SNAIL LAKE REGIONAL PARK TRAIL REDEVELOPMENT FEASIBILITY STUDY

RAMSEY COUNTY, MN

AUGUST 22, 2022

RAMSEY COUNTY
Parks & Recreation

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ACKNOWLEDGMENTS

The Ramsey County Parks & Recreation Department gratefully acknowledges the team who contributed to this report. Site investigations began in February 2022 and concluded with this report in August 2022. Site improvements are tentatively planned for 2023-2024 construction, pending 2023-2024 funding availability.

Alternatives considered and recommendations advanced in this report have been assembled through close coordination with multiple stakeholders. Reviewing agencies included the City of Shoreview, Metropolitan Council Environmental Services (MCES) and the Ramsey County Parks & Recreation Department.

RAMSEY COUNTY
B. Gus Blumer, Landscape Architect and Project Manager
Scott Yonke, Director of Planning and Development
Ben Karp, Landscape Architect
Mike Goodnature, Natural Resources Manager

CITY OF SHOREVIEW
Tom Wesolowski, City Engineer
Mark Maloney, Public Works Director
David Yang, Engineer

METROPOLITAN COUNCIL ENVIRONMENTAL SERVICES
Michael Villari, Senior Engineer
Andrea Johnson, Foth Engineering

SRF CONSULTING GROUP
Michael McGarvey, Landscape Architect and Project Director
Stewart Crosby, Landscape Architect and Senior Project Manager
Steve Prusak, Civil Engineer and Project Manager
Adam Garfield, Civil Engineer
Jacques DuVal, Water Resources Engineer
Casey Black, Structures Engineer

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INTRODUCTION AND DESCRIPTION OF THE SNAIL LAKE SITE

Vadnais-Snail Lake Regional Park is comprised of two sections. It includes 444 acres in the Snail and Grass Lake section that is owned by Ramsey County, and the 1,252-acre Vadnais Lake and Sucker Lake section that is owned by the Saint Paul Water Utility. Recreational facilities within the larger section are operated by Ramsey County Parks & Recreation via a Joint Powers Agreement.

The Snail Lake/Grass Lake segments have had rising surface and groundwaters affecting the region over the past decade, but mostly from 2014 to 2021. Developed neighborhoods that include habitable structures, park infrastructure, and regional transportation infrastructure have become adversely affected from the result of the high water. Reliance on the natural basins and wetland complexes for flood water storage in the overall watershed have become important to prevent further negative impacts to the regional transportation system, residential neighborhoods, and business districts. Much of the available storage for excess water is located within park land that is encompassed by the regional park system.

The cause of high water has been influenced by a multitude of factors. These include increased annual precipitation, development in areas of low elevation, rising regional groundwater, segmenting of natural historic surface water courses, and the elimination of natural water storage basins.

In 2021 the same area that had previously received record high precipitation was subject to a significant drought. Surface and ground water receded to pre-2011 levels, exposing flooded trails.

The Ramsey County Parks & Recreation Department has been working with other agencies since 2016 to help address flooding with short term and long-term solutions. Agency partners include Ramsey County Public Works, Ramsey-Washington Metro Watershed District (RWMWD), the City of Shoreview, the City of Vadnais Heights, City of Little Canada, Metropolitan Council Environmental Services (MCES) and the Department of Natural Resources. This ongoing agency coordination and partnership has been necessary to understand impacts beyond the regional park boundaries and the necessity of collaboratively managing regional surface and ground water.

Ramsey County completed a Regional Park Master Plan Update in 2020 that addressed public infrastructure impacted by the high water levels in the park. This document prioritized the trails included in this study as a target for reconstruction. Recommendations stated here will be considered as feasible solutions for future improvements.

Snail Lake Regional Trail Existing conditions, North side of Segment A.

Snail Lake Regional Trail Existing conditions, south side of Segment A.

PROJECT PURPOSE AND GOALS

The purpose of this study is to develop a floodplain and wetland impact analysis and to identify trail reconstruction options for approximately 1,700 linear feet of existing trail on the east side of Wetland A in Snail Lake Regional Park (Figure 1). This trail segment has been inundated by high-water several times in recent years and the County desires to reconstruct the trail to keep it free from flooding and useable during low water periods. Trail options include raising the paved trail and/or constructing boardwalk structures above predetermined flood levels.

In addition to raising the trail to avoid flooding, the project has several goals that include the following:

- Minimize impacts to the floodplain, wetlands, and private property.
- Consider aesthetics when designing the new trails and minimize impacts to viewsheds to and from the wetland.
- Coordinate trail reconstruction with Metropolitan Council Environmental Services (MCES) to maintain access via easement to trunk sewer line structures along the trail corridor.
- Maximize the use of existing paved trails as much as possible.
- Restore previously installed native plantings within the basin.

LAWS AND DESIGN STANDARDS

Design of the trail and boardwalk system will meet several design standards and laws, including the following:

Americans with Disabilities Act

36 CFR Part 1191, Appendix D, Chapter 10, Section 1017 of the Americans with Disabilities Act (ADA) requires trails to comply with the following:

- The surface of trails, passing spaces, and resting intervals shall be firm and stable
- The clear tread width of trails shall be 36 inches minimum.
- Trails with a clear tread width less than 60 inches shall provide passing spaces at intervals of 1,000 feet minimum.
- Tread obstacles on trails, passing spaces, and resting intervals shall not exceed 1/2 inch in height measured vertically to the highest point.
- Openings in the surface of trails, passing spaces, and resting intervals shall not allow the passage of a sphere more than 1/2 inch in diameter.
- Not more than 30 percent of the total length of a trail shall have a running slope steeper than 8.33 percent. The running slope of any segment of a trail shall not be steeper than 12 percent. Where the running slope of a segment of trail is steeper than 5 percent, resting intervals shall be provided at the top and bottom of each segment.
    - The maximum length of each segment shall be no more than:
        - 200 feet for slopes steeper than 5 percent but not steeper than 8.33 percent;
        - 30 feet for slopes steeper than 8.33 percent but not steeper than 10 percent;
        - 10 feet for slopes steeper than 10 percent but not steeper than 12 percent.

Minnesota State Statutes

8820.9995, Minimum Off-Road and Shared Use Path Standards. This rule requires a minimum eight-foot surface width for two-way shared use paths, with a desired ten-foot width. The shoulder/clear zone from the edge of each side of the travel lane must be two feet. The maximum in-slope is 1:2 (rise:run). The standard design speed is 20 miles per hour (MPH); however, a 30 MPH design speed must be used for grades longer than 500 feet and greater than 4 percent, from the uphill point where the grade equals 4 percent to 500 feet beyond the downhill point where the grade becomes less than 4 percent. The maximum allowable grade is 8.3 percent.

Boardwalk Grade Recommendations

The maximum grade for a trail with a wooden surface should be 2 percent (1/4 inch per foot). The intent of boardwalk grade for this study is to maintain a level (0 percent) grade across all structural improvements. Termini of the boardwalk may be sloped but will remain at or below the maximum grade.

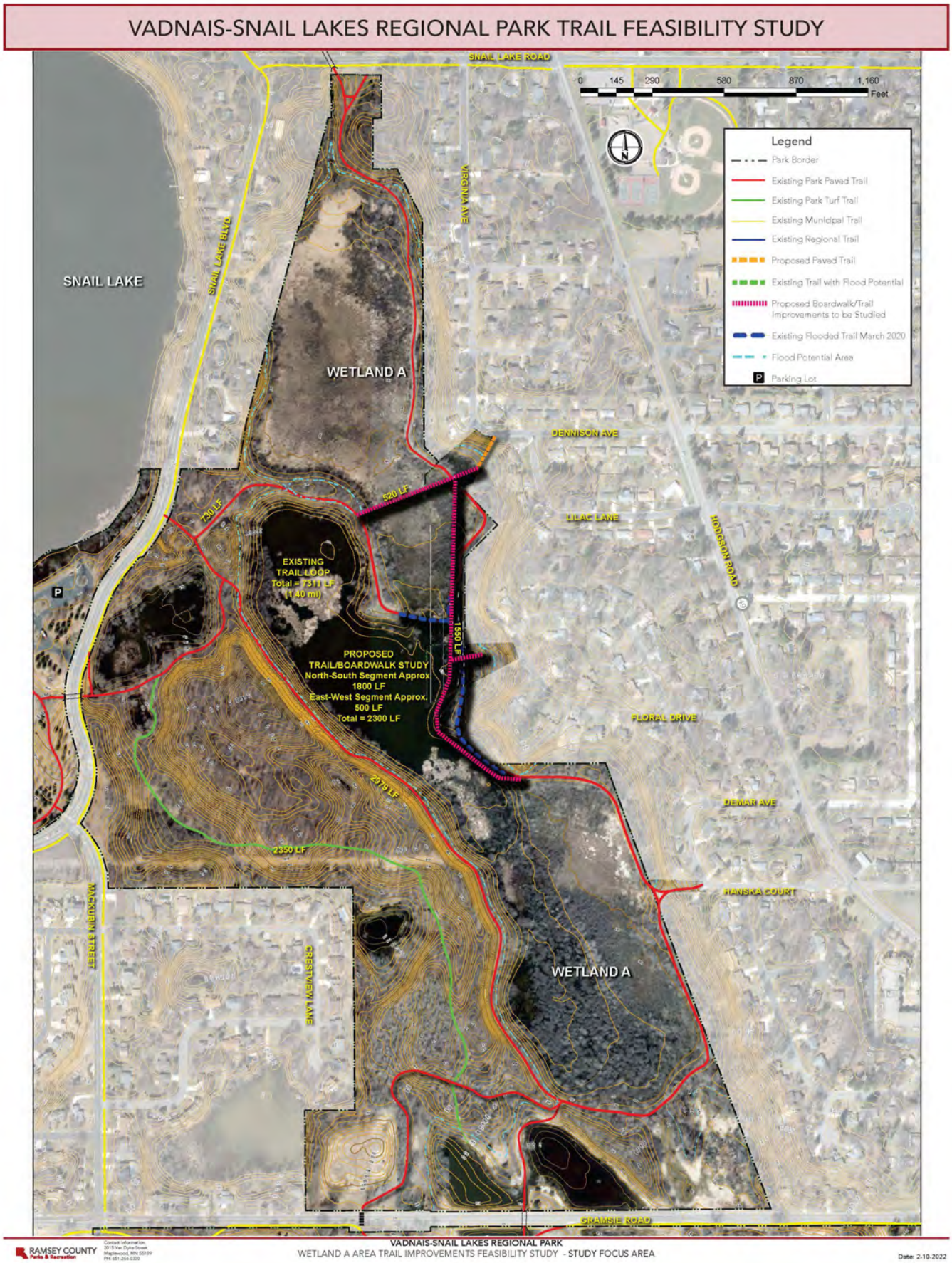


FIGURE 1: FEASIBILITY STUDY LOCATION MAP

MODELING AND FLOODPLAIN ANALYSIS

Permitting Summary

Wetland A is landlocked basin with a starting elevation likely controlled by groundwater and evapotranspiration. The 884.1 outlet elevation of the basin is significantly higher than the normal starting elevation of the basin. Through conversations with the Watershed District, the starting elevation of Wetland A was determined to be approximately 875.0 and was field verified by investigating existing soils and vegetation. Based on sensitivity of the landlocked basin, as seen by the recently recorded flooding, the following information was used for the modeling and analysis:

- An XP-SWMM model for the Beltline watershed was received from the RWMWD. This model was a skeleton scale model of the Beltline watershed.
- Water surface elevation and piezometer data of Grass Lake and Wetland A provided by RWMWD.

Modeling Matrix

Wetland A was modeled with the XP-SWMM model provided by RWMWD using Atlas 14 (96 hour) rainfall data. Since the outlet elevation is much higher than the existing elevation of the trail, the project basis of the design revolves around the flooding potential and inundation period of the trail at a given elevation. Furthermore, the starting elevation was considered given the sensitivity of the landlocked basin. A modeling summary and corresponding exhibits of Wetland A is included in Table 1 below, and in Appendix C. The summary provides the following information for a given trail elevation:

- Starting elevations of the wetland
- Level of protection by rainfall event
- Inundation period using measured surface elevations between 2019 and 2020

The modeling summary informs which trail elevations will be analyzed in the alternatives evaluation.

TABLE 1: MODELING MATRIX

Wetland A - Modeling Summary								
Boardwalk / Trail Elevation = 877.5								
Boardwalk / Trail Height (1)	Wetland A Starting Elevation (2)	Protection from 96-Hour Rainfall Event (3)					Inundation Period (4)	Notes
		1-Year (3.36")	5-Year (4.36")	10-Year (5.03")	25-Year (6.16")	100-Year (8.32")	3/6/17 - 10/16/20	
2.5 Feet (5)	875	X	X				26 of 44 Months (59% of Time)	- Approximate Elevation of existing trail
	876	X						
	877							
Boardwalk / Trail Elevation = 880.0								
Boardwalk / Trail Height (1)	Wetland A Starting Elevation (2)	Protection from 96-Hour Rainfall Event (3)					Inundation Period (4)	Notes
		1-Year (3.36")	5-Year (4.36")	10-Year (5.03")	25-Year (6.16")	100-Year (8.32")	3/6/17 - 10/16/20	
5 Feet (5)	875	X	X	X	X		2 of 44 Months (5% of Time)	
	876	X	X	X				
	877	X	X	X				
Boardwalk/Trail Elevation = 882.0								
Boardwalk / Trail Height (1)	Wetland A Starting Elevation (2)	Protection from 96-Hour Rainfall Event (3)					Inundation Period (4)	Notes
		1-Year (3.36")	5-Year (4.36")	10-Year (5.03")	25-Year (6.16")	100-Year (8.32")	3/6/17 - 10/16/20	
7.0 Feet (5)	875	X	X	X	X	X	0 of 44 Months (0% of Time)	
	876	X	X	X	X			
	877	X	X	X	X			
Boardwalk / Trail Elevation = 884.1								
Boardwalk / Trail Height (1)	Wetland A Starting Elevation (2)	Protection from 96-Hour Rainfall Event (3)					Inundation Period (4)	Notes
		1-Year (3.36")	5-Year (4.36")	10-Year (5.03")	25-Year (6.16")	100-Year (8.32")	3/6/17 - 10/16/20	
9.1 Feet (5)	875	X	X	X	X	X	0 of 44 Months (0% of Time)	- Elevation 884.1 is the ultimate outlet elevation from the surrounding area.
	876	X	X	X	X	X		
	877	X	X	X	X	X		

Notes:
(1) Boardwalk / Trail height is the height over starting elevation 875
(2) Wetland A starting elevations may fluctuate between 875 and 877 as shown by the Piezomenter and Water Surface elevation data
(3) A rainfall event is an estimate of how long it will be between rainfall events of a given magnitude
(4) Inundation period is time in which water is present on the boardwalk / trail
(5) Difference from proposed trail elevation to low water.

Regulatory Matrix

Regulatory and permitting authority for stormwater management falls to the Minnesota Pollution Control Agency (MPCA) and the Ramsey-Washington Metro Watershed District. Table 2 below contains a regulatory matrix summarizing the stormwater management requirements of the various agencies. A larger version of the matrix is included in Appendix B. The regulatory agencies include:

- MPCA
- Ramsey-Washington Metro Watershed District (RWMWD)
- Wetland Conservation Act / U.S. Army Corps of Engineers

Specific criteria that impact permit approval include surface water runoff rates and volumes, the cleanliness of this drainage, the quantity of fill with the floodplain and area of wetland impacts. Limiting the total amount of construction disturbance and preserving (or ideally reducing) the amount of impervious surface are approaches to achieving the water rate, volume and quality requirements. Fill within the floodplain is not limited but requires 1:1 replacement to fully offset the loss of storage. Wetland impacts at this site are unavoidable. Improvements must first seek to minimize disturbance and then mitigate necessary impacts at a 1:2 ratio. Boardwalks are preferred alternatives for trails across or adjacent to wetland areas as they greatly reduce floodplain fill and wetland impacts from a comparable grade raise. Permitting agencies generally will not consider direct fill trail alternatives should a boardwalk be a feasible option, regardless of the additional costs to the owner.

