ENGINEER'S REPORT

ROSEAU LAKE REHABILITATION PROJECT

ROSEAU RIVER WATERSHED DISTRICT

JUNE 2019

Roseau Lake Rehabilitation Project

Final Engineer's Report

June 2019

This Roseau Lake Rehabilitation 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.

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ACRONYMS AND SHORT FORMS

ac-ft	Acre Feet
BMP	Best Management Practice
BWSR	Board of Water and Soil Resources
CD	County Ditch
cfs	cubic feet per second
CMP	Corrugated Metal Pipe
CN	Curve Number
CR	County Road
DEM	Digital Elevation Model
EAW	Environmental Assessment Worksheet
EFM	Ecosystem Functions Model
EPA	Environmental Protection Agency
FDR	Flood Damage Reduction
fps	feet per second
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GPS	Geographic Positioning System
HEC	USACE Hydrologic Engineering Center
HMS	HEC Hydrologic Modeling System
LTFS	Long Term Flood Solutions
MnDOT	Minnesota Department of Transportation
MnDNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service, formally the SCS
NRE	Natural Resource Enhancement
NWI	National Wetland Inventory
NWS	National Weather Service
R	Clark Storage Coefficient

RAS	HEC River Analysis System
RCP	Reinforced Concrete Pipe
ROW	Right-of-way
RRFDRWG	Red River Flood Damage Reduction Work Group
RRWD	Roseau River Watershed District
RRWMA	Roseau River Wildlife Management Area
SCS	Soil Conservation Service
SHPO	State Historical Preservation Office
SWCD	Soil and Water Conservation District
SWPPP	Storm Water Pollution Prevention Plan
SWMM	Storm Water Management Model
T_C	Time of Concentration
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WSE	Water Surface Elevation
WMA	Wildlife Management Area

1 Project Goals and Location

The Roseau River Watershed District (RRWD) established a project team to develop a multipurpose project to rehabilitate Roseau Lake. The project team developed the following purpose and need statement to guide the design:

> *The purpose of this project is to improve habitat conditions in the Roseau Lake and the Roseau River and to manage the available storage capacity of the lake basin to reduce flood damages near and downstream of the lake basin.*

The RRWD is flood prone, and affected by repetitive flooding. The west portion of the RRWD is the ancestral bed of Lake Agassiz, which is unable to drain quickly due to the flat slopes averaging 3 to 5 feet of elevation drop in per mile. In addition, steeper topography in the southern and eastern portions of the watershed drain more quickly, and inundate the downstream flatter land to the north and west. Figure 1 shows the area with the Roseau Lake located just east of Ross, MN and 5.5 miles northwest of the City of Roseau in the northwest corner of Roseau County, Minnesota. This report is a summary of planning and engineering for the Roseau Lake Rehabilitation Project (Project) which provides benefits by changing when Roseau Lake floods.

2 Background

Roseau Lake historically provided a diversity of habitats for many aquatic mammals, birds, fish, amphibians, and reptiles. In 1914 the Roseau River was channelized and a legal ditch system was created through the lake basin draining Roseau Lake. Figure 2 illustrates the local ditch systems and topographical survey of the project. The existing ditches drain the basin, but they are also the primary conduit of Roseau River backwater, which starts to fill the basin with a river flow between 300 and 700 cfs (between elevation 1026 and 1028). The direct connection between Roseau Lake and the Roseau River results in fluctuating Roseau Lake water levels, which are not desirable for wildlife. The Project will create a more stable water level during the summer and fall.

In addition, there have been discussions to create a flood damage reduction (FDR) project in the basin since 1949. The direct connection with the Roseau River results in flooding of the basin early during the flood event eliminating potential storage capacity during the flood peak. One of the Project's goals is to use this potential storage capacity to reduce flooding in areas adjacent to and downstream of the Roseau Lake, which are subject to relatively frequent and severe inundation starting between 900 and 1400 cfs. Figure 3 shows the 100-year FEMA floodplain limits. The potential Roseau Lake flood storage volume below elevation 1034 (stage 14 feet at Ross) is 21,090 acre-feet.

The United States Army Corps of Engineers (USACE) and the Minnesota Department of Natural Resources (DNR) have developed projects for Roseau Lake, but ultimately all previous attempts have stalled due to lack of funding or lack of sustained interest. In a renewed effort to re-examine the problem, the RRWD has begun the project planning process and engineering.

The Project restarted in April 2014 and Project Team meetings have occurred periodically since 2014 with the Concept Report completed on December 2015. The Red Board Step 1 Submittal was approved in January 2016, followed by a public meeting in June 2016. Red Board Step 2 was approved April 2017. The USACE and RRWD are following the Points of Concurrence process as outline in Chapter 3 of the Project Team Handbook with the following concurrence point completion dates:

- Concurrence Point 1 - October 3, 2016 - purpose and need
- Concurrence Point 2 – July 24, 2017 - strategy and elimination
- Concurrence Point 3 – May 16, 2018 - alternatives analysis and selection of preferred option

The Concurrence Point documents are provided in Appendix A.

3 Project Objectives

There is a region-wide goal to reduce peak flows along the Red River of the North (Red River) mainstem by 20 percent during a flooding event similar to the 1997 flood. The 1997 flood at the Ross gage was a little larger than the 10-year event with a peak flow of 4670 cfs, stage of 17.3 feet, and elevation of 1037.3. All elevations discussed in this report refer to the North American Vertical Datum of 1988 (NAVD 88), and to convert from stage to elevation at the Ross gage 1020 feet is added to the Ross stage. The Project is compatible with the region-wide peak flow and volume reduction goals as set forth in the RRBC LTFS Basin Wide Flood Flow Reduction Strategy Report.

On February 10, 2011 a Citizen Advisory Committee identified the following specific issues:

- Flooding is occurring more frequently than in the past
- Water reaches Roseau Lake faster than previously
- There is a greater monetary risk for farmers than in the past
- Banks along the Roseau River are sloughing and having rotational failure
- Agricultural land is flooding before the Lake Basin fills
- There has been a loss of drainage capacity
- There are breakouts along the Roseau River
- Land values are decreasing
- Damage to infrastructure is occurring

The Preliminary Engineer's Report dated October 2016 provides a summary of additional project objectives:

- Reduce peak flows on the Roseau River by up to 25% for 2-year to 50-year flood frequency events
- Improve the condition of the Roseau Lake for aquatic habitat
- Provide migratory habitat for waterfowl and shoreland birds in spring and fall
- Stabilize water levels in the Roseau Lake area during the nesting season
- Increase the capacity to manage and reduce water level fluctuations (water level fluctuation) in Roseau Lake to improve plant community diversity and condition
- Contribute to improved hydrologic conditions at Big Swamp
- Improve instream hydrology, connectivity, water quality, and overall physical habitat conditions for fish and aquatic biota

- Improve timing of water storage and release from the Roseau Lake basin to reduce peak flows on the Roseau River
- Increase flows occurring below flood stage at non-damaging river levels
- Improve the quantity and quality of wildlife habitat in and surrounding the Roseau Lake basin area
- Provide an option to hold water in the Roseau Lake basin when natural conditions would prohibit this
- Develop an agreed upon operating plan

Figure 1. Project Location

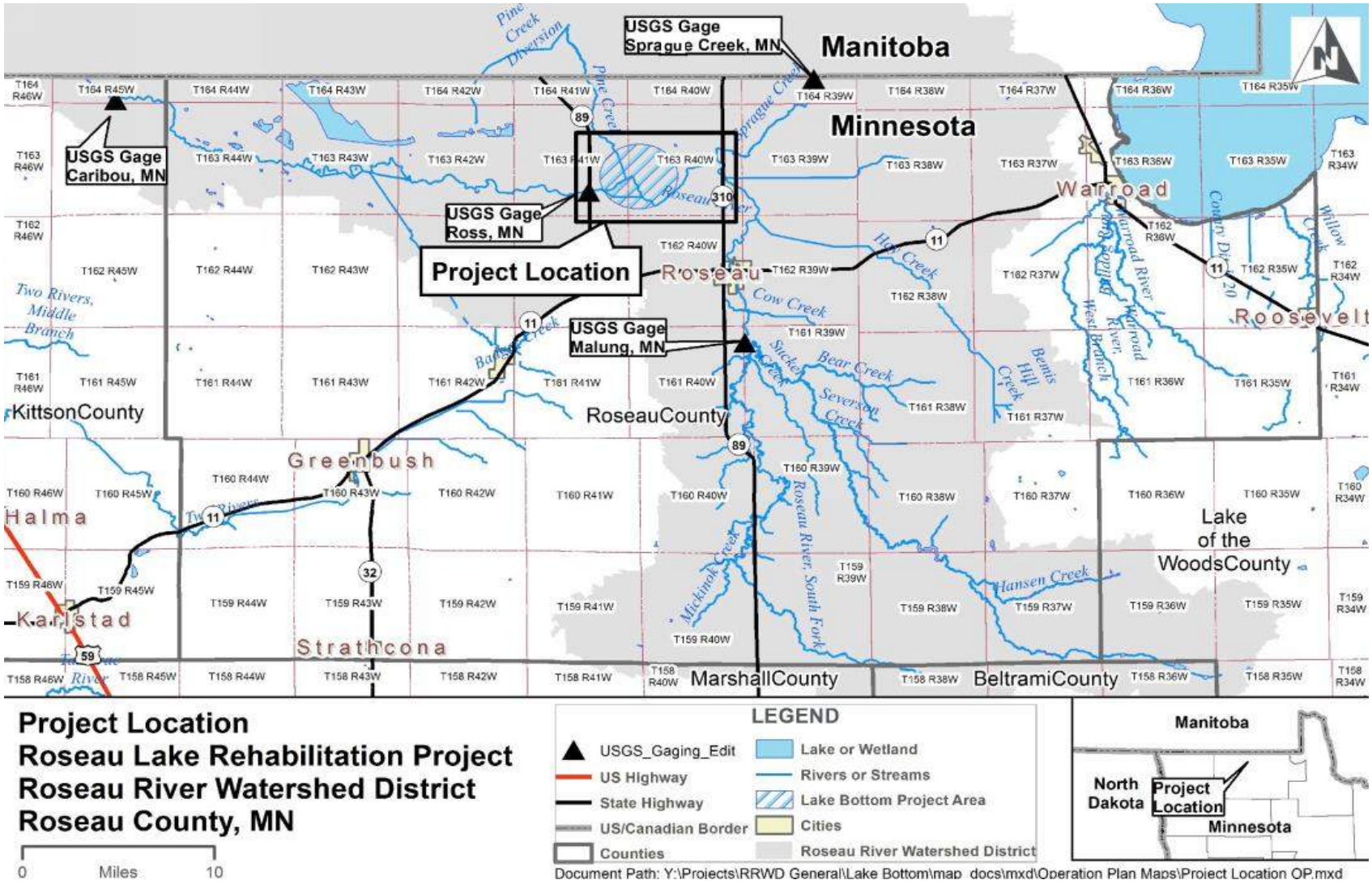
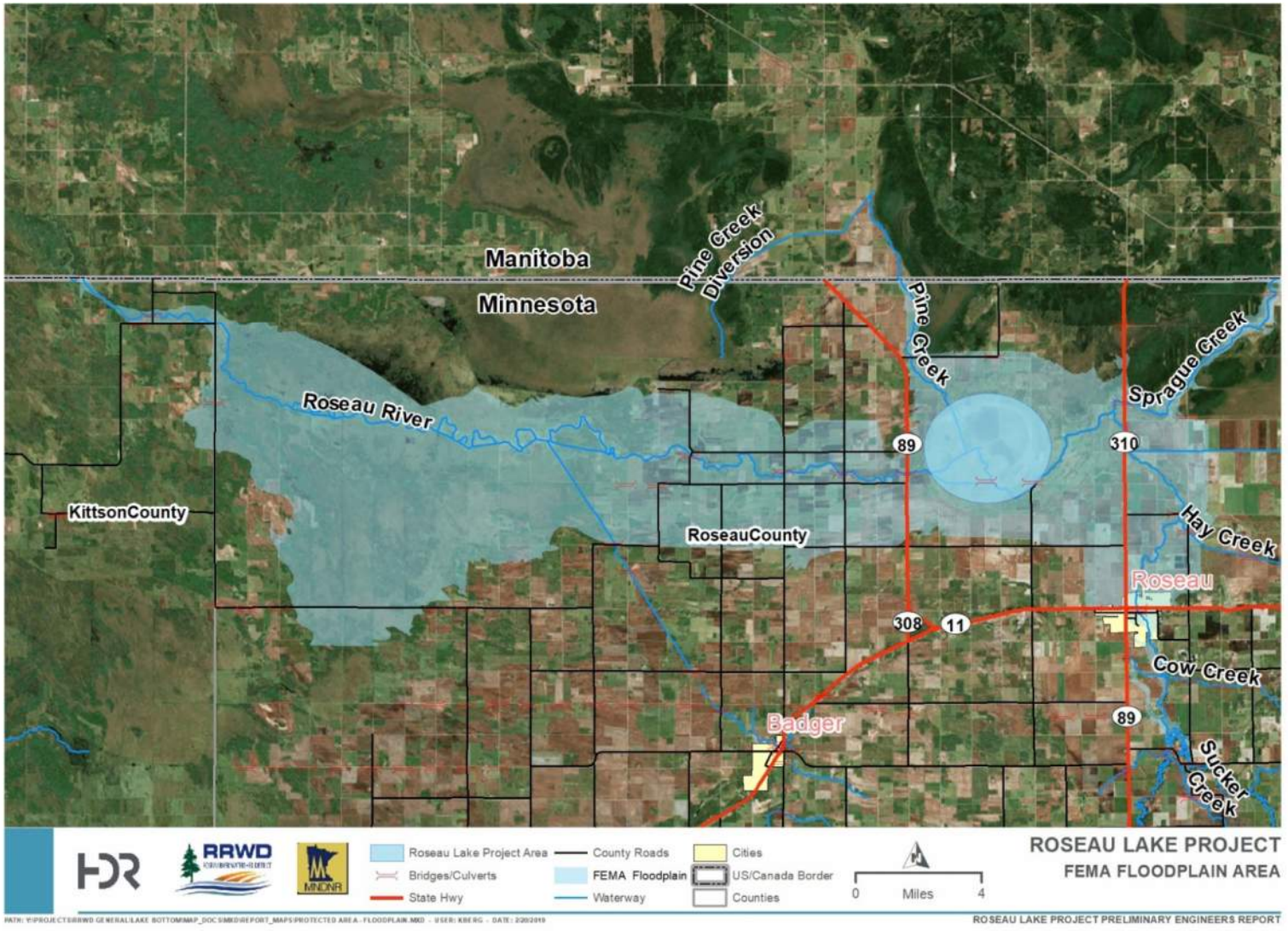


Figure 2. Ditch Systems and Topographical Survey

Figure 3. FEMA 100-year Floodplain Area



4 Criteria

The following plans, statues, and rules were used to establish the criteria used to design the Project.

4.1 Roseau River Watershed District Plan

The RRWD was 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 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:

4.1.1 Flood Damage Reduction (FDR) 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.
- Preserve ground water supply and recharge areas.

4.1.2 Natural Resource Enhancement (NRE) 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.

4.2 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 SWCD Comprehensive Plan.

Goals in this water plan that contribute to the Roseau Lake Rehabilitation project include:

- 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

4.3 Minnesota Statutes and Rules

Section 103D of Minnesota Statutes pertains to Watershed Districts with the following subdivisions particularly applicable to the Roseau Lake Rehabilitation 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 report is intended to satisfy the requirements of 103D.605, 103D.701, and 103D.711.

Additional Statutory requirements include interaction with Statute 103E (Roseau County Ditch Authority). Judicial Ditch 61 Lateral 5B, Lateral 6, Lateral 7, and Pine Creek each flow into the proposed project site and will be impacted by the Project. The RRWD will need the approval of the County Ditch Authority to proceed with any associated drainage system modifications and improvements.

4.4 State Historic Preservation Office

A cultural resources record search will be conducted for the Project through the Minnesota State Historic Preservation Office (SHPO). The records search will focus on previously conducted cultural resources investigations, and previously recorded archaeological and architectural sites within the Project area.

4.5 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, the Project will disturb more than one acre of public water wetlands and requires preparation of an EAW.

4.6 USACE Section 404

A Section 404 permit will be required because excavation and fill will take place through a wetland that is connected to the Roseau River. Meetings will be held with USACE permitting authorities regarding the proposed project. The permit may require 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.

4.7 Minnesota Department of Natural Resources

The project will require a thorough a review of the proposed design by the MnDNR and a dam safety permit 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. The impoundment embankment will likely be classified as a Class III low hazard dam. A MnDNR Public Waters Work Permit is required for work within Roseau Lake, the Roseau River, and channels draining to the Roseau River.

4.8 Wetland Conservation Act

The Wetland Conservation Act (WCA) permitting authorities met with the project team regarding the proposed Project. 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.

4.9 National Pollutant Discharge Elimination System Requirements

A storm water permit is required for Project 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 (BMPs), to minimize pollution for the specific site. The final engineering plans for the Project will address the SWPPP for the site using seeding, mulch, fiber rolls, silt fence, filter fabric, and riprap.

5 Data

The following is a list of information used in the Project alternative development and includes survey information, basin wide hydrologic modeling, and USGS gage information.

- International Water Institute. 2008 to 2010. Red River Basin Mapping Initiative. Red River Lidar Topography is available on-line at http://www.iwinst.org/lidar/. Block I delivered July 30, 2010 with 12.6 cm RMSE vertical accuracy, 1 meter horizontal accuracy, NAVD88 vertical datum, and UTM Zone 14 NAD83 horizontal coordinates.
- HDR Survey Grade GPS Field survey. Fall 2015. Survey covered the Roseau River channel between Highway 310 and 89, top of banks surveyed 1 mile west of Highway 310 and 0.25 mile East of Highway 89, and Roseau Lake basin below elevation 1034.5 including ditches and culverts with Horizontal accuracy 2.47 cm, Vertical accuracy 3.03 cm, NAVD88 vertical datum, and Minnesota County Coordinates, Roseau County, US Survey Foot NAD83 horizontal datum.
- HDR Survey Grade GPS Field survey. September 2017. Six Roseau River channel cross sections between Highway 89 to County Road 119 with Horizontal accuracy 2.47 cm, Vertical accuracy 3.03 cm, NAVD88 vertical datum, and Minnesota County Coordinates, Roseau County, US Survey Foot NAD83 horizontal datum.
- U.S. Army Corps of Engineers Saint Paul District. 2013. HEC-HMS Model Development for Various Tributaries below the Red River of the North at Halstad, MN. April 2013. HDR Engineering completed the Roseau River model as part of the Minnesota Expanded Distributed Detention Strategy Study, which is available with the final report on-line at: http://www.rrbdin.org/resources/hydrologymodels/phase-2-northern-basin
- Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffrey Bonnin (2013). NOAA Atlas 14 Volume 8 Version 2, Precipitation-Frequency Atlas of the United States, Midwestern States. NOAA, National Weather Service, Silver Spring, MD.
- USGS gage information:
    - Roseau River at Ross, MN maintained by USGS – near project outlet, contributing drainage area 1,090 sq. mi. The gage datum is 1018.61 NGVD29. The conversion to NAVD88 is 1.358 feet so to convert stage information to NAVD88 datum add 1019.97 feet. https://waterdata.usgs.gov/mn/nwis/uv/?site_no=05107500&PARAmeter_cd=00065,00060
    - Roseau River at Roseau maintained by MNDNR, upstream of project, drainage area 473 sq. mi. http://www.dnr.state.mn.us/waters/csg/site_report.html?mode=getsitereport&site=71035001
    - Roseau River near Malung, MN approximately 3 miles upstream of Roseau maintained by USGS - upstream of project, contributing drainage area 430 sq. mi. https://waterdata.usgs.gov/mn/nwis/uv/?site_no=05104500&PARAmeter_cd=00065,00060

- Sprague Creek at Canada/US border maintained by USGS - upstream of project, drainage area 176 sq. mi. https://waterdata.usgs.gov/mn/nwis/uv/?site_no=05106000&PARAmeter_cd=00065,00060

6 Hydrologic Analysis

A detailed review of flows at Roseau Lake was necessary to understand the source of flow and quantify the design events. The hydrologic analysis included a delineation of the basin and subbasins, review of flow measurements at Ross gage, and use of an already created hydrologic model to determine peak flows from design storms. The Ross gage recurrence interval peak flows are based on actual measurements while the peak flows from the hydrologic model are based on a hypothetical storm event intended to replicate site conditions. The Ross gage design event flows presented in this report are different from the hydrologic model peak flows. The Ross gage design events are based on actual measured water levels and flows and is the best information available to define the flood event probability. The intent of the model is to demonstrate the impact of the Project on different flood events.

6.1 Basin Delineation

The total drainage area of the project is 1,085 square miles. The primary tributaries to Roseau Lake are the Roseau River (646 sq. mi.), Sprague Creek (332 sq. mi.), Pine Creek (77 sq. mi. total area with 23.5 sq.mi. downstream of RRWMA diversion), and JD61 (22.8 sq. mi.). See Table 1 for subbasin areas.

Table 1. Drainage Area at Ross, MN

Description	HMS ID	Drainage Area (square miles)	Percent (%)
Roseau River	Reach-61	646.2	59.5%
Sprague Creek	Reach-189	332.4	30.6%
Pine Creek	Reach-91	23.5	2.2%
JD 61	Reach-83	22.8	2.1%
Local drainage D/S Sprague	W35000	18.7	1.7%
West Intercept Ditch	W27460	14.2	1.3%
Other Local Drainage	W34300,W36350, and W34990	27.7	2.6%

Over the last 100 years human activity in the watershed altered drainage patterns and timing. Extensive ditching has taken place throughout the Roseau River watershed in an attempt to improve agricultural production and wildlife management including a diversion structure on Pine Creek with a capacity of 600 cfs diverting flow to the Roseau River Wildlife Management Area (RRWMA) pools. Due to the basin wide ditching effort, the time it takes for water to reach Roseau Lake has decreased resulting in higher flood peaks with shorter durations.

6.2 Gage Analysis

Table 2 shows the Roseau River peak flow history at Ross, MN with the highest peak flow 10,500 CFS in June of 2002. (USGS Gage # 05107500).

Table 2. History of Peak Flows at Ross, MN

Date	River Stage (feet)	Peak Flow (cfs)
June 16, 2002	18.89	10,500
April 10, 1952	N/A	7,601
May 12, 1950	18.25	6,560
April 7, 1931	N/A	6,531
July 1, 1919	17.50	5,250
April 21, 1966	17.17	4,670
April 26, 1997	17.30	4,670
April 29, 1979	17.31	4,570
May 23, 1996	17.40	4,530
May 21, 2004	16.77	4,300
April 20, 1965	16.50	3,780
April 27, 1974	16.41	3,550
April 20, 1969	16.36	3,500
April 21, 2009	16.35	3,460
May 4, 1970	15.99	3,440
April 17, 2011	15.94	3,380
April 11, 2006	16.14	3,300
April 28, 1975	15.91	3,280
April 29, 1948	15.88	3,220
April 30, 1967	14.98	2,860

HDR conducted a Log-Pearson Type III analysis of Ross gage annual peak flood data to determine the flood recurrence interval. Only the past 50 years of record (1961 to 2014) were used, because much of the land within the watershed has been altered for agricultural purposes within the last 50 years.

Table 3 provides Roseau River at Ross design flows, associated stage, and corresponding water surface elevation at the gage.

Table 3. Recurrence Intervals at Ross, MN

Recurrence Interval (years)	Peak Flow @ Ross, MN (cfs)	River Stage @ Ross, MN (feet)	River Water Surface Elevation NAVD88 (feet)
500	10,535	18.9	1038.9
100	8,078	18.5	1038.5
50	7,022	18.3	1038.3
25	5,965	18.0	1038.0
10	4,564	17.2	1037.2
5	3,490	16.1	1036.1
2.5	2,373	14.3	1034.3
2	1,990	13.1	1033.1
1	300	5.0	1025.0

Note that the USGS 100-year flow Ross using the period from 1919 to 2005 was 7,170 cfs https://pubs.usgs.gov/sir/2009/5250/pdf/sir2009-5250.pdf.

Table 4 provides the Roseau River at Ross flow, stage, elevation, and recurrence interval based on the USGS Ross gage data and rating curve (USGS Gage # 05107500).

Table 4. Flow, Stage, Elevation, and Recurrence Intervals

Flow (cfs)	Stage (feet)	Elevation (NAVD 1988)	Recurrence Interval Based on 1961 to 2014	Percent Exceeded since 1961 (%)	Number of Times the Annual Peak Flow Exceeded This Value since 1961
100	3.0	1023.0		100%	52
200	3.9	1023.9		100%	52
300	6.0	1026.0	1-year	98%	51
400	6.5	1026.5		96%	51
500	7.6	1027.6		96%	50
600	7.8	1027.8		94%	50
700	8.0	1028.0		94%	49
800	8.1	1028.1		90%	47
900	8.8	1028.8		85%	44
1000	9.2	1029.2		83%	43
1062	9.4	1029.4	1.25-year	83%	43
1100	9.5	1029.5		83%	43

Flow (cfs)	Stage (feet)	Elevation (NAVD 1988)	Recurrence Interval Based on 1961 to 2014	Percent Exceeded since 1961 (%)	Number of Times the Annual Peak Flow Exceeded This Value since 1961
1200	10.1	1030.1		81%	42
1300	10.7	1030.7		71%	37
1400	10.8	1030.8		67%	36
1500	11.3	1031.3		65%	35
1600	11.7	1031.7		60%	31
1659	11.8	1031.8	1.667-year	59%	29
1700	11.9	1031.9		58%	29
1800	13.0	1033.0		56%	28
1900	13.1	1033.1		50%	25
1990	13.1	1033.1	2-year	48%	24
2000	13.2	1033.2		48%	24
2100	13.6	1033.6		46%	23
2200	14.2	1034.2		44%	22
2300	14.3	1034.3		44%	22
2373	14.3	1034.3	2.5-year	42%	21
2400	14.4	1034.4		42%	21
2500	14.6	1034.6		38%	20
2600	14.8	1034.8		35%	18
2700	14.9	1034.9		33%	17
2800	15.0	1035.0		27%	16
2900	15.1	1035.1		27%	14
3000	15.6	1035.6		27%	14
3100	15.7	1035.7		27%	14
3200	15.8	1035.8		27%	14
3300	15.9	1035.9		23%	13

Flow (cfs)	Stage (feet)	Elevation (NAVD 1988)	Recurrence Interval Based on 1961 to 2014	Percent Exceeded since 1961 (%)	Number of Times the Annual Peak Flow Exceeded This Value since 1961
3400	16.0	1036.0		19%	11
3490	16.1	1036.1	5-year	13%	9
3500	16.2	1036.2		13%	9
3600	16.4	1036.4		13%	7
3700	16.5	1036.5		13%	7
3800	16.6	1036.6		12%	6
3900	16.7	1036.7		12%	6
4000	16.8	1036.8		12%	6
4100	16.9	1036.9		12%	6
4200	17.0	1037.0		12%	6
4300	17.1	1037.1		10%	6
4400	17.1	1037.1		10%	5
4500	17.2	1037.2		8%	4
4564	17.2	1037.2	10-year	6%	4
4600	17.4	1037.4		6%	3
4700	17.4	1037.4		2%	1
4800	17.4	1037.4		2%	1
4900	17.5	1037.5		2%	1
5000	17.5	1037.5		2%	1
5965	18.0	1038.0	25-year	2%	1
7022	18.3	1038.3	50-year	2%	1
8078	18.5	1038.5	100-year	2%	1
10535	18.9	1038.9	500-year	0%	0

6.3 Hydrologic Modeling

The Expanded Distributed Detention Strategy Study (DDS) HEC-HMS model created for the Roseau River Watershed District (District Model) was used as the base condition for the (HDR

Engineering, 2013) hydrologic model. The base condition HEC-HMS model was then updated with Atlas 14 precipitation values and the updated HEC-HMS hydrographs provided inflows for the unsteady HEC-RAS simulation. Figure 2 shows the inflow locations.

6.3.1 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 the storage coefficient, divided by the sum of the time of concentration and storage coefficient, is reasonably consistent over a region. A USACE study of various gages in the Red River Basin was used to estimate watershed ratios of R/(R+Tc) (U.S. Army Corps of Engineers - St. Paul District, 1990).

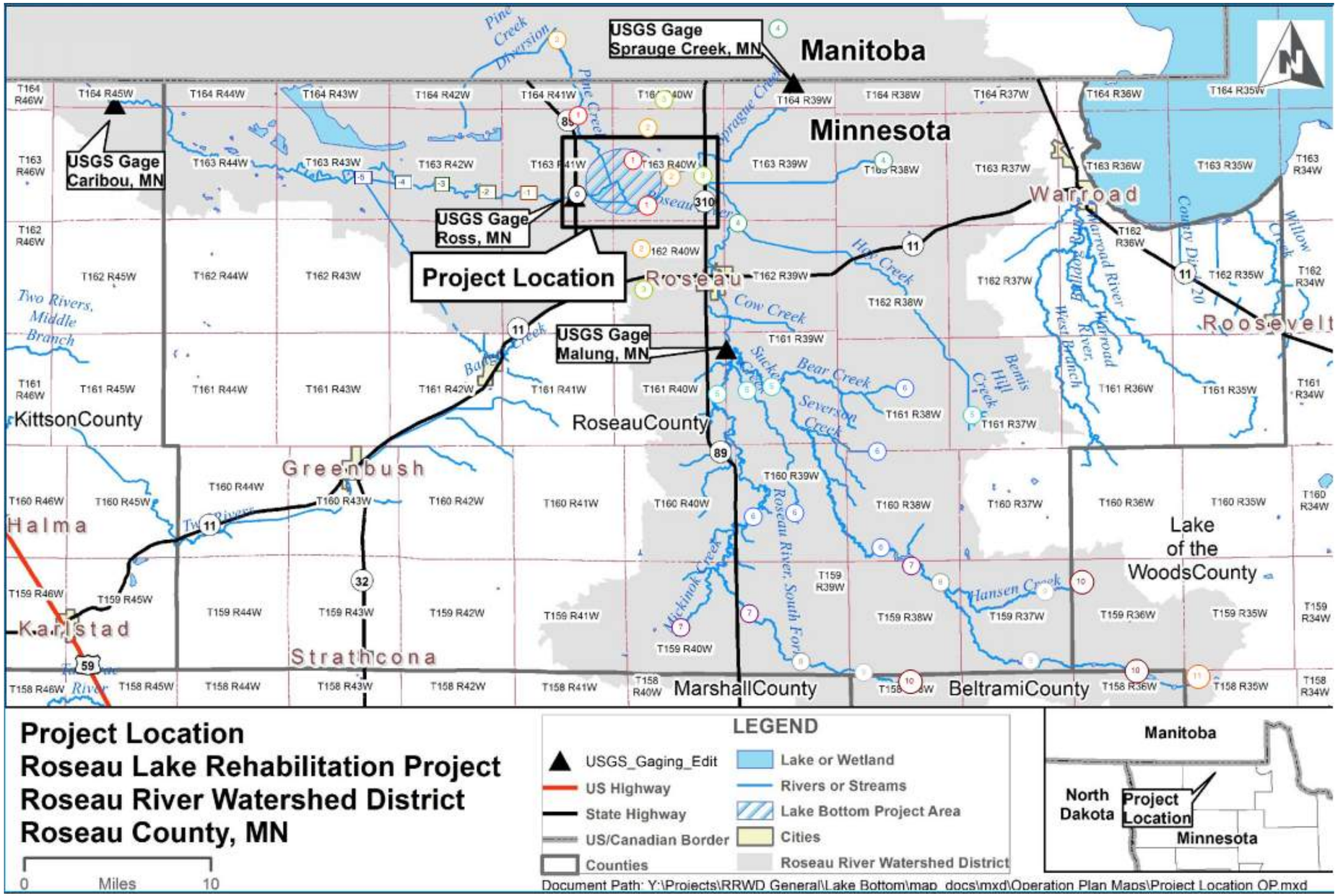
6.3.2 Design Rainfall Distribution

Per NOAA Atlas 14, the SCS Type II rainfall distribution is no longer the recommended rainfall distribution. The NRCS recommends a MSE-3 Type Curve for the state of Minnesota. A 10-day hyetograph is not provided for the MSE-3 method, so the 96-hour hyetograph was scaled to obtain the 10-day hyetograph.

6.3.3 Time of Concentration

The time of concentration 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 from a MnDNR GIS program using land slope, land use, and degree of channelization with the results compared to several historic storm events. The time of concentration varies across the subbasins from 6 to 70 hours with a median subbasin time of concentration of 20 hours. It takes approximately 11 days for bankfull flows to travel from the farthest reaches of the watershed to the Ross gage. The 24-hour events are not the critical duration flows, but are expected to represent a summer rainfall type event. See Figure 4 for travel time in days upstream and downstream from Ross gage for a bankfull flow event.

Figure 4. Roseau River Bankfull Travel Time



6.3.4 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. Ten-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 Curve Number method used the twenty-four hour duration storm events to represent typical summer storms. The USACE HEC-HMS model uses curve numbers ranging from 64 to 84 for 24-hour events, and the median curve number across all subbasins is 75. Factors affecting curve number values include hydrologic soil group, hydrologic condition and antecedent moisture condition, land cover, and cropping practice (Gupta, 2008).

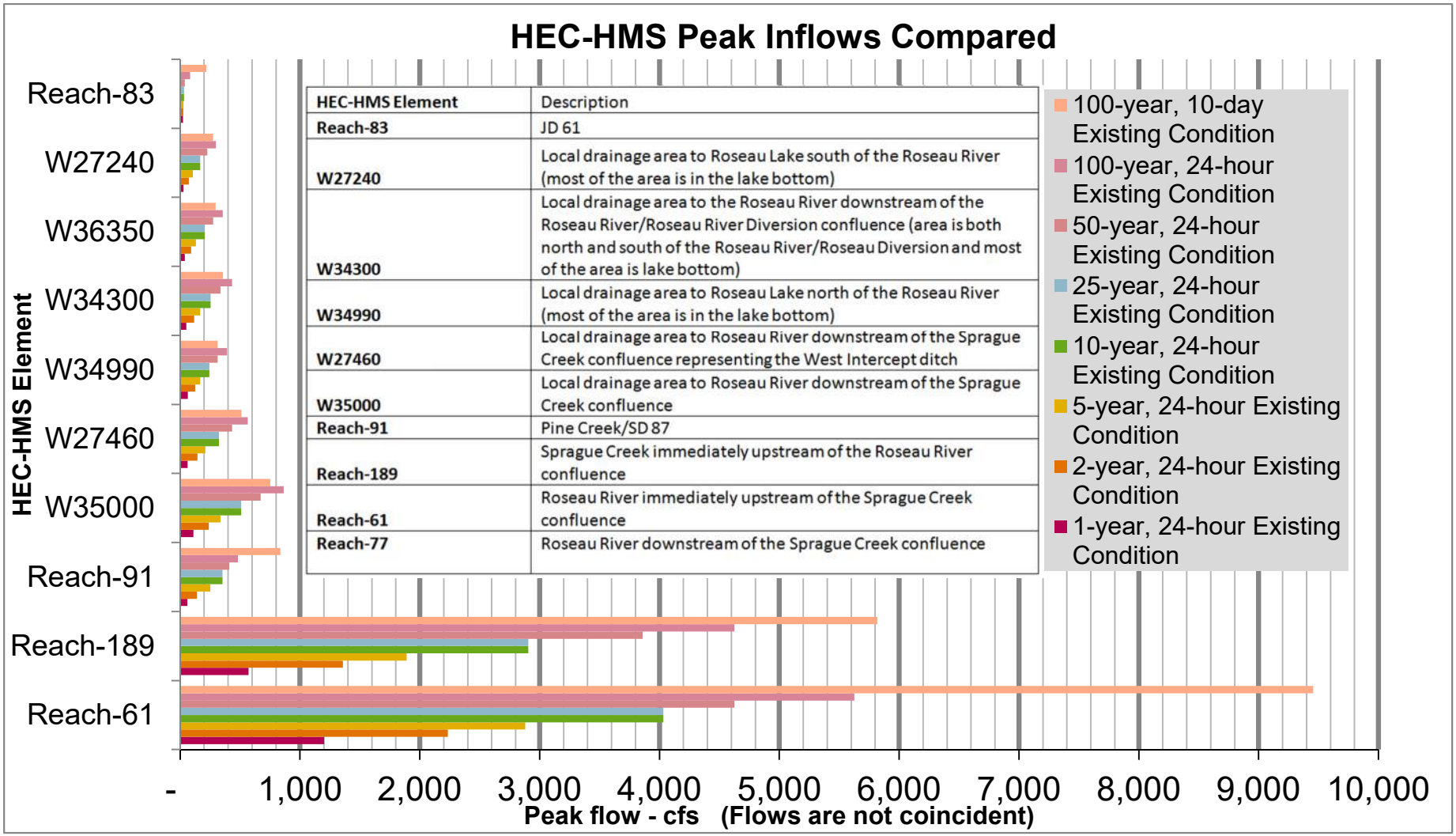
6.3.5 Peak Inflows

The HEC-HMS model existing peak flows and total flow volumes for the upstream subbasins are summarized in Table 5. Figure 5 provides the subbasin peak flows for the 1-year through 100-year 24-hour events and the 100-year 10-day event and shows the majority of flow comes from the Roseau River and Sprague Creek. Pine Creek, JD 61, and local surface runoff contribute smaller amounts. The 10-day events correspond with the Ross gage recurrence intervals better than the 24-hour events. The 24-hour events have a much smaller duration and the peak is lower than the Ross gage recurrence interval. The 24-hour events are intended to simulate summer rainfall events, with the 2002 event being an outlier.

Table 5. Modeled Existing Peak Inflows and Total Volumes

Event		Roseau River Upstream of Confluence with Sprague Creek (Reach-61)	Sprague Creek Upstream of Confluence with Roseau River (Reach-189)	Pine Creek at Confluence with Roseau River (Reach-91)	JD 61 LAT 7 Confluence with Roseau River (Reach-83)	Local Drainage Downstream of Sprague Creek (W35000)	West Intercept at Confluence with Roseau River (W27460)
100-Yr 10-Day	Peak Flow (cfs)	9,456	5,819	837	218	751	511
	Total Volume (ac-ft)	198,262	101,701	22,407	5,898	5,602	4,030
100-Yr 24-Hr	Peak Flow (cfs)	5,626	4,626	481	83	863	564
	Total Volume (ac-ft)	111,589	60,956	14,467	3,164	3,183	2,227
10-Yr 10-Day	Peak Flow (cfs)	4,650	2,504	412	400	377	248
	Total Volume (ac-ft)	100,948	54,357	13,599	5,739	2,890	2,023
10-Yr 24-Hr	Peak Flow (cfs)	2,879	1,890	252	28	337	209
	Total Volume (ac-ft)	44,494	24,021	7,948	1,119	1,255	831
5-Yr 10-Day	Peak Flow (cfs)	4,043	2,177	366	454	297	192
	Total Volume (ac-ft)	80,571	43,385	11,715	5,443	2,312	1,599
5-Yr 24-Hr	Peak Flow (cfs)	2,223	1,358	140	26	240	144
	Total Volume (acre-feet)	31,884	17,260	6,610	762	896	577
2-Yr 10-Day	Peak Flow (cfs)	3,173	1,709	282	31	121	137
	Total Volume (ac-ft)	59,639	32,113	9,660	1,608	2,294	1,174
2-Yr 24-Hr	Peak Flow (cfs)	1,542	803	68	24	151	87
	Total Volume (ac-ft)	20,334	11,045	5,362	451	568	351

Figure 5. Existing Condition Flow Contribution



7 Alternatives

HDR analyzed several project concepts and variables with each having varied levels of flood reduction and wildlife benefits. Table 6 lists and describes the evaluated alternatives. Figure 6 shows the embankment alignments.

Table 6. Description of Evaluated Alternatives

Alternative	Description
Existing Conditions	No constructed embankments.
1	Only Northwest and North River embankments in place.
2a	No Island Embankment or South River Cell Embankment, all other embankments in place.
2a'	No Island Embankment or South River Cell Embankment, all other embankments in place. South Embankment does not cross West Intercept.
2a-1	No Island Embankment or South River Cell Embankment, all other embankments in place. River restriction placed downstream of Roseau Lake and upstream of Ross.
2c	No South River Cell Embankment, all other embankments in place.
2d	No Island Embankment, all other embankments in place.
2e	All embankments in place.

Below is a general description of the variables adjusted as part of the embankment alternatives.

- Embankments
  - Embankments were configured to store floodwater and more efficiently manage available storage.
- Exterior Drainage Ditches
  - Small exterior ditch along the Northwest Embankment to convey surface flow allowing Pine Creek and flow from the north to enter the main pool.
  - Large exterior ditch along the Northwest Embankment to route Pine Creek and flow from the north around the main pool except for NRE purposes.
  - Small exterior ditch along the South Embankment to convey surface flow.
  - Large exterior ditch along the South Embankment to convey the West Intercept Ditch flow downstream of the project area.
- Embankment heights from elevations of 1030 to 1050 feet with the majority of model runs having embankment heights with an elevation of 1036 feet.
- Main pool inlet weir
  - Location of weir at downstream end of project, middle of project, and upstream end of project was reviewed.
  - Weir lengths of 500 to 2000 feet were analyzed.
  - Crest elevations were adjusted from 1032 to 1036 feet.
- Gated inlet/outlet structure operation

- Always open
- Always closed
- Open at the rising limb of the hydrograph, then closed when Roseau River water levels reach the weir crest elevation, and remain closed until Roseau drops below 1400 cfs at which point the gate is opened until the desired wildlife enhancement stage is reached
- Closed at the rising limb of the hydrograph and remain closed until Roseau drops below 1400 cfs at which point the gate is opened until the desired wildlife enhancement stage is reached

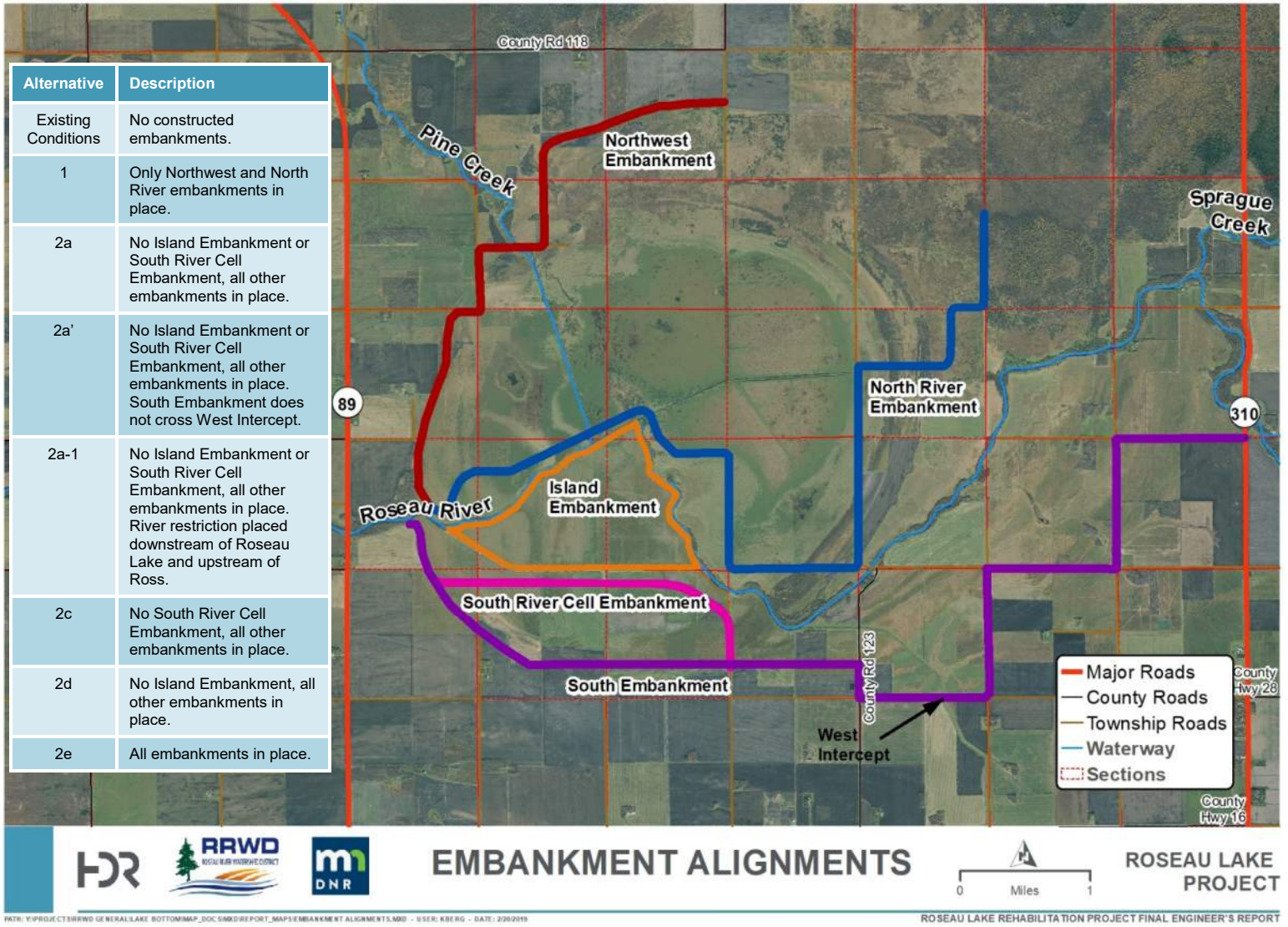
8 Hydraulic Analysis

8.1 Existing Condition Hydraulics

Figure 7 shows a general schematic of the layout and the storage area locations. An unsteady HEC-RAS model with multiple inflow locations was created to simulate the hydraulics through the project reach from the Sprague Creek/Roseau River confluence through the Ross gage at Highway 89 with the following information:

- Flows from HEC-HMS model of Roseau River with inflow locations identified on Figure 3.
- Downstream boundary condition is from the USGS Roseau River gage at Ross 2015 rating curve obtained from the USGS website. The rating curve is stage verses flow information with the stage correlated to the NAVD88 datum and entered into the model. https://waterdata.usgs.gov/nwisweb/get_ratings?file_type=exsa&site_no=05107500
- Roughness Coefficients were obtained from the FEMA flood insurance study and regulatory model, which had values of 0.035 to 0.13 for the channel and 0.035 to 0.13 for the overbank. The coefficient limits were adjusted based on field observations and aerial imagery.
- Channel, low overbank, and lakebed geometry were obtained from the HDR field survey conducted the fall of 2015.
- Overbank geometry from Red River Lidar Topography, July 2010.
- Lateral weirs were placed along the Roseau River and cutoff channel banks, which are generally higher than the adjacent lake basin. A lateral weir was also placed at the divide between the South Cell and the SE Spillover storage areas.
- Storage areas were created for the main pool which is to the north of the Roseau River, the South Cell which is south of the Roseau and west of County Road 123, the SE Spillover area which is south of the Roseau and east of County Road 123, and the Island Area which is south of the Roseau River and north of the cutoff channel.

Figure 6. Embankment Alignments



Alternative	Description
Existing Conditions	No constructed embankments.
1	Only Northwest and North River embankments in place.
2a	No Island Embankment or South River Cell Embankment, all other embankments in place.
2a'	No Island Embankment or South River Cell Embankment, all other embankments in place. South Embankment does not cross West Intercept.
2a-1	No Island Embankment or South River Cell Embankment, all other embankments in place. River restriction placed downstream of Roseau Lake and upstream of Ross.
2c	No South River Cell Embankment, all other embankments in place.
2d	No Island Embankment, all other embankments in place.
2e	All embankments in place.

