maximum of 30 days. The maximum depth for Retention A and A2 is 3 feet, and Retention C2 has a maximum depth of 7 feet.

Figure 4. Retention A Inundation Depth for 24-hour, 100-year rainfall event, Aerial Wetland Review Areas Included

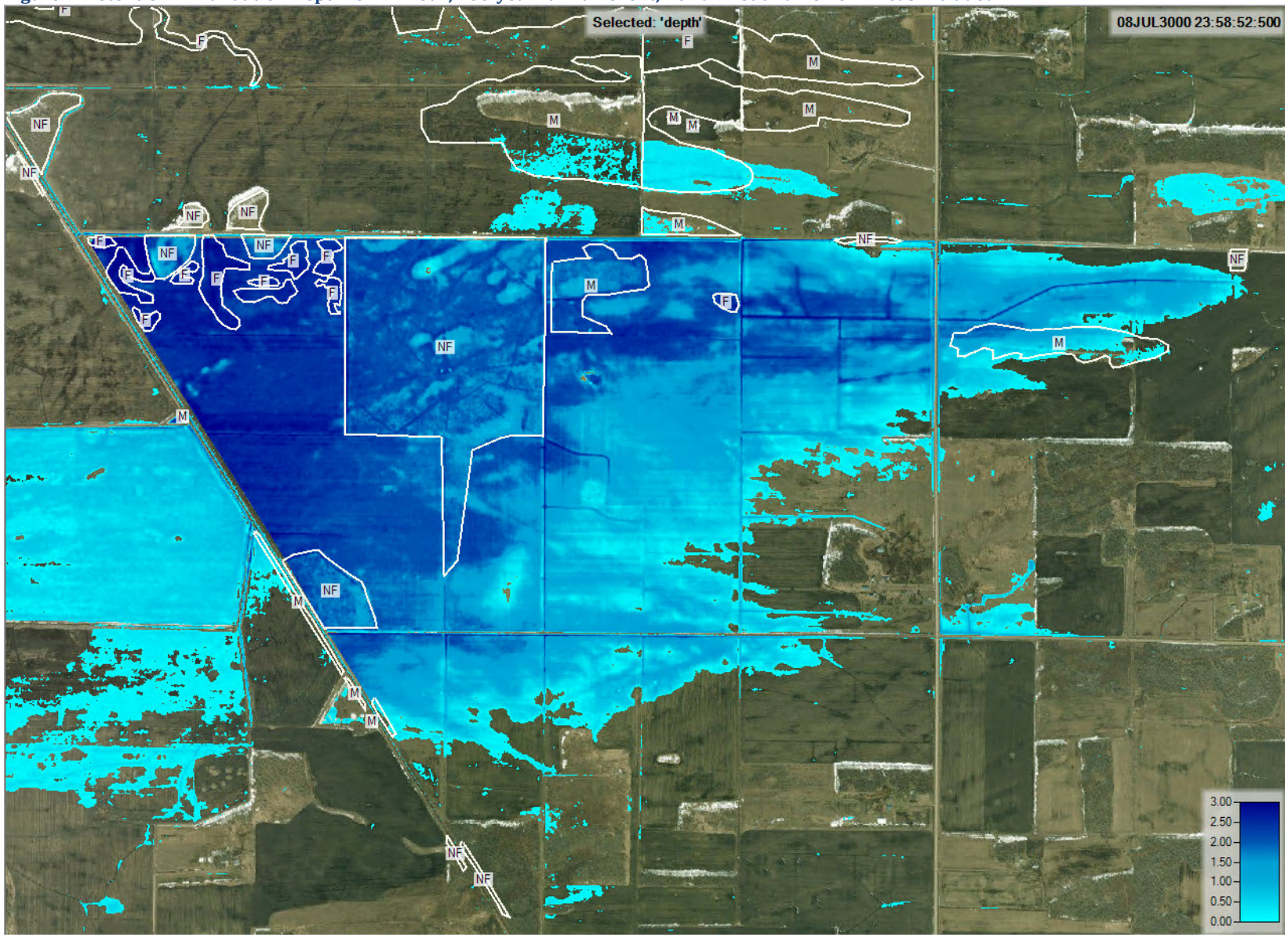


Figure 5. Retention A2 Inundation Depth for 24-hour, 100-year rainfall event, Aerial Wetland Review Areas Included

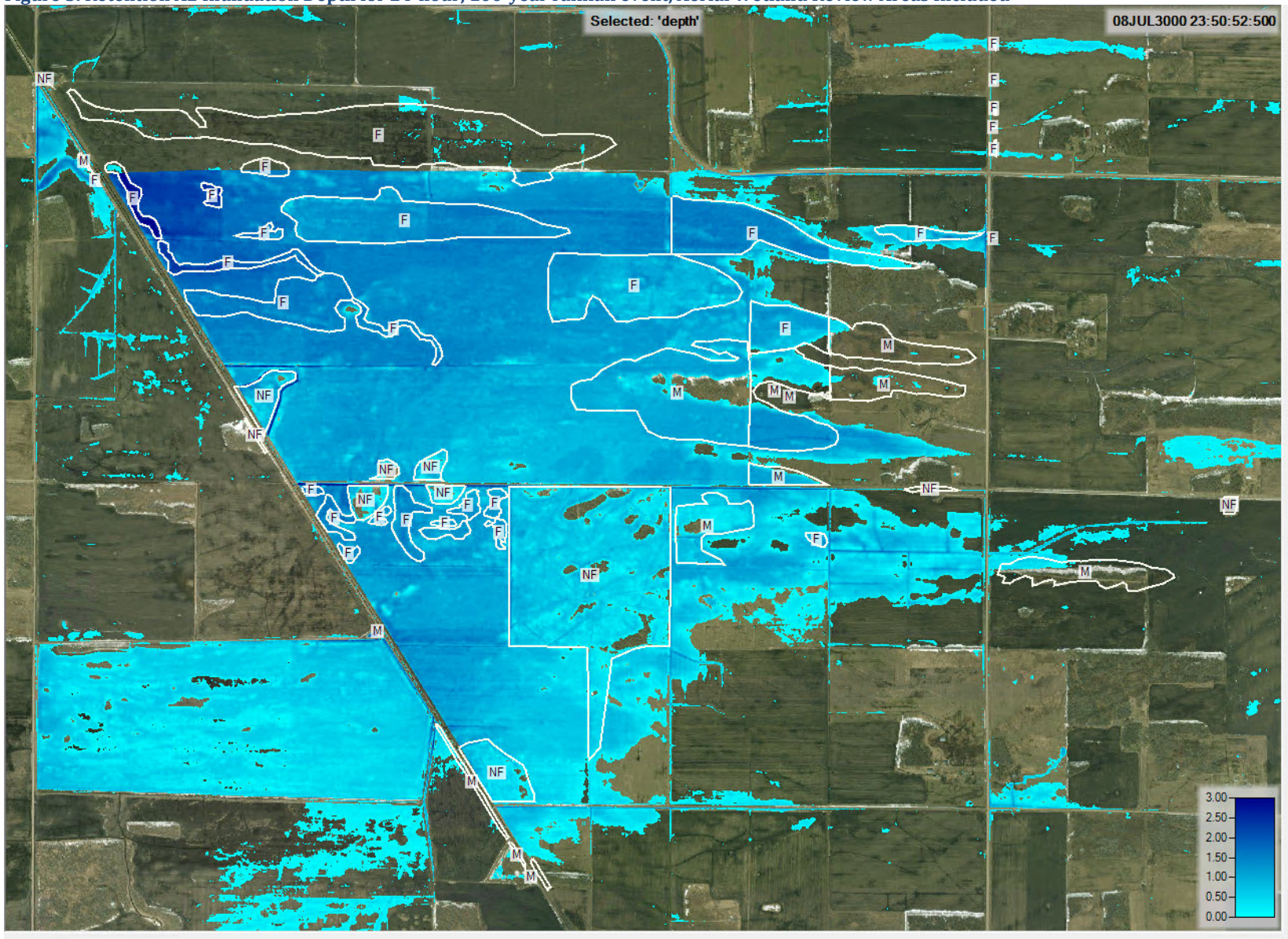
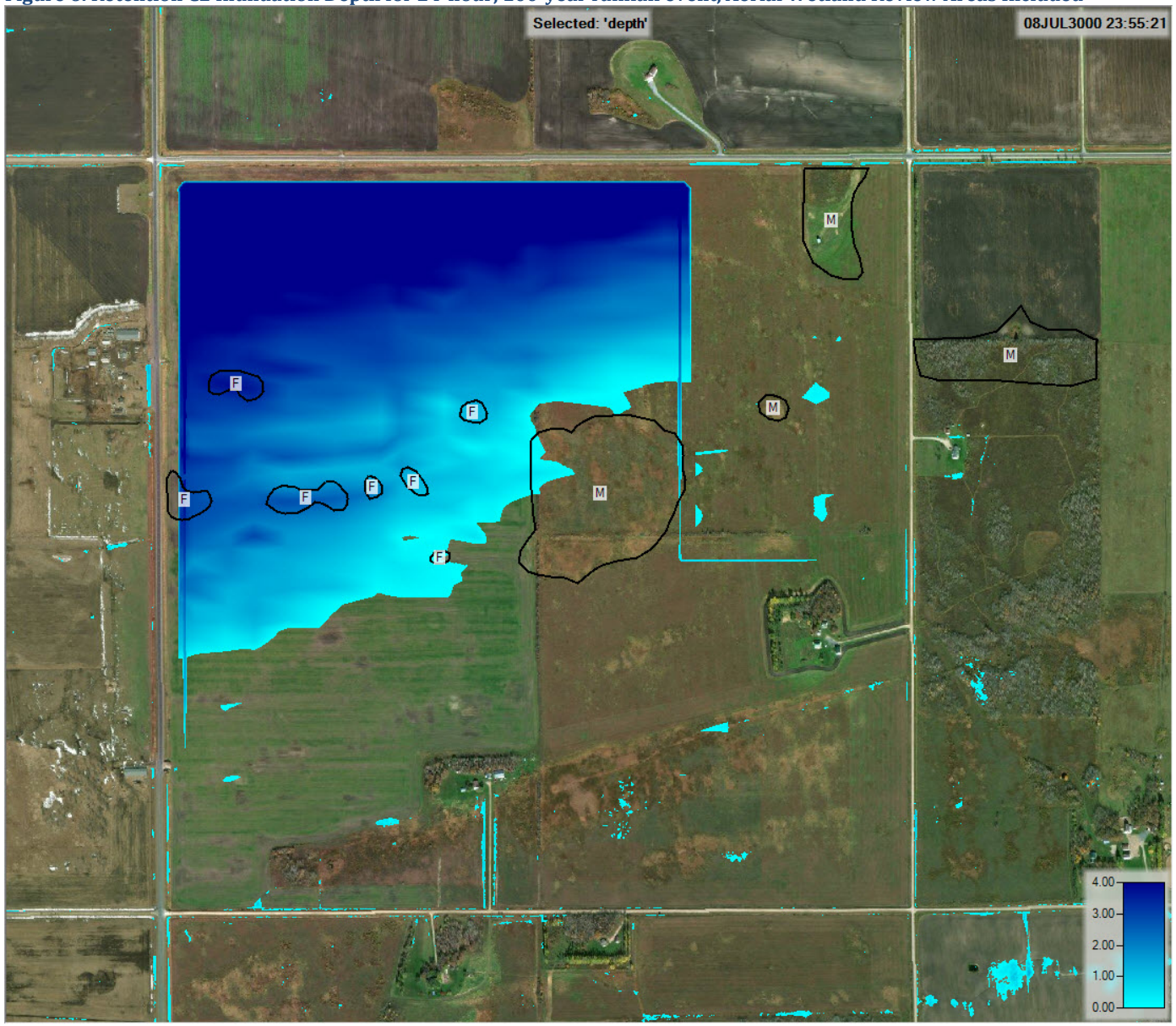


Figure 6. Retention C2 Inundation Depth for 24-hour, 100-year rainfall event, Aerial Wetland Review Areas Included



3. Assessment Based on Practicability

Preliminary cost estimates for each of the 10 alternatives are shown in Table 14 and estimated reductions in acres of inundation during the 10-year rainfall event for cultivated crops and hay/pasture are shown in Table 15. Depending on the alternative, construction cost estimates included a combination of earthwork quantities, lengths of culvert, structural costs, erosion control quantities, mobilization costs, clearing and grubbing area, and field laboratory costs. All of these construction costs except for mobilization and field laboratory were estimated from probable quantities and unit cost assumptions. Mobilization and field laboratory costs are calculated as percentages of other items, so they vary based on the scale of the alternative. The other rows in Table 14 are also based on a percentage of the construction costs so they follow a pattern based on the size and scale of the alternative. Right of way costs assume that the RRWD will purchase lands that are directly impacted by construction and purchase flowage easements where lands are at risk of inundation. $800 per acre was assumed for purchase and $350 per acre for easement.

The cost of Retention A2 is greater than A because there is more earthwork. These quantities were calculated using AutoCAD Civil 3D and are based on a maximum embankment height that does not put the adjacent structures at risk of flooding. Table 16 has detailed model results based on these embankment elevations and spillways. The results are from a HEC-HMS model developed for the project. The model is designed to route all drainage area runoff into retention until the spillway elevation is reached, then excess flows pass through to the downstream channel. Retention A has a spillway elevation of 1034.5 feet and Retention A2 has a spillway elevation of 1033.0 feet. All the available site storage below these spillway elevations is considered gated storage and shown in Table 15. Any storage above the spillway is considered ungated storage and would only be retained for a short period of time. Table 15 also includes lengths for the conveyance alternatives, reductions in flood damages to agricultural lands during a 10-year rainfall event, and reduction in road damages during a 25-year rainfall event.

When looking at the retention areas for practicability, Retention A is less costly than Retention A2, creates more gated storage (2,000 acre-feet vs 1,800 acre-feet) and covers a smaller footprint (1,200 acres vs 1,900 acres). Raising the embankment height of Retention A2 to gain additional storage would create a larger pool. The larger pool footprint would impact some adjacent structures. Retention C2 is the least costly, provides less storage than the other sites, and has the smallest footprint (270 acre-feet storage and 170 acres footprint), but this site can be revised in a future design phase to provide more efficient storage. Table 15 shows that Retention A2 provides the greatest flood damage reduction, but this is a result of removing more agricultural land from production. Retention A appears more practical than A2 (lower cost, more storage, smaller footprint). Although Retention A2 provides less storage in acre-feet, the site contains more agricultural land than Retention A. In determining costs and benefits of these alternatives, the inundation footprint was included as a legal cost, assuming the RRWD would purchase the land, removing it from crop production, or purchase a flowage easement which may cause crop production to cease as well. So the reduction in damages to agricultural land (results in Table 15) includes the lands that have been removed from agricultural production. In the results, Retention A2 will show a greater reduction in crop damages because less crop land will be in production. The downstream benefits of Retention A are similar to Retention A2.