TABLE 2: REGULATORY MATRIX

ENTITY	SURFACE WATER RATES	SURFACE WATER QUANTITY	SURFACE WATER QUALITY	FLOOD CONTROL	WETLAND MANAGEMENT
Minnesota Pollution Control Agency (MPCA) via the NPDES (National Pollution Discharge Elimination System) Permit Program ▪ Required for construction activity that disturbs greater than 1 acre.	▪ N/A	▪ Abstraction of the first 1 inch over the site's new impervious surface area OR 0.5 inch over the site's new and reconstructed impervious surface area, whichever is greater. ▪ Pretreatment must be used before filtration/infiltration.	▪ Water quality volume is equal to 1 inch of runoff from the new impervious surfaces. ▪ Permanent pond volume of 1800 Cubic Feet (CF)/acre of storage below the outlet. ▪ Water quality volume maximum discharge 5.66 Cubic Feet per Second (cfs) per acre of pond surface area. ▪ Filtration systems must be designed to remove at least 80% of Total Suspended Solids (TSS).	▪ N/A	▪ N/A
Ramsey-Washington Metro Watershed District (RWMWD) ▪ Permit required for land alterations that disturb a surface area of 1 acre or greater ▪ Watershed District is the Local Governing Unit (LGU) for wetland management.	▪ Runoff rates shall not exceed existing runoff rates for the 2-year, 10-year, and 100-year critical storm events using Atlas-14 rainfall depths. ▪ Runoff rates may be restricted to less than the existing rates when the capacity of downstream conveyance systems is limited.	▪ Stormwater runoff volume shall be retained onsite in the amount of 1.1 inches of runoff from the new and reconstructed impervious surfaces. ▪ Provide sufficient pretreatment before infiltration/filtration Best Management Practices (BMP) ▪ If infiltration on site is infeasible, BMP selection must follow the Alternative Compliance Sequencing: o 55% filtration credit. o 80% iron-enhanced filtration credit. ▪ No exemptions for trails	▪ BMPs must achieve 90% TSS removal from runoff generated by a Nationwide Urban Runoff Program (NURP) water quality storm (2.5" rainfall) or on an annual basis. ▪ For linear projects, costs specific to satisfying the volume reduction and water quality standards shall not exceed a cost cap for costs directly associated with the design, testing, land acquisition, and construction of the volume reduction and water quality BMPs only.	▪ Placement of fill within the 100-year floodplain needs to be mitigated by providing compensatory storage. Compensatory storage shall fully offset the loss of storage. ▪ Boardwalks have generally been considered exempt but will need to confirm.	▪ Follow the minimize, rectify, reduce, and replace wetland sequencing. ▪ Unavoidable wetland impacts shall be mitigated at a 2:1 ratio. ▪ Average and minimum wetland buffer width for wetland classification Manage A is 75 feet and 37.5 feet, respectively. ▪ Stormwater management BMP not allowed in wetland buffer area. ▪ Wetland replacement through mitigation is allowed in the buffer area if the buffer disturbance is provided adjacent to the wetland replacement. ▪ Boardwalks are exempt from wetland impacts.
City of Shoreview ▪ City of Shoreview follows rules laid out by NPDES and RWMWD.	▪ City of Shoreview follows rules laid out by NPDES and RWMWD.	▪ City of Shoreview follows rules laid out by NPDES and RWMWD.	▪ City of Shoreview follows rules laid out by NPDES and RWMWD.	▪ City of Shoreview follows rules laid out by NPDES and RWMWD.	▪ City of Shoreview follows rules laid out by NPDES and RWMWD.
Department of Natural Resources (DNR) ▪ N/A – Wetland A is not a DNR public water.	▪ N/A	▪ N/A	▪ N/A	▪ N/A	▪ N/A
Wetland Conservation Act / U.S. Army Corps of Engineers ▪ Joint Permit application will be submitted.	▪ N/A	▪ N/A	▪ N/A	▪ N/A	▪ Joint Permit application will be submitted.

LEGEND OF ACRONYMS
NPDES: National Pollution Discharge Elimination System
RMWMD: Ramsey-Washington Metro Watershed District
LGU: Local Governing Unit
DNR: Department of Natural Resources
BMP: Best Management Practices
CF: Cubic Feet
CFS: Cubic Feet per Second
TSS: Total Suspended Solids
NURP: Nationwide Urban Runoff Program

METROPOLITAN COUNCIL ENVIRONMENTAL SERVICES

Metropolitan Council Environmental Services (MCES) sanitary sewer easement is present along the eastern edge of the basin and several manholes are located adjacent to the trail within the study area. This pipe is a regional interceptor that collects various local sewers into a larger pipe which ultimately leads to a wastewater treatment plant. Flooding solutions must provide access to these structures for maintenance as a condition of the Metropolitan Council approval of the 2020 Vadnais Snail Lakes Regional Park Master Plan update. The ability to travel continuously between consecutive structures is not necessary as long as MCES maintenance vehicles, including a boiler truck, CCTV truck or a Vactor truck can park within 500 feet of a manhole. If direct drive-in access is not available, then MCES can utilize an easement machine to make up the difference. The easement machine is similar to an ATV so a paved surface would not be required. Where appropriate, Ramsey County Parks and MCES shall work together to find a solution that accommodates both recreation and public infrastructure access.

Structures at Station 9+75 and north of the terminus of Trail A reconstruction will remain accessible from the existing trail. Preserving access to the structures at Station 12+25, 15+85 and 16+15 will require leaving the existing trail embankment between Stations 13+00 and 17+00 on Trail A for options constructing boardwalk diverting from the existing Trail A alignment (2B, 2C, 2D, 3B, 3C and 3D). All options, including grade raises and boardwalks, include improvements to the existing trail access from Floral Drive. This trail is on City of Shoreview property and will be subject to their approval. Widening and/or surface reinforcement will be required to facilitate a boiler truck access to the existing trail. Pavement within this stretch of Trail A may remain in place or be removed as required by permitting agencies. It is recommended that a small pad at the foot of the slope be maintained to facilitate a Y-turn for service vehicles.

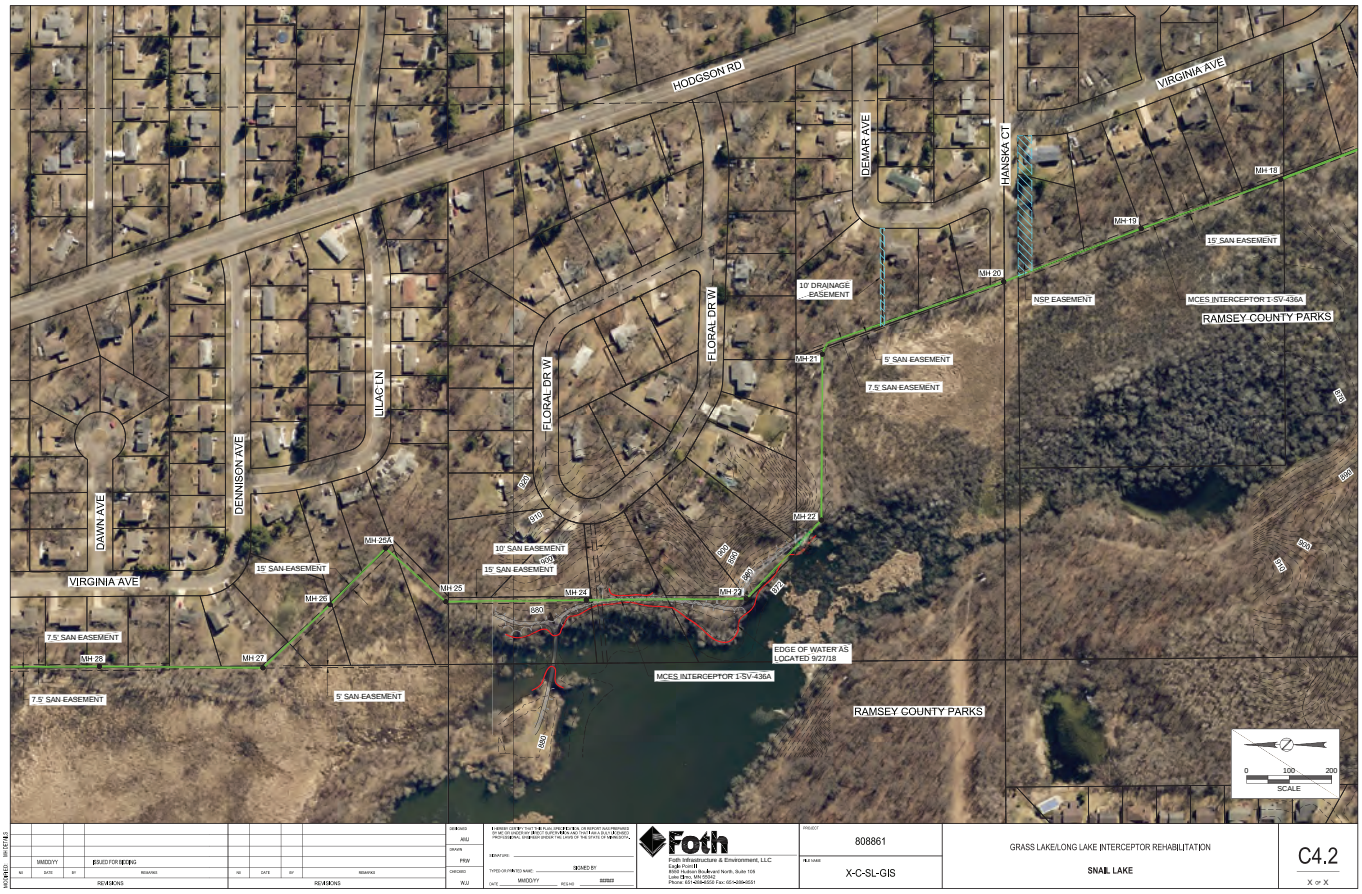
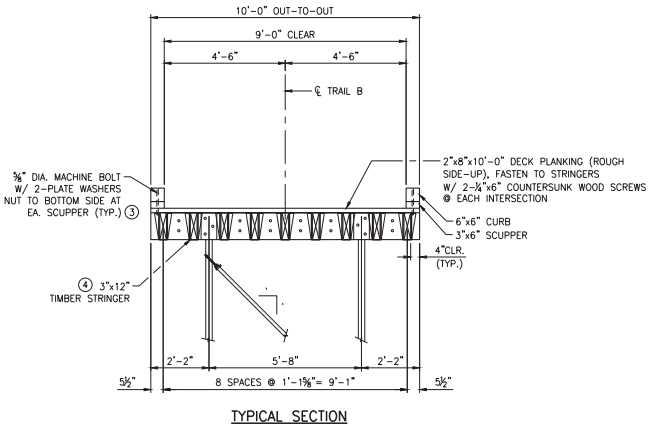


FIGURE 2: METROPOLITAN COUNCIL ENVIRONMENTAL SERVICES PIPE LAYOUT

BOARDWALK DESIGN AND OPTIONS

The boardwalk proposed for the Snail Lake Trail would be ten feet wide with a nine-foot clear tread width and flat, non-sloped profile. In locations where the boardwalk is 30-inches or less from the ground, no railing is needed. The boardwalk will have a 6-inch-wide curb on both sides to keep people from the boardwalk edge. If the boardwalk is more than 30-inches from the ground, a 42-inch railing is required for fall protection. The railing can be made of wood with mesh panels or metal posts with cable rails. There are many types of boardwalk designs. The two identified for the Snail Lake Trail include a custom-constructed timber decked boardwalk on 3-inch helical pile, and a custom-designed modular wood decked boardwalk on either helical pile or swamp pad footings. Metal decked boardwalk designs are not recommended due to noise concerns. Boardwalks with plastic decking are also available but not considered for static electricity issues and their requirements for additional structural support. The benefit of helical pile is that the boardwalk will not shift over time due to frost heave. Boardwalks on swamp pad footings are prone to movement.



Typical boardwalk cross-section.

Low boardwalk without railing.

Helical pile foundation.

Boardwalk with 42-inch railing.

ALTERNATIVES EVALUATION

Several options were considered for the trail improvements along the east side of Wetland A. Alternatives reviewed strove to satisfy the project goals listed in the introduction to this study. Except where boardwalks required more open space for constructibility, the trail alignment was held to its existing location and evaluated at different raised elevations. Coordination with MCES identified that standard trail boardwalk design widths and capacities would not function with their maintenance vehicles. Preserving at-grade access to the sewer facilities and the close proximity of the trail to privately held parcels did not suggest that realignment away from the standing water was viable.

Within the range of 877.5 (the approximate unflooded elevation of the existing trail) and 884.1 (the ultimate overtopping elevation of the basin), three elevations (877.5, 880.0 and 882.0) were identified for evaluation. Respectively, these three elevations correspond to 5-, 25- and 50-year rainfall events. A rainfall event is an estimate of how long it will be between consecutive rainfalls of a given magnitude. Adding these potential rainfall events on top of basin water surface elevation data collected between March 2017 and October 2020 provided an estimate of how frequently a new trail built to the target elevation would expect to be flooded during this highly variable period. Surface water elevation ranged from 875.5 to 880.5 within this 44 month period and the lowest existing trail elevation is approximately 873.0 near the southern end of the study area. The 877.5 elevation raises the lowest points of the existing trail above the lowest recorded surface elevation but is still vulnerable to frequent flooding (26 of 44 months estimated, 59% of data period). An 880.0 elevation is near the top of the recorded range and would eliminate most flooding potential except in times of peak groundwater (2 of 44 months estimated, 5% of data period). Constructing the trail to 882.0 is well above the highest recorded water elevation and would provide absolute protection (0 of 44 months estimated). within the target area of this report. However, there are other lengths of trail around the basin that have not recently flooded but are lower than the 882.0 elevation. Improving only the target area without addressing these other segments will still leave the overall system vulnerable and could just shift inaccessibility to other locations. While restoration of the use and enjoyment of the trail is a priority, it must be noted that improving flood protection increases construction disturbance and costs at the expense of aesthetics and ability to permit.

Two trail segments are addressed in each alternative. Trail A extends north/south along the east side of Wetland A and is depicted in the graphics from Station 8+99 to Station 18+00. Trail segment B extends along the northeast side of Wetland A and is depicted in the graphics from Station 26+00 to Station 33+60. Segment B intersects with Segment A at Station 17+10.

The following section includes a summary of all the options investigated during the study. Each option is described in detail on pages 16- 27, with a plan-view graphic provided to show the extents of impact. The graphics, along with trail profiles are included in the appendix at a larger scale.

No Build Alternative

Under a No Build Alternative, the segment of trail on the east side of Wetland A will not be modified by grade change or the addition of boardwalks. The trail will remain at its elevation and will continue to flood during high-water events. The trail may not be available for use for significant periods of time.

Snail Lake Regional Trail Existing conditions, east side of Segment B.

Recommendation Matrix

Table 3 below lists the options and ranks each as high, medium or low, based on the criteria noted above, and as noted here:

Q1: Is the option permittable by governing agencies (Watershed District, US Army Corps of Engineers, MPCA)?

- Low Grade raise/fill and/or excessive impacts
- Med Some boardwalk
- **High All boardwalk**

Q2: If permittable, are overall disturbances to the floodplain and wetlands minimized?

- **Low Minimal fill <500 CY**
- Med Medium fill > 500 CY & <2,000 CY
- High High fill > 2,000 CY

Q3: Is trail access (both public and MCES) restored in a meaningful way?

- Low 5 year flood protection
- Med 25 year flood protection
- **High 50 year flood protection**

Q4: Is the solution cost reasonable to achieve project goals? Is the solution effective and efficient?

- Low High cost relative to benefit, does not meet project goals.
- Med Balanced cost and benefit, may have same benefits as an option with lower cost.
- **High Achieves project goals but does not overbuild, benefits justify cost.**

TABLE 3: RECOMMENDATION MATRIX

ELEVATION	OPTION	Q1	Q2	Q3	Q4	NOTES
877.5	1A	LOW	MED	LOW	LOW	NOT PERMITTABLE
877.5	1B	HIGH	LOW	LOW	LOW	LOW FLOOD PROTECTION & RESILIENCY
877.5	1C	MED	LOW	LOW	LOW	LOW FLOOD PROTECTION & RESILIENCY
877.5	1D	HIGH	LOW	LOW	LOW	LOW FLOOD PROTECTION & RESILIENCY
880.0	2A	LOW	HIGH	MED	LOW	NOT PERMITTABLE
880.0	2B	HIGH	LOW	MED	HIGH	RECOMMENDED OPTION
880.0	2C	MED	MED	MED	MED	MEDIUM DISTURBANCE LEVEL
880.0	2D	HIGH	LOW	MED	HIGH	INCLUDES DENNISON AVENUE CONNECTION
882.0	3A	LOW	HIGH	HIGH	LOW	NOT PERMITTABLE
882.0	3B	HIGH	MED	HIGH	MED	MEDIUM DISTURBANCE LEVEL
882.0	3C	LOW	HIGH	HIGH	LOW	NOT PERMITTABLE
882.0	3D	HIGH	LOW	HIGH	MED	OPTION 2D ACHIEVES SAME BENEFITS AT LOWER COST

Recommended Option

Option 1A: Trail A & B Grade Raise to Minimum Elevation of 877.5 (5 Year Event)

This option would construct a new trail above a 5-year flood event to a minimum elevation of 877.5 along both Trail Segments A and B using fill material to raise the grade. The trail would utilize the existing alignment and reconstruct 1700 linear feet of trail. Culverts would be needed in four locations to balance water levels on both sides of the elevated trail. This option would require raising the trail grade up to four feet between Stations 10+50 and 12+500 on Trail A and up to 2 feet between Stations 32+00 and 33+50 on Trail B. The anticipated amount of fill material needed is 1,050 cubic yards. This option would impact 0.38 acres of wetlands and require 0.07 acres of tree removal. MCES vehicles would be able to access sewer structures utilizing the raised trail.