Figure 7. Existing Conditions HEC-RAS Schematic and Storage Area Locations

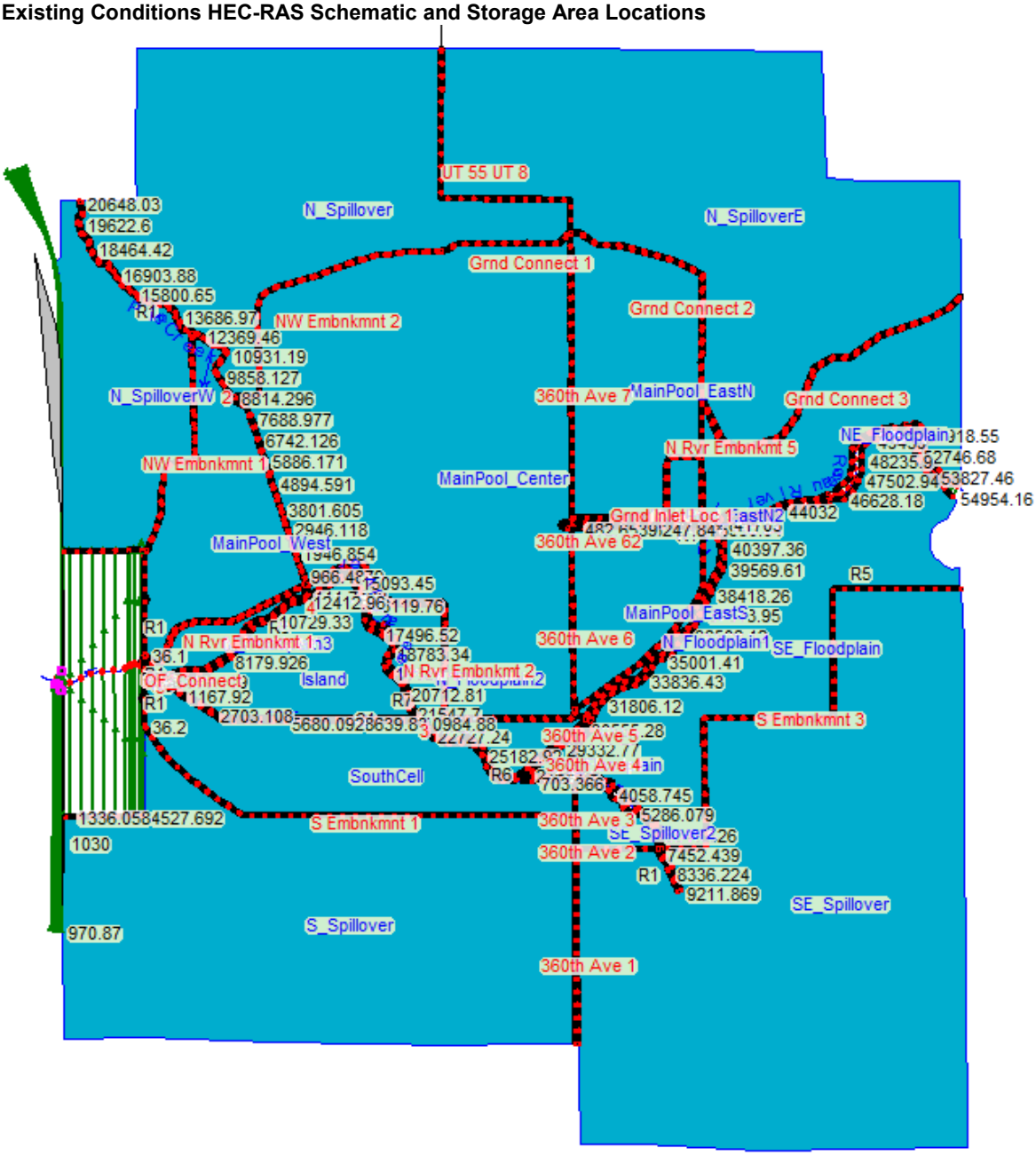


Table 7 provides a summary of the peak flow and associated peak water surface elevations for the Roseau River at Ross, MN as determined using HEC-RAS.

Table 7. Modeled Existing Conditions Peak Flow and Water Surface Elevations at Ross Gage

Event	Peak Flow Rate (cfs)	Peak Water Surface Elevation (feet)
100-year gage	8,078	1038.50
100-Year 10-Day	9,509	1038.75
100-Year 24-Hour	4,599	1037.36
10-year gage	4,564	1037.20
10-Year 10 Day	3,816	1036.74
10-Year 24-Hour	2,163	1033.70
5-year gage	3,490	1036.10
5-Year 10 Day	3,077	1035.84
5-Year 24-Hour	1,718	1032.36
2-year gage	1,990	1033.10
2-Year 10 Day	2,474	1034.56
2-Year 24-Hour	1,204	1030.60
2017 Event	2,205	1033.82

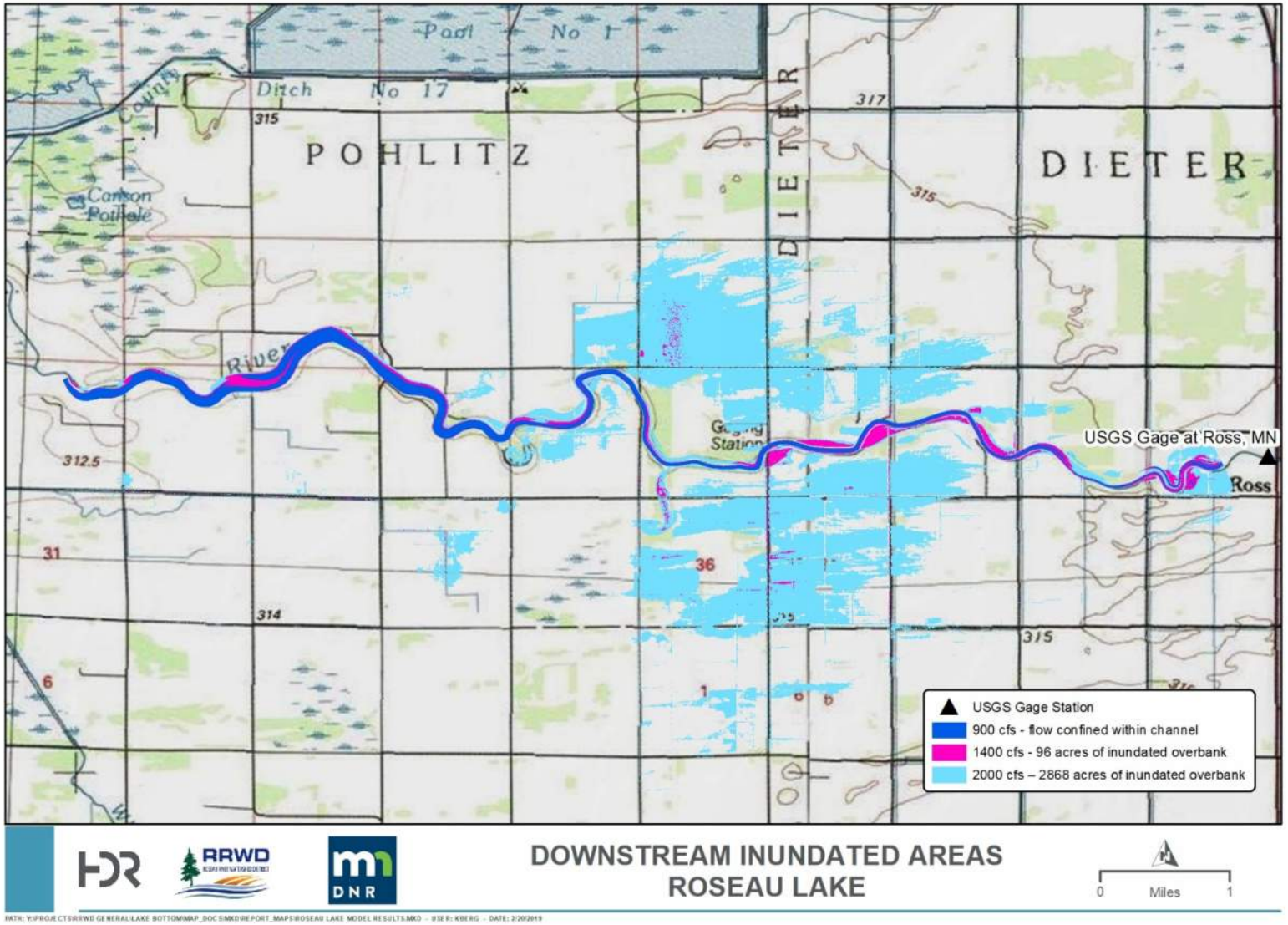
8.1.1 Downstream Model

A separate steady-state HEC-RAS model was created for the area downstream of the project from the Highway 89 to County Road 119 (Ross gage to the Big Swamp) to determine overbank inundation areas for a range of flows. The model was created using Red River Valley Lidar information to define the overbank area and six surveyed channel cross sections collected by HDR in September 2017 to define the channel. The “n” values matched the FEMA floodplain model and the downstream boundary condition is a normal depth analysis using the channel slope. Table 8 is a summary of flow verses overbank inundation and Figure 8 shows the inundation areas for 900 cfs, 1400 cfs, and 2000 cfs. The drainage of many thousands of additional acres adjacent to the Roseau River are affected by the backwater from the Roseau River.

Table 8. Downstream Overbank Inundation Area

Flow Rate (cfs)	Overbank Inundation Area (acres)
500	0
600	0
700	0
800	0
900	1
1,000	5
1,100	16
1,200	36
1,300	60
1,400	96
1,500	223
1,600	435
1,700	1,000
1,800	1,504
1,900	2,158
2,000	2,868
2,100	3,697
2,200	4,511
2,300	5,302
2,400	6,081
2,500	6,668

Figure 8 - Downstream Inundated Areas



8.2 Embankment Alternatives

Hydraulic analyses were completed on all the alternatives listed in Table 6. The embankment alternatives do not create additional flood storage, but are intended to more efficiently manage existing storage during a flood event. The embankments manage the lake basin water levels by funneling low flows downstream of Highway 89 during the rising limb of the hydrograph, providing storage during the hydrograph peak, and reducing flood damages downstream. The embankment alternatives consist of the following main features:

- Embankments
    - Northwest Embankment
    - North River Embankment
    - South Embankment
    - Island Embankment
    - South River Cell Embankment
- Storage Volume
- Weirs
- Inlet Channel and Gated Inlet/Outlet Structure
- Cutoff Channel Weir
- Exterior Gated Structures
- Exterior Drainage Ditches
- Drainage Culverts
- Outlet Structure
- Roadways, Field Entrances, and Embankment Access

Alternatives 1, 2a, and 2a' were selected for more detailed analysis (Figure 9 through Figure 11). Concurrence Point documents 1 through 3 are included in Appendix A of this report and provides the reasoning for the selection of Alternatives 1, 2a, and 2a'. Table 9 provides details of the alternative features for these alternatives.

Table 9. Alternative Details

Alternative	1	2a	2a'
Embankments	Only Northwest and North River embankments in place.	No Island Embankment or South River Cell Embankment, all other embankments in place.	No Island Embankment or South River Cell Embankment, all other embankments in place. South Embankment does not cross West Intercept.
Storage Volume	21,090 ac-ft (Main Pool)		
Main Pool Weir Elevation	1034 feet		
Inlet Channel and Gated Inlet Structure	Inlet channel: 100 foot bottom width with 5:1 (H:V) side slopes. Gated structure: eight 8'(H)x6'(V) box culverts passing under CR 123 with a sluice gate on each culvert.		
Cutoff Channel Structure	A structure, such as a boulder weir, box culvert, or low water crossing, will direct low flows into the historic natural channel to restore fish habitat.		
Outlet Structure	Gated Low Flow Outlet at project mid-point		
Exterior Gated Structures	Located along the embankments at the Pine Creek and JD 61 Lateral 7 crossings.	Located along the embankments at the Pine Creek, JD 61 Lateral 7, and West Intercept Ditch crossing. One additional structure located approximately 1 mile north of West Intercept structure on the South Embankment.	Located along the embankments at the Pine Creek and JD 61 Lateral 7 crossings.
Exterior Drainage Ditches	7 to 12 feet deep. Pine Creek and West Intercept Ditch are routed around the project during high flows. 30 foot bottom width with 4:1 (H:V) side slopes.	7 to 12 feet deep. Pine Creek and West Intercept Ditch are routed around the project during high flows. 30 foot bottom width with 4:1 (H:V) side slopes.	Exterior drainage along the Northwest embankment, 7 to 12 feet deep. 30 foot bottom width with 4:1 (H:V) side slopes. Pine Creek is routed around the project during high flows. Exterior Drainage along the South Embankment, 3 feet deep. Only used to convey local surface drainage. 13 foot bottom width with 4:1 (H:V) side slopes.
Drainage Culverts	To maintain existing drainage patterns. See Figure 9 through 11 for locations.		
Roadways, Field Entrances, and Embankment Access	Affected roadways will be rebuilt and raised to elevation 1036 feet. Vehicle access to the perimeter outlet structures is incorporated into design.		

Figure 9. Alternative 1

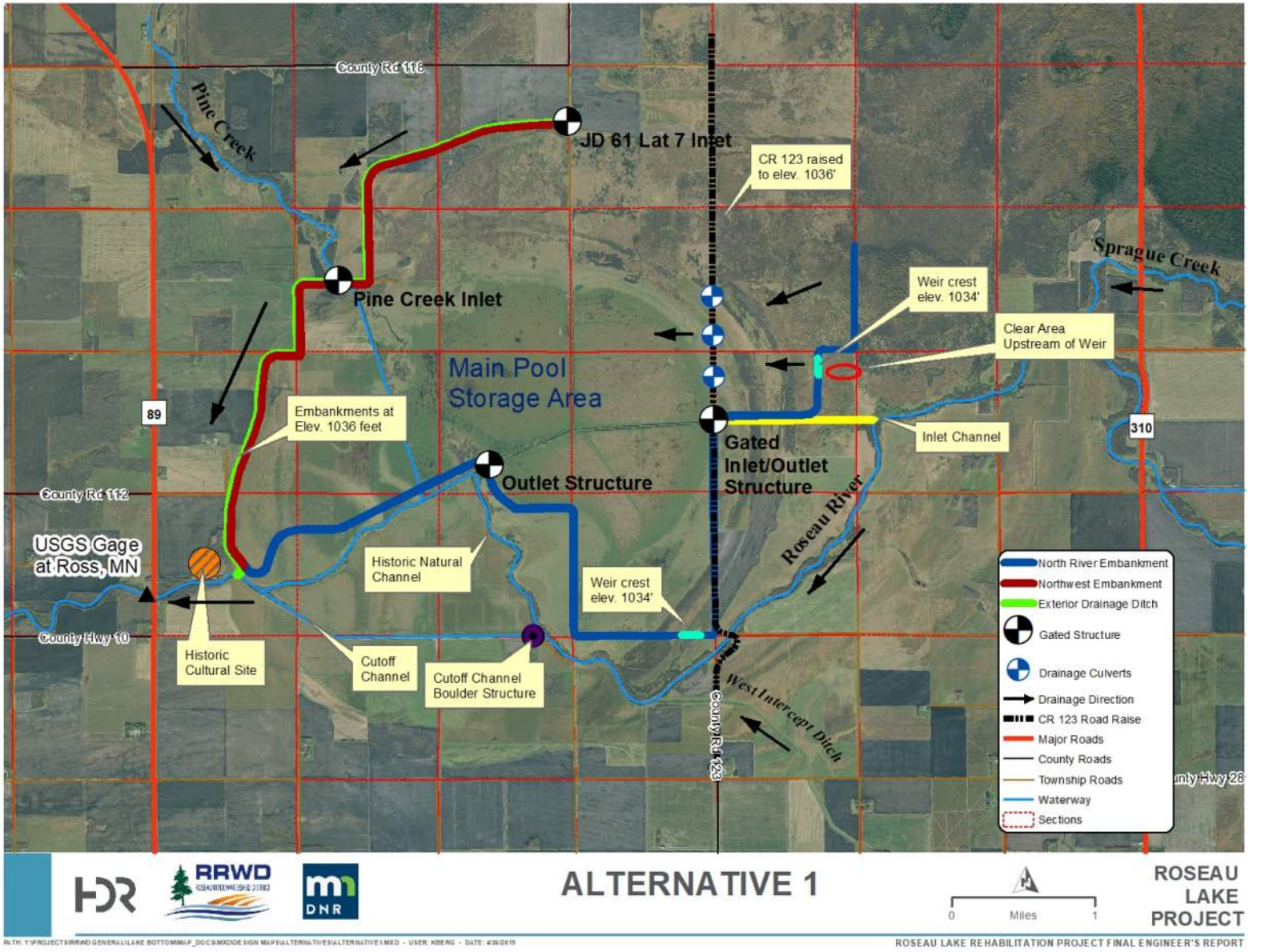


Figure 10. Alternative 2A

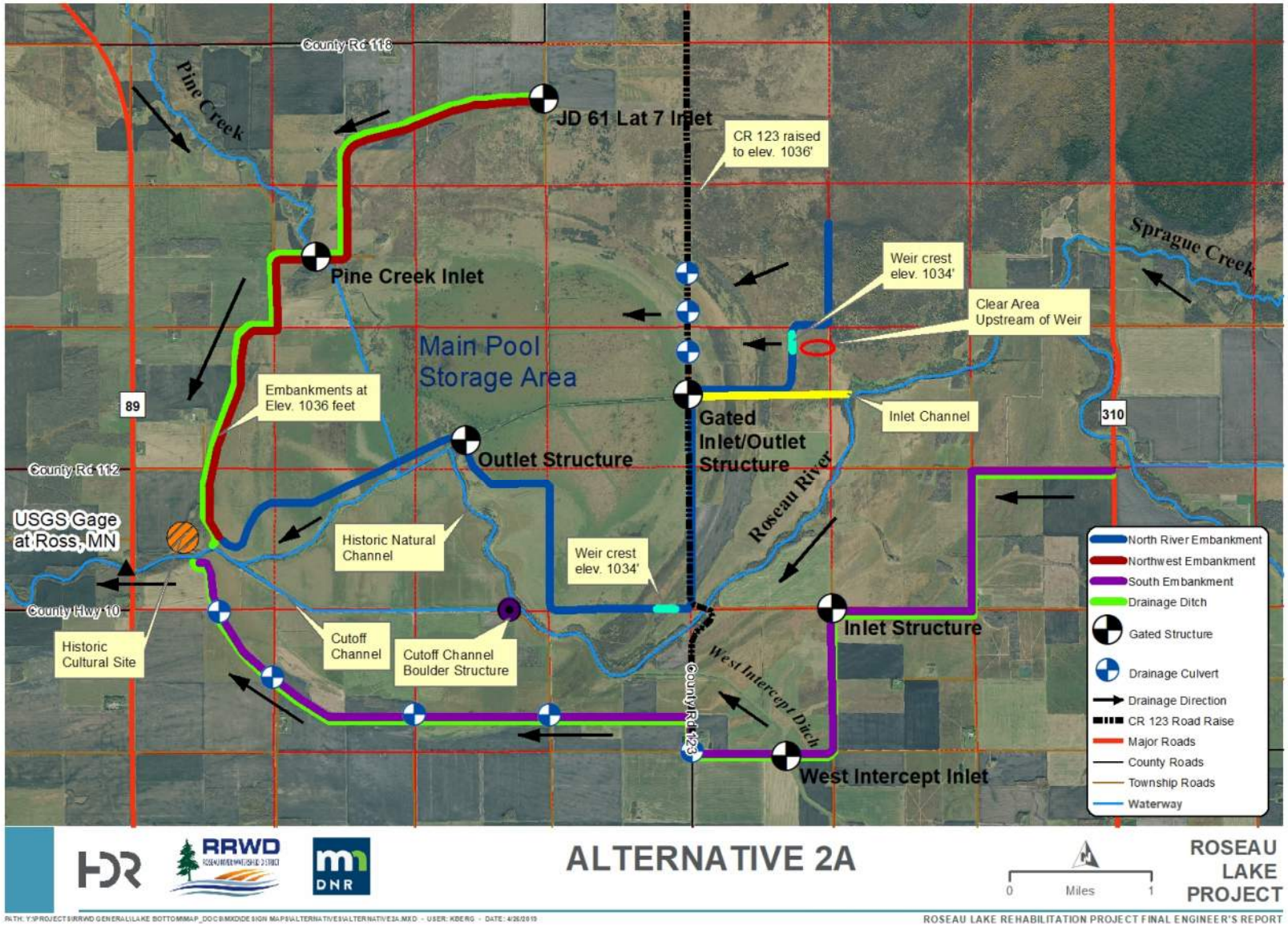
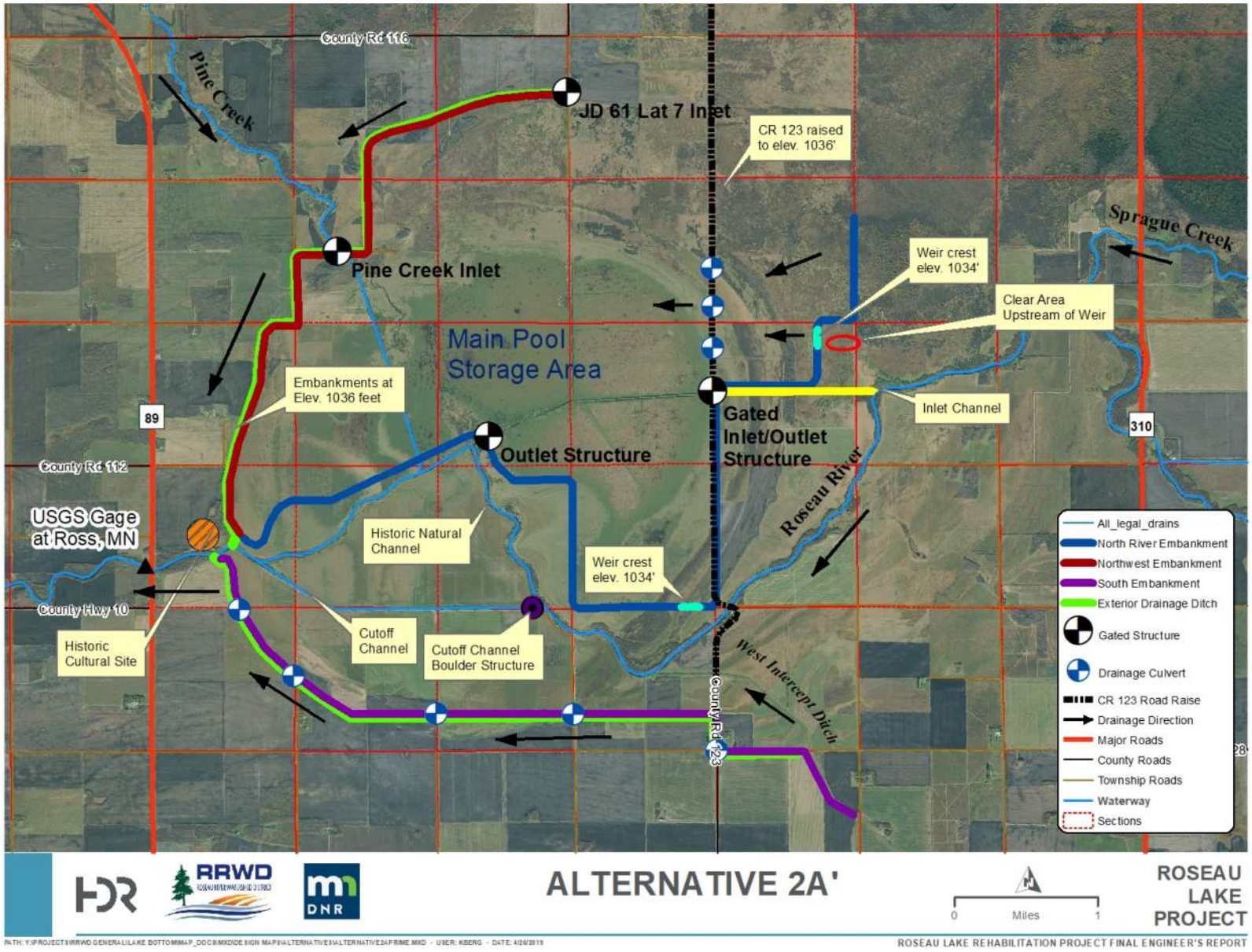


Figure 11. Alternative 2A'



8.2.1 Embankments

The embankments are offset from the channel banks to prevent rotational failure/sloughing with the following factors influence the embankment alignment:

- Topography
- Property Lines
- Public or Private Land Ownership
- Land Use
- Wetlands
- Cultural Resources

Figure 12 depicts the typical embankment cross sections. Figure 13 shows the location of the various cross sections. Factors influencing the embankment cross section design include the presence of exterior drainage, depth of exterior drainage ditch, presence of long-term retention of water, and depth of water. There are approximately 13.1, 22.4, and 16.4 miles of embankment for Alternatives 1, 2a, and 2a' respectively. Figure 14 shows the embankment height based on ground surface elevation and an embankment elevation of 1036 feet for Alternative 2a.

The embankments will be overtopped during the 5-yr flood event. Turf reinforcement on the embankments will help to minimize erosion during overtopping.

Figure 12. Typical Embankment Cross Sections

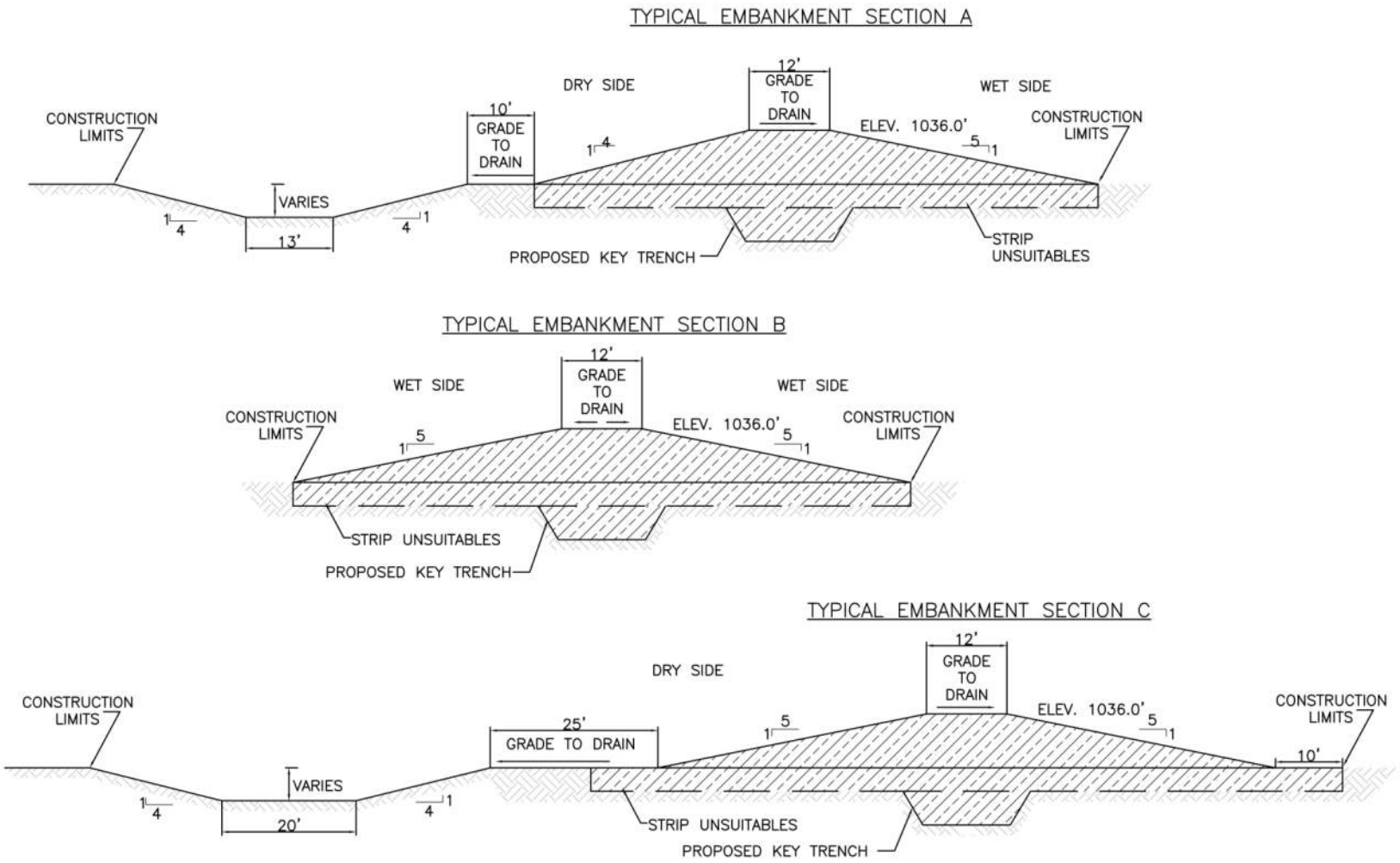


Figure 13. Typical Embankments Identified

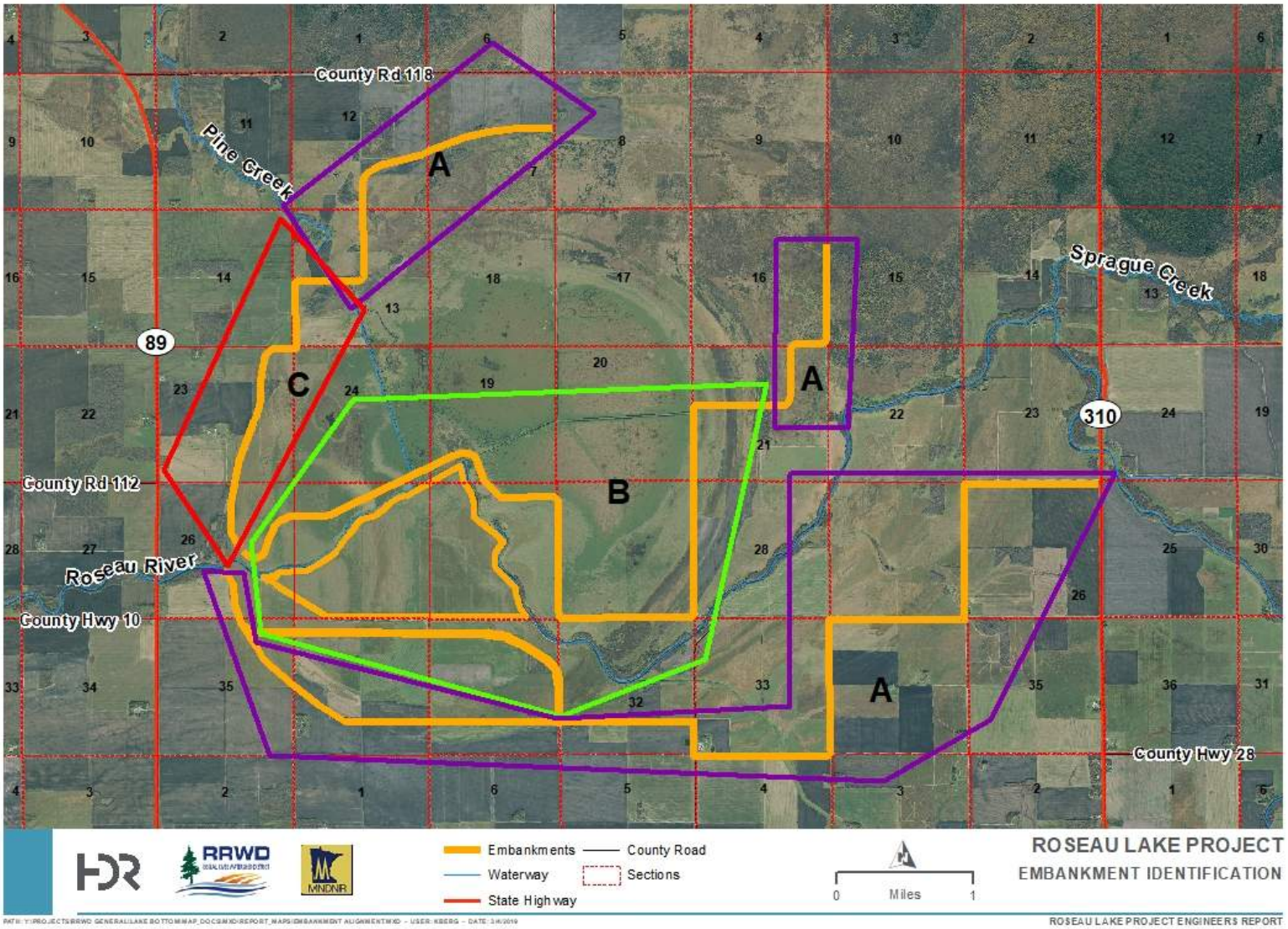
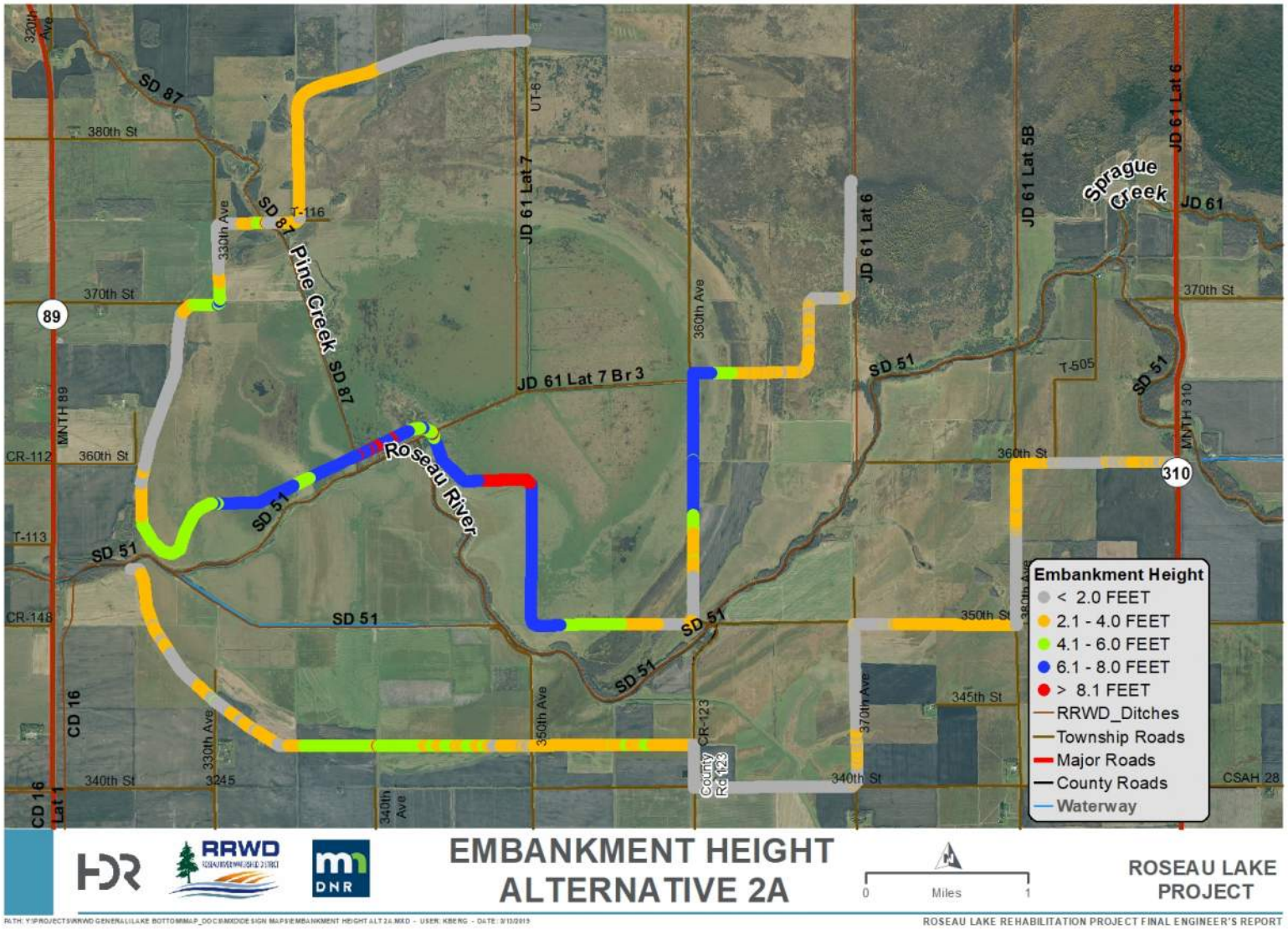


Figure 14. Typical Embankments Identified



8.2.2 Storage Volumes

The individual features collectively result in a project that stores floodwater with both ungated and gated storage. Ungated storage refers to the volume of water retained within the embankments above the weir crest elevation. Gated storage refers to the volume of water released through the gated structures below the weir crest elevation.

The weirs that allow flow into the main pool have an elevation of 1,034 feet with an embankment elevation of 1,036 feet. Therefore, the storage volume within the embankments below 1,034 is gated storage and the storage volume between 1,034 and 1,036 feet is ungated storage. The project provides 21,090 acre-feet of gated storage below the weir crest elevation of 1034 for Alternatives 1, 2a, and 2a'.

Roseau Lake floods under existing conditions so when the main pool is above the weir crest elevation there is no change between existing and proposed conditions and no new storage created by the project. Table 10 summarizes the cumulative storage within the embankment footprint. Above a weir crest elevation of 1034 feet the project does not create new storage or change the timing of when the area floods so the 12,764 acre-feet of ungated storage between 1034 feet and 1036 feet elevation has no impact on downstream FDR. The South Cell and Island storage areas also flood under existing conditions and had weirs to allow flow into the storage areas. This resulted in no new flood storage for these areas, which is why the South Cell and Island storage areas are not included in Alternatives 1, 2a, and 2a'.

Table 10. Elevation Storage Values within Embankment Footprint

Elevation (Feet)	Main Pool (Acre-Feet)
1022	1
1026	89
1027	118
1028	1,655
1029	3,192
1030	5,650
1031	10,020
1032	13,700
1033	17,618
1034	21, 090
1035	27,500
1036	33,854

8.2.3 Weirs

Weirs are locations along the embankments that are two feet lower than the embankment that provide a defined and stabilized location for flow into and out of the main pool. The weir into the main pool (located along the North River Embankment, east of CR 123) allows the main pool to fill in a controlled manner with a minimal differential between the river and main pool water levels. The second weir (located along the North River Embankment, west of CR 123) functions as a backup weir in the case the culverts under CR 123 get plugged. The weir sizing considerations are as follows:

- Rate of flood hydrograph rise from elevation 1034 (the weir crest elevation) to 1036 feet (embankment crest elevation)
- Location
- Efficiency of the area upstream of the weir to convey flow to the weir
- Backwater of the weir
- Embankment overtopping elevation

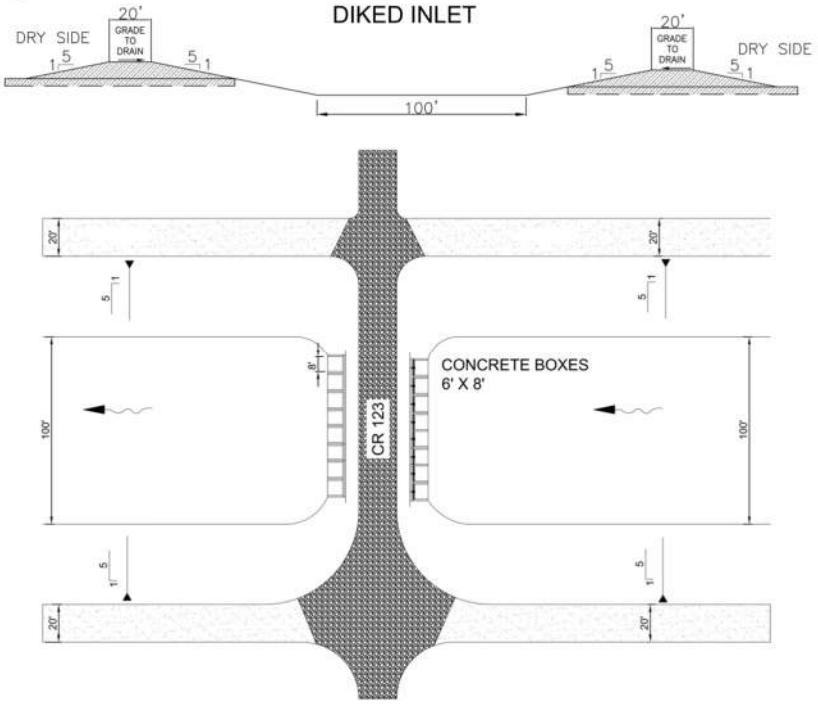
8.2.4 Inlet/Outlet Channel and Gated Structure

The principal low flow inlet/outlet for the project is a channel that connects the Roseau River to the main pool storage area and allows water to enter and exit Roseau Lake in a controlled manner through a channel and series of gated box culverts under County Road 123 (CR 123).

The proposed channel bottom width is 100 feet with 5:1 (H:V) side slopes and an invert elevation of 1026.0'. The gated structure consists of eight 8'(H)x6'(V) box culverts passing under CR 123 with a sluice gate on each culvert which are accessed from CR 123. Figure 15 represents conceptual designs for both the inlet channel and 8'x6' RCBs through CR 123.

The sluice gates on the eight 8'x6' concrete box culverts will be accessed by CR 123 and will be operated for downstream FDR and NRE purposes.

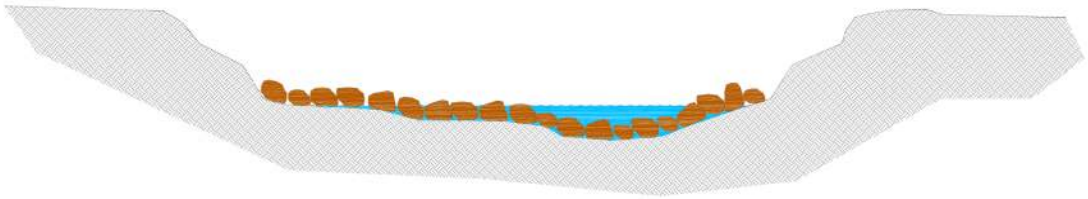
Figure 15. Inlet/Outlet Channel and Gated Structure



8.2.5 Cutoff Channel Structure

Currently the majority of low flow travels down the cutoff channel. A proposed structure will direct low flows down the historic natural channel on the north side of the island to enhance fish habitat. This structure may consist of a boulder weir, concrete box culvert low flow crossing, or other means of directing flow down the historic natural channel. One possibility would be to place a 4-foot thick layer of large riprap in the channel creating a boulder structure that would direct all flow below 200 cfs down the historic natural channel. Flow above 200 cfs would split between the two channels. As water levels increase more flow goes down the cutoff channel until the flood flows go out of bank, the entire area is inundated, and split flow is no longer applicable. Figure 16 is a cross section of the cutoff channel boulder structure, which is one potential cutoff channel structure option.

Figure 16. Cutoff Channel Boulder Structure



8.2.6 Gated Structures

Alternatives 1 and 2a' have exterior drainage gated structures located along the embankments at the Pine Creek and JD 61 Lateral 7 crossings. Alternative 2a has two additional crossings, one at the West Intercept Ditch and another located approximately one mile north of the West Intercept Ditch structure (

Figure **10**). These structures provide the ability to divert flows around the project. The Pine Creek and JD 61 Lateral 7 structures also provide the ability to regulate flow into the main pool for NRE operation.

8.2.7 Exterior Drainage Ditches

Ditches along the exterior embankments provide basic drainage, reduce backwater, and provide the ability to route early water from the north and south around the project site. The side slopes of the exterior ditches will be 4:1 (H:V). The size of the ditch depends on the amount of water being routed around the project. See Figure 17 for a plan view of the proposed exterior drainage patterns. When only local surface drainage is conveyed, the ditches are 3 feet deep with a bottom width of 13 ft. For the option where Pine Creek and West Intercept Ditch are routed around the project during high flows the exterior drainage ditches have a 30 foot bottom width and are 7 to 12 feet deep to correspond to a ditch invert 3 feet above the channel inverts:

- Pine Creek invert = elevation 1020.5 plus 3 feet = 1023.5
- West Intercept Ditch invert = elevation 1022.5 plus 3 feet = 1025.5

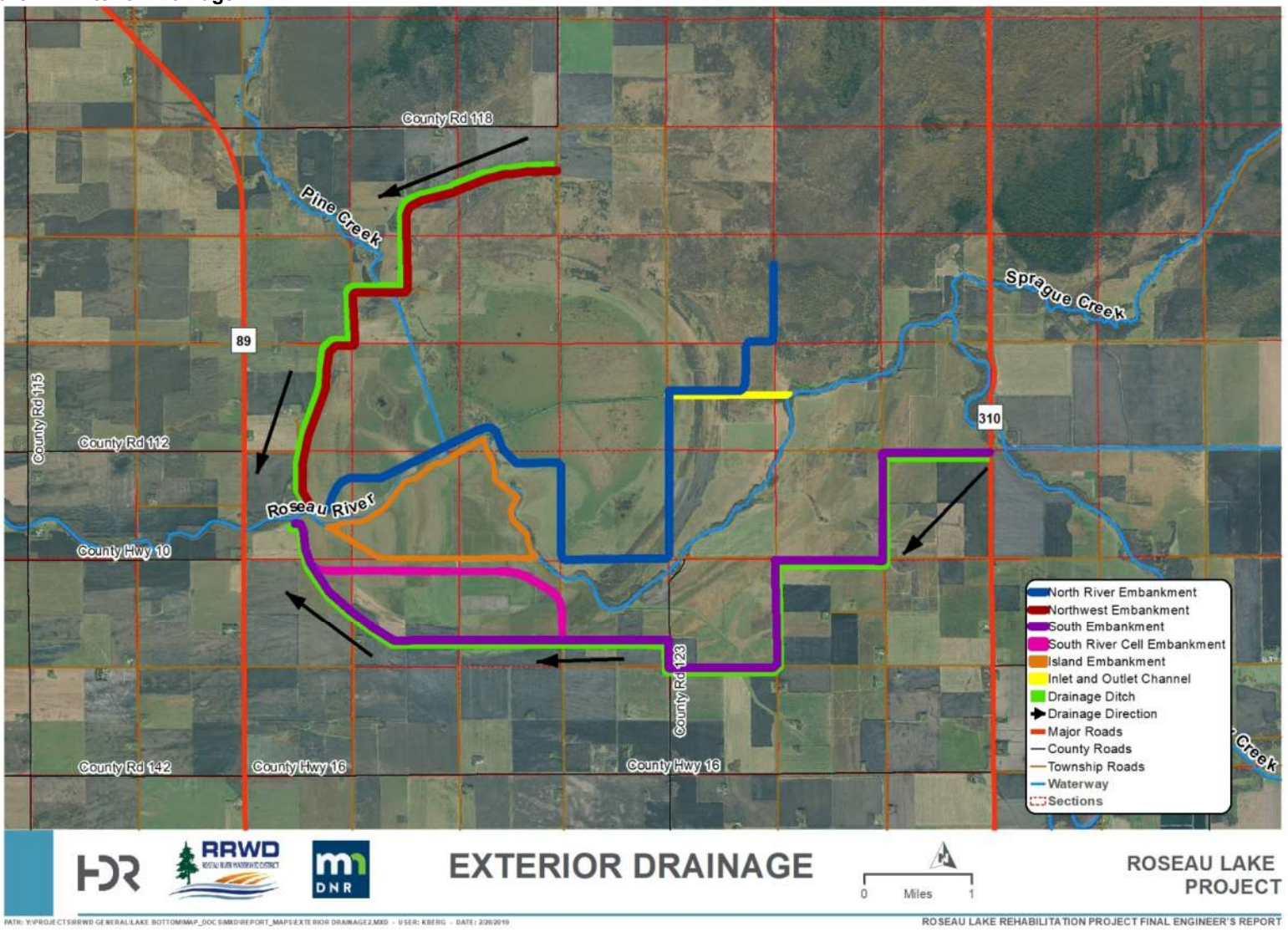
For Alternative 1 and 2a, both the Northwest Embankment and South Embankment ditches will be 7 to 12 feet deep with a 30 foot bottom width and 4:1 (H:V) side slopes.