For the conveyance alternatives, on average, the cost increases as the length of ditch improvement increases. Flood damage reduction varies with length of ditch improvement and cost. Diversion 3 (as an inlet to Retention A), Improving CD 16, New Conveyance Along CR 115, and Improving CD 17 Br 1 show a substantially lower amount of road damages compared to other alternatives.

Table 14. Cost Estimates for 10 Alternatives

Project Construction Item	Retention A	Retention A2	Retention A w/Diversion 3	Retention C2	New Conveyance Along CR115	Improve CD 16	Improve SD 69	Improve CD 17 Br 1	Improve Whitney Ditch (SD 20)	Improve WD 3
Construction	$1,522,749	$1,728,916	$2,912,420	$848,955	$533,967	$331,180	$508,000	$165,520	$192,000	$428,077
Engineering	$228,412	$259,337	$436,863	$127,343	$80,095	$49,677	$76,200	$24,828	$28,800	$64,212
Project Admin	$152,275	$172,892	$291,242	$84,896	$53,397	$33,118	$50,800	$16,552	$19,200	$42,808
Legal Costs (R.O.W.)	$524,495	$772,636	$571,040.05	$132,227	$20,848	$37,333	$94,158	$20,364	$62,501	$70,788
Road and Utility	$-	$-	$-	$3,750	$-	$13,500	$30,000	$54,000	$-	$81,750
Contingencies	$304,550	$345,783	$582,484	$169,791	$106,793	$66,236	$101,600	$33,104	$38,400	$85,615
Total Costs	$2,732,481	$3,279,565	$4,794,049	$1,366,962	$795,101	$531,044	$860,758	$314,368	$340,901	$773,250

Table 15. Retention Storage, Conveyance Length, and Project Benefits

	Retention A	Retention A2	Retention A w/Diversion 3	Retention C2	New Conveyance Along CR 115	Improve CD 16	Improve SD 69	Improve CD 17 Br 1	Improve Whitney Ditch (SD 20)	Improve WD 3
Gated Storage (acre-ft) or Length of Conveyance (miles)	2,000	1,800	2,000	270	4.4	8.1	12.7	2.3	4.8	14.6
Reduction in inundation for Ag Land - 10-year rainfall event (Acres)	414	521	563	99	47	48	75	100	255	120
Reduction in Roads Overtopped – 25-year rainfall event (feet)	130	155	1,290	30	340	670	5	505	130	5

Table 16. Retention Sites A and A2 Model Results

	Retention A			Retention A2		
	10-Year, 24-Hour	**25-Year, 24-Hour**	**100-Year, 10-Day**	**10-Year, 24-Hour**	**25-Year, 24-Hour**	**100-Year, 10-Day**
Peak Inflow (CFS)	371	538	835	443	646	982
Peak Storage (AC-FT)	1,886	2,300	2,777	1,975	2,316	3,405
Maximum Water Surface Elevation (FT NAVD88)	1,034.4	1,034.7	1,035.4	1,033.1	1,033.3	1,033.8
Peak Outflow (CFS)	-	50	628	18	92	494
Overflow Volume (AC-FT)	-	666	4,962	361	1,344	6,202

4. Assessment Based on Purpose and Need

Following the assessment of environmental and practicability considerations, a preferred alternative plan is to be selected that also meets the project purpose and need.

Table 17 is an overall assessment of the alternative impacts in the subwatershed. Each alternative has its own column which displays the ability to meet the several goals at each Regional Assessment Location (RAL) in the subwatershed. The RALs are listed in the first column of the table and are listed in order from east to west across the watershed. See
Figure 7 for a map showing the RALs.

The Project Goal column contains three goals for each RAL. The goals listed are as follows:

- Flood Reduction – protect agricultural land and reduce time of inundation to less than 24 hours for the 10-year 24-hour event
- Peak Flow and Volume – contribute to a regional goal of reducing peak flow along the Red River by 20 percent
- Maximum Water Surface Elevation – provide a six-inch reduction in water surface elevation for the 2-year 24-hour event

These goals were developed during the scoping process and are included in the Project's purpose and need. Green shaded cells in show that an alternative meets the goal, whereas red shaded cells show that the goal is not met. A legend is provided with Table 17 to show this.

This table is helpful in selecting the alternative plan because it gives a visual view of where the alternative benefits the subwatershed. The improvements to existing ditches and the new conveyance along CR 115 increase volume and peak flows at some RALs (indicated by light red). These downstream impacts will be evaluated in the design phase of the project to determine the magnitude of the effects.

Table 17. Results at Regional Assessment Locations

Regional Assessment Location	Project Goal	Alternative								
		Retention A/A2	Diversion 3	Retention C2	New Ditch along CR 115	Improvement CD 16	Improvement CD 17	Improvement WD 3	Improvement SD 69	Improvement Whitney Ditch (SD 20)
CD 16 LAT 1	FLOOD REDUCTION	0	0	+	0	+	0	0	0	0
	PEAK FLOWS AND VOLUMES	0	0	++	0	--	0	0	0	0
	MAXIMUM WSE*	0	0	++	0	++	0	0	0	0
CD 16	FLOOD REDUCTION	0	+	+	+	+	0	0	0	0
	PEAK FLOWS AND VOLUMES	0	+	0	0	-	0	0	0	0
	MAXIMUM WSE	0	0	0	0	+	0	0	0	0
CR 115	FLOOD REDUCTION	0	+	0	+	-	0	0	0	0
	PEAK FLOWS AND VOLUMES	0	0	0	--	-	0	0	0	0
	MAXIMUM WSE	0	0	0	++	0	0	0	0	0
WD 3 LAT 1	FLOOD REDUCTION	0	++	0	+	0	+	0	0	0
	PEAK FLOWS AND VOLUMES	0	+	0	+	0	0	-	0	0
	MAXIMUM WSE	0	+	0	+	0	0	+	0	0
CD 17	FLOOD REDUCTION	0	++	0	0	0	++	+	0	0
	PEAK FLOWS AND VOLUMES	0	+	0	0	0	-	+	0	0
	MAXIMUM WSE	0	+	0	0	0	0	+	0	0
WD 3 LAT 2	FLOOD REDUCTION	0	++	0	0	0	0	+	0	0
	PEAK FLOWS AND VOLUMES	0	+	0	0	0	0	-	0	0
	MAXIMUM WSE	0	+	0	0	0	0	0	0	0
WD 3 LAT 3	FLOOD REDUCTION	0	+	0	0	0	0	+	0	0
	PEAK FLOWS AND VOLUMES	0	+	0	0	0	0	-	0	0
	MAXIMUM WSE	0	0	0	0	0	0	+	0	0
SD 69	FLOOD REDUCTION	+	0	0	0	0	0	+	+	+
	PEAK FLOWS AND VOLUMES	++	0	0	0	0	0	0	0	0
	MAXIMUM WSE	+	0	0	0	0	0	0	0	0
Whitney Ditch (SD 20)	FLOOD REDUCTION	+	-	0	0	0	0	+	+	+
	PEAK FLOWS AND VOLUMES	++	-	0	0	0	0	0	0	-
	MAXIMUM WSE	+	0	0	0	0	0	0	0	-

NOTES

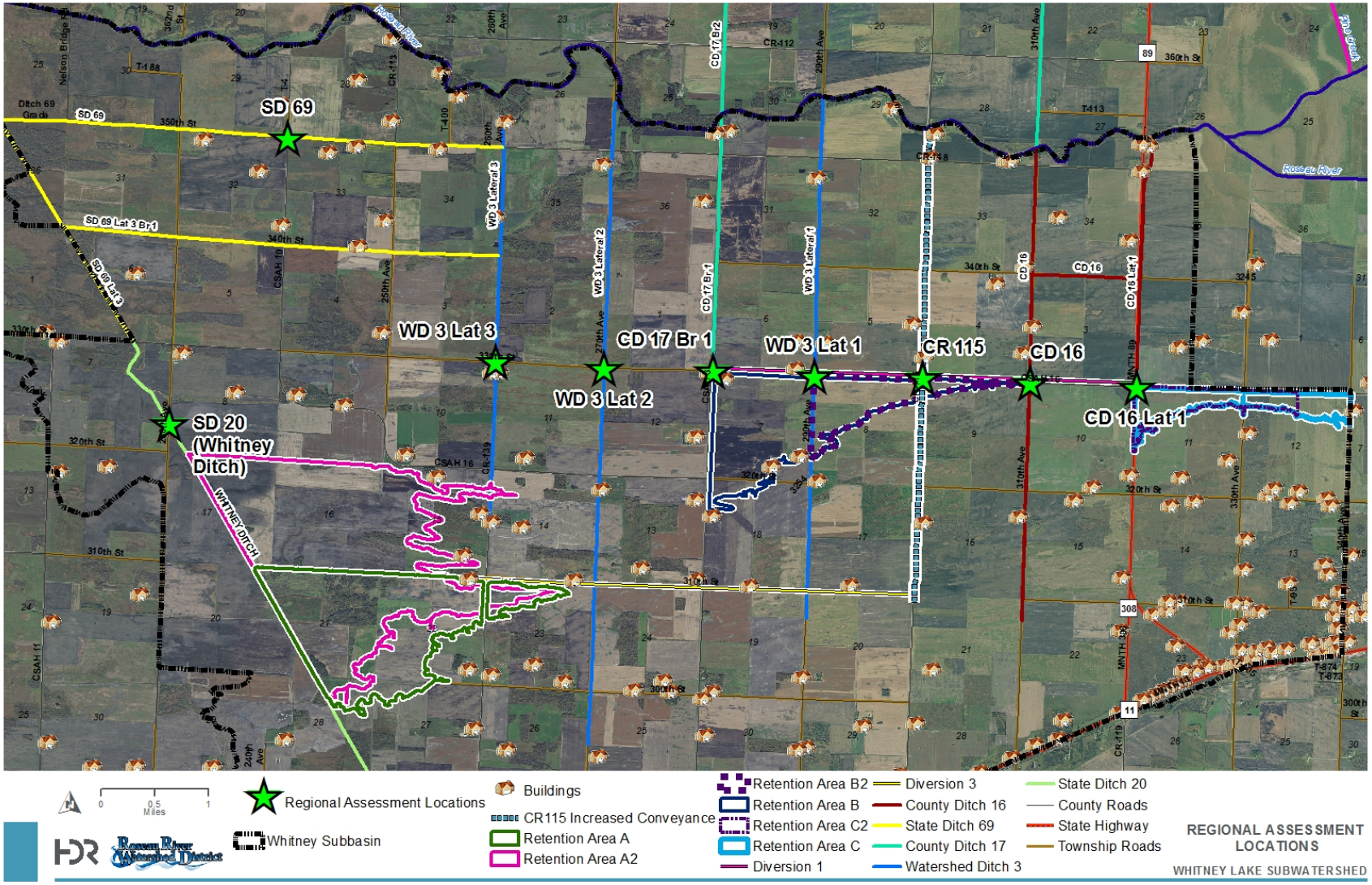
*WSE = Water Surface Elevation

**Meets Goal:

- Flood Reduction — Protect agricultural land and reduce time of inundation to less than 24 hrs for the 10-year 24 hour event
- Peak Flow and Volume — Contribute to a regional goal of reducing peak flow along the Red River by 20 percent
- Maximum WSE — Provide a six-inch reduction in water surface elevation for the 2-year 24-hour event

++	MEETS GOAL**
+	POSITIVE EFFECT
0	NO EFFECT
-	NEGATIVE EFFECT
--	LIKELY DOWNSTREAM IMPACTS

Figure 7. Regional Assessment Locations



Based on Table 17, and Sections 1 and 2 of this report, the following comprehensive alternative plan was proposed to the Whitney Lake Subwatershed Project Team (Table 18):

Table 18. Preferred Alternative Plan

Preferred Alternative Plan
Retention A
Diversion 3
Retention C2
New Conveyance along CR 115
Improvements to CD 16
Improvements to CD 17 Br 1

Figure 8 shows the preferred alternative plan with benefitted areas. The benefitted area is the drainage area as well as the protected area of the alternative. The benefitted areas of the preferred alternative plan provides a comprehensive project that benefits the entire Whitney Lake Subwatershed. Figure 9 shows the preferred alternative.