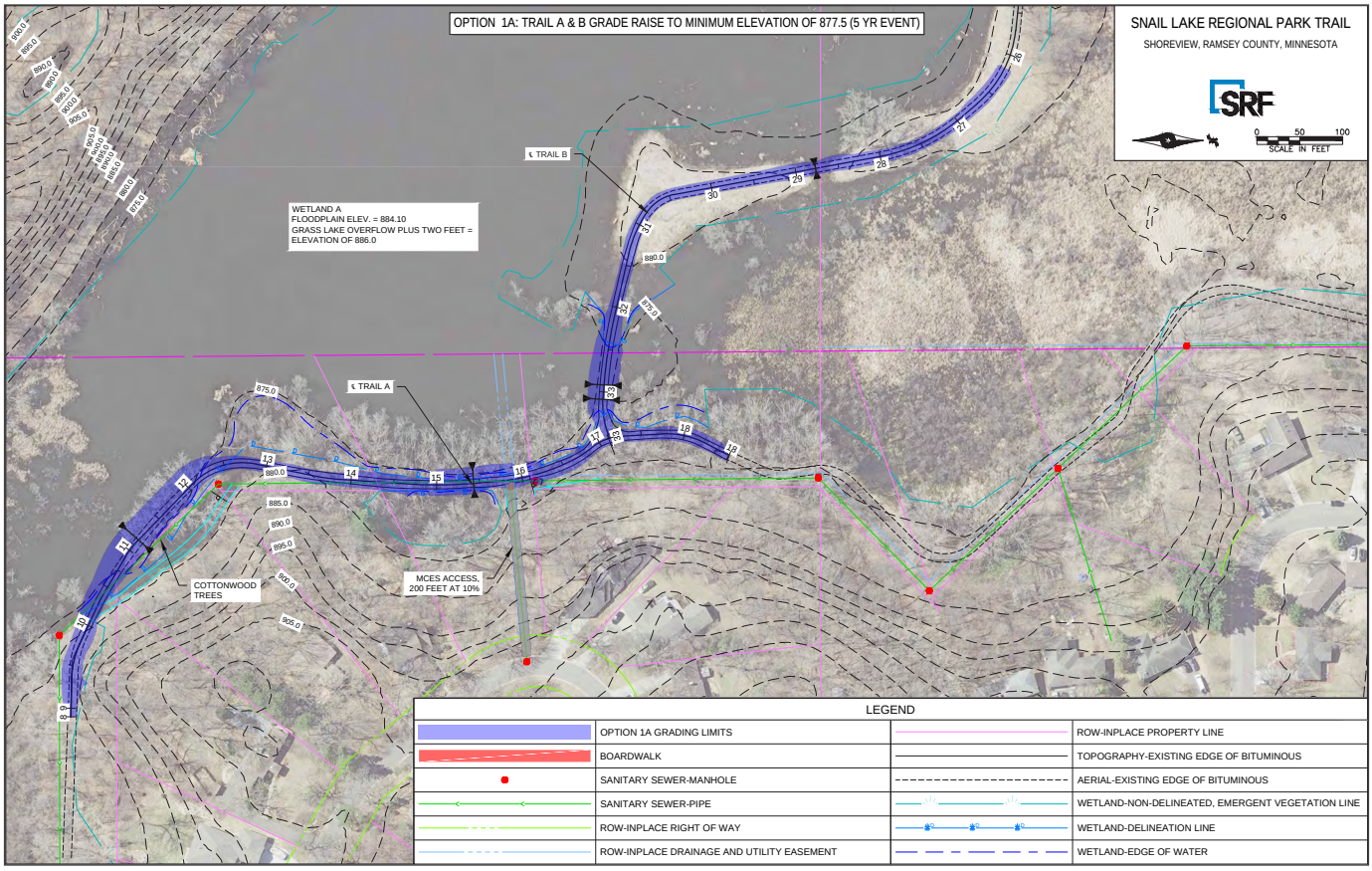


FIGURE 3: OPTION 1A (Not Permittable due to excessive grading and fill impacts)

Option 1B: Trail A & B With Boardwalk at Elevation 877.5 (5 Year Event)

This option would also construct a new trail above a 5-year flood event to a minimum elevation of 877.5, but it would include two boardwalks at Stations 10+45 to 12+30 and Stations 32+25 to 33+60. The total length of boardwalk structure would be 320 linear feet. Utilizing boardwalks at these two locations would reduce the wetland and floodplain impacts. 1385 feet of trail would also reconstructed. The amount of fill required for this option would be 190 cubic yards. Because the boardwalk structure will be within the floodplain, the anticipated volume of that structure needs to be accounted for as a floodplain impact. The total floodplain impact including fill and the boardwalk structure is 270 cubic yards. The amount of wetland impacts would be 0.15 acres and 0.07 acres of tree removal would be required. MCES vehicles would be able to access all but one structure utilizing the raised trail. The structure to the southeast would be approximately 250 feet from the trail, on the south side of the boardwalk.

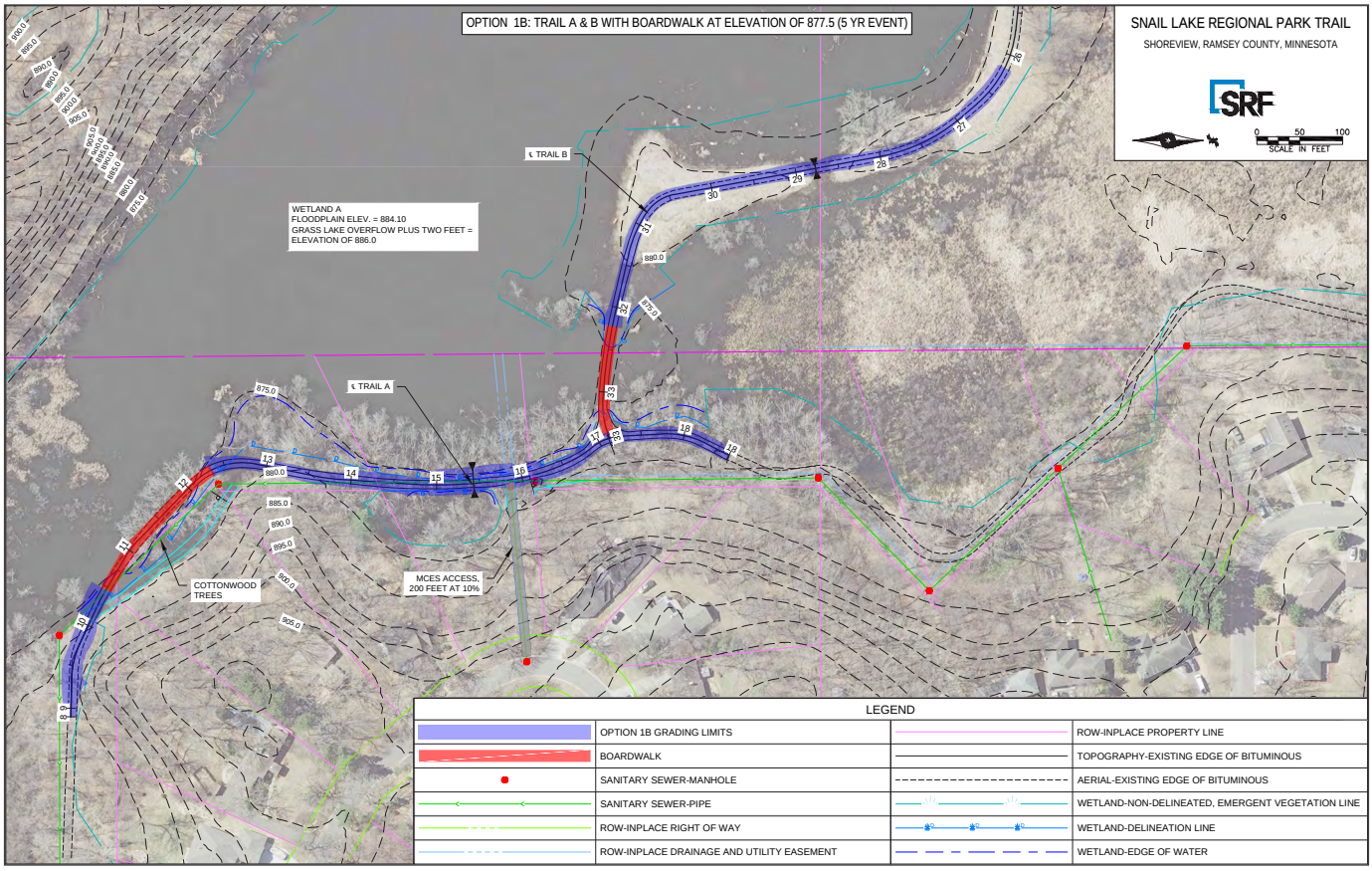


FIGURE 4: OPTION 1B (Permittable)

Option 1C: Trail A With Boardwalk, Trail B Grade Raise to Minimum Elevation of 877.5 (5 Year Event)

Trail Option 1C is a hybrid of Options 1A and 1B. This option includes one boardwalk between Stations 10+45 to 12+30 on Trail Segment A. Trail Segment B would not have boardwalk structures and would be raised using only fill material. Option 1C would require 410 cubic yards of fill material, 190 linear feet of boardwalk and 1513 linear feet of reconstructed trail. The total fill volume including fill material and boardwalk structure is 460 cubic yards. 0.22 acres of wetlands would be impacted, and 0.07 acres of trees would need to be removed. MCES vehicles would be able to access all but one structure utilizing the raised trail. The structure to the southeast would be approximately 250 feet from the trail, on the south side of the boardwalk.

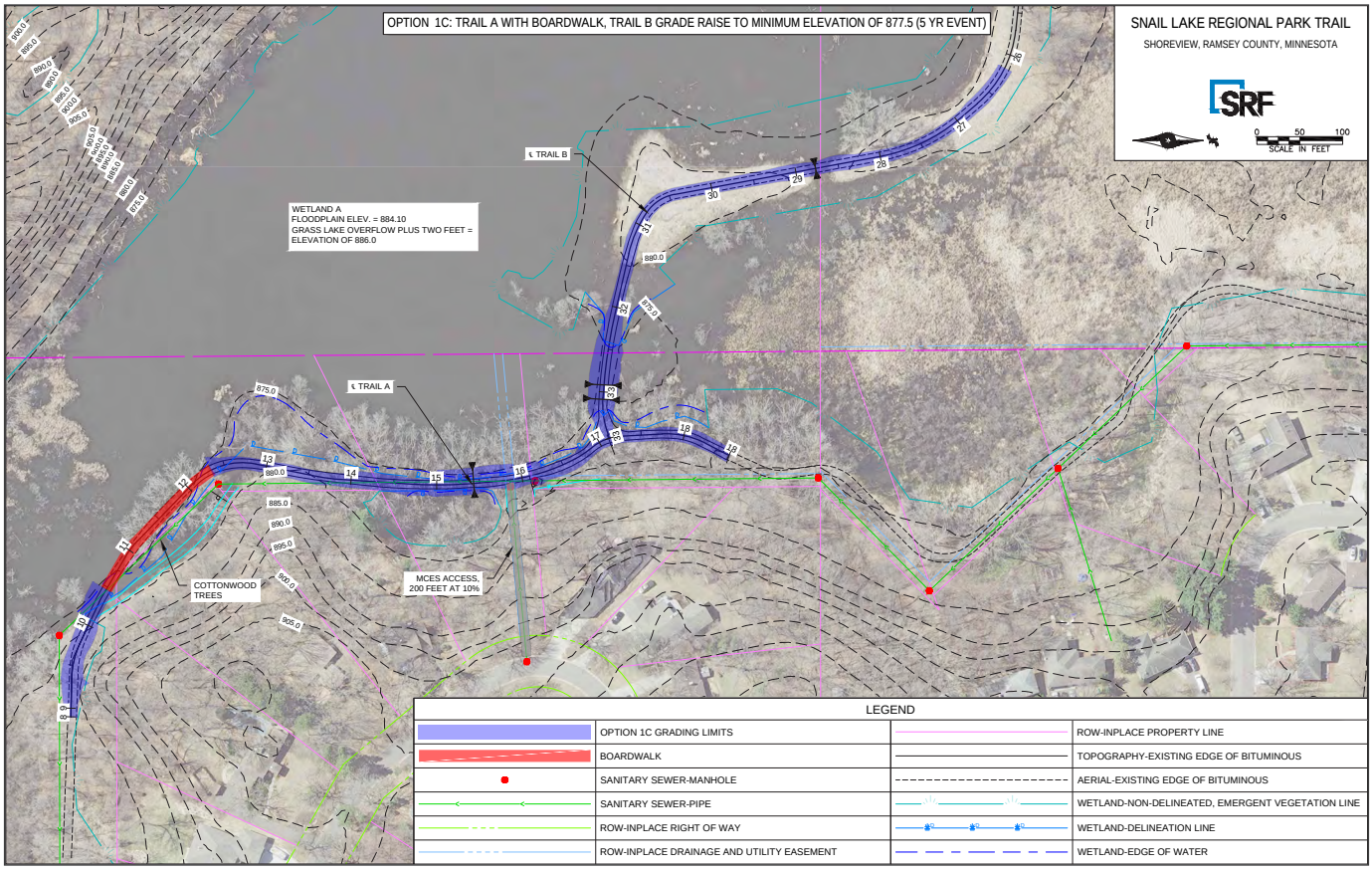


FIGURE 5: OPTION 1C (Permittable)

Option 1D: Trail A Boardwalk at Elevation 877.5 With Dennison Boardwalk at Elevation 882.0 (5 Year Event)

Trail Option 1D includes a 430-foot-long boardwalk north of Trail Segment A. This is referenced as the Dennison Boardwalk in the concept plans. This boardwalk would replace approximately 650 linear feet of Trail Segment B from Station 27+40 to Station 33+60. Option 1D would also include a boardwalk between Stations 10+45 to 12+30 on Trail A and 780 linear feet of trail reconstruction. The total length of boardwalk in this option is 620 linear feet. Option 1D would require 150 cubic yards of fill material and would not impact any wetlands and would require minimal tree removal to install the Dennison Boardwalk. MCES vehicles would be able to access all but one structure utilizing the raised trail. The structure to the southeast would be approximately 250 feet from the trail, on the south side of the boardwalk.

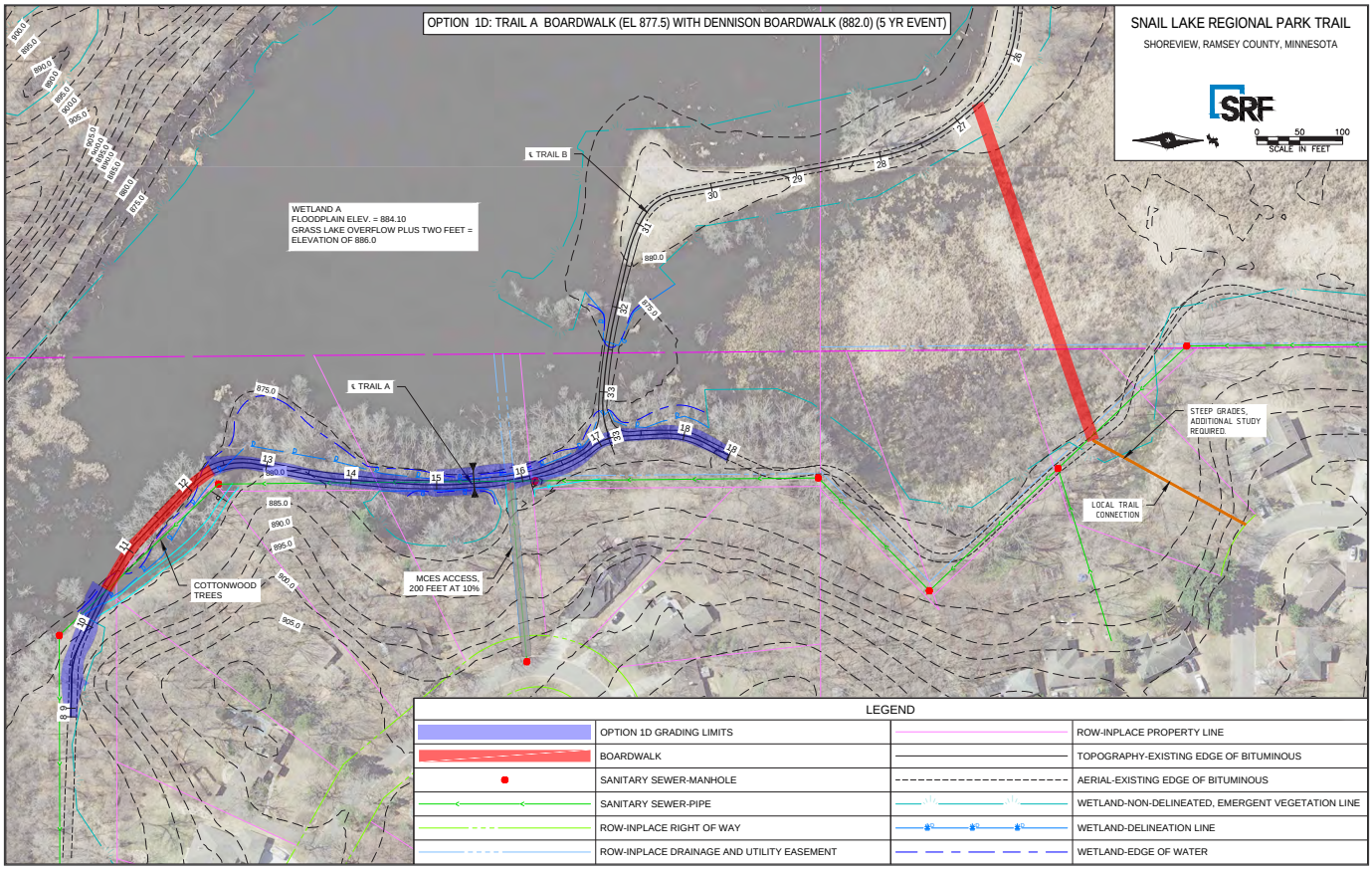


FIGURE 6: OPTION 1D (Permittable)

Option 2A: Trail A & B Grade Raise to Minimum Elevation of 880.0 (25 Year Event)

This option would construct a new trail above a 25-year flood event to a minimum elevation of 880.0 along both Trail Segments A and B using fill material to raise the grade. The trail would utilize the existing alignment and reconstruct 1700 linear feet of trail. Culverts would be needed in four locations to balance water levels on both sides of the elevated trail. This option would require raising the trail grade up to 7 feet between Stations 10+50 and 13+00 on Trail A and up to 5 feet between Stations 31+50 and 33+50 on Trail B. The anticipated amount of fill material needed is 3,620 cubic yards. This option would impact 0.62 acres of wetlands and require 0.19 acres of tree removal. MCES vehicles would be able to access sewer structures utilizing the raised trail.