For Alternative 2a', the Northwest Embankment will be 7 to 12 feet deep with a 30 foot bottom width and 4:1 (H:V) side slopes. The South Embankment ditch will begin at the West Intercept and will be 3 feet deep with a 13 foot bottom width and 4:1 (H:V) side slopes.

8.2.8 Drainage Culverts

Drainage culverts (new or extended) maintain existing drainage patterns. Culverts within the embankment will have flap or screw gates to prevent uncontrolled backwater through the embankment. Figure 9 through Figure 11 show the locations of the drainage culverts for Alternatives 1, 2a, and 2a'.

Figure 17. Exterior Drainage



8.2.9 Outlet Structure

The project will have a secondary outlet structure located where the North River Embankment intersects the existing drainage ditch between the Roseau River and JD61 Lat7 Br3 (see *Outlet Structure* labeled on Figure 9 through Figure 11). The outlet structure consists of one 8'x4' sluice gate and a second bay with stop logs. This outlet structure will be accessed by travelling down the North River Embankment for approximately 2 miles from either Highway 89 or from County Road 123. The embankment is at elevation 1036 and overtops during the 5-year event or by wave action during a 2-year event, and may need to be accessed by boat during a flood emergency.

8.2.10 Roadways, Field Entrances, and Embankment Access

The embankments overtop on a relative frequent basis so placing the main control structures on the periphery of Roseau Lake will allow for more reliable access, while structures placed in the midpoint of the project will be accessed by boat or after flood waters have receded. Access roads to the principal outlet structures and field access point upgrades will allow for maintenance vehicle access around the perimeter of the project.

The roadways affected by the proposed embankment include CR 123, 330th Ave, 350th Ave, 360th Ave, 370th Ave, and 380th Ave. Where these roadways and embankment intersect the roadways will be raised to the required embankment elevation. CR 123 will be raised to elevation 1036 to improve access across Roseau Lake and provide access to the gated inlet structure, with the road raise box culverts will be required to convey flow from the inlet weir through CR 123 to the main pool.

9 Hydraulic Analysis Results

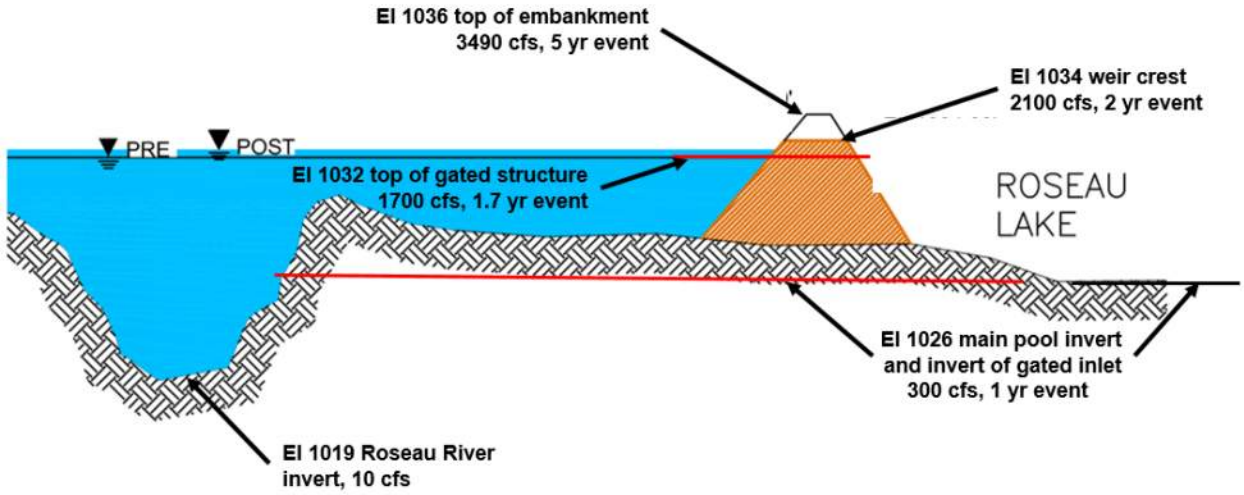
An unsteady HEC-RAS model was used to assess the impacts of the proposed project, which consists of the following main features:

- Embankments
- Main Pool Gated Inlet/Outlet and Weir
- Pine Creek and Judicial Ditch 61 Inlets and Exterior Drainage Ditches
- Drainage Culverts

9.1 Embankments

The embankments and exterior drainage ditches direct flow downstream during the rising limb of hydrographs with peaks below elevation 1034, which is approximately 2150 cfs (between a 2 and 2.5 year event). The embankments overtop during the 5 year event (3490 cfs, elevation 1036) at which point and the storage areas are overwhelmed resulting in no flood reduction benefit for larger events. See Figure 18 for a profile view with water surface elevations.

Figure 18. Project Profile with Approximate Water Levels



There have been 14 Roseau River flood events since 1961 that peaked above the elevation of 1036 feet. Due to the high likelihood of overtopping turf reinforcement matting or similar is recommended along the top of the embankments to minimize erosion.

9.2 Main Pool Gated Inlet/Outlet and Weir

The rising limb of the Roseau River is an important consideration in the design of the inlet structures to make sure the main pool fills prior to embankment overtopping the majority of the time. For the 14 events peaking above elevation 1036 since 1961, it took between 1 and 19 days for the Roseau River to rise from elevation 1034 to1036 at the Ross gage with 7 of the 14 events taking 4 days or less.

The hydraulic modeling identified the optimum weir location at the upstream end of the project to take advantage of the slightly higher upstream water levels. The weir was sized so the main pool reached elevation 1036 feet within 3 to 4 days, which is the average time for the Roseau River to rise from elevation 1034 to 1036. A weir crest elevation of 1034 feet corresponds to an existing condition Roseau River flow of 2,150 cfs, which is slightly above the 2-year existing condition event at the Ross gage.

9.3 Pine Creek and JD 61 Inlet; Exterior Drainage Ditches

The Northwest Embankment and associated exterior ditches provide for management of Pine Creek and JD 61 Lat 7 flows. Pine Creek below the diversion to the WMA contributes 2.2% of the drainage area at Ross gage, and the JD61 drainage area is 2.1% of the contributing drainage area at Ross. The gated structures will not be used to actively manage Pine Creek and JD 61 Lat 7 flows for FDR purposes since they contribute a relatively small amount of flow as compared to the Roseau River. Instead, flow from these tributaries will be shunted around Roseau Lake so storage is available for Roseau River flow. The Pine Creek and JD 61 gated structures will also be used to allow NRE flows to enter the main pool.

9.4 Drainage Culverts

Drainage culverts with flap gates are located along the embankments to allow areas to drain to the river when the river is low. The drainage culverts minimize standing water but do not provide a downstream FDR benefit nor do they factor into the wildlife management operation.

9.5 Result Tables and Figures

Hydraulic analyses were completed on all the alternatives listed in Table 6, with Alternatives 1, 2A, and 2A' being analyzed in detail. Only the Alternative 2a' hydraulic results are presented in this report because there is no significant difference in downstream benefits between 2a and 2a'. There are significant advantages to 2a' because it avoids the West Intercept Ditch making the option less expensive and easier to operate.

Table 11 and Table 12 provide a summary of results from a 100-Year 10-Day Spring Runoff Event, 10-Year 10-Day, 10-Year 24-Hour, 5-Year 10-Day, 5-Year 24-Hour, 2-Year 10-Day, and 2-Year 24-Hour Summer Rain Events at the Ross stage and near the inlet structure.

Table 11. Existing Condition vs. Alternative 2A' Peak Flow and Water Surface Elevations at Ross Gage

Event	Existing Peak Flow Rate (cfs)	Existing Peak Water Surface Elevation (feet)	2a' Peak Flow Rate (cfs)	2a' Peak Water Surface Elevation (feet)	Flow change from Existing (cfs)
100-Year 10-Day	9,509	1038.75	9,509*	1038.77	0*
100-Year 24-Hour	4,599	1037.36	4,581	1037.35	-18
50-Year 24-Hour	4,391	1037.36	3,451	1036.36	-940
25-Year 24-Hour	2,771	1035.28	2,665	1035.05	-106
10-Year 10 Day	3,816	1036.74	3,779	1036.70	-37
10-Year 24-Hour	2,163	1033.7	2,069	1033.39	-94
5-Year 10 Day	3,077	1035.84	3,040	1035.78	-37
5-Year 24-Hour*	1,718	1032.36	1,718*	1032.36	0*
2-Year 10 Day	2,474	1034.56	2,275	1034.03	-199
2-Year 24-Hour*	1,204	1030.60	1,204*	1030.60	0*

*Inlet gate operation to reduce downstream flow.

Table 12. Existing Condition vs. Alternative 2A' Peak Flow and Water Surface Elevations at INLET

Event	Existing Peak Flow Rate (cfs)	Existing Peak Water Surface Elevation (feet)	2a' Peak Flow Rate (cfs)	2a' Peak Water Surface Elevation (feet)	Flow Change from Existing (cfs)
100-Year 10-Day	3,610	1039.46	3,505	1039.45	-105
100-Year 24-Hour	4,937	1037.72	3,504	1037.69	-1433
50-Year 24-Hour	4,390	1036.74	3,432	1036.7	-958
25-Year 24-Hour	3,889	1035.79	3,269	1035.85	-620
10-Year 10 Day	4,311	1037.09	3,237	1037.04	-1074
10-Year 24-Hour	3,378	1034.66	3,058	1034.66	-320
5-Year 10 Day	3,951	1036.25	3,147	1036.19	-804
5-Year 24-Hour	2,980	1033.77	2,846	1034.39	-134
2-Year 10 Day	3,439	1035.25	3,004	1035.25	-435
2-Year 24-Hour	2,222	1032.79	2,211	1033.75	-11

Figure 19 shows the flow hydrographs for existing conditions and Alternative 2a' for the 2, 5, and 10-year 10-day events at Ross. The main pool begins to fill at hydrograph day 7 and is above the weir crest elevation of 1034 feet at hydrograph day 13 for the 2-year 10-day event. There is a peak flow reduction for the 2-year 10-day event of 199 cfs with increased benefits expected for slightly smaller events.

Figure 19. Existing Condition vs. 2a' Flow Hydrographs for the 2, 5, and 10-year 10-day events at Ross

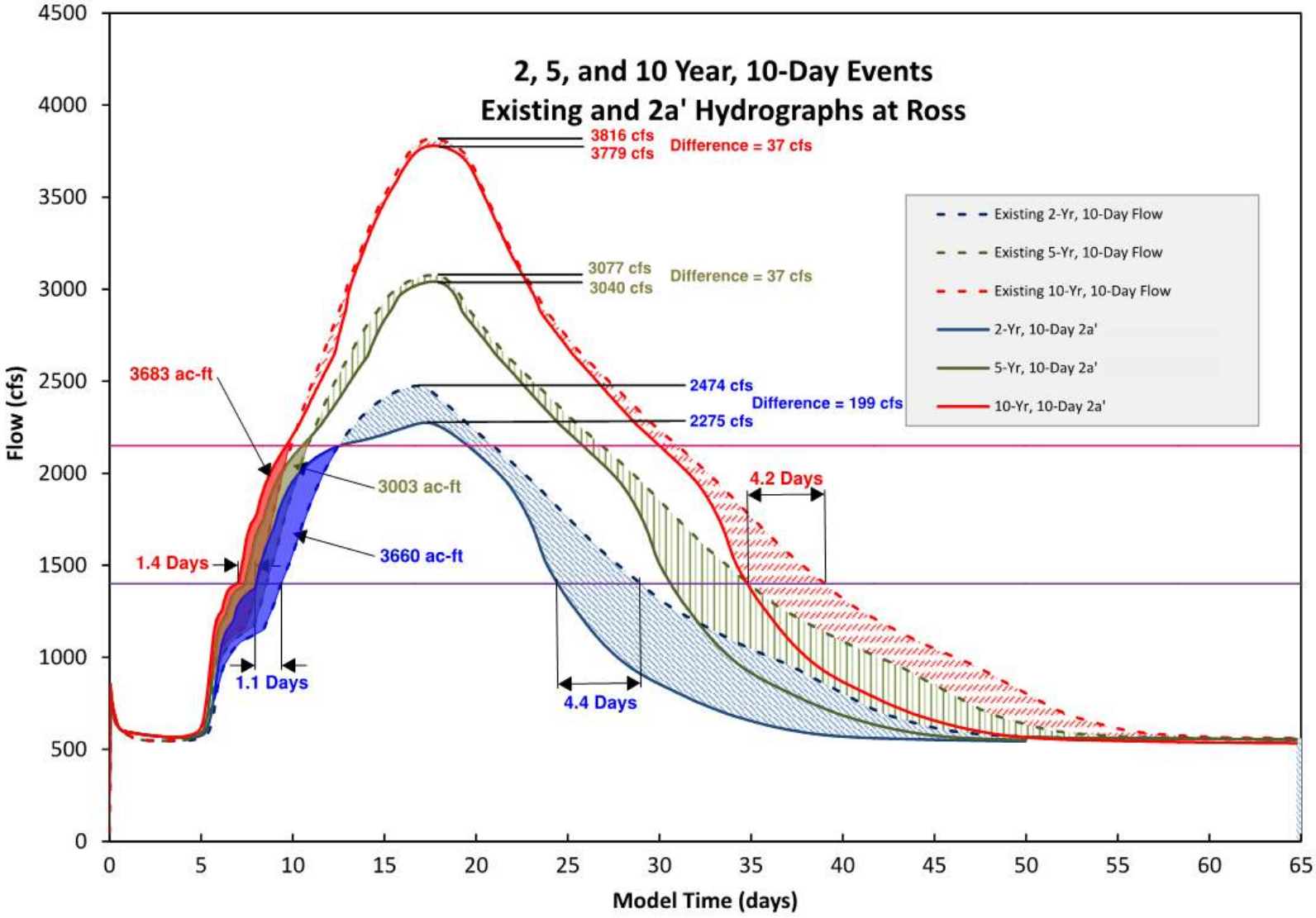


Figure 20 shows the 10-year 24-hour flow hydrographs for existing conditions and Alternative 2a' at Ross.

Figure 20. Existing Condition vs. 2a' Flow Hydrographs for the 10-year 24-hour events at Ross

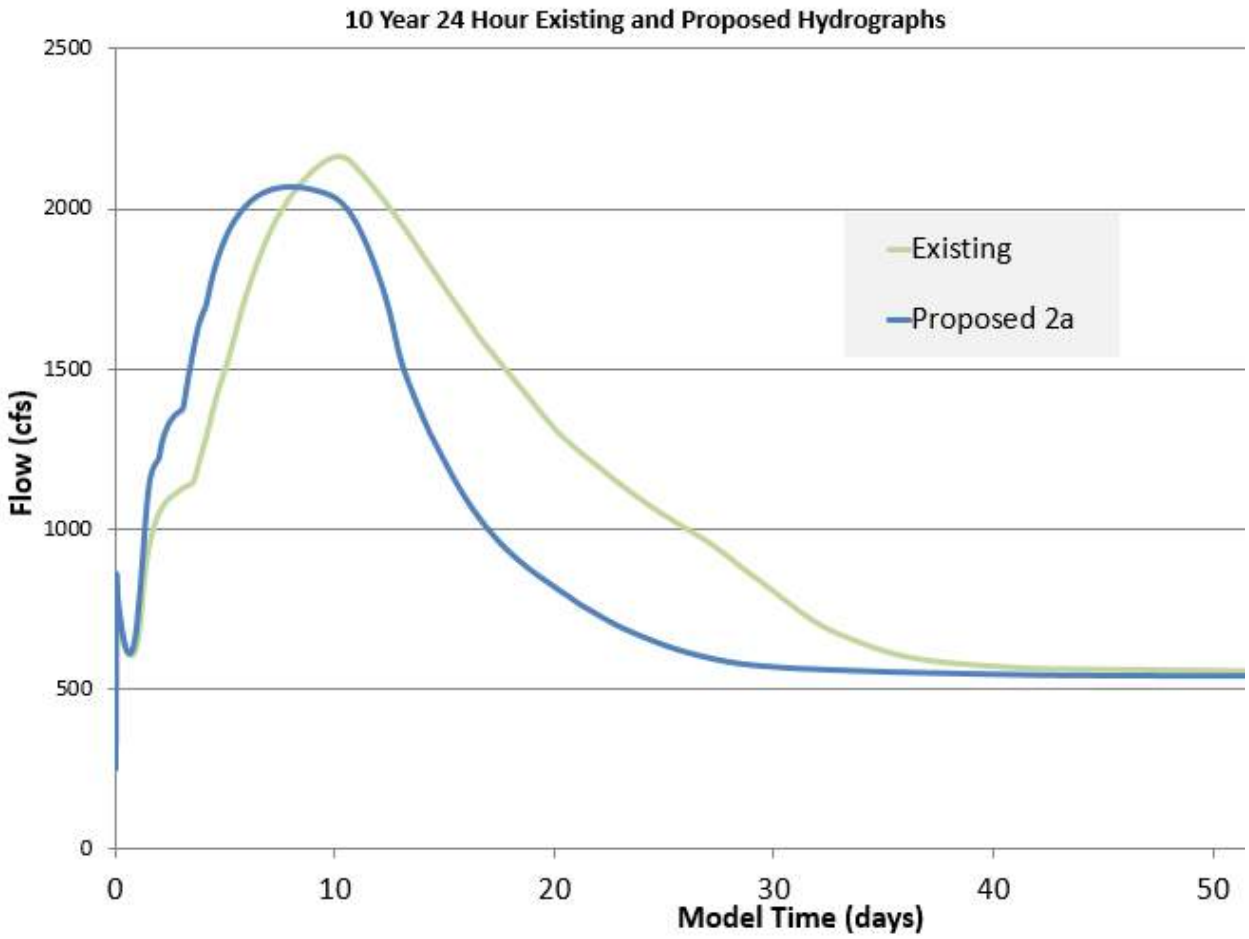


Figure 21 shows the water surface elevation (stage) for existing conditions and Alternative 2a' in the main pool for the 2, 5, and 10-year 24-hr events. There is enough flow during the 10-year 24-hour event to fill the main pool to elevation 1034 resulting in a 94 cfs FDR benefit.

The embankment height, weir crest elevation, and gate operation impact FDR benefits. Once main pool levels are above the embankment height the storage area is inundated so there is no FDR benefit. Once the main pool level is above the weir crest elevation the project no longer changes flood storage from existing conditions so there is no new FDR benefit. A higher embankment and weir crest would provide the ability to send more flow downstream, but more flow downstream would create a downstream rise during the lower flow events.

Figure 21. Existing Condition vs. 2a' Stage in Main Pool for the 10-year 24-hour event

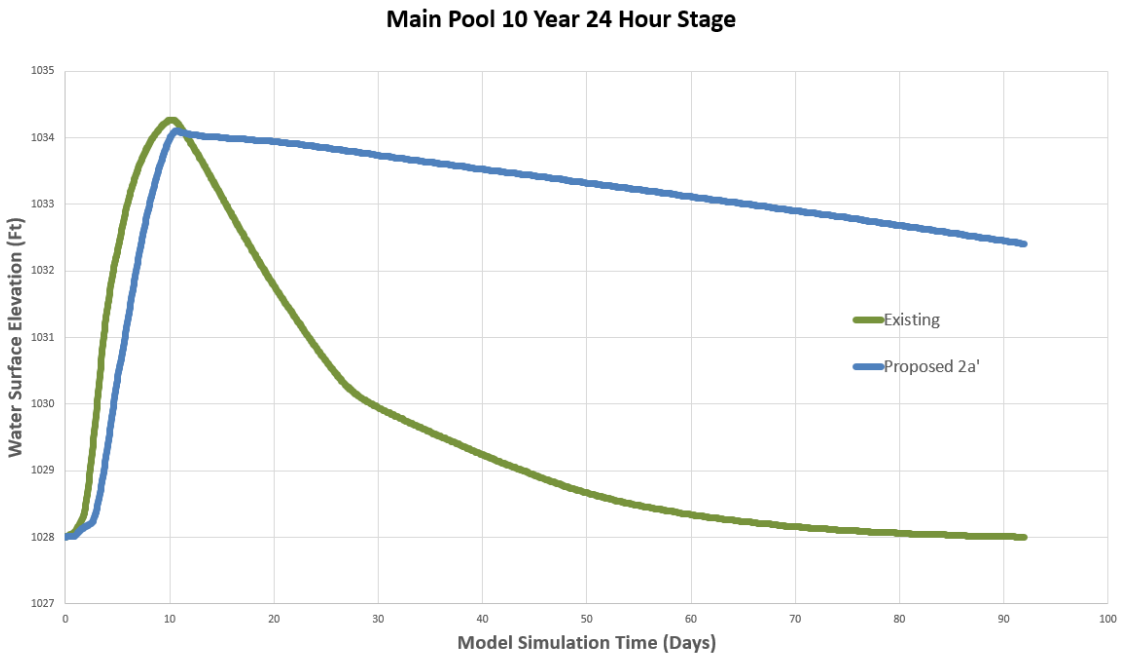
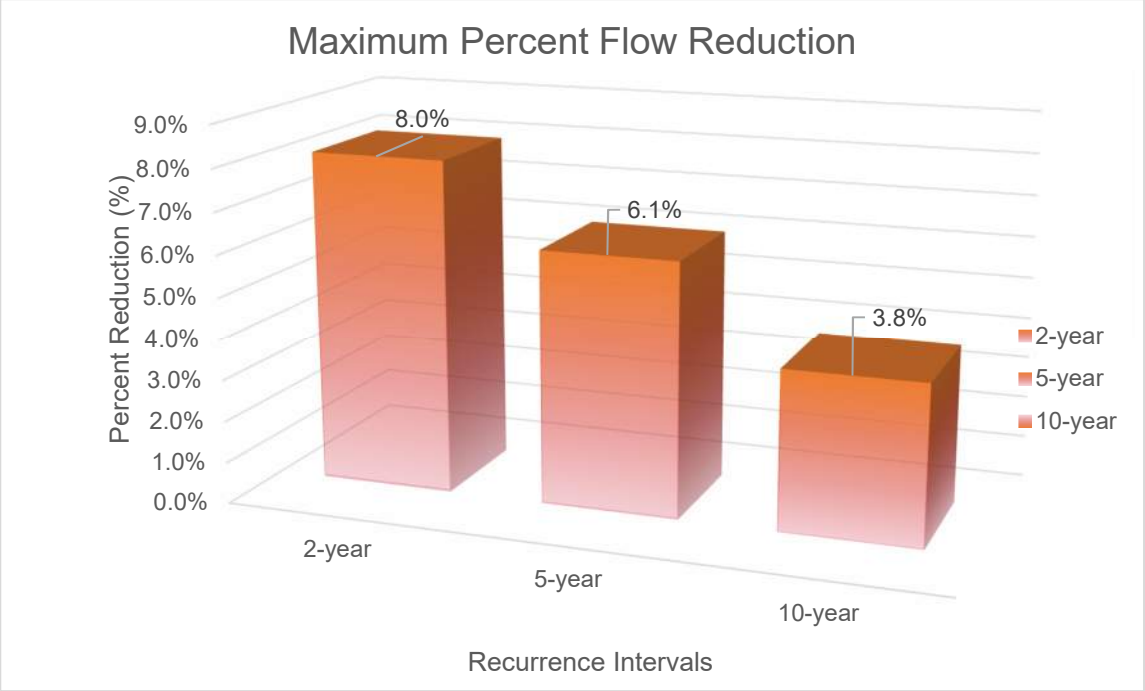


Figure 22 shows the maximum potential percent flow reduction for the project for the 2, 5, and 10-year events.

Figure 22. Maximum Percent Flow Reduction for the 2, 5, and 10-year events



10 Operating Plan

The Roseau Lake Rehabilitation project is an NRE project with FDR benefits, which restores shallow lake ecological functions to a portion of Roseau Lake while improving management of flood water storage to benefit both near-basin and downstream landowners.

The Project provides NRE benefits by moderating water level fluctuations in Roseau Lake during nesting and brood-rearing times for waterfowl, providing reliable spring-through-fall shallow lake conditions improving forage for migratory birds, and moderating downstream peak flows to enhance habitat conditions in the Big Swamp. The Project provides flood control benefits by improving floodwater storage timing and balancing priority use of the basin at any given time based on flood conditions.

The DNR will operate the gates on the new structures located at the inlet to the lake, at the outlet structure for the lake, and at Pine Creek. (At the request of the DNR, RRWD may assist with operation of the structures.) Risk to public safety will be a consideration in the operation of the new water control structures.

10.1 Operation Goals

The operating goal is to maintain constant lake levels during nesting and manage the flood storage potential of Roseau Lake which lowers peak flows and shortens the inundation duration on surrounding land and downstream of the project. Water level management in the basin will favor NRE goals outside of flood events during spring through fall. During flood events, priority for water level management in the basin will favor FDR. As a flood abates, discharge of water from the basin will be managed so water on agricultural lands near the basin will drain more efficiently than pre-project conditions.

10.2 Gate Operation

Operation of the Project will depend on the estimated size of the upcoming storm event. Events with a forecasted peak greater than 2150 cfs (stage 14 feet) will trigger one operation and forecasted events less than 2150 cfs another gate operation. This trigger point is slightly more than the 2-year event at Ross and corresponds with the weir crest elevation of 1034.

The operational guidelines discussed below, therefore, emphasize achievement of targets and do not delve into specifics of how to achieve those targets through manipulation of water control structures. The operator for any given event must have the data necessary to make sound decisions.

The optimum FDR results when the river forecast level enters through the weir has the following gate operation:

- During the rising limb of the hydrograph the gates are closed to route flow around the main pool.
- The gated inlet structures remain closed as the flood water enters the inlet weir at elevation 1034 (stage 14 feet). The weir is sized so Roseau Lake fill within 3 to 4 days.

Based on past events this is the average time the Roseau River takes to rise from elevation 1034 to 1036 (stage 14 to 16 feet, flow 2150 to 3400 cfs) at the Ross gage. Having the storage area full prior to embankment overtopping for most Roseau River flood events will reduce embankment erosion. The 5-year recurrence interval flood at the USGS gage at Ross, MN (3,490 cfs – elevation 1036.3, stage 16.3).

When the river forecast level is below the weir elevation the intent of the FDR gate operation is to divert a portion of the Roseau River into Roseau Lake. The gate operation is as follows:

- stage <11.9 feet (1700 cfs, elevation 1031.9) – all gates closed
- stage 12 to 13 feet (1700 to 1800 cfs, elevation 1033) – half of the gates open
- stage 13 to 14 feet (1800 to 2150 cfs, elevation 1034) – all of the gates are open
- stage >14 feet (2150 cfs) – all gates closed

When the river forecast level is less than 1700 cfs the Project will allow lands adjacent to and upstream of the lake to drain first, then release water from basin. Roseau Lake outflow will be metered to keep flow within the channel downstream of the project to the extent possible and maintain the seasonal NRE pool elevations. The existing downstream channel capacity is approximately 1400 cfs with a corresponding stage of 10.8 ft and elevation 1030.8. Once the river drops below 1400 cfs (stage 10.8 feet) the gates will be operated until the desired NRE stage is achieved. There are smaller gated structures on Pine Creek and JD61 Lat7, which will be closed during the spring runoff to save storage for FDR purposes and then operated for NRE purposes. The NRE pool elevation during non-flood operation is based on seasonal operation by the DNR to benefit wildlife management.

10.3 Wildlife Management Operation

The spring and summer season is defined as ice-out on the Roseau River to Labor Day. The fall season is Labor Day until ice begins to form on the Roseau River (ice-up). The winter season is ice-up to ice-out.

The transition from winter to spring has an initial focus on storage for flood damage reduction. Following the spring runoff then the Project will be operated for spring migration. The transition from summer to fall corresponds with a management emphasis from production to fall migration and hunting. This transition is variable but typically measured in weeks. The transition from fall to winter corresponds with an emphasis from fall migration. The overwinter drawdown should occur around December 1 and be maintained through the winter. The transition is variable but will likely occur over a 2-week period to re-flood Roseau Lake in order to attain the NRE goals.

The target Roseau Lake pool elevations for wildlife management is as follows:

- Spring and Summer Season: < 1028.0 feet
- Fall Season: 1028.0 to 1031.0 feet
- Winter Season: < 1026.0 feet

Inletting of water from the river to supplement lake levels is allowable so long as river levels are above elevation 1026.0 (stage 6.0 ft, flow 300 cfs) at the Ross gage.

The basin will be drawn down in entirety during winter to provide full storage capacity for the following spring. NRE management during spring and summer will emphasize shallow marsh management for a host of wildlife requiring such habitats for breeding, nesting, brood-rearing, and foraging. In fall, NRE management will allow for additional water on the basin to enhance availability of fall migration habitat for waterfowl and to increase opportunity for waterfowl hunting. Shallow marsh management will curb the spread of invasive plant species (e.g., reed canary grass) and enable colonization of native species (e.g., softstem bulrush) on some sites.

The intent of wildlife management is to provide flexibility to take advantage of opportunities. The DNR wildlife manager will report annually to the Roseau River Watershed Board on operations and maintenance activities that involve the infrastructure installed and operated as part of this project. In addition, the DNR & RRWD will confer as operations and maintenance issues arise so necessary action occurs in a timely manner to meet project objectives.

10.4 Departure From Normal Operation

Issues that cause a departure from normal operations should be emergency in nature, temporary and, to the extent possible, isolated in their effect on the larger project and its objectives. Normal procedures should resume once the immediate threat has passed. If the RRWD is made aware of an issue that could cause a change in operations, they will notify the DNR as soon as possible. Likewise, the DNR will notify the RRWD of any complicating factors. If time allows, the two parties will decide on a course of action. If a life-threatening situation arises, either party is authorized to immediately do whatever is necessary to remedy the situation.

The rate of discharge will be affected by the agricultural calendar in that a more aggressive rate of discharge will occur if the event happens prior to 1 May or post-harvest in the fall as opposed to 1 May through harvest. Operation may need to be adjusted due to (but not limited 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;
- “Stacked” events where the crest of one flood has not passed or has only recently passed at Roseau Lake prior to the crest arriving from the next significant event; and
- Unintended accumulation of water along stretches of the exterior ditches (e.g., intersection of Pine Creek with the exterior ditch and intersection of exterior ditches with the river).

10.5 Timing to Fill Roseau Lake

Roseau Lake will be at elevation 1026 feet at the start of the spring season for storage. The storage capacity from 1026 feet to the weir crest elevation of 1034 feet is approximately 21,090 acre-feet. For illustrative purposes the total gated flow area is 384 square feet, assuming an average velocity of 5 feet/second, the resulting average inflow rate is 1,920 cfs. At this gated flow rate Roseau Lake will take approximately 5.5 days to rise from elevation 1026 feet to 1034 feet.

10.6 Water Release

The gage at Ross will inform flow release from Roseau Lake. The intent is to operate the outlet gates so flow from Roseau Lake does not exceed the channel capacity (1,400 cfs) during the falling limb of the hydrograph. Flows will be released until the wildlife management stage for the applicable season is achieved.

10.7 Flood Forecast Information

The Roseau River gage at Ross and upstream gages will be used to predict whether flows will be less than or greater than the 2-year event. The Roseau River gage at Malung and the Sprague Creek gage at the US/Canada border represent a combined drainage area of 606 square miles, or approximately 56% of the drainage area at the project site. The drainage area at the confluence of the Roseau River and Sprague Creek is 978.6 square miles while the drainage area at Ross is 1085.4 square miles. Table 13 summarizes the contributing drainage area at Ross.

Table 13. Contributing Drainage Area

Description	HMS ID	Drainage Area (sq. miles)	Percent (%)
Roseau River	Reach-61	646.2	59.5%
Sprague Creek	Reach-189	332.4	30.6%
Pine Creek	Reach-91	23.5	2.2%
JD 61	Reach-83	22.8	2.1%
Local drainage D/S Sprague	W35000	18.7	1.7%
West Intercept Ditch	W27460	14.2	1.3%
Other Local Drainage	W34300,W36350, and W34990	27.7	2.6%

Roseau River flood events typically occur in April due to snowmelt or in May and June due to rain events. The 5-year 24-hour precipitation event is 2.84 inches. Rainfall or snow water equivalent above this amount are expected to result in flooding. 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.

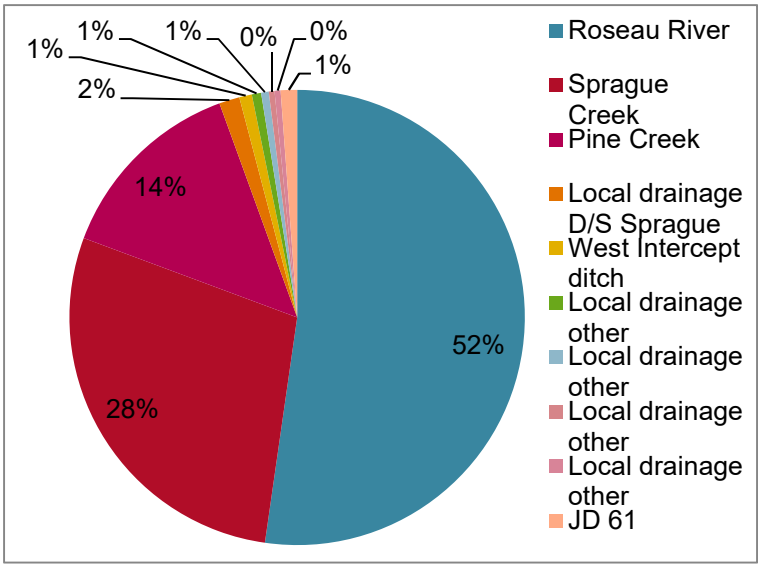
Information for snowpack from 2003 to the present can be found at the following website: http://www.nohrsc.noaa.gov/interactive/html/graph.html?station=RNRM5&w=600&h=400&o=a&uc=0&by=2009&bm=1&bd=12&bh=6&ey=2009&em=6&ed=19&eh=6&data=0&units=0&region=us.

Rainfall estimates for the area are available at the following website: http://water.weather.gov/precip/.

The snow water equivalent, recent precipitation, and flood forecast information provides predictive information to help frame whether the project will be operated in a low, normal, or high flow manner. The measured flow at the stream gages will be used to operate the inlet gates.

Figure 23 shows the project site flood flow volume breakdown for the 2-year 24-hour storm. As shown, Pine Creek has 2.2% of the drainage area but contributes 14% of the volume. For larger events, the percentage breakdown remains relatively consistent except the Roseau River percentage goes up and Pine Creek goes down.

Figure 23. 2-year, 24-hour Existing Condition Total Volume Contribution



The following gages are publically available to inform the operation of the Roseau Lake project. The contributing project drainage area is 1,085 square miles, with a contributing drainage area due to the Roseau River of 640 square miles and contributing drainage area due to Sprague Creek of 332 square miles.

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

https://waterdata.usgs.gov/mn/nwis/uv/?site_no=05107500&PARAmeter_cd=00065,00060

- Roseau River at Roseau maintained by MNDNR, upstream of project, drainage area 473 square miles. http://www.dnr.state.mn.us/waters/csg/site_report.html?mode=getsitereport&site=71035001
- Roseau River near Malung, MN approximately 3 miles upstream of Roseau maintained by USGS - upstream of project, contributing drainage area 430 square miles. https://waterdata.usgs.gov/mn/nwis/uv/?site_no=05104500&PARAmeter_cd=00065,00060
- Sprague Creek at Canada/US border maintained by USGS - upstream of project, drainage area 176 square miles. https://waterdata.usgs.gov/mn/nwis/uv/?site_no=05106000&PARAmeter_cd=00065,00060
- Pine Creek does not have a MNDNR or USGS gage and has a drainage area at the project site of 77 square miles. (23.5 square miles downstream of diversion to the WMA).

The NWS provides a flood forecast at Malung and Ross:

- Malung http://water.weather.gov/ahps2/hydrograph.php?wfo=fgf&gage=malm5&prob_type=stage&source=hydrograph
- Ross http://water.weather.gov/ahps2/hydrograph.php?wfo=fgf&gage=rssm5&prob_type=stage&source=hydrograph

Additional Red River basin gages in the United States and Canada can be found at the following location: https://nd.water.usgs.gov/floodinfo/red.html.

- Red River of the North at Pembina, ND maintained by USGS – upstream of Roseau River confluence, drainage area 40,200 square miles. The NWS provides a flood forecast at this gage. https://waterdata.usgs.gov/nd/nwis/uv/?site_no=05102490&PARAmeter_cd=00065,00060
- Roseau River near Dominion city, MB maintained by Government of Canada – downstream of project, contributing drainage area 1,938 square miles. http://wateroffice.ec.gc.ca/report/real_time_e.html?stn=05OD001
- Roseau River near Caribou, MN maintained by USGS – downstream of project, contributing drainage area 1,420 square miles. https://waterdata.usgs.gov/mn/nwis/uv/?site_no=05112000&PARAmeter_cd=00065,00060

Operation should be based on actual gage readings on the Roseau River and Sprague Creek. Note that approximately 40% of the project contributing drainage area is not represented by the upstream river gages, which is why the flood forecast at Ross will inform operations.

10.8 Operation Responsibilities and Coordination

Most of the project infrastructure, excepting the levees, will occur on RoLWMA. As such, the DNR wildlife manager will assume primary responsibility for reporting annually to the Roseau River Watershed Board of Managers on operation and maintenance activities that involve the infrastructure installed and operated as part of this project. In addition, the DNR & RRWD will confer as operation and maintenance issues arise so that necessary action is taken in a timely manner to meet project objectives.

RRWD staff will be granted access to restricted areas of the RoLWMA levee system for the purpose of inspection of the project's infrastructure. Such access will be granted upon notification of the DNR wildlife manager and will be limited to times and places that will not disrupt management activities or disturb wildlife (as determined by the wildlife manager).

The DNR's annual report to the RRWD Board of Directors will include (but is not limited to): a summary of the RoLWMA waterfowl breeding pairs survey, a summary of the RoLWMA waterfowl brood count survey, a physical condition summary of structures and gauges, and Roseau Lake water levels.

The operating plan should be evaluated every 5 years for updates to the plan to address shortcomings and make adjustments to the plan based on new data or experience in operating the project. Revisions to the operating plan may be considered at 5-year intervals or sooner as circumstances dictate. Modifications to the plan must be agreed to by both (RRWD and MN DNR) parties.

11 Other Considerations

11.1 Wetland Mitigation

Any wetland disturbed by construction equipment, excavation, or fill material must be permitted. A wetland delineation, permit application, and mitigation plan will be developed prior to construction. Data from the National Wetlands Inventory (NWI) has been overlaid with the limits of construction to provide the amount of wetland impacts for the project alternatives. The estimated area of wetland disturbance by each project alternative is summarized in Table 14. These estimates are generally accepted to be conservative. An illustration of this area of disturbance is shown in **Error! Reference source not found.** for Alternative 2a'.

Table 14. Wetland Mitigation

Alternative	Wetland Area Affected by Project Footprint
Alternative 1	89 Acres
Alternative 2a	105 Acres
Alternative 2a'	91 Acres

11.1 Invasive Species

Because construction will be taking place in the area of the DNR Roseau Lake WMA and because wetlands are present, it is important that no new invasive species are introduced and that any existing invasive species not be spread further. Contractors and project managers should follow Best Management Practices (BMPs) for preventing the spread of invasive species. Further analyses will be completed as a part of this project, but are not included in this report.

11.2 Maintaining Low Flow Pathways

The DNR has expressed interest in maintaining the existing flow routes for the low flows in the Roseau River. Alternatives 1, 2A, and 2A' all include a rock structure on the cutoff channel to divert more flow down the natural Roseau River channel.

11.3 Project Phasing

Funding will be one of the major limiting factors for the completion of the project due to the scale of the project, so project phasing to align with the amount of available funding will be examined.

11.4 Land Ownership, Land Use, and Right of Way

A majority of the land within Roseau Lake is owned and managed by the MnDNR. This public land is used for conservation of plants and animals and for public recreation while a small portion is leased for agricultural purposes. The remaining land near or on the outer edges of the proposed embankments is owned privately or by The Roseau River Watershed District.

Figure 24 illustrates the land ownership with Alternative 2a' footprint for the project site. Approximately 40% of the land near the project is private land and is mainly wooded, used for agriculture, or in the Conservation Reserve Program (CRP).

The landscape within the project site primarily consists of grasslands, wetlands, or previously cropped land that is not currently farmed. The land inside the basin is very flat with some areas having less than one foot in elevation change per mile. Along the edges of the basin near the higher ground, farming does still occur when the land is not flooded due to high river stages. There are also groves of trees located along the river in some areas. A land use map of the project area with the Alternative 2a' footprint is shown in Figure 25.

Figure 24. Land Ownership

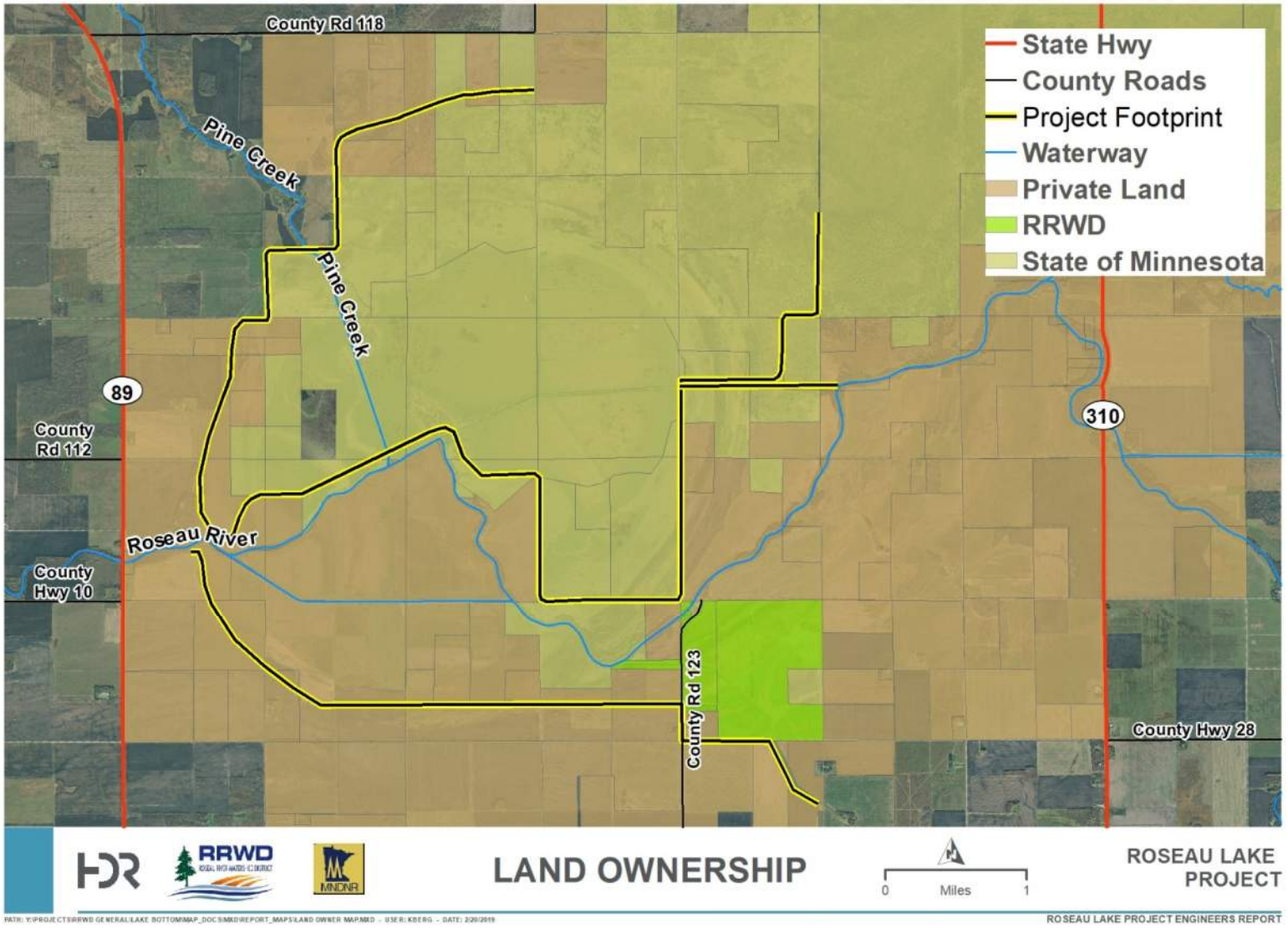
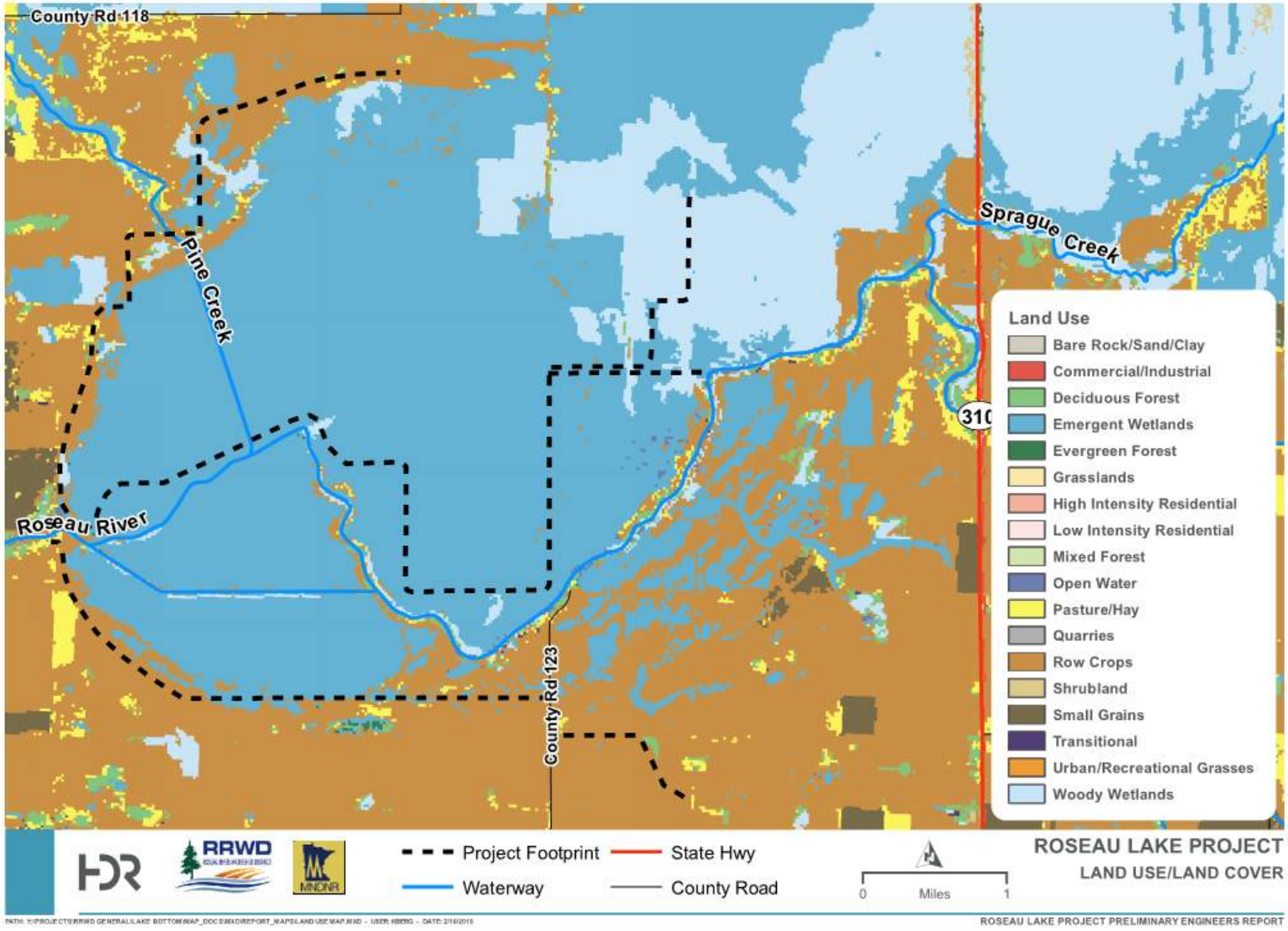


Figure 25. Land Use



A majority of the storage area is on public land while much of the embankments are located on privately owned land. Easements or land acquisition will be required to obtain the necessary right-of-way for the project footprint including embankments and ditches plus 20 feet on each side of the immediate footprint with estimated right of way summarized in Table 15. The MnDNR and RRWD also own property where segments of the proposed embankments are located and compose the public right-of-way area.