Figure 8. Benefitted Areas of the Preferred Alternative

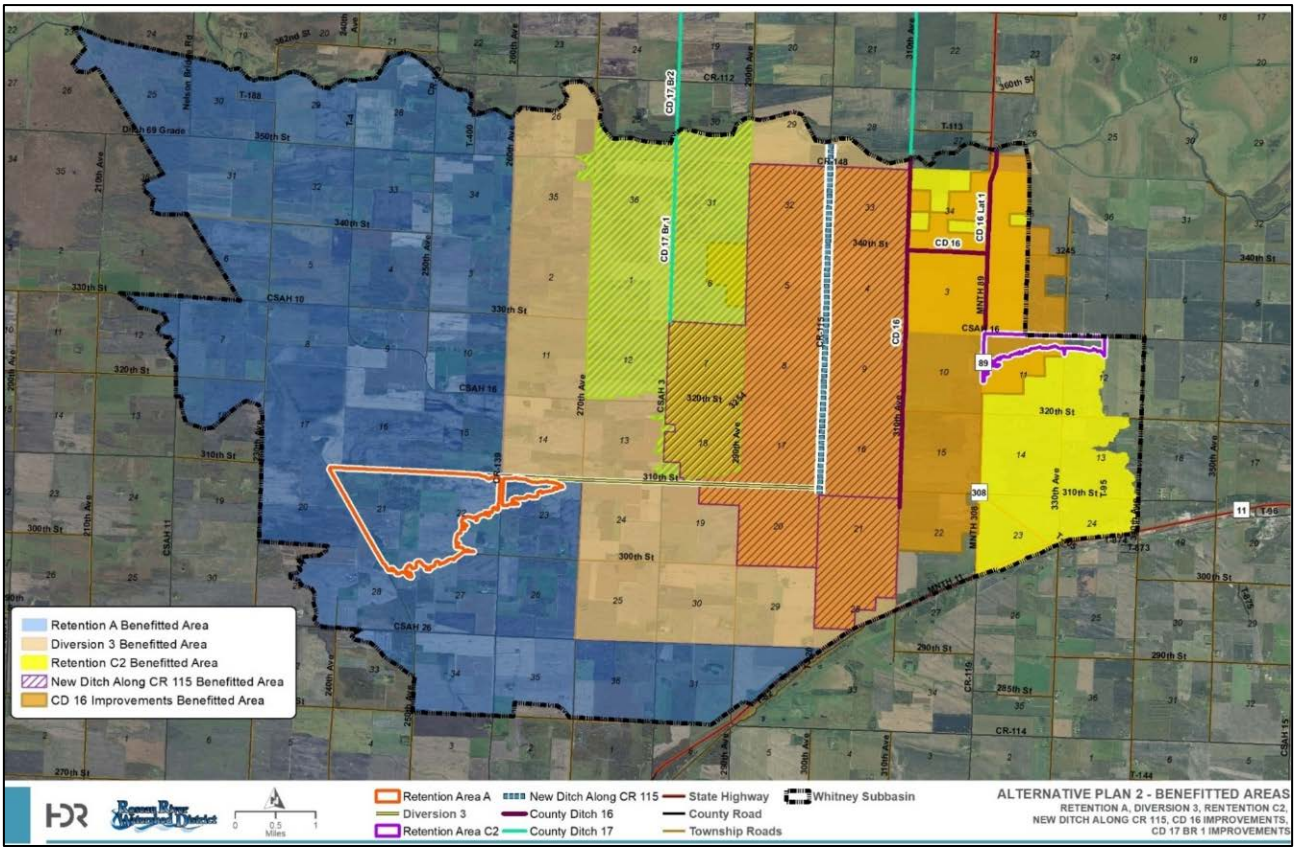
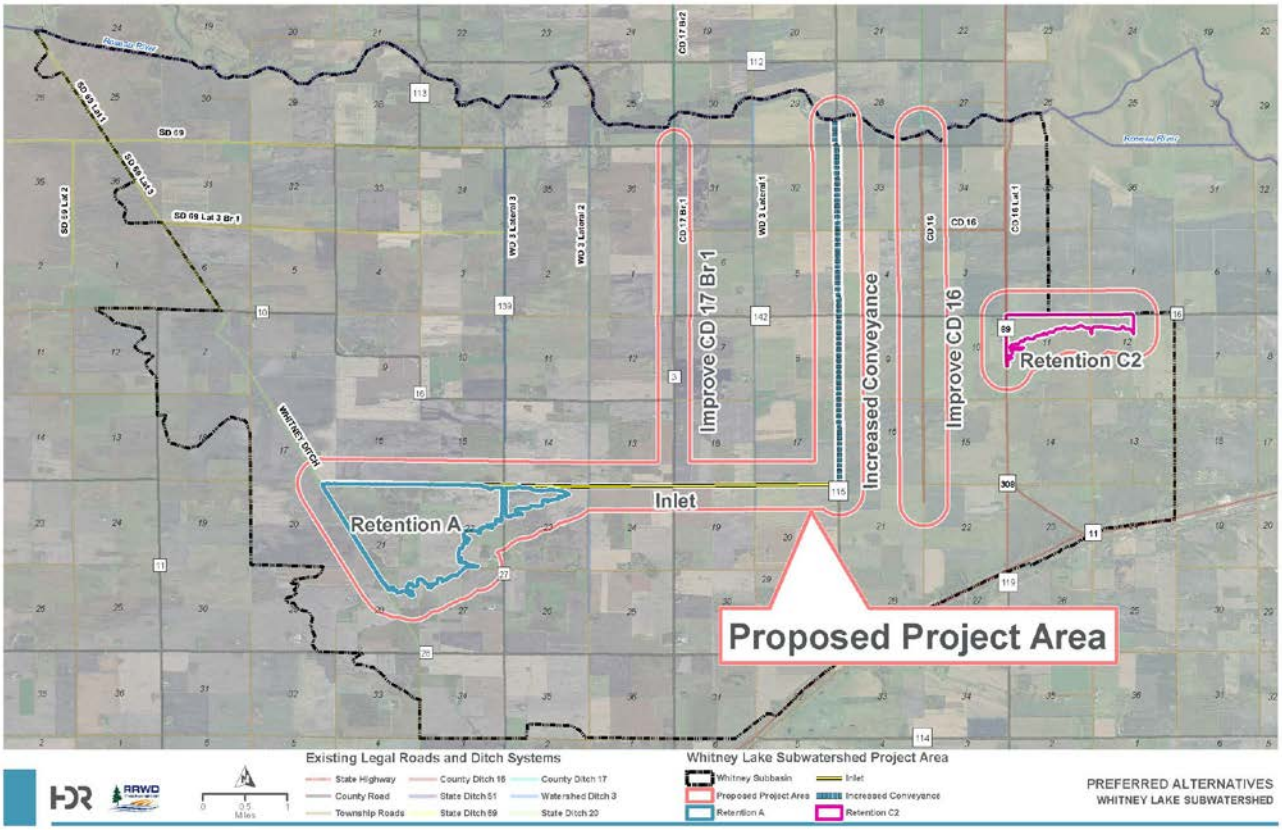


Figure 9. Preferred Alternative



Concurrence Point 3 Conclusions

After evaluating the 10 individual alternatives for environmental effects, practicability, and meeting the project purpose, a preferred alternative plan was selected by the Whitney Lake Subwatershed Project Team.

Table 19 summarizes the relevant impacts to the environment and flood damage reduction benefits of the preferred alternative plan.

Table 19. Preferred Alternative Plan – Summary of Impacts

Preferred Alternative Plan	
Reduction in flood damages during 10-year rainfall event (Cultivated Crops and Hay/Pasture, Acres)	973
Reduction in flood damages during 25-year rainfall event (Road overtopped, linear feet)	2,835
NWI Wetlands (Direct Impacts due to construction, Acres)	57.1

Appendix B

Geotechnical Report

GEOTECHNICAL EXPLORATION
AND ENGINEERING REVIEW

Whitney Lake Subwatershed Flood Damage Reduction Project
Rural Badger and Roseau, Minnesota

NTI Project No. 18.FGO.06667

NTI
NORTHERN TECHNOLOGIES, LLC

3522 4th Avenue South
Fargo, ND 58103
P: 701.232.1822 F: 701.232.1864

www.NTIgeo.com

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December 11, 2018

HDR
213 LaBree Avenue North
Suite 203
Thief River Falls, MN 56701

Attn: Mr. Nate Dalager
Mr. Jake Huwe

Subject: Geotechnical Exploration (factual)
Proposed Whitney Lake Subwatershed Flood Damage Reduction Project
Rural Badger and Roseau, Minnesota
NTI Project No. 18.FGO.06667

In accordance with your request and subsequent September 19, 2018 authorization, Northern Technologies, LLC (NTI) conducted a Geotechnical Exploration for the above referenced project. Our services included advancement of exploration borings and preparation of a factual engineering report with respect to our geotechnical services. Our work was performed in general accordance with our proposal of September 18, 2018.

Soil samples obtained at the site will be held for 60 days (from issue of report) at which time they will be discarded. Please advise us in writing if you wish to have us retain them for a longer period. You will be assessed an additional fee if soil samples are retained beyond 60 days.

We appreciate the opportunity to have been of service on this project. If there are any questions regarding the soils explored or our review and recommendations, please contact us at your convenience at (701) 232-1822.

Northern Technologies, LLC

Daniel Gibson

Dan Gibson, P.E.
Senior Engineer

Josh Holmes, P.E.
Senior Engineer

GEOTECHNICAL EXPLORATION
AND ENGINEERING REVIEW

Whitney Lake Subwatershed Flood Damage Reduction Project
Rural Badger and Roseau, Minnesota

NTI Project No. 18.FGO.06667

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GEOTECHNICAL EXPLORATION AND ENGINEERING REVIEW

Whitney Lake Subwatershed Flood Damage Reduction Project
Rural Badger and Roseau, Minnesota

NTI Project No. 18.FGO.06667

1.0 INTRODUCTION

1.1 Site / Project Description

The proposed Whitney Lake Subwatershed Flood Damage Reduction Project is to be constructed in rural areas to the north of Badger and west of Roseau near the Canada / Minnesota border as shown on the appended Borehole Location Plan provided by HDR. The project will consist of a diversion channel and earthen retention embankments to reduce flood damage in the area. The purpose of our investigation was to identify soils and perform laboratory testing as directed by HDR.

1.2 Scope of Services

The purpose of this report is to present a summary of our geotechnical exploration and laboratory testing for founding of the project. Our "scope of services" was limited to the following:

1. Explore the project subsurface by means of fourteen (14) standard penetration borings extending to depths of 16 to 46 feet, and conduct laboratory tests (as directed by HDR) on representative samples to characterize the engineering and index properties of the soils. ***Note: Soil borings SB 3, 5, 7, & 14 were deleted from the drilling program due to wet conditions and the possibility of damaging township roads accessing the sites.***
2. Prepare a factual report presenting our findings from our field exploration and laboratory testing based on the Scope of Work provided by HDR.

2.0 EXPLORATION PROGRAM RESULTS

2.1 Exploration Scope and Procedures

Site geotechnical drilling occurred on October 22 & 23, 2018 with individual borings advanced at approximate locations as presented on the diagrams and corresponding coordinates within the appendices. Coordinates on the boring logs may differ slightly than the original plan to allow for access or avoidance of utilities. HDR staked the boring locations and provided elevations. NTI performed the borings in relatively close proximity to the staked locations.

NTI and its sub consultant (Soil Engineering Testing) performed the field exploration and laboratory under guidance from ASTM Standards and common practice within the geotechnical engineering field. We provide additional information on field and laboratory procedures within the report appendices.

2.2 Surface Conditions

The property for the proposed Whitney Lake Subwatershed Flood Damage Reduction Project is currently farm fields, grasslands, wooded areas, and roadway ditches. Surfaces consist of grass cover and fallow farm land at the boring locations.

2.3 Subsurface Conditions

Please refer to the boring logs within the appendices for a detailed description and depths of stratum at each boring. The boreholes were abandoned using high solids bentonite grout per Minnesota Department of Health statutes. Minor settlement of upper infill soil and grout will occur with Owner responsible for final closure of the boreholes. The general geologic origin of retained soil samples is listed on the boring logs. The upper portion of the soil profile for each boring was sampled using auger flights and is approximate.

The overall subsurface soil profile at the borings consists of approximately 0.7 to 4 feet of topsoil and topsoil/fill underlain by relatively thin layers of soft and medium Glacial Lake Sediment (GLS) soils followed by soft to stiff Lake Modified Glacial Till (LMGT) which extends to the termination depth of the borings (maximum 46 feet). The GLS soils are comprised of silty fat clay and fat clay with trace amounts of sand. LMGT soils are comprised of lean clay, sandy lean clay, and occasional layers of sand. The LMGT clay soils have trace amounts of sand and gravel with occasional rocks and cobbles. The soils have varying color, moisture content and unit weight. Additional comment on the evaluation of recovered soil samples is presented within the report appendices and boring logs.

2.4 Groundwater Conditions

The drill crew observed the borings for groundwater and noted cave-in depth of borings, if any, during and at the completion of drilling activities. These observations and measurements are noted on the boring logs.

We encountered measurable groundwater from depths of 2 to 44.5 feet below grade at select boring locations during and / or at the completion of drilling operations. Boring logs noted if samples were saturated during classification of the samples. We anticipate the shallow groundwater (2 feet) is due to recent rainfall and is a temporary perched condition. The groundwater encountered at 8 feet or deeper was contained within silt and sand lenses and layers that were generally confined by clay soils above and/or below the layers. Additionally, occasional silt and sand seems are likely present and may be water bearing during spring thaw or times of heavy precipitation at all boring locations. The moisture content of lens soils and host clays can vary annually and per recent precipitation. Such soils and other regional dependent conditions may produce groundwater entry of project excavations.

2.5 Laboratory Test Program

2.5.1 SPT and Hand Penetrometer – Boring logs include SPT "N"-values and hand penetrometer readings obtained on cohesive soils during laboratory classification of retained soils.

2.5.2 Moisture and Density – We performed moisture and density testing on the samples requested by HDR. Moisture and dry density of the soils ranged from 7 to 49 percent (excluding topsoil) and 77 to 142 lbs/ft^3, respectively. We anticipate the high density values are due to the presence of small rocks and pebbles included within the test sample. Results of all tests are included within the boring logs and testing summary.

2.5.3 Atterberg Limits (LL/PL) – We performed a total of twelve (12) Atterberg limit tests on samples selected by HDR. The liquid limits (LL) ranged from 17 to 94 and the plastic limits (PL) ranged from 9 to 24. Results of all tests are included within the boring logs, testing summary, and Appendix B.

2.5.4 Standard Proctor Test – Two Standard Proctor tests were performed on composite samples from augur cuttings of soils encountered from 5 to 10 feet below grade at soil borings SB-2 & 12. The test reports are included within Appendix B.

2.5.5 Hydraulic Conductivity Test – Two hydraulic conductivity or permeability tests were performed on thin walled tube samples obtained at a depth of 10 feet at soil boring SB-2 & 12. The result of the tests are in Appendix B.

2.5.6 UU Triaxial Tests – We performed three UU Triaxial Tests on samples at a depth of 10 feet at soil borings SB-2, 4, & 12. Results are included in the testing summary and/or on individual reports within the appendices of this report. Additional information and data on the compressive strength of soils is included within the pocket penetrometer column on the boring logs.

3.0 CLOSURE

The area coverage of borings in relation to the entire project is very small. For this and other reasons, we do not warrant conditions below the depth of our borings, or that the strata logged from our borings are necessarily typical of the site.

This factual report has been prepared for the exclusive use of HDR for specific application to the proposed Flood Damage Reduction Project in Rural Badger and Roseau, Minnesota. Northern Technologies, LLC has endeavored to comply with generally accepted geotechnical engineering practice common to the local area. Northern Technologies, LLC makes no other warranty, expressed or implied.

Northern Technologies, LLC

Daniel Gibson

Dan Gibson, P.E.
Senior Engineer

Josh Holmes, P.E.
Senior Engineer

Attachments

R:\Fargo\PROJECTS\Geo\GEOREP 2018\Whitney Lake Subwatershed\Whitney Lake Report.docx

APPENDIX A

GEOTECHNICAL EVALUATION OF RECOVERED SOIL SAMPLES

We visually examined recovered soil samples to estimate distribution of grain sizes, plasticity, consistency, moisture condition, color, presence of lenses and seams, and apparent geologic origin. We then classified the soils according to the Unified Soil Classification System (ASTM D2488). A chart describing this classification system and general notes explaining soil sampling procedures are presented within the appendices.

The stratification depth lines between soil types on the logs are estimated based on the available data. Insitu, the transition between type(s) may be distinct or gradual in either the horizontal or vertical directions. The soil conditions have been established at our specific boring locations only. Variations in the soil stratigraphy may occur between and around the borings, with the nature and extent of such change not readily evident until exposed by excavation. These variations must be properly assessed when utilizing information presented on the boring logs. We request that you, your design team or contractors contact NTI immediately if local conditions differ from those assumed by this report, as we would need to review how such changes impact our recommendations. Such contact would also allow us to revise our recommendations as necessary to account for the changed site conditions.

FIELD EXPLORATION PROCEDURES

Soil Sampling – Standard Penetration Boring:

Soil sampling was performed according to the procedures described by ASTM D-1586. Using this procedure, a 2 inch O.D. split barrel sampler is driven into the soil by a 140 pound weight falling 30 inches. After an initial set of six inches, the number of blows required to drive the sampler an additional 12 inches is recorded (known as the penetration resistance (i.e. “N-value”) of the soil at the point of sampling. The N-value is an index of the relative density of cohesionless soils and an approximation of the consistency of cohesive soils.