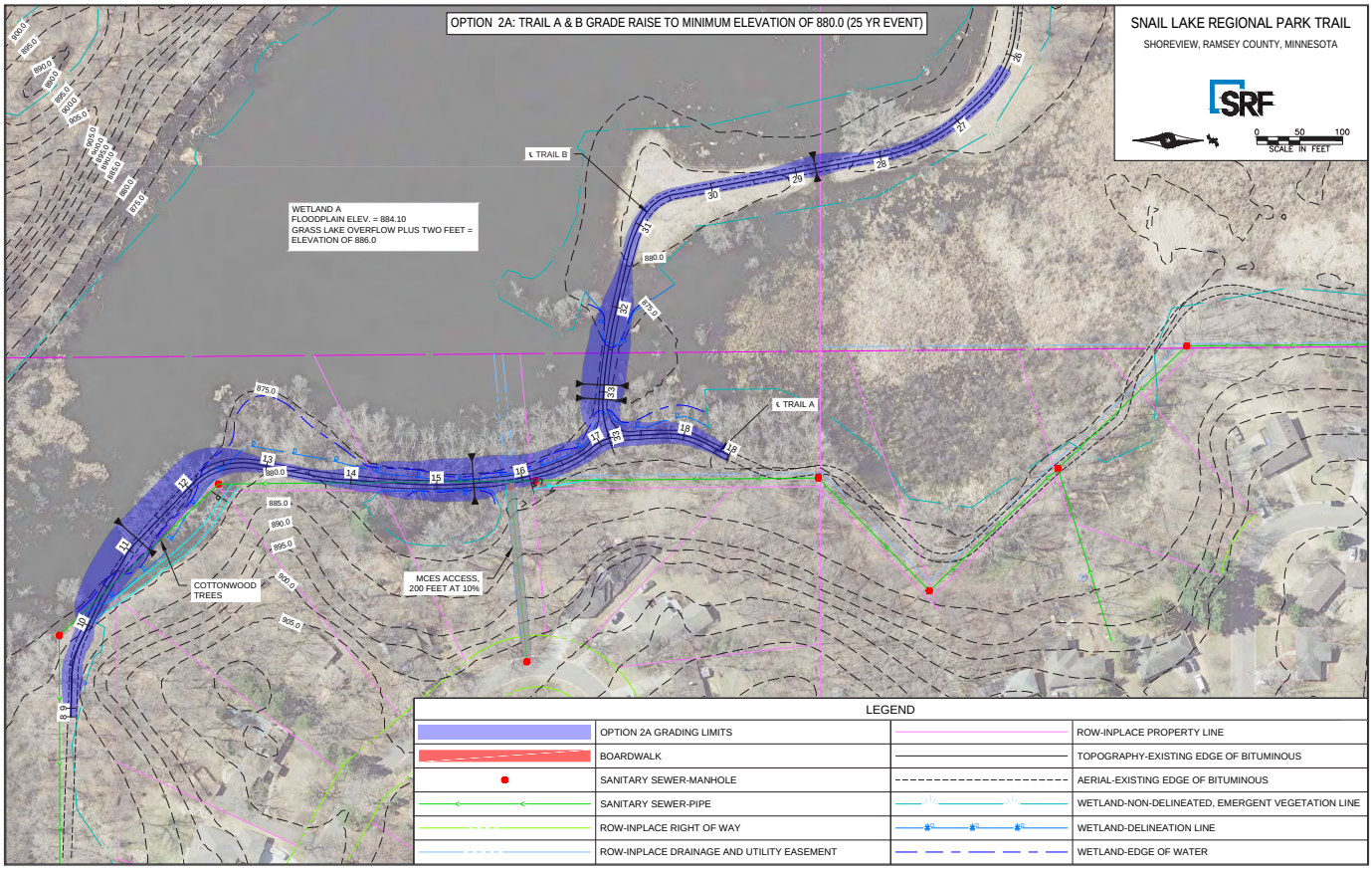


FIGURE 7: OPTION 2A (Not Permittable due to excessive grading and fill impacts)

Option 2B: Trail A & B With Boardwalk at Elevation of 880.0 (25 Year Event)

This option would also construct a new trail above a 25-year flood event to a minimum elevation of 880.0, but it would include three boardwalks at Stations 10+45 to 18+50 on Trail A and Stations 28+30 to 29+20 and 31+50 to 33+60 on Trail B. The total length of boardwalk structure would be 1060 linear feet. Utilizing boardwalks at these three locations would reduce the wetland and floodplain impacts. 630 feet of trail would also be reconstructed. The amount of fill required for this option would be 180 cubic yards. Because the boardwalk structure will be within the floodplain, the anticipated volume of that structure needs to be accounted for as a floodplain impact. The total floodplain impact including fill and the boardwalk structure is 440 cubic yards. The amount of wetland impacts would be 0.10 acres and 0.02 acres of tree removal would be required. MCES vehicles would be able to access all but one structure utilizing the raised trail. The structure to the southeast would be approximately 250 feet from the trail, on the south side of the boardwalk.

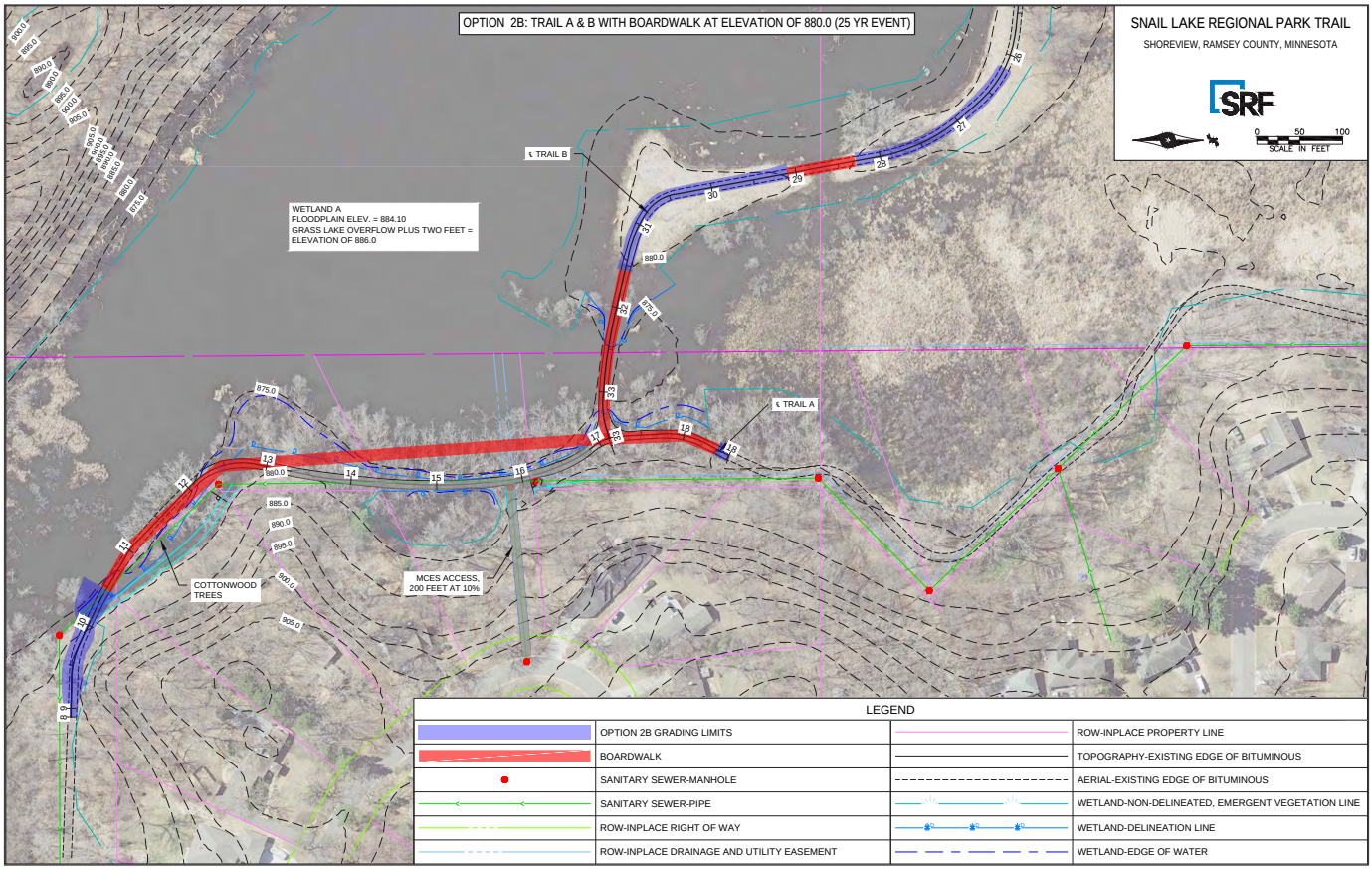


FIGURE 8: OPTION 2B (Permittable)

Option 2C: Trail A With Boardwalk, Trail B Grade Raise to Minimum Elevation of 880.0 (25 Year Event)

Trail Option 2C is a hybrid of Options 2A and 2B. This option includes one boardwalk between Stations 10+45 to 18+50 on Trail Segment A. Trail Segment B would not have boardwalk structures and would be raised using only fill material. Option 2C would require 1080 cubic yards of fill material, 790 linear feet of boardwalk and 904 linear feet of reconstructed trail. The total fill volume including fill material and boardwalk structure is 1280 cubic yards. 0.22 acres of wetlands would be impacted, and 0.02 acres of trees would need to be removed. MCES vehicles would be able to access all but one structure utilizing the raised trail. The structure to the southeast would be approximately 250 feet from the trail, on the south side of the boardwalk.

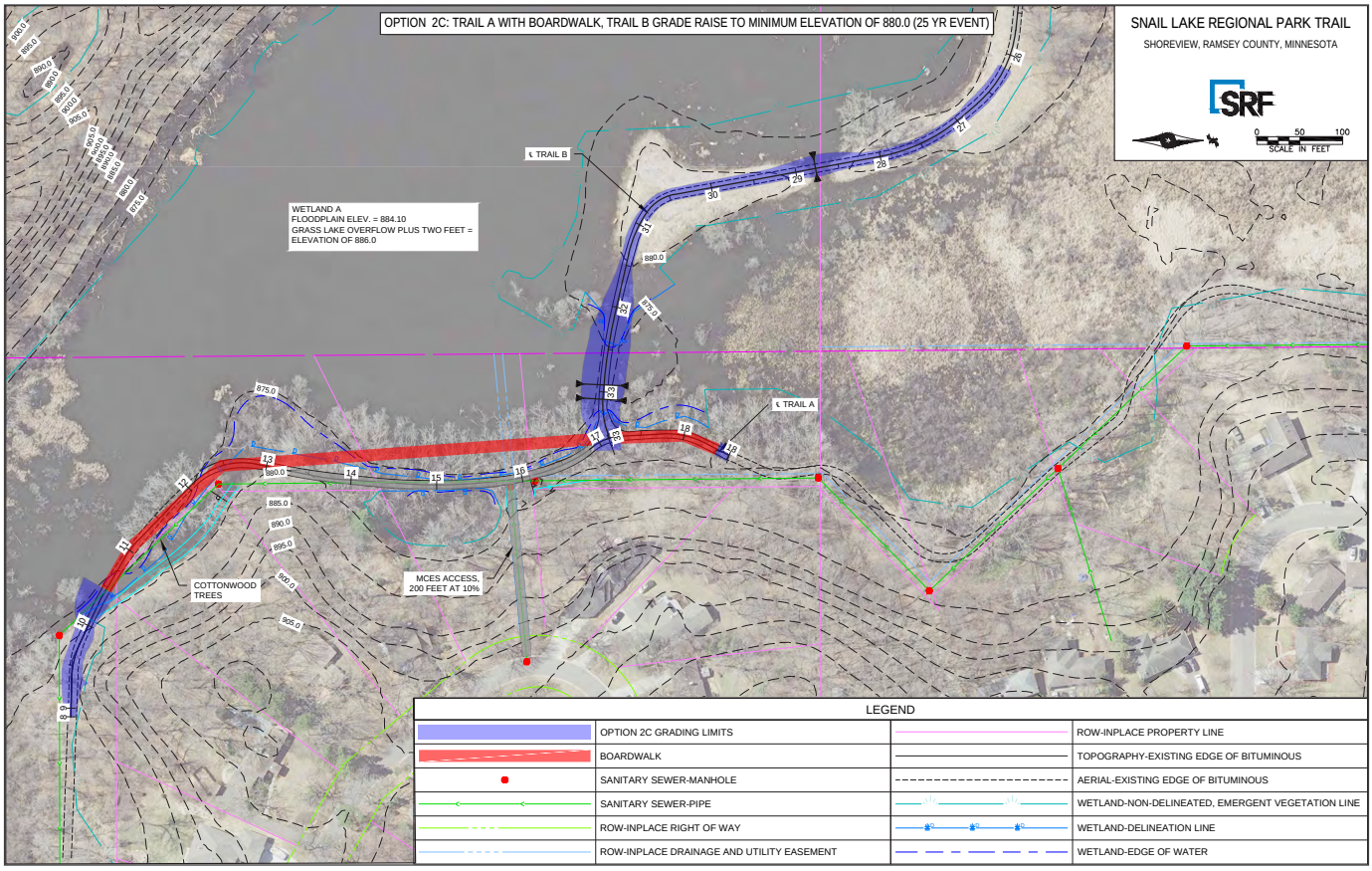


FIGURE 9: OPTION 2C (Permittable)

Option 2D: Trail A Boardwalk at Elevation of 880.0 With Dennison Boardwalk at Elevation 882.0 (25 Year Event)

Trail Option 2D includes a 430-foot-long boardwalk north of Trail Segment A. This is referenced as the Dennison Boardwalk in the concept plans. This boardwalk would replace approximately 650 linear feet of Trail Segment B from Station 27+40 to Station 33+60. Option 2D would also include a boardwalk between Stations 10+45 to 18+50 on Trail A and 171 linear feet of trail reconstruction. The total length of boardwalk in this option is 1210 linear feet. Option 1D would require 300 cubic yards of fill material and would not impact any wetlands and would require minimal tree removal to install the Dennison Boardwalk. MCES vehicles would be able to access all but one structure utilizing the raised trail. The structure to the southeast would be approximately 250 feet from the trail, on the south side of the boardwalk.