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

Alternative	Private ROW Required (Acres)	Public ROW Required (Acres)	Total ROW Required (Acres)
Alternative 1	176	163	339
Alternative 2a	385	180	565
Alternative 2a'	291	150	441

Land inundated by the project may also require easements to provide operational flexibility and are taken account in the cost estimate tables but not included is this table.

Table 16 shows the temporary construction impacts for the embankments and ditches. The impact area was calculated based on the estimate that the right-of-way for the embankments and ditches is doubled. Temporary construction impacts include areas for construction equipment operation and access but not inundation due to the project.

Table 16. Temporary Construction Impacts for Embankments and Ditches

Alternative	Temporary Construction Impacts on Private Land (Acres)	Temporary Construction Impacts on Public Land (Acres)	Total Temporary Construction Impacts (Acres)
Alternative 1	185	171	356
Alternative 2a	532	208	740
Alternative 2a'	298	171	469

11.5 Geotechnical

Initial borings were collected in the projected area with results presented in Appendix B. A seepage, and slope stability analysis will be completed during final design.

The Roseau River Watershed is comprised of a large range of soil types and this is true for the land near Roseau Lake. The NRCS Web Soil Survey (Natural Resources Conservation Service, 2002) was utilized to evaluate soil information at the Project site. The complete list of soil types within and surrounding the project area are displayed in Table 17. The majority of the area within the proposed embankment consists of Lallie mucky silt loam. This soil type is mainly found where depressions on lake plains occur and have very poor drainage. The soils mainly found under or near the potential embankment areas are Colvin silty clay loam, Borup silt

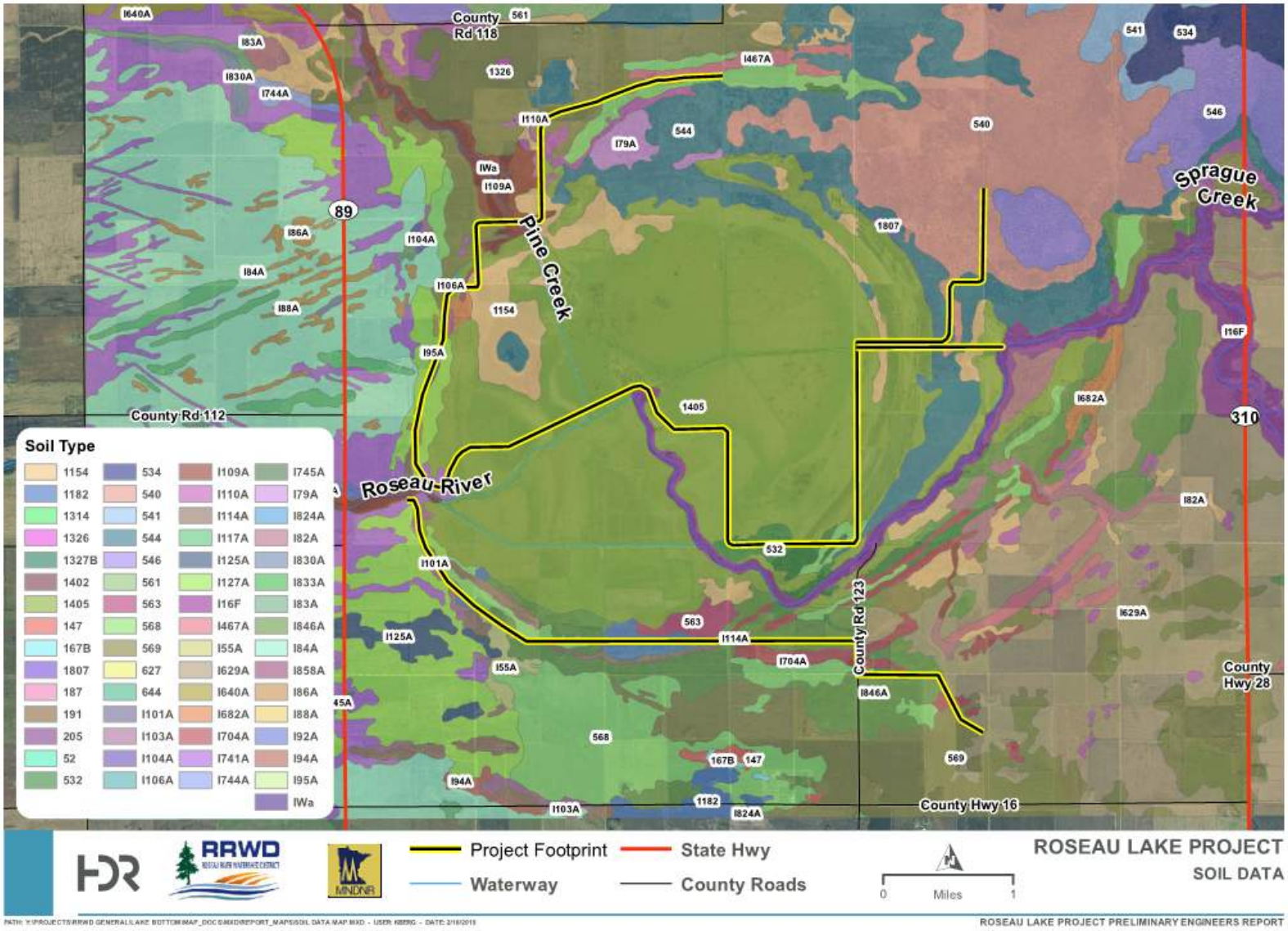
loam, and Cathro muck. Soil types found within and near the project area are displayed in Figure 26.

Table 17. Soil Map Unit Descriptions

Map Unit	Map Unit Description	Area in Project	Percent in Project
1405	Lallie mucky silt loam, map 18-22, 0 to 1 percent slopes	6167.9	30.45%
I629A	Colvin silty clay loam, 0 to 2 percent slopes	2141.1	10.57%
544	Cathro muck, map 18-22, 0 to 1 percent slopes	1887.9	9.32%
540	Seelyeville muck, 0 to 1 percent slopes	1562.7	7.71%
I846A	Borup silt loam, 0 to 2 percent slopes	1203.4	5.94%
569	Wabanica silt loam, 0 to 2 percent slopes	1093.4	5.40%
I16F	Fluvaquents,frequently flooded-Hapludolls complex, 0 to 30 percent slopes	917.5	4.53%
1154	Sax muck, 0 to 1 percent slopes	850.8	4.20%
568	Zippel very fine sandy loam, 0 to 2 percent slopes	746.5	3.69%
I127A	Percy loam, 0 to 2 percent slopes	630.8	3.11%
546	Lupton muck, map 22-30, 0 to 1 percent slopes	351.0	1.73%
I109A	Fluvaquents, 0 to 2 percent slopes, frequently flooded	264.6	1.31%
I467A	Bearden silt loam, 0 to 1 percent slopes	259.0	1.28%
I704A	Glyndon very fine sandy loam, 0 to 1 percent slopes	258.6	1.28%
I110A	Augsburg, Borup, and Colvin soils, very poorly drained, 0 to 1 percent slopes	253.8	1.25%
I82A	Cathro muck, dense till, 0 to 1 percent slopes	246.9	1.22%
532	Sago muck, 0 to 1 percent slopes	223.2	1.10%
I84A	Percy loam, 0 to 2 percent slopes, very cobbly	186.7	0.92%
I741A	Boash clay loam, dense till, 0 to 2 percent slopes	158.4	0.78%
I125A	Skagen loam, 0 to 3 percent slopes	118.7	0.59%
1182	Warroad fine sandy loam, 0 to 2 percent slopes	113.2	0.56%
I79A	Berner, Cathro, and Haug soils, ponded, 0 to 1 percent slopes	111.9	0.55%
I682A	Borup-Glyndon complex, 0 to 2 percent slopes	109.4	0.54%
I114A	Foldahl fine sandy loam, dense till, 0 to 3 percent slopes	107.5	0.53%
563	Northwood muck, 0 to 1 percent slopes	79.1	0.39%

Map Unit	Map Unit Description	Area in Project	Percent in Project
I784A	Rosewood fine sandy loam, 0 to 3 percent slopes	68.3	0.34%
I103A	Kratka fine sandy loam, dense till, 0 to 2 percent slopes	53.1	0.26%
I86A	Percy mucky loam, 0 to 1 percent slopes	21.9	0.11%
I104A	Strandquist loam, dense till, 0 to 2 percent slopes	12.6	0.06%
1807	Cathro muck, ponded, map 22-30, 0 to 1 percent slopes	12.2	0.06%
I83A	Wildwood muck, dense till, 0 to 1 percent slopes	9.9	0.05%
1326	Augsburg and Wabanica soils, depressional, 0 to 1 percent slopes	9.0	0.04%
I117A	Skagen loam, 0 to 3 percent slopes, very cobbly	6.2	0.03%
I101A	Foxhome sandy loam, dense till, 0 to 3 percent slopes	5.6	0.03%
I106A	Enstrom loamy fine sand, dense till, 0 to 3 percent slopes	4.6	0.02%
IWa	Water	3.6	0.02%
I95A	Kratka and Strathcona soils, dense till, 0 to 1 percent slopes	3.5	0.02%
I92A	Grano clay, 0 to 2 percent slopes	2.0	0.01%

Figure 26. Soil Types for Project Area



RRWD contracted Terracon Consultants, Inc. of Grand Forks, North Dakota to perform a geotechnical exploration at the project location that consisted of 17 soil borings at depths of 20 or 60 feet. Sixteen soil borings were completed by Terracon Consultants, from August 9, 10, 14, 15, and 16, 2017 with Figure 27 showing the locations of the completed borings. One of the borings could not be completed due to site access. Samples were analyzed by Terracon Consultants, Inc. for several key engineering properties including:

- Water content (ASTM D2216)
- Dry density (ASTM D7263-09 Method B)
- Atterberg limits (ASTM D4318)
- Grain size distribution (ASTM D422)
- Hydraulic conductivity (ASTM D5084)
- One-dimensional consolidation properties (ASTM D2435)
- UU Triaxial (ASTM D2850)
- Hydraulic Conductivity (ASTM D5084)

Detailed geotechnical information on the borehole logs and laboratory test results can be found in the Geotechnical Exploration Report provided by Terracon Consultants, Inc. (Appendix B).

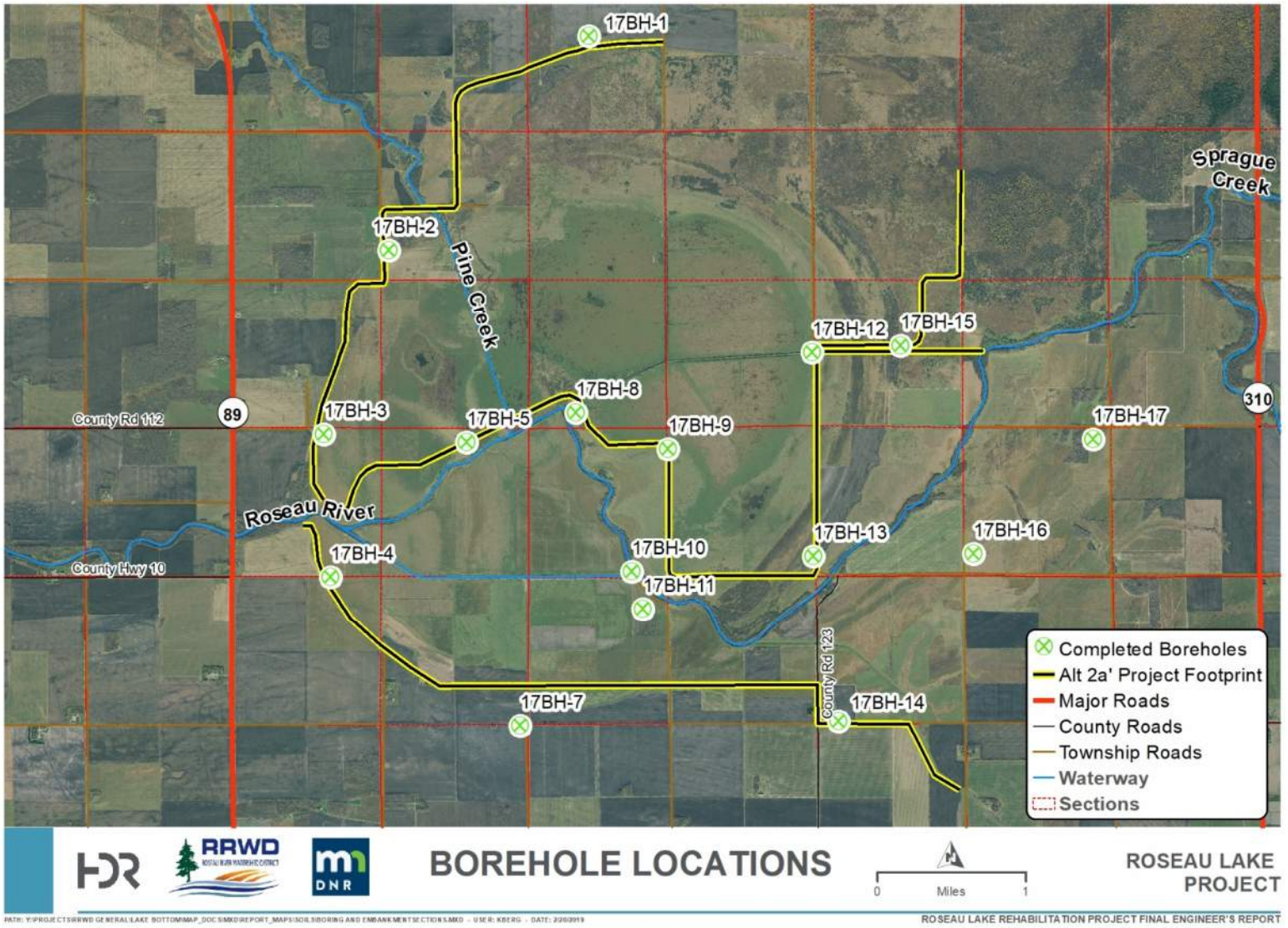
Table 18 is from the *Geotechnical Exploration Report* (Appendix B) provided by Terracon Consultants, Inc. and shows a typical profile of the subsurface conditions found at the site.

Table 18. Typical Profile of Subsurface Conditions at the Roseau Lake site (Table 3.1 from the Geotechnical Exploration Report provided by Terracon Consultants, Inc.)

Stratum	Approximate Depth to Bottom of Stratum (feet)	Material Description	Consistency
1	1 ½ to 6	Topsoil/existing fill	N/A
2	4 ½ to 9 ½	Lean clay/silt with various amounts of sand	Ranges from soft to medium stiff
3	36 ½	Dark gray fat clay	Ranges from very soft to soft
4	Undetermined	Sandy lean clay	Ranges from soft to hard

Groundwater was encountered at depths ranging from 7.5 to 31 feet below ground surface in three of the sixteen borings.

Figure 27. Borehole Locations



Poor foundation materials (e.g. topsoil consisting of organic clay and fill) in all boreholes were present. Excavation of existing topsoil, organics, peat, and non-native fill within the embankment footprint cannot be placed in wetlands. It is anticipated that any non-usable material can be used to flatten the embankment slope or as fill in in the borrow sites.

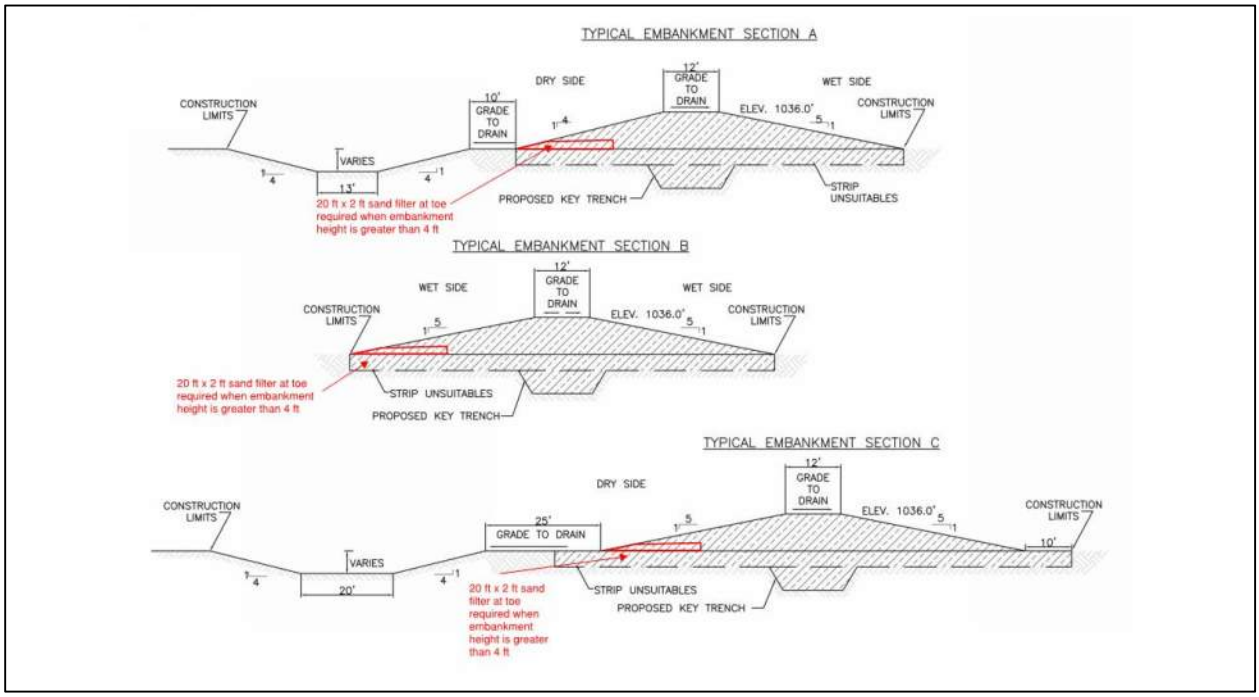
The laboratory testing program did not include tests on all soil layers to assess the material properties of the foundation soils. The properties were based on several factors, including published correlations and the results of past testing of similar soils. The values of the properties selected for use in the stability and seepage analyses are considered reasonable and conservative for the materials present at the site.

Two subsurface conditions were modeled. The first condition included a subsurface stratigraphy with a silt layer 5 feet in thickness and 8 feet below ground surface. This was modeled as a worst case condition at the site as seepage problems were anticipated. This silt layer is located in some of the outer boreholes (BH 2, 7, 13, 14, and 16). The second condition was a subsurface stratigraphy that did not include an inter-bedded silt layer. This was modeled to conservatively represent the remaining conditions at the site.

Preliminary results of the stability analyses indicated that acceptable factors of safety can be achieved and that stable embankments for the proposed project can be constructed at the site.

Preliminary steady state seepage analysis results indicate that a sand filter located at the toe will be needed to remediate a high hydraulic gradient when the embankment is greater than 4 feet in height as shown on Figure 28 with a typical embankment cross section.

Figure 28. Typical Embankment Cross Sections describing where improvements are needed (sand filter).



It should be noted the analysis of settlement of the embankments has not been completed at this stage in the project. Standard penetrations values for the on-site foundations soils (clay) correlate to *soft* to *very soft* conditions in all boreholes with the exception of BH 3. This indicates that settlement under the weight of the new embankments could be a concern.

11.6 Potential Groundwater Impacts

Groundwater levels were inconsistent during the geotechnical drilling and were encountered at depths ranging from 7.5 to 31 feet below ground surface. In three of the sixteen borings groundwater level was in the fat clay layer and a silt layer . Section 3.2 of the Geotechnical Exploration Report completed by Terracon (See Appendix B) describes why long term groundwater observations are required to better define groundwater levels in project location.

No groundwater was encountered within the upper *silty sand* and *silt with sand* layers (located in BH's 2, 7, and 13) so there was no indication of an aquifer in this layer. The placement of the embankment and the sub cut geometry in the areas where removal of peat/topsoil/organics/fill is needed is not expected to impact groundwater based on the information gathered to date.

The exterior ditches at the Northwest and South embankments will need to be evaluated for groundwater impacts during design.

11.7 Environmental Consequences

The DNR is working on the Environmental Review (ER) for the project which will provide details on potential negative environmental effects of the proposed Roseau Lake Rehabilitation project and ways to avoid or minimize impacts before the project is permitted and built. The Project is not expected to cause significant negative environmental consequences.

11.7.1 Water Quality

The Minnesota Pollution Control Agency (MPCA) states that there is not enough data is available on Roseau Lake to determine the water quality condition. The MPCA has a Roseau River HSPF Modeling project in progress with a completion date of 2019. The Hydrological Simulation Program - FORTRAN (HSPF) is a comprehensive package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants (EPA website, 2019). However, the MPCA has deemed the section of the Roseau River that runs through Roseau Lake (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. Two MPCA biological monitoring stations are located within the Roseau Lake footprint on the Roseau River. The MPCA also has a water quality monitoring station located on the Roseau River downstream of Roseau Lake at Highway 89.

11.7.2 Fish and Wildlife

The Project components will enhance fish and wildlife habitat. As indicated in Section 3 - Project Objectives the project goals include significant efforts to conduct NREs in the project area. Some upland habitats will be subjected to periodic inundation in accordance with the Project purpose and operating plan. Historically, these habitats have been subjected to frequent inundation and are adjacent to agricultural production.

The DNR manages the Roseau Lake Wildlife Management Area to provide habitat for small mammals, furbearers, amphibians, brushland wildlife species, grassland species, wetland species, migratory waterfowl, songbirds, deer, moose, sharp-tailed grouse, and wood ducks (MN DNR website, 2019).

11.8 Potential Borrow Sources

In order to make the project as economical as possible it was assumed that the potential sources of borrow would be located in close proximity to the project location. The combination of NRCS Soil Survey maps and soil information from the geotechnical investigation were used to determine locations likely of containing a suitable borrow source.

The first criteria used in selecting potential borrow locations was that the site be located within the project footprint. This ensures that the site will be relatively close to the project and additional storage volume would be created. The second criteria used was the maximum hauling distance along any portion of the embankment would be 1 mile. In addition, attempts would be made to locate borrow sources completely on one landowners property.

The exterior drainage ditches will be the primary source of material for the embankments but depending on the alternative the ditches may be shallow and not get below the organic material layer so borrow sources may be necessary. Ultimately borrow sources will be chosen by the DNR, RRWD, and willing landowners.

11.9 Erosion Control

11.9.1 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 laid out as part of the design.

11.9.2 Prevention of Embankment Erosion

In order to prevent erosion from occurring during project operation the embankments will be lined with turf reinforcement matting along the crest. Armorflex and riprap will be used at the inlet and outlet hydraulic structures and, if necessary, at the cutoff channel and inlet weirs that allow water into the main pool.

11.9.1 Vegetation

Newly constructed channels and embankments will be vegetated with appropriate seed mixes in accordance with Board of Soil and Water Resources (BWSR) seeding guidelines (Native Vegetation Establishment Enhancement Guidelines). 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).

11.10 Field Entrances and Embankment Access

Sufficient turning radius will be provided at the principal outlet structures. Field access points will be designed such that adequate accessibility is achieved for maintenance vehicles and will be provided as necessary around the perimeter of the project.

12 Opinion of Probable Costs

Table 19, Table 20, and Table 21 summarize the concept level costs for Alternative 1, 2a, and 2a'.

Table 19. Alternative 1 Concept Level Costs

Item Description	Quantity	Unit Cost	Cost
Wetland Impact (acres)	89	$3,000.00	$267,535
Embankment Fill (CY)	541684	$4.00	$2,166,736
Road Raise Fill (CY)	38842	$4.00	$155,368
Class IV Aggregate Surfacing (ton)	50000	$14.00	$700,000
Channel/Ditch Cut (CY)	1683310	$1.75	$2,945,793
Hydraulic Structures	12		$2,292,600
Riprap and Armorflex (CY)	2916		$360,486
ROW (acres)	1000	$750.00	$750,000
Erosion Control and Seeding Cost (acres)	339		$189,349
Overtopping Reinforcement Mat (SY)	150000	$3.50	$525,000
Mobilization and Clearing/Grubbing	lump sum		$380,000
Engineering, Admin, Meetings (15%)	lump sum		$1,609,930
Contingencies (25% of Construction)	lump sum		$536,643
Total Conceptual Cost			**$12,879,440**

Table 20. Alternative 2A Concept Level Costs

Item Description	Quantity	Unit Cost	Cost
Wetland Impact (acres)	105	$ 3,000.00	$314,785
Embankment Fill (CY)	929657	$4.00	$3,718,629
Road Raise Fill (CY)	38842	$ 4.00	$155,368
Class IV Aggregate Surfacing (ton)	50000	$14.00	$700,000
Channel/Ditch Cut (CY)	3184651	$ 1.75	$5,573,139
Hydraulic Structures	22		$3,288,800
Riprap and Armorflex (CY)	4166		$585,286
ROW (acres)	1000	$750.00	$750,000
Erosion Control and Seeding Cost (acres)	565		$308,775
Overtopping Reinforcement Mat (SY)	150000	$3.50	$525,000
Mobilization and Clearing/Grubbing	lump sum		$400,000
Engineering, Admin, Meetings (15%)	lump sum		$2,447,967
Contingencies (25% of Construction)	lump sum		$815,989
Total Conceptual Cost			**$19,583,738**

Table 21. Alternative 2A' Concept Level Costs

Item Description	Quantity	Unit Cost	Cost
Wetland Impact (acres)	91	$ 3,000.00	$273,925
Embankment Fill (CY)	740124	$4.00	$2,960,496
Road Raise Fill (CY)	38842	$ 4.00	$155,368
Class IV Aggregate Surfacing (ton)	50000	$14.00	$700,000
Channel/Ditch Cut (CY)	1998844	$ 1.75	$3,497,977
Hydraulic Structures	20		$2,692,600
Riprap and Armorflex (CY)	3016		$414,886
ROW (acres)	1000	$750.00	$750,000
Erosion Control and Seeding Cost (acres)	441		$243,766
Overtopping Reinforcement Mat (SY)	135000	$3.50	$472,500
Mobilization and Clearing/Grubbing	lump sum		$400,000
Engineering, Admin, Meetings (15%)	lump sum		$1,884,228
Contingencies (25% of Construction)	lump sum		$628,076
Total Conceptual Cost			**$15,073,820**

13 Recommendations

The Roseau Lake Rehabilitation Project will use embankments, exterior drainage ditches, weirs, and gate operation to change the timing of how Roseau Lake fills for wildlife enhancement, peak flow reductions, and reduce peak flows in the Roseau River. The Project also improves aquatic habitat conditions by creating a seasonal pool for Natural Resource Enhancement.

The following characteristics were reviewed for Alternatives 1, 2A, and 2A':

- Hydraulic results
- Compatibility with the project goals, and
- Overall project cost

Alternative 2A' is the recommended alternative because it is the least cost option that is compatible with the stated project goals and provides for operational flexibility to benefit surrounding landowners.

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Appendix A

Roseau Lake Rehabilitation

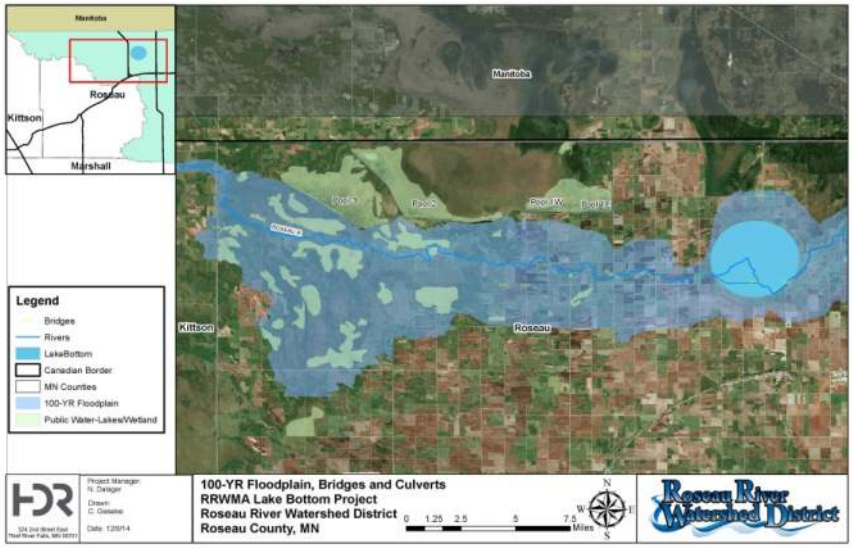
Purpose and Need

July 14, 2016

Problem Statement

Habitat loss and degradation - Roseau Lake was historically an important lake basin which provided a diversity of habitats for many aquatic mammals, birds, fish, amphibians, and reptiles. The lake was almost completely drained in 1914 when the Roseau River was channelized and a legal ditch system was created through the lake basin. The lake basin area now functions as a lake only when Roseau River flows reaches a moderate flood level (~800 cfs) and is dry during most months of each year.

Most of the lake basin and surrounding upland areas are part of a MN DNR Wildlife Management Area. The area provides shallow water, wetland, and associated upland habitats that are substantially degraded compared to historic conditions. The temporary and inconsistent presence of a pool combined with frequent bounce has led to generally undesirable plant communities dominated by annual species and invasive plants with relatively low wildlife habitat value. There is no current capacity to maintain a permanent pool or to manage water levels to reduce bounce, improve plant communities, and restore shallow lake functions.



The channelization work also resulted in lost stream habitats near the lake. Specifically, a 3.2 mile long segment of channel that previously flowed through the lake basin was diverted through a ditch and the channel has now been abandoned

expect during higher flows. This is a direct loss of stream channel that could provide habitat for fish.

Flood Damage Reduction - The areas near and downstream of the Roseau Lake are subject to relatively frequent and severe inundation by flood waters. Damages from these floods occur during a wide range of flood events and result in crop losses and damages to roads downstream of the lake. Approximately 209 miles of roads, 54 large bridges and culvert road crossings, and 74,240 acres of agricultural land are affected by a 100-year event.

The Roseau Lake currently provides about 60,000 acre-feet of flood water storage during a 100 year flood event and about 30,000 acre-feet of storage during a 50 year event; however, since the lake is filled early in a flood event, much of this storage capacity is unavailable during the peak of a flood. The lake basin begins to fill when flows in the Roseau River reach a 1.5 year event level approximately 800 cubic feet per second (cfs) at the Ross gage (USGS Gage 05107500). Since the lake fills prior to the peak, the storage capacity available during the flood peak is reduced substantially which results in higher peak flows downstream. The lake basin water levels need to be managed to pass more water downstream prior to peak flow periods so that a larger volume of the existing storage capacity is available to reduce flood damages downstream.

Purpose and Need Statement

The purpose of this project is to improve habitat conditions in the Roseau Lake and the Roseau River and to manage the available storage capacity of the lake basin to reduce flood damages near and downstream of the drained lake basin.

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
180 FIFTH STREET EAST, SUITE 700
ST. PAUL MINNESOTA 55101-1678

OCT 0 3 2016

REPLY TO
ATTENTION OF
Operations
Regulatory (2014-02233-CLJ)

Ms. Tracy Halstensgard
Roseau River Watershed District
109 3rd Avenue SW
Roseau, Minnesota 56751

Dear Ms. Halstensgard:

This letter serves as Corps of Engineers (Corps) concurrence with the purpose and need statement from the Roseau Lake Rehabilitation summary dated July 14, 2016, as part of the Flood Damage Reduction (FDR) Project Development and Clean Water Act (CWA) Section 404 merger process for the proposed Roseau Lake Rehabilitation project. The summary that was received by our Bemidji field office on August 2, 2016, identifies habitat degradation resulting from drainage within Roseau Lake as well as flood damages that occur as a result of Roseau Lake filling with water early in a flood event. The purpose of the overall project is to improve habitat conditions in the Roseau Lake and Roseau River and to manage the available storage capacity of the lake basin to reduce flood damages near and downstream of the drained lake basin. The project location is in Roseau County, Minnesota.

As a result of our review of the Roseau Lake Rehabilitation summary, we concur with the proposed project purpose. The project purpose would be used in our analysis of practicable alternatives in the scoping document(s) and other supplemental material, in accordance with the CWA Section 404 (b)(1) Guidelines, and would ultimately guide our decision regarding the range of alternatives that should be carried forward for further analysis. Concurrence Point 1 for project purpose has therefore been satisfied for our review of the Roseau Lake Rehabilitation project.

The next step of the FDR/Section 404 merger process would involve an initial screening of alternatives and determining which alternatives would be carried forward for further analysis. The Corps would evaluate practicable alternatives that would meet the overall project purpose. A practicable alternative is defined as one that is capable of being done after taking into consideration cost, existing technology, and logistics in light of the overall project purpose.

We are requesting you to provide detailed information regarding the evaluation and dismissal of alternatives as either not practicable or more environmentally damaging than the alternatives that were retained for further evaluation. The primary screening criteria should be the ability of each alternative to meet the project purpose. Secondary criteria may include environmental impacts and the practicability of each alternative. Please see the Corps Concurrence Point Guidance (December 2011) in the Red River Basin Project Team Handbook for examples.

Operations
Regulatory (2014-02233-CLJ)

If you have any questions, please contact Craig Jarnot in our Bemidji Regulatory field office at (651) 290-5337. In any correspondence or inquiries, please refer to the Regulatory number shown above.

Sincerely,

Chad S. Konickson
Chief, Regulatory Branch

Cf: Nate Dalager, HDR Engineering, Inc.
Henry Van Offelen, MNDNR

Roseau Lake Concurrence Point 2

(May 4, 2017)

The Roseau River Watershed District (RRWD) has established a project team to develop a multipurpose project to rehabilitate Roseau Lake. The project team has established the following purpose and need statement:

> *The purpose of this project is to improve habitat conditions in the Roseau Lake and the Roseau River and to manage the available storage capacity of the lake basin to reduce flood damages near and downstream of the lake basin.*

The U.S. Army Corps of Engineers concurred with this purpose and need statement on October 3, 2016. 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 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 further for further review. The first screening evaluates a "do nothing" alternative and the four flood damages reduction "measures" described in Technical Paper 11. In this first screening, each of these alternatives was evaluated in the context of the purpose and need which has both flood damage reduction and natural resource components. No other alternatives were identified by any member of the project team during the screening process.

INITIAL SCREENING OF ALTERNATIVES

Alternative 1: Do nothing.

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

Rationale: Under current conditions the shallow lake habitats in the lake basin are degraded and the water storage provided when the lake fills is timed early in the flood hydrograph (prior to the peak). Selection of the do nothing alternative would not change this condition. The plant communities in the lakes basin area would continue to be dominated by plants that are tolerant of large water level fluctuations and long periods of inundation which provide relatively poor habitat. Water levels could not be managed to promote better plant communities or provided shallow water habitats during migration. Water storage under this alternative would continue to be timed early in the flood peak.

Alternative 2: Reduce runoff volume.

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

Rationale: The volume of runoff reaching Roseau Lake in a runoff event can contribute to degraded habitat conditions. In any given runoff event, a larger volume of runoff will result in a larger water level fluctuation and a longer duration of inundation which degrades habitat conditions. Reducing runoff volume has the potential to contribute to improved habitat conditions in the basin; however, there is no practicable way to achieve substantial runoff reduction and runoff reduction on its own will not result in active water level management in the basin.

While implementing activities upstream of Roseau Lake has some potential to reduce runoff volumes, their potential is limited by practical and logistical constraints. It is unlikely that any of these activities could be implemented in sufficient quantity to reduce inflows to achieve the purpose and need.

Runoff reduction in the lake's watershed could only be accomplished by increase evapotranspiration through land use change and reduction in surface drainage. Roseau Lake has a large drainage area (1,085 square miles) with the Roseau River contributing 640 square miles. Approximately 40% of the Roseau River watershed already is in public ownership, another 20% of the contributing area is enrolled in the Conservation Reserve Program. Changing land use on these remaining lands within the watershed are unlikely and since a large portion of the watershed already is in a natural condition, the amount of runoff reduction would be relatively small.

Alternative 3: Increase Conveyance:

Decision: This alternative does not meet purpose and need.

Rationale: Increasing conveyance through the lake basin area would result in increased flood peaks downstream and would not result in improved water level management within the lake basin.

Alternative 4: Increase temporary flood storage.

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

Rationale: Increasing temporary flood storage in the lake basin could be accomplished by establishing infrastructure to better manage water which enters and leaves the basin. Creating the ability to manage water would provide management options to improve habitat conditions within the basin and would provide options to pass water downstream early in the flood and more effectively use the available water storage.

Alternative 5: Avoidance and Protection.

Decision: This alternative was considered and rejected because it will not meet the purpose and need.

Rationale: Avoidance and protection related strategies will not improve habitat conditions in the lake basin. Applying this strategy to private agricultural lands in this area by building embankments would substantially reduce floodplain storage and increase flood peaks downstream.

SECONDARY SCREENING OF ALTERNATIVES

The preliminary engineers report outlined three general "scenarios" which fit under the Alternative 4 category above - "increase temporary flood storage". 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.

The following review includes an expanded set of nine alternatives compared to the three scenarios presented in the preliminary engineer's report. The scenarios presented in the preliminary engineer's report included three combinations of six different embankments (Figures 1 and 2). This alternatives analysis is based on the full range of alternatives using the embankment to create a series of nine alternatives (Table 1, Appendix A).

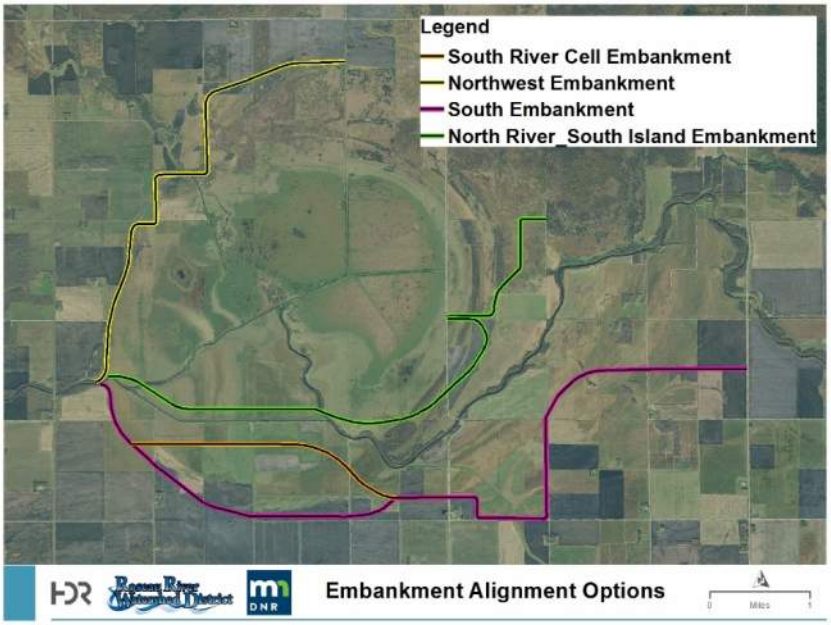


Figure 1. Embankment alignment options including the south river cell embankment, northwest embankment, south embankment, and north river south island embankment.

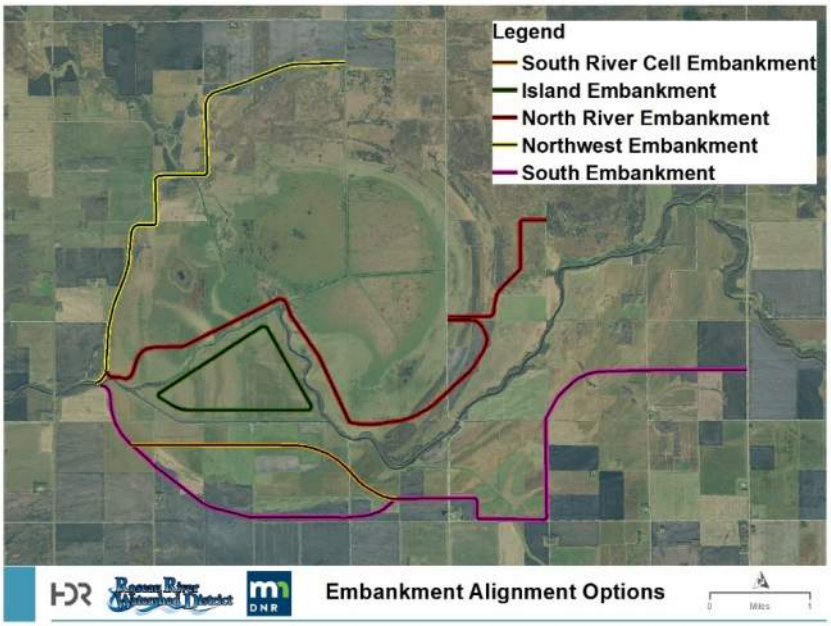


Figure 2. Embankment alignment options including the south river cell embankment, island embankment, north river embankment, northwest embankment, and south embankment

Table 1. List of alternatives considered based on configuration of embankments.

	Embankments Included in Option					
Alternatives	**Northwest**	**South**	**North River**	**North River/ South Island**	**Island**	**South River Cell**
1	x		x			
1a	x			x		
2	x	x				
2a	x	x	x			
2b	x	x		x		
2c	x	x	x		x	
2d	x	x	x			x
2e	x	x	x		x	x
2f	x	x		x		x

EVALUATION OF ARRAY OF ALTERNATIVES:

Alternative 1: Northwest and North River Embankments. This alternative provides for management of a pool within portions of the original lake basin.

Decision: *Carried forward*.

Rationale: This alternative has the potential to meet the purpose and need by potentially providing some habitat improvement to the Roseau Lake bed and flood reduction benefits.

Alternative 1a: Northwest and North River South Island Embankments. This alternative enlarges the pool area and disconnects the natural river channel.

Decision: *Not carried forward*.

Rationale: This alternative requires a structure in the river channel resulting in river channel habitat loss, which conflicts with the project purpose. There is also an increased potential flooding of the island area since it would be included in the flood pool area.

Alternative 2: Northwest and South Embankments. This alternative likely returns this lake basin outlet to something similar to its historic condition. Given current hydrologic conditions and the river channel this alternative without outlet controls would result in a lake that fills and drains in a manner similar to its current condition without a project. This alternative with outlet controls could result in flooding of the entire lake basin and surrounding private lands.

Decision: *Not carried forward*.

Rationale: Does not meet purpose and need. Alternative 2 increases local flooding risks locally and does not increase the ability to manage water levels in a confined pool area to meet wildlife habitat goals.

Alternative 2a: Northwest, South, and North River Embankments. This alternative provides for management of water levels within a large portion of the lake basin, maintains river channel connectivity, and creates a confined area of floodplain storage

Decision: *Carried forward*.

Rationale: This alternative has the potential to meet the purpose and need and requires further analysis.

Alternative 2b: Northwest, South, and North River/S. Island Embankments. This alternative increases the lake pool area and disconnects the river channel.

Decision: *Not carried forward*.

Rationale: This alternative requires a structure in the river channel resulting in river channel habitat loss, which conflicts with the project purpose. There is also an increased potential flooding of the island area.

Alternative 2c: Northwest, South, North River, and Island Embankments. This alternative adds an embankment around the island to alternative 2a.

Decision: *Carried forward*.

Rationale: This alternative has the potential to meet the purpose and need and requires further analysis.

Alternative 2d: Northwest, South, North River, and South River Cell. This alternative adds an embankment to alternative 2a which creates a separate water storage cell south of river.

Decision: *Carried forward*. Rationale: This alternative has the potential to meet the purpose and need and requires further analysis.

Alternative 2e: Northwest, South, North River embankment with Island and South River Cell. This alternative adds embankment to alternative 2a which creates separate water storage cells within the island and south of the river.

Decision: *Carried forward*.

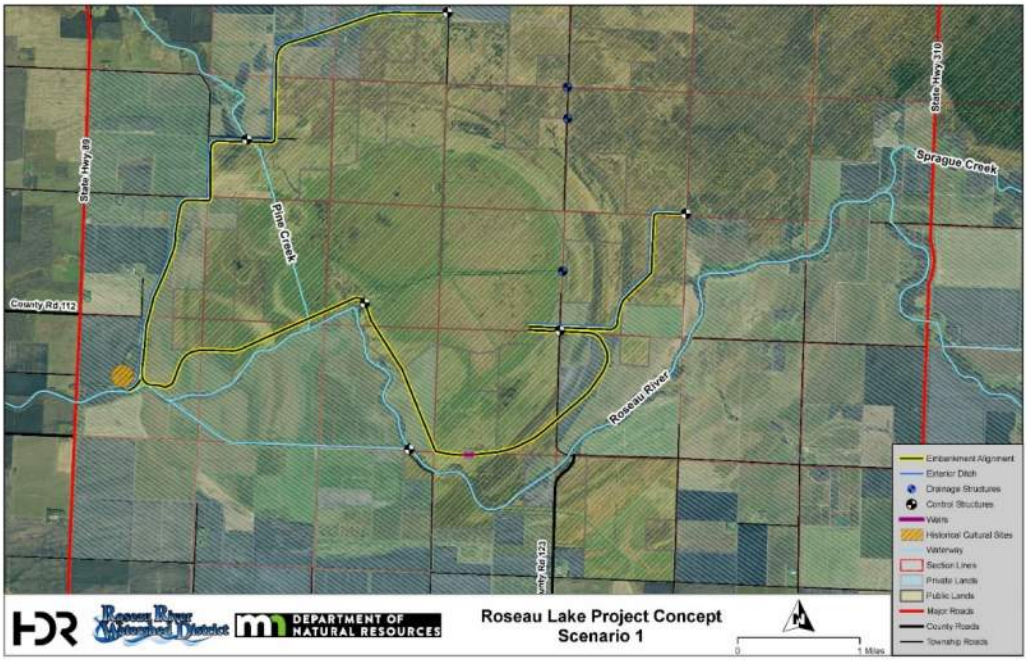
Rationale: This alternative has the potential to meet the purpose and need and requires further analysis.

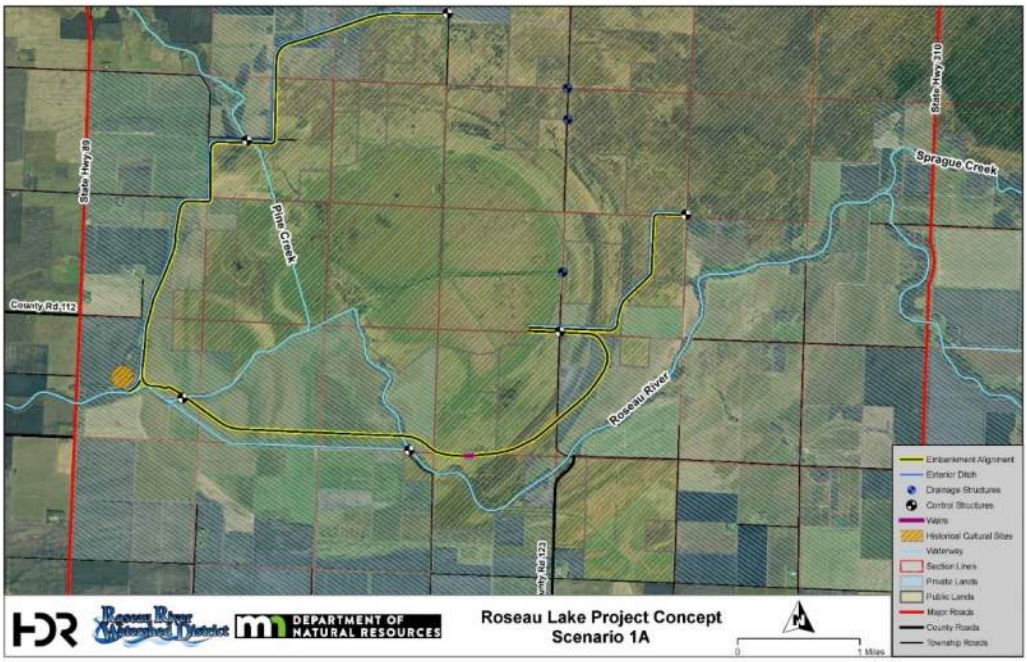
Alternative 2f: Northwest, South, North River/south island embankment with Island and South River cells. This alternative adds embankment to alternative 2 which creates separate water storage cells within the island and south of the river.