Soil Sampling – Power Auger Boring:

The boring(s) was/were advanced with a 6 inch nominal diameter continuous hollow stem flight auger. As a result, samples recovered from the boring are disturbed, and our determination of the depth, extent of various stratum and layers, and relative density or consistency of the soils is approximate.

Soil Classification:

Soil samples were visually and manually classified in general conformance with ASTM D-2488 as they were removed from the sampler(s). Representative fractions of soil samples were then sealed within respective containers and returned to the laboratory for further examination and verification of the field classification. In addition, select samples were submitted for laboratory tests. Individual sample information, identification of sampling methods, method of advancement of the samples and other pertinent information concerning the soil samples are presented on boring logs and related report attachments.

General Notes

DRILLING & SAMPLING SYMBOLS		LABORATORY TEST SYMBOLS	
SYMBOL	**DEFINITION**	**SYMBOL**	**DEFINITION**
C.S.	Continuous Sampling	W	Moisture content-percent of dry weight
P.D.	2-3/8" Pipe Drill	D	Dry Density-pounds per cubic foot
C.O.	Cleanout Tube	LL, PL	Liquid and plastic limits determined in accordance with ASTM D 423 and D 424
3 HSA	3 ¼" I.D. Hollow Stem Auger	Q_u	Unconfined compressive strength-pounds per square foot in accordance with ASTM D 2166-66
4 FA	4" Diameter Flight Auger		
6 FA	6" Diameter Flight Auger		
2 ½ C	2 ½" Casing		
4 C	4" Casing		**Additional insertions in Qu Column**
D.M.	Drilling Mud	Pq	Penetrometer reading-tons/square foot
J.W.	Jet Water	S	Torvane reading-tons/square foot
H.A.	Hand Auger	G	Specific Gravity – ASTM D 854-58
NXC	Size NX Casing	SL	Shrinkage limit – ASTM 427-61
BXC	Size BX Casing	pH	Hydrogen ion content-meter method
AXC	Size AX casing	O	Organic content-combustion method
SS	2" O.D. Split Spoon Sample	M.A.*	Grain size analysis
2T	2" Thin Wall Tube Sample	C*	One dimensional consolidation
3T	3" Thin Wall Tube Sample	Q_c*	Triaxial Compression
			* See attached data Sheet and/or graph

Water Level Symbol

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In sand, the indicated levels can be considered reliable groundwater levels. In clay soils, it is not possible to determine the groundwater level within the normal scope of a test boring investigation, except where lenses or layers of more pervious water bearing soil is present and then a long period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed soils may not indicate the true level of the groundwater table. The available water level information is given at the bottom of the log sheet.

Descriptive Terminology

DENSITY		CONSISTENCY	
TERM	**"N" VALUE**	**TERM**	**"N" VALUE**
Very Loose	0-4	Soft	0-4
Loose	5-8	Medium	5-8
Medium Dense	9 – 15	Rather Stiff	9 – 15
Dense	16 – 30	Stiff	16 – 30
Very Dense	Over 30	Very Stiff	Over 30

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch OD split spoon.

Relative Proportions

TERMS	**RANGE**
Trace	0-5%
A little	5-15%
Some	15-30%
With	30-50%

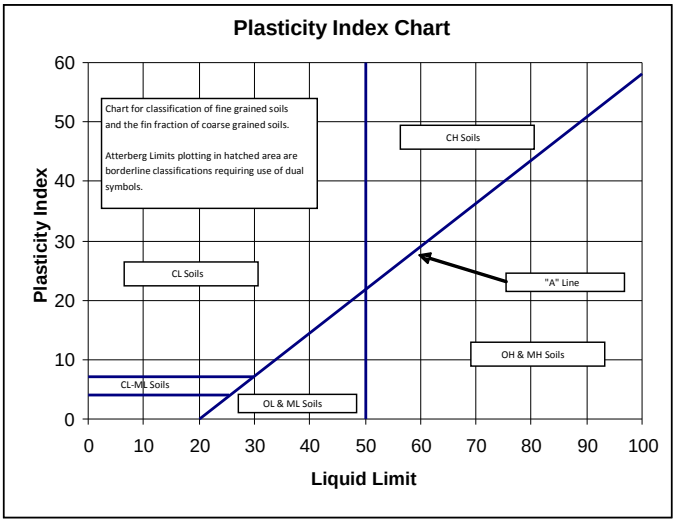
Particle Sizes

Boulders		Over 3"
Gravel -	Coarse	¾" – 3"
	Medium	#4 – ¾"
Sand -	Coarse	#4 - #10
	Medium	#10 - #40
	Fine	#40 - #200
Silt and Clay		Determined by plasticity characteristics.

Note: Sieve sizes are U.S. Standard.

Classification of Soils for Engineering Purposes

ASTM Designation D-2487 and D 2488 (Unified Soil Classification System)

Major Divisions			Group Symbol	Typical Names	Classification Criteria	
Course Grained Soils More than 50% retained on No. 200 sieve *	***Gravels*** 50% or more of coarse fraction retained on No. 4 sieve.	Clean Gravels	**GW**	Well –graded gravels and gravel-sand mixtures, little or no fines.	$C_u = D_{60} / D_{10}$ greater than 4. $C_z = (D_{30})^2 / (D_{10} \times D_{60})$ between 1 & 3.	
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines.	Not meeting both criteria for GW materials.	
		Gravels with Fines	**GM**	Silty gravels, gravel-sand-silt mixtures.	Atterberg limits below "A" line, or P.I. less than 4.	Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols.
			GC	Clayey gravels, gravel-sand-clay mixtures.	Atterberg limits above "A" line with P.I. greater than 7.	
	Sands More than 50% of coarse fraction passes No 4 sieve.	Clean Sands	**SW**	Well-graded sands and gravelly sands, little or no fines.	$C_u = D_{60} / D_{10}$ greater than 6. $C_z = (D_{30})^2 / (D_{10} \times D_{60})$ between 1 & 3.	
			SP	Poorly-graded sands and gravelly sands, little or no fines.	Not meeting both criteria for SW materials.	
		Sands with Fines	**SM**	Silty sands, sand-silt mixtures.	Atterberg limits below "A" line, or P.I. less than 4.	Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures.	Atterberg limits above "A" line with P.I. greater than 7.	
					Classification on basis of percentage of fines. Less than 5% passing No. 200 Sieve: GW, GP, SW, SP More than 12% passing No. 200 Sieve: GM, GC, SM, SC From 5% to 12% passing No. 200 Sieve: Borderline Classification requiring use of duel symbols.	
Fine Grained Soils More than 50% passes No. 200 sieve *	***Silts and Clays*** Liquid Limit of 50% or less		**ML**	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands.		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.		
			OL	Organic silts and organic silty clays of low plasticity.		
	Silts and Clays Liquid Limit greater than 50%.		**MH**	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts.		
			CH	Inorganic clays of high plasticity, fat clays.		
			OH	Organic clays of medium to high plasticity.		
	Highly Organic Soils		**Pt**	Peat, muck and other highly organic soils.		

APPENDIX B

NTI
NORTHERN TECHNOLOGIES, LLC

Fargo
3522 4th Ave S
Fargo, North Dakota 58103
P: 701.232.1822 F: 701.232.1864
www.NTIgeo.com

SUMMARY OF LABORATORY RESULTS

Report To:	HDR 213 LaBree Ave North, Suite 203 Thief River Falls, MN	Project:	Whitney Lake Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06667.000
Attention:	Jake Huwe	Location:	Roseau, Minnesota

Borehole	Sample #	Depth (ft)	Water Content (%)	Dry Density (pcf)	Liquid Limit	Plastic Limit	Maximum Size (mm)	% < #200 Sieve	Unconfined Compression Peak (psf)	Unconfined Compression %	Void Ratio	Other Tests
SB-01	3	4.5			65	15						
SB-02	1	0.0	38.0									
SB-02	2	2.0	38.8	84.9	18	10						
SB-02	NA	4.5	49.4	76.6								
SB-02	4	7.0	16.6	131.2								
SB-02	6	12.0	11.2	140.1								
SB-02	7	14.5	10.6	146.1	94	24						
SB-02	8	17.0	7.6	138.8								
SB-02	9	19.5	8.4	136.2								
SB-02	10	24.5	7.7	133.6								
SB-02	11	29.5	8.3	134.8								
SB-02	12	34.5	8.5	135.5								
SB-02	13	39.5	9.8	147.5	17	10						
SB-02	14	44.5	11.2									
SB-04	4	7.0			21	11						
SB-06	8	17.0			18	9						
SB-08	6	12.0			17	9						
SB-10	7	14.5			18	10						
SB-12	1	0.0	30.0									
SB-12	2	2.0	21.7		19	10						
SB-12	NA	4.5	11.6	138.4								
SB-12	4	7.0	11.6	135.0								
SB-12	6	12.0	11.0	142.7								
SB-12	7	14.5	12.3									
SB-12	8	17.0	10.9	140.2								
SB-12	9	19.5	11.2	138.0	18	10						
SB-12	10	24.5	11.3									
SB-12	11	29.5	10.9	138.2								
SB-12	12	34.5	11.3	139.3	18	10						
SB-12	13	39.5	11.6	133.1								
SB-12	14	44.5	10.8	139.4								
SB-13	3	4.5			17	9						

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Fargo
3522 4th Ave S
Fargo, North Dakota 58103
P: 701.232.1822 F: 701.232.1864
www.NTIgeo.com

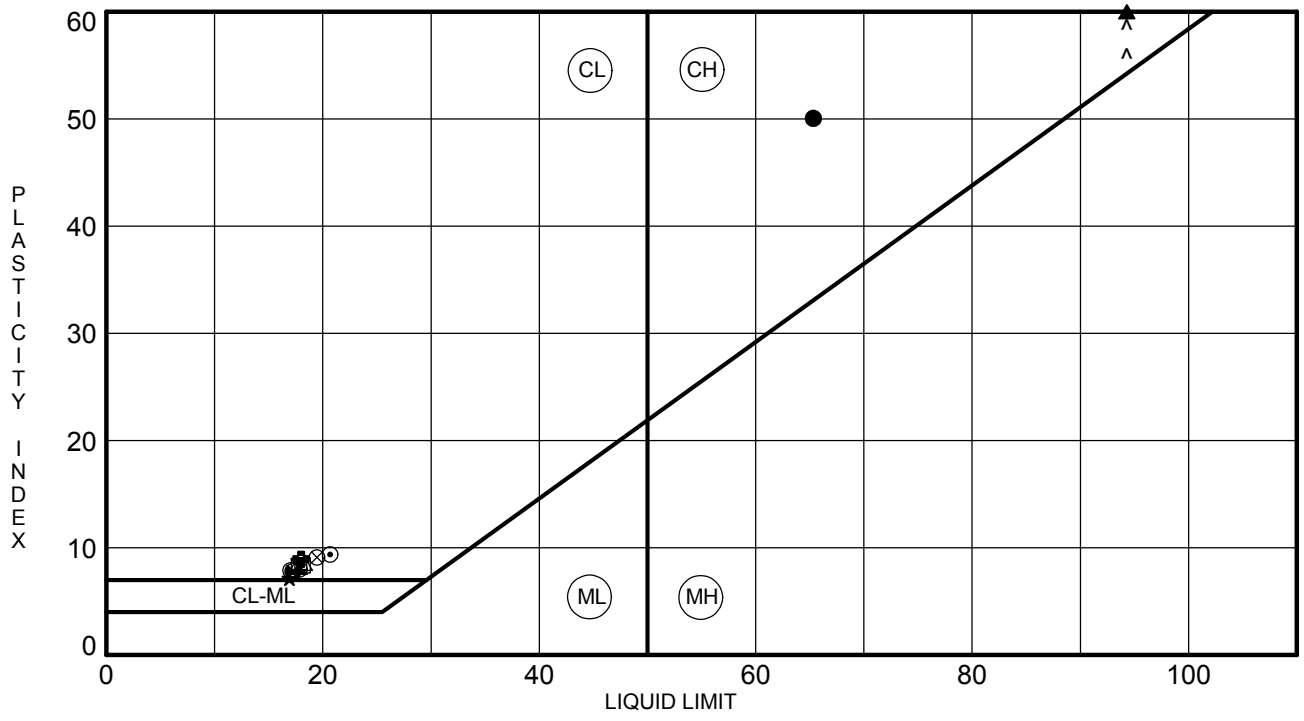
ATTERBERG LIMITS' RESULTS

ASTM D4318

Report To:	HDR 213 LaBree Ave North, Suite 203 Thief River Falls, MN	Project:	Whitney Lake Subwatershed Flood Damage Reduction
Attention:	Jake Huwe	Project Number: Location:	18.FGO06667.000 Roseau, Minnesota

Sample Data

	BOREHOLE	SAMPLE #	DEPTH	LL	PL	PI	Fines	Classification
●	SB-01	3	4.5	65	15	50		FAT CLAY (CH)
⊠	SB-02	2	2.0	18	10	8		LEAN CLAY (CL)
▲	SB-02	7	14.5	94	24	70		FAT CLAY (CH)
★	SB-02	13	39.5	17	10	7		LEAN CLAY (CL)
⊙	SB-04	4	7.0	21	11	10		LEAN CLAY (CL)
✿	SB-06	8	17.0	18	9	9		LEAN CLAY (CL)
○	SB-08	6	12.0	17	9	8		LEAN CLAY (CL)
△	SB-10	7	14.5	18	10	8		LEAN CLAY (CL)
⊗	SB-12	2	2.0	19	10	9		LEAN CLAY (CL)
⊕	SB-12	9	19.5	18	10	8		LEAN CLAY (CL)



Cc:

Submitted by,
Northern Technologies, LLC

Chris Nelson
(12/7/18)

