Prepared by: EOR, April 2023

For the Prior Lake-Spring Lake Watershed District

Sponsored by the Board of Water and Soil Resources

Adopted by the PLSLWD Board of Managers April 11, 2023

Buck Wetland Enhancement Feasibility Study

EOR water ecology community

Cover Image

Buck Wetland July 2021

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1. BACKGROUND AND PROJECT PURPOSE

1.1. Introduction

The Prior Lake-Spring Lake Watershed District (PLSLWD) authorized the Buck Wetland Enhancement Feasibility Study to develop design alternatives and costs to complete a wetland enhancement project. Potential project goals examined as part of this feasibility study included enhancing the existing wetland area, reducing the phosphorus load from the watershed, and providing downstream flood reduction.

The Buck Wetland Enhancement Project Area is shown in Figure 1. There are two wetlands within the project area, referred to during this study as the east wetland and west wetland. The east and west wetlands are connected by an existing ditch. The east wetland flows into the west wetland, which then discharges into Buck Lake, and ultimately to Lower Prior Lake. The west wetland is highly altered by past ditching and excavation.

The total area draining to the project area is approximately 1,180 acres. The land use within the watershed upstream of the project area is primarily rural and agricultural. Figure 1 shows the contributing watershed in relation to the project area.

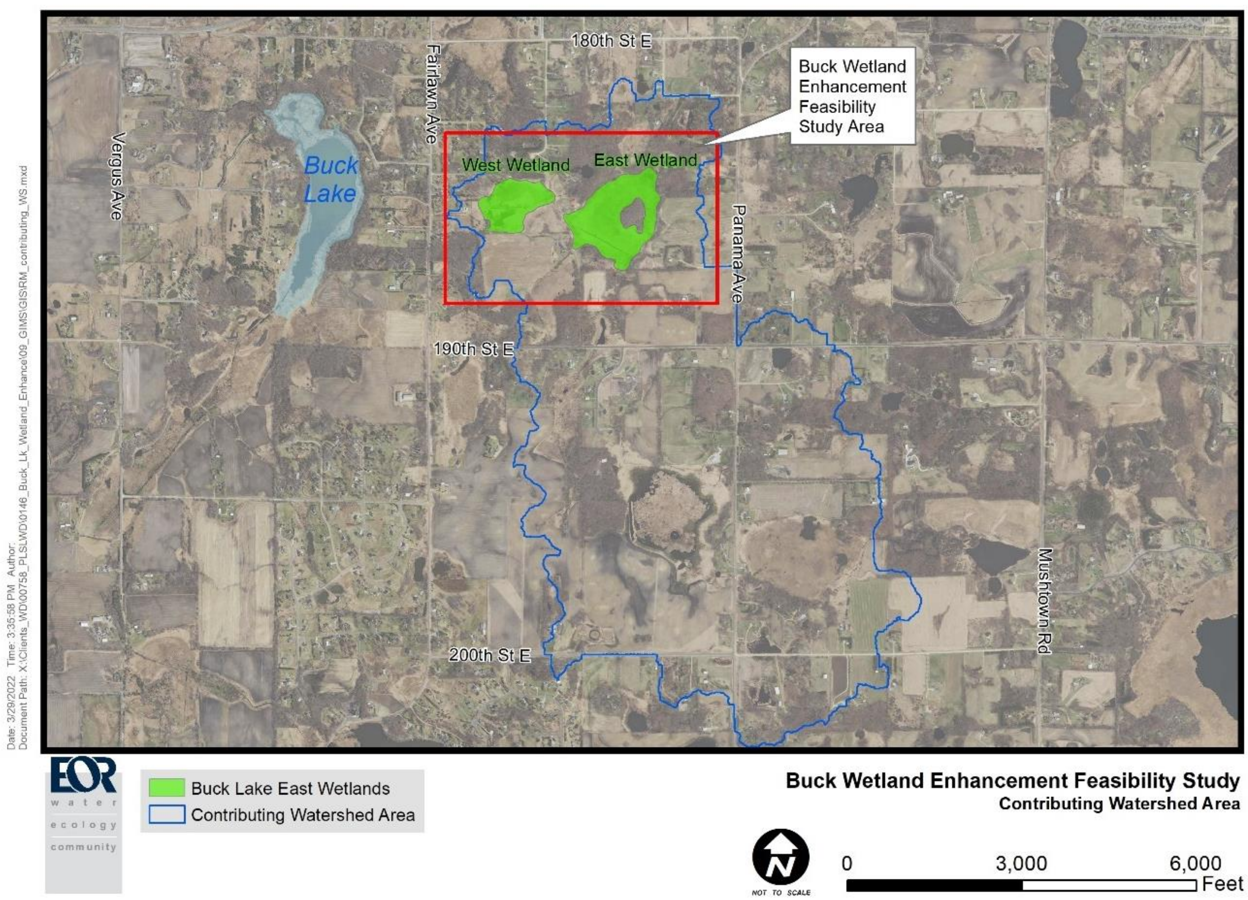


Figure 1. Buck Wetland Enhancement Feasibility Study Project Area

Using information collected during the field survey and the existing calibrated PCSWMM model for the watershed, design concepts were developed to meet three objectives for the project. In this study, the design concepts are reviewed and compared, and the next steps of the project are discussed.

1.2. Background and Previous Studies

1.2.1. Flood Reduction

The Buck Wetland Enhancement Project was originally identified as a flood reduction concept in the Prior Lake Stormwater Management and Flood Mitigation Study completed by Barr Engineering in 2016 (2016 Flood Study). One of the scenarios identified in the 2016 Flood Study proposed a restrictive outlet and overflow structure at the west wetland to decrease the discharge rate from the wetland, increase detention time in the wetland, and reduce flood levels in the downstream waterbodies of Spring Lake and Upper and Lower Prior Lake.

The Upper Watershed Blueprint Study (UWB), completed in March 2021, identified programs, projects, and policies to reduce phosphorus and reduce flooding in the PLSLWD. The UWB acknowledges the challenge that often projects that are most beneficial to water quality provide little flood mitigation, and projects that are most efficient for flood reduction offer minimal water quality benefit. Therefore, the UWB sorted projects into two categories: flood reduction and water quality. The Buck Wetland Enhancement Project was listed primarily as a water quality project. The study indicated a high total phosphorus (TP) load within the watershed, up to 500 lbs/yr. The Buck Wetland Enhancement Project scored high in the project scoring matrix from the UWB due to its low estimated cost per estimated pound of phosphorus removed.

1.2.2. Water Quality

Upper Prior Lake was listed on the Minnesota Pollution Control Agency's list of impaired waters in 2002. Its impaired use is aquatic recreation, and the pollutant is for excess nutrients, primarily total phosphorus. A Total Maximum Daily Load was developed for Spring and Upper Prior Lake in 2012 and requires a TP reduction of 2,959 lbs/yr to Spring Lake. The Buck Wetland Enhancement Project is within the Upper Prior Lake Watershed; therefore, water quality benefits are being explored and considered as a part of the design objectives and will be evaluated in the project scenarios.

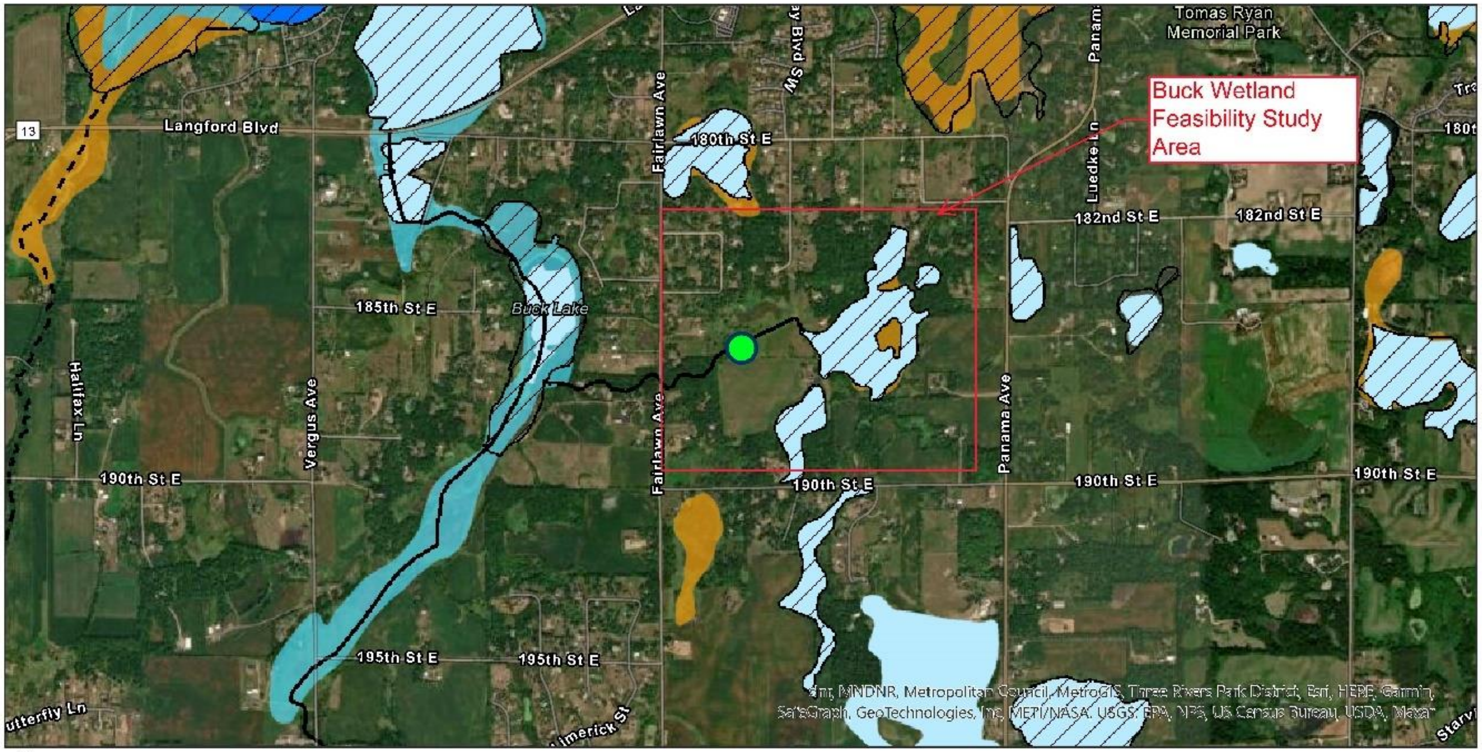
1.2.3. Existing Wetland Designation

Figure 2 shows the existing Minnesota Department of Natural Resources (MnDNR) designations for the waterbodies within the project area. The east wetland is considered a public water basin, and the ditch flowing through the west wetland is considered a public water watercourse. These regulatory designations have an impact on the design objectives and scenarios that are considered for this study, as there are limitations for the work that can be completed within these public waters.

The east wetland was assessed by PLSLWD for the 2012 Comprehensive Wetland Plan. The wetland was classified as a Basic Protection wetland with moderate vegetation and wildlife quality. No data was collected for the west wetland.