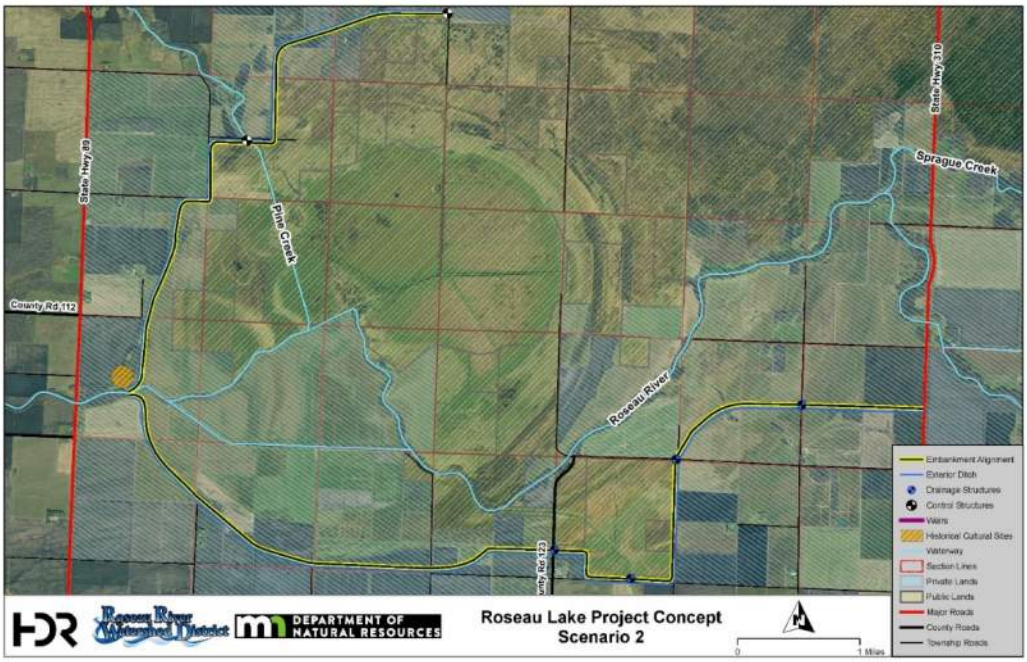
Decision: *Not carried forward*.

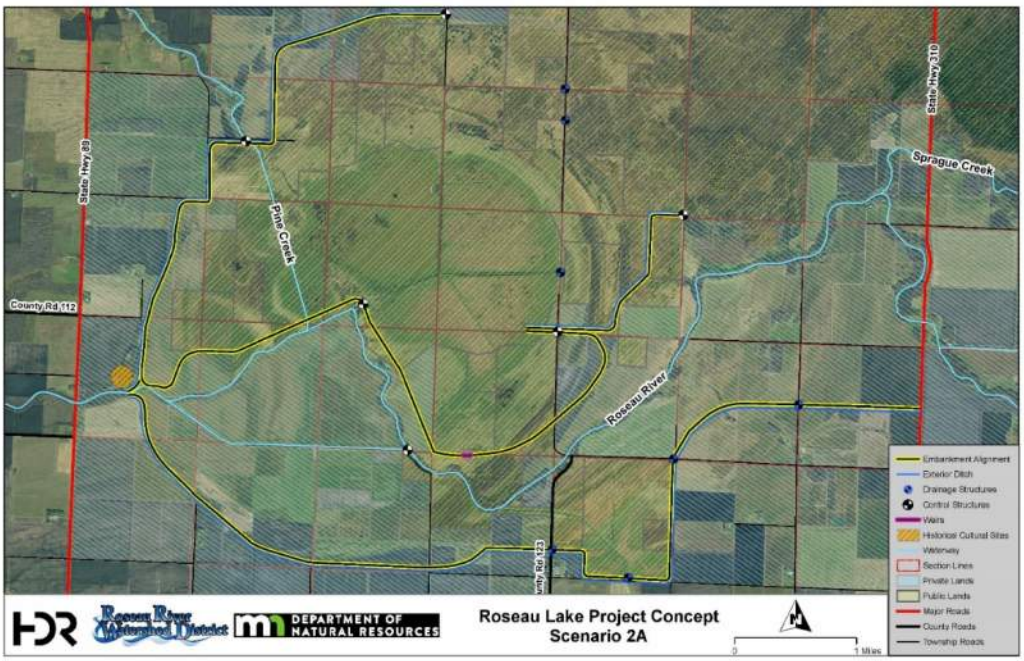
Rationale: This alternative requires a structure in the river channel resulting in river channel habitat loss, which conflicts with the project purpose. There is also an increased potential flooding of the island area.

Appendix A. Maps of nine alternatives considered in Concurrence Point 2






State Hwy 89
State Hwy 310
Sprague Creek
Pine Creek
County Rd 112
Roseau River
Embankment Alignment
Exterior Ditch
Drainage Structures
Control Structures
Weirs
Historical Cultural Sites
Waterway
Section Lines
Private Lands
Public Lands
Major Roads
County Roads
Township Roads
DEPARTMENT OF NATURAL RESOURCES
Roseau Lake Project Concept
Scenario 2
0
1 Miles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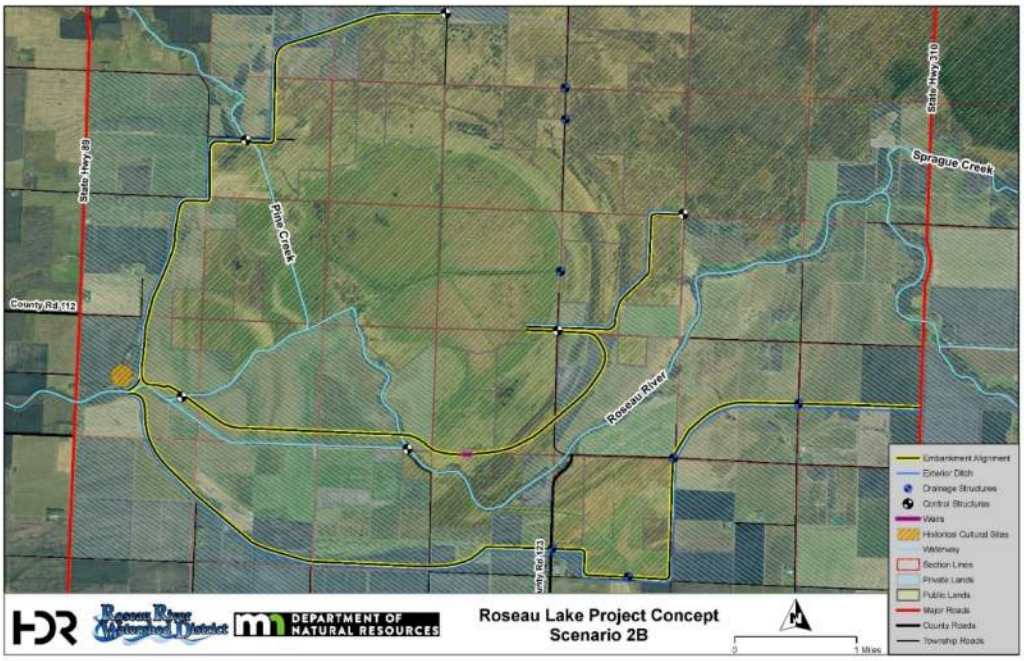
State Hwy 310
Sprague Creek
Pine Creek
County Rd 112
Roseau River
Embankment Alignment
Exterior Ditch
Drainage Structures
Control Structures
Weirs
Historical Cultural Sites
Waterway
Section Lines
Private Lands
Public Lands
Major Roads
County Roads
Township Roads
DEPARTMENT OF NATURAL RESOURCES
Roseau Lake Project Concept
Scenario 2A
0
1 Miles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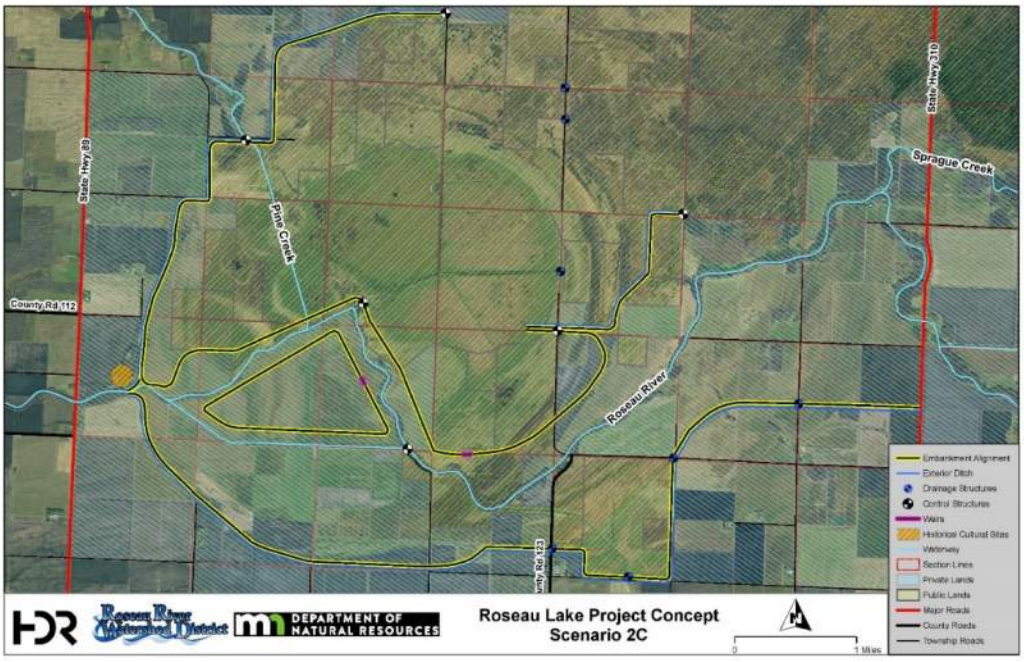
State Hwy 310
Sprague Creek
Pine Creek
County Rd 112
Roseau River
County Rd 123
Embankment Alignment
Exterior Ditch
Drainage Structures
Control Structures
Weirs
Historical Cultural Sites
Waterway
Section Lines
Private Lands
Public Lands
Major Roads
County Roads
Township Roads
DEPARTMENT OF NATURAL RESOURCES
Roseau Lake Project Concept
Scenario 2B
0
1 Miles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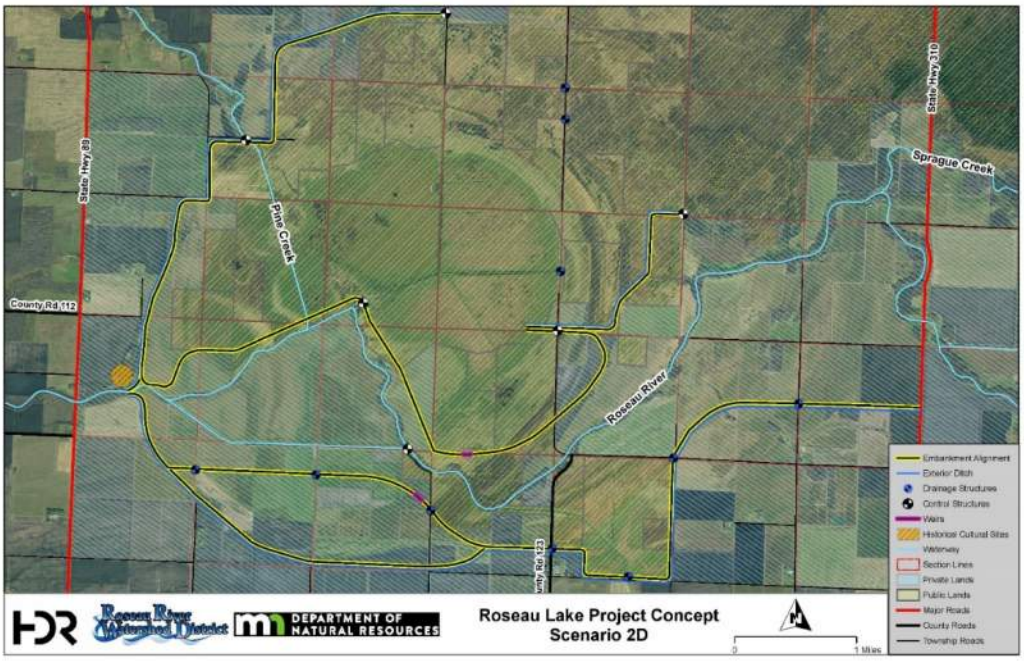
Pine Creek
County Rd 112
Roseau River
County Rd 123
Embankment Alignment
Exterior Ditch
Drainage Structures
Control Structures
Weirs
Historical Cultural Sites
Waterway
Section Lines
Private Lands
Public Lands
Major Roads
County Roads
Township Roads
DEPARTMENT OF NATURAL RESOURCES
Roseau Lake Project Concept
Scenario 2C
0
1 Miles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Sprague Creek
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Roseau River
County Rd 123
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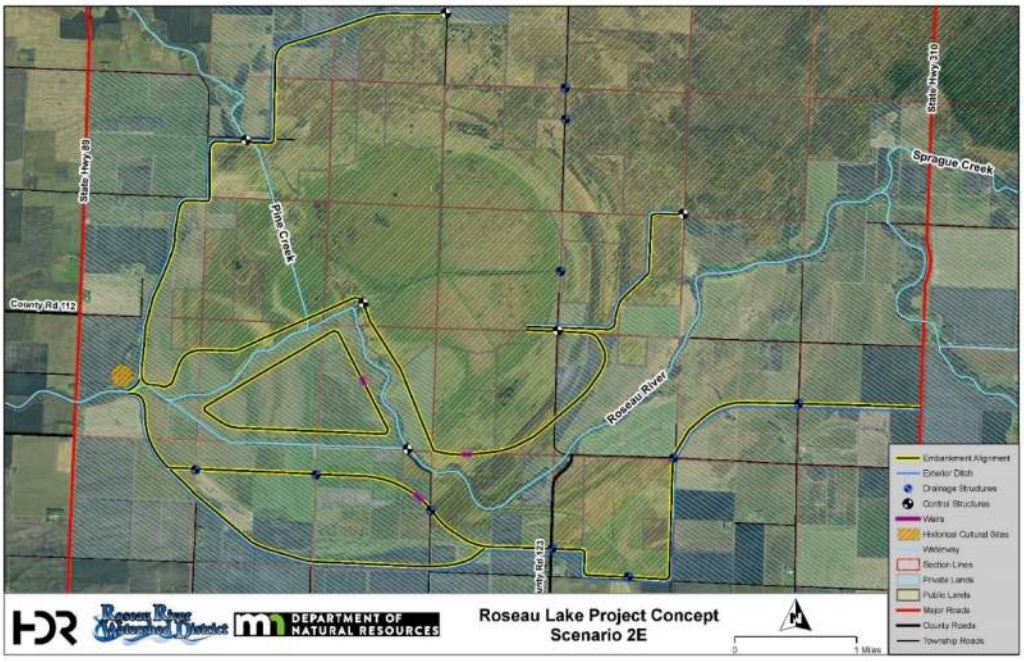
Drainage Structures
Control Structures
Weirs
Historical Cultural Sites
Waterway
Section Lines
Private Lands
Public Lands
Major Roads
County Roads
Township Roads
DEPARTMENT OF NATURAL RESOURCES
Roseau Lake Project Concept
Scenario 2D
0
1 Miles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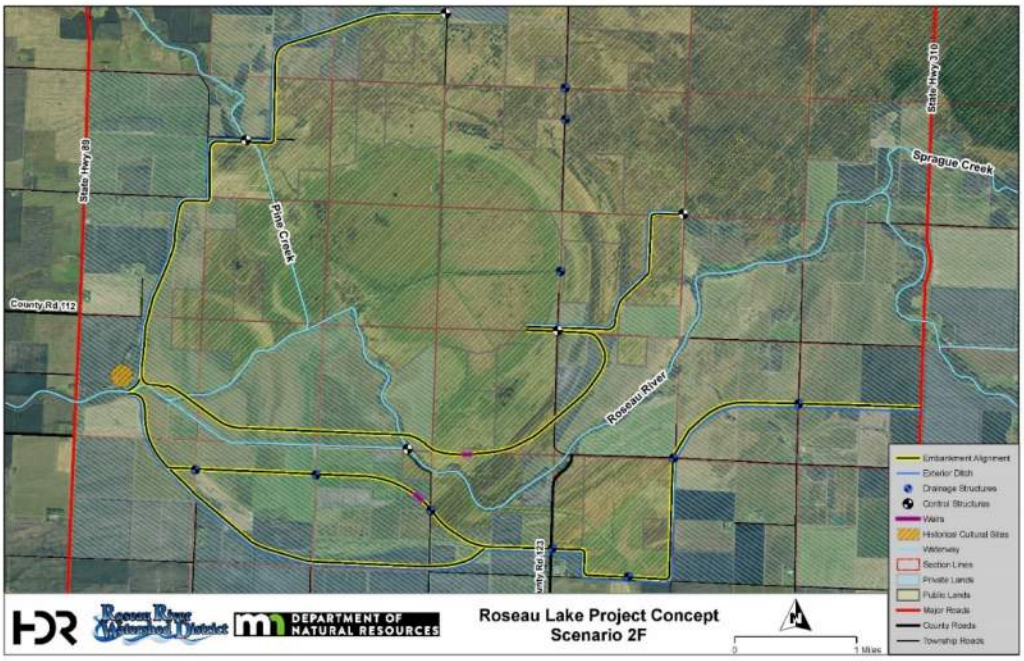
State Hwy 310
Sprague Creek
Pine Creek
County Rd 112
Roseau River
County Rd 123
Embankment Alignment
Exterior Ditch
Drainage Structures
Control Structures
Weirs
Historical Cultural Sites
Waterway
Section Lines
Private Lands
Public Lands
Major Roads
County Roads
Township Roads
DEPARTMENT OF NATURAL RESOURCES
Roseau Lake Project Concept
Scenario 2E
0
1 Miles


State Hwy 89
State Hwy 310
Sprague Creek
Pine Creek
County Rd 112
Roseau River
County Rd 123
DEPARTMENT OF NATURAL RESOURCES
Roseau Lake Project Concept
Scenario 2F
0
1 Miles
Embankment Alignment
Exterior Ditch
Drainage Structures
Control Structures
Weirs
Historical Cultural Sites
Waterway
Section Lines
Private Lands
Public Lands
Major Roads
County Roads
Township Roads

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
180 FIFTH STREET EAST, SUITE 700
ST. PAUL, MN 55101-1678

REPLY TO ATTENTION OF
REGULATORY BRANCH

Regulatory File No. 2014-02233-CLJ

JUL 2 4 2017

Ms. Tracy Halstensgard
Roseau River Watershed District
109 3rd Avenue SW
Roseau, Minnesota 56751

Dear Ms. Halstensgard:

This letter serves as Corps of Engineers (Corps) concurrence with the preliminary list of alternatives and the alternatives carried forward identified in the Roseau Lake Concurrence Point 2 submittal (CP2 submittal) dated June 15, 2017, as part of the Flood Damage Reduction (FDR) Project Development and Clean Water Act (CWA) Section 404 merger process for the proposed Roseau Lake Project. The CP2 submittal identifies five alternatives which will be carried forward for additional analysis. The CP2 submittal also includes strategies and measures that were assessed but not carried forward for further analysis due to those strategies and measures not meeting the purpose and need of the project, having substantial environmental effects, or not being practicable to accomplish. The project location is in Roseau County, Minnesota.

As a result of our review of the project investigation, we concur with the five alternatives presented for further analysis. These alternatives include:

1. Alternative 1: Northwest and north embankments
2. Alternative 2a: Northwest, south, and north river embankments
3. Alternative 2c: Northwest, south, north river, and island embankments
4. Alternative 2d: Northwest, south, north river, and south river cell
5. Alternative 2e: Northwest, south, north river embankment with island, and south river cell

The next step of the FDR/Section 404 merger process would involve an in-depth analysis for each alternative identified above which compares the direct, indirect, and cumulative effects on the aquatic ecosystem to aid in the identification of your selected alternative or alternatives that meet the project purpose and need. Sufficient information must be provide to demonstrate that your selected alternative avoids impacts to the aquatic ecosystem to the greatest extent practicable. It is our responsibility to determine whether the selected alternative or alternatives represent the least environmentally damaging practical alternative.

We are requesting you provide the in-depth analysis for each alternative and the identification of your selected alternative. Please see the Corps Concurrence Point Guidance (December 2011) in the Red River Basin Project Team Handbook for examples.

Regulatory Branch (File No. 2014-02233-CLJ)

If you have any questions, please contact Craig Jarnot in our Bemidji Regulatory field office at (651) 290-5337. In any correspondence or inquiries, please refer to the Regulatory number shown above.

Sincerely,

Chad Konickson
Chief, Regulatory Branch

cc: Nate Dalager, HDR Engineering, Inc.
Matt Johnson, BWSR
Randy Prachar, MNDNR

Concurrence Point No. 3: Alternatives Analysis: Roseau Lake Rehabilitation Project

Introduction/Background

The Roseau River Watershed District Board (RRWD) established a Project Team for the Roseau Lake Area to develop a multipurpose project addressing natural resource and flooding problems. The Roseau Lake Project Team (RL PT) process was aligned with the 1998 MN Mediation Agreement (http://www.rrwmb.org/files/FDRW/FDRAGMT.pdf) and the U.S. Army Corps of Engineers Section 404 Concurrence Points Guidance (U.S. Army Corps of Engineers, St. Paul District December, 2009), 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 Strategy Elimination), is intended to describe and document Concurrence Point #3. Concurrence Point #3 identifies potential options associated with the primary strategies carried forward from Concurrence Point #2, further analyzes and refines those options, and identifies a preferred option for recommendation to the Roseau River Watershed Board of Directors.

The RL PT 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: Oct. 3, 2016)

The RRWD established the RL PT to provide an environmental, economic, and socially acceptable solution to address flood damage reduction and natural resource concerns and opportunities related to the Roseau Lake Area. The RL PT established the project purpose as:

> *The purpose of this project is to improve habitat conditions in the Roseau Lake and the Roseau River and to manage the available storage capacity of the lake basin to reduce flood damages near and downstream of the lake basin.*

Alternatives Carried Forward (from Concurrence Point #2 Received: July 24, 2017).

The Roseau Lake Project Team in coordination with Craig Jarnot, Army Corps of Engineers, Bemidji, MN evaluated the range of alternatives/strategies to address the project Purpose and Need (Figure 1). The alternatives identified during this process were:

> **Alternative 1**: Northwest and North River Embankments. This alternative provides for management of a pool within portions of the original lake basin therefore has the potential to meet the purpose and need by providing some habitat improvement to the Roseau Lake bed and flood reduction benefits.

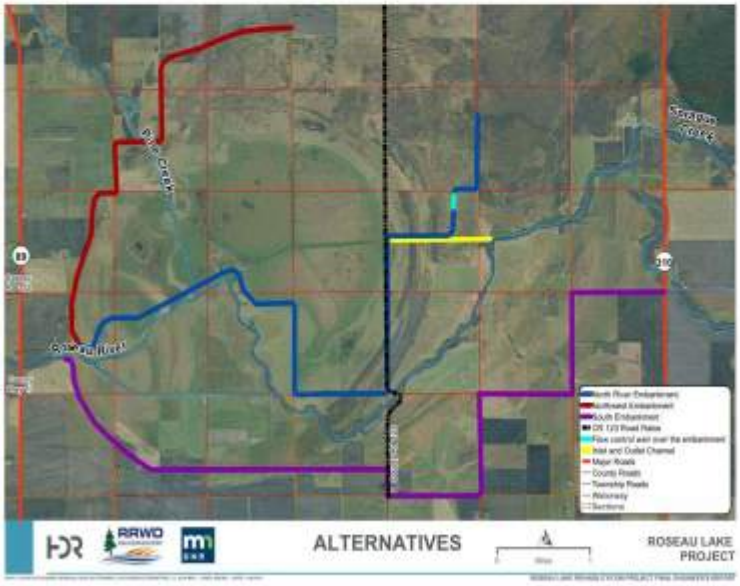
Alternative 2a: Northwest, South, and North River Embankments. This alternative provides for management of water levels within a large portion of the lake basin, maintains river channel connectivity, and creates a confined area of floodplain storage. This alternative has the potential to meet the purpose and need and requires further analysis.

Alternative 2c: Northwest, South, North River, and Island Embankments. This alternative adds an embankment around the island to alternative 2a therefore has the potential to meet the purpose and need and requires further analysis.

Alternative 2d: Northwest, South, North River, and South River Cell. This alternative adds an embankment to alternative 2a which creates a separate water storage cell south of river. This alternative has the potential to meet the purpose and need and requires further analysis.

Alternative 2e: Northwest, South, North River embankment with Island and South River Cell. This alternative adds embankment to alternative 2a which creates separate water storage cells within the island and south of the river. This alternative has the potential to meet the purpose and need and requires further analysis.

Figure 1. Map of Roseau Lake area that includes embankments and other features associated with the Roseau Lake rehabilitation Project Alternatives.



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Note that the specific alignments of the embankments and the inlet structure have undergone detailed review since Concurrence Point 2. This review has reduced wetland impacts associated with the embankments and a realignment of the inlet to reduce wetland impacts.

Overview of Conceptual Operating Plan

A general understanding of the operating plan is needed to evaluate and compare the potential effects of the alternatives on the Roseau Lake area and the Roseau River. This section describes the general plan for operating this project which will be subject to final approval by the project team, watershed district board, and permitting authorities (e.g State of Minnesota).

Roseau Lake Water Management

The conceptual plan for operations of Roseau Lake include establishment of a winter, spring, summer, and fall pools with planned drawdown periods (Table 1). This basic water level management plan should increase the quantity and quality of wildlife habitat provided by the Roseau Lake compared to current conditions while providing improved management of the existing 60,000 acre-feet of flood storage during 100-year frequency spring floods. Final water levels will be established as the project moves through final development and permitting.

Table 1. Conceptual plan for operation of Roseau Lake rehabilitation project. (Note: this conceptual plan will be subject to review and future final approvals and agreements within the project team, watershed district board, and permitting authorities).

Time Period	Operations
December to spring event (typically April when flows reach 1,990 cfs)	Winter pool maintained. All water bypasses pool.
Spring Runoff Event	Pool begins to fill through (an) inlet(s) or by overtopping north river embankments depending on alternative. In large events, water is held throughout entire area. All embankments would be overtopped at elevation 1036.0.
Post-spring event drawdown	Pool is drawn down to summer pool elevation of ≤1028.0. Water levels in the Roseau River downstream will remain higher than existing conditions.
Summer	Pool maintained at elevation ≤1028.0.
Summer events	Pool begins to fill through (an) inlet(s) or by overtopping north river embankments depending on alternative selected.
Fall	Pool allowed to flood up to 1030.5.
Fall-to-winter drawdown	Pool draw down to elevation ≤1026.0.

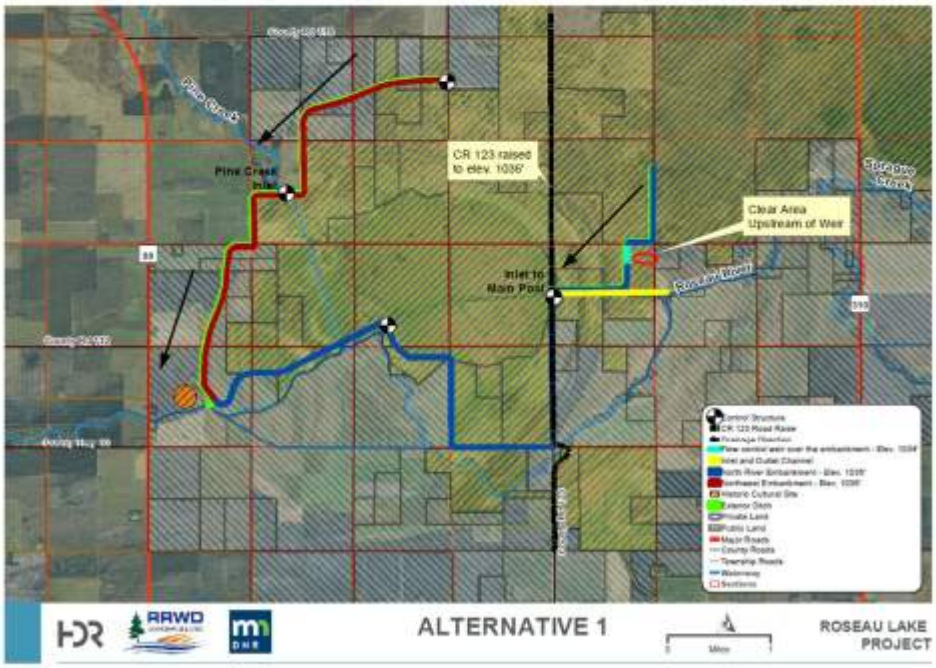
Roseau River Water Management

Water management through the existing Roseau River channel and the ditch cutoff channel will be modified by construction of a fixed rock weir with multiple box culvert crossings placed in the existing cutoff channel. Currently, most flow is diverted through the ditch channel and water only flows in the historic channel during high flows. Operation of this project will reverse this situation. All flow below 500 cfs will be diverted into the historic channel. At discharges above 500 cfs, the water flow will be split between the cutoff channel and the historic channel. For example, at 1,400 cfs 75% of the flow would be diverted through the historic channel. In large events, the entire area would be inundated as it is currently.

Detailed description of alternatives

Additional details of the conceptual design and operation features of each alternative are provided in this section to help evaluate the environmental effects and the degree to which each alternative is expected to meet project natural resource and flood damage reduction objectives.

Alternative 1:



4

Structural elements:

1. Northwest and North River Embankments aligned as indicated in Figure 1 at an elevation of 1036 feet. The total length of embankment is 13.25 miles, average height is 1.34 feet above ground, and average width is 24.9 feet resulting in an embankment footprint of 42.2 acres and 541,000 cubic yards of fill.
2. Ditches located parallel to the North River Embankment, parallel to the Northwest Embankment, and the inlet/outlet ditch. The total length of the ditches is 12.76 miles, ditch footprint of 144 acres, and cut volume of 2,153,013 cubic yards.
3. Roseau River Inlet. This alternative requires construction of an inlet which is proposed for the eastern portion of the north river embankment. Preliminary design consists of a trapezoidal channel with a 100 foot bottom width and 5H:1V side slopes from the Roseau River to the main pool. The inlet structure is located at CR 123 and is composed of eight 8′ x 6′ RCB box culverts with sluice gates. If the Roseau River rises faster than flow through the gated inlet can fill the main pool then a 1,000 foot long weir along the east side of the project will allow flood flows to enter the main pool.
4. County Road 123 will be raised to elevation 1036 with equalizer box culverts installed to the north of the inlet structure to convey flow through the raised road.

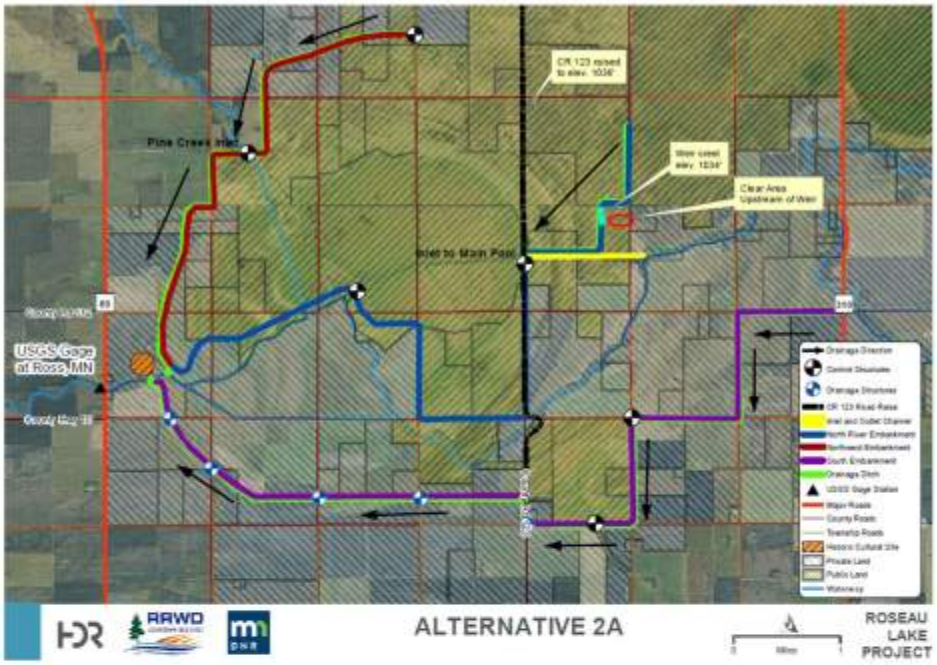
Operation Concept:

This alternative follows the general operating concept sending early flow downstream to save main pool capacity to reduce the Roseau River peak for a range of events. Water flows into the impoundment through the inlet channel and inlet weirs. Pine Creek low flows are diverted around the main pool by the Northwest Embankment and parallel ditch to provide increased storage for Roseau River flow and provide gravity drainage around the main pool. Because there is no dike on the south side of the river to contain breakout flows on the river, the inlet channel may operate more frequently than any of the alternatives in the 2 series. The upshot of such operation is that the main pool would fill earlier in a given flood event and more frequently within a given year than alternatives in the 2 series.

Key issues comparing this alternative to other alternatives:

1. Embankment footprint wetland impacts are comparable to that of alternative 2a.
2. Limited capacity to manage summer water levels in pool. Increased risks of large water level fluctuations in order to manage FDR south of the river.
3. Flooded areas on the south side of the project are not as clearly defined compared to alternatives with a southern embankment.

Alternative 2a:



Structural elements:

1. Northwest, South, and North River Embankments aligned as indicated in Figure 1 at an elevation of 1036 feet. Total length of embankment is 22.55 miles, average height is 1.39 feet above ground, and average width is 25.1 feet resulting in an embankment footprint of 71.9 acres and 930,000 cubic yards of embankment fill.
2. Ditches located parallel to the North River Embankment, parallel to the Northwest Embankment, South Embankment, and the inlet/outlet ditch. The total length of the ditches is 22.2 miles, ditch footprint of 251 acres, and cut volume of 3,709,000 cubic yards.
3. Roseau River Inlet. This alternative requires construction of an inlet which is proposed for the eastern portion of the north river embankment. Preliminary design consists of a trapezoidal channel with a 100 foot bottom width and 5H:1V side slopes from the Roseau River to the main pool. The inlet structure is located at CR 123 and is composed of eight 8' x 6' RCB box culverts with sluice gates. If the Roseau River rises faster than flow through the gated inlet can fill the main pool then a 1,000 foot long weir along the east side of the project will allow flood flows to enter the main pool.
4. County Road 123 will be raised to 1036 with equalizer box culverts installed to the north of the inlet structure to convey flow through the raised road.

Operation Concept:

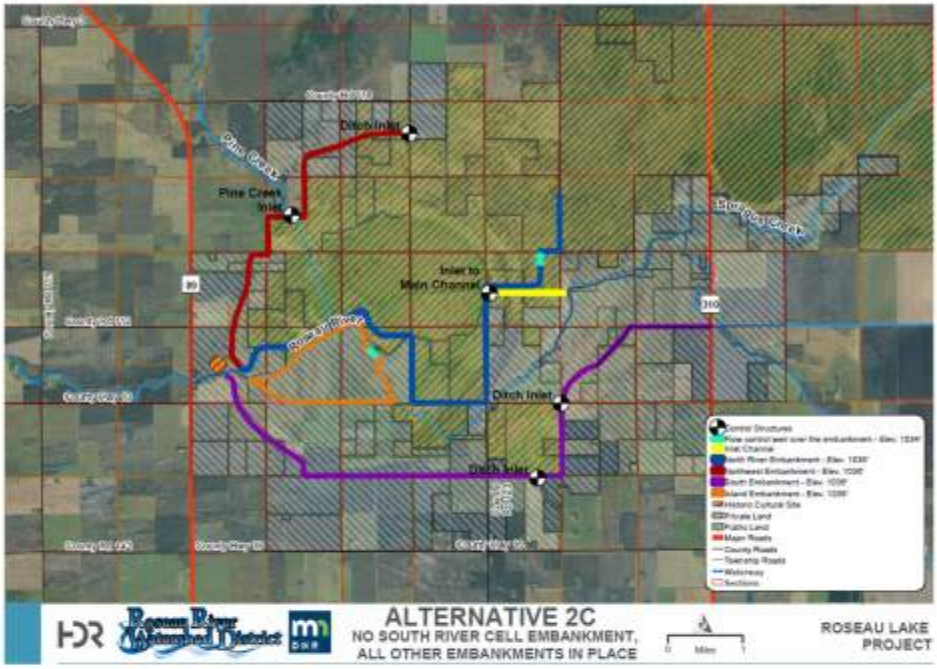
This alternative follows the general operating concept sending early flow downstream to reserve the main pool capacity for storage to reduce the Roseau River peak. Water flows into the impoundment through the inlet channel and inlet weirs. Pine Creek low flows are diverted around the main pool by the Northwest Embankment and parallel ditch to provide increased storage for Roseau River flow and provide gravity drainage around the main pool. The South Embankment keeps the Roseau River from flooding land to the south. A ditch parallel to the South Embankment is included to convey surface runoff and West Intercept Ditch flow so local flood damages are reduced south of the embankment. The Northwest Embankment and South Embankment are intended to reduce flooding adjacent to the main pool.

Following the flood peak the water level in the main pool would be managed for wildlife enhancement purposes.

Key issues comparing this alternative to other alternatives:

1. Embankment footprint wetland impacts are comparable to that of Alternative 1.
2. Optimal FDR management provided near-basin.
3. Full range of water level management options afforded by this alternative.

Alternative 2c:



Structural elements:

1. South, Northwest, North River, and Island Embankments aligned as indicated in Figure 1 at an elevation of 1036 feet. The total length of embankment is 27.5 miles, average height is 1.45 feet above ground, and average width is 25.8 feet resulting in an embankment footprint of 89.2 acres and 1,121,000 cubic yards of fill.
2. Ditches located parallel to the North River Embankment, parallel to the Northwest Embankment, South Embankment, and the inlet/outlet ditch. The total length of the ditches is 22.2 miles, ditch footprint of 251 acres, and cut volume of 3,709,000 cubic yards.
3. Roseau River Inlet. This alternative requires construction of an inlet which is proposed for the eastern portion of the north river embankment. Preliminary design consists of a trapezoidal channel with a 100 foot bottom width and 5H:1V side slopes from the Roseau River to the main pool. The inlet structure is located at CR 123 and is composed of eight 8′ x 6′ RCB box culverts with sluice gates. If the Roseau River rises faster than flow through the gated inlet can fill the main pool then a 1,000 foot long weir along the east side of the project will allow flood flows to enter the main pool.

Operation Concept:

This alternative follows the general operating concept sending early flow downstream to save main pool capacity to reduce the Roseau River peak. Water flows into the impoundment through the inlet channel

8

and inlet weirs. Pine Creek low flows are diverted around the main pool by the Northwest Embankment and parallel ditch to provide increased storage for Roseau River flow and provide gravity drainage around the main pool. The South Embankment keeps the Roseau River from flooding land to the south. A ditch parallel to the South Embankment is included to convey surface runoff and West Intercept Ditch flow so local flood damages are reduced south of the embankment. The Northwest Embankment and South Embankment are intended to reduce flooding adjacent to the main pool.

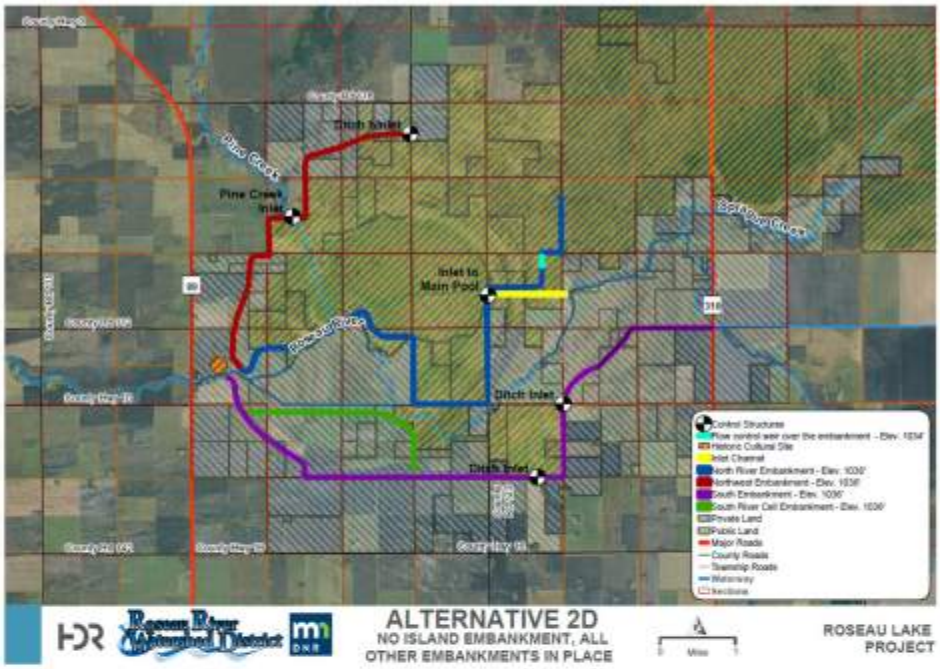
Alternative 2c includes the Island Embankment which has a weir to allow flood flows to flood the island when water levels exceed 1034. Culverts with flap gates will allow the area to drain after the Roseau River recedes.

Following the flood peak the water level in the main pool would be managed for wildlife enhancement purposes.

Key issues comparing this alternative to other alternatives:

1. Increased embankment footprint and wetland impacts compared to Alternatives 1 and 2a.
2. Potential for fish entrapment in additional cell.
3. Increased costs with minimal increase in potential flood damage reduction benefit.
4. Increased operational complexity and maintenance costs associated with multiple cells.
5. Higher construction costs and mitigation costs relative to alternatives 1 and 2a.

Alternative 2d:



Structural elements:

1. South, Northwest, North River, and South Cell Embankments aligned as indicated in Figure 1 at an elevation of 1036 feet. The total length of embankment is 22.55 miles, average height is 1.38 feet above ground, and average width is 24.9 feet resulting in an embankment footprint of 71.9 acres and 1,031,000 cubic yards of fill.
2. Ditches located parallel to the North River Embankment, parallel to the Northwest Embankment, South Embankment, and the inlet/outlet ditch. The total length of the ditches is 22.2 miles, ditch footprint of 251 acres, and cut volume of 3,709,000 cubic yards.
3. Roseau River Inlet. This alternative requires construction of an inlet which is proposed for the eastern portion of the north river embankment. Preliminary design consists of a trapezoidal channel with a 100 foot bottom width and 5H:1V side slopes from the Roseau River to the main pool. The inlet structure is located at CR 123 and is composed of eight 8′ x 6′ RCB box culverts with sluice gates. If the Roseau River rises faster than flow through the gated inlet can fill the main pool then a 1,000 foot long weir along the east side of the project will allow flood flows to enter the main pool.

Operation Concept:

This alternative follows the general operating concept sending early flow downstream to save main pool capacity to reduce the Roseau River peak. Water flows into the impoundment through the inlet channel and inlet weirs. Pine Creek low flows are diverted around the main pool by the Northwest Embankment and parallel ditch to provide increased storage for Roseau River flow and provide gravity drainage around the main pool. The South Embankment keeps the Roseau River from flooding land to the south. A ditch parallel to the South Embankment is included to convey surface runoff and West Intercept Ditch flow so local flood damages are reduced south of the embankment. The Northwest Embankment and South Embankment are intended to reduce flooding adjacent to the main pool.

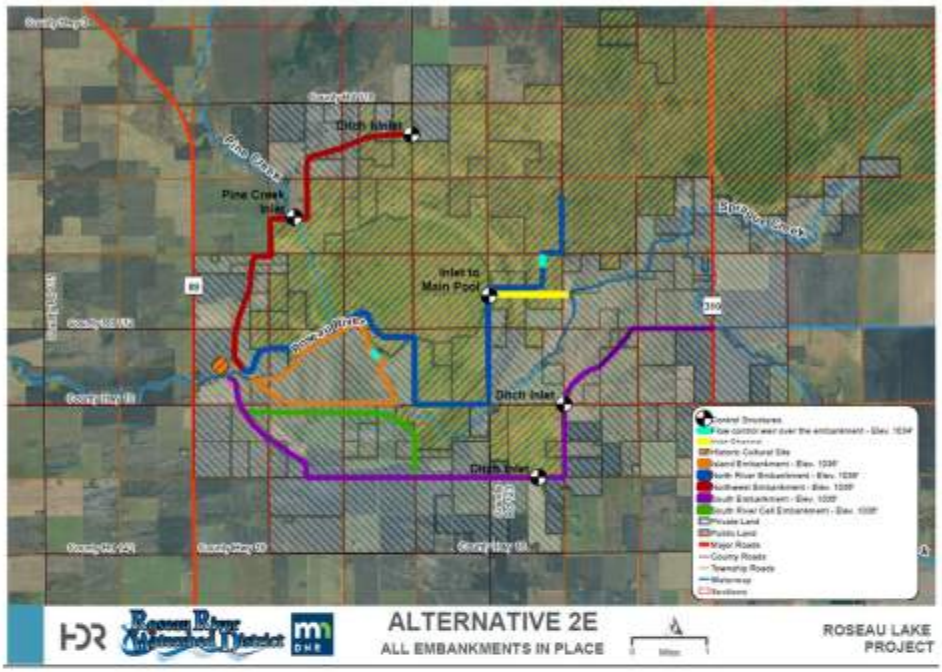
Alternative 2d includes the South Cell Embankment with a weir to allow flood flows to flood the south cell when water levels exceed 1034. Culverts with flap gates would allow the area to drain after the Roseau River recedes.

Following the flood peak the water level in the main pool would be managed for wildlife enhancement purposes.

Key issues comparing this alternative to other alternatives:

1. Increased embankment footprint and wetland impacts compared to alternatives 1 and 2a.
2. Potential for fish entrapment in additional cell.
3. Increased costs with minimal increase in potential flood damage reduction benefit.
4. Increased operational complexity and maintenance costs associated with multiple cells.
5. Higher construction costs and mitigation costs relative to alternatives 1 and 2a.

Alternative 2e:



Structural elements:

1. South, Northwest, North River, Island, and South Cell Embankments aligned as indicated in Figure 1 at an elevation of 1036 feet. The total length of embankment is 27.5 miles, average height is 1.43 feet above ground, and average width is 25.5 feet resulting in an embankment footprint of 89.2 acres and 1,223,000 cubic yards of fill.
2. Ditches (shown on Figure XXX) are located parallel to the North River Embankment, parallel to the Northwest Embankment, South Embankment, and the inlet/outlet ditch. The total length of the ditches is 22.2 miles, ditch footprint of 251 acres, and cut volume of 3,709,000 cubic yards.
3. Roseau River Inlet. This alternative requires construction of an inlet which is proposed for the eastern portion of the north river embankment. Preliminary design consists of a trapezoidal channel with a 100 foot bottom width and 5H:1V side slopes from the Roseau River to the main pool. The inlet structure is located at CR 123 and is composed of eight 8′ x 6′ RCB box culverts with sluice gates. If the Roseau River rises faster than flow through the gated inlet can fill the main pool then a 1,000 foot long weir along the east side of the project will allow flood flows to enter the main pool.