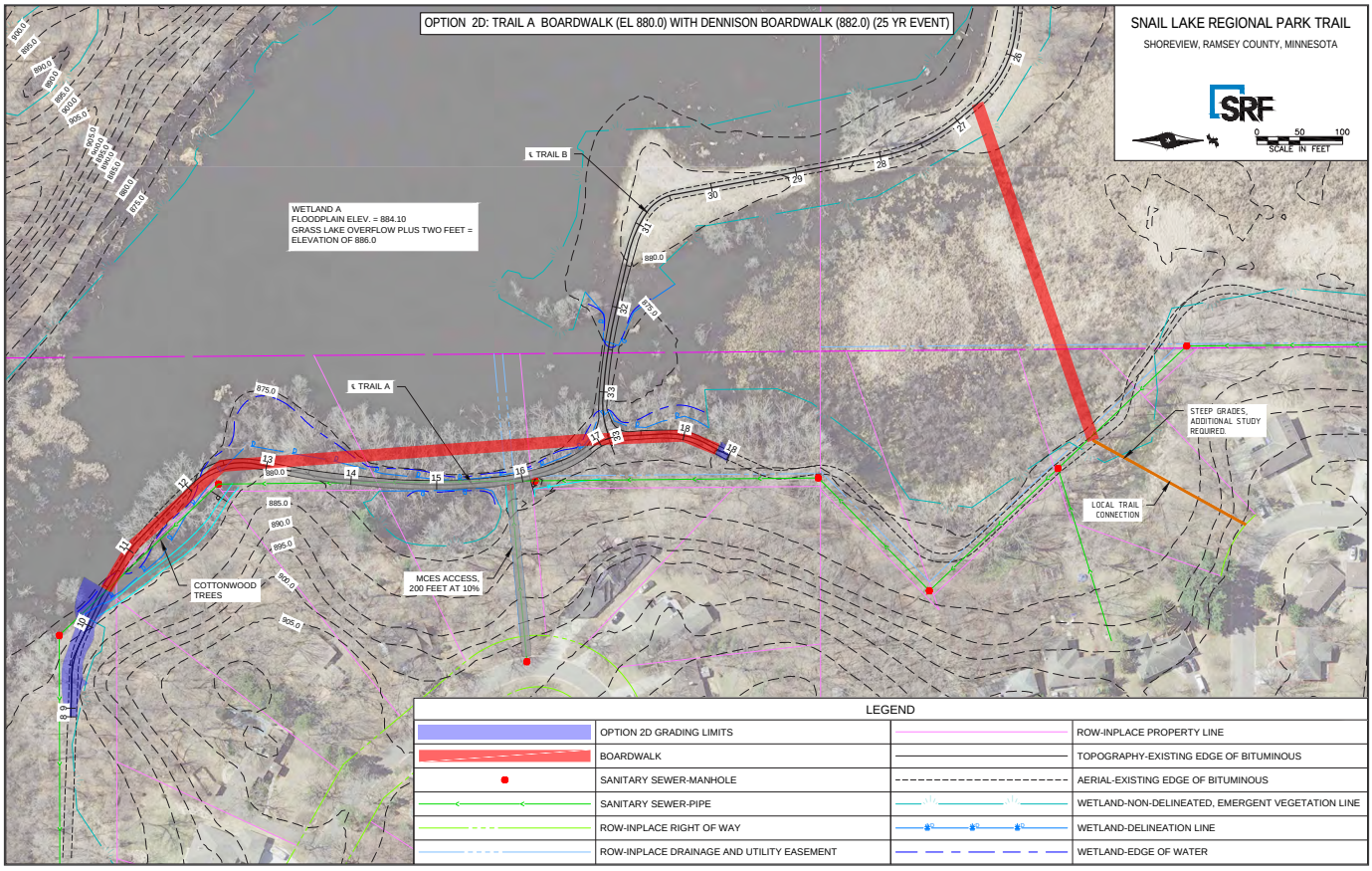


FIGURE 10: OPTION 2D (Permittable)

Option 3A: Trail A & B Grade Raise to Minimum Elevation of 882.0 (50 Year Event)

This option would construct a new trail above a 50-year flood event to a minimum elevation of 882.0 along both Trail Segments A and B using fill material to raise the grade. The trail would utilize the existing alignment and reconstruct 1700 linear feet of trail. Culverts would be needed in four locations to balance water levels on both sides of the elevated trail. This option would require raising the trail grade up to 9 feet between Stations 9+50 and 18+50 on Trail A and up to 7 feet between Stations 26+00 and 33+50 on Trail B. The anticipated amount of fill material needed is 7,680 cubic yards. This option would impact 0.81 acres of wetlands and require 0.51 acres of tree removal. MCES vehicles would be able to access sewer structures utilizing the raised trail.

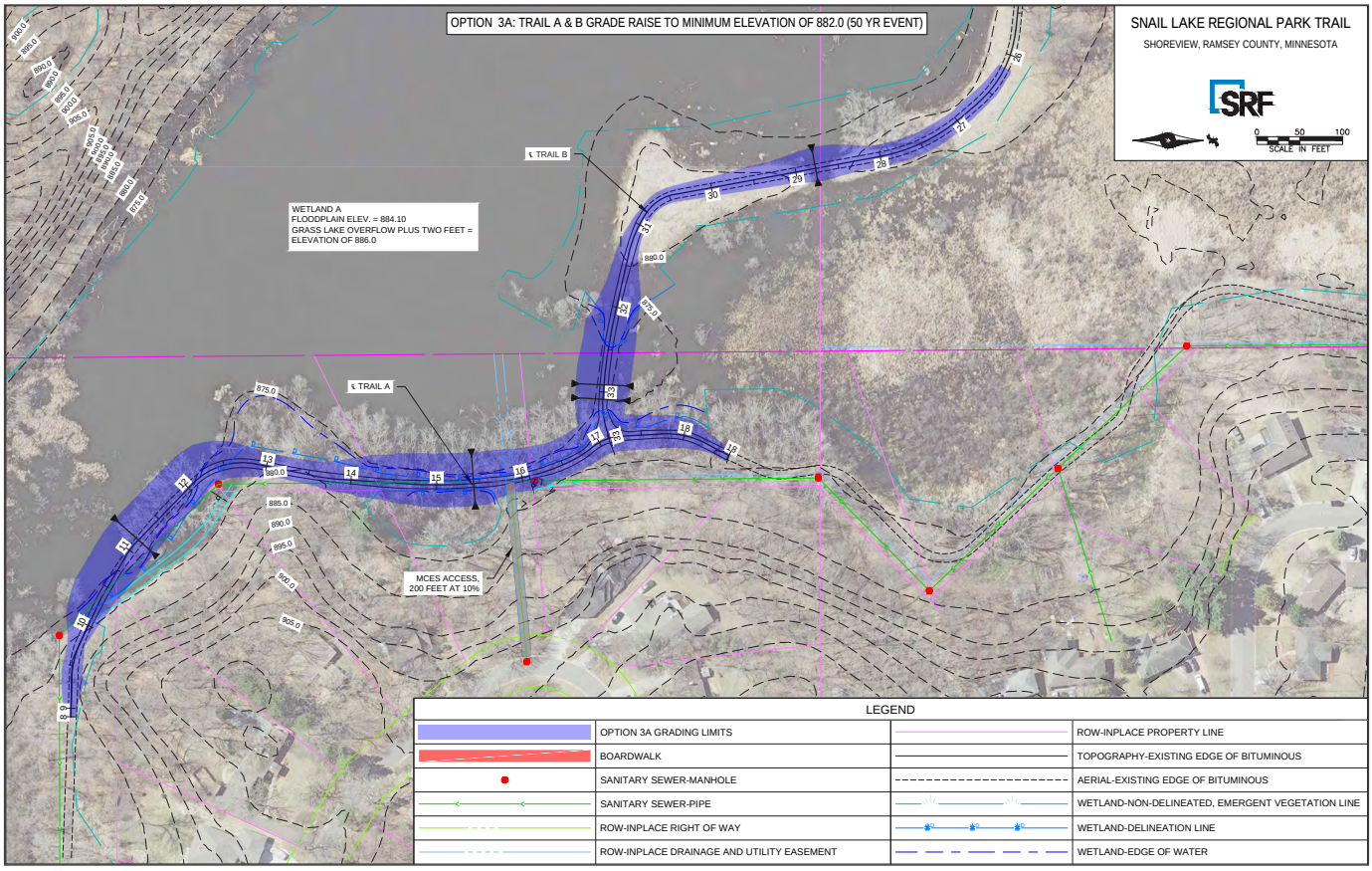


FIGURE 11: OPTION 3A (Not Permittable due to excessive grading and fill impacts)

Option 3B: Trail A & B With Boardwalk at Elevation of 882.0 (50 Year Event)

This option would also construct a new trail above a 50-year flood event to a minimum elevation of 882.0, but it would include two boardwalks at Stations 9+65 to 17+75 on Trail A and Stations 26+20 to 33+60 on Trail B. The total length of boardwalk structure would be 1560 linear feet. Utilizing boardwalks at these two locations would reduce the wetland and floodplain impacts. 138 feet of trail would also be reconstructed. The amount of fill required for this option would be 150 cubic yards. Because the boardwalk structure will be within the floodplain, the anticipated volume of that structure needs to be accounted for as a floodplain impact. The total floodplain impact including fill and the boardwalk structure is 530 cubic yards. The amount of wetland impacts would be 0.04 acres and 0.01 acres of tree removal would be required. MCES vehicles would be able to access all but one structure utilizing the raised trail. The structure to the southeast would be approximately 250 feet from the trail, on the south side of the boardwalk.

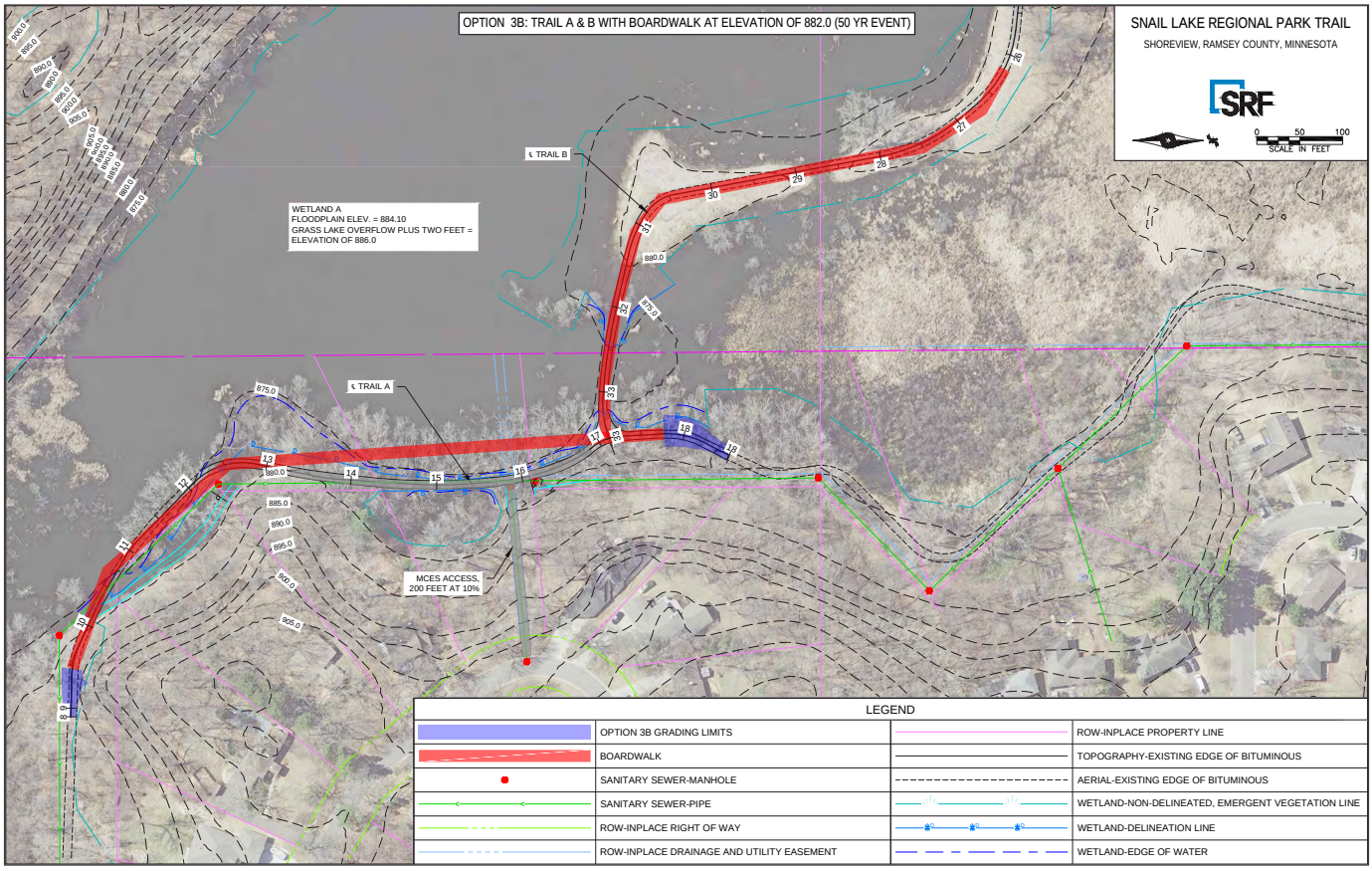


FIGURE 12: OPTION 3B (Permittable)

Option 3C: Trail A With Boardwalk, Trail B Grade Raise to Minimum Elevation of 882.0 (50 Year Event)

Trail Option 3C is a hybrid of Options 3A and 3B. This option includes one boardwalk between Stations 9+65 to 17+75 on Trail Segment A. Trail Segment B would not have boardwalk structures and would be raised using only fill material. Option 3C would require 2460 cubic yards of fill material, 770 linear feet of boardwalk and 871 linear feet of reconstructed trail. The total fill volume including fill material and boardwalk structure is 2650 cubic yards. 0.21 acres of wetlands would be impacted, and 0.04 acres of trees would need to be removed. MCES vehicles would be able to access all but one structure utilizing the raised trail. The structure to the southeast would be approximately 250 feet from the trail, on the south side of the boardwalk.

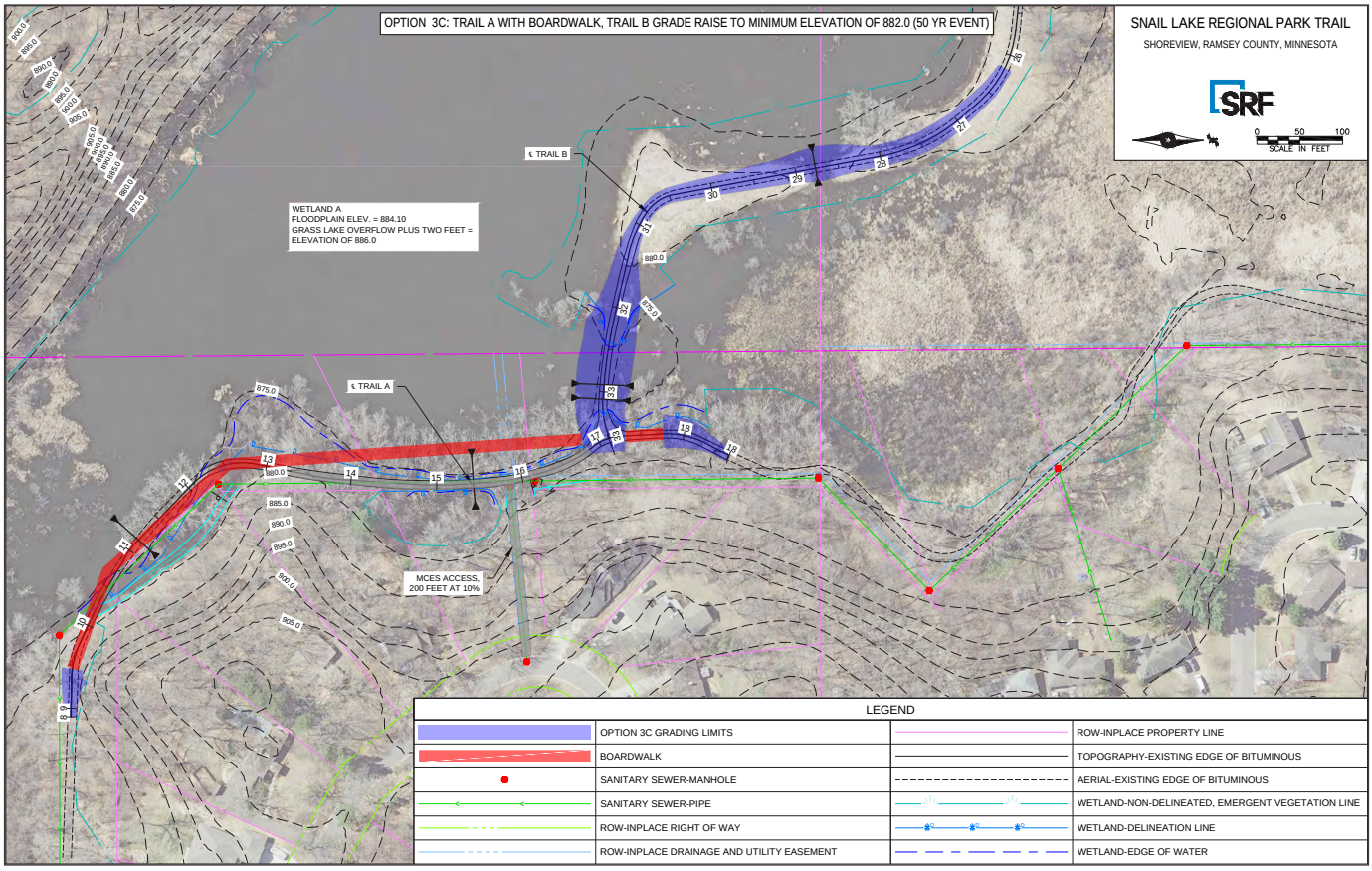


FIGURE 13: OPTION 3C (Not Permittable due to excessive grading and fill impacts)

Option 3D: Trail A Boardwalk at Elevation 882.0 With Dennison Boardwalk at Elevation 882.0 (50 Year Event) Trail Option 3D includes a 430-foot-long boardwalk north of Trail Segment A. This is referenced as the Dennison Boardwalk in the concept plans. This boardwalk would replace approximately 650 linear feet of Trail Segment B from Station 27+40 to Station 33+60. Option 3D would also include a boardwalk between Stations 9+65 to 17+75 on Trail A and 138 linear feet of trail reconstruction. The total length of boardwalk in this option is 1250 linear feet. Option 3D would require 310 cubic yards of fill material and would not impact any wetlands and would require minimal tree removal to install the Dennison Boardwalk. MCES vehicles would be able to access all but one structure utilizing the raised trail. The structure to the southeast would be approximately 250 feet from the trail, on the south side of the boardwalk.