DEPARTMENT OF NATURAL RESOURCES

Lake & Flood Elevations Online



N

0 0.15 0.3 0.6 Miles

Datums for LiDAR contours:
Vertical NAV88 | Horizontal NAD83

Sources:
-MNDNR contours from MnTOPO
-FEMA National Flood Hazard Layer
See LFEO FAQ for data source details:
http://files-intranet.dnr.state.mn.us/user_files/3687/lfeo-faq.pdf

Date: Wed Nov 09 2022 15:20:16

Comments: null

National Flood Hazard Layer (NFHL)

Flood Hazard Zones

- 1% Annual Chance Flood Hazard (100 Year Floodplain)
- Floodway
- Zone D (Area of Undetermined Flood Hazard)
- 0.2% Annual Chance Flood Hazard (500 Year Floodplain)
- Area with Reduced Flood Risk Due to Levee

Estimated 1% Water Surface Elevations

Minnesota Public Waters Delineations

Public Water Watercourses

- Public Water Watercourse
- Public Ditch/Altered Natural Watercourse

Public Waters Basins

Disclaimer: The State of Minnesota, Department of Natural Resources, Ecological and Water Resources Division assumes no responsibility for and disclaims all liability for any typographical or other errors on this site. The DNR may make changes to the lake floodplain elevations at any time and without notice.

Figure 2. MnDNR Existing Designations for Waterbodies within the Project Area

1.3. Design Objectives

Based on the information gathered from previous studies and the information known about the watershed area and the project location, the following primary design objectives for the project have been established:

- Enhance the existing wetland functions via restored hydrology and vegetation
- Provide water quality benefit (i.e., reduce TP loading to Spring Lake)
- Reduce flood levels (on Spring and Prior Lakes)

To achieve these design objectives, multiple scenarios were reviewed with varying levels of change from existing conditions. The scenarios and their quantified benefits are discussed in Section 3 of this report.

2. METHODS

2.1. Data Collection

Assessment of this project area prior to this study was completed from a desktop review using LiDAR, aerial imagery, and reports completed for the entire Upper Watershed (the portion of PLSLWD tributary to Spring Lake). This study included the collection of additional data to assess existing conditions of the project area in more detail. The additional data collected has been considered when designing the concept scenarios for this study and may be used during the final design and permitting process if this project is selected for implementation by the Board.

2.1.1. Topographic Survey and Field Assessment of Wetland Quality

During the field survey, topographic information of the main flow paths for water through the wetland area as well as active land uses/structures within the wetland area were surveyed. To assess wetland condition, an MPCA Rapid Floristic Quality Assessment (RFQA) was completed for the east and west wetlands in July 2021. The RFQA is a vegetation-based, ecological condition assessment that assigns wetland condition categories of poor, fair, good, or exceptional (MPCA 2014).

The plant community types and RFQA condition scores for each wetland can be seen in Figure 3. The RFQA results indicated the east wetland is in fair quality floristic condition and the west wetland is in poor quality floristic condition. The east wetland's fair quality is due to areas of remnant fresh meadow and shrub-carr (shrub-dominated wetland) that are dominated by native vegetation. The west wetland's poor quality is due to dominance of almost exclusively invasive species. Invasive cattail dominates the shallow marsh in the west wetland and only two other species were observed in this area. Reed canary grass dominates fresh meadow in the west wetland with cover ranging from 75-95%. Areas of shallow open water are also present in the west wetland but were excluded from the RFQA because insufficient quantity of vegetation was present for analysis.

2.1.2. Rare Species and Wildlife

EOR reviewed the MnDNR Natural Heritage Information System for records of rare species within a 1-mile buffer of the wetland basins. No records were identified. Observations made during the field assessment identified no rare species or obvious critical habitat.

Landowners identified a portion of the west wetland as an annual nesting area for sandhill cranes (Figure 4). Sandhill cranes are protected by the federal Migratory Bird Treaty Act, which prohibits the taking (including killing, capturing, selling, trading, and transport) of protected migratory bird species. The nesting season typically begins in April and extends through August. Permitting for project implementation will need to take this into consideration.

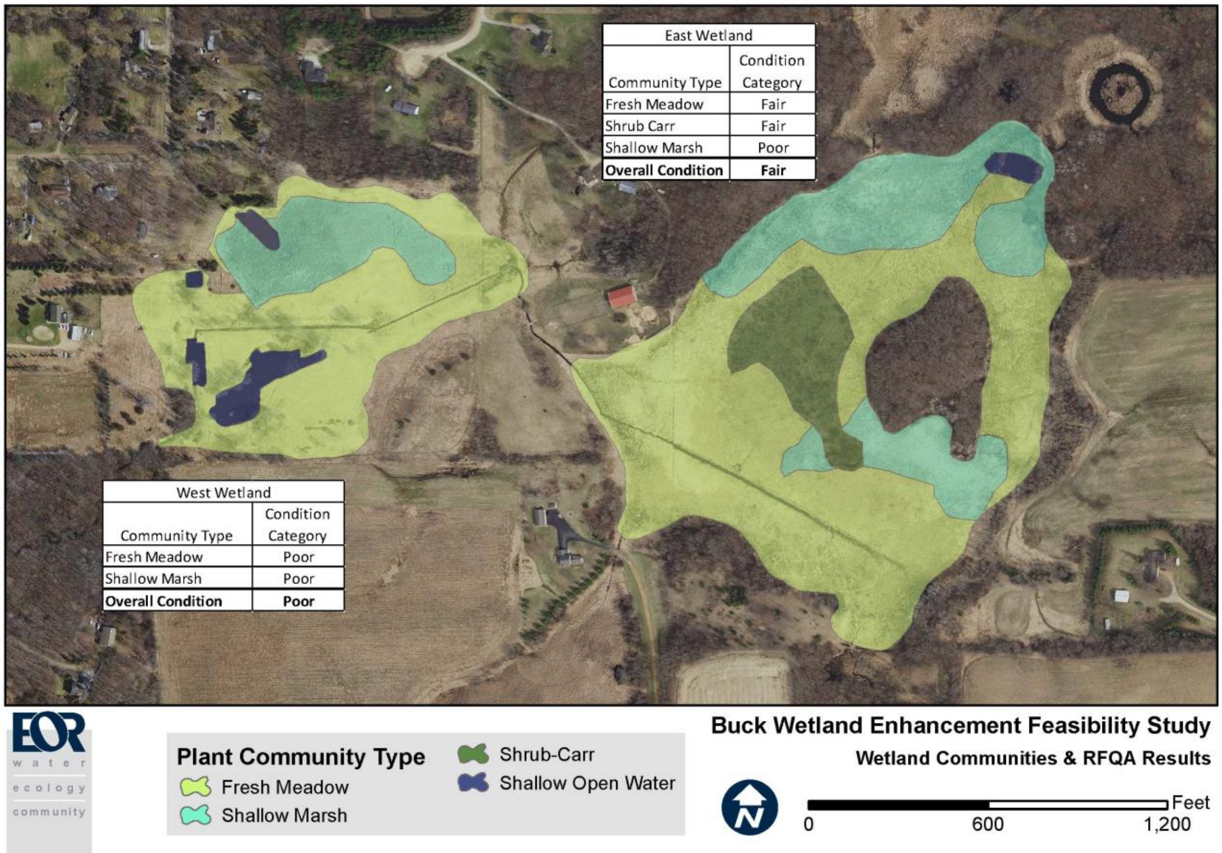


Figure 3. Wetland Communities and RFQA Results

Figure 4. Approximate sandhill crane nesting area location provided by landowner.

2.1.3. Wetland Sediment Core Phosphorus Analysis

Wetlands can either be a phosphorus sink (i.e., absorbs phosphorus from the water that passes through it) or a phosphorus source (i.e., contributes additional phosphorus to the water that passes through it). For a wetland to be able to remove phosphorus, the wetland soils must not already have high levels of phosphorus (also known as legacy loads of phosphorus), which typically occurs downstream of tiled agricultural lands and/or historic animal feeding operations prior to the advancement of runoff controls. In addition, for a wetland to be able to remove phosphorus, the chemical nature of the wetland soils must have the capacity to bind phosphorus. Before assuming the water quality benefits and phosphorus removal benefits as a result of increased inundation within a wetland storage area, it is necessary to complete an investigation of the wetland soils. If the soils are found to be high in phosphorus or do not have a high phosphorus binding capacity, it would be recommended that the wetland soils be scraped to improve the phosphorus binding capacity prior to construction.

In July 2022, EOR staff collected twenty soil samples from 15 sampling locations distributed throughout the project area. Analysis of the sediment cores collected provides evidence to suggest that wetland soils are not overly saturated with phosphorus. Furthermore, the wetland soils have a relatively high capacity for retaining phosphorus. The full report regarding this phosphorus analysis is included in Appendix A.

2.2. Modeling

The PLSLWD existing PCSWMM model of the Upper Watershed was used to analyze water level changes related to the concept scenarios for this project, both at the study area and at Spring and Prior Lakes. The model was updated to simulate 2-, 10-, and 100-year, 24-hour storm events, as well as a 100-year 30-day storm event. Details within the east and west wetland flow path were also reviewed and updated to match the topographic survey. As a result, an updated "Existing Conditions" model was used specifically for this project to compare existing conditions more accurately to proposed scenarios. The modeling results for concept scenarios are discussed in Section 3.1.

3. CONCEPT SCENARIOS

Based on landowner input at the April 5, 2022 meeting and given the relatively higher quality of the east wetland as compared to the west wetland, it was determined that this feasibility study and concept scenarios should focus on the west wetland, with no alteration of the east wetland (physically or hydrologically). As such, four (4) concept scenarios were developed for the west wetland. The focus, description, and goal of each concept scenario is included in Table 1. Concept Scenarios 1-3 are illustrated in Figures 5 through 7. Concept plans (typically defined as 30% complete construction plans) for all scenarios are contained in Appendix B.

Table 1. Concept Scenario Descriptions

Scenario	Focus	Description	Goals
1	Wetland Enhancement	Excavation to increase open water, ditch filling and ditch blocks to restore wetland hydrology by reconnecting runoff to wetland soils and vegetation, and removal of reed canary grass via ~1-ft deep wetland scrape to restore native vegetation.	Increase water levels for events less than the 2-year, 24-hour event to filter particulate phosphorus, increase phosphorus uptake by vegetation, and reduce invasive species cover.
2	Water Quality	Scenario 1 + an Iron-Enhanced Sand Filter (IESF) to filter more particulate phosphorus and capture soluble phosphorus.	Maximize phosphorus load reduction by detaining and filtering as much of the annual runoff volume as possible without negatively impacting wetland enhancement activities.
3	Flood Reduction	Scenario 1 + an earthen berm and gated outlet structure to maximize detention of runoff.	Maximize flood reduction on Prior Lake and Spring Lake.
4	Hybrid	Scenarios 1 + 2 + 3	Maximize benefits of Scenarios 1-3.