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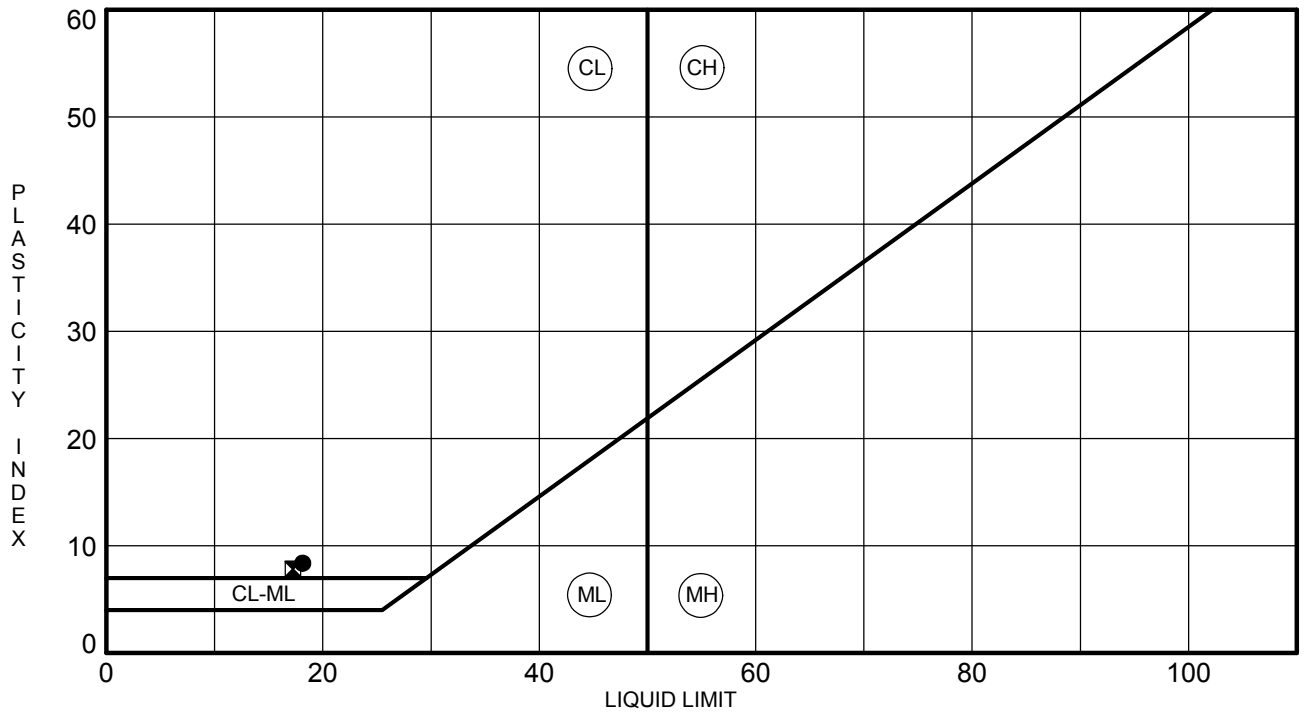
ATTERBERG LIMITS' RESULTS

ASTM D4318

Report To:	HDR 213 LaBree Ave North, Suite 203 Thief River Falls, MN	Project:	Whitney Lake Subwatershed Flood Damage Reduction
Attention:	Jake Huwe	Project Number:	18.FGO06667.000
		Location:	Roseau, Minnesota

Sample Data

	BOREHOLE	SAMPLE #	DEPTH	LL	PL	PI	Fines	Classification
●	SB-12	12	34.5	18	10	8		LEAN CLAY (CL)
⊠	SB-13	3	4.5	17	9	8		LEAN CLAY (CL)



Cc:

Submitted by,
Northern Technologies, LLC

Chris Nelson
(12/7/18)

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Fargo, North Dakota 58103
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LABORATORY COMPACTION CHARACTERISTICS OF SOIL

Report To:	HDR 213 LaBree Ave North, Suite 203 Thief River Falls, MN	Project:	Whitney Lake Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06667.000
Attention:	Jake Huwe	Location:	Roseau, Minnesota

Sample Information

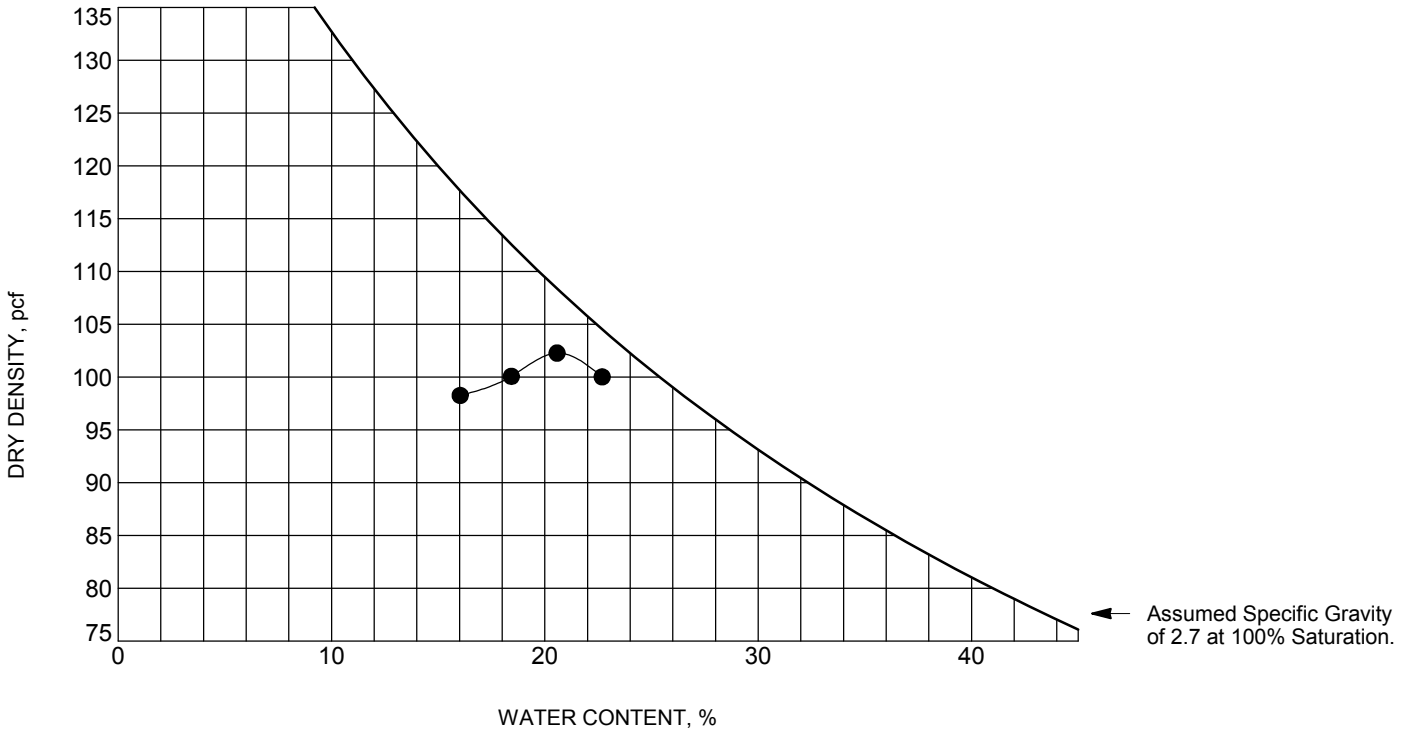
Sample Location:	SB-02	Date Sampled:	10/22/2018
Sample Number:	NA	Sample Type:	Bag Sample
Soil Description:	LEAN CLAY (CL)		

Laboratory Information

Test Method:	ASTM D698 Method A	Rammer Type:	Manual
Preparation Method:	Dry		

Sample Data

Maximum Dry Density:	102.3 pcf	Liquid Limit:	
Optimum Water Content:	20.6 %	Plastic Limit:	



Comments:

Cc:

Submitted by.
Northern Technologies, LLC

Chris Nelson
(12/7/18)

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LABORATORY COMPACTION CHARACTERISTICS OF SOIL

Report To:	HDR 213 LaBree Ave North, Suite 203 Thief River Falls, MN	Project:	Whitney Lake Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06667.000
Attention:	Jake Huwe	Location:	Roseau, Minnesota

Sample Information

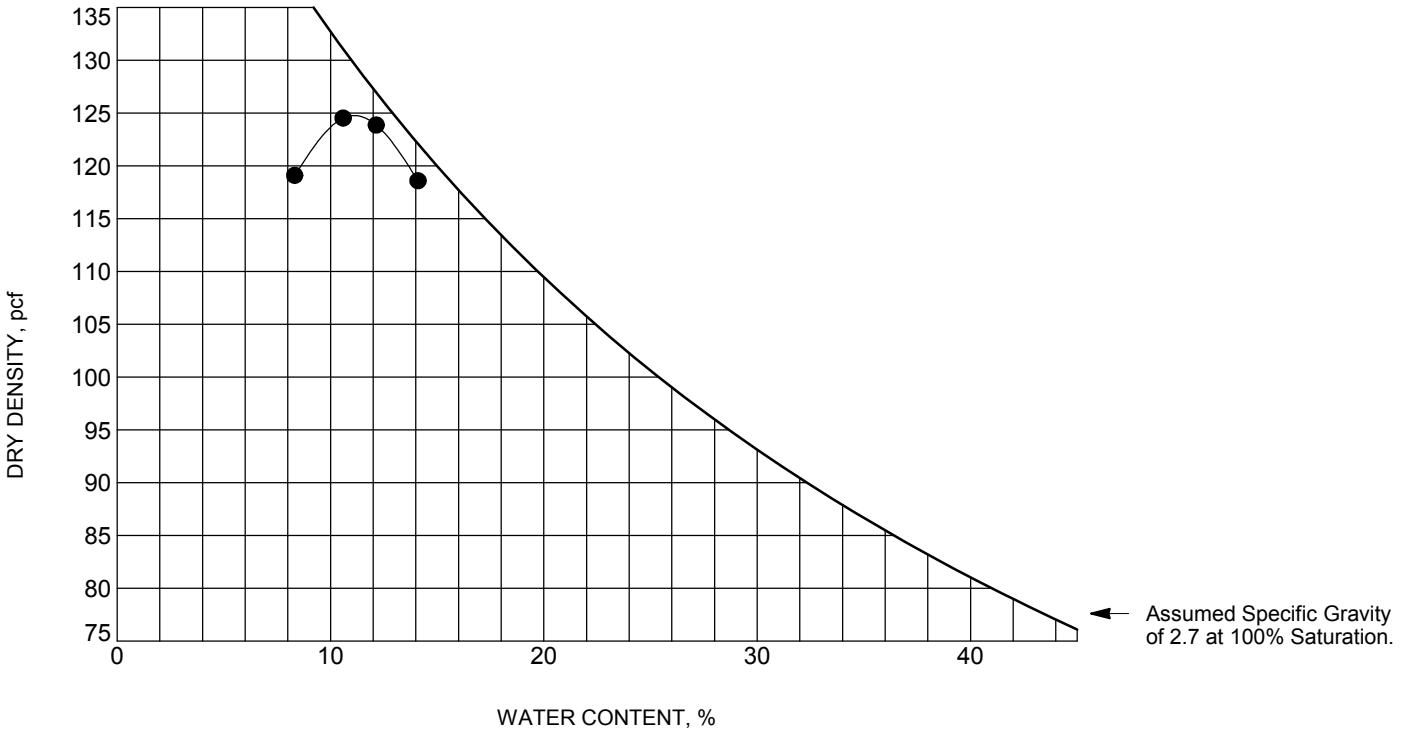
Sample Location:	SB-12	Date Sampled:	10/23/2018
Sample Number:	NA	Sample Type:	Bag Sample
Soil Description:	LEAN CLAY (CL)		

Laboratory Information

Test Method:	ASTM D698 Method A	Rammer Type:	Manual
Preparation Method:	Dry		

Sample Data

Maximum Dry Density:	124.8 pcf	Liquid Limit:	
Optimum Water Content:	11.1 %	Plastic Limit:	



Comments:

Cc:

Submitted by.
Northern Technologies, LLC

Chris Nelson
(12/7/18)

Hydraulic Conductivity Test Data ASTM D5084

Project: Whitney Date: 11/26/2018

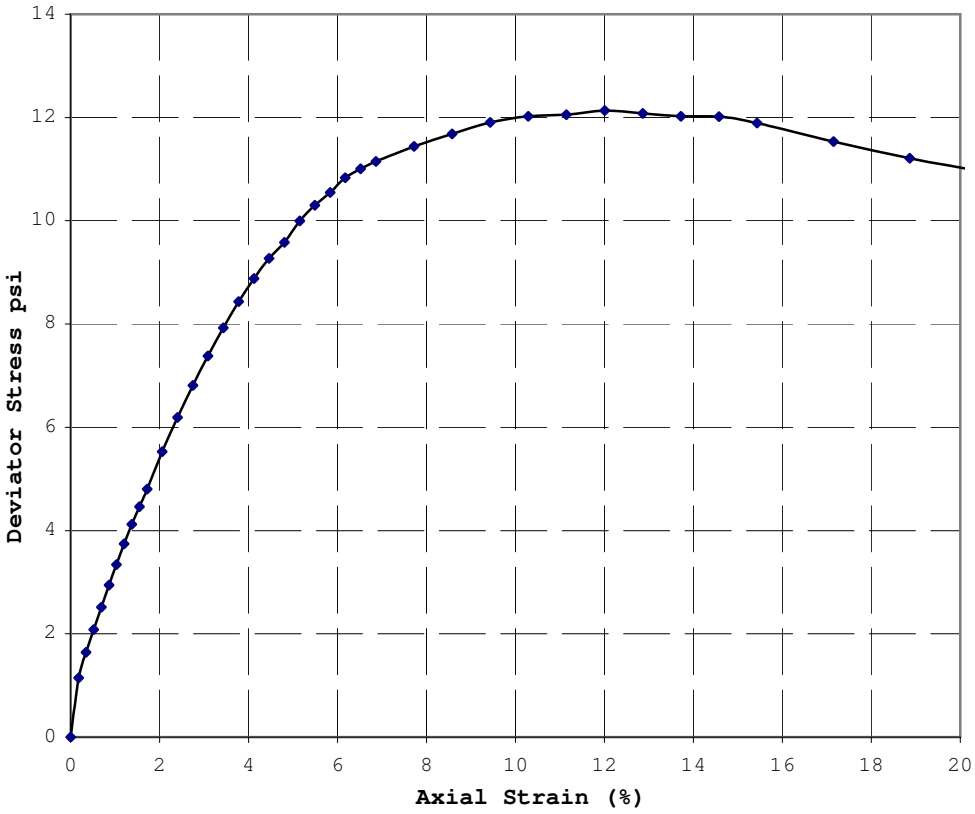
Client: Northern Technologies, LLC Job No.: 11716

Boring No.:	SB-02	SB-12					
Sample No.:	5	5					
Depth (ft):	9.5-11	9.5-11					
Location:							
Sample Type:	TWT	TWT					
Soil Type:	Sandy Lean Clay w/a little gravel (CL)	Sandy Lean Clay w/a little gravel (CL)					
Atterberg Limits							
LL							
PL							
PI							
Permeability Test	Intact	Intact					
Before Test Conditions: Saturation %:							
Porosity:							
Ht. (in):	2.90	2.72					
Dia. (in):	2.87	2.86					
Dry Density (pcf):	126.4	129.2					
Water Content:	12.7%	11.6%					
Test Type:	Falling	Falling					
Max Head (ft):	5.0	5.0					
Confining press. (Effective-psi):	2.0	2.0					
Trial No.:	8-12	8-12					
Water Temp ℃:	22.0	22.0					
% Compaction							
% Saturation (After Test)	99.4%	99.9%					
Coefficient of Permeability							
K @ 20 ℃ (cm/sec)	**8.4×10^{-8}**	**4.8×10^{-8}**					
K @ 20 ℃ (ft/min)	**1.7×10^{-7}**	**9.5×10^{-8}**					
Notes:							

9530 James Ave South
SOIL ENGINEERING TESTING, INC.
Bloomington, MN 55431

Triaxial U-U Stress/Strain Curves (ASTM:D2850)

Project: Whitney | Job: 11716
Client: Northern Technologies, LLC | Date: 11/21/18
Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