Operation Concept:

This alternative follows the general operating concept sending early flow downstream to save main pool capacity to reduce the Roseau River peak. Water flows into the impoundment through the inlet channel and inlet weirs. Pine Creek low flows are diverted around the main pool by the Northwest Embankment and parallel ditch to provide increased storage for Roseau River flow and provide gravity drainage around the main pool. The South Embankment keeps the Roseau River from flooding land to the south. A ditch parallel to the South Embankment is included to convey surface runoff and West Intercept Ditch flow so local flood damages are reduced south of the embankment. The Northwest Embankment and South Embankment are intended to reduce flooding adjacent to the main pool.

Alternative 2e includes the Island and South Cell Embankments which have weirs to allow flood flows to flood the island and south cell areas when water levels exceed 1034. Culverts with flap gates will allow the areas to drain after the Roseau River recedes.

Following the flood peak the water level in the main pool would be managed for wildlife enhancement purposes.

Key issues comparing this alternative to other alternatives:

1. Increased embankment footprint and wetland impacts compared to alternatives 1 and 2a.
2. Potential for fish entrapment in additional cells.
3. Increased costs with minimal increase in potential flood damage reduction benefit.
4. Increased operational complexity and maintenance costs associated with multiple cells.
5. Higher construction costs and mitigation costs relative to alternatives 1 and 2a.

Additional Alternative Considered

The Roseau Lake Project Team also identified another alternative during discussions and evaluation of the five alternatives identified in Concurrence Point 1. This sixth alternative had the same embankment alignment as alternative 2a but it also included a structure on the Roseau River upstream of Highway 89 which would control flows at the outlet of the project area rather than through an inlet channel on the upstream portion of the project. This alternative would have passively filled the lake basin by overtopping the North River Embankment which would be constructed to a lower elevation than proposed in the other alternatives. After thorough review and evaluation, this sixth alternative was eliminated from further consideration for three primary reasons. First, the outlet control structure had substantial effects on fish passage in the Roseau River during operation and also during most of the year. Second, the design and operation of this alternative greatly increased the risk and likelihood of stranding large numbers of fish in the pool after a flood event compared to other alternatives. Third, this alternative with an outlet-based control and lower North River Embankment does not provide as much water level management control as the other alternatives which include inlet and outlet controls for the lake basin.

Alternative Analysis (Concurrence Point #3)

Concurrence Point 3 completes a review of the five alternatives established in concurrence point 2. The analysis of these alternatives was conducted using guidance provided by the Army Corps in 2009[1].

For purposes of this project a screening of these current five alternatives was conducted prior to a detailed screening.

Initial screening and elimination of Alternatives 2C, 2d, and 2e.

Alternatives 2c, 2d, and 2e were eliminated from detailed screening for the following reasons:

1) Wetland impacts – these all have larger wetland impacts and associated mitigation costs than the other alternatives.
2) Ability to meet project goals and objectives – These alternatives did not have an increased ability to meet project objectives compared to alternatives 1 and 2a.
3) Cost effectiveness – These alternatives achieved FDR benefits similar to the other alternative but at higher cost.

Detailed screening of alternatives 1 and 2a.

The remaining alternatives (1 and 2a) were evaluated based on the degree to which they meet the project purpose related to fish and wildlife and flood damage reduction objectives and their environmental effects.

Assessment of fish and wildlife habitat benefits - One primary element of the purpose and need is improvement of fish and wildlife habitat. The specific fish and wildlife habitat objectives established by the project team in for the project include:

1. Manage water levels to provide fall migratory habitat.
2. Consistently establish and maintain a spring pool for migratory birds.
3. Restore perennial flow to the Roseau River oxbow channel.
4. Improve hydrologic conditions within the Roseau River to improve channel stability.
5. Reduce the magnitude and frequency of inundation within the Big Swamp area during ≤10-year events to improve habitat conditions.
6. Minimize entrapment of fish within the summer pool.
7. Maintain fish passage on the portion of the river passing through the project area.
8. Reduce the magnitude and frequency of bounce within the normal summer pool during ≤10-year events to improve nesting success of waterfowl and other ground nesting birds.

Alternatives 1 and 2a have similar capacities to meet the first seven fish and wildlife related objectives. The ability to meet objectives 8 varies between the alternatives. Compared to Alternative 2a,

[1] Section 404 Concurrence Point Guidance. December 2009. U.S Army Corps of Engineers, St. Paul District. 9 pages.
Section 4. PT handbook.

Alternative 1 provides slightly less capacity to manage the volume and timing of water that enters the lake basin and that passes through the river corridor.

Assessment of flood damage reduction benefits - The second primary element of the purpose and need is reduction of flood damages in the project area and downstream. The flood damage reduction objectives for the project established by the project team include:

- Reduce the extent and duration of flooded lands downstream of the project area during 1-10 year frequency events.
- Reduce the extent and duration of flooded lands in the project area during 1-10 year frequency events.

Alternative 1 and 2a reduce the number of downstream acres flooded and the duration of flooding compared to current conditions (Table 1). Peak flows downstream at the Ross gage are also reduced compared to current conditions. Alternative 1 reduces the number of flooded acres downstream of the project 1.1 percent more than Alternative 2a (9,976 compared to 10,092 acres).

Table 1 – Downstream Flood Damage Reduction Benefits for 10 Year 10 Day Event.

Alternative	Peak water surface elevation/flooding duration of the Main Pool area during 10-year, 10-day event	Peak overbank elevation/ flooding duration along the river corridor in event 10-year, 10-day event	Peak flow at Ross Gage during 10-year, 10-day event. (cfs)	Flooded areas between Highway 89 and County Road 113 (acres)	Downstream reduction in Flooded Acres	Downstream reduction in flooding duration (days)
Existing Conditions	1037.24/85 days	1037.24/80 days	3,771	10,338	-	-
1	1037.06/80 days	1037.06/70 days	3,568	9,976	362	5
2a	1037.11/80 days	1037.11/70 days	3,626	10,092	246	5
2c	1037.11/80 days	1037.11/70 days	3,621	10,092	246	5
2d	1037.06/80 days	1037.05/70 days	3,574	10,009	329	5
2e	1037.05/80 days	1037.05/70 days	3,569	9,976	362	5

Alternative 1 will flood more acres of locally compared to Alternative 2a because it does not include the South Embankment which confines the flooded area in the southern area of the project.

Assessment of Environmental Effects - The environmental effects statements provided in the draft Roseau Lake Environmental Assessment Worksheet (EAW) were used as a basis for evaluating the environmental effects of each alternative. The specific environmental effects listed in the EAW include:

- Effects on wetland habitat near Roseau Lake.
- Effects on wetland habitat along the corridor for the outlet.

- Effects on the Roseau River.

Both alternatives increase the capacity to manage water levels within the Roseau Lake basin which should improve the condition of wetland plant communities within the Roseau Lake (currently degraded due to uncontrolled water level fluctuations). Both alternatives will also reduce the duration of more frequent flooding in the river corridor which should help to improve the condition of wetland plant communities within the Roseau River corridor.

Alternative 2a is expected to have 13 more acres of wetland impacts compared to alternative 1 due to the inclusion of the South River Embankment (Table 2). Alternative 1 includes 13.25 miles of embankment with a 42.2 acre footprint compared to 22.55 miles of embankment with a 71.9 acre footprint. The 13 acres of additional impacts attributed to the South Embankment are primarily in wetland areas which are currently or previously being cropped.

Effect of both alternatives on the Roseau River should be similar given the proposed operating plan which will divert all low flows to almost 3 miles of natural channel which is currently cut off from most flow events.

Table 2. Estimated wetland acres impacted by Roseau Lake Rehabilitation Project alternatives.

Alternative	Wetland Impacts (Acres)
1 - Northwest and North River Embankments	89
2a - Northwest, South, and North River Embankments	102
2c - Northwest, South, North River, and Island Embankments	116
2d - Northwest, South, North River, and South River Cell	123
2e - Northwest, South, North River embankment with Island and South River Cell	136

Selection of the Preferred Alternative

Alternative 2a is the preferred alternative based on this evaluation. Both alternatives improve fish and wildlife habitat in the project area and have similar downstream flood damage reduction benefits. Alternative 2a reduces local flooding more than Alternative 1 because the South Embankment provides local residents and water managers with some certainty about the flood footprint associated with this

project. Inclusion of this South Embankment defines the flood footprint for this project and enables clear delineation of the areas that will require flowage easements which are in the long term interest of the public. Inclusion of the South Embankment in Alternative 2a does increase the acres of wetland impacts; however, the majority of the wetland impacts would be associated with lower quality wetlands compared to the other embankments.

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
180 FIFTH STREET EAST, SUITE 700
ST. PAUL, MN 55101-1678

REPLY TO ATTENTION OF
REGULATORY BRANCH

Regulatory File No. 2014-02233-CLJ

Ms. Tracy Halstensgard
Roseau River Watershed District
109 3rd Avenue SW
Roseau, Minnesota 56751

DEC 2 1 2018

Dear Ms. Halstensgard:

This letter is in regards to your request for Corps approval of concurrence point #3 for the Roseau Lake Rehabilitation Project. The project location is in Roseau County, Minnesota.

As a result of our review of the Alternatives Analysis sent to us on 17 December 2018, we concur that your preferred alternative, identified as Alternative 2a in your Alternatives Analysis, appears to be the Least Environmentally Damaging Practicable Alternative (LEDPA) of the alternatives analyzed in the project investigation.

Because the LEDPA determination can only be made as part of a permit decision, concurrence point 3 is characterized as a non-binding preliminary determination. The next step of the FDR/Section 404 merger process would involve avoidance and minimization of impacts to Waters of the U.S. during project design of Alternative 2a.

We are requesting you provide details on the measures taken to avoid and minimize impacts to Waters of the U.S. during your project design. We also recommend engaging the Corps during the project design to identify potential minimization and reduce the possibility of having to re-design a project to satisfy Clean Water Act Section 404 requirements.

If you have any questions, please contact Craig Jarnot in our Bemidji Regulatory field office at (651) 290-5337. In any correspondence or inquiries, please refer to the Regulatory number shown above.

Sincerely,

Chad Konickson
Chief, Regulatory Branch

cc: Nate Dalager, HDR
Henry Van Offelen, BWSR
Matt Johnson, BWSR
Scott Johnson, Roseau SWCD

Appendix B

Geotechnical Exploration Report

Roseau Lake Rehabilitation
Roseau County, Minnesota
October 4, 2017
Terracon Project No. M5175049

Prepared for:
Roseau River Watershed District
Roseau, Minnesota

Prepared by:
Terracon Consultants, Inc.
Grand Forks, North Dakota

October 4, 2017

Roseau River Watershed District
108 3rd Ave SW
Roseau, MN 56751

Attn: Ms. Tracy Halstensgard
P: [218] 242 1737
E: rrwd@mncable.net

Re: Geotechnical Exploration Report
Roseau Lake Rehabilitation
Roseau County, Minnesota
Terracon Project No. M5175049

Dear Ms. Halstensgard:

Terracon Consultants, Inc. has completed the geotechnical exploration services for the above referenced project. This study was performed as directed by HDR in general accordance with our proposal number PM5175049 dated May 23, 2017. This report presents the findings of the subsurface exploration.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Jonathan J. Malaterre, EI
Staff Engineer

William R. Olson, PE
Geotechnical Department Manager

Enclosures
cc: 1 – HDR

TABLE OF CONTENTS

GEOTECHNICAL EXPLORATION REPORT
ROSEAU LAKE REHABILITATION
ROSEAU COUNTY, MINNESOTA

Terracon Project No. M5175049
October 4, 2017

1.0 INTRODUCTION

Geotechnical services were completed for Roseau Lake in Roseau County, Minnesota. Seventeen (17) soils borings were proposed, however, due to site access, only sixteen (16) soil borings were advanced to depths ranging from 20 to 60 feet below existing grade. Logs of the borings along with a Site Location Map, and an Exploration Plan are included in Appendix A of this report.

2.0 PROJECT INFORMATION

2.1 Project Description

The project included advancing soil borings and performing laboratory testing as directed by HDR, Inc.

2.2 Site Location and Description

Item	Description
Location	The project was located at several different locations at the existing Roseau Lake 5 ½ miles northwest of Roseau, Minnesota. See Appendix A, Exhibit A-1: Site Location Map and Exhibit A-2: Exploration Plan.
Existing improvements	None
Existing topography	Agricultural fields/wetlands
Current ground cover	Trees/agricultural fields/grass

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Stratum	Approximate Depth to Bottom of Stratum (feet)	Material Description	Consistency
1	1 ½ to 6	Topsoil/existing fill	N/A
2	4 ½ to 9 ½	Lean clay/silt with various amounts of sand	Ranges from soft to medium stiff
3	36 ½	Dark gray fat clay	Ranges from very soft to soft
4	Undetermined	Sandy lean clay	Ranges from soft to hard

Conditions at each boring location are indicated on the attached individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. Details for each of the borings can be found on the boring logs in Appendix A of this report. A discussion of the field sampling is included in Appendix A.

3.2 Groundwater

The boreholes were observed while drilling for the presence and level of groundwater. The groundwater levels measured in the boreholes can be found on the boring logs and are summarized below.

Boring number	Depth of groundwater while drilling, ft.
B-8	31
B-12	12
B-16	7 ½

Groundwater was not observed in the remaining borings while drilling or for the short duration they were allowed to remain open. However, this does not necessarily mean these borings terminated above groundwater or that the measurements above are static groundwater levels. Due to the low permeability of the 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 observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the building may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

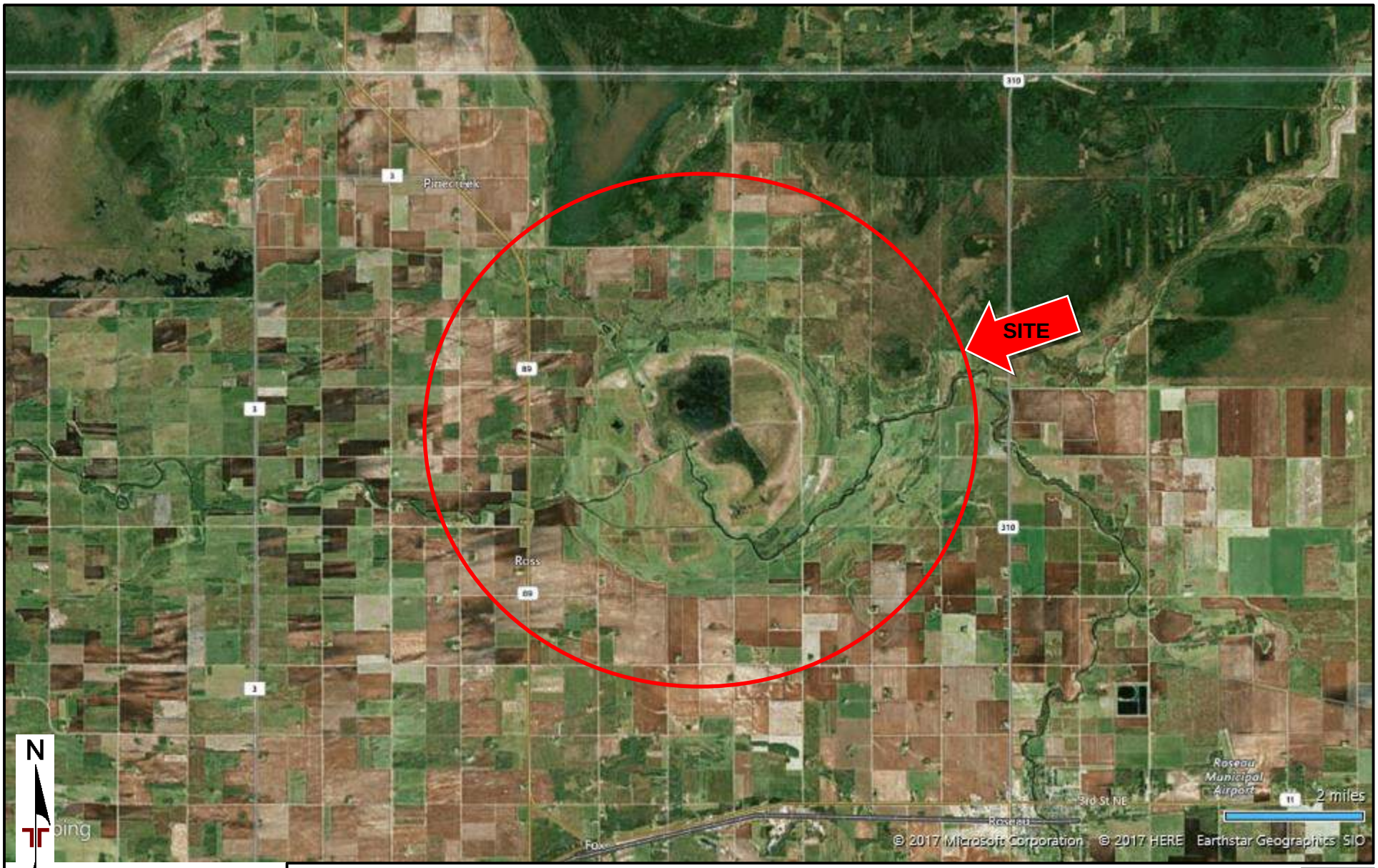
4.0 GENERAL COMMENTS

The information presented in this exploration summary report is based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This exploration summary report does not reflect variations that may occur between borings or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that the need for further exploration and testing can be evaluated. Any interpretation or design performed by others based on this data is done at their risk.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This exploration summary report has been prepared for the exclusive use of our client and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended or made. Analysis, design, and associated recommendations as well as site safety, excavation support, dewatering requirements are the responsibility of others.

APPENDIX A
FIELD EXPLORATION



AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager:	JJM
Drawn by:	JJM
Checked by:	WRO
Approved by:	WRO

Project No.	M5175049
Scale:	1"=2,000'
File Name:	
Date:	10/2/2017

Terracon
1555 N 42nd St, Unit B
Grand Forks, ND 58203-0809

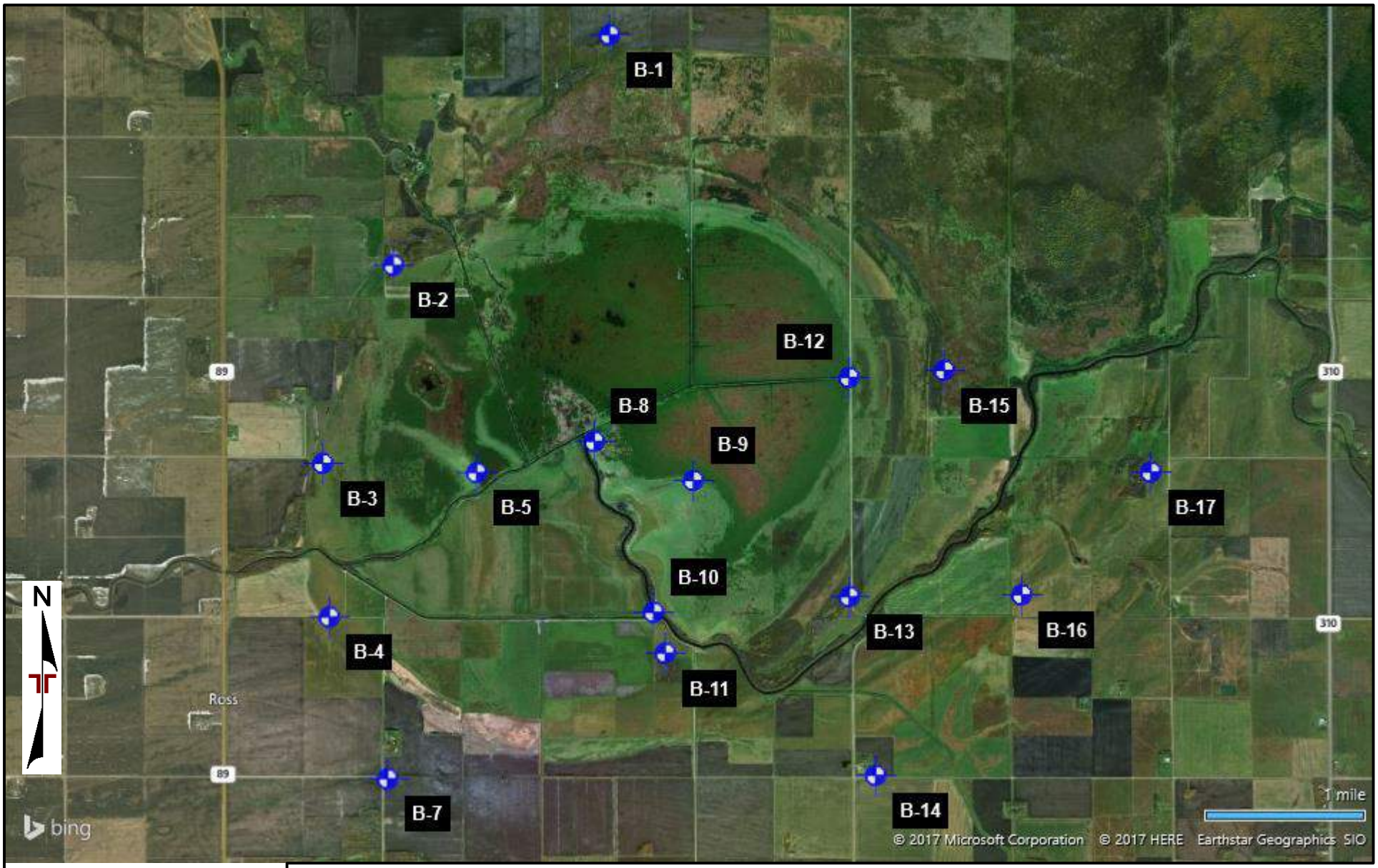
SITE LOCATION

Roseau Lake Rehabilitation

Roseau County
Roseau, Minnesota

Exhibit

A-1



AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager:	JJM
Drawn by:	JJM
Checked by:	WRO
Approved by:	WRO

Project No.	M5175049
Scale:	AS SHOWN
File Name:	
Date:	10/2/2017

Terracon
1555 N 42nd St, Unit B
Grand Forks, ND 58203-0809

EXPLORATION PLAN

Roseau Lake Rehabilitation
Roseau County
Roseau, Minnesota

Exhibit
A-2

Field Exploration Description

Sixteen (16) soil test borings were completed from August 9 – 16. The borings were advanced at the approximate locations selected by HDR, Inc. as indicated on Exhibit A-2. The coordinates indicated on the boring logs were obtained using a hand-held GPS unit. The locations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

The borings were drilled with a track-mounted rotary drill rig using 3 ¼ hollow stem augers to advance the boreholes. Soil samples were obtained using split-barrel and Shelby tube sampling procedures. In the split-barrel sampling procedure the number of blows required to advance a standard 2-inch O.D., 1-3/8-inch I.D split-barrel sampler from 6 to 18 inches of penetration by means of a 140-pound hammer with a free fall of 30 inches is used to obtain the Standard Penetration Test (SPT) or N-value. The SPT is used to estimate the in-situ relative density of cohesionless soils and the consistency of cohesive soils. In the Shelby tube sampling procedure, a thin wall seamless steel tube with a sharp cutting edge is pushed into the soil by hydraulic pressure to obtain a relatively undisturbed sample of cohesive soil.

An automatic SPT hammer was used to advance the split-barrel sampler in the borings performed at this site. A greater efficiency is typically achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. Published correlations between the SPT values and soil properties are based on the lower efficiency cathead and rope method. This higher efficiency affects the standard penetration resistance blow count (N) value by increasing the penetration per hammer blow over what would be obtained using the cathead and rope method. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions.

Upon completion, our borings were sealed from the bottom up to the ground surface with high solids bentonite grout in accordance with state regulations. Copies of the sealing records are attached.

A field log of each boring was prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller’s interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

BORING LOG NO. B-1

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.95859° Longitude: -95.86783°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	FILL - FAT CLAY WITH SAND, trace gravel, dark gray and brown				0.5	5-2-3 N=5					
					0.7	2-2-3 N=5					
		5			0.9	2-2-3 N=5					
	6.0										
	FAT CLAY (CH), dark gray, soft, silt lenses, iron concretions				2.2			30		54-17-37	
		10			1.5	2-1-3 N=4					
					1	1-1-2 N=3					
	14.5										
	FAT CLAY (CH), dark gray, soft to very soft, silt lenses	15			1.5	0-1-1 N=2					
		20			1.5	0-0-1 N=1					
	21.0										
	Boring Terminated at 21 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343623

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-14-2017 | Boring Completed: 08-14-2017

Drill Rig: D-90 | Driller: CAS

Project No.: M5175049 | Exhibit: A-4

BORING LOG NO. B-2

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.93775° Longitude: -95.89762°

DEPTH	GRAPHIC LOG	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		TOPSOIL - ORGANIC CLAY (OH), black				0.7	3-3-3 N=6					
1.5		**LEAN CLAY WITH SAND (CL)**, gray, soft, silt lenses				0.7	2-2-2 N=4					
												77
			5			1.3	1-1-1 N=2					
6.0		**SILT WITH SAND (ML)**, gray, stiff				1	3-5-7 N=12		14		NP	81
10.0		**FAT CLAY (CH)**, dark gray, soft, silt lenses	10			1.3	3-2-2 N=4					
						1.5	2-1-2 N=3					
			15			1.5	1-1-0 N=1					
			20			1.1	0-1-1 N=2					
21.0		***Boring Terminated at 21 Feet***										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343624

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-14-2017 | Boring Completed: 08-14-2017

Drill Rig: D-90 | Driller: CAS

Project No.: M5175049 | Exhibit: A-5

BORING LOG NO. B-3

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.91982° Longitude: -95.90733°

DEPTH	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		TOPSOIL - ORGANIC CLAY (OH), black				0.1	2-1-2 N=3					
1.5		**SANDY LEAN CLAY (CL)**, trace gravel, olive brown and yellow, medium stiff to stiff to medium stiff				1	2-3-2 N=5					
			5			1.1	3-4-6 N=10					
						1.1	3-5-7 N=12					
			10			1.5	4-4-4 N=8					
12.0		**SANDY FAT CLAY (CH)**, trace gravel, dark gray, stiff				2.3			12		59-15-44	
			15			1.5	3-4-5 N=9					
			20			1.5	4-4-5 N=9					
21.0		***Boring Terminated at 21 Feet***										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343625

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-16-2017 | Boring Completed: 08-16-2017

Drill Rig: D-90 | Driller: CAS

Project No.: M5175049 | Exhibit: A-6

BORING LOG NO. B-4

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.90591° Longitude: -95.90643°

DEPTH	GRAPHIC LOG		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		TOPSOIL - ORGANIC CLAY (OH), black										
1.5					X	1	2-4-4 N=8		30			
		FAT CLAY (CH), dark gray, medium stiff, silt lenses			X	1.1	2-2-2 N=4		28			
4.5												
		SANDY LEAN CLAY (CL), trace gravel, olive brown, medium stiff	5		X	1	2-2-3 N=5					
					X	1.5	2-3-3 N=6		14		20-11-9	
9.5												
		SANDY LEAN CLAY (CL), trace gravel, gray, medium stiff	10		X	1.3	2-3-3 N=6					
					X	1.5	2-4-4 N=8					
			15		X	1.3	2-3-4 N=7					
			20		X	1.3	2-4-5 N=9					
21.0												
		Boring Terminated at 21 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343627

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-16-2017 | Boring Completed: 08-16-2017

Drill Rig: D-90 | Driller: CAS

Project No.: M5175049 | Exhibit: A-7

BORING LOG NO. B-5

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.91898° Longitude: -95.88615°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	TOPSOIL - ORGANIC CLAY (OH), black										
	1.5				0.3	2-2-3 N=5					
	LEAN CLAY (CL), dark gray, soft, silt lenses, iron concretions				1	1-2-1 N=3					
		5			1.3	2-1-2 N=3					
	8.5				1.1	2-1-2 N=3					
	FAT CLAY (CH), dark gray, very soft to soft, silt lenses	10			1.5	0-0-1 N=1					
					1.5	0-1-1 N=2					
		15			1.5	0-1-1 N=2					
	21.0	20			1.1	1-1-1 N=2					
	Boring Terminated at 21 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343626

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-16-2017 | Boring Completed: 08-16-2017

Drill Rig: D-90 | Driller: CAS

Project No.: M5175049 | Exhibit: A-8

BORING LOG NO. B-7

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.89126° Longitude: -95.8984°

DEPTH	GRAPHIC LOG		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		TOPSOIL - ORGANIC CLAY (OH), black										
1.5		**SILT WITH SAND (ML)**, gray, medium stiff				1	4-4-5 N=9					
						1.1	2-3-2 N=5					
			5			1.3	3-3-3 N=6					
6.0		**SANDY LEAN CLAY (CL)**, trace gravel, dark gray, soft				1.3	1-1-1 N=2					
9.5		**LEAN CLAY (CL)**, trace organics, dark gray and black, soft	10			1.3	1-1-1 N=2					
						1	0-1-1 N=2					
14.5		**FAT CLAY (CH)**, dark gray, soft, silt lenses	15			1.5	0-1-1 N=2					
			20			1.5	0-1-1 N=2					
21.0		***Boring Terminated at 21 Feet***										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343629

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-16-2017 | Boring Completed: 08-16-2017

Drill Rig: D-90 | Driller: CAS

Project No.: M5175049 | Exhibit: A-9

BORING LOG NO. B-8

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.92181° Longitude: -95.86994°

DEPTH	GRAPHIC LOG	DESCRIPTION	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0		**TOPSOIL - ORGANIC CLAY (OH)**, black and dark gray			0.5	1-2-2 N=4		30			
1.5		**LEAN CLAY (CL)**, brown, soft, silt lenses			1.1	1-1-2 N=3		28			
4.5		**FAT CLAY (CH)**, dark gray, soft, silt lenses			1.5			33		84-28-56	
5					1	1-1-2 N=3		49			
10					0.8	1-1-1 N=2		45			
					1.3	1-1-1 N=2		26			
15					2.1			42		62-22-40	
20					1.5	0-1-1 N=2		62			
25					1.5	1-1-1 N=2		97			
30			▽		1.5	1-1-1 N=2		99			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343637

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-09-2017 | Boring Completed: 08-09-2017

Drill Rig: D-90 | Driller: MAR

Project No.: M5175049 | Exhibit: A-10

BORING LOG NO. B-8

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.92181° Longitude: -95.86994°

DEPTH	GRAPHIC LOG	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
FAT CLAY (CH), dark gray, soft, silt lenses *(continued)*										
35				2			86			
36.5										
SANDY LEAN CLAY (CL), trace gravel, dark gray, soft to very stiff to hard, occasional cobbles and boulders										
40				1.5	2-1-1 N=2		17			
45				1.5	1-1-1 N=2		15			
50				0.5	3-6-14 N=20		15			
55				1	14-22-31 N=53		14			
60				1	30-45-60 N=105		13			
61.0										
Boring Terminated at 61 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343637

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-09-2017 | Boring Completed: 08-09-2017

Drill Rig: D-90 | Driller: MAR

Project No.: M5175049 | Exhibit: A-10

BORING LOG NO. B-9

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.91827° Longitude: -95.85629°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	TOPSOIL - ORGANIC CLAY, dark gray, wood debris										
	1.5				1	1-1-2 N=3		56			
	FAT CLAY (CH), dark gray, soft, silt lenses				1.5	2-2-2 N=4		28		58-19-39	
		5			1.3	2-2-2 N=4		54			
					1.3	1-1-1 N=2		60			
		10			1	1-1-1 N=2		54			
					1.5	0-1-1 N=2		50			
		15			1.5	0-1-1 N=2		47			
		20			2			44		80-25-55	
	21.5										
	Boring Terminated at 21.5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343633

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-09-2017 | Boring Completed: 08-09-2017

Drill Rig: D-90 | Driller: MAR

Project No.: M5175049 | Exhibit: A-11

BORING LOG NO. B-10

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.90633° Longitude: -95.86177°

DEPTH	GRAPHIC LOG	DESCRIPTION	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		TOPSOIL - ORGANIC CLAY (OH), black									
1.5		**LEAN CLAY (CL)**, gray, medium stiff, silt lenses			0.3	4-5-4 N=9		18			
					0.7	3-3-3 N=6		22		39-18-21	
5					1.1	2-2-2 N=4		23			
					1.8			28		35-18-17	
9.0		**FAT CLAY (CH)**, dark gray, soft, silt lenses, trace wood & organics at 12'									
10					1.1	2-1-2 N=3		29			
					2			42		73-25-48	
15					0.5	1-1-1 N=2		41			
20					2.3			46		61-19-42	
25					1.1	1-1-1 N=2		61			
30					1.3	0-1-1 N=2		83			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343634

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-14-2017 | Boring Completed: 08-14-2017

Drill Rig: D-90 | Driller: MAR

Project No.: M5175049 | Exhibit: A-12

BORING LOG NO. B-10

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.90633° Longitude: -95.86177°

DEPTH	GRAPHIC LOG	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
FAT CLAY (CH), dark gray, soft, silt lenses, trace wood & organics at 12' *(continued)*											
36.0		35		X	1.5	0-1-1 N=2		81			
FAT CLAY WITH SAND (CH), dark gray, soft, silt lenses											
		40		X	1.5	0-1-1 N=2		18			
		45		X	1.5	0-1-1 N=2		29			
49.5											
SILT (ML), gray, stiff to very stiff to hard		50		X	1.5	5-6-5 N=11		19			
		55		X	1.1	7-9-11 N=20		14			
		60		X	0.7	5-13-18 N=31		15			
61.0											
Boring Terminated at 61 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343634

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-14-2017 | Boring Completed: 08-14-2017

Drill Rig: D-90 | Driller: MAR

Project No.: M5175049 | Exhibit: A-12

BORING LOG NO. B-11

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.90264° Longitude: -95.86015°

DEPTH	GRAPHIC LOG	DESCRIPTION	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		TOPSOIL - ORGANIC CLAY (OH), black			0.3	2-2-2 N=4					
1.5		**LEAN CLAY (CL)**, gray and dark gray, soft, silt lenses, iron concretions			1.1	2-1-1 N=2					
5					1.3	2-2-2 N=4					
					0.5	1-1-1 N=2					
9.5											
		FAT CLAY (CH), dark gray, very soft, silt lenses			1.5	1-0-1 N=1					
10											
					1.5	0-1-1 N=2					
15					1.5	0-1-1 N=2					
20					1.5	0-1-0 N=1					
21.0											
		Boring Terminated at 21 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343630

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-15-2017 | Boring Completed: 08-15-2017

Drill Rig: D-90 | Driller: MAR

Project No.: M5175049 | Exhibit: A-13

BORING LOG NO. B-12

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.9276° Longitude: -95.83484°

DEPTH	GRAPHIC LOG	DESCRIPTION	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		TOPSOIL - ORGANIC CLAY, black			0.8	4-3-3 N=6		25			
1.5		**LEAN CLAY (CL)**, soft, brown, silt lenses			1.1	2-1-2 N=3		38			
4.5		**FAT CLAY (CH)**, dark gray, medium stiff to soft, silt lenses, iron concretions			1.1	2-2-3 N=5		32			
7.0		**FAT CLAY (CH)**, dark gray, soft to very soft to soft, silt lenses			1	1-2-1 N=3		51			
10					1.1	1-1-1 N=2		51			
			▽		2.1			52		75-21-54	
15					1.5	0-1-1 N=2		61			
20					1.5	0-1-1 N=2		66			
25					1.5	0-1-1 N=2		27			
30					1.5	0-0-1 N=1		98			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343631

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-10-2017 | Boring Completed: 08-10-2017

Drill Rig: D-90 | Driller: MAR

Project No.: M5175049 | Exhibit: A-14

BORING LOG NO. B-12

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.9276° Longitude: -95.83484°

DEPTH	GRAPHIC LOG		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		FAT CLAY (CH), dark gray, soft to very soft to soft, silt lenses *(continued)*										
			35			1.5	1-1-1 N=2		95			
			40			2.3			37		51-17-34	
			45			1.5	1-1-1 N=2		30			
			50			2.3			34		53-16-37	
54.5		**SANDY LEAN CLAY (CL)**, trace gravel, gray, stiff, occasional cobbles and boulders	55			1.5	12-14-17 N=31		9			
			60			1.1	16-22-23 N=45		8			
61.0		***Boring Terminated at 61 Feet***										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343631

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-10-2017 | Boring Completed: 08-10-2017

Drill Rig: D-90 | Driller: MAR

Project No.: M5175049 | Exhibit: A-14

BORING LOG NO. B-13

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.90774° Longitude: -95.83481°

DEPTH	GRAPHIC LOG	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		FILL - POORLY GRADED SAND WITH GRAVEL, brown				1	7-5-4 N=9					
1.5		**SILTY SAND (SM)**, fine grained, brown, loose				1.1	5-3-3 N=6				NP	27
			5			0.8	4-4-3 N=7					
7.0		**FAT CLAY (CH)**, dark gray, soft				2.3						
			10			1.3	2-1-2 N=3					
12.0		**SILT (ML)**, brown, very stiff to stiff, silt lenses				1.1	5-8-11 N=19					
			15			1	6-5-7 N=12					
19.5		**FAT CLAY (CH)**, dark gray, soft, silt lenses	20			0.7	2-1-2 N=3					
21.0		***Boring Terminated at 21 Feet***										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343636

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-09-2017 | Boring Completed: 08-09-2017

Drill Rig: D-90 | Driller: MAR

Project No.: M5175049 | Exhibit: A-15

BORING LOG NO. B-14

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.89156° Longitude: -95.83117°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	TOPSOIL - ORGANIC CLAY (OH), black				0.7	4-3-2 N=5					
	1.5 **LEAN CLAY (CL)**, olive yellow, medium stiff, silt lenses, iron concretions				1	2-3-2 N=5					
		5			1.1	2-3-3 N=6					
	7.0 **FAT CLAY (CH)**, dark gray, soft, silt lenses				0.8	2-1-2 N=3					
	8.5 **SILT (ML)**, dark gray, very stiff to stiff to very stiff to medium stiff, silt lenses	10			1.1	6-8-11 N=19					
					1	3-4-5 N=9					
		15			1.1	3-5-9 N=14					
	21.0 ***Boring Terminated at 21 Feet***	20			1.1	5-3-4 N=7					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343638

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-10-2017 | Boring Completed: 08-10-2017

Drill Rig: D-90 | Driller: MAR

Project No.: M5175049 | Exhibit: A-16

BORING LOG NO. B-15

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.92823° Longitude: -95.82172°

DEPTH	GRAPHIC LOG	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		TOPSOIL - ORGANIC CLAY (OH), black				0.5	1-0-0 N=0					
1.5		**LEAN CLAY (CL)**, dark gray, soft to medium stiff, silt lenses, iron concretions				0.5	1-1-1 N=2					
			5			1.2	3-3-4 N=7					
6.0		**FAT CLAY (CH)**, dark gray, medium stiff to soft, silt lenses				1.1	2-2-2 N=4					
			10			1	2-2-3 N=5					
						1	0-1-1 N=2					
			15			2.1			70		67-23-44	
			20			1.5	1-1-1 N=2					
21.0		***Boring Terminated at 21 Feet***										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343639

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-10-2017 | Boring Completed: 08-10-2017

Drill Rig: D-90 | Driller: MAR

Project No.: M5175049 | Exhibit: A-17

BORING LOG NO. B-16

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.90792° Longitude: -95.81105°

DEPTH	GRAPHIC LOG		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		TOPSOIL - ORGANIC CLAY (OH), black				0.1	2-1-2 N=3					
1.5		**LEAN CLAY (CL)**, gray, soft, silt lenses, iron concretions				1.1	2-2-2 N=4					
4.5		**FAT CLAY (CH)**, dark gray, medium stiff, silt lenses	5			1.3	2-2-3 N=5					
7.0		**SILT (ML)**, dark gray, medium stiff		▽		1	5-6-6 N=12					
			10			1.1	6-6-9 N=15					
						1.3	6-5-4 N=9					
14.5		**FAT CLAY (CH)**, dark gray, soft, silt lenses	15			1	2-1-2 N=3					
			20			1.5	1-1-1 N=2					
21.0		***Boring Terminated at 21 Feet***										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343635

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-10-2017 | Boring Completed: 08-10-2017

Drill Rig: D-90 | Driller: MAR

Project No.: M5175049 | Exhibit: A-18

BORING LOG NO. B-17

PROJECT: Roseau Lake Rehabilitation

CLIENT: Roseau River Watershed District
Roseau, Minnesota

SITE: Roseau County
Roseau, Minnesota

LOCATION See Exhibit A-2

Latitude: 48.91903° Longitude: -95.79326°

DEPTH	GRAPHIC LOG	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		TOPSOIL - ORGANIC CLAY (OH), black				0.5	2-3-2 N=5					
1.5		**LEAN CLAY (CL)**, brownish gray, soft, silt lenses, iron concretions				1	2-2-2 N=4					
			5			1.1	2-1-2 N=3					
6.0		**FAT CLAY (CH)**, dark gray, soft, silt lenses				1.3	2-1-3 N=4					
			10			1.5	1-2-1 N=3					
						0.5	1-1-1 N=2					
			15			1	1-1-1 N=2					
21.0			20			1.5	0-1-1 N=2					
		Boring Terminated at 21 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3 ¼ inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with grout from bottom up after completion. Well and Boring Sealing Record No. H343632

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

Boring Started: 08-14-2017 | Boring Completed: 08-14-2017

Drill Rig: D-90 | Driller: CAS

Project No.: M5175049 | Exhibit: A-19

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 343623

WELL OR BORING LOCATION

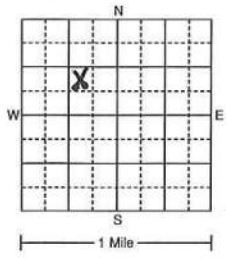
County Name: Roseau

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
~~Jadis~~ ~~N. Roseau UT~~	163N	40W	7	NW¼ SW¼ NW¼

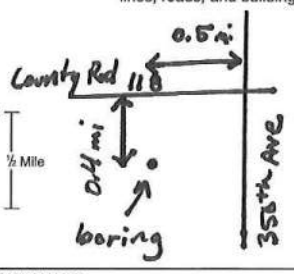
GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.95859 Longitude -95.86783

Numerical Street Address or Fire Number and City of Well or Boring Location
½ mi W of 350th Ave, ½ mile S. Roseau

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.



PROPERTY OWNER'S NAME/COMPANY NAME
STATE LAND - DNR BUREAU

Property owner's mailing address if different than well location address indicated above
500 Lafayette Road
St. Paul, MN 55155-4030

WELL OWNER'S NAME/COMPANY NAME
NO WELL

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

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Fat clay w/sand	dk gray + brown	N/A	0	6
Fat clay	dk gray	soft	6	21

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project #M5175049
Boring B-1

MINN. DEPT OF HEALTH COPY H 343623

Date Sealed: 8/14/17
Date Well or Boring Constructed: 8/14/17

Depth Before Sealing: 21 ft.
Original Depth: 21 ft.

AQUIFER(S)
[X] Single Aquifer [ ] Multiaquifer

WELL/BORING
[ ] Water-Supply Well [ ] Monit. Well
[X] Env. Bore Hole [ ] Other

STATIC WATER LEVEL
[ ] Measured [X] Estimated Date Measured
25 ft. [X] below [ ] above land surface

CASING TYPE(S) N/A
[ ] Steel [ ] Plastic [ ] Tile [ ] Other

WELLHEAD COMPLETION N/A
Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other
Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other

CASING(S)
Diameter N/A Depth
in. from to ft. [ ] Yes [ ] No Set in oversize hole? [ ] Yes [ ] No [ ] Unknown Annular space initially grouted?
in. from to ft. [ ] Yes [ ] No [ ] Yes [ ] No [ ] Unknown
in. from to ft. [ ] Yes [ ] No [ ] Yes [ ] No [ ] Unknown

SCREEN/OPEN HOLE
Screen from to ft. Open Hole from 0 to 21 ft.

OBSTRUCTIONS
[ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction
Type of Obstructions (Describe)
Obstructions removed? [ ] Yes [ ] No Describe

PUMP
Type
[ ] Removed [X] Not Present [ ] Other

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal
in. from to ft. [ ] Perforated [ ] Removed
in. from to ft. [ ] Perforated [ ] Removed
Type of Perforator

VARIANCE
Was a variance granted from the MDH for this well? [ ] Yes [X] No TN#

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material high solids bentonite from 0 to 21 ft. yards 1 bags
from to ft. yards bags
from to ft. yards bags

OTHER WELLS AND BORINGS UNKNOWN
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.

Terracon Consultants, Inc — Licensee Business Name
M1665 — License or Registration No.
Certified Representative Signature
3621 — Certified Rep. No.
9/22/2017 — Date
Christopher Schill — Name of Person Sealing Well or Boring

HE-01434-14 ID# 53159 5/13R

Exhibit A-20

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 343624

WELL OR BORING LOCATION

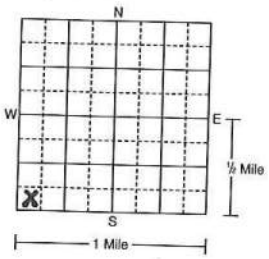
County Name: Roseau

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
Dieter	163N	41W	13	SW¼ SW¼ SW¼

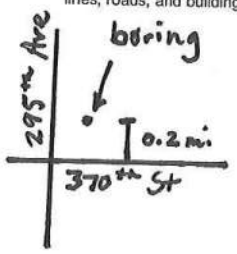
GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.937750 Longitude -95.897620

Numerical Street Address or Fire Number and City of Well or Boring Location
295th Ave, Roseau

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.



PROPERTY OWNER'S NAME/COMPANY NAME: Eric Douglas

Property owner's mailing address if different than well location address indicated above:
12240 238th St. N
Scandia, MN 55073

WELL OWNER'S NAME/COMPANY NAME: NO WELL

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

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1
Lean clay	gray	soft	1	6
Silt w/sand	brown	med dense	6	10
Fat clay	dk gray	soft	10	21

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project # M51750 49
Boring B-2

Date Sealed: 8/14/17
Date Well or Boring Constructed: 8/14/17

Depth Before Sealing _____ ft. Original Depth _____ ft.

AQUIFER(S): [X] Single Aquifer [ ] Multiaquifer

WELL/BORING: [ ] Water-Supply Well [ ] Monit. Well [X] Env. Bore Hole [ ] Other _____

STATIC WATER LEVEL: [ ] Measured [X] Estimated Date Measured _____
25 ft. [X] below [ ] above land surface

CASING TYPE(S): N/A
[ ] Steel [ ] Plastic [ ] Tile [ ] Other _____

WELLHEAD COMPLETION: N/A
Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other _____
Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other _____

CASING(S): N/A

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
_____ 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 _____ to _____ ft. Open Hole from 0 to 21 ft.

OBSTRUCTIONS
[ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction
Type of Obstructions (Describe) _____
Obstructions removed? [ ] Yes [ ] No Describe _____

PUMP
Type _____
[ ] Removed [X] Not Present [ ] Other _____

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal
_____ in. from _____ to _____ ft. [ ] Perforated [ ] Removed
_____ in. from _____ to _____ ft. [ ] Perforated [ ] Removed
Type of Perforator _____

VARIANCE
Was a variance granted from the MDH for this well? [ ] Yes [X] No TN# _____

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material: high solids bentonite from 0 to 21 ft. _____ yards 1 bags
_____ from _____ to _____ ft. _____ yards _____ bags
_____ from _____ to _____ ft. _____ yards _____ bags

OTHER WELLS AND BORINGS: UNKNOWN
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.