3.1. Modeling Results

3.1.1. Hydrologic and Hydraulic Results

The concept scenarios were modeled in PCSWMM to compare the effects each scenario would have on water levels within the wetland area for the estimated 2-, 10-, and 100-year, 24-hour storm events based on National Oceanic and Atmospheric Administration (NOAA) data. Table 2 outlines the change in water surface elevation of the west wetland for each scenario. The east wetland within the project area will not experience any change in water levels as a result of the concept scenarios.

Table 2. PCSWMM Model Results 2-, 10-, and 100-year 24-hour Storm Events

	2-year, 24-hour event		10-year, 24-hour event		100-year, 24-hour event	
Scenario	West Wetland Peak Water Surface Elevation	Increase from Existing Conditions (ft)	West Wetland Peak Water Surface Elevation	Increase from Existing Conditions (ft)	West Wetland Peak Water Surface Elevation	Increase from Existing Conditions (ft)
Existing	956.3	-	957.7	-	959.6	-
1	956.3	0.0	957.7	0.0	959.6	0.0
2	958.1	1.8	958.5	0.8	959.8	0.2
3	958.9	2.6	959.6	1.9	960.7	1.1
4	958.9	2.6	959.6	1.9	960.7	1.1

Figures were developed to show the extent of the increased inundation to the west wetland as a result of the scenarios. The additional inundation shown on the figures is temporary inundation that occurs at the peak of the modeled storm event.

- Figure 5 shows the estimated inundation area in comparison to the existing inundation area for the 2-year, 24-hour storm for Scenario 1, where no changes to the inundation area are expected for the 2-year, 24-hour storm. Based on data from NOAA, the 2-year, 24-hour storm represents a rainfall quantity over a 24-hour period that has a 50 percent probability of occurring during the year. There are also no changes to the inundation area for the 10- and 100-yr, 24-hour storm events for Scenario 1.
- Figure 6 shows the estimated inundation area in comparison to the existing inundation area for the 2-year, 24-hour storm event for Scenario 2. Scenario 2 is also expected to have an increase in inundation area for the 10- and 100-year, 24-hour storm events (Table 2). The slight increase in the 100-year, 24-hour storm event for Scenario 2 may be optimized during final design to show no change in water surface elevation. The modeling for this scenario assumes a permanent pool at elevation 954.1 would be established. During final design, it is possible that the outlet structure could be modified to include active management of the permanent pool so that the permanent pool could be lowered when storm events are not occurring. If this is desired, the final design

would include a recommendation for how to manage the outlet structure before and after storm events.

- Figure 7 shows the estimated inundation area in comparison to the existing inundation area for the 100-year, 24-hour storm event for Scenarios 3 and 4. These scenarios show the largest change in inundation for the 100-year, 24-hour storm event, however, they also show an increase in water surface elevation for the more frequent storm events (Table 2). The modeling assumes a permanent pool at elevation 958.0 would be established. During final design, it is possible that the outlet structure could be modified to include active management of the permanent pool so that the permanent pool could be lowered when storm events are not occurring. If this is desired, the final design would include a recommendation for how to manage the outlet structure before and after storm events.

Table 3 shows the expected flood reduction on Upper Prior Lake and Spring Lake for the 100-year, 30-day storm event for the modeled scenarios. Note that there are minimal expected flood improvements for Scenarios 1 and 2, which is expected because the focus of those scenarios is on wetland enhancement and water quality, however the increased inundation does show to have some impact on Upper Prior Lake and Spring Lake

Table 3. Flood Reductions Prior Lake and Spring Lake for the 100-yr 30-day storm event.

Scenario	Flood Reduction on Upper Prior Lake (ft)	Flood Reduction on Spring Lake (ft)
Existing	-	-
Scenario 1	-0.01	0.00
Scenario 2	-0.04	-0.04
Scenario 3	-0.13	-0.07
Scenario 4	-0.13	-0.07