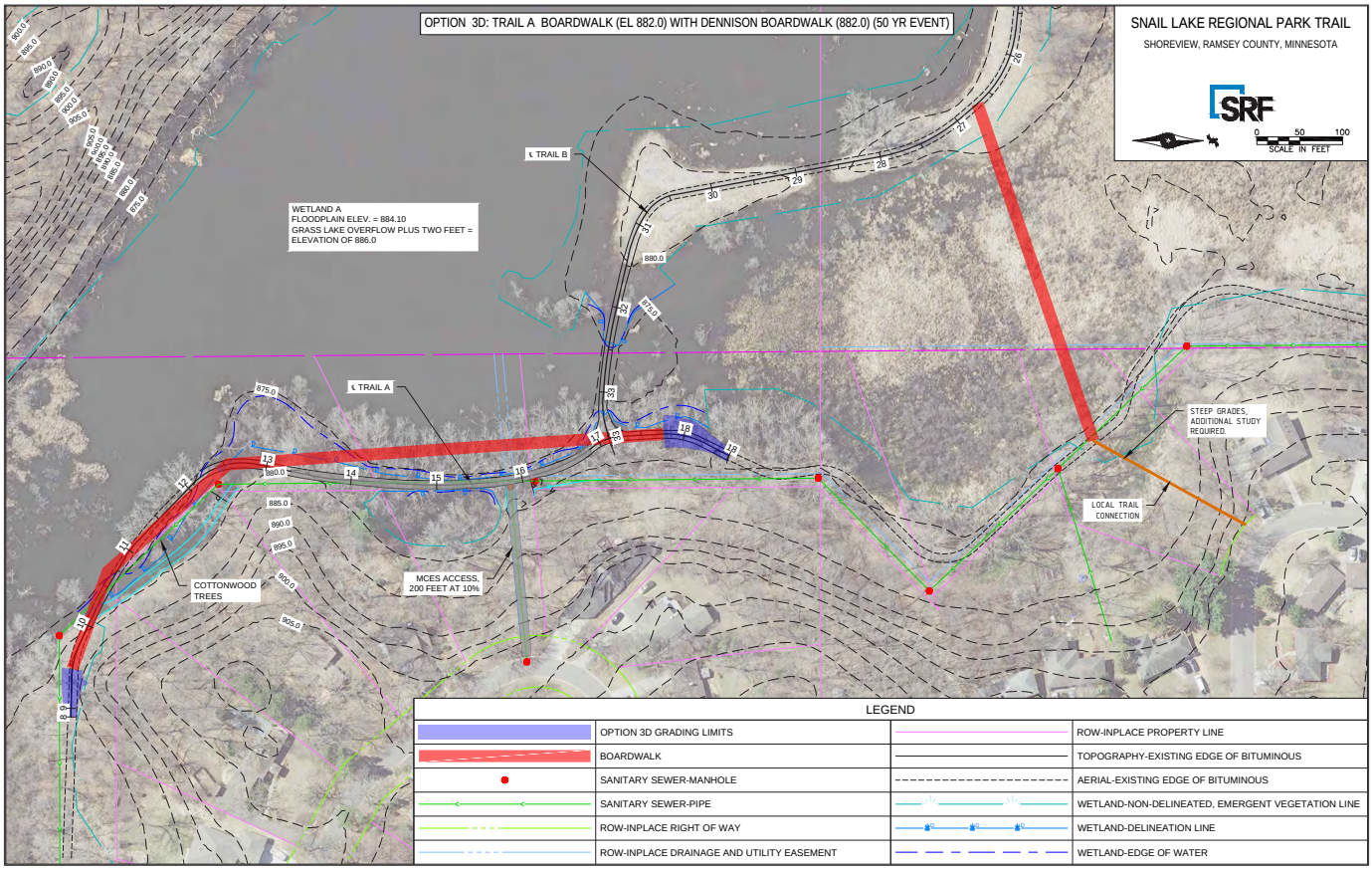


FIGURE 14: OPTION 3D (Permittable)

RECOMMENDED OPTION

SRF considered all options reviewed based on the following principal criteria:

- Is the option permittable by governing agencies (Watershed District, US Army Corps of Engineers, MPCA)?
- If permittable (allowable by governing agencies) are overall disturbances to the floodplain and wetlands minimized?
- Is trail access (both public and MCES) restored in a meaningful way?
- Is the solution cost reasonable to achieve project goals? Is the solution effective and efficient?

Limiting overall wetland impacts and areas of disturbance is critical for achieving a permittable project. Our study investigated potential for any project impacts to be mitigated within the project site. Off-site mitigation via credit purchase is expensive and not readily available in Ramsey County. Options 2A and 3A (grade raise only) were not feasible to mitigate on site and were eliminated from consideration.

Providing a solution that restores reliable trail access and does not significantly impact viewsheds of the wetland requires a balance of priorities. Constructing a new trail to an absolute flood protection level (Options 3X)

would require a 7-to-9-foot grade raise and only serve to shift the current flooding potential to other areas in the basin. Conversely, filling in just the existing low areas to an elevation of 877.5 (Options 1X) would limit visual obstruction and provide improved flood protection but not to a level where flooding is uncommon enough (flooding estimated 59% of the time) to justify the investment. **Building a trail to a minimum 880 elevation (Option 2X) best minimizes impacts while providing near-absolute flood protection (5% flooding estimated) at justifiable expense.**

Of all options at the 880 elevation, Option 2B maintains the greatest extent of the existing trail and route. If constructed, existing Trail A could remain in place to provide MCES periodic access to their sewer facilities. Maintaining Trail B across the two low points is not essential for maintenance. Since Option 2B does not avoid all wetland impacts, the differential in overall area of disturbance between it and 2C is not great. Either could be advanced based on overall agency sensitivity to impacts and/or cost considerations by the client. Option 2D is permittable, but the additional cost of the Dennison Boardwalk makes this a less feasible option. This option could be included in a public bid as an alternate. The final improvement plan will consider whether a connection to Dennison Avenue is desired. Building this alignment on boardwalk would allow for abandonment of the current Trail B embankment as it connects to Trail A. Removing this impervious surface and leveling this no longer needed fill in the floodplain will further enhance the ability to permit this project and implement a permanent solution.

One reason for not elevating trails in this location to an elevation of 882 is that existing trails beyond this project would be inundated. Therefore trails above an elevation of 880 would not be reasonable because they would be inaccessible.

TABLE 4: SUMMARY OF OPTIONS

Option	Description	Fill/Deck Elevation	Flood Protection (Year Storm Event)	Trail Reconstruction (LF)	Boardwalk Structure Length (LF)	Floodplain Fill Volume (CY)	Wetland Impacts (AC)	Permittable Yes/No
~~1A~~	~~Trail A & B Grade Raise~~	~~877.5~~	~~5~~	~~1700~~	~~0~~	~~1050~~	~~0.38~~	~~No~~
1B	Trail A & B Boardwalk	877.5	5	1385	320	270	0.15	Yes
1C	Trail A Boardwalk, Trail B Grade Raise	877.5	5	1513	190	460	0.22	Yes
1D	Trail A Boardwalk, Dennison Boardwalk	877.5/882.0	5	780	620	150	0.00	Yes
~~2A~~	~~Trail A & B Grade Raise~~	~~880.0~~	~~25~~	~~1700~~	~~0~~	~~3620~~	~~0.62~~	~~No~~
2B	Trail A & B Boardwalk	880.0	25	630	1060	440	0.10	Yes
2C	Trail A Boardwalk, Trail B Grade Raise	880.0	25	904	790	1280	0.22	Yes
2D	Trail A Boardwalk, Dennison Boardwalk	880.0/882.0	25	171	1210	300	0.00	Yes
~~3A~~	~~Trail A & B Grade Raise~~	~~882.0~~	~~50~~	~~1700~~	~~0~~	~~7680~~	~~0.81~~	~~No~~
3B	Trail A & B Boardwalk	882.0	50	138	1560	530	0.04	Yes
~~3C~~	~~Trail A Boardwalk, Trail B Grade Raise~~	~~882.0~~	~~50~~	~~871~~	~~770~~	~~2650~~	~~0.21~~	~~No~~
3D	Trail A Boardwalk, Dennison Boardwalk	882.0/882.0	50	138	1250	310	0.00	Yes

Recommended Option Not Permittable

COST ESTIMATE

A planning-level construction cost estimate has been prepared for the recommended option, 2B. This option includes a combination of boardwalks and trail at an elevation of 880.0, which is a 25-year event. It includes 1,060 linear feet of boardwalk and 630 linear feet of reconstructed trail.

The cost estimate takes into account all aspects of trail construction, including vegetation removal, wetland mitigation costs, trail removal, trail and boardwalk construction.

The estimated cost for Option 2B is $1,797,540.

With a conservative estimate for final design and construction administration as 25% of construction cost, a potential full project cost to design and build trail improvements could be $2,246,930. Detailed versions of the cost estimates are included in the appendix.

TABLE 5: RECOMMENDED OPTION COST ESTIMATE

Engineer's Estimate - Snail Lake Trail Feasibility Study					
NOTES	ITEM DESCRIPTION	UNIT	UNIT PRICE	OPTION 2B	
				QUANTITY	AMOUNT
	TRAIL & BOARDWALK CONSTRUCTION:				
(3)	CLEAR & GRUB TREE	ACRE	$6,000.00	0.02	$120.00
	COMMON EXCAVATION (CUT)	CU YD	$20.00	30	$600.00
	COMMON EMBANKMENT (FILL)	CU YD	$20.00	180	$3,600.00
(2)	BITUMINOUS PAVEMENT & AGGREGATE	LIN FT	$60.00	630	$37,800.00
(5)	BOARDWALK	LIN FT	$1,200.00	1059	$1,270,800.00
(1)	WETLAND IMPACTS	ACRE	$10,000.00	0.10	$1,000.00
(4)	TEMPORARY EASEMENTS FOR CONSTRUCTION	SQ FT	$5.00		
(7)	CROSS CULVERTS & MCES MANHOLE RECONSTRUCTION	LUMP SUM	$20,000.00		
	TRAIL & BOARDWALK CONSTRUCTION SUBTOTAL:			$1,313,920.00	
(6)	TURF ESTABLISHMENT & EROSION CONTROL		10%		$132,000.00
	GENERAL CONTINGENCY		25%		$329,000.00
	TRAIL & BOARDWALK CONSTRUCTION TOTAL:			$1,774,920.00	
	COMPENSATORY STORAGE REQUIRED (1:1 RATIO):			**150**	
	MITIGATION OPTION			**B**	
(3)	CLEAR & GRUB TREE	ACRE	$6,000.00	0.02	$120.00
	COMMON EXCAVATION (CUT)	CU YD	$20.00	1190	$23,800.00
	COMPENSATORY STORAGE TOTAL:			$23,920.00	
	ONSITE WETLAND IMPACT MITIGATION REQUIRED (1:2 RATIO):			**0.20**	
(1)	WETLAND CREATION	ACRE	$10,000.00	0.25	$2,500.00
(1)	WETLAND IMPACTS (PERMANENT)	ACRE	$10,000.00		
(1)	WETLAND IMPACTS (TEMPORARY)	ACRE	$10,000.00	0.02	$200.00
	ONSITE WETLAND IMPACT MITIGATION TOTAL:			$2,700.00	
	OFFSITE WETLAND IMPACT MITIGATION:				
(8)	OUTSTANDING WETLAND IMPACTS (PERMANENT)	ACRE	$80,000.00	-0.05	-$4,000.00
TOTAL ESTIMATED OPTION COST (CONSTRUCTION + MITIGATION)				**$1,797,540.00**	
FINAL DESIGN & CONSTRUCTION ADMINISTRATION (25%)				**$449,390.00**	
TOTAL ESTIMATED PROJECT COST				**$2,246,930.00**	

NOTES:

(1) PER DELINEATED WETLANDS FOR RAPID STABILIZATION AND FINAL SEEDING
(2) FOR 10 FOOT BIT TRAIL (3 INCH DEPTH) OVER 11 FOOT AGG BASE (6 INCH DEPTH)
(3) PER ESTIMATED TREE LINES FROM AERIAL IMAGERY
(4) FOR TEMPORARY GRADING IMPACTS TO PRIVATE PARCELS EAST OF EXISTING TRAIL
(5) FOR 9 FOOT CLEAR WIDTH, NON-VEHICLE RATED TIMBER BOARDWALK ON HELICAL PILES WITH 4.5 FOOT TALL RAILS WHEN DROPOFF EXCEEDS 30 INCHES
(6) CONTINGENCY FOR SITE PROTECTION DURING CONSTRUCTION AND FINAL SEEDING OF FINISHED SLOPES
(7) CONTINGENCY FOR CROSS CULVERT REPLACEMENT AND/OR MCES SANITARY SEWER STRUCTURE RECONSTRUCTION
(8) POSITIVE VALUES ARE IMPACTS TO BE MITIGATED OFFSITE VIA CREDITS. UNIT PRICE LISTED IS 2019 AVERAGE COST PER CREDIT FOR BSA 7. BLANK OR NEGATIVE VALUES SUGGEST THAT MITIGATION CAN BE ACHIEVED ONSITE WITH SOME OPTIONS CREATING EXCESS.

NEXT STEPS

This report has compared various trail improvement solutions and identified a recommended alternative for further investigation and design. Funding for final design and construction will need to be secured before advancing this concept to a higher level. As design progresses, the various permitting agencies will be engaged for guidance and review in order to achieve required agency approvals. Stakeholders, including area residents and trail users, will be invited to an informational open house in fall 2022 to be able to ask questions regarding the feasibility study outcome and timing of the next steps in the project. Construction will begin when a complete and fully permitted design is approved. This is anticipated to occur in 2023 – 2024, pending funding availability.

APPENDIX

A. Wetland A Study Area

B. Regulatory Matrix

C. Modeling Summary

D. Alternative Evaluation Graphics

E. MCES Facilities

F. Geotechnical Report

G. Cost Estimates

APPENDIX A

Wetland A Study Area

VADNAIS-SNAIL LAKES REGIONAL PARK TRAIL FEASIBILITY STUDY

RAMSEY COUNTY
Parks & Recreation

Contact Information:
2015 Van Dyke Street
Maplewood, MN 55109
PH: 651-266-0300

VADNAIS-SNAIL LAKES REGIONAL PARK
WETLAND A AREA TRAIL IMPROVEMENTS FEASIBILITY STUDY - STUDY FOCUS AREA

Date: 2-10-2022

APPENDIX B

Regulatory Matrix

ENTITY	SURFACE WATER RATES	SURFACE WATER QUANTITY	SURFACE WATER QUALITY	FLOOD CONTROL	WETLAND MANAGEMENT
Minnesota Pollution Control Agency (MPCA) via the NPDES (National Pollution Discharge Elimination System) Permit Program ▪ Required for construction activity that disturbs greater than 1 acre.	▪ N/A	▪ Abstraction of the first 1 inch over the site's new impervious surface area OR 0.5 inch over the site's new and reconstructed impervious surface area, whichever is greater. ▪ Pretreatment must be used before filtration/infiltration.	▪ Water quality volume is equal to 1 inch of runoff from the new impervious surfaces. ▪ Permanent pond volume of 1800 Cubic Feet (CF)/acre of storage below the outlet. ▪ Water quality volume maximum discharge 5.66 Cubic Feet per Second (cfs) per acre of pond surface area. ▪ Filtration systems must be designed to remove at least 80% of Total Suspended Solids (TSS).	▪ N/A	▪ N/A
Ramsey-Washington Metro Watershed District (RWMWD) ▪ Permit required for land alterations that disturb a surface area of 1 acre or greater ▪ Watershed District is the Local Governing Unit (LGU) for wetland management.	▪ Runoff rates shall not exceed existing runoff rates for the 2-year, 10-year, and 100-year critical storm events using Atlas-14 rainfall depths. ▪ Runoff rates may be restricted to less than the existing rates when the capacity of downstream conveyance systems is limited.	▪ Stormwater runoff volume shall be retained onsite in the amount of 1.1 inches of runoff from the new and reconstructed impervious surfaces. ▪ Provide sufficient pretreatment before infiltration/filtration Best Management Practices (BMP) ▪ If infiltration on site is infeasible, BMP selection must follow the Alternative Compliance Sequencing: o 55% filtration credit. o 80% iron-enhanced filtration credit. ▪ No exemptions for trails	▪ BMPs must achieve 90% TSS removal from runoff generated by a Nationwide Urban Runoff Program (NURP) water quality storm (2.5" rainfall) or on an annual basis. ▪ For linear projects, costs specific to satisfying the volume reduction and water quality standards shall not exceed a cost cap for costs directly associated with the design, testing, land acquisition, and construction of the volume reduction and water quality BMPs only.	▪ Placement of fill within the 100-year floodplain needs to be mitigated by providing compensatory storage. Compensatory storage shall fully offset the loss of storage. ▪ Boardwalks have generally been considered exempt but will need to confirm.	▪ Follow the minimize, rectify, reduce, and replace wetland sequencing. ▪ Unavoidable wetland impacts shall be mitigated at a 2:1 ratio. ▪ Average and minimum wetland buffer width for wetland classification Manage A is 75 feet and 37.5 feet, respectively. ▪ Stormwater management BMP not allowed in wetland buffer area. ▪ Wetland replacement through mitigation is allowed in the buffer area if the buffer disturbance is provided adjacent to the wetland replacement. ▪ Boardwalks are exempt from wetland impacts.
City of Shoreview ▪ City of Shoreview follows rules laid out by NPDES and RWMWD.	▪ City of Shoreview follows rules laid out by NPDES and RWMWD.	▪ City of Shoreview follows rules laid out by NPDES and RWMWD.	▪ City of Shoreview follows rules laid out by NPDES and RWMWD.	▪ City of Shoreview follows rules laid out by NPDES and RWMWD.	▪ City of Shoreview follows rules laid out by NPDES and RWMWD.
Department of Natural Resources (DNR) ▪ N/A – Wetland A is not a DNR public water.	▪ N/A	▪ N/A	▪ N/A	▪ N/A	▪ N/A
Wetland Conservation Act / U.S. Army Corps of Engineers ▪ Joint Permit application will be submitted.	▪ N/A	▪ N/A	▪ N/A	▪ N/A	▪ Joint Permit application will be submitted.