Terracon Consultants, Inc. (Licensee Business Name) M1665 (License or Registration No.)
Certified Representative Signature 3621 (Certified Rep. No.) 9/22/2017 (Date)
Christopher Schill (Name of Person Sealing Well or Boring)

MINN. DEPT OF HEALTH COPY H 343624

HE-01434-14 ID# 53159

5/13R

Exhibit A-21

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 343625**

WELL OR BORING LOCATION

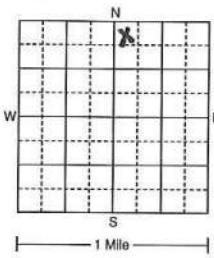
County Name: Roseau

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
Dieter	163N	41W	26	NW¼ NW¼ NE¼

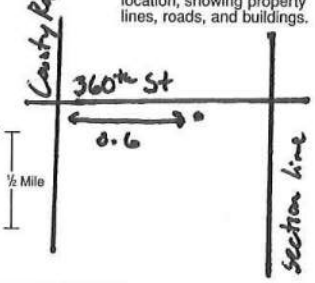
GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.91982 Longitude -95.90733

Numerical Street Address or Fire Number and City of Well or Boring Location: 360th Street

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.



PROPERTY OWNER'S NAME/COMPANY NAME: Ardell Magnosson

Property owner's mailing address if different than well location address indicated above:
32105 St HWY 310
Roseau, MN 56751

WELL OWNER'S NAME/COMPANY NAME: NO WELL

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

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Sandy lean clay	yellow	med stiff	1½	12
Sandy lean clay	dk gray	med stiff	12	21

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project #M5175049
Boring B-3

MINN. DEPT OF HEALTH COPY **H 343625**

Date Sealed: 8/16/17
Date Well or Boring Constructed: 8/16/17

Depth Before Sealing: 21 ft. Original Depth: 21 ft.

AQUIFER(S): [X] Single Aquifer [ ] Multiaquifer

WELL/BORING: [ ] Water-Supply Well [ ] Monit. Well [X] Env. Bore Hole [ ] Other

STATIC WATER LEVEL: [ ] Measured [X] Estimated Date Measured
25 ft. [X] below [ ] above land surface

CASING TYPE(S): N/A
[ ] Steel [ ] Plastic [ ] Tile [ ] Other

WELLHEAD COMPLETION: N/A
Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other
Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other

CASING(S): N/A

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
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 to ft. Open Hole from 0 to 21 ft.

OBSTRUCTIONS: [ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction
Type of Obstructions (Describe):
Obstructions removed? [ ] Yes [ ] No Describe:

PUMP: Type:
[ ] Removed [X] Not Present [ ] Other:

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal
in. from to ft. [ ] Perforated [ ] Removed
in. from to ft. [ ] Perforated [ ] Removed
Type of Perforator:

VARIANCE: Was a variance granted from the MDH for this well? [ ] Yes [X] No TN#

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material: high solids bentonite from 0 to 21 ft. yards 1 bags
from to ft. yards bags
from to ft. yards bags

OTHER WELLS AND BORINGS: UNKNOWN
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.

Terracon Consultants, Inc. — Licensee Business Name
M1665 — License or Registration No.
Certified Representative Signature
3621 — Certified Rep. No.
9/22/2017 — Date
Christopher Schill — Name of Person Sealing Well or Boring

HE-01434-14 ID# 53159 5/13R

Exhibit A-22

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

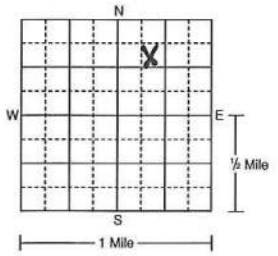
Minnesota Well and Boring Sealing No. H 343627
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION
County Name: Roseau
Township Name: Dieter | Township No.: 163N | Range No.: 41W | Section No.: 35 | Fraction (sm. → lg.): SE¼ NW¼ NE¼

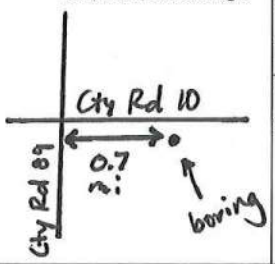
GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.90591 Longitude -95.90643

Numerical Street Address or Fire Number and City of Well or Boring Location
County Rd 10

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.



Date Sealed: 8/16/17
Date Well or Boring Constructed: 8/16/17

Depth Before Sealing: 21 ft.
Original Depth: 21 ft.

AQUIFER(S)
[X] Single Aquifer [ ] Multiaquifer

WELL/BORING
[ ] Water-Supply Well [ ] Monit. Well
[X] Env. Bore Hole [ ] Other

STATIC WATER LEVEL
[ ] Measured [X] Estimated Date Measured
25 ft. [X] below [ ] above land surface

CASING TYPE(S) N/A
[ ] Steel [ ] Plastic [ ] Tile [ ] Other

WELLHEAD COMPLETION N/A
Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other
Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other

PROPERTY OWNER'S NAME/COMPANY NAME
Roberta A Johnson
Property owner's mailing address if different than well location address indicated above
35219 County Road 115
Badger, MN 56714

WELL OWNER'S NAME/COMPANY NAME
NO WELL
Well owner's mailing address if different than property owner's address indicated above

CASING(S) N/A

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
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 ft. to ft. Open Hole from 0 to 21 ft.

OBSTRUCTIONS
[ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction
Type of Obstructions (Describe)
Obstructions removed? [ ] Yes [ ] No Describe

PUMP
Type
[ ] Removed [X] Not Present [ ] Other

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal
in. from to ft. [ ] Perforated [ ] Removed
in. from to ft. [ ] Perforated [ ] Removed
Type of Perforator

VARIANCE
Was a variance granted from the MDH for this well? [ ] Yes [X] No TN#

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material: high solids bentonite from 0 to 21 ft. yards 1 bags
from to ft. yards bags
from to ft. yards bags

OTHER WELLS AND BORINGS UNKNOWN
Other unsealed and unused well or boring on property? [ ] Yes [ ] No How many?

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Fat clay	dk gray	med stiff	1½	5
Sandy lean clay	brown	med stiff	5	21

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project # M5175049
Boring B-4

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.

Terracon Consultants, Inc — Licensee Business Name
M1665 — License or Registration No.
Certified Representative Signature
3621 — Certified Rep. No.
9/22/2017 — Date
Christopher Schill — Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY H 343627

HE-01434-14 ID# 53159 5/13R

Exhibit A-23

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. H 343626
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION

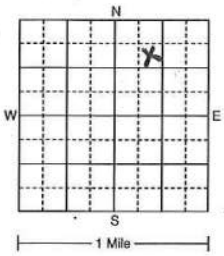
County Name: Roseau

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
Dieter	163N	41W	25	SE ¼ NW ¼ NE ¼

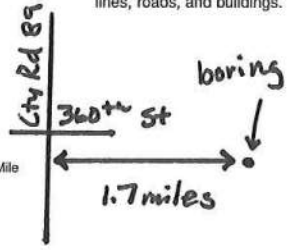
GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.91898 Longitude -95.88615

Numerical Street Address or Fire Number and City of Well or Boring Location
360th Street

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.



Date Sealed: 8/16/17
Date Well or Boring Constructed: 8/16/17

Depth Before Sealing: 21 ft.
Original Depth: 21 ft.

AQUIFER(S)
☒ Single Aquifer ☐ Multiaquifer

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

STATIC WATER LEVEL
☐ Measured ☒ Estimated Date Measured
25 ft. ☒ below ☐ above land surface

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

WELLHEAD COMPLETION N/A
Outside: ☐ Well House ☐ At Grade ☐ Pitless Adapter/Unit ☐ Buried ☐ Well Pit ☐ Other
Inside: ☐ Basement Offset ☐ Well Pit ☐ Buried ☐ Other

PROPERTY OWNER'S NAME/COMPANY NAME
STATE OF MINN DNR
Property owner's mailing address if different than well location address indicated above
500 Lafayette Dr
St. Paul, MN 55155-4030

WELL OWNER'S NAME/COMPANY NAME
NO WELL
Well owner's mailing address if different than property owner's address indicated above

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 to ft. Open Hole from 0 to 21 ft.

OBSTRUCTIONS
☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill ☒ No Obstruction
Type of Obstructions (Describe)
Obstructions removed? ☐ Yes ☐ No Describe

PUMP
Type
☐ Removed ☒ Not Present ☐ Other

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
in. from to ft. ☐ Perforated ☐ Removed
in. from to ft. ☐ Perforated ☐ Removed
Type of Perforator

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 high solids bentonite from 0 to 21 ft. yards 1 bags
from to ft. yards bags
from to ft. yards bags

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

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Lean clay	dk gray	soft	1½	8½
Fat clay	dk gray	soft	8½	21

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project # M5175049
Boring B-5

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.

Terracon Consultants, Inc. — Licensee Business Name
M1665 — License or Registration No.
Certified Representative Signature
3621 — Certified Rep. No.
9/22/17 — Date
Christopher Schill — Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY H 343626

HE-01434-14 ID# 53159 5/13R

Exhibit A-24

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. H 343629
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION

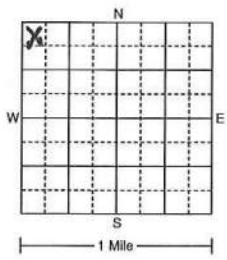
County Name: Roseau

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
Ross	162N	41W	1	NW¼ NW¼ NW¼

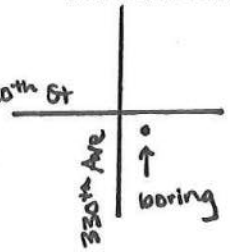
GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.89126 Longitude -95.8984

Numerical Street Address or Fire Number and City of Well or Boring Location
330th Ave

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.



PROPERTY OWNER'S NAME/COMPANY NAME: John Magnusson
Property owner's mailing address if different than well location address indicated above:
31645 County Road 123
Roseau, MN 56751

WELL OWNER'S NAME/COMPANY NAME: NO WELL
Well owner's mailing address if different than property owner's address indicated above:

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Silt w/sand	brown	loose	1½	6
Sandy lean clay	dk gray	soft	6	10
Lean clay	dk gray	soft	10	15
Fat clay	dk gray	soft	15	21

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project # M5175049
Boring B-7

MINN. DEPT OF HEALTH COPY H 343629

Date Sealed: 8/16/17
Date Well or Boring Constructed: 8/16/17
Depth Before Sealing: 21 ft.
Original Depth: 21 ft.

AQUIFER(S)
[X] Single Aquifer [ ] Multiaquifer

WELL/BORING
[ ] Water-Supply Well [ ] Monit. Well
[X] Env. Bore Hole [ ] Other

STATIC WATER LEVEL
[ ] Measured [X] Estimated Date Measured
25 ft. [X] below [ ] above land surface

CASING TYPE(S) N/A
[ ] Steel [ ] Plastic [ ] Tile [ ] Other

WELLHEAD COMPLETION N/A
Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other
Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other

CASING(S)
Diameter N/A Depth Set in oversize hole? Annular space initially grouted?
_____ 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 _____ to _____ ft. Open Hole from 0 to 21 ft.

OBSTRUCTIONS
[ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction
Type of Obstructions (Describe)
Obstructions removed? [ ] Yes [ ] No Describe

PUMP
Type
[ ] Removed [X] Not Present [ ] Other

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal
_____ in. from _____ to _____ ft. [ ] Perforated [ ] Removed
_____ in. from _____ to _____ ft. [ ] Perforated [ ] Removed
Type of Perforator

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 high solids bentonite from 0 to 21 ft. _____ yards 1 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.

Terracon Consultants, Inc. — Licensee Business Name
M1665 — License or Registration No.
Certified Representative Signature
3621 — Certified Rep. No.
9/22/2017 — Date
Christopher Schill — Name of Person Sealing Well or Boring

HE-01434-14 ID# 53159 5/13R

Exhibit A-25

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 1031

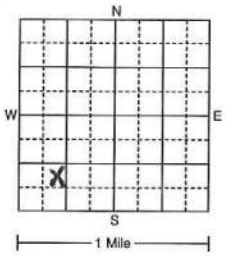
Minnesota Well and Boring Sealing No. H 343637
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION
County Name: Roseau
Township Name: Dieter | Township No.: 163N | Range No.: 40W | Section No.: 19 | Fraction (sm. → lg.): NE¼ SW¼ SW¼

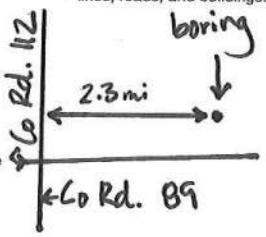
GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.92181 Longitude -95.86994

Numerical Street Address or Fire Number and City of Well or Boring Location
2.3mi E of Co Rd 89 & Co. Rd 112

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.



PROPERTY OWNER'S NAME/COMPANY NAME: State of Minn DNR
Property owner's mailing address if different than well location address indicated above:
500 Lafayette Dr
St. Paul, MN 55155-4030

WELL OWNER'S NAME/COMPANY NAME: NO WELL
Well owner's mailing address if different than property owner's address indicated above:

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Lean clay	brown	soft	1½	6½
Fat clay	dk gray	soft	6½	36½
Sandy lean clay	dk gray	hard	36½	61

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project # M5175049
Boring B-8

MINN. DEPT OF HEALTH COPY H 343637

Date Sealed: 8/9/17
Date Well or Boring Constructed: 8/9/17
Depth Before Sealing: 61 ft.
Original Depth: 61 ft.

AQUIFER(S)
☒ Single Aquifer ☐ Multiaquifer

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

STATIC WATER LEVEL
☒ Measured ☐ Estimated Date Measured 8/9/17
31 ft. ☒ below ☐ above land surface

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

WELLHEAD COMPLETION N/A
Outside: ☐ Well House ☐ At Grade ☐ Pitless Adapter/Unit ☐ Buried ☐ Well Pit ☐ Other
Inside: ☐ Basement Offset ☐ Well Pit ☐ Buried ☐ Other

CASING(S)
Diameter N/A | Depth | Set in oversize hole? | Annular space initially grouted?
_____ 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 _____ to _____ ft. Open Hole from 0 to 61 ft.

OBSTRUCTIONS
☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill ☒ No Obstruction
Type of Obstructions (Describe) _____
Obstructions removed? ☐ Yes ☐ No Describe _____

PUMP
Type _____
☐ Removed ☒ Not Present ☐ Other _____

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
_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed
_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed
Type of Perforator _____

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 from 0 to 61 ft. yards 3 bags
_____ from _____ to _____ ft. yards _____ bags
_____ from _____ to _____ ft. yards _____ bags

OTHER WELLS AND BORINGS UNKNOWN
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.

Terracon Consultants, Inc. — Licensee Business Name
M1665 — License or Registration No.
Certified Representative Signature
3621 — Certified Rep. No.
9/22/2017 — Date
Michael Roberts — Name of Person Sealing Well or Boring

HE-01434-14 ID# 53159 5/13R

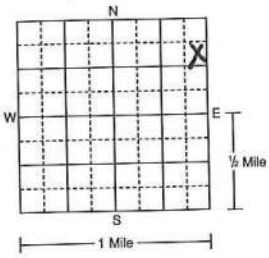
Exhibit A-26

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 1031

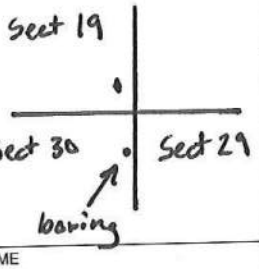
Minnesota Well and Boring Sealing No. H 343633
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION
County Name: Roseau
Township Name: Dieter | Township No.: 163N | Range No.: 40W | Section No.: 30 | Fraction (sm. → lg.): SE¼NE¼NE¼
GPS LOCATION – decimal degrees (to four decimal places)
Latitude: 48.91827 Longitude: -95.85629
Numerical Street Address or Fire Number and City of Well or Boring Location: 3mi E of Co. Rd. 89

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.



PROPERTY OWNER'S NAME/COMPANY NAME: Terry & Carol Kveen
Property owner's mailing address if different than well location address indicated above: N69 W24073 Orchard Ct Menomonee Falls, WI 53051

WELL OWNER'S NAME/COMPANY NAME: NO WELL
Well owner's mailing address if different than property owner's address indicated above:

Date Sealed: 8/9/17
Date Well or Boring Constructed: 8/9/17
Depth Before Sealing: 21½ ft. Original Depth: 21½ ft.

AQUIFER(S): [X] Single Aquifer [ ] Multiaquifer
WELL/BORING: [ ] Water-Supply Well [ ] Monit. Well [X] Env. Bore Hole [ ] Other
STATIC WATER LEVEL: [ ] Measured [X] Estimated Date Measured: 25 ft. [X] below [ ] above land surface

CASING TYPE(S): N/A
[ ] Steel [ ] Plastic [ ] Tile [ ] Other

WELLHEAD COMPLETION: N/A
Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other
Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other

CASING(S): N/A
Diameter ____ in. from ____ to ____ ft. | Set in oversize hole? [ ] Yes [ ] No | Annular space initially grouted? [ ] Yes [ ] No [ ] Unknown

SCREEN/OPEN HOLE: Screen from ____ to ____ ft. Open Hole from 0 to 21½ ft.

OBSTRUCTIONS: [ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction
Type of Obstructions (Describe):
Obstructions removed? [ ] Yes [ ] No Describe:

PUMP: N
Type: [ ] Removed [X] Not Present [ ] Other

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal
____ in. from ____ to ____ ft. [ ] Perforated [ ] Removed
____ in. from ____ to ____ ft. [ ] Perforated [ ] Removed
Type of Perforator:

VARIANCE
Was a variance granted from the MDH for this well? [ ] Yes [X] No TN#:

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material: bentonite from 0 to 21½ ft. ____ yards 2 bags
____ from ____ to ____ ft. ____ yards ____ bags
____ from ____ to ____ ft. ____ yards ____ bags

OTHER WELLS AND BORINGS: UNKNOWN
Other unsealed and unused well or boring on property? [ ] Yes [ ] No How many?

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Fat clay	dk gray	soft	1½	21½

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project # M5175049
Boring B-9

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.

Terracon Consultants, Inc. — Licensee Business Name — M1665 — License or Registration No.
Certified Representative Signature — 3621 — Certified Rep. No. — 9/22/2017 — Date
Michael Roberts — Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY H 343633

HE-01434-14 ID# 53159 5/13R

Exhibit A-27

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. H 343634
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION

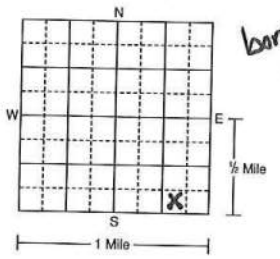
County Name: Roseau

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
Dieter	163N	40W	30	SW¼SE¼NE¼

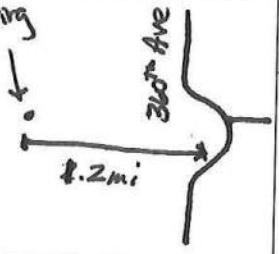
GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.90633 Longitude -95.86177

Numerical Street Address or Fire Number and City of Well or Boring Location
1.2mi W of 360th Avenue

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.



PROPERTY OWNER'S NAME/COMPANY NAME: Terry + Carol Kveen

Property owner's mailing address if different than well location address indicated above:
N69 W24073 Orchard Ct
Menomonee Falls, WI 53051

WELL OWNER'S NAME/COMPANY NAME: NO WELL

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

Date Sealed: 8/14/17
Date Well or Boring Constructed: 8/14/17

Depth Before Sealing: 61 ft. Original Depth: 61 ft.

AQUIFER(S): [X] Single Aquifer [ ] Multiaquifer

WELL/BORING: [ ] Water-Supply Well [ ] Monit. Well [X] Env. Bore Hole [ ] Other

STATIC WATER LEVEL: [ ] Measured [X] Estimated Date Measured
25 ft. [X] below [ ] above land surface

CASING TYPE(S): N/A
[ ] Steel [ ] Plastic [ ] Tile [ ] Other

WELLHEAD COMPLETION: N/A
Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other
Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other

CASING(S): N/A

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
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 ft. to ft. Open Hole from 0 to 61 ft.

OBSTRUCTIONS: [ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction
Type of Obstructions (Describe):
Obstructions removed? [ ] Yes [ ] No Describe:

PUMP: Type:
[ ] Removed [X] Not Present [ ] Other

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal
in. from to ft. [ ] Perforated [ ] Removed
in. from to ft. [ ] Perforated [ ] Removed
Type of Perforator:

VARIANCE: Was a variance granted from the MDH for this well? [ ] Yes [X] No TN#

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material: bentonite from 0 to 61 ft. yards 3 bags
from to ft. yards bags
from to ft. yards bags

OTHER WELLS AND BORINGS: UNKNOWN
Other unsealed and unused well or boring on property? [ ] Yes [ ] No How many?

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Lean clay	gray	~~N/A~~ soft	1½	9
Fat clay	dk gray	~~N/A~~ soft	9	49½
Silt	gray	med stiff	49½	61

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project # M5175049
Boring B-10

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.

Terracon Consultants, Inc. — Licensee Business Name
M1665 — License or Registration No.
Certified Representative Signature
3621 — Certified Rep. No.
9/22/2017 — Date
Michael Roberts — Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY H 343634

HE-01434-14 ID# 53159

5/13R

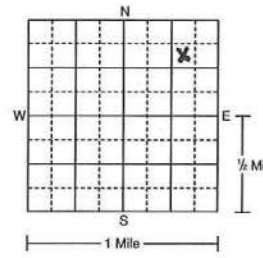
Exhibit A-28

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

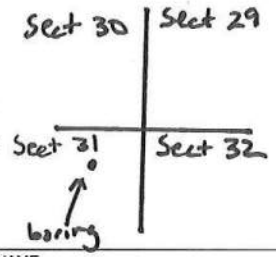
Minnesota Well and Boring Sealing No. H 343630
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION
County Name: Roseau
Township Name: Jadis | Township No.: 31 | Range No.: 163N | Section No.: 40W | Fraction (sm. → lg.): SW¼NE¼NE¼
GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.9026 Longitude -95.8601
Numerical Street Address or Fire Number and City of Well or Boring Location: 350th Avenue

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.



Date Sealed: 8/15/17
Date Well or Boring Constructed: 8/15/17
Depth Before Sealing: 21 ft. | Original Depth: 21 ft.

AQUIFER(S): [X] Single Aquifer [ ] Multiaquifer
WELL/BORING: [ ] Water-Supply Well [ ] Monit. Well [X] Env. Bore Hole [ ] Other
STATIC WATER LEVEL: [ ] Measured [X] Estimated Date Measured
25 ft. [X] below [ ] above land surface

CASING TYPE(S): N/A
[ ] Steel [ ] Plastic [ ] Tile [ ] Other

WELLHEAD COMPLETION: N/A
Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other
Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other

PROPERTY OWNER'S NAME/COMPANY NAME: Kreen Joint Revocable Trust
Property owner's mailing address if different than well location address indicated above:
4760 N 186th St
Brookfield, WI 53045

WELL OWNER'S NAME/COMPANY NAME: NO WELL
Well owner's mailing address if different than property owner's address indicated above:

CASING(S): N/A

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
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 ____ to ____ ft. Open Hole from 0 to 21 ft.

OBSTRUCTIONS: [ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction
Type of Obstructions (Describe):
Obstructions removed? [ ] Yes [ ] No Describe:

PUMP: Type:
[ ] Removed [X] Not Present [ ] Other

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal
in. from ____ to ____ ft. [ ] Perforated [ ] Removed
in. from ____ to ____ ft. [ ] Perforated [ ] Removed
Type of Perforator:

VARIANCE: Was a variance granted from the MDH for this well? [ ] Yes [X] No TN#

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material: bentonite from 0 to 21 ft. ____ yards 1 bags
from ____ to ____ ft. ____ yards ____ bags
from ____ to ____ ft. ____ yards ____ bags

OTHER WELLS AND BORINGS: UNKNOWN
Other unsealed and unused well or boring on property? [ ] Yes [ ] No How many?

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Lean clay	gray	soft	1½	10
Fat clay	dk gray	soft	10	21

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project # M5175049
Boring B-11

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.

Terracon Consultants, Inc. — Licensee Business Name — M1665 — License or Registration No.
Certified Representative Signature — 3621 — Certified Rep. No. — 9/22/17 — Date
Michael Roberts — Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY H 343630

HE-01434-14 ID# 53159 5/13R

Exhibit A-29

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. H 343631
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION

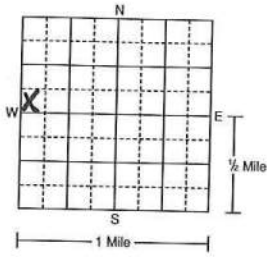
County Name: Roseau

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
N. Roseau UT	163N	40W	21	SW¼SW¼NW¼

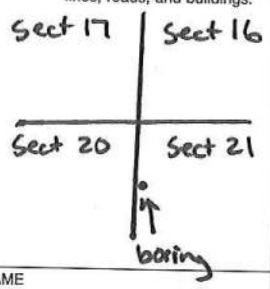
GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.9276 Longitude -95.8348

Numerical Street Address or Fire Number and City of Well or Boring Location
360th Avenue

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.



PROPERTY OWNER'S NAME/COMPANY NAME: State of Minn Dr

Property owner's mailing address if different than well location address indicated above:
500 Lafayette Dr.
St. Paul, MN 55155

WELL OWNER'S NAME/COMPANY NAME: NO WELL

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

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Lean clay	brown	soft	1½	9½
Fat clay	dk gray	med stiff	7½	54½
Sandy lean clay	gray	stiff	54½	61

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project # M5175049
Boring B-12

MINN. DEPT OF HEALTH COPY H 343631

Date Sealed: 8/10/17
Date Well or Boring Constructed: 8/10/17
Depth Before Sealing: 61 ft.
Original Depth: 61 ft.

AQUIFER(S): [X] Single Aquifer [ ] Multiaquifer

WELL/BORING: [ ] Water-Supply Well [ ] Monit. Well [X] Env. Bore Hole [ ] Other

STATIC WATER LEVEL: [X] Measured [ ] Estimated Date Measured 8/10/17
12 ft. [X] below [ ] above land surface

CASING TYPE(S): N/A
[ ] Steel [ ] Plastic [ ] Tile [ ] Other

WELLHEAD COMPLETION: N/A
Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other
Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other

CASING(S): N/A

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
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 ____ to ____ ft. Open Hole from 0 to 61 ft.

OBSTRUCTIONS
[ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction
Type of Obstructions (Describe)
Obstructions removed? [ ] Yes [ ] No Describe

PUMP
Type
[ ] Removed [X] Not Present [ ] Other

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal
in. from ____ to ____ ft. [ ] Perforated [ ] Removed
in. from ____ to ____ ft. [ ] Perforated [ ] Removed
Type of Perforator

VARIANCE
Was a variance granted from the MDH for this well? [ ] Yes [X] No TN#

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material bentonite from 0 to 61 ft. ____ yards 3 bags
____ from ____ to ____ ft. ____ yards ____ bags
____ from ____ to ____ ft. ____ yards ____ bags

OTHER WELLS AND BORINGS: UNKNOWN
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.

Terracon Consultants, Inc. — Licensee Business Name
M1665 — License or Registration No.
Certified Representative Signature
3621 — Certified Rep. No.
9/22/2017 — Date
Michael Roberts — Name of Person Sealing Well or Boring

HE-01434-14 ID# 53159 5/13R

Exhibit A-30

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

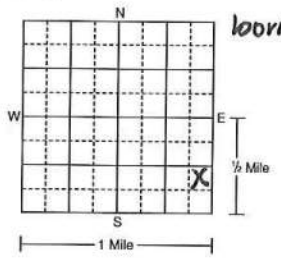
Minnesota Well and Boring Sealing No. H 343636
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION
County Name: Roseau
Township Name: N. Roseau UT | Township No.: 163N | Range No.: 40W | Section No.: 29 | Fraction (sm. → lg.): NE¼ SE¼ SE¼

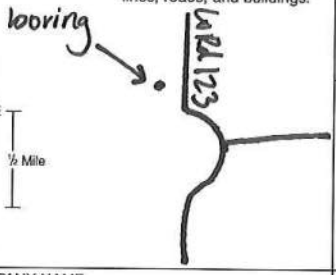
GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.9077 Longitude -95.8348

Numerical Street Address or Fire Number and City of Well or Boring Location
Co. Rd 123

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.



PROPERTY OWNER'S NAME/COMPANY NAME: State of Minn DNR
Property owner's mailing address if different than well location address indicated above:
500 Lafayette Dr.
St. Paul, MN 55155

WELL OWNER'S NAME/COMPANY NAME: NO WELL
Well owner's mailing address if different than property owner's address indicated above:

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Poorly graded sand	brown	N/A	0	2
Silty sand	brown	loose	2	7
Fat clay	dk gray	soft	7	12
Silt	brown	med stiff	12	19½
Fat clay	dk gray	soft	19½	21

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project # M5175049
Boring B-13

MINN. DEPT OF HEALTH COPY H 343636

Date Sealed: 8/9/17
Date Well or Boring Constructed: 8/9/17
Depth Before Sealing: 21 ft.
Original Depth: 21 ft.

AQUIFER(S): [X] Single Aquifer [ ] Multiaquifer
WELL/BORING: [ ] Water-Supply Well [ ] Monit. Well [X] Env. Bore Hole [ ] Other
STATIC WATER LEVEL: [ ] Measured [X] Estimated Date Measured
25 ft. [X] below [ ] above land surface

CASING TYPE(S): N/A
[ ] Steel [ ] Plastic [ ] Tile [ ] Other

WELLHEAD COMPLETION: N/A
Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other
Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other

CASING(S) Diameter: N/A Depth
_____ in. from _____ to _____ ft. [ ] Yes [ ] No Set in oversize hole? [ ] Yes [ ] No [ ] Unknown Annular space initially grouted?
_____ in. from _____ to _____ ft. [ ] Yes [ ] No [ ] Yes [ ] No [ ] Unknown
_____ in. from _____ to _____ ft. [ ] Yes [ ] No [ ] Yes [ ] No [ ] Unknown

SCREEN/OPEN HOLE
Screen from _____ to _____ ft. Open Hole from 0 to 21 ft.

OBSTRUCTIONS
[ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction
Type of Obstructions (Describe)
Obstructions removed? [ ] Yes [ ] No Describe

PUMP
Type
[ ] Removed [X] Not Present [ ] Other

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal
_____ in. from _____ to _____ ft. [ ] Perforated [ ] Removed
_____ in. from _____ to _____ ft. [ ] Perforated [ ] Removed
Type of Perforator

VARIANCE
Was a variance granted from the MDH for this well? [ ] Yes [X] No TN#

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material bentonite from 0 to 21 ft. _____ yards 1 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 [X] 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.

Terracon Consultants, Inc — Licensee Business Name
M1665 — License or Registration No.
Certified Representative Signature
3621 — Certified Rep. No.
9/22/17 — Date
Michael Roberts — Name of Person Sealing Well or Boring

HE-01434-14 ID# 53159 5/13R

Exhibit A-31

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

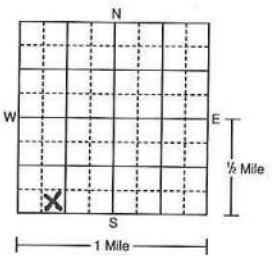
Minnesota Well and Boring Sealing No. H 343638
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION
County Name: Roseau
Township Name: Jadis | Township No.: 163N | Range No.: 40W | Section No.: 33 | Fraction (sm. → lg.): SE¼SW¼SW¼

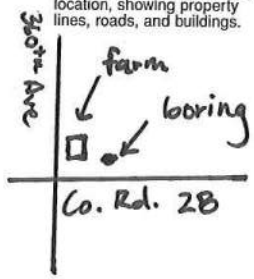
GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.8915 Longitude -95.8311

Numerical Street Address or Fire Number and City of Well or Boring Location: Co. Rd. 28

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.



PROPERTY OWNER'S NAME/COMPANY NAME: Terry & Carol Kveen
Property owner's mailing address if different than well location address indicated above: N69 W24073 Orchard Ct, Menomonee Falls, MN 53051

WELL OWNER'S NAME/COMPANY NAME: NO WELL
Well owner's mailing address if different than property owner's address indicated above:

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Lean clay	yellow	med stiff	1½	7
Fat clay	dk gray	soft	7	8½
Silt	dk gray	med stiff	8½	21

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project #M5178049
Boring B-14

Date Sealed: 8/10/17
Date Well or Boring Constructed: 8/10/17
Depth Before Sealing: 21 ft. Original Depth: 21 ft.

AQUIFER(S): [X] Single Aquifer [ ] Multiaquifer
WELL/BORING: [ ] Water-Supply Well [ ] Monit. Well [X] Env. Bore Hole [ ] Other
STATIC WATER LEVEL: [ ] Measured [X] Estimated Date Measured
25 ft. [X] below [ ] above land surface

CASING TYPE(S): N/A
[ ] Steel [ ] Plastic [ ] Tile [ ] Other

WELLHEAD COMPLETION: N/A
Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other
Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other

CASING(S): N/A
Diameter / Depth / Set in oversize hole? / Annular space initially grouted?
_____ 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 _____ to _____ ft. Open Hole from 0 to 21 ft.

OBSTRUCTIONS
[ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction
Type of Obstructions (Describe): _____
Obstructions removed? [ ] Yes [ ] No Describe: _____

PUMP
Type: _____
[ ] Removed [X] Not Present [ ] Other: _____

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal
_____ in. from _____ to _____ ft. [ ] Perforated [ ] Removed
_____ in. from _____ to _____ ft. [ ] Perforated [ ] Removed
Type of Perforator: _____

VARIANCE
Was a variance granted from the MDH for this well? [ ] Yes [X] No TN#: _____

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material: bentonite from 0 to 21 ft. _____ yards 1 bags
_____ from _____ to _____ ft. _____ yards _____ bags
_____ from _____ to _____ ft. _____ yards _____ bags

OTHER WELLS AND BORINGS: UNKNOWN
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.

Terracon Consultants, Inc. — Licensee Business Name
M1665 — License or Registration No.
Certified Representative Signature
362 — Certified Rep. No.
9/22/17 — Date
Michael Roberts — Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY H 343638

HE-01434-14 ID# 53159 5/13R

Exhibit A-32

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 1031

Minnesota Well and Boring Sealing No. H 343639
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

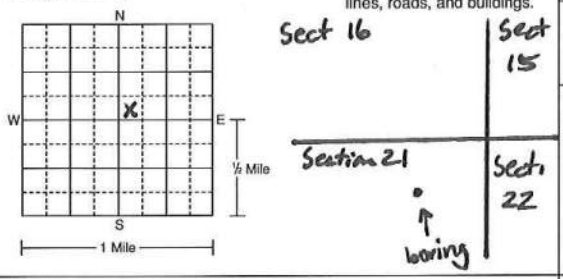
WELL OR BORING LOCATION
County Name: Roseau

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
N. Roseau VT	163N	40W	21	SW¼ SW¼ NE¼

GPS LOCATION – decimal degrees (to four decimal places)
Latitude 48.9282 Longitude -95.8217

Numerical Street Address or Fire Number and City of Well or Boring Location
360th Avenue

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.

PROPERTY OWNER'S NAME/COMPANY NAME: State of Minn DNR
Property owner's mailing address if different than well location address indicated above:
500 Lafayette Dr.
St. Paul, MN 55155

WELL OWNER'S NAME/COMPANY NAME: NO WELL
Well owner's mailing address if different than property owner's address indicated above:

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Lean clay	dk gray	soft	1½	6
Fat clay	dk gray	soft	6	21

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project # M5175049
Boring B-15

MINN. DEPT OF HEALTH COPY H 343639

Date Sealed: 8/10/17
Date Well or Boring Constructed: 8/10/17
Depth Before Sealing: 21 ft.
Original Depth: 21 ft.

AQUIFER(S)
☒ Single Aquifer ☐ Multiaquifer

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

STATIC WATER LEVEL
☐ Measured ☒ Estimated Date Measured
25 ft. ☐ below ☐ above land surface

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

WELLHEAD COMPLETION N/A
Outside: ☐ Well House ☐ At Grade ☐ Pitless Adapter/Unit ☐ Buried ☐ Well Pit ☐ Other
Inside: ☐ Basement Offset ☐ Well Pit ☐ Buried ☐ Other

CASING(S)
Diameter N/A Depth — Set in oversize hole? — Annular space initially grouted?
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 to ft. Open Hole from 0 to 21 ft.

OBSTRUCTIONS
☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill ☒ No Obstruction
Type of Obstructions (Describe)
Obstructions removed? ☐ Yes ☐ No Describe

PUMP
Type
☐ Removed ☒ Not Present ☐ Other

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
in. from to ft. ☐ Perforated ☐ Removed
in. from to ft. ☐ Perforated ☐ Removed
Type of Perforator

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 from 0 to 21 ft. yards 1 bags
from to ft. yards bags
from to ft. yards bags

OTHER WELLS AND BORINGS UNKNOWN
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.

Terracon Consultants, Inc. — Licensee Business Name
M1665 — License or Registration No.
Certified Representative Signature
3621 — Certified Rep. No.
9/22/17 — Date
Michael Roberts — Name of Person Sealing Well or Boring

HE-01434-14 ID# 53159 5/13R

Exhibit A-33

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 343635

WELL OR BORING LOCATION

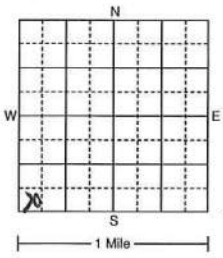
County Name: Roseau

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
Jadis	163N	40W	27	SW¼ SW¼ SW¼

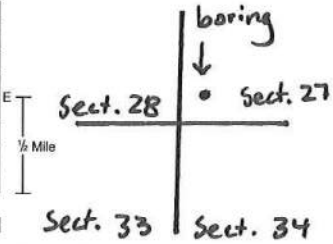
GPS LOCATION – decimal degrees (to four decimal places): Latitude 48.9079 Longitude -95.8110

Numerical Street Address or Fire Number and City of Well or Boring Location: N/A

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.



Date Sealed: 8/10/17 — Date Well or Boring Constructed: 8/10/17

Depth Before Sealing: 21 ft. — Original Depth: 21 ft.

AQUIFER(S): [X] Single Aquifer [ ] Multiaquifer

WELL/BORING: [ ] Water-Supply Well [ ] Monit. Well [X] Env. Bore Hole [ ] Other

STATIC WATER LEVEL: [X] Measured [ ] Estimated Date Measured 8/10/17 — 7½ ft. [X] below [ ] above land surface

CASING TYPE(S): N/A — [ ] Steel [ ] Plastic [ ] Tile [ ] Other

WELLHEAD COMPLETION: N/A

Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other

Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other

PROPERTY OWNER'S NAME/COMPANY NAME: Wahlberg Trust

Property owner's mailing address if different than well location address indicated above:
309 7th Ave SE
Roseau, MN 56751

WELL OWNER'S NAME/COMPANY NAME: NO WELL

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

CASING(S): Diameter N/A — Depth — Set in oversize hole? — Annular space initially grouted?

_____ 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 _____ to _____ ft. Open Hole from 0 to 21 ft.

OBSTRUCTIONS: [ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction

Type of Obstructions (Describe): _____

Obstructions removed? [ ] Yes [ ] No Describe: _____

PUMP: Type _____ [ ] Removed [X] Not Present [ ] Other _____

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

[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal

_____ in. from _____ to _____ ft. [ ] Perforated [ ] Removed

_____ in. from _____ to _____ ft. [ ] Perforated [ ] Removed

Type of Perforator: _____

VARIANCE: Was a variance granted from the MDH for this well? [ ] Yes [X] No TN# _____

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

Grouting Material bentonite from 0 to 21 ft. _____ yards 1 bags

_____ from _____ to _____ ft. _____ yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Lean clay	gray	soft	1½	4½
Fat clay	dk gray	med stiff	4½	7
Silt	dk gray	med stiff	7	14½
Fat clay	dk gray	soft	14½	21

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

Terracon Project #M5175049
Boring B-16

OTHER WELLS AND BORINGS: Other unsealed and unused well or boring on property? [ ] Yes [X] 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.

Terracon Consultants, Inc. — Licensee Business Name — M1665 — License or Registration No.

Certified Representative Signature — 3621 — Certified Rep. No. — 9/22/17 — Date

Michael Roberts — Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY — H 343635

HE-01434-14 ID# 53159 5/13R

Exhibit A-34

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 343632

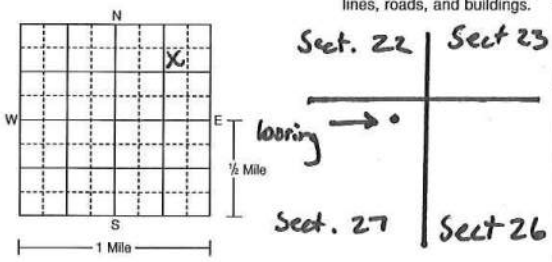
WELL OR BORING LOCATION
County Name: Roseau

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
Jadis	163N	40W	27	SW¼ NE¼ NE¼

GPS LOCATION – decimal degrees (to four decimal places): Latitude 48.9190 Longitude -95.7932

Numerical Street Address or Fire Number and City of Well or Boring Location: N/A

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.



Date Sealed: 8/14/17
Date Well or Boring Constructed: 8/14/17

Depth Before Sealing: 21 ft. Original Depth: 21 ft.

AQUIFER(S): [X] Single Aquifer [ ] Multiaquifer

WELL/BORING: [ ] Water-Supply Well [ ] Monit. Well [X] Env. Bore Hole [ ] Other

STATIC WATER LEVEL: [ ] Measured [X] Estimated Date Measured: 25 ft. [X] below [ ] above land surface

CASING TYPE(S): N/A — [ ] Steel [ ] Plastic [ ] Tile [ ] Other

WELLHEAD COMPLETION: N/A
Outside: [ ] Well House [ ] At Grade [ ] Pitless Adapter/Unit [ ] Buried [ ] Well Pit [ ] Other
Inside: [ ] Basement Offset [ ] Well Pit [ ] Buried [ ] Other

PROPERTY OWNER'S NAME/COMPANY NAME: Carol Pederson
Property owner's mailing address if different than well location address indicated above:
717 8th Ave SW
Roseau, MN 56751

WELL OWNER'S NAME/COMPANY NAME: NO WELL
Well owner's mailing address if different than property owner's address indicated above:

CASING(S): Diameter N/A — Depth — Set in oversize hole? — Annular space initially grouted?
_____ 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 _____ to _____ ft. Open Hole from 0 to 21 ft.

OBSTRUCTIONS: [ ] Rods/Drop Pipe [ ] Check Valve(s) [ ] Debris [ ] Fill [X] No Obstruction
Type of Obstructions (Describe): _____
Obstructions removed? [ ] Yes [ ] No Describe: _____

PUMP: Type _____ [ ] Removed [X] Not Present [ ] Other _____

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
[X] No Annular Space Exists [ ] Annular Space Grouted with Tremie Pipe [ ] Casing Perforation/Removal
_____ in. from _____ to _____ ft. [ ] Perforated [ ] Removed
_____ in. from _____ to _____ ft. [ ] Perforated [ ] Removed
Type of Perforator _____

VARIANCE: Was a variance granted from the MDH for this well? [ ] Yes [X] No TN# _____

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material: bentonite from 0 to 21 ft. yards 1 bags
_____ from _____ to _____ ft. yards _____ bags
_____ from _____ to _____ ft. yards _____ bags

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Topsoil	black	N/A	0	1½
Lean clay	brown	soft	1½	6
Fat clay	dk gray	soft	6	21

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

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Terracon Project # M5175049
Boring B-17

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.

Terracon Consultants, Inc. — Licensee Business Name — M1665 — License or Registration No.
Certified Representative Signature — 3621 — Certified Rep. No. — 9/22/17 — Date
Christopher Schill — Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY H 343632

HE-01434-14 ID# 53159 5/13R

Exhibit A-35

APPENDIX B
SUPPORTING INFORMATION

Laboratory Testing

Representative samples were selected for laboratory analysis. As directed by HDR, soil samples were tested for the following engineering properties:

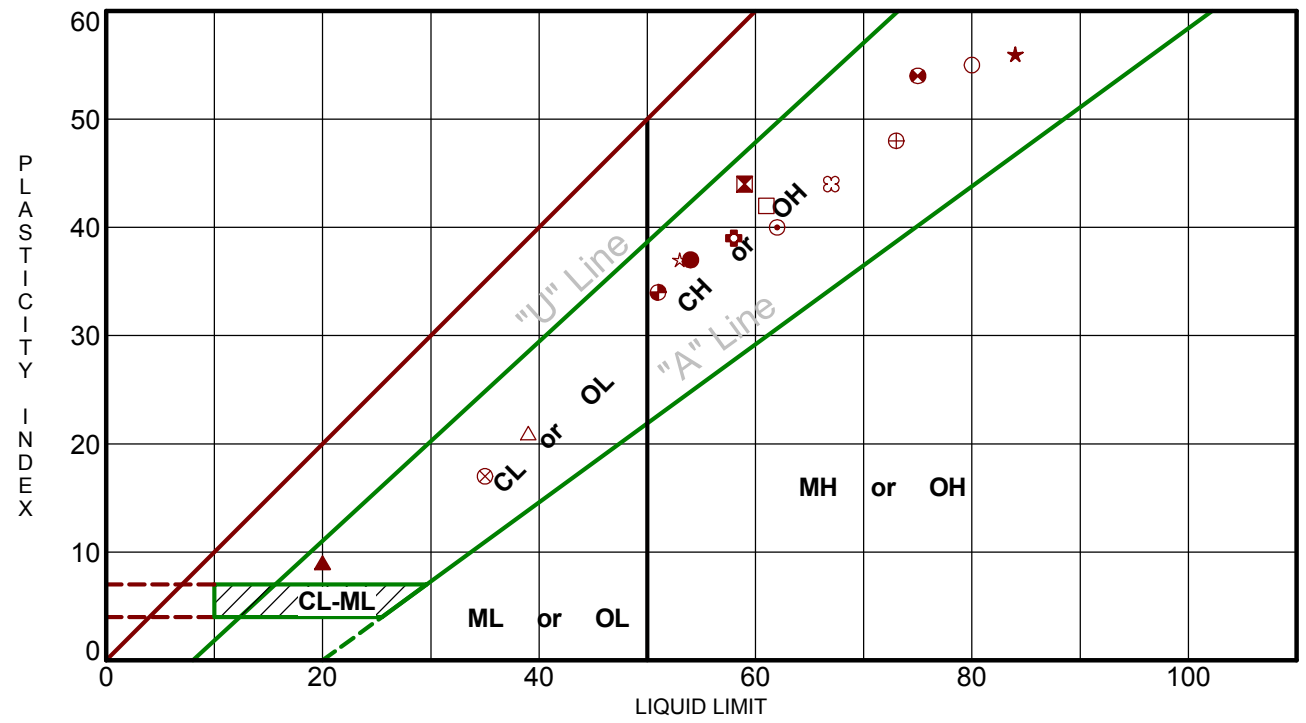
- Water content (ASTM D2216)
- Dry density (ASTM D7263-09 Method B)
- Atterberg limits (ASTM D4318)
- Grain size distribution (ASTM D422)
- Hydraulic conductivity (ASTM D5084)
- One-dimensional consolidation properties (ASTM D2435)
- UU Triaxial (ASTM D2850)
- Hydraulic Conductivity (ASTM D5084)

The laboratory test results are found on the boring logs opposite the samples they represent. Unconfined compressive strength test results are provided on the following pages.

Procedural standards noted above are for reference to methodology in general. In some cases variations to methods are applied as a result of local practice or professional judgment.