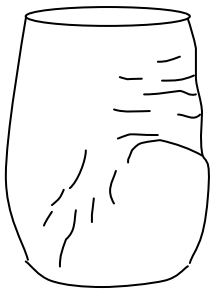
Boring: SB-02 Depth: 9.5-11
Sample #:
Soil Type: Sandy Lean Clay w/a little gravel (CL)

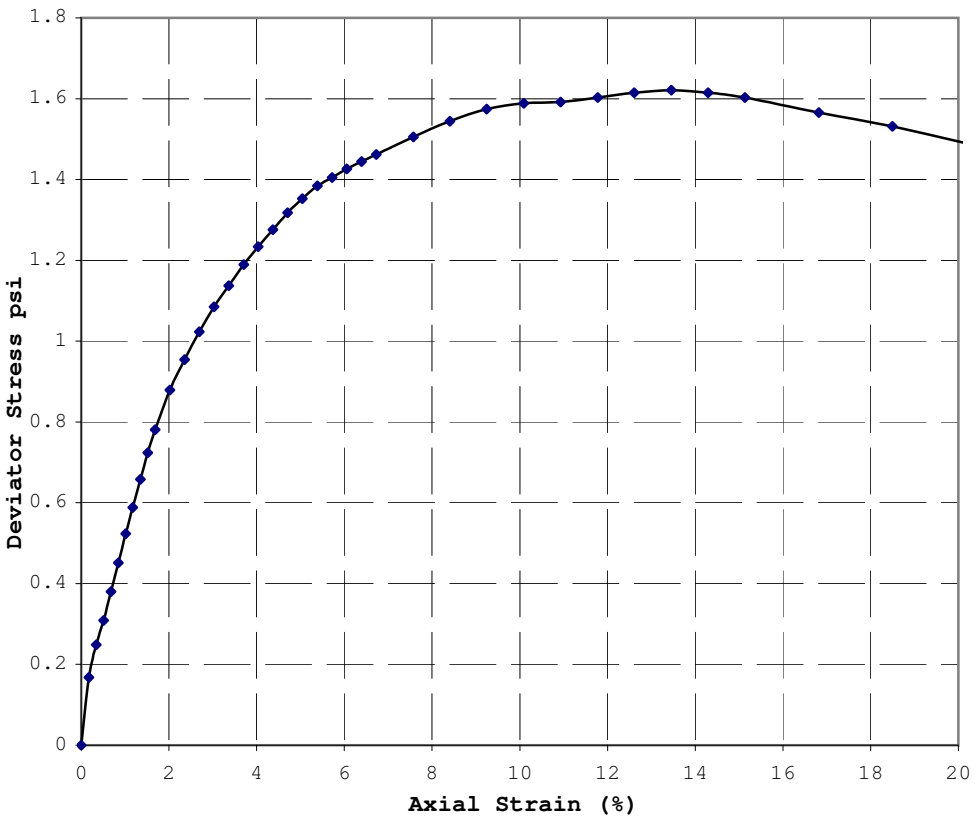
Strain Rate (in/min): 0.060
Sample Type: 3T
Dia. (in) 2.88 Ht. (in) 5.83
Height to Diameter Ratio: 2.02

Max Deviator Stress: 12.14 psi
Strain at Failure (%): 12.0
Confining Pressure: 5 psi

W.C. (%) 11.6
Yd (pcf): 128.9

Sketch of Specimen After Failure





Boring: SB-04 Depth: 9.5-11
Sample #:
Soil Type: Sandy Lean Clay w/a trace of gravel (CL)

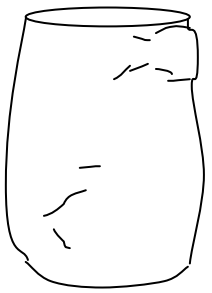
Strain Rate (in/min): 0.060
Sample Type: 3T

Dia. (in): 2.87 Ht. (in): 5.95
Height to Diameter Ratio: 2.07

Max Deviator Stress: 1.62 tsf
Strain at Failure (%): 13.5
Confining Pressure: 10 tsf

W.C. (%): 11.7
Yd (pcf): 128.1

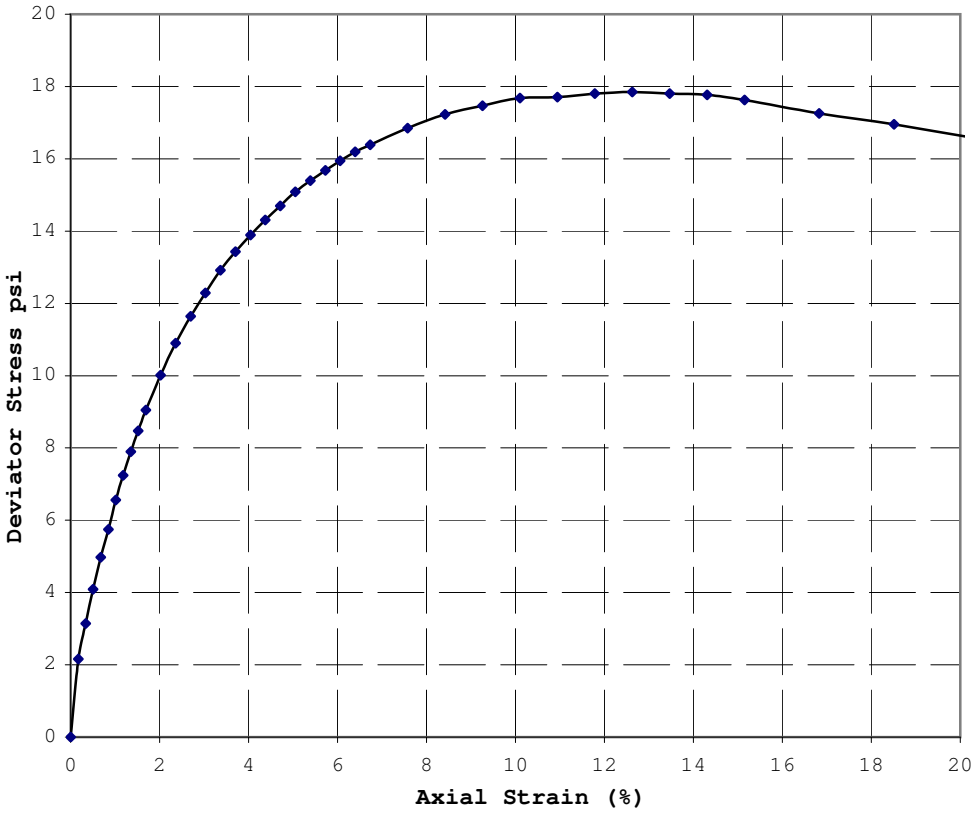
Sketch of Specimen After Failure



9530 James Ave South
SOIL ENGINEERING TESTING, INC.
Bloomington, MN 55431

Triaxial U-U Stress/Strain Curves (ASTM:D2850)

Project: Whitney | Job: 11716
Client: Northern Technologies, LLC | Date: 11/21/18
Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



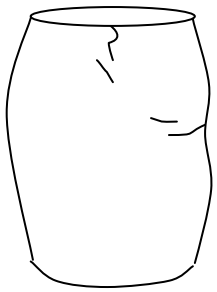
Boring: SB-12 Depth: 9.5-11
Sample #:
Soil Type: Sandy Lean Clay w/a little gravel (CL)

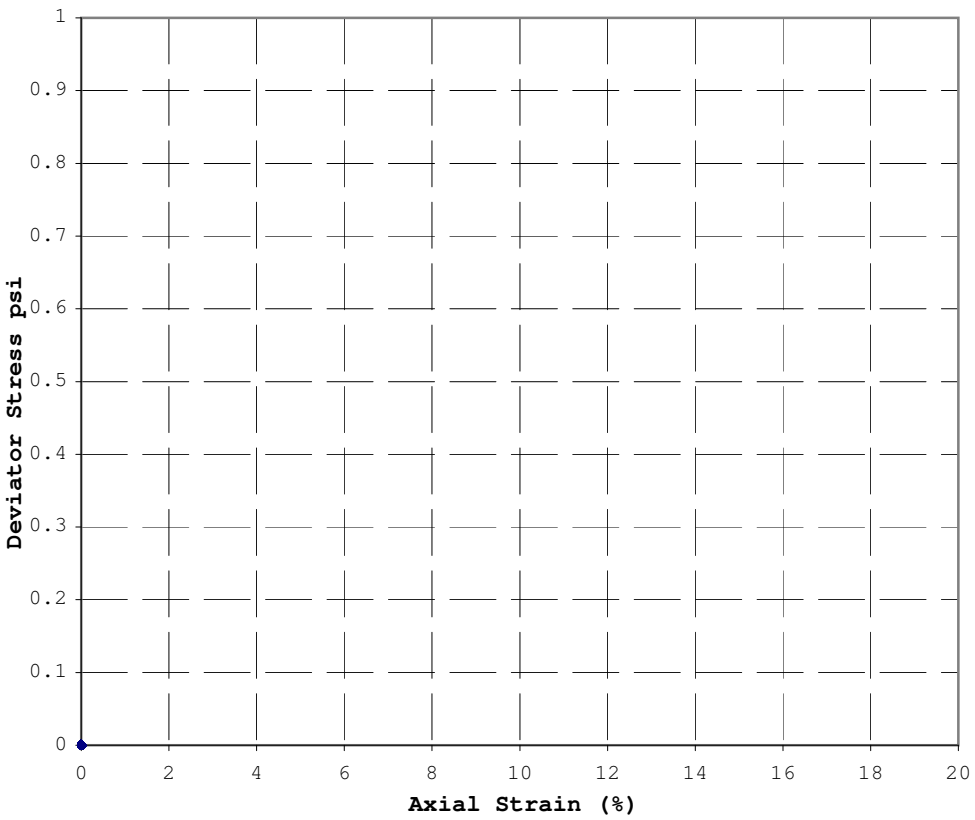
Strain Rate (in/min): 0.060
Sample Type: 3T
Dia. (in) 2.87 Ht. (in) 5.94
Height to Diameter Ratio: 2.07

Max Deviator Stress: 17.85 psi
Strain at Failure (%): 12.6
Confining Pressure: 15 psi

W.C. (%) 11.4
Yd (pcf): 129.7

Sketch of Specimen After Failure





Boring: Depth:
Sample #:
Soil Type:

Strain Rate (in/min):
Sample Type:

Dia. (in): Ht. (in):
Height to Diameter Ratio:

Max Deviator Stress: tsf
Strain at Failure (%):
Confining Pressure: tsf

W.C. (%):
Yd (pcf):

Sketch of Specimen After Failure

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APPENDIX C

Northern Technologies, LLC
3522 4th Avenue S.
Fargo, ND 58103
P: 701-232-1822 F: 701-232-1864
www.ntigeo.com

BORING NUMBER SB-01

Long: -96° 6' 43.4988"
Lat: 48° 51' 45.6012"

CLIENT HDR
PROJECT NAME Whitney Lake Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06667.000
PROJECT LOCATION Roseau, Minnesota
DATE STARTED 10/22/18 **COMPLETED** 10/22/18
GROUND ELEVATION 1031.1 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING 9.00 ft / Elev 1022.10 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING 8.00 ft / Elev 1023.10 ft
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0	TOPSOIL, ORGANIC CLAY WITH SILT, (OL) black	AU 1									
	0.9 / 1030.2										
	SILTY FAT CLAY, (CH/CL) light brown to light gray, medium, trace laminations of silt	SS 2	67	3-4-2 (6)	0.9						
	4.0 / 1027.1										
5	FAT CLAY, (CH) gray to brown, soft, trace sand	SS 3	67	2-2-2 (4)	0.9			65	15	50	
		ST 4									
	9.0 / 1022.1										
10	LEAN CLAY, (CL) gray, moist, medium, trace sand, trace gravel	SS 5	89	1-2-3 (5)	0.8						
		SS 6	89	2-3-4 (7)	1.8						
15	15.0 / 1016.1	SS 7	94	2-6-9 (15)	6.0						
	LEAN CLAY, (CL) brown, rather stiff to stiff, trace sand, trace gravel	SS 8	117	4-8-9 (17)	6.0						
20		SS 9	72	4-7-12 (19)	6.0						
25		SS 10	117	7-13-13 (26)	3.8						

(Continued Next Page)

Northern Technologies, LLC
3522 4th Avenue S.
Fargo, ND 58103
P: 701-232-1822 F: 701-232-1864
www.ntigeo.com

BORING NUMBER SB-01

Long: -96° 6' 43.4988"
Lat: 48° 51' 45.6012"

CLIENT HDR **PROJECT NAME** Whitney Lake Subwatershed Flood Damage Reduction

PROJECT NUMBER 18.FGO06667.000 **PROJECT LOCATION** Roseau, Minnesota

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
		LEAN CLAY, (CL) brown, rather stiff to stiff, trace sand, trace gravel *(continued)*										
30			SS 11	117	6-14-11 (25)	6.0						
35			SS 12	100	5-12-13 (25)	6.0						
40			SS 13	89	7-13-12 (25)	6.0						
45			SS 14	133	7-11-14 (25)	6.0						
		46.0 985.1										

Bottom of borehole at 46.0 feet.
Borehole grouted.

Northern Technologies, LLC
3522 4th Avenue S.
Fargo, ND 58103
P: 701-232-1822 F: 701-232-1864
www.ntigeo.com

BORING NUMBER SB-02

Long: -96° 5' 54.5784"
Lat: 48° 50' 53.6784"

CLIENT HDR
PROJECT NAME Whitney Lake Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06667.000
PROJECT LOCATION Roseau, Minnesota
DATE STARTED 10/22/18 **COMPLETED** 10/22/18
GROUND ELEVATION 1031.6 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
▽ **AT TIME OF DRILLING** 44.50 ft / Elev 987.10 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0		0.8 TOPSOIL, ORGANIC CLAY WITH SILT, (OL) black 1030.8	AU 1					38				
		LEAN CLAY, (CL) dark gray to light brown, medium, mottled	SS 2	61	1-2-4 (6)	2.1	85	39	18	10	8	
5			SS 3	67	1-2-3 (5)	1.4	77	49				
		7.5 1024.1 SILTY FAT CLAY, (CH/CL) gray, medium, trace sand	SS 4	89	1-2-3 (5)	1.6	131	17				
10			ST 5									
		11.0 1020.6 FAT CLAY, (CH) brown, medium to very stiff, trace sand, trace gravel	SS 6	89	2-3-3 (6)	1.0	140	11				
15			SS 7	111	2-3-4 (7)	2.5	146	11	94	24	70	
			SS 8	122	4-10-14 (24)	6.0	139	8				
20			SS 9	111	5-10-15 (25)	6.0	136	8				
25			SS 10	122	7-7-13 (20)		134	8				

(Continued Next Page)

Northern Technologies, LLC
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Fargo, ND 58103
P: 701-232-1822 F: 701-232-1864
www.ntigeo.com

BORING NUMBER SB-02

Long: -96° 5' 54.5784"
Lat: 48° 50' 53.6784"

CLIENT HDR
PROJECT NAME Whitney Lake Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06667.000
PROJECT LOCATION Roseau, Minnesota

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
		FAT CLAY, (CH) brown, medium to very stiff, trace sand, trace gravel *(continued)*										
30			SS 11	122	7-8-14 (22)		135	8				
35			SS 12	111	8-16-24 (40)		136	8				
		37.0 994.6 LEAN CLAY, (CL) light brown to gray, rather stiff										
40			SS 13	133	3-6-6 (12)	2.5	148	10	17	10	7	
		44.5 ▽ 987.1										
45		SILTY SAND, (SM) brown, fine to medium grained, wet, medium dense	SS 14	133	2-5-8 (13)			11				
		46.0 985.6										

Bottom of borehole at 46.0 feet.
Borehole grouted.