APPENDIX C

Modeling Summary

Wetland A - Modeling Summary

Boardwalk / Trail Elevation = 877.5

Boardwalk / Trail Height (1)	Wetland A Starting Elevation (2)	Protection from 96-Hour Rainfall Event (3)					Inundation Period (4)	Notes
		1-Year (3.36")	5-Year (4.36")	10-Year (5.03")	25-Year (6.16")	100-Year (8.32")	3/6/17 - 10/16/20	
2.5 Feet (5)	875	X	X				26 of 44 Months (59% of Time)	- Approximate Elevation of existing trail
	876	X						
	877							

Boardwalk / Trail Elevation = 880.0

Boardwalk / Trail Height (1)	Wetland A Starting Elevation (2)	Protection from 96-Hour Rainfall Event (3)					Inundation Period (4)	Notes
		1-Year (3.36")	5-Year (4.36")	10-Year (5.03")	25-Year (6.16")	100-Year (8.32")	3/6/17 - 10/16/20	
5 Feet (5)	875	X	X	X	X		2 of 44 Months (5% of Time)	
	876	X	X	X				
	877	X	X	X				

Boardwalk/Trail Elevation = 882.0

Boardwalk / Trail Height (1)	Wetland A Starting Elevation (2)	Protection from 96-Hour Rainfall Event (3)					Inundation Period (4)	Notes
		1-Year (3.36")	5-Year (4.36")	10-Year (5.03")	25-Year (6.16")	100-Year (8.32")	3/6/17 - 10/16/20	
7.0 Feet (5)	875	X	X	X	X	X	0 of 44 Months (0% of Time)	
	876	X	X	X	X			
	877	X	X	X	X			

Boardwalk / Trail Elevation = 884.1

Boardwalk / Trail Height (1)	Wetland A Starting Elevation (2)	Protection from 96-Hour Rainfall Event (3)					Inundation Period (4)	Notes
		1-Year (3.36")	5-Year (4.36")	10-Year (5.03")	25-Year (6.16")	100-Year (8.32")	3/6/17 - 10/16/20	
9.1 Feet (5)	875	X	X	X	X	X	0 of 44 Months (0% of Time)	- Elevation 884.1 is the ultimate outlet elevation from the surrounding area.
	876	X	X	X	X	X		
	877	X	X	X	X	X		

Notes:

(1) Boardwalk / Trail height is the height over starting elevation 875

(2) Wetland A starting elevations may fluctuate between 875 and 877 as shown by the Piezomenter and Water Surface elevation data

(3) A rainfall event is an estimate of how long it will be between rainfall events of a given magnitude

(4) Inundation period is time in which water is present on the boardwalk / trail

(5) Difference from proposed trail elevation to low water.

APPENDIX D

Alternative Evaluation Graphics

OPTION 1A: TRAIL A & B GRADE RAISE TO MINIMUM ELEVATION OF 877.5 (5 YR EVENT)

SNAIL LAKE REGIONAL PARK TRAIL

SHOREVIEW, RAMSEY COUNTY, MINNESOTA

SRF

0 50 100
SCALE IN FEET

WETLAND A
FLOODPLAIN ELEV. = 884.10
MASTER PLAN ELEV. = 886.00

℄ TRAIL B

℄ TRAIL A

COTTONWOOD TREES

MCES ACCESS, 200 FEET AT 10%

LEGEND			
	OPTION 1A GRADING LIMITS		ROW-INPLACE PROPERTY LINE
	BOARDWALK		TOPOGRAPHY-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-MANHOLE		AERIAL-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-PIPE		WETLAND-NON-DELINEATED, EMERGENT VEGETATION LINE
	ROW-INPLACE RIGHT OF WAY		WETLAND-DELINEATION LINE
	ROW-INPLACE DRAINAGE AND UTILITY EASEMENT		WETLAND-EDGE OF WATER

C:\srf-pw\d0113347\15302_Option1-877.5.dwg : 1A

Job # 15302
6/29/2022 - 10:24AM

OPTION 1B: TRAIL A & B WITH BOARDWALK AT ELEVATION OF 877.5 (5 YR EVENT)

SNAIL LAKE REGIONAL PARK TRAIL

SHOREVIEW, RAMSEY COUNTY, MINNESOTA

SRF

0 50 100
SCALE IN FEET

WETLAND A
FLOODPLAIN ELEV. = 884.10
MASTER PLAN ELEV. = 886.00

℄ TRAIL B

℄ TRAIL A

COTTONWOOD TREES

MCES ACCESS, 200 FEET AT 10%

LEGEND			
	OPTION 1B GRADING LIMITS		ROW-INPLACE PROPERTY LINE
	BOARDWALK		TOPOGRAPHY-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-MANHOLE		AERIAL-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-PIPE		WETLAND-NON-DELINEATED, EMERGENT VEGETATION LINE
	ROW-INPLACE RIGHT OF WAY		WETLAND-DELINEATION LINE
	ROW-INPLACE DRAINAGE AND UTILITY EASEMENT		WETLAND-EDGE OF WATER

C:\srf-pw\d0113347\15302_Option1-877.5.dwg : 1B

Job # 15302
6/29/2022 - 10:24AM

OPTION 1C: TRAIL A WITH BOARDWALK, TRAIL B GRADE RAISE TO MINIMUM ELEVATION OF 877.5 (5 YR EVENT)

SNAIL LAKE REGIONAL PARK TRAIL

SHOREVIEW, RAMSEY COUNTY, MINNESOTA

SRF

0 50 100
SCALE IN FEET

℄ TRAIL B

℄ TRAIL A

WETLAND A
FLOODPLAIN ELEV. = 884.10
MASTER PLAN ELEV. = 886.00

COTTONWOOD TREES

MCES ACCESS, 200 FEET AT 10%

LEGEND			
	OPTION 1C GRADING LIMITS		ROW-INPLACE PROPERTY LINE
	BOARDWALK		TOPOGRAPHY-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-MANHOLE		AERIAL-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-PIPE		WETLAND-NON-DELINEATED, EMERGENT VEGETATION LINE
	ROW-INPLACE RIGHT OF WAY		WETLAND-DELINEATION LINE
	ROW-INPLACE DRAINAGE AND UTILITY EASEMENT		WETLAND-EDGE OF WATER

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Job # 15302
6/29/2022 - 10:24AM

OPTION 1D: TRAIL A BOARDWALK (EL 877.5) WITH DENNISON BOARDWALK (882.0) (5 YR EVENT)

SNAIL LAKE REGIONAL PARK TRAIL

SHOREVIEW, RAMSEY COUNTY, MINNESOTA

SRF

0 50 100
SCALE IN FEET

WETLAND A
FLOODPLAIN ELEV. = 884.10
MASTER PLAN ELEV. = 886.00

℄ TRAIL B

℄ TRAIL A

STEEP GRADES, ADDITIONAL STUDY REQUIRED.

LOCAL TRAIL CONNECTION

COTTONWOOD TREES

MCES ACCESS, 200 FEET AT 10%

LEGEND

	OPTION 1D GRADING LIMITS		ROW-INPLACE PROPERTY LINE
	BOARDWALK		TOPOGRAPHY-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-MANHOLE		AERIAL-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-PIPE		WETLAND-NON-DELINEATED, EMERGENT VEGETATION LINE
	ROW-INPLACE RIGHT OF WAY		WETLAND-DELINEATION LINE
	ROW-INPLACE DRAINAGE AND UTILITY EASEMENT		WETLAND-EDGE OF WATER

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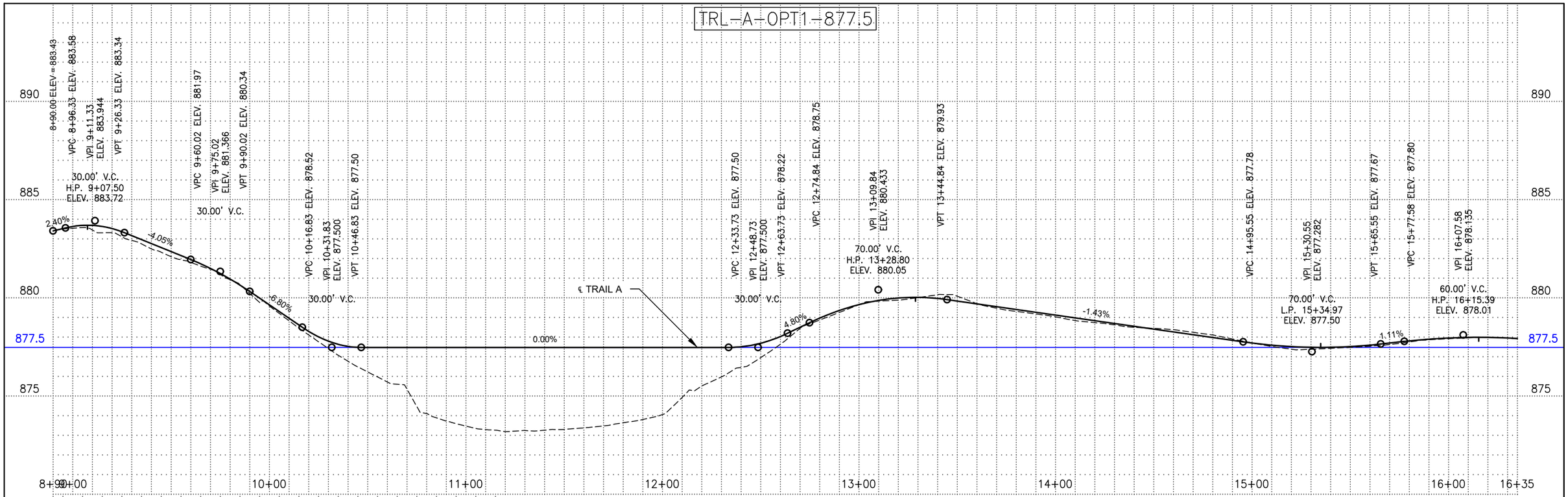

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Job # 15302
6/28/2022 - 5:02PM

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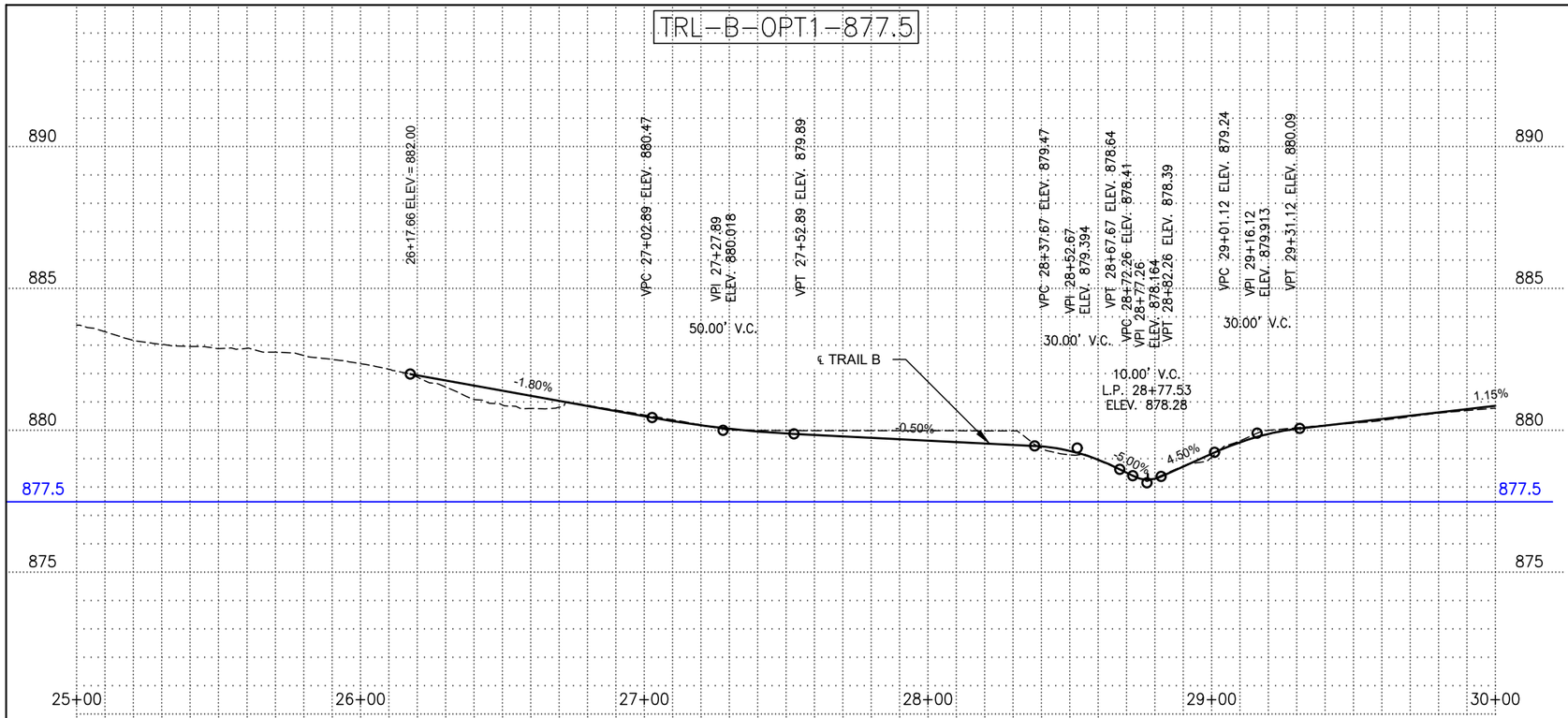

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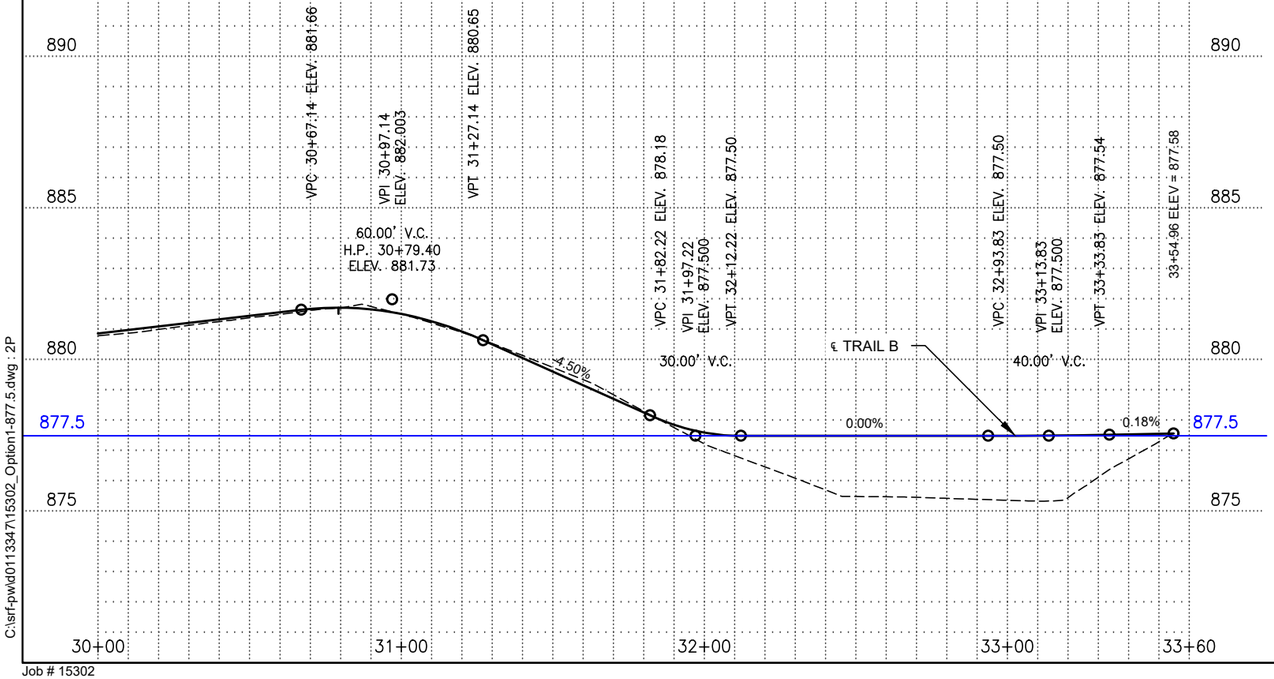

0 5 10
SCALE IN FEET
VERTICAL

0 25 50
SCALE IN FEET
HORIZONTAL

SRF

C:\srf-pw\d0113347\15302_Option1-877.5.dwg : 2P

Job # 15302
6/28/2022 - 5:02PM

OPTION 2A: TRAIL A & B GRADE RAISE TO MINIMUM ELEVATION OF 880.0 (25 YR EVENT)