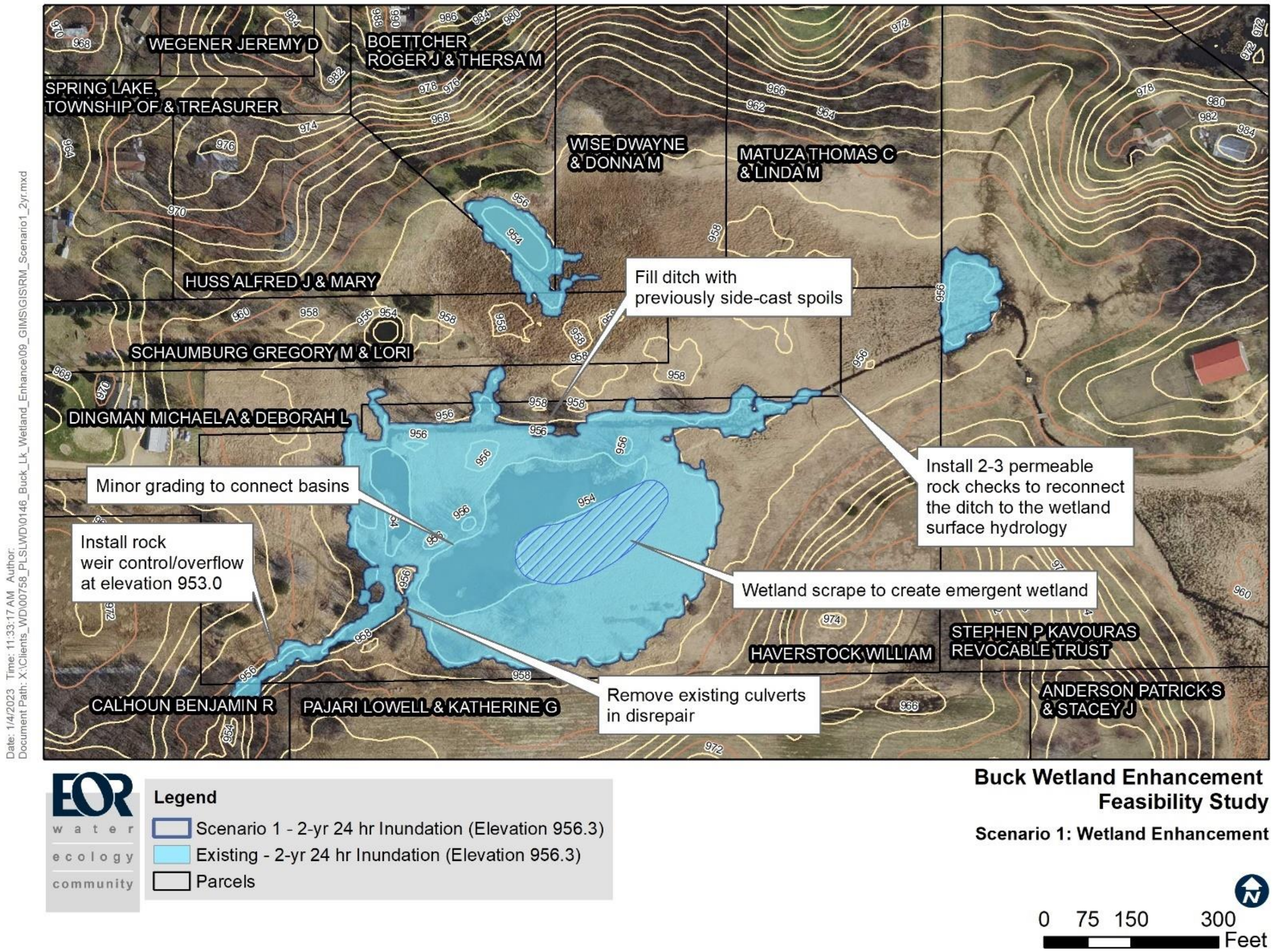


Figure 5. Scenario 1: Existing and Proposed 2-year Inundation Comparison

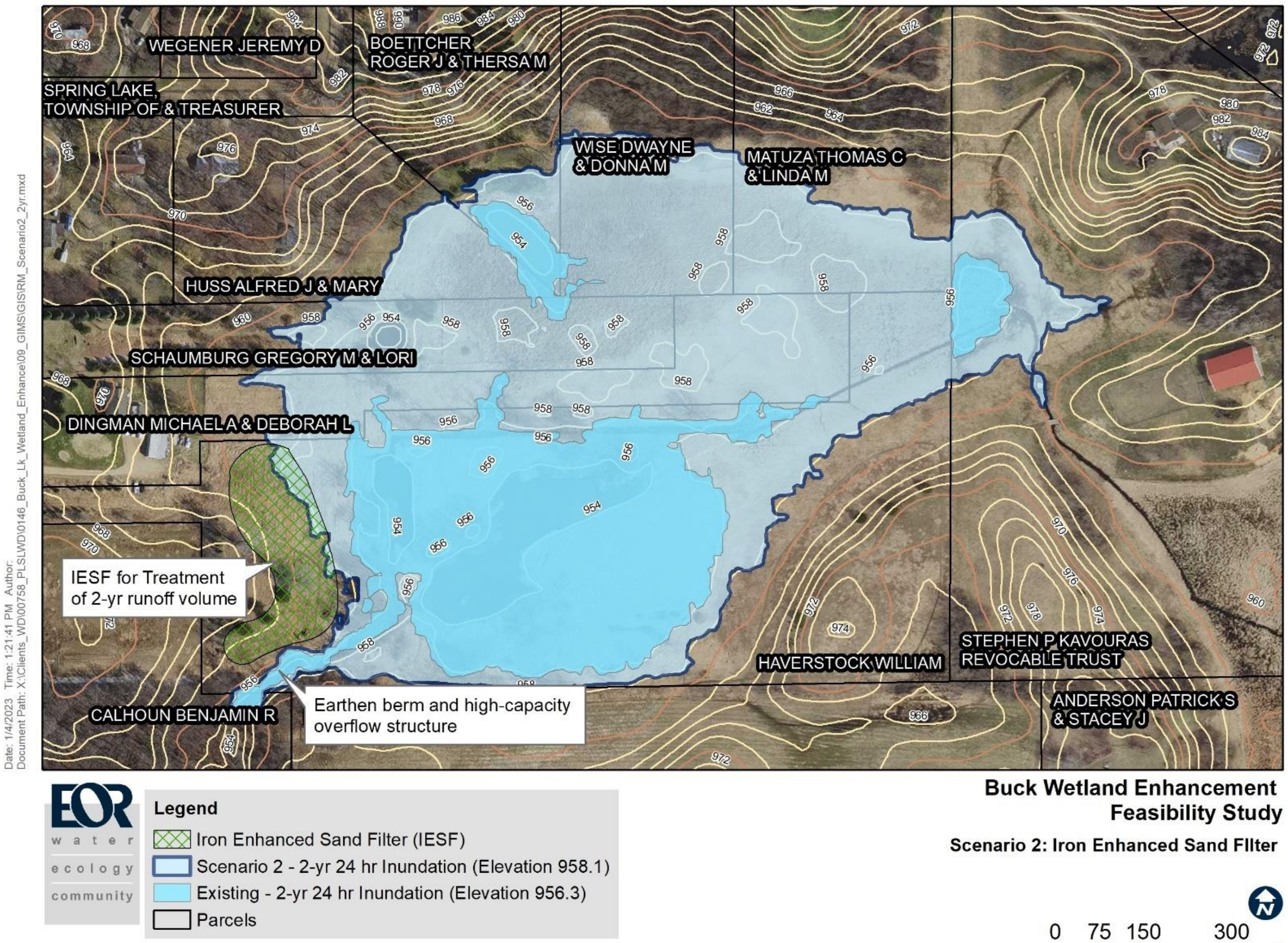


Figure 6. Scenario 2: Existing and Proposed 2-year Inundation Comparison

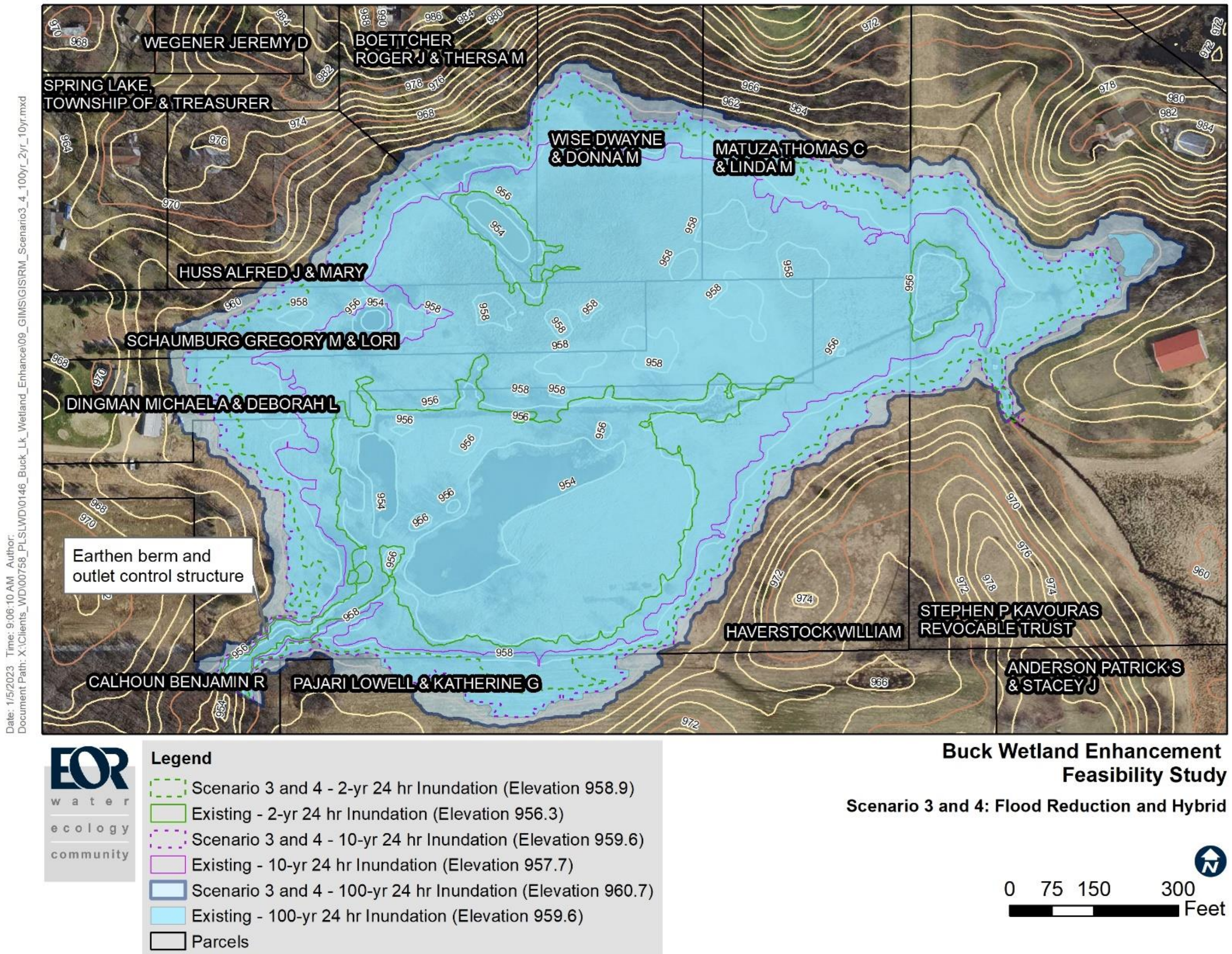


Figure 7. Scenario 3 and 4: Existing and Proposed 100-year Inundation Comparison

3.1.2. Water Quality Results

As previously noted, the Upper Watershed Blueprint estimated that this watershed has a high TP load of up to 500 lbs/yr (Upper Watershed Blueprint, 2021). However, review of District monitoring data from Site ST-11 (watercourse downstream of this wetland at Fairlawn Avenue) suggests that TP loading is high, but not necessarily as high as the Upper Watershed Blueprint estimate.

Based on the average phosphorus concentrations from monitoring years 2011-2013, it is estimated that the TP load to the west wetland is 360 lbs/yr. This alternate estimate factors that the west wetland is upstream of the monitoring station and only receives 86% of the flow volume (and TP load) as compared to Site ST-11 (see Figure 8). The monitoring data also suggests that, on average, the majority (53%) of TP is Soluble Reactive Phosphorus (SRP). SRP is the soluble, filterable fraction of phosphorus, and because one of the goals of this project is to address water quality, a scenario that includes a water quality filtering mechanism, such as an Iron Enhanced Sand Filter, is considered in order to maximize the water quality improvements.

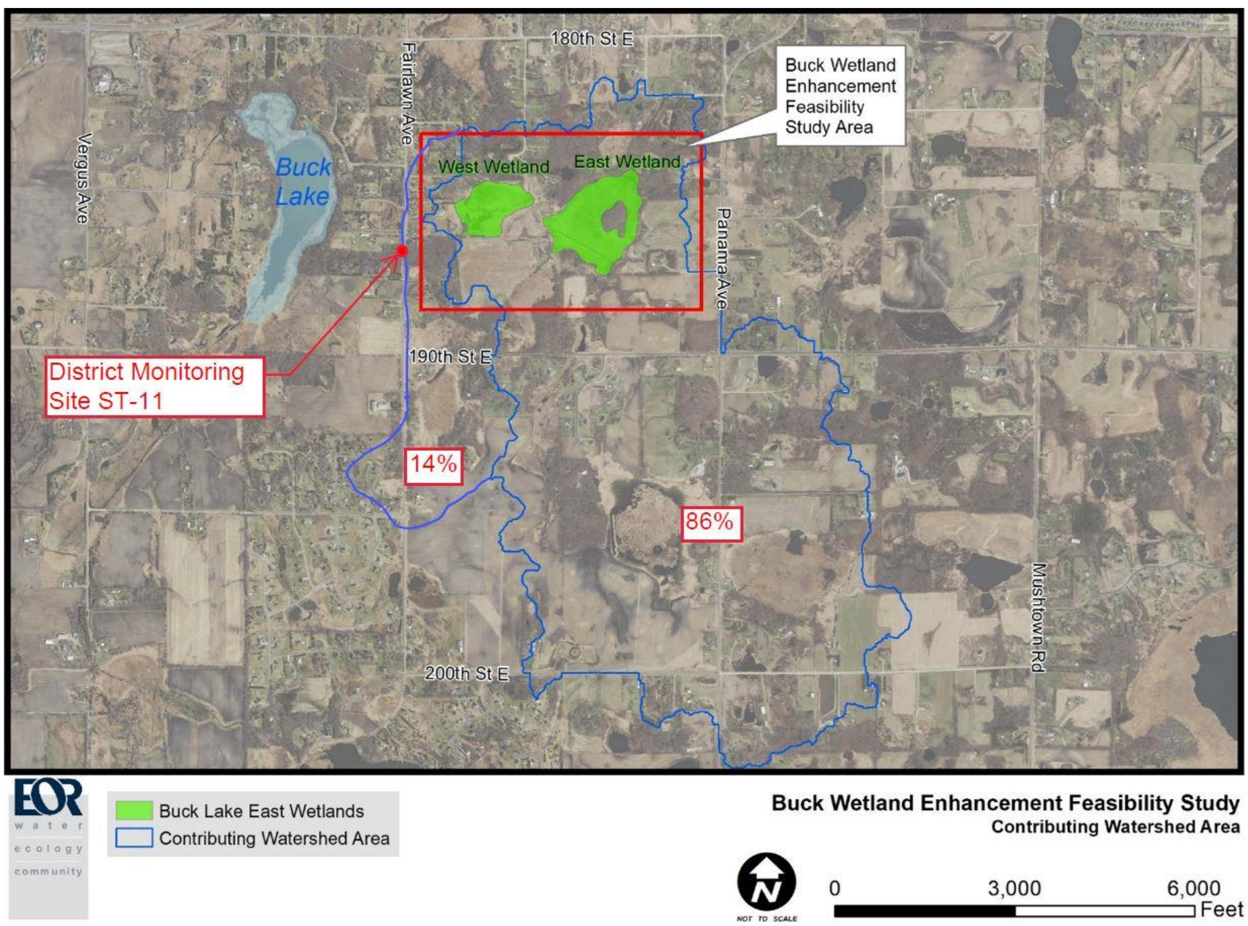


Figure 8. Monitoring Site ST-11 Contributing Watershed Percentages

This range in estimated annual TP loading (360-500 lbs/yr) is reflected in the reporting of water quality load reduction efficacy reported in Table 4. The predicted range of annual TP load reduction for Scenarios 1 & 3 is 55-75 lbs. The predicted range of annual TP load reduction for Scenarios 2 and 4 (both of which include the IESF) is 175-240 lbs.

The predicted lifespan of the IESF is 20 years at the low end of the range of TP loading (360 lbs/yr) and is related to the SRP concentration in the stream and the mass of iron in the IESF. On average the IESF is predicted to treat approximately 67% of the flow based on the filter footprint. Of the water that gets treated, 60% of the SRP and 85% of the particulate phosphorus is captured according to literature values in the Minnesota Stormwater Manual which equates to approximately 72% TP captured given the monitored SRP to TP ratio of Site ST-11. This means that the system is predicted to capture 48% of the average annual TP load. Based on the estimated 20-year lifespan, TP removal is predicted to be 3,500 lbs. This project would address the required TMDL TP reduction of 2,959 lb/yr by approximately 2% to 8% depending on the scenario.

3.2. Engineer's Opinion of Probable Cost

Table 4 shows the flood reduction and water quality benefits for each scenario, and the associated engineering and construction costs. The detailed Engineer's Opinion of Probable Cost for each scenario are included in Appendix C.

Table 4. Summary of Scenario Costs and Benefits

Scenario	TP Load Reduction (lb/yr)	Flood Reduction on Upper Prior Lake (ft)[2]	Flood Reduction on Spring Lake (ft)[2]	Engineering & Permitting Cost	Construction Cost (w/20% Contingency)	Total Cost[3]	20-yr Lifecycle Cost Benefit ($/lb TP)
Scenario 1	55-75[1]	-0.01-ft	0.00-ft	$24,000	$95,000	$119,000	$80-110
Scenario 2	175-240	-0.04-ft	-0.04-ft	$170,000	$681,000	$851,000	$180-240
Scenario 3	55-75[1]	-0.13-ft	-0.07-ft	$39,000	$156,000	$195,000	$130-180
Scenario 4	175-240	-0.13-ft	-0.07-ft	$185,000	$740,000	$925,000	$190-265

[1] The Minnesota Stormwater Manual suggest the efficacy of Stormwater Ponds and Wetlands is a 38% TP load reduction, however, Scenarios 1 and 3 have significantly less permanent pool than design guidance therefore efficacy is conservatively estimated to be much lower at 15%.