Northern Technologies, LLC
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www.ntigeo.com

BORING NUMBER SB-04

Long: -96° 4' 23.736"
Lat: 48° 50' 53.4444"

CLIENT HDR
PROJECT NAME Whitney Lake Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06667.000
PROJECT LOCATION Roseau, Minnesota
DATE STARTED 10/22/18 **COMPLETED** 10/22/18
GROUND ELEVATION 1033.1 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0		TOPSOIL, ORGANIC CLAY WITH SILT, (OL) black	AU 1									
		3.0 1030.1	SS 2	67	2-4-5 (9)	3.4						
		SILTY FAT CLAY, (CH/CL) gray to brown, rather stiff, trace sand										
5		5.5 1027.6	SS 3	83	2-3-4 (7)	1.0						
		7.0 1026.1 LEAN CLAY, (CL/CH) light gray to light brown, medium, trace sand, trace gravel										
		LEAN CLAY, (CL) light brown, medium, trace sand, trace gravel	SS 4	122	1-3-3 (6)	1.3			21	11	10	
10			ST 5									
		12.5 1020.6	SS 6	94	2-3-4 (7)	2.6						
		14.0 1019.1 LEAN CLAY, (CL) brown, medium, trace sand, trace gravel										
15		Gray, medium to rather stiff, trace sand, trace gravel	SS 7	100	2-3-5 (8)	1.5						
			SS 8	111	2-4-5 (9)	2.0						
20			SS 9	100	2-4-5 (9)	2.6						
		21.0 1012.1										

Bottom of borehole at 21.0 feet.
Borehole grouted.

Northern Technologies, LLC
3522 4th Avenue S.
Fargo, ND 58103
P: 701-232-1822 F: 701-232-1864
www.ntigeo.com

BORING NUMBER SB-06

Long: -96° 4' 22.0044"
Lat: 48° 49' 10.1676"

CLIENT HDR
PROJECT NAME Whitney Lake Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06667.000
PROJECT LOCATION Roseau, Minnesota
DATE STARTED 10/23/18 **COMPLETED** 10/23/18
GROUND ELEVATION 1037.1 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0		1.0 TOPSOIL, ORGANIC CLAY WITH SILT, (OL) black 1036.1	AU 1									
		LEAN CLAY, (CL) light brown to light gray, medium to rather stiff, trace sand, trace gravel	SS 2	56	2-3-3 (6)	0.8						
5			SS 3	94	3-4-6 (10)	3.6						
		6.5 1030.6										
		LEAN CLAY, (CL) gray, rather stiff to very stiff, trace sand, trace gravel	SS 4	100	3-4-7 (11)	6.0						
10			SS 5	89	8-11-21 (32)	2.3						
		11.5 1025.6										
		SANDY LEAN CLAY, (CL) brown, very stiff, trace sand, trace gravel	SS 6	122	15-48-44 (92)							
15			SS 7	133	8-15-21 (36)	6.0						
		16.5 1020.6										
		LEAN CLAY, (CL) dark brown, very stiff, trace sand, trace gravel	SS 8	94	10-16-17 (33)	6.0			18	9	9	
20			SS 9	100	7-20-26 (46)	5.8						
25			SS 10	122	12-17-26 (43)	6.0						
		27.0 1010.1										
		SANDY LEAN CLAY, (CL) brown, very stiff, trace sand, trace gravel										
30		31.0 1006.1	SS 11	111	10-20-24 (44)	6.0						

Bottom of borehole at 31.0 feet.
Borehole grouted.

Northern Technologies, LLC
3522 4th Avenue S.
Fargo, ND 58103
P: 701-232-1822 F: 701-232-1864
www.ntigeo.com

BORING NUMBER SB-08

Long: -96° 1' 44.5404"
Lat: 48° 50' 51.2916"

CLIENT HDR
PROJECT NAME Whitney Lake Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06667.000
PROJECT LOCATION Roseau, Minnesota
DATE STARTED 10/23/18 **COMPLETED** 10/23/18
GROUND ELEVATION 1039 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0		0.9 TOPSOIL, ORGANIC CLAY WITH SILT, (OL) black 1038.1	AU 1									
		LEAN CLAY, (CL) light brown, rather stiff, trace sand, trace gravel	SS 2	94	4-6-7 (13)	6.0						
		4.0 1035.0										
5		LEAN CLAY, (CL) brown, rather stiff to stiff, trace sand, trace gravel	SS 3	111	3-5-7 (12)	5.9						
			SS 4	111	4-5-7 (12)	5.1						
10			SS 5	111	3-5-6 (11)	3.8						
			SS 6	117	4-5-7 (12)	4.1			17	9	8	
15			SS 7	122	4-6-9 (15)	6.0						
			SS 8	94	8-10-13 (23)	6.0						
		19.0 1020.0										
20		LEAN CLAY, (CL) gray, stiff, trace sand, trace gravel	SS 9	111	6-9-12 (21)	4.9						
25			SS 10	117	6-8-12 (20)	6.0						
30												
		31.0 1008.0	SS 11	133	5-9-11 (20)	6.0						

Bottom of borehole at 31.0 feet.
Borehole grouted.

Northern Technologies, LLC
3522 4th Avenue S.
Fargo, ND 58103
P: 701-232-1822 F: 701-232-1864
www.ntigeo.com

BORING NUMBER SB-09

Long: -96° 0' 25.0488"
Lat: 48° 50' 52.0656"

CLIENT HDR
PROJECT NAME Whitney Lake Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06667.000
PROJECT LOCATION Roseau, Minnesota
DATE STARTED 10/23/18 **COMPLETED** 10/23/18
GROUND ELEVATION 1041.8 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0		0.9 TOPSOIL, ORGANIC CLAY WITH SILT, (OL) black 1041.0	AU 1									
		LEAN CLAY, (CL) light brown, medium to stiff, trace sand, trace gravel	SS 2	67	2-3-5 (8)	4.6						
5			SS 3	100	4-6-8 (14)	6.0						
			SS 4	117	3-6-9 (15)	6.0						
10			SS 5	128	2-7-10 (17)	6.0						
		11.5 1030.3										
		LEAN CLAY, (CL) brown, stiff, trace sand, trace gravel	SS 6	133	3-6-10 (16)	4.4						
15		15.0 1026.8	SS 7	106	3-6-13 (19)	3.6						
		LEAN CLAY, (CL) gray, stiff to rather stiff, trace sand, trace gravel	SS 8	106	4-8-10 (18)	5.6						
20			SS 9	78	2-7-10 (17)	2.6						
25			SS 10	100	3-7-9 (16)	4.2						
30		31.0 1010.8	SS 11	122	3-6-8 (14)	2.3						

Bottom of borehole at 31.0 feet.
Borehole grouted.

Northern Technologies, LLC
3522 4th Avenue S.
Fargo, ND 58103
P: 701-232-1822 F: 701-232-1864
www.ntigeo.com

BORING NUMBER SB-10

Long: -95° 59' 9.0636"
Lat: 48° 50' 51.828"

CLIENT HDR
PROJECT NAME Whitney Lake Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06667.000
PROJECT LOCATION Roseau, Minnesota
DATE STARTED 10/23/18 **COMPLETED** 10/23/18
GROUND ELEVATION 1047.2 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0		0.7 TOPSOIL, ORGANIC CLAY WITH SILT, (OL) black 1046.5	AU 1									
		LEAN CLAY, (CL) brown, medium to stiff, trace sand, trace gravel	SS 2	39	2-3-4 (7)	1.1						
5			SS 3	89	3-5-7 (12)	6.0						
			SS 4	89	5-7-8 (15)	6.0						
10		Rock	SS 5		8-11-13 (24)							
			SS 6	39	7-10-11 (21)	5.8						
15			SS 7	111	4-7-10 (17)	3.7			18	10	8	
			SS 8	78	2-4-7 (11)	2.7						
20		20.5 1026.7	SS 9	100	4-7-9 (16)	6.0						
		LEAN CLAY, (CL) gray, stiff to rather stiff, trace sand, trace gravel										
25			SS 10	100	4-5-9 (14)	2.9						
30		31.0 1016.2	SS 11	100	4-6-7 (13)	3.7						

Bottom of borehole at 31.0 feet.
Borehole grouted.

Northern Technologies, LLC
3522 4th Avenue S.
Fargo, ND 58103
P: 701-232-1822 F: 701-232-1864
www.ntigeo.com

BORING NUMBER SB-11

Long: -95° 57' 52.9236"
Lat: 48° 50' 52.6668"

CLIENT HDR
PROJECT NAME Whitney Lake Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06667.000
PROJECT LOCATION Roseau, Minnesota
DATE STARTED 10/23/18 **COMPLETED** 10/23/18
GROUND ELEVATION 1051.8 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0		0.7 FILL/TOPSOIL, CLAY, black, trace sand, trace gravel 1051.1	AU 1									
		FILL, brown trace black, trace sand, trace gravel	SS 2		6-7-9 (16)	4.5						
		4.0 1047.8										
5		LEAN CLAY, (CL) brown, rather stiff to stiff, trace sand, trace gravel	SS 3	89	4-6-7 (13)	6.0						
			SS 4	56	6-12-13 (25)							
10			SS 5	133	3-6-9 (15)	6.0						
			SS 6	133	3-6-10 (16)	5.0						
15			SS 7	94	3-6-10 (16)	4.6						
		18.0 1033.8	SS 8	111	3-7-8 (15)	5.5						
		LEAN CLAY, (CL) gray, rather stiff to stiff, trace sand, trace gravel										
20			SS 9	122	3-7-9 (16)	4.2						
25			SS 10	122	3-7-10 (17)	4.4						
30		31.0 1020.8	SS 11	122	3-6-10 (16)	1.7						

Bottom of borehole at 31.0 feet.
Borehole grouted.

Northern Technologies, LLC
3522 4th Avenue S.
Fargo, ND 58103
P: 701-232-1822 F: 701-232-1864
www.ntigeo.com

BORING NUMBER SB-12

Long: -95° 55' 13.7028"
Lat: 48° 52' 35.9616"

CLIENT HDR
PROJECT NAME Whitney Lake Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06667.000
PROJECT LOCATION Roseau, Minnesota
DATE STARTED 10/23/18 **COMPLETED** 10/23/18
GROUND ELEVATION 1040.3 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
▽ **AT TIME OF DRILLING** 2.00 ft / Elev 1038.30 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0		0.7 TOPSOIL, ORGANIC CLAY WITH SILT, (OL) black 1039.6	AU 1					30				
		LEAN CLAY, (CL) brown, soft to stiff, trace sand, trace gravel ▽	SS 2	78	1-2-2 (4)			22	19	10	9	
5			SS 3	100	3-2-3 (5)	1.0	138	12				
			SS 4	100	2-3-5 (8)	2.6	135	12				
10			ST 5									
			SS 6	89	6-8-7 (15)	2.3	143	11				
15			SS 7	33	5-7-10 (17)	0.7		12				
		17.5 1022.8 LEAN CLAY, (CL) gray, rather stiff, trace sand, trace gravel	SS 8	100	3-5-6 (11)	1.6	140	11				
20			SS 9	111	3-5-6 (11)	1.9	138	11	18	10	8	
25			SS 10	67	4-6-7 (13)			11				

(Continued Next Page)

Northern Technologies, LLC
3522 4th Avenue S.
Fargo, ND 58103
P: 701-232-1822 F: 701-232-1864
www.ntigeo.com

BORING NUMBER SB-12

Long: -95° 55' 13.7028"
Lat: 48° 52' 35.9616"

CLIENT HDR
PROJECT NAME Whitney Lake Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06667.000
PROJECT LOCATION Roseau, Minnesota

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
		LEAN CLAY, (CL) gray, rather stiff, trace sand, trace gravel *(continued)*										
30			SS 11	106	3-4-7 (11)	2.2	138	11				
35			SS 12	117	4-4-6 (10)	1.4	139	11	18	10	8	
40			SS 13	133	4-6-8 (14)	2.5	133	12				
45			SS 14	128	6-6-8 (14)	2.8	139	11				
46.0		994.3										

Bottom of borehole at 46.0 feet.
Borehole grouted.

Northern Technologies, LLC
3522 4th Avenue S.
Fargo, ND 58103
P: 701-232-1822 F: 701-232-1864
www.ntigeo.com

BORING NUMBER SB-13

Long: -95° 55' 13.8"
Lat: 48° 52' 22.6884"

CLIENT HDR
PROJECT NAME Whitney Lake Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06667.000
PROJECT LOCATION Roseau, Minnesota
DATE STARTED 10/23/18 **COMPLETED** 10/23/18
GROUND ELEVATION 1044.3 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0		1.0 TOPSOIL, ORGANIC CLAY WITH SILT, (OL) black 1043.3	AU 1									
		LEAN CLAY, (CL) brown, medium to stiff, trace sand, trace gravel	SS 2	56	2-3-3 (6)	1.6						
5			SS 3	83	2-3-6 (9)	2.9			17	9	8	
			ST 4									
10			SS 5	111	3-4-7 (11)	2.2						
			SS 6	100	3-4-7 (11)	3.2						
15			SS 7	11	6-9-11 (20)	1.7						
			SS 8	28	6-9-9 (18)	3.1						
20			SS 9	33	6-9-12 (21)	1.8						
		21.0 1023.3										

Bottom of borehole at 21.0 feet.
Borehole grouted.

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. / Minnesota Unique Well No. or W-series No. (Leave blank if not known): H 362975

WELL OR BORING LOCATION

County Name: Roseau

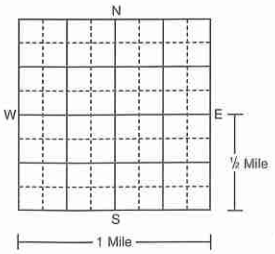
Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
Moose	162 N	42 W	10	SE ¼ NE ¼ NE ¼

GPS LOCATION – decimal degrees (to four decimal places)

Latitude _____ Longitude _____

Numerical Street Address or Fire Number and City of Well or Boring Location: Various Locations in Moose Twp.

Show exact location of well or boring in section grid with "X."



Sketch map of well or boring location, showing property lines, roads, and buildings.