SNAIL LAKE REGIONAL PARK TRAIL

SHOREVIEW, RAMSEY COUNTY, MINNESOTA

SRF

0 50 100
SCALE IN FEET

WETLAND A
FLOODPLAIN ELEV. = 884.10
MASTER PLAN ELEV. = 886.00

℄ TRAIL B

℄ TRAIL A

COTTONWOOD TREES

MCES ACCESS, 200 FEET AT 10%

LEGEND

	OPTION 2A GRADING LIMITS		ROW-INPLACE PROPERTY LINE
	BOARDWALK		TOPOGRAPHY-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-MANHOLE		AERIAL-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-PIPE		WETLAND-NON-DELINEATED, EMERGENT VEGETATION LINE
	ROW-INPLACE RIGHT OF WAY		WETLAND-DELINEATION LINE
	ROW-INPLACE DRAINAGE AND UTILITY EASEMENT		WETLAND-EDGE OF WATER

C:\srf-pw\d0113347\15302_Option2-880.0.dwg : 2A

Job # 15302
6/29/2022 - 10:32AM

OPTION 2B: TRAIL A & B WITH BOARDWALK AT ELEVATION OF 880.0 (25 YR EVENT)

SNAIL LAKE REGIONAL PARK TRAIL

SHOREVIEW, RAMSEY COUNTY, MINNESOTA

SRF

0 50 100
SCALE IN FEET

WETLAND A
FLOODPLAIN ELEV. = 884.10
MASTER PLAN ELEV. = 886.00

℄ TRAIL B

℄ TRAIL A

COTTONWOOD TREES

MCES ACCESS, 200 FEET AT 10%

LEGEND

	OPTION 2B GRADING LIMITS		ROW-INPLACE PROPERTY LINE
	BOARDWALK		TOPOGRAPHY-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-MANHOLE		AERIAL-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-PIPE		WETLAND-NON-DELINEATED, EMERGENT VEGETATION LINE
	ROW-INPLACE RIGHT OF WAY		WETLAND-DELINEATION LINE
	ROW-INPLACE DRAINAGE AND UTILITY EASEMENT		WETLAND-EDGE OF WATER

C:\srf-pw\d0113347\15302_Option2-880.0.dwg : 2B

Job # 15302
6/29/2022 - 10:32AM

OPTION 2C: TRAIL A WITH BOARDWALK, TRAIL B GRADE RAISE TO MINIMUM ELEVATION OF 880.0 (25 YR EVENT)

SNAIL LAKE REGIONAL PARK TRAIL

SHOREVIEW, RAMSEY COUNTY, MINNESOTA

SRF

0 50 100
SCALE IN FEET

WETLAND A
FLOODPLAIN ELEV. = 884.10
MASTER PLAN ELEV. = 886.00

℄ TRAIL B

℄ TRAIL A

COTTONWOOD TREES

MCES ACCESS, 200 FEET AT 10%

LEGEND

	OPTION 2C GRADING LIMITS		ROW-INPLACE PROPERTY LINE
	BOARDWALK		TOPOGRAPHY-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-MANHOLE		AERIAL-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-PIPE		WETLAND-NON-DELINEATED, EMERGENT VEGETATION LINE
	ROW-INPLACE RIGHT OF WAY		WETLAND-DELINEATION LINE
	ROW-INPLACE DRAINAGE AND UTILITY EASEMENT		WETLAND-EDGE OF WATER

C:\srf-pw\d0113347\15302_Option2-880.0.dwg : 2C

Job # 15302
6/29/2022 - 10:32AM

OPTION 2D: TRAIL A BOARDWALK (EL 880.0) WITH DENNISON BOARDWALK (882.0) (25 YR EVENT)

SNAIL LAKE REGIONAL PARK TRAIL

SHOREVIEW, RAMSEY COUNTY, MINNESOTA

SRF

0 50 100
SCALE IN FEET

WETLAND A
FLOODPLAIN ELEV. = 884.10
MASTER PLAN ELEV. = 886.00

℄ TRAIL B

℄ TRAIL A

COTTONWOOD TREES

MCES ACCESS, 200 FEET AT 10%

STEEP GRADES, ADDITIONAL STUDY REQUIRED.

LOCAL TRAIL CONNECTION

LEGEND

	OPTION 2D GRADING LIMITS		ROW-INPLACE PROPERTY LINE
	BOARDWALK		TOPOGRAPHY-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-MANHOLE		AERIAL-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-PIPE		WETLAND-NON-DELINEATED, EMERGENT VEGETATION LINE
	ROW-INPLACE RIGHT OF WAY		WETLAND-DELINEATION LINE
	ROW-INPLACE DRAINAGE AND UTILITY EASEMENT		WETLAND-EDGE OF WATER

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Job # 15302
6/29/2022 - 10:59AM

TRL-A-OPT2-880.0

8+90.00 ELEV = 883.43
VPC 8+96.33 ELEV. 883.58
VPI 9+11.33 ELEV. 883.944
VPT 9+26.33 ELEV. 883.34
30.00' V.C.
H.P. 9+07.50
ELEV. 883.72
2.40%
-4.05%
-6.80%
VPC 9+70.02 ELEV. 881.57
VPI 9+75.02 ELEV. 881.366
VPT 9+80.02 ELEV. 881.03
10.00' V.C.
VPC 9+90.09 ELEV. 880.34
VPI 9+95.09 ELEV. 880.000
VPT 10+00.09 ELEV. 880.00
10.00' V.C.
℄ TRAIL A
0.00%

890
885
880.0
875

8+90 9+00 10+00 11+00 12+00 13+00 14+00 15+00 16+00 16+35

TRL-A-OPT2-880.0

VPC 18+42.00 ELEV. 880.00
VPI 18+47.00 ELEV. 880.000
VPT 18+52.00 ELEV. 880.09
18+57.02 ELEV = 880.19
10.00' V.C.
℄ TRAIL A
0.00%
1.85%

890
885
880.0
875

16+35 17+00 18+00 18+60

SCALE IN FEET
0 5 10
VERTICAL

SCALE IN FEET
0 25 50
HORIZONTAL

SRF

C:\srf-pw\d0113347\15302_Option2-880.0.dwg : 2P1

Job # 15302
6/28/2022 - 5:23PM

TRL-B-OPT2-880.0

890
885
880.0
875

26+17.66 ELEV = 882.00
VPC 27+03.77 ELEV. 880.45
VPI 27+28.77 ELEV. 880.000
VPT 27+53.77 ELEV. 880.00
50.00' V.C.
-1.80%
℄ TRAIL B
-0.00%
VPC 29+09.98 ELEV. 880.00
VPI 29+24.98 ELEV. 880.000
VPT 29+39.98 ELEV. 880.17
30.00' V.C.
L.P. 29+09.98
ELEV. 880.00

25+00 26+00 27+00 28+00 29+00 30+00

TRL-B-OPT2-880.0

890
885
880.0
875

VPC 30+77.14 ELEV. 881.75
VPI 30+97.14 ELEV. 881.980
VPT 31+17.14 ELEV. 881.08
40.00' V.C.
H.P. 30+85.28
ELEV. 881.80
VPC 31+26.13 ELEV. 880.68
VPI 31+41.13 ELEV. 880.000
VPT 31+56.13 ELEV. 880.00
30.00' V.C.
33+60.00 ELEV = 880.00
℄ TRAIL B
1.15%
4.50%
0.00%

30+00 31+00 32+00 33+00 33+60

0 5 10
SCALE IN FEET
VERTICAL

0 25 50
SCALE IN FEET
HORIZONTAL

SRF

C:\srf-pw\d0113347\15302_Option2-880.0.dwg : 2P2

Job # 15302
6/28/2022 - 5:23PM

OPTION 3A: TRAIL A & B GRADE RAISE TO MINIMUM ELEVATION OF 882.0 (50 YR EVENT)

SNAIL LAKE REGIONAL PARK TRAIL

SHOREVIEW, RAMSEY COUNTY, MINNESOTA

SRF

0 50 100
SCALE IN FEET

WETLAND A
FLOODPLAIN ELEV. = 884.10
MASTER PLAN ELEV. = 886.00

℄ TRAIL B

℄ TRAIL A

COTTONWOOD TREES

MCES ACCESS, 200 FEET AT 10%

LEGEND

	OPTION 3A GRADING LIMITS		ROW-INPLACE PROPERTY LINE
	BOARDWALK		TOPOGRAPHY-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-MANHOLE		AERIAL-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-PIPE		WETLAND-NON-DELINEATED, EMERGENT VEGETATION LINE
	ROW-INPLACE RIGHT OF WAY		WETLAND-DELINEATION LINE
	ROW-INPLACE DRAINAGE AND UTILITY EASEMENT		WETLAND-EDGE OF WATER

C:\srf-pw\d0113347\15302_Option3-882.0.dwg : 3A

Job # 15302
6/29/2022 - 10:49AM

OPTION 3B: TRAIL A & B WITH BOARDWALK AT ELEVATION OF 882.0 (50 YR EVENT)

SNAIL LAKE REGIONAL PARK TRAIL

SHOREVIEW, RAMSEY COUNTY, MINNESOTA

SRF

0 50 100
SCALE IN FEET

WETLAND A
FLOODPLAIN ELEV. = 884.10
MASTER PLAN ELEV. = 886.00

℄ TRAIL B

℄ TRAIL A

COTTONWOOD TREES

MCES ACCESS, 200 FEET AT 10%

LEGEND

	OPTION 3B GRADING LIMITS		ROW-INPLACE PROPERTY LINE
	BOARDWALK		TOPOGRAPHY-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-MANHOLE		AERIAL-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-PIPE		WETLAND-NON-DELINEATED, EMERGENT VEGETATION LINE
	ROW-INPLACE RIGHT OF WAY		WETLAND-DELINEATION LINE
	ROW-INPLACE DRAINAGE AND UTILITY EASEMENT		WETLAND-EDGE OF WATER

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Job # 15302
6/29/2022 - 10:49AM

OPTION 3C: TRAIL A WITH BOARDWALK, TRAIL B GRADE RAISE TO MINIMUM ELEVATION OF 882.0 (50 YR EVENT)

SNAIL LAKE REGIONAL PARK TRAIL

SHOREVIEW, RAMSEY COUNTY, MINNESOTA

SRF

0 50 100
SCALE IN FEET

WETLAND A
FLOODPLAIN ELEV. = 884.10
MASTER PLAN ELEV. = 886.00

℄ TRAIL B

℄ TRAIL A

COTTONWOOD TREES

MCES ACCESS, 200 FEET AT 10%

LEGEND

	OPTION 3C GRADING LIMITS		ROW-INPLACE PROPERTY LINE
	BOARDWALK		TOPOGRAPHY-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-MANHOLE		AERIAL-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-PIPE		WETLAND-NON-DELINEATED, EMERGENT VEGETATION LINE
	ROW-INPLACE RIGHT OF WAY		WETLAND-DELINEATION LINE
	ROW-INPLACE DRAINAGE AND UTILITY EASEMENT		WETLAND-EDGE OF WATER

C:\srf-pw\d0113347\15302_Option3-882.0.dwg : 3C

Job # 15302
6/29/2022 - 10:49AM

OPTION 3D: TRAIL A BOARDWALK (EL 882.0) WITH DENNISON BOARDWALK (882.0) (50 YR EVENT)

SNAIL LAKE REGIONAL PARK TRAIL

SHOREVIEW, RAMSEY COUNTY, MINNESOTA

SRF

0 50 100
SCALE IN FEET

WETLAND A
FLOODPLAIN ELEV. = 884.10
MASTER PLAN ELEV. = 886.00

℄ TRAIL B

℄ TRAIL A

COTTONWOOD TREES

MCES ACCESS, 200 FEET AT 10%

STEEP GRADES, ADDITIONAL STUDY REQUIRED.

LOCAL TRAIL CONNECTION

LEGEND

	OPTION 3D GRADING LIMITS		ROW-INPLACE PROPERTY LINE
	BOARDWALK		TOPOGRAPHY-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-MANHOLE		AERIAL-EXISTING EDGE OF BITUMINOUS
	SANITARY SEWER-PIPE		WETLAND-NON-DELINEATED, EMERGENT VEGETATION LINE
	ROW-INPLACE RIGHT OF WAY		WETLAND-DELINEATION LINE
	ROW-INPLACE DRAINAGE AND UTILITY EASEMENT		WETLAND-EDGE OF WATER

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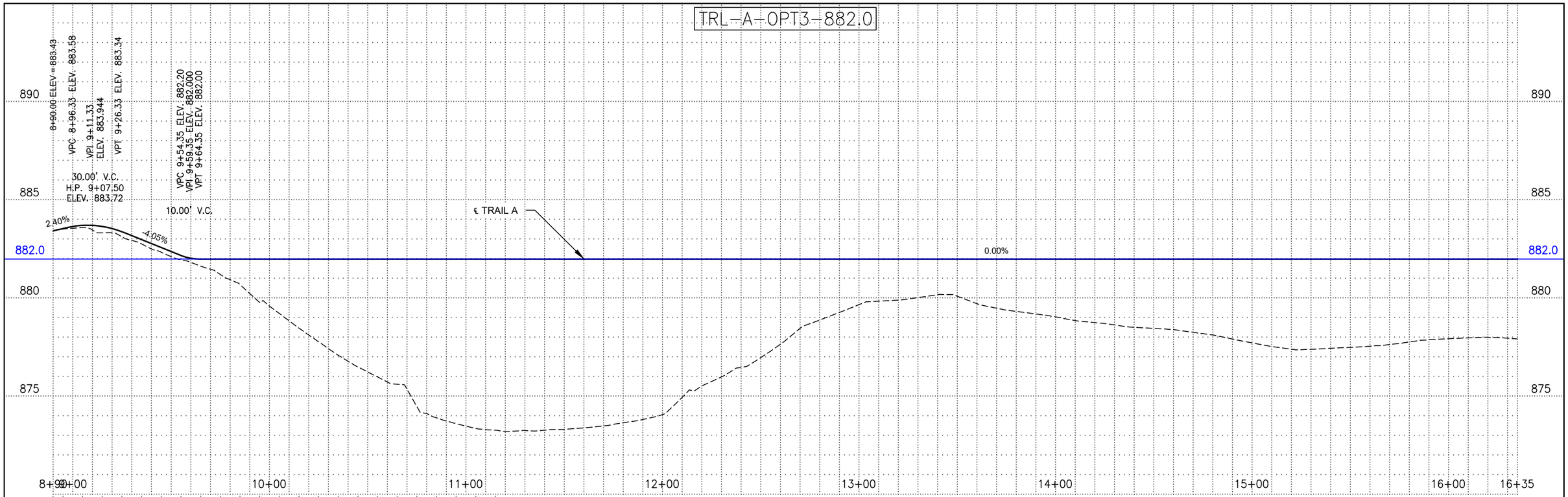

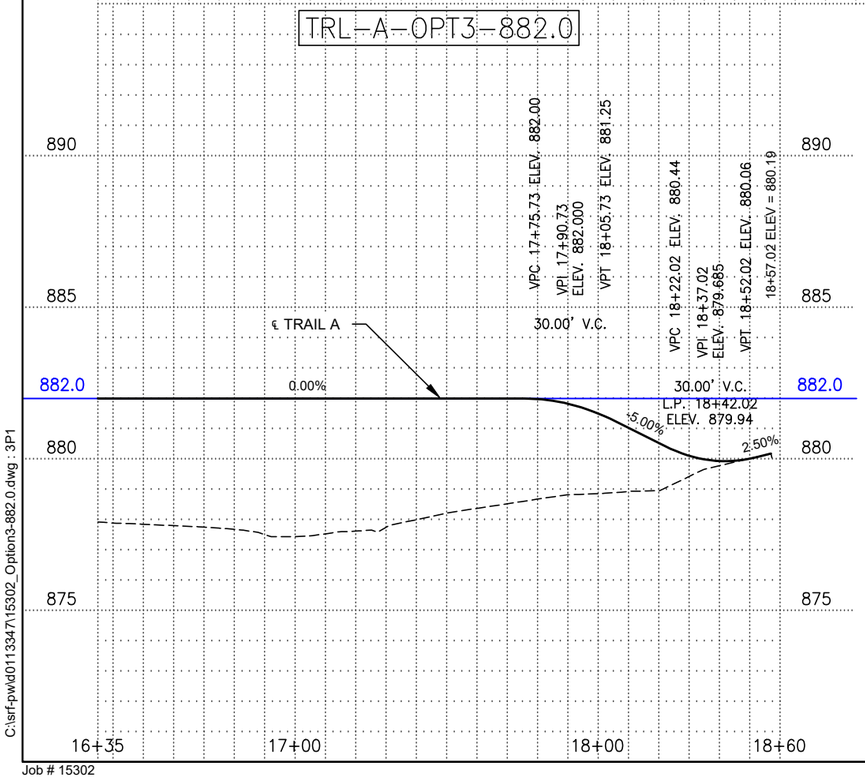

0 5 10
SCALE IN FEET
VERTICAL

0 25 50
SCALE IN FEET
HORIZONTAL

SRF

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Job # 15302
6/29/2022 - 9:34AM

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