[2] Based on the 100-year, 30-day storm event.

[3] Cost does not include any needed easement acquisition costs.

4. ENGAGEMENT

4.1. Permitting

Per coordination with MnDNR during this study, it is known that permanent flowage easements will be required for increasing existing water levels of the public watercourse (ditch) within the west wetland (per Minnesota Statute 103G.407). All scenarios will require further coordination and permitting with MnDNR, the Local Government Unit for the Wetland Conservation Act (WCA), and the United States Army Corps of Engineers (USACE) for work within the wetland and MnDNR public watercourse. These costs are accounted for in the engineer's Opinion of Probable Cost. Once a scenario has been chosen, MnDNR identified several considerations and recommendations to aid in permitting discussions for the preferred scenario such as:

- Provide examples of a similar project in public waters.
- Agency determination is needed to confirm what is currently a public watercourse due to historical alteration.
- An Environmental Assessment Worksheet (EAW) would be required for any 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 according to Minnesota Statutes, chapter 103G, the DNR or local governmental unit is the RGU.
- Ensure the project is included in the District's current Water Resources Management Plan.
- Outline how the outlet will be managed, and how it will affect the Ordinary High Water Level (OHWL).
- Based on Minnesota Statute 103G.407, flowage easements would be required for those properties abutting the OHWL of the public watercourse. However, MnDNR encourages the District to also obtain flowage easements on land which will be inundated even if it is not directly abutting the OHWL.
- Public waters rules that may apply to this project are: fill, excavation, water level control structure rules/statutes. Determine fill/excavation once public waters have been clarified.
- Restoration rules may also apply.

Additionally, as noted above, sand hill cranes have been reported to nest in a small portion of the west wetland. Construction and permitting will involve special consideration, practices, and timing (outside of April to August) to accommodate the sand hill cranes.

4.2. Public Engagement

Two meetings were conducted with riparian landowners during the course of this study. The purpose of the first meeting, convened on April 5, 2022, was to introduce the background and goals of the study, report on the wetland conditions assessment, discuss potential outcomes and next steps, and receive input from residents regarding what they value most about the wetland. Generally speaking, the residents reported that they most value the nature and wildlife viewing the wetland affords and well as the open space / natural viewshed, thus their preferred interest in restoring the more-degraded west wetland. Comments were mixed with respect to the potential goals of the District, but at a high level, residents were generally supportive of potential project elements that enhance the wetland but opposed to elements that would raise the wetland flood elevation.

The purpose of the second meeting, convened on November 1, 2022, was to revisit the goals of the study, present finding regarding monitoring data and phosphorus loading, present findings from the sediment core testing, and present and receive feedback on the concept scenarios. Residents were supportive of wetland enhancement (Scenario 1) including filling the ditch, creating more shallow open water, and vegetative enhancements. Residents also seemed open to further exploration of improving water quality (Scenario 2) if water levels didn't change too much or if actively used low areas could be raised above the inundation level using fill. An increase in the flood elevation to the extents as shown in Scenarios 3 and 4 was generally not supported by residents.

5. NEXT STEPS

The following are the recommended next steps:

- Acceptance by the Board of the feasibility study
- Continued landowner engagement
- With landowner interest, Board selection of a concept scenario for final design
- Authorize final design and wetland permitting
- Pursue landowner agreements and easements
- MnDNR, WCA, and USACE permit coordination

6. REFERENCES

Minnesota Pollution Control Agency (MPCA). 2014. Rapid Floristic Quality Assessment Manual. wq-bwm2-02b. Minnesota Pollution Control Agency, St. Paul, MN

Prior Lake Spring Lake Watershed District (PLSLWD). 2016. Prior Lake Stormwater Management & Flood Mitigation Study. Barr Engineering, Minneapolis, MN

Prior Lake Spring Lake Watershed District (PLSLWD). 2021. Upper Watershed Blueprint. Wenck Associates, Inc. Maple Plain, MN

APPENDIX A. PHOSPHORUS TESTING ANALYSIS

technical memo

Project Name	Buck Wetland Enhancement Feasibility Study	**Date**	~~08/22/2022~~ 1/5/2023
To	Joni Giese, District Administrator		
Cc			
From	Pat Conrad, Joe Pallardy		
Regarding	Wetland Sediment Core Bray Phosphorus Concentrations		

Project Background

Prior Lake experienced record precipitation and a historic flooding event in the spring of 2014. The Buck East Wetland Enhancement Project was originally identified as a flood reduction concept in the Prior Lake Stormwater Management and Flood Mitigation Study completed by Barr Engineering in 2016 (2016 Flood Study). The Prior Lake Spring Lake Watershed District (PLSLWD) has been actively studying ways to reduce flood levels of Spring and Prior Lakes.

One of the scenarios identified in the 2016 Flood Study proposed a restrictive outlet and overflow structure at the wetland east of Buck Lake. In addition to providing flood reduction benefits, the project was envisioned to provide water quality improvement through enhancement of the wetland. This wetland enhancement was also identified in the Upper Watershed Blueprint study as having a potential 100 lb/yr Total Phosphorus (TP) reduction to Spring Lake and also having a positive impact on the water quality of Buck Lake. The TP removal estimate in the Upper Watershed Blueprint study was based the very general assumption that the wetland enhancement would achieve a 40% reduction.

It has been shown that there is considerable variation in the ability for wetlands to remove phosphorus. In certain situations, wetlands can actually serve as a source of phosphorus. This occurs when wetland soils have become saturated in phosphorus, typically associated with past loading from land uses. Due to the historic agricultural use of the areas immediately adjacent to and upstream of the site, a more thorough investigation was performed on the existing phosphorus content of the wetland soils and their ability to bind additional phosphorus.

Methods

On July 8, 2022, EOR staff collected twenty (20) soil samples from 15 sampling locations distributed throughout the Buck wetland project area. Soil samples from the top 18" of soil were collected at all sampling locations. A second sample was collected at four of the sampling locations (S1, S4, S10, and S13) at a depth of 18-36" to determine if there were significant differences is phosphorus concentrations with increasing soil depth.

Soil samples were analyzed by the University of Minnesota Research Analytical Laboratory for extractable phosphorus (P) using the Bray-1 method along with a suite of related soil chemical properties. Extractable P is the amount of phosphorus that can be extracted, or removed, from the soil by using one of a number of different types of chemical extractants. These extractants have been developed to remove certain forms of P from the soil and are considered to be a more accurate index of what might be actually available for uptake by plants or algae.

Lab Results

Typical Bray phosphorus (P) concentrations for wetland soils range from 10 to 200 ppm with a mean value of 30 ppm (Carbonell et al., 1998; Khalid et al., 1979). Eighteen (18) of the 20 sediment cores had Bray-P concentrations below 30 ppm, providing evidence to suggest that this wetland basin does not contain phosphorus enriched legacy sediments. For reference, a value of 25-30 ppm is considered optimal for agricultural crop production, therefore Bray-P measurements approaching and exceeding 100 ppm are considered quite high. EOR has observed Bray-P concentrations in wetland soils that exceed 100 ppm, these locations are most often directly adjacent to pollution sources (e.g., feedlots).

Sample results are presented in **Table 1**. Sample Location 15 had the highest observed Bray phosphorus concentration at 35 ppm. The remainder of the locations had extractable phosphorus concentrations below 30 ppm, apart from Sample Location 10 which had a Bray Phosphorus (P) concentration of 31 ppm in the top 18 inches. Anecdotal evidence collected during the site visit suggests there was fill material placed near Sampling Location 10. Further, Bray P concentrations observed in the 18-36” profile at Sample Location 10 were only 16 ppm.

Table 1. Soil Sample Results

Sample ID	Location	Bray- P (ppm)	Iron (ppm)	Calcium (ppm)	Texture	Organic Matter %
S1 (0-18”)	1	9	300+	3456	Medium	21.7
S1 (18-36”)	2	9	144	2785	Medium	6.7
S2	3	11	300+	3414	Peat	39.9
S3	4	7	300+	3808	Medium	16.2
S4 (0-18”)	5	16	300+	3910	Medium	25.8
S4 (18-36”)	6	12	300+	3046	Medium	23.4
S5	7	4	204	4446	Medium	31.1
S6	8	10	86	3096	Medium	8.7
S7	9	4	153	4222	Medium	34.4
S8	10	7	257	4077	Peat	41.8
S9	11	17	72	2917	Medium	5.6
S10 (0-18”)	12	**31**	300+	3755	Medium	25.4
S10 (18-36”)	13	16	265	3319	Medium	13.6
S11	14	3	43	3584	Medium	3.1
S12	15	22	251	3178	Medium	12.4
S13 (0-18”)	16	4	35	3131	Medium	3.4
S13 (18-36”)	17	4	15	2844	Medium	1.2
Sp1	18	14	300+	3644	Peat	37.7
Sp2	19	7	300+	3916	Course	14.1
S15	20	**35**	300+	3016	Medium	13.4

According to a study conducted on the phosphorus sorption capacity of wetland soils, significant correlations were observed (under both aerobic and anaerobic conditions) between phosphorus sorption (the ability of wetland soils to bind phosphorus) and related soil properties, especially extractable iron, aluminum, and calcium. Soils with high P concentrations and low iron concentrations are more likely to export P. All sample locations had low Bray-P concentrations and high iron and/or high calcium concentrations, so it could be inferred that the Buck wetland soils have relatively high phosphorus-retaining capacities. **Figure 1** shows phosphorus concentrations plotted alongside iron concentrations for the samples collected.