See Attached Map

PROPERTY OWNER'S NAME/COMPANY NAME: Roseau River Watershed District

Property owner's mailing address if different than well location address indicated above:

714 6th St SW
Roseau, MN 56751

WELL OWNER'S NAME/COMPANY NAME: Same as above

Well owner's mailing address if different than property owner's address indicated above:

Same as above

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Glacial Drift			0	End

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

Whitney Lake Subwatershed
Moose Twp.
(FGO06667)

MINN. DEPT OF HEALTH COPY H 362975

Date Sealed: 10/22/2018

Date Well or Boring Constructed: 10/22/2018

Depth at Time of Sealing: 45.0 ft.

Original Depth: 45.0 ft.

AQUIFER(S): ☐ Single Aquifer ☐ Multiaquifer

WELL/BORING: ☐ Water-Supply Well ☐ Monit. Well ■ Env. Bore Hole ☐ Other _____

STATIC WATER LEVEL: ■ Measured Date Measured 10/24/2018 ☐ Estimated

8.00 ft. ■ below ☐ above land surface

CASING TYPE(S): ☐ Steel ☐ Plastic ☐ Tile ■ Other N/A

WELLHEAD COMPLETION

Outside: ☐ Pitless Adapter/Unit ☐ At Grade ☐ Well Pit ☐ Buried ■ Other _____

Inside: ☐ Basement Offset ☐ Well House ☐ Well Pit ☐ Buried ■ Other _____

CASING(S)

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
N/A in. from _____	to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in. from _____	to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in. from _____	to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE: Screen from N/A to _____ ft. Open Hole from _____ to _____ ft.

OBSTRUCTIONS: ☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill ■ No Obstruction

Type of Obstructions (Describe) _____

Obstructions removed? ☐ Yes ☐ No Describe _____

PUMP: ■ Not Present ☐ Present, Removed Prior to Sealing ☐ Other _____

Type _____

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE: ☐ No Annular Space Exists ☐ Annular Space Grouted with Tremie Pipe ■ Casing Perforation/Removal

Casing Diameter

N/A in. from _____ to _____ ft. ☐ Perforated ☐ Removed

_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed

Type of Perforator N/A

VARIANCE: Was a variance granted from the MDH for this well? ☐ Yes ■ No TN# _____

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)

Grouting Material Bentonite Grout from 0 to End ft. _____ yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

OTHER WELLS AND BORINGS: Other unsealed and unused well or boring on property? ☐ Yes ■ No How many? _____

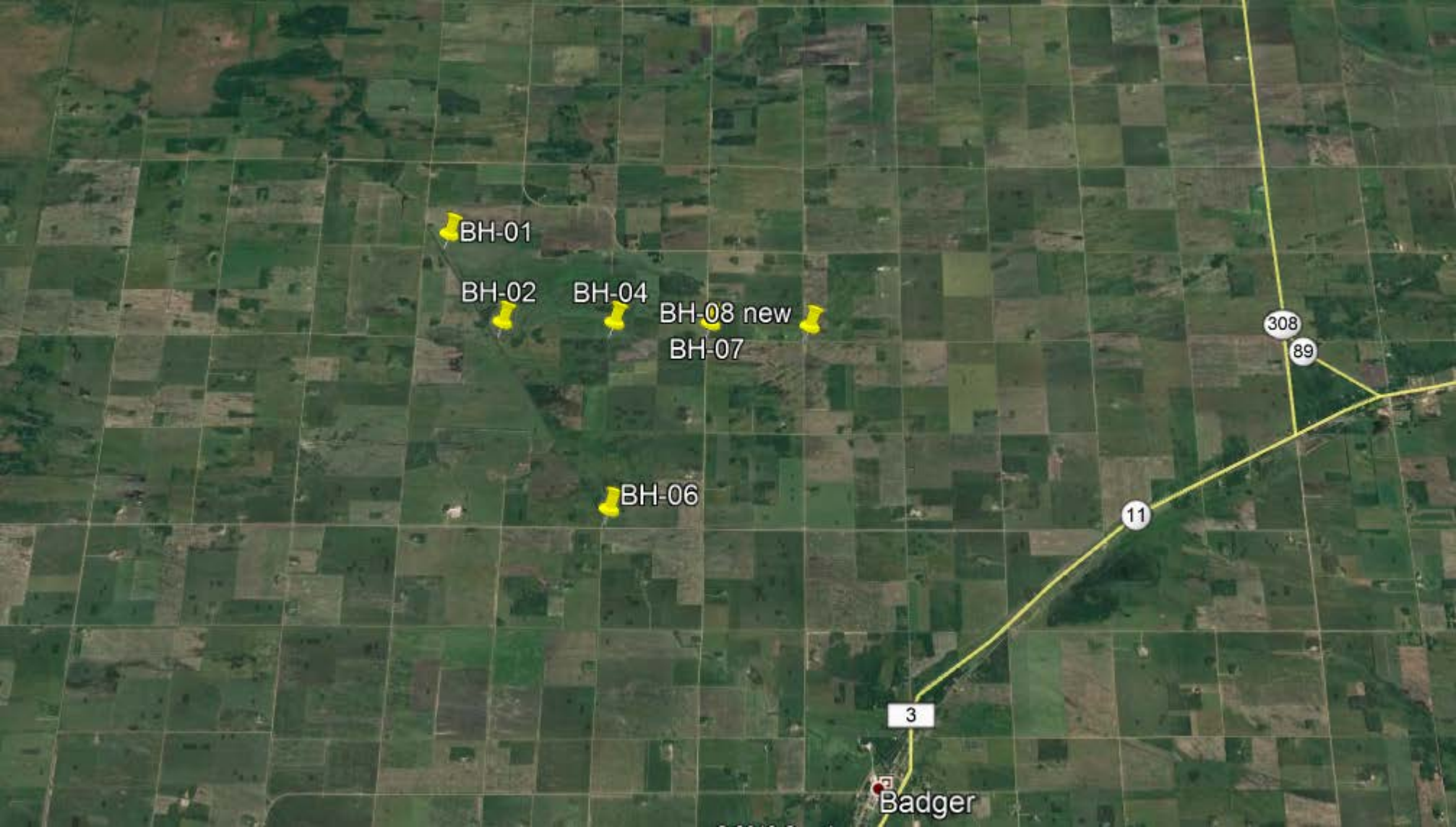
LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

Northern Technologies, LLC — 3574
Licensee Business Name — *License or Registration No.*

Christopher Kaiser for Bill Canty — 11/16/2018
Certified Representative Signature — *Certified Rep. No.* — *Date*

Bradley Halvorson
Name of Person Sealing Well or Boring


BH-01
BH-02
BH-04
BH-08 new
BH-07
BH-06
308
89
11
3
Badger

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. H 362976
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION

County Name: Roseau

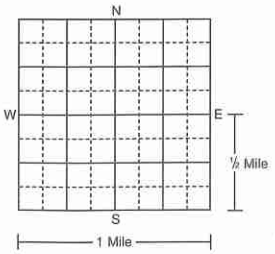
Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
Ross	162 N	41 W	20	NW¼ NW¼ NW¼

GPS LOCATION – decimal degrees (to four decimal places)

Latitude _____ Longitude _____

Numerical Street Address or Fire Number and City of Well or Boring Location: Various Locations in Ross Twp.

Show exact location of well or boring in section grid with "X."



Sketch map of well or boring location, showing property lines, roads, and buildings.

See Attached Map

PROPERTY OWNER'S NAME/COMPANY NAME: Roseau River Watershed District

Property owner's mailing address if different than well location address indicated above:

714 6th St SW
Roseau, MN 56751

WELL OWNER'S NAME/COMPANY NAME: Same as above

Well owner's mailing address if different than property owner's address indicated above:

Same as above

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Glacial Drift			0	End

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

Whitney Lake Subwatershed
Ross Twp.
(FGO06667)

MINN. DEPT OF HEALTH COPY H 362976

Date Sealed: 10/22/2018

Date Well or Boring Constructed: 10/22/2018

Depth at Time of Sealing: 45.0 ft.

Original Depth: 45.0 ft.

AQUIFER(S): ☐ Single Aquifer ☐ Multiaquifer

WELL/BORING: ☐ Water-Supply Well ☐ Monit. Well ■ Env. Bore Hole ☐ Other

STATIC WATER LEVEL: ■ Measured Date Measured 10/24/2018 ☐ Estimated
44.00 ft. ■ below ☐ above land surface

CASING TYPE(S): ☐ Steel ☐ Plastic ☐ Tile ■ Other N/A

WELLHEAD COMPLETION

Outside: ☐ Pitless Adapter/Unit ☐ At Grade ☐ Well Pit ☐ Buried ■ Other

Inside: ☐ Basement Offset ☐ Well House ☐ Well Pit ☐ Buried ■ Other

CASING(S)

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
N/A in. from ___ to ___ ft.		☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
___ in. from ___ to ___ ft.		☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
___ in. from ___ to ___ ft.		☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE: Screen from N/A to ___ ft. Open Hole from ___ to ___ ft.

OBSTRUCTIONS: ☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill ■ No Obstruction

Type of Obstructions (Describe) _____

Obstructions removed? ☐ Yes ☐ No Describe _____

PUMP: ■ Not Present ☐ Present, Removed Prior to Sealing ☐ Other _____

Type _____

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE

☐ No Annular Space Exists ☐ Annular Space Grouted with Tremie Pipe ■ Casing Perforation/Removal

Casing Diameter
N/A in. from ___ to ___ ft. ☐ Perforated ☐ Removed
___ in. from ___ to ___ ft. ☐ Perforated ☐ Removed

Type of Perforator N/A

VARIANCE: Was a variance granted from the MDH for this well? ☐ Yes ■ No TN# _____

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)

Grouting Material Bentonite Grout from 0 to End ft. ___ yards ___ bags
___ from ___ to ___ ft. ___ yards ___ bags
___ from ___ to ___ ft. ___ yards ___ bags

OTHER WELLS AND BORINGS: Other unsealed and unused well or boring on property? ☐ Yes ■ No How many? _____

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

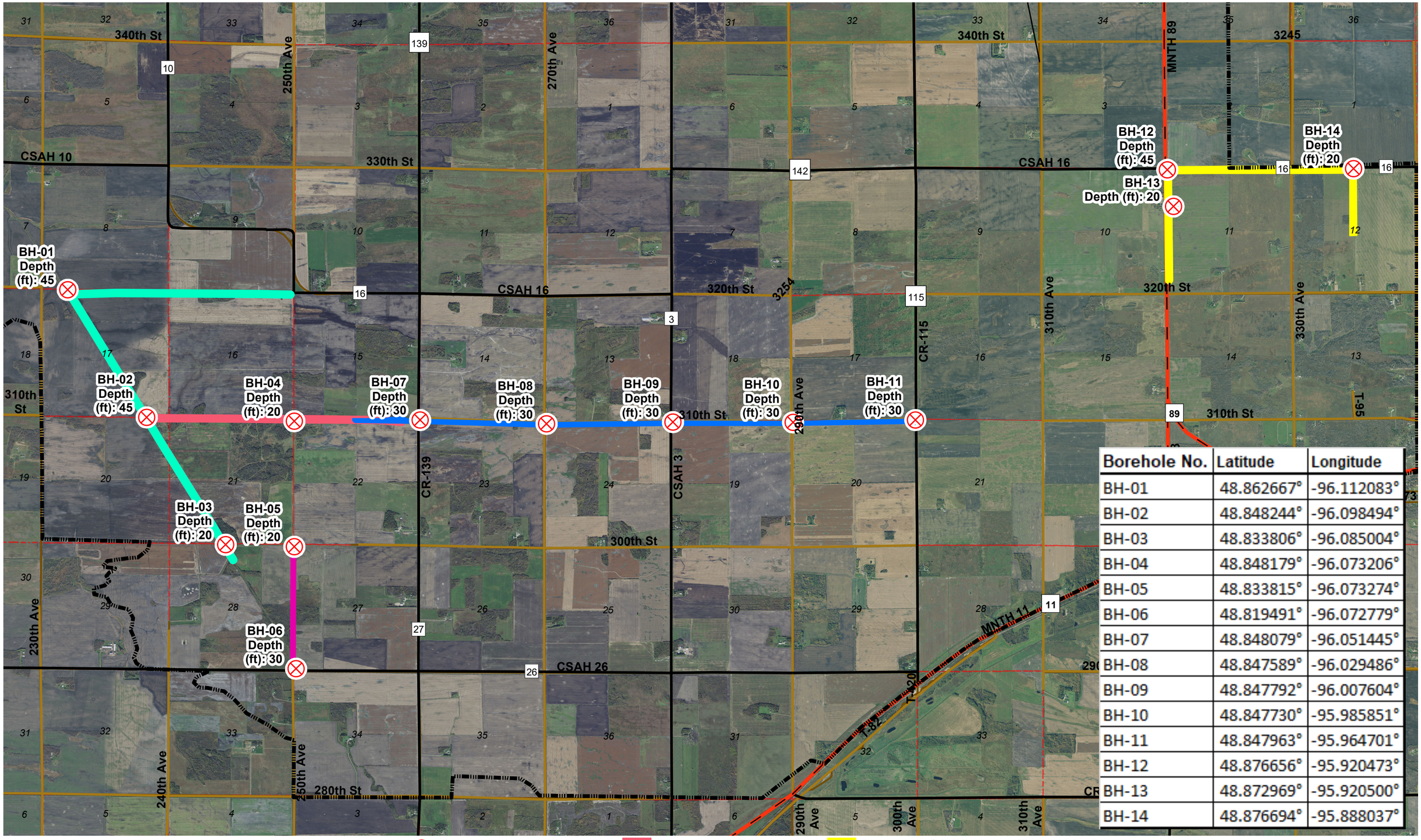
This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

Northern Technologies, LLC — 3574
Licensee Business Name — *License or Registration No.*

Christopher Kaiser for Bill Canty — 11/16/2018
Certified Representative Signature — *Certified Rep. No.* — *Date*

Bradley Halvorson
Name of Person Sealing Well or Boring


BH-12
BH-13
BH-11
BH-10
308
89



Borehole No.	Latitude	Longitude
BH-01	48.862667°	-96.112083°
BH-02	48.848244°	-96.098494°
BH-03	48.833806°	-96.085004°
BH-04	48.848179°	-96.073206°
BH-05	48.833815°	-96.073274°
BH-06	48.819491°	-96.072779°
BH-07	48.848079°	-96.051445°
BH-08	48.847589°	-96.029486°
BH-09	48.847792°	-96.007604°
BH-10	48.847730°	-95.985851°
BH-11	48.847963°	-95.964701°
BH-12	48.876656°	-95.920473°
BH-13	48.872969°	-95.920500°
BH-14	48.876694°	-95.888037°

Proposed Boring Locations
Whitney Subbasin
Diversion 3
Retention A Dike
Retention A Inlet Channel
Retention A2 Dike
Retention C2 Dike
State Highway
County Road
Township Roads

0 0.5 1 Miles

HDR | Roseau River Watershed District

PROPOSED BOREHOLE LOCATIONS AND DEPTHS

WHITNEY LAKE SUBWATERSHED