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
B-1	7 - 9	54	17	37		CH	FAT CLAY
B-3	12 - 14	59	15	44		CH	FAT CLAY
B-4	7 - 8.5	20	11	9		CL	LEAN CLAY
B-8	4.5 - 6.5	84	28	56		CH	FAT CLAY
B-8	14.5 - 16.5	62	22	40		CH	FAT CLAY
B-9	2 - 3.5	58	19	39		CH	FAT CLAY
B-9	19.5 - 21.5	80	25	55		CH	FAT CLAY
B-10	2 - 3.5	39	18	21		CL	LEAN CLAY
B-10	7 - 9	35	18	17		CL	LEAN CLAY
B-10	12 - 14	73	25	48		CH	FAT CLAY
B-10	19.5 - 21.5	61	19	42		CH	FAT CLAY
B-12	12 - 14	75	21	54		CH	FAT CLAY
B-12	39.5 - 41.5	51	17	34		CH	FAT CLAY
B-12	49.5 - 51.5	53	16	37		CH	FAT CLAY
B-15	14.5 - 16.5	67	23	44		CH	FAT CLAY

PROJECT: Roseau Lake Rehabilitation

SITE: Roseau County
Roseau, Minnesota

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

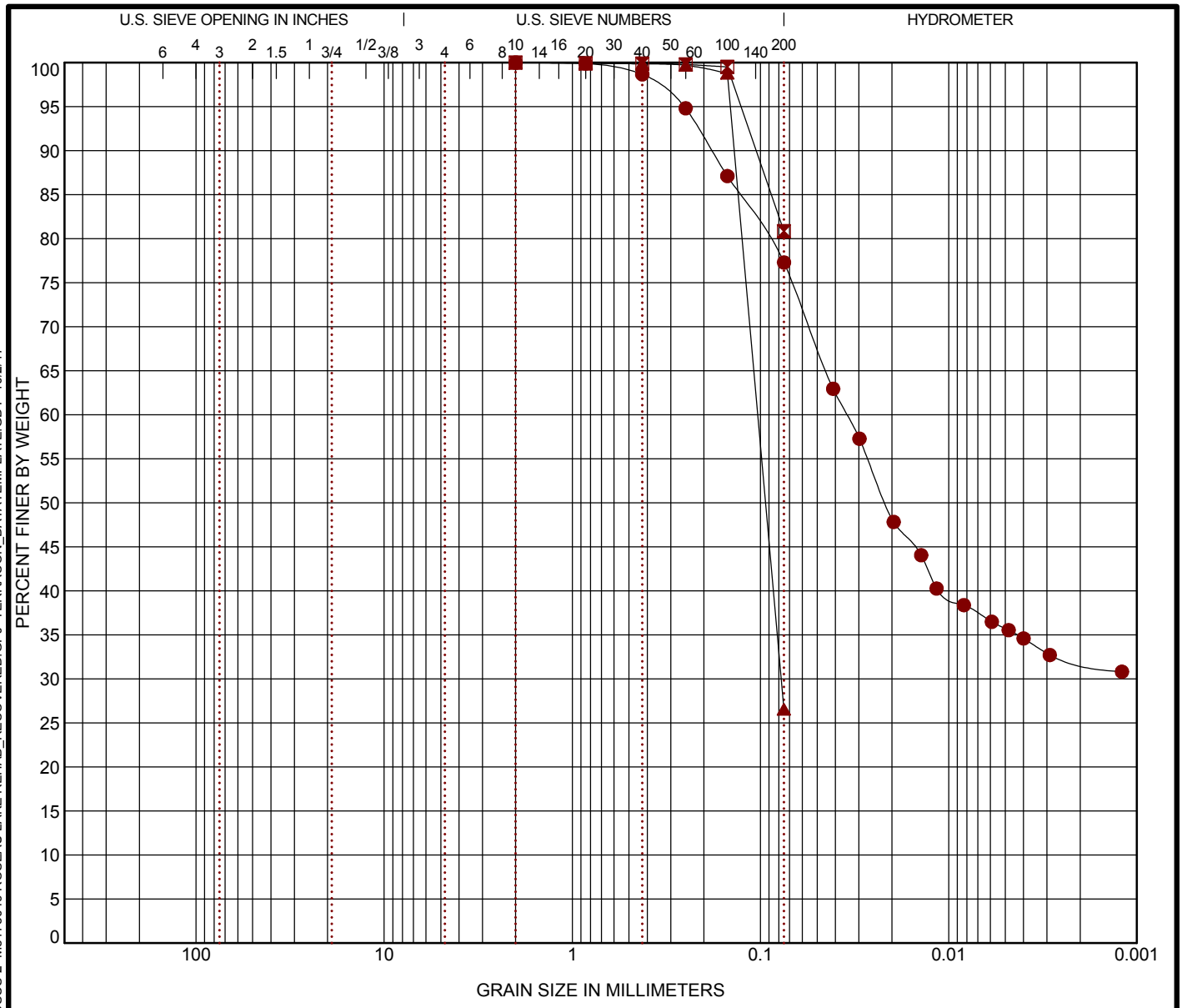
PROJECT NUMBER: M5175049

CLIENT: Roseau River Watershed District

EXHIBIT: B-2

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
B-2	3 - 5	LEAN CLAY WITH SAND CL						
B-2	7 - 8.5	SILT with SAND (ML)	14	NP	NP	NP		
B-13	2 - 3.5	SILTY SAND (SM)		NP	NP	NP		

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
B-2	3 - 5	2	0.035			0.0	22.7	41.6		35.7
B-2	7 - 8.5	2				0.0	19.1		80.9	
B-13	2 - 3.5	2	0.103	0.078		0.0	73.4		26.6	

PROJECT: Roseau Lake Rehabilitation

SITE: Roseau County
Roseau, Minnesota

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

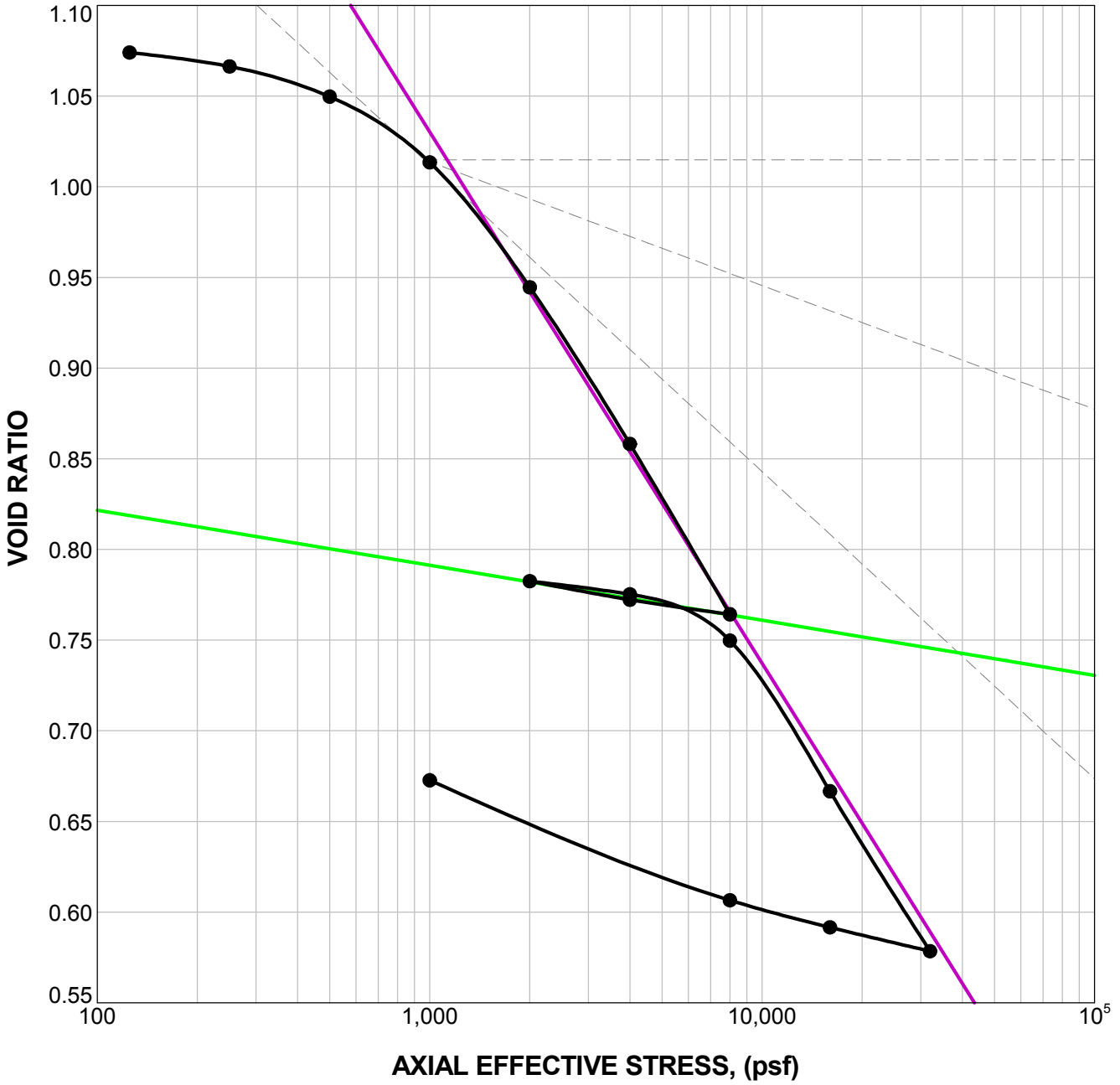
PROJECT NUMBER: M5175049

CLIENT: Roseau River Watershed District
Roseau, Minnesota

EXHIBIT: B-3

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 M5175049 ROSEAU LAKE REHAB_RECOVERED.GPJ TERRACON_DATATEMPLATE.GDT 10/2/17

CONSOLIDATION TEST (D2435)



Natural		Initial Dry Density (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c (vr / log stress)	C_r (vr / log stress)	Initial Void Ratio
Saturation	Moisture									
109.9 %	43.9 %	81.1	80	55	2.70		1,184	0.293	0.030	1.078

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY	CH	

NOTES:

Borehole: B-9 Depth: 19.5 ft Specimen #: 8

PROJECT: Roseau Lake Rehabilitation

SITE: Roseau County
Roseau, Minnesota

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

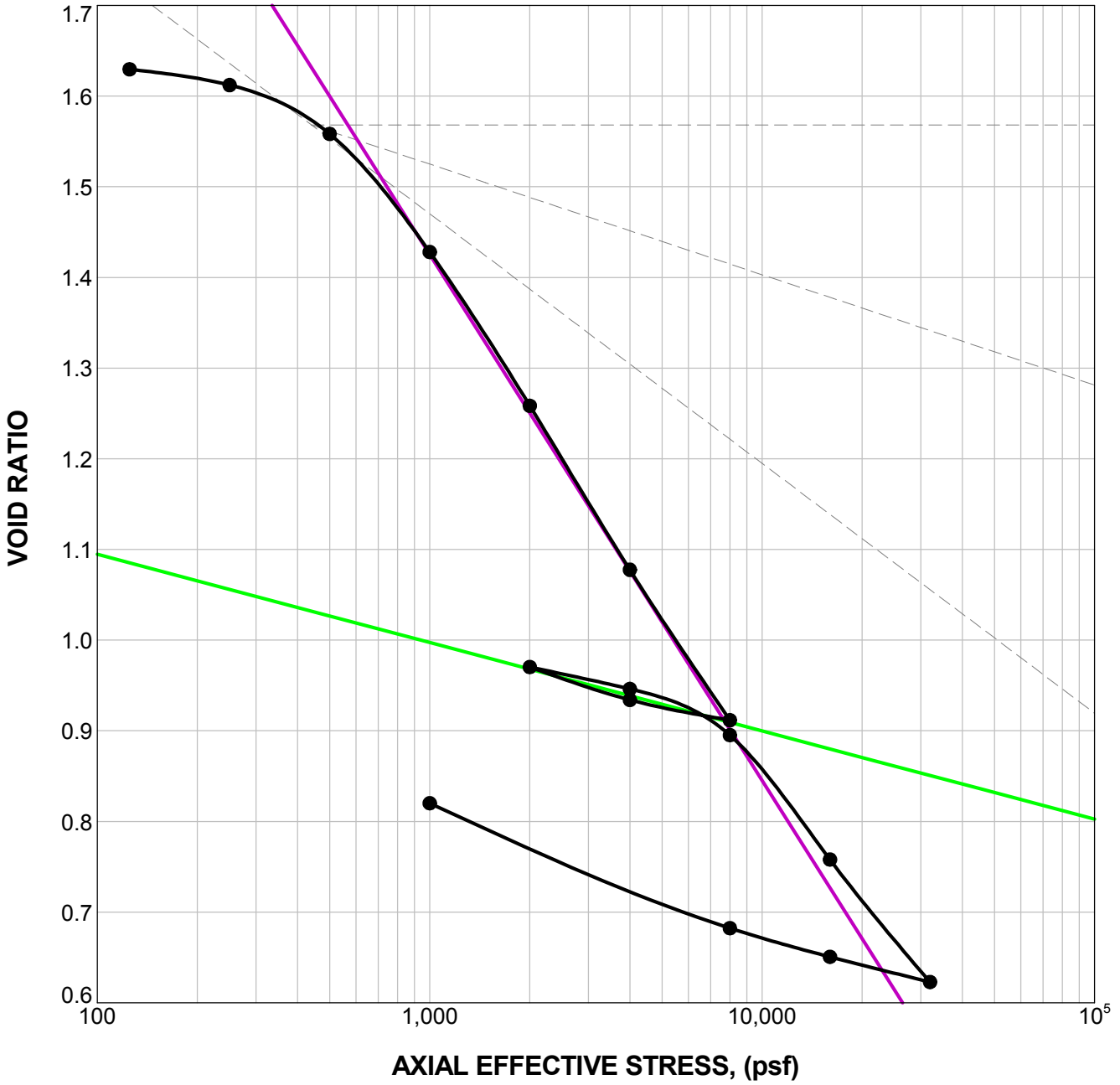
PROJECT NUMBER: M5175049

CLIENT: Roseau River Watershed District
Roseau, Minnesota

EXHIBIT: B-4

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CONS_LOAD-DEF_PROP_STRESS-VOIDRATIO M5175049 ROSEAU LAKE REHAB_RECOVERED.GPJ TERRACON_DATATEMPLATE.GDT 10/2/17

CONSOLIDATION TEST (D2435)



Natural		Initial Dry Density (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c (vr / log stress)	C_r (vr / log stress)	Initial Void Ratio
Saturation	Moisture									
98.1 %	59.4 %	63.9	75	54	2.70		606	0.580	0.097	1.636

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY	CH	

NOTES:

Borehole: B-12 Depth: 12 ft Specimen #: 6

PROJECT: Roseau Lake Rehabilitation

SITE: Roseau County
Roseau, Minnesota

Terracon
1555 N 42nd St Unit B
Grand Forks, ND

PROJECT NUMBER: M5175049

CLIENT: Roseau River Watershed District
Roseau, Minnesota

EXHIBIT: B-5

HYDRAULIC CONDUCTIVITY REPORT

Terracon
1555 N. 42nd St., Unit B
Grand Forks, ND 58203
701-772-2832

Client
Roseau River Watershed District

Project
Roseau Lake Rehabilitation

Project Number: M5175049

Test Method:	ASTM D5084 Method C	Sample No.:	Boring B-2 - 3' - 5'
Sample Type:	Remolded	Location :	
Date Sampled :	8/14/2017	Operator :	wro
Soil Type :	LEAN CLAY with SAND (CL) - gray		
Proctor Results :	111.9 pcf	Molded @ :	94.9 % compact
	15.8 %		15.6 % M.C.

Initial Sample Parameters

Wet Wt. (g)	664.79	Diameter (in)	2.850	Height (in)	3.228	Water Content Pan No.:	136
Dry Wt. (g)	575.32		2.876		3.217	Wet Wt.	70.25
Area (cm^2)	41.350		2.844		3.202	Dry Wt.	62.97
Area (in^2)	6.409	Average (in)	2.857	Average(in)	3.216	Pan Wt.	16.16
Density (pcf)	106.2					W.C. (%)	15.6
Assumed Sp.G.	2.65		Void Ratio:	0.556		% Saturation	74.0
Vol Wet (cc)	337.74	Vol. Solids Vs(cc)	217.10	Porosity n (%):	36		

Final Sample Parameters

Wet Wt. (g)	715.94	Diameter (in)	2.897	Height (in)	3.202	Water Content Pan No.:	19
Dry Wt. (g)	593.41		2.859		3.267	Wet Wt.	797.36
Area (cm^2)	42.048		2.886		3.192	Dry Wt.	674.89
Area (in^2)	6.517	Average (in)	2.881	Average(in)	3.220	Pan Wt.	81.79
Density (pcf)	107.6					W.C. (%)	20.6
						% Saturation	101.8

Panel No.:	2	Chamber No.:	3			Hydraulic Gradient:	17.9
Cell Press.(psi)	58.4	Back Press.(psi)	54.1	Tail Press. (psi)	52.0		
		● Pipette	○ Burette	Pipe Area (cm^2)	0.079	Fluid:	De-aired tap water

Date and Time	Temp	Head (h1)	Tail (h2)	Elapsed Time (S)	Total Head	k (cm / s)	k_{20} (cm/sec)	dt / dh
9/13/17 7:21	23	26.40	25.00		144.26			
9/13/17 9:15	23	28.00	23.40	6840	140.68	2.87E-08	2.67E-08	1.00
9/13/17 11:26	23	30.00	21.50	7860	136.31	3.13E-08	2.92E-08	0.95
9/13/17 13:29	23	32.00	19.80	7380	132.17	3.26E-08	3.04E-08	0.85
9/13/17 15:37	23	34.00	18.20	7680	128.14	3.15E-08	2.93E-08	0.80

HYDRAULIC CONDUCTIVITY (k_{20}) = AVERAGE 2.89E-08 cm/sec

HYDRAULIC CONDUCTIVITY REPORT

Terracon
1555 N. 42nd St., Unit B
Grand Forks, ND 58203
701-772-2832

Client
Roseau River Watershed District

Project
Roseau Lake Rehabilitation

Project Number: M5175049

Test Method:	ASTM D5084 Method C	Sample No.:	Boring B-10, Sample #4, 7' -9'
Sample Type:	3-inch Shelby tube	Location :	
Date Sampled :	8/14/2017	Operator :	wro
Soil Type :	LEAN CLAY (CL) - gray, silt lenses		
Proctor Results :	pcf	Molded @ :	% compact
	%		% M.C.

Initial Sample Parameters

Wet Wt. (g)	651.57	Diameter (in)	2.808	Height (in)	3.275	Water Content Pan No.:	170
Dry Wt. (g)	510.51		2.802		3.279	Wet Wt.	94.00
Area (cm^2)	39.821		2.800		3.262	Dry Wt.	77.22
Area (in^2)	6.172	Average (in)	2.803	Average(in)	3.272	Pan Wt.	16.49
Density (pcf)	96.2					W.C. (%)	27.6
Assumed Sp.G.	2.65		Void Ratio:	0.718		% Saturation	101.8
Vol Wet (cc)	330.94	Vol. Solids Vs(cc)	192.65	Porosity n (%):	42		

Final Sample Parameters

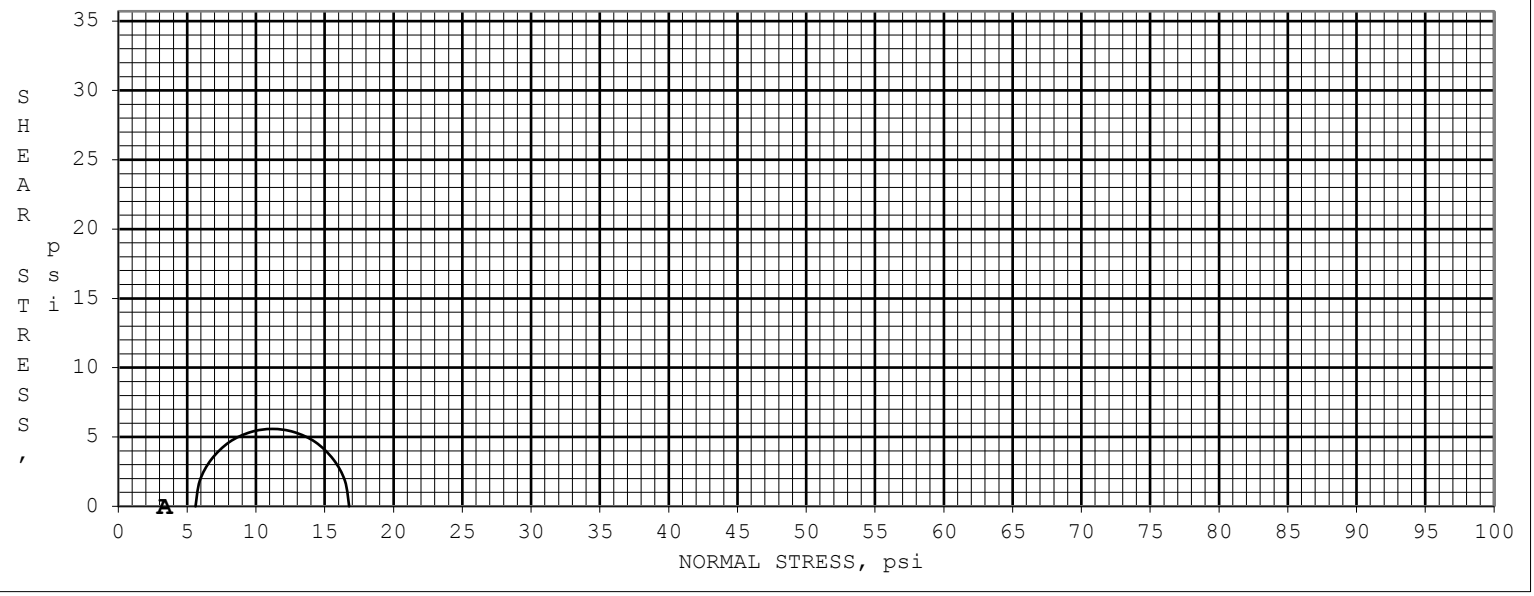
Wet Wt. (g)	648.83	Diameter (in)	2.802	Height (in)	3.242	Water Content Pan No.:	45
Dry Wt. (g)	505.15		2.803		3.237	Wet Wt.	727.37
Area (cm^2)	39.858		2.809		3.230	Dry Wt.	583.74
Area (in^2)	6.178	Average (in)	2.805	Average(in)	3.236	Pan Wt.	78.75
Density (pcf)	96.2					W.C. (%)	28.4
						% Saturation	104.6

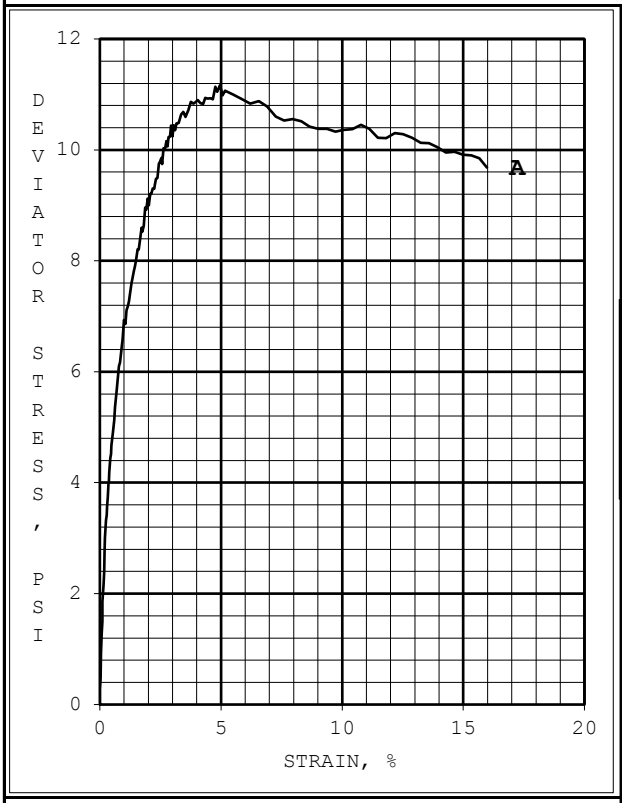
Panel No.:	1	Chamber No.:	1			Hydraulic Gradient:	16.9
Cell Press.(psi)	59.3	Back Press.(psi)	54.1	Tail Press. (psi)	52.1		
		● Pipette	○ Burette	Pipe Area (cm^2)	0.079	Fluid:	De-aired tap water

Date and Time	Temp	Head (h1)	Tail (h2)	Elapsed Time (S)	Total Head	k (cm / s)	k_{20} (cm/sec)	dt / dh
9/13/17 7:21	23	25.60	25.20		139.75			
9/13/17 9:15	23	26.90	23.80	6840	136.72	2.64E-08	2.46E-08	1.08
9/13/17 11:26	23	28.30	22.50	7860	133.70	2.35E-08	2.18E-08	0.93
9/13/17 13:29	23	29.60	21.30	7380	130.90	2.36E-08	2.20E-08	0.92
9/13/17 15:37	23	31.00	20.00	7680	127.88	2.51E-08	2.34E-08	0.93

HYDRAULIC CONDUCTIVITY (k_{20}) = AVERAGE 2.29E-08 cm/sec

Exhibit B-7





SPECIMEN #:		A		
INITIAL	WATER CONTENT, % FROM TRIMMINGS	33.0		
	DRY DENSITY, pcf	87.8		
	SATURATION, %	97		
	VOID RATIO	0.92		
WATER CONTENT, % AFTER SHEAR		33.4		

A	B	C

MINOR PRINCIPAL STRESS, psi	5.6		
MOHR'S CIRCLES DRAWN AT % STRAIN	5.0		
DEVIATOR STRESS AT % STRAIN, psi	11.2		
STRAIN AT PEAK DEVIATOR STRESS, %	5.0		
DEVIATOR STRESS AT 15% STRAIN, psi	9.9		
INITIAL DIAMETER, inch	2.844		
INITIAL HEIGHT, inch	5.620		
STRAIN RATE, %/minute	0.33		

CONTROLLED - STRAIN TEST

DESCRIPTION OF SPECIMENS: LEAN CLAY, VERY DARK GRAYISH BROWN TRACE YELLOWISH BROWN

LL	PL	PI	Gs 2.7 EST.

SAMPLE TYPE: 3" SHELBY TUBE

TEST TYPE: UU

REMARKS:

PROJECT: ROSEAU LAKE REHABILITATION
ROSEAU, MINNESOTA M5175049

BORING #: B-8

SAMPLE #: 3

DEPTH, feet: 4.5 - 6.5

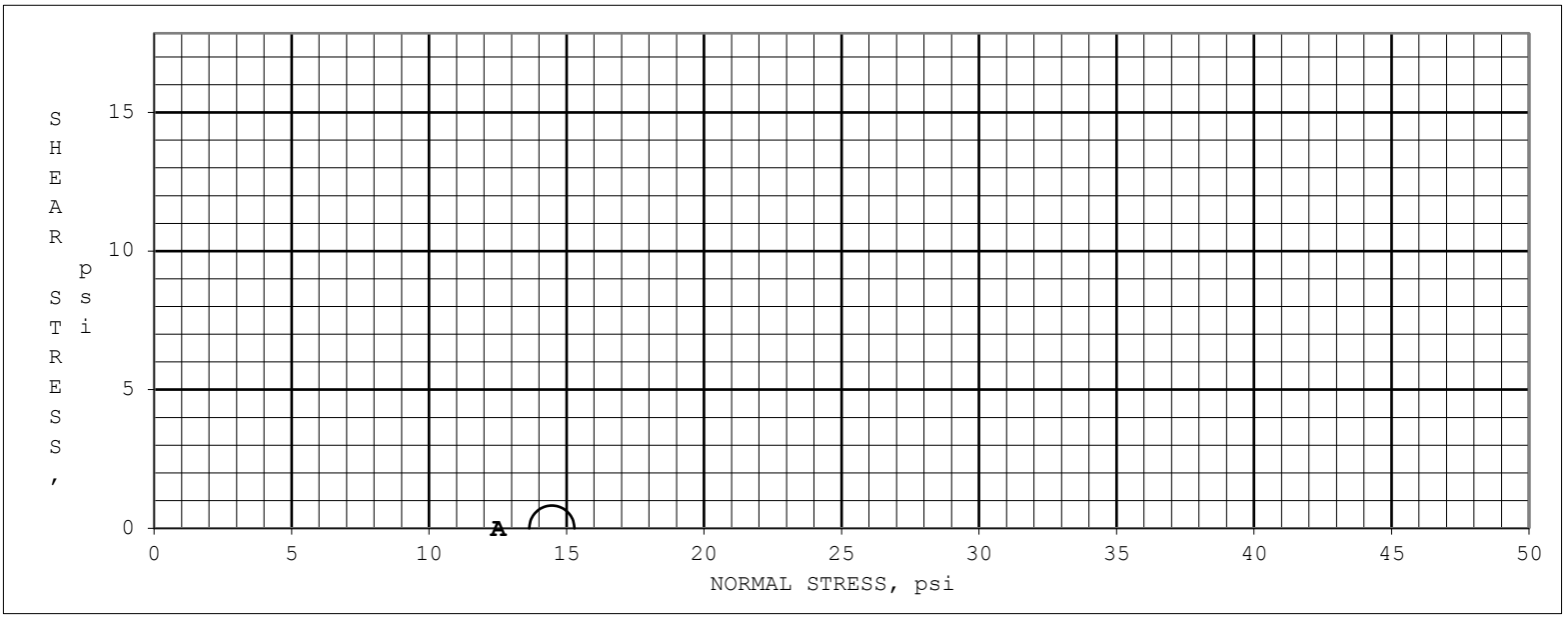
LABORATORY: TERRACON - LENEXA

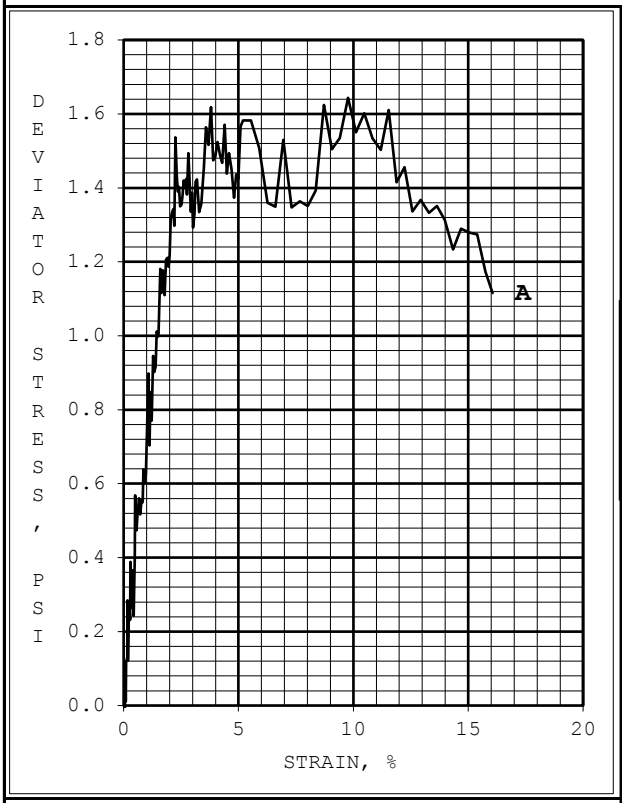
DATE: 9/15/2017

TRIAXIAL COMPRESSION TEST REPORT

PROCEDURE: ASTM D2850, UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION, MEMBRANE CORRECTION APPLIED. OTHER TESTS WERE CONDUCTED IN GENERAL ACCORDANCE WITH ASTMS D2216 AND D4318 IF APPLICABLE.

Terracon





SPECIMEN #:		A		
INITIAL	WATER CONTENT, % FROM TRIMMINGS	54.2		
	DRY DENSITY, pcf	67.3		
	SATURATION, %	97		
	VOID RATIO	1.51		
WATER CONTENT, % AFTER SHEAR		59.3		

A	B	C

MINOR PRINCIPAL STRESS, psi	13.6		
MOHR'S CIRCLES DRAWN AT % STRAIN	9.8		
DEVIATOR STRESS AT % STRAIN, psi	1.6		
STRAIN AT PEAK DEVIATOR STRESS, %	9.8		
DEVIATOR STRESS AT 15% STRAIN, psi	1.3		
INITIAL DIAMETER, inch	2.895		
INITIAL HEIGHT, inch	5.877		
STRAIN RATE, %/minute	0.33		

CONTROLLED - STRAIN TEST

DESCRIPTION OF SPECIMENS: FAT CLAY, GRAY

LL	PL	PI	Gs 2.7 EST.

SAMPLE TYPE: 3" SHELBY TUBE

TEST TYPE: UU

REMARKS:

PROJECT: ROSEAU LAKE REHABILITATION
ROSEAU, MINNESOTA M5175049

BORING #: B-8

SAMPLE #: 7

DEPTH, feet: 14.5 - 16.0

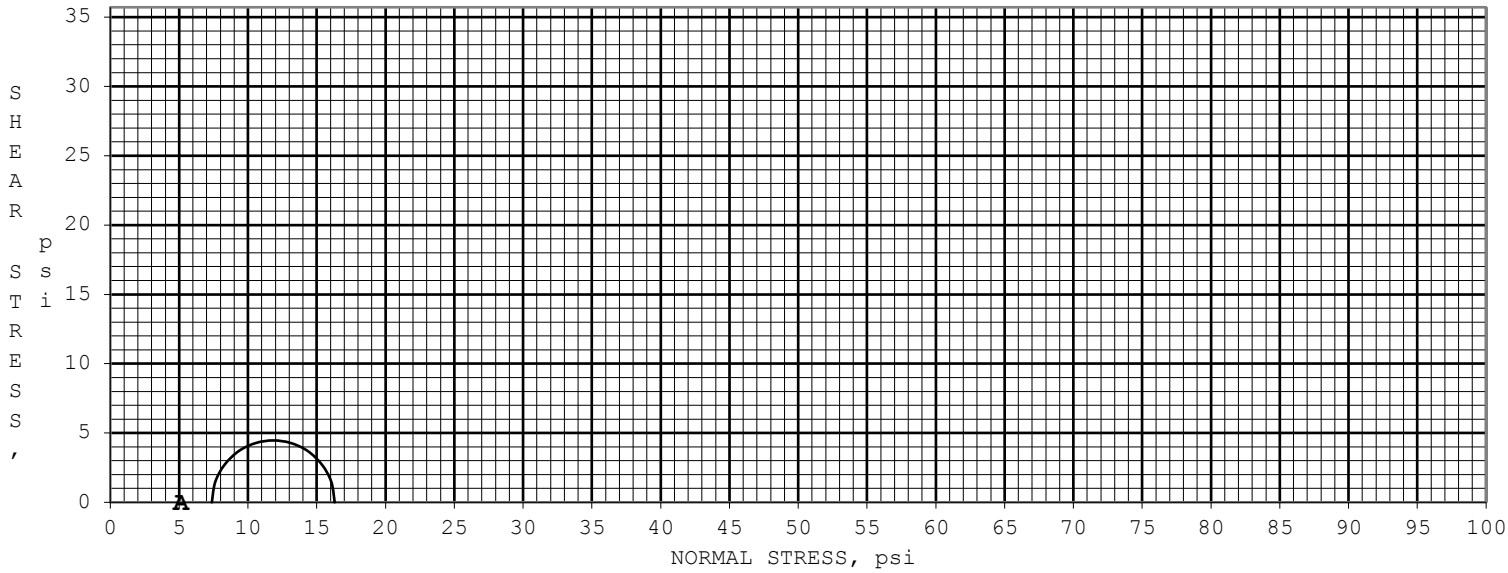
LABORATORY: TERRACON - LENEXA

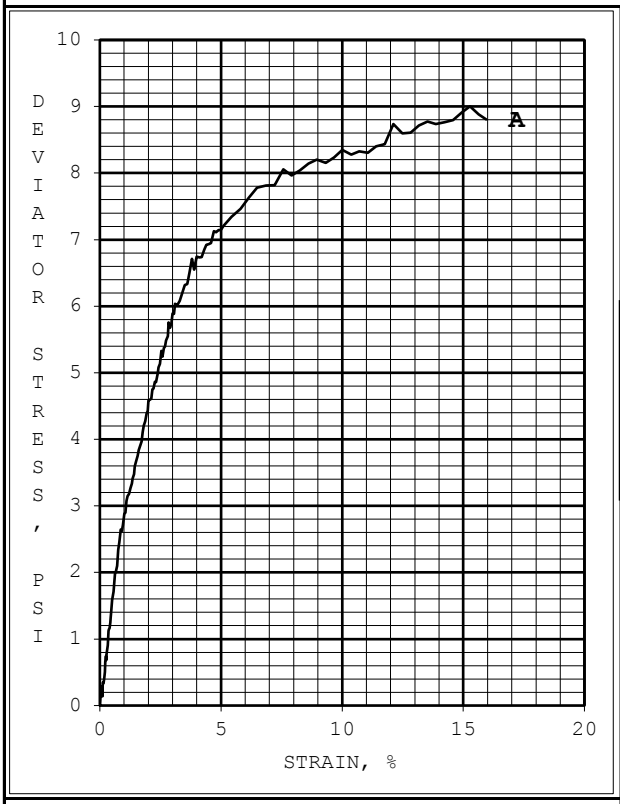
DATE: 9/15/2017

TRIAXIAL COMPRESSION TEST REPORT

PROCEDURE: ASTM D2850, UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION, MEMBRANE CORRECTION APPLIED. OTHER TESTS WERE CONDUCTED IN GENERAL ACCORDANCE WITH ASTMS D2216 AND D4318 IF APPLICABLE.

Terracon





SPECIMEN #:		A		
INITIAL	WATER CONTENT, % FROM TRIMMINGS	23.1		
	DRY DENSITY, pcf	101.9		
	SATURATION, %	95		
	VOID RATIO	0.65		
WATER CONTENT, % AFTER SHEAR		25.4		

A | B | C

MINOR PRINCIPAL STRESS, psi	7.4		
MOHR'S CIRCLES DRAWN AT % STRAIN	15.0		
DEVIATOR STRESS AT % STRAIN, psi	8.9		
STRAIN AT PEAK DEVIATOR STRESS, %	15.0		
DEVIATOR STRESS AT 15% STRAIN, psi	8.9		
INITIAL DIAMETER, inch	2.843		
INITIAL HEIGHT, inch	5.217		
STRAIN RATE, %/minute	0.33		

CONTROLLED - STRAIN TEST

DESCRIPTION OF SPECIMENS: LEAN CLAY, DARK GRAY TRACE DARK BROWN

LL	PL	PI	Gs 2.7 EST.

SAMPLE TYPE: 3" SHELBY TUBE

TEST TYPE: UU

REMARKS:

PROJECT: ROSEAU LAKE REHABILITATION
ROSEAU, MINNESOTA M5175049

BORING #: B-10

SAMPLE #: 4

DEPTH, feet: 7.0 - 9.0

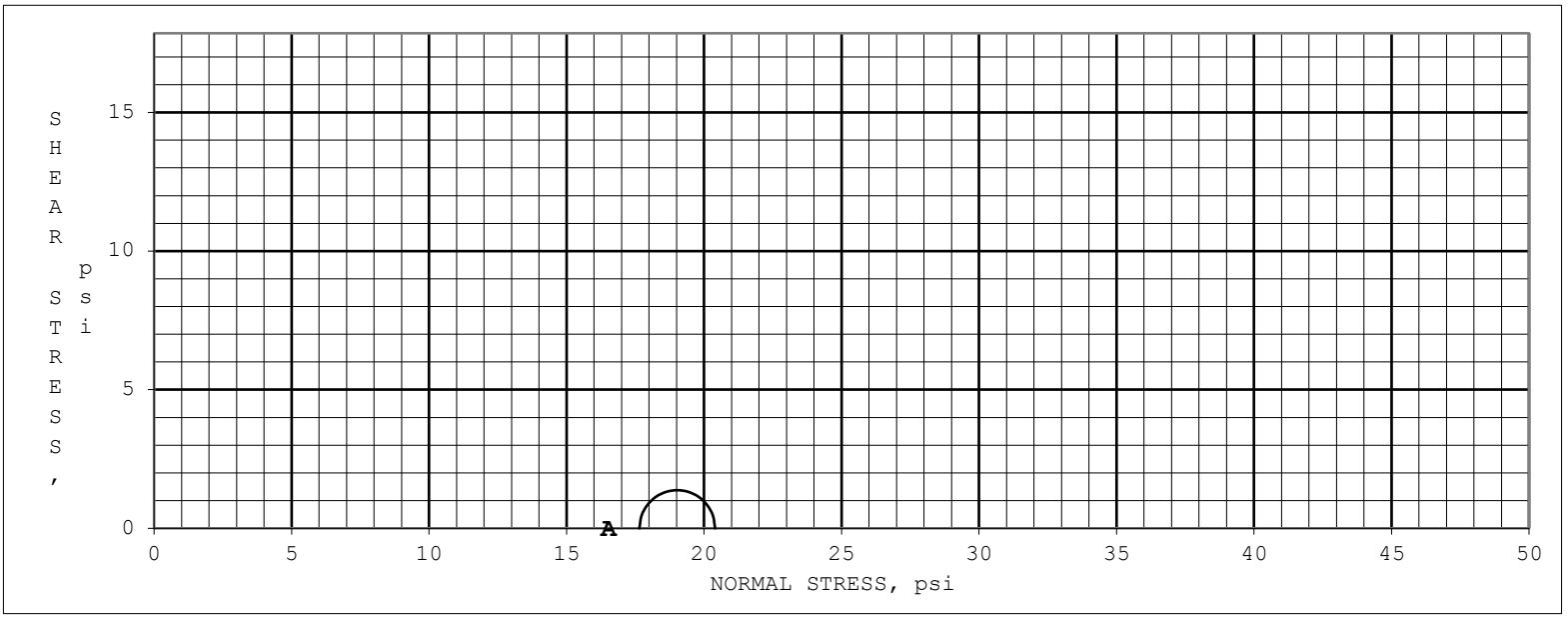
LABORATORY: TERRACON - LENEXA

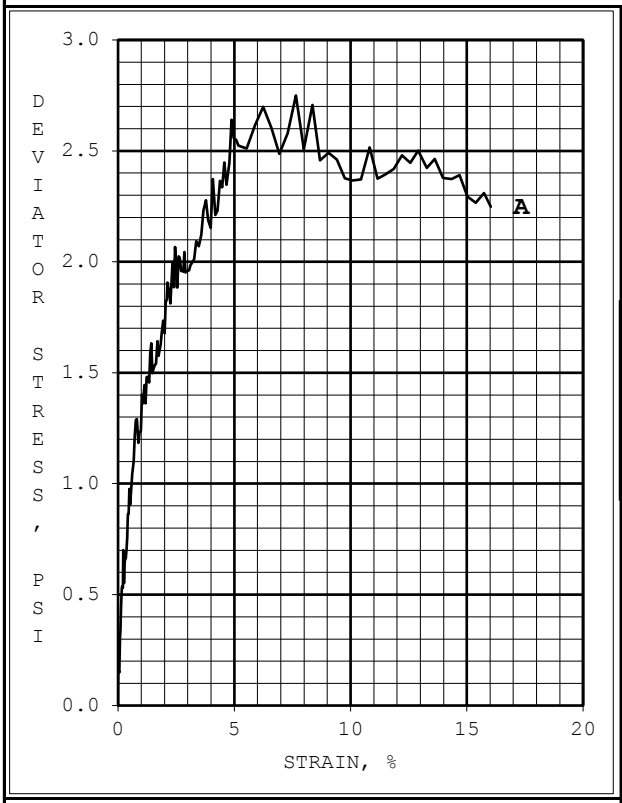
DATE: 9/15/2017

TRIAXIAL COMPRESSION TEST REPORT

PROCEDURE: ASTM D2850, UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION, MEMBRANE CORRECTION APPLIED. OTHER TESTS WERE CONDUCTED IN GENERAL ACCORDANCE WITH ASTMS D2216 AND D4318 IF APPLICABLE.

Terracon





SPECIMEN #:		A		
INITIAL	WATER CONTENT, % FROM TRIMMINGS	51.1		
	DRY DENSITY, pcf	72.1		
	SATURATION, %	103		
	VOID RATIO	1.34		
WATER CONTENT, % AFTER SHEAR		50.7		

A	B	C

MINOR PRINCIPAL STRESS, psi	17.7		
MOHR'S CIRCLES DRAWN AT % STRAIN	7.7		
DEVIATOR STRESS AT % STRAIN, psi	2.7		
STRAIN AT PEAK DEVIATOR STRESS, %	7.7		
DEVIATOR STRESS AT 15% STRAIN, psi	2.3		
INITIAL DIAMETER, inch	2.773		
INITIAL HEIGHT, inch	5.736		
STRAIN RATE, %/minute	0.33		

CONTROLLED - STRAIN TEST

DESCRIPTION OF SPECIMENS: FAT CLAY, VERY DARK GRAY TRACE LIGHT GRAY

LL	PL	PI	Gs 2.7 EST.

SAMPLE TYPE: 3" SHELBY TUBE

TEST TYPE: UU

REMARKS:

PROJECT: ROSEAU LAKE REHABILITATION
ROSEAU, MINNESOTA M5175049

BORING #: B-10

SAMPLE #: 8

DEPTH, feet: 19.0 - 21.0

LABORATORY: TERRACON - LENEXA

DATE: 9/15/2017

TRIAXIAL COMPRESSION TEST REPORT

PROCEDURE: ASTM D2850, UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION, MEMBRANE CORRECTION APPLIED. OTHER TESTS WERE CONDUCTED IN GENERAL ACCORDANCE WITH ASTMS D2216 AND D4318 IF APPLICABLE.

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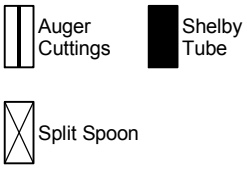
APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING



WATER LEVEL

Water Initially Encountered

Water Level After a Specified Period of Time

Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (psf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 500	0 - 1
Loose	4 - 9	Soft	500 to 1,000	2 - 4
Medium Dense	10 - 29	Medium Stiff	1,000 to 2,000	4 - 8
Dense	30 - 50	Stiff	2,000 to 4,000	8 - 15
Very Dense	> 50	Very Stiff	4,000 to 8,000	15 - 30
		Hard	> 8,000	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

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Exhibit: C-1

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.

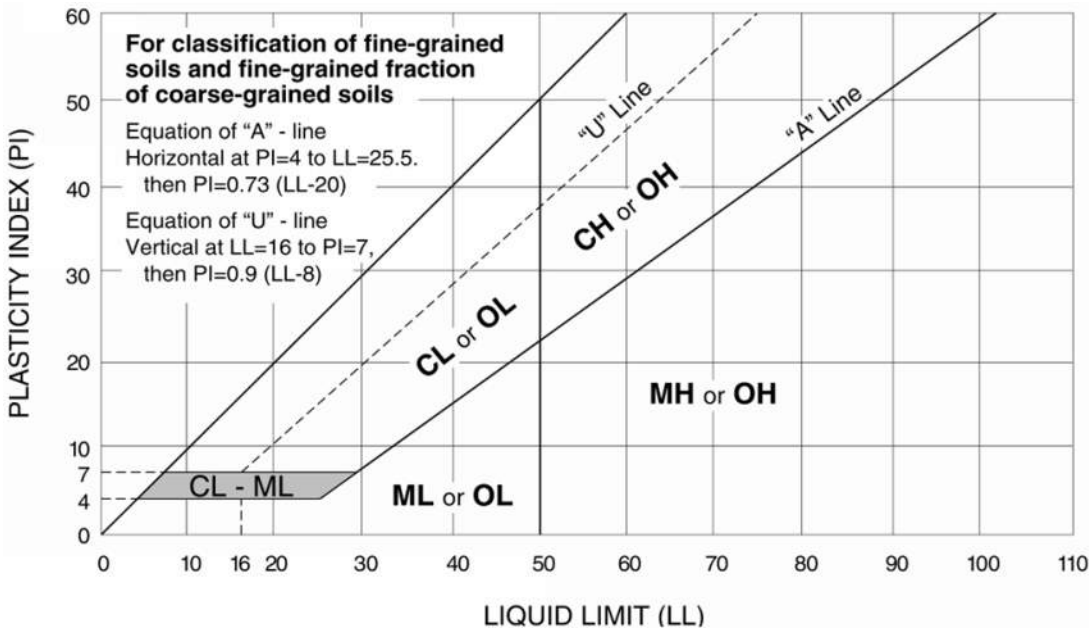

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Exhibit C-2