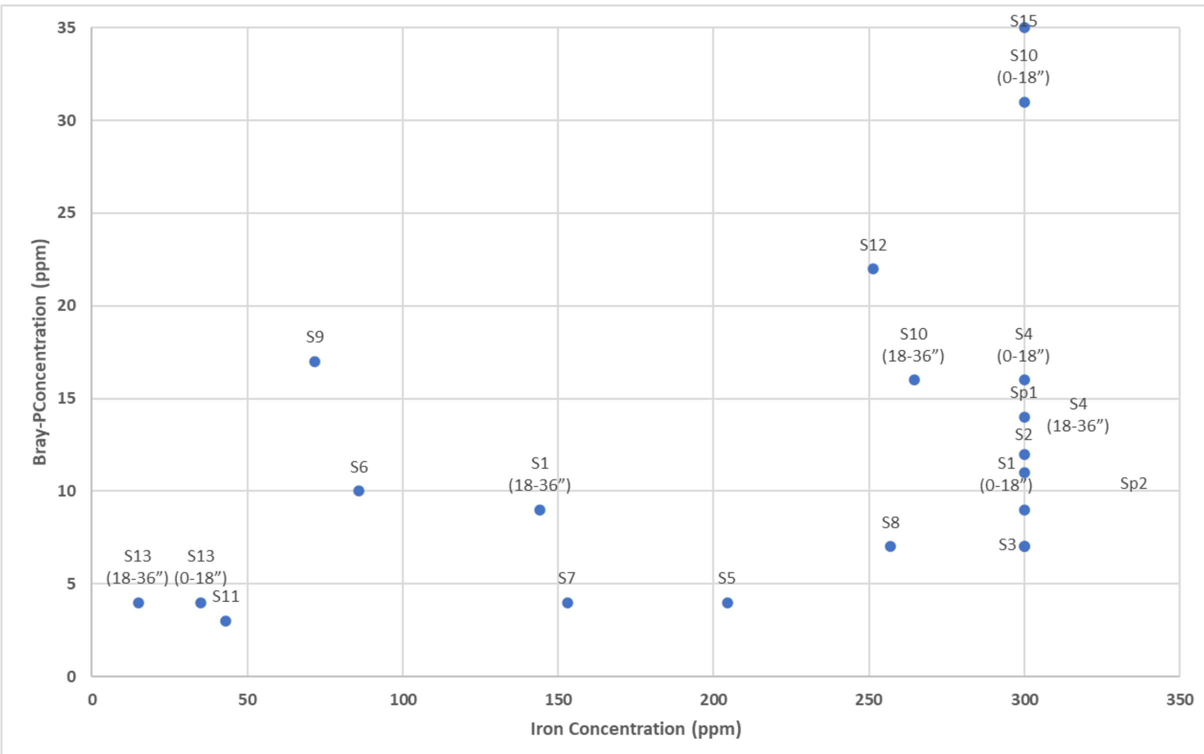


Figure 1. Soil Sample Results as Iron v. Phosphorus Concentrations

Conclusion

Analysis of sediment cores collected from the Buck wetland provide evidence to suggest that wetland soils are not currently overly saturated with phosphorus. Furthermore, the wetland soils have a relatively high capacity for retaining phosphorus. As a result of these findings, restoration of this wetland can be assumed to provide phosphorus reduction with no additional excavation of soils. The general assumption of a 40% reduction in phosphorus loading is appropriate.

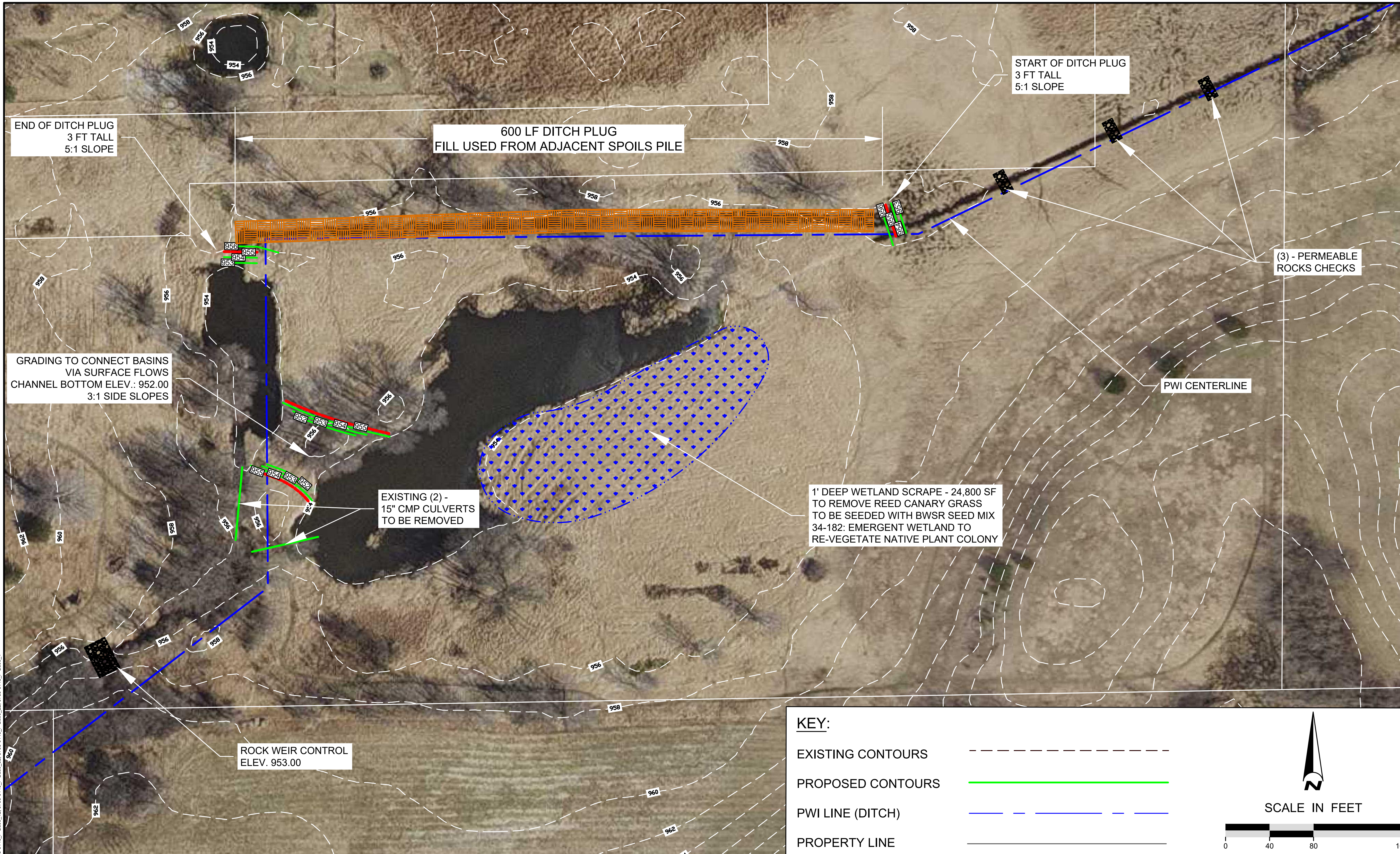
Literature Cited

Carbonell, A. A., Aarabi, M. A., DeLaune, R. D., Gambrell, R. P., & Patrick Jr, W. H. (1998). Arsenic in wetland vegetation: availability, phytotoxicity, uptake and effects on plant growth and nutrition. *Science of the Total Environment*, *217*(3), 189-199.

Khalid, R. A., Patrick Jr, W. H., & Peterson, F. J. (1979). Relationship between rice yield and soil phosphorus evaluated under aerobic and anaerobic conditions. *Soil science and Plant nutrition*, *25*(2), 155-164.

Reddy, K. R., O Connor, G. A., & Gale, P. M. (1998). *Phosphorus sorption capacities of wetland soils and stream sediments impacted by dairy effluent* (Vol. 27, No. 2, pp. 438-447). American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

APPENDIX B. CONCEPT SCENARIO PLANS



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NO	DATE	BY	REVISION
6			
5			
4			
3			
2			
1	01/03/2022	DEM	FEASIBILITY STUDY

GSOC GOPHER STATE ONE CALL — 811 Know what's below. Call before you dig.

DRAFT

SUBMISSION DATE: 01/03/2022

DESIGN BY	DRAWN BY	CHECKED BY
EOR	DEM	XXX

EOR PROJECT NO. 0758-0146

EOR water ecology community
Emmons & Olivier Resources, Inc.
1919 University Ave W, Suite 300, St Paul, MN 55104
Tele: 651.770.8448
www.eorinc.com

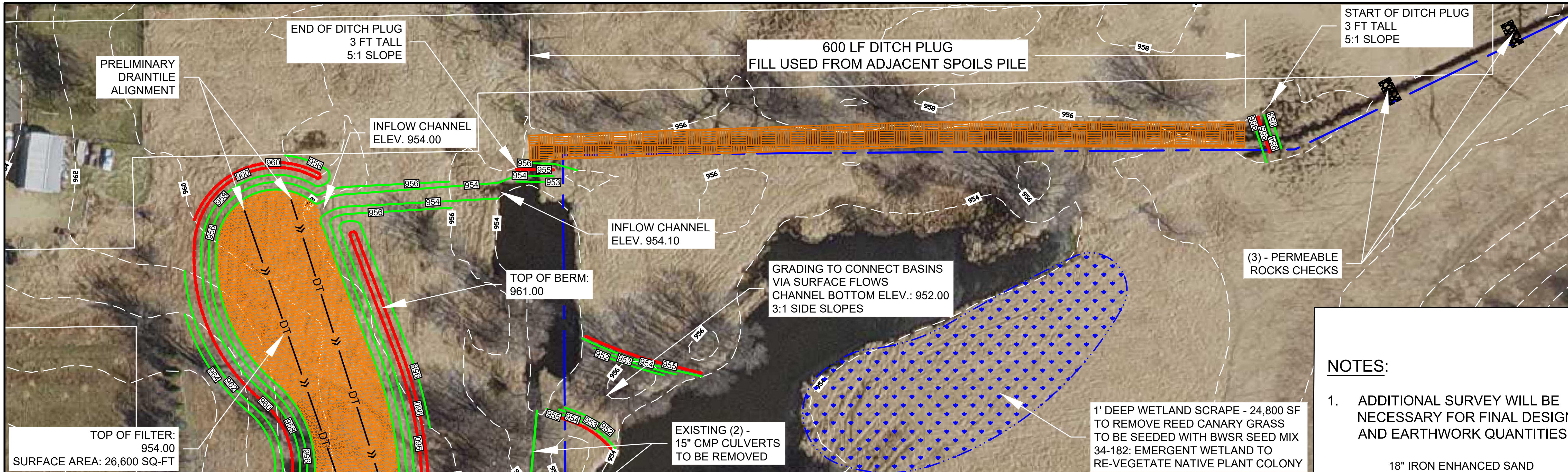
PLSLWD

BUCK WETLAND ENHACEMENT
FEASIBILITY STUDY
SPRING LAKE TOWNSHIP, SCOTT COUNTY, MINNESOTA

STATE PROJECT NO. ---
CITY PROJECT NO. ---

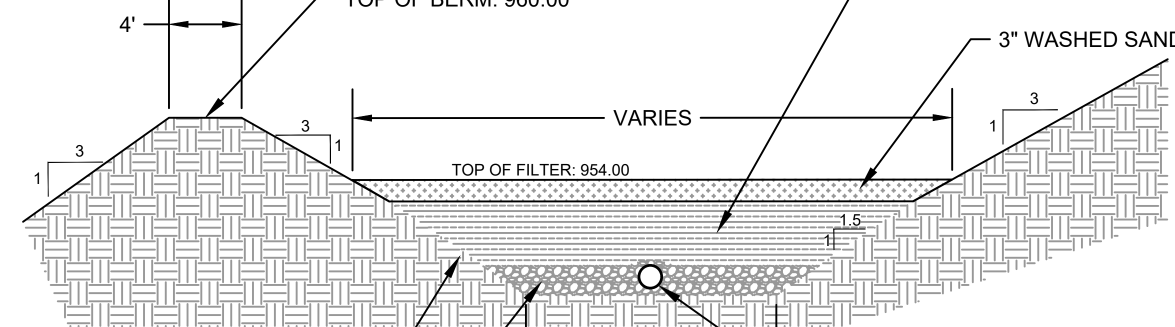
WETLAND ENHANCEMENT OPTION
SCENARIO 1

SHEET 01 OF 04 SHEETS



NOTES:

1. ADDITIONAL SURVEY WILL BE NECESSARY FOR FINAL DESIGN AND EARTHWORK QUANTITIES.



IRON ENHANCED SAND FILTER CROSS SECTION

NOT TO SCALE

KEY:

EXISTING CONTOURS

PROPOSED CONTOURS

PWI LINE (DITCH)

PROPERTY LINE

N

SCALE IN FEET

0 40 80 160

NO	DATE	BY	REVISION
6			
5			
4			
3			
2			
1	01/03/2022	DEM	FEASIBILITY STUDY

GSOC GOPHER STATE ONE CALL

811 Know what's below. Call before you dig.

DRAFT

SUBMISSION DATE: 01/03/2022

DESIGN BY	DRAWN BY	CHECKED BY
EOR	DEM	XXX

EOR PROJECT NO. 0758-0146

EOR
Emmons & Olivier Resources, Inc.
water ecology community
1919 University Ave W, Suite 300, St Paul, MN 55104
Tele: 651.770.8448
www.eorinc.com

PLSLWD

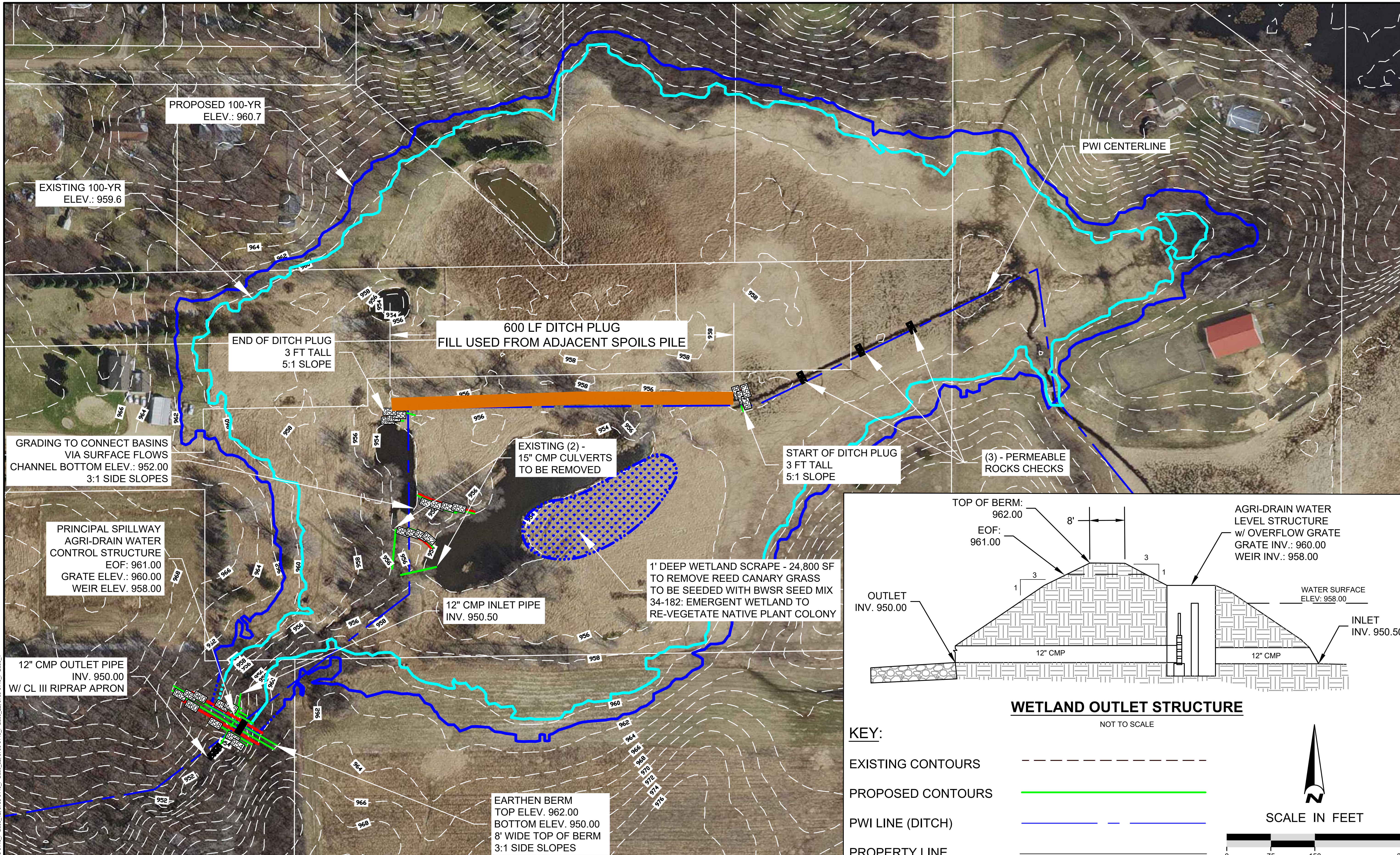
BUCK WETLAND ENHACEMENT
FEASIBILITY STUDY
SPRING LAKE TOWNSHIP, SCOTT COUNTY, MINNESOTA

STATE PROJECT NO. ---
CITY PROJECT NO. ---

WATER QUALITY OPTION
SCENARIO 2

SHEET 02 OF 04 SHEETS

Plot Date: 01/03/2023
Drawing name: X:\Clients_WD\00758_PLSLWD\0146_Buck_Lk_Wetland_Enhance\09_GIMS\dwg\0758-0146_CD.dwg



NO	DATE	BY	REVISION
6			
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1	01/03/2022	DEM	FEASIBILITY STUDY

GSOC GOPHER STATE ONE CALL

811 Know what's below. Call before you dig.

DRAFT

SUBMISSION DATE: 01/03/2022

DESIGN BY	DRAWN BY	CHECKED BY
EOR	DEM	XXX

EOR PROJECT NO. 0758-0146

EOR Emmons & Olivier Resources, Inc.
water ecology community
1919 University Ave W, Suite 300, St Paul, MN 55104
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PLSLWD

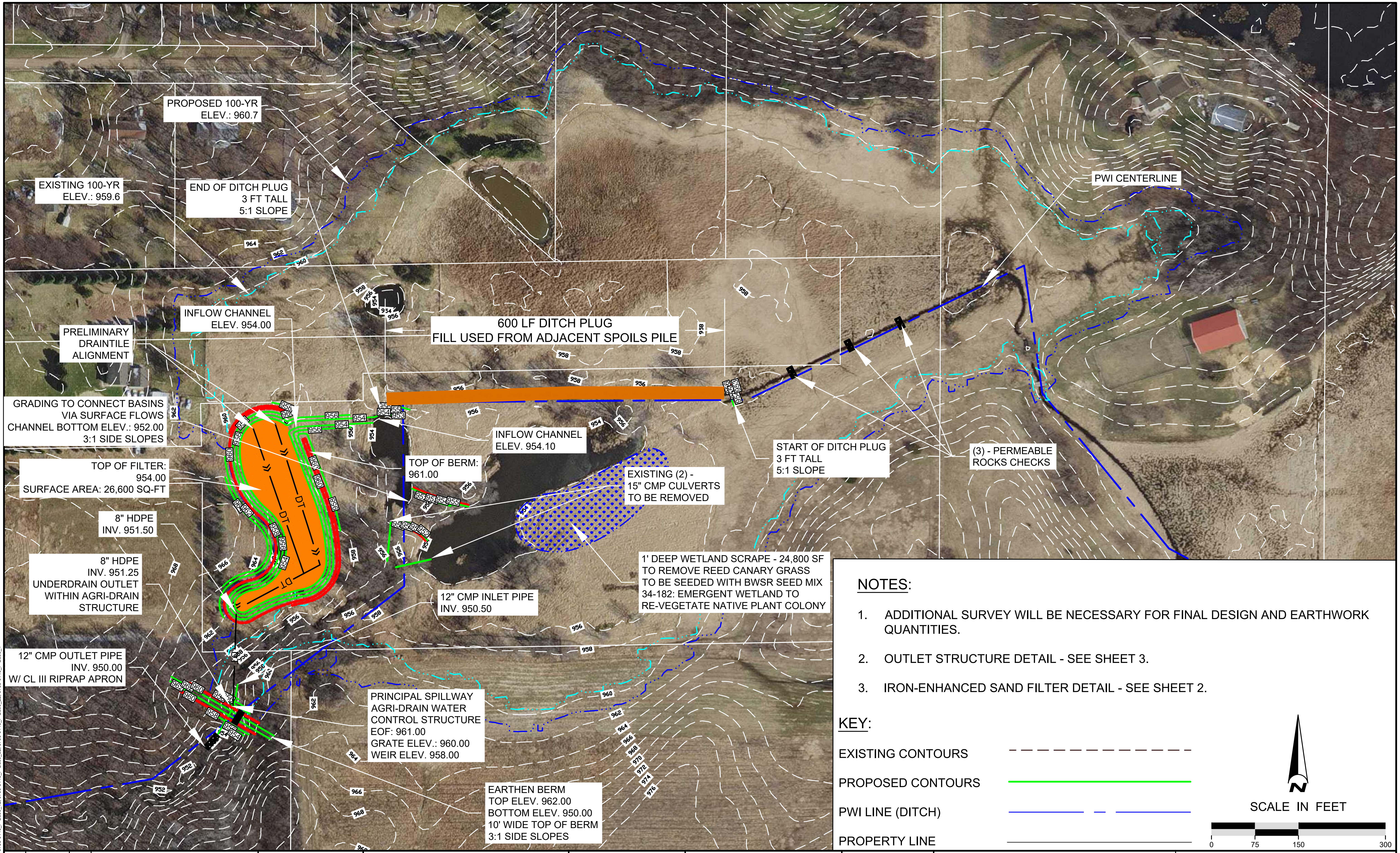
BUCK WETLAND ENHACEMENT FEASIBILITY STUDY
SPRING LAKE TOWNSHIP, SCOTT COUNTY, MINNESOTA

STATE PROJECT NO. ---
CITY PROJECT NO. ---

FLOOD REDUCTION OPTION
SCENARIO 3

SHEET 03 OF 04 SHEETS

Plot Date: 01/03/2023



NOTES:

1. ADDITIONAL SURVEY WILL BE NECESSARY FOR FINAL DESIGN AND EARTHWORK QUANTITIES.
2. OUTLET STRUCTURE DETAIL - SEE SHEET 3.
3. IRON-ENHANCED SAND FILTER DETAIL - SEE SHEET 2.

KEY:

EXISTING CONTOURS

PROPOSED CONTOURS

PWI LINE (DITCH)

PROPERTY LINE

N

SCALE IN FEET

0 75 150 300

NO	DATE	BY	REVISION
6			
5			
4			
3			
2			
1	01/03/2022	DEM	FEASIBILITY STUDY

GSOC GOPHER STATE ONE CALL — 811 Know what's below. Call before you dig.

DRAFT

SUBMISSION DATE: 01/03/2022

DESIGN BY EOR | DRAWN BY DEM | CHECKED BY XXX

EOR PROJECT NO. 0758-0146

EOR water ecology community — Emmons & Olivier Resources, Inc. 1919 University Ave W, Suite 300, St Paul, MN 55104 Tele: 651.770.8448 www.eorinc.com

PLSLWD

BUCK WETLAND ENHACEMENT FEASIBILITY STUDY SPRING LAKE TOWNSHIP, SCOTT COUNTY, MINNESOTA

STATE PROJECT NO. --- CITY PROJECT NO. ---

HYBRID OPTION
SCENARIO 4

SHEET 04 OF 04 SHEETS

APPENDIX C. ENGINEER’S OPINION OF PROBABLE COST

ENGINEER'S OPINION OF PROBABLE COST (EOPC) - Capital Improvement					
BUCK WETLAND ENHANCEMENT FEASIBILTY STUDY - WETLAND ENHANCEMENT - SCENARIO 1					
PREPARED BY EMMONS & OLIVIER RESOURCES, INC.					
EOR JOB NO.		00758-0146			
DATE PREPARED		1/3/2022			
Item	**MnDOT Reference #**	**Unit**	**Estimated**	**Estimated Unit Cost**	**Extended Cost**
Mobilization	2021.501	LS	1.00	8,000.00	$ 8,000.00
Clearing and Grubbing	2101.501	LS	1.00	5,000.00	$ 5,000.00
Remove 15" CMP Culverts	2104.502	EA	2.00	800.00	$ 1,600.00
Common Excavation	2106.507	CY	1,500.00	30.00	$ 45,000.00
Random Riprap, Class III	2511.507	CY	100.00	150.00	$ 15,000.00
BWSR Seed Mix 34-182 - Emergent Wetland (5.2lbs/AC)	2575.508	LB	5.00	80.00	$ 400.00
Temporary Erosion and Sediment Control	SP	LS	1.00	2,000.00	$ 2,000.00
Seeding and Restoration	SP	LS	1.00	2,000.00	$ 2,000.00
			Construction Totals	**Refined Total**	**$ 79,000.00**
			Construction Contingency	**20.00%**	**$ 15,800.00**
				Final Construction Total	**$ 94,800.00**

EOR Professional Fees		
PLANNING AND ENGINEERING	**15.00%**	$ 14,220.00
PERMITTING AND APPROVALS	**4.00%**	$ 3,792.00
BIDDING AND CONSTRUCTION ADMIN	**6.00%**	$ 5,688.00
PROFESSIONAL FEES TOTAL		**$ 23,700.00**
TOTAL PROJECT COST		**$ 118,500.00**
ESTIMATED ACCURACY RANGE* **	**-10.0%**	**$ 106,650.00**
	15.0%	**$ 136,275.00**

ENGINEER'S OPINION OF PROBABLE COST (EOPC) - Capital Improvement					
BUCK WETLAND ENHANCEMENT FEASIBILTY STUDY - WATER QUALITY - SCENARIO 2					
PREPARED BY EMMONS & OLIVIER RESOURCES, INC.					
EOR JOB NO.		00758-0146			
DATE PREPARED		1/3/2022			
Item	**MnDOT Reference #**	**Unit**	**Estimated**	**Estimated Unit Cost**	**Extended Cost**
Mobilization	2021.501	LS	1.00	28,000.00	$ 28,000.00
Clearing and Grubbing	2101.501	LS	1.00	5,000.00	$ 5,000.00
Remove 15" CMP Culverts	2104.502	EA	2.00	800.00	$ 1,600.00
Common Excavation	2106.507	CY	12,500.00	15.00	$ 187,500.00
Storm Sewer, HDPE 8"	2503.503	LF	570.00	55.00	$ 31,350.00
Storm Sewer, CMP 12"	2503.503	LF	60.00	80.00	$ 4,800.00
Agri-Drain Outlet Control Structure	2506.502	EA	1.00	10,000.00	$ 10,000.00
Random Riprap, Class III	2511.507	CY	100.00	160.00	$ 16,000.00
Turf Reinforcement Mat	2575.504	SY	25.00	35.00	$ 875.00
BWSR Seed Mix 34-182 - Emergent Wetland (5.2lbs/AC)	2575.508	LB	5.00	80.00	$ 400.00
Washed Sand (P)	2105.507	CY	250.00	45.00	$ 11,250.00
Washed Aggregate - River Run Pea Stone (P)	2105.507	CY	650.00	70.00	$ 45,500.00
IESF Mixture (Iron Filings - 5% by Weight)	2106.507	CY	1,400.00	140.00	$ 196,000.00
EPDM Liner, 45 mil	2511.504	SY	3,000.00	1.50	$ 4,500.00
Temporary Erosion and Sediment Control	SP	LS	1.00	10,000.00	$ 10,000.00
Seeding and Restoration	SP	LS	1.00	15,000.00	$ 15,000.00
			Construction Totals	**Refined Total**	**$ 567,775.00**
			Construction Contingency	**20.00%**	**$ 113,555.00**
				Final Construction Total	**$ 681,330.00**

EOR Professional Fees		
PLANNING AND ENGINEERING	**15.00%**	$ 102,199.50
PERMITTING AND APPROVALS	**4.00%**	$ 27,253.20
BIDDING AND CONSTRUCTION ADMIN	**6.00%**	$ 40,879.80
PROFESSIONAL FEES TOTAL		**$ 170,332.50**
TOTAL PROJECT COST		**$ 851,662.50**
ESTIMATED ACCURACY RANGE* **	**-10.0%**	**$ 766,496.25**
	15.0%	**$ 979,411.88**

ENGINEER'S OPINION OF PROBABLE COST (EOPC) - Capital Improvement					
BUCK WETLAND ENHANCEMENT FEASIBILTY STUDY - FLOOD REDUCTION - SCENARIO 3					
PREPARED BY EMMONS & OLIVIER RESOURCES, INC.					
EOR JOB NO.		00758-0146			
DATE PREPARED		1/3/2022			
Item	**MnDOT Reference #**	**Unit**	**Estimated**	**Estimated Unit Cost**	**Extended Cost**
Mobilization	2021.501	LS	1.00	16,000.00	$ 16,000.00
Clearing and Grubbing	2101.501	LS	1.00	5,000.00	$ 5,000.00
Remove 15" CMP Culverts	2104.502	EA	2.00	800.00	$ 1,600.00
Common Borrow	2105.507	CY	700.00	30.00	$ 21,000.00
Common Excavation	2106.507	CY	1,400.00	30.00	$ 42,000.00
Storm Sewer, CMP 12"	2503.503	LF	80.00	80.00	$ 6,400.00
Agri-Drain Outlet Control Structure	2506.502	EA	1.00	15,000.00	$ 15,000.00
Random Riprap, Class III	2511.507	CY	100.00	150.00	$ 15,000.00
Turf Reinforcement Mat	2575.504	SY	25.00	35.00	$ 875.00
BWSR Seed Mix 34-182 - Emergent Wetland (5.2lbs/AC)	2575.508	LB	5.00	80.00	$ 400.00
Temporary Erosion and Sediment Control	SP	LS	1.00	3,000.00	$ 3,000.00
Seeding and Restoration	SP	LS	1.00	4,000.00	$ 4,000.00
			Construction Totals	**Refined Total**	**$ 130,275.00**
			Construction Contingency	**20.00%**	**$ 26,055.00**
				Final Construction Total	**$ 156,330.00**

EOR Professional Fees		
PLANNING AND ENGINEERING	**15.00%**	$ 23,449.50
PERMITTING AND APPROVALS	**4.00%**	$ 6,253.20
BIDDING AND CONSTRUCTION ADMIN	**6.00%**	$ 9,379.80
PROFESSIONAL FEES TOTAL		**$ 39,082.50**
TOTAL PROJECT COST		**$ 195,412.50**
ESTIMATED ACCURACY RANGE* **	**-10.0%**	**$ 175,871.25**
	15.0%	**$ 224,724.38**

ENGINEER'S OPINION OF PROBABLE COST (EOPC) - Capital Improvement					
BUCK WETLAND ENHANCEMENT FEASIBILTY STUDY - HYBRID - SCENARIO 4					
PREPARED BY EMMONS & OLIVIER RESOURCES, INC.					
EOR JOB NO.		00758-0146			
DATE PREPARED		1/3/2022			
Item	**MnDOT Reference #**	**Unit**	**Estimated**	**Estimated Unit Cost**	**Extended Cost**
Mobilization	2021.501	LS	1.00	30,000.00	$ 30,000.00
Clearing and Grubbing	2101.501	LS	1.00	5,000.00	$ 5,000.00
Remove 15" CMP Culverts	2104.502	EA	2.00	800.00	$ 1,600.00
Common Borrow	2105.507	CY	700.00	30.00	$ 21,000.00
Common Excavation	2106.507	CY	12,500.00	15.00	$ 187,500.00
Storm Sewer, HDPE 8"	2503.503	LF	850.00	55.00	$ 46,750.00
Storm Sewer, CMP 12"	2503.503	LF	80.00	80.00	$ 6,400.00
Agri-Drain Outlet Control Structure	2506.502	EA	1.00	15,000.00	$ 15,000.00
Random Riprap, Class III	2511.507	CY	100.00	150.00	$ 15,000.00
Turf Reinforcement Mat	2575.504	SY	25.00	35.00	$ 875.00
BWSR Seed Mix 34-182 - Emergent Wetland (5.2lbs/AC)	2575.508	LB	5.00	80.00	$ 400.00
Washed Sand (P)	2105.507	CY	250.00	45.00	$ 11,250.00
Washed Aggregate - River Run Pea Stone (P)	2105.507	CY	650.00	70.00	$ 45,500.00
IESF Mixture (Iron Filings - 5% by Weight)	2106.507	CY	1,400.00	140.00	$ 196,000.00
EPDM Liner, 45 mil	2511.504	SY	3,000.00	1.50	$ 4,500.00
Temporary Erosion and Sediment Control	SP	LS	1.00	13,000.00	$ 13,000.00
Seeding and Restoration	SP	LS	1.00	17,000.00	$ 17,000.00
			Construction Totals	**Refined Total**	**$ 616,775.00**
			Construction Contingency	**20.00%**	**$ 123,355.00**
				Final Construction Total	**$ 740,130.00**

EOR Professional Fees		
PLANNING AND ENGINEERING	**15.00%**	$ 111,019.50
PERMITTING AND APPROVALS	**4.00%**	$ 29,605.20
BIDDING AND CONSTRUCTION ADMIN	**6.00%**	$ 44,407.80
PROFESSIONAL FEES TOTAL		**$ 185,032.50**
TOTAL PROJECT COST		**$ 925,162.50**
ESTIMATED ACCURACY RANGE* **	**-10.0%**	**$ 832,646.25**
	15.0%	**$ 1,063,936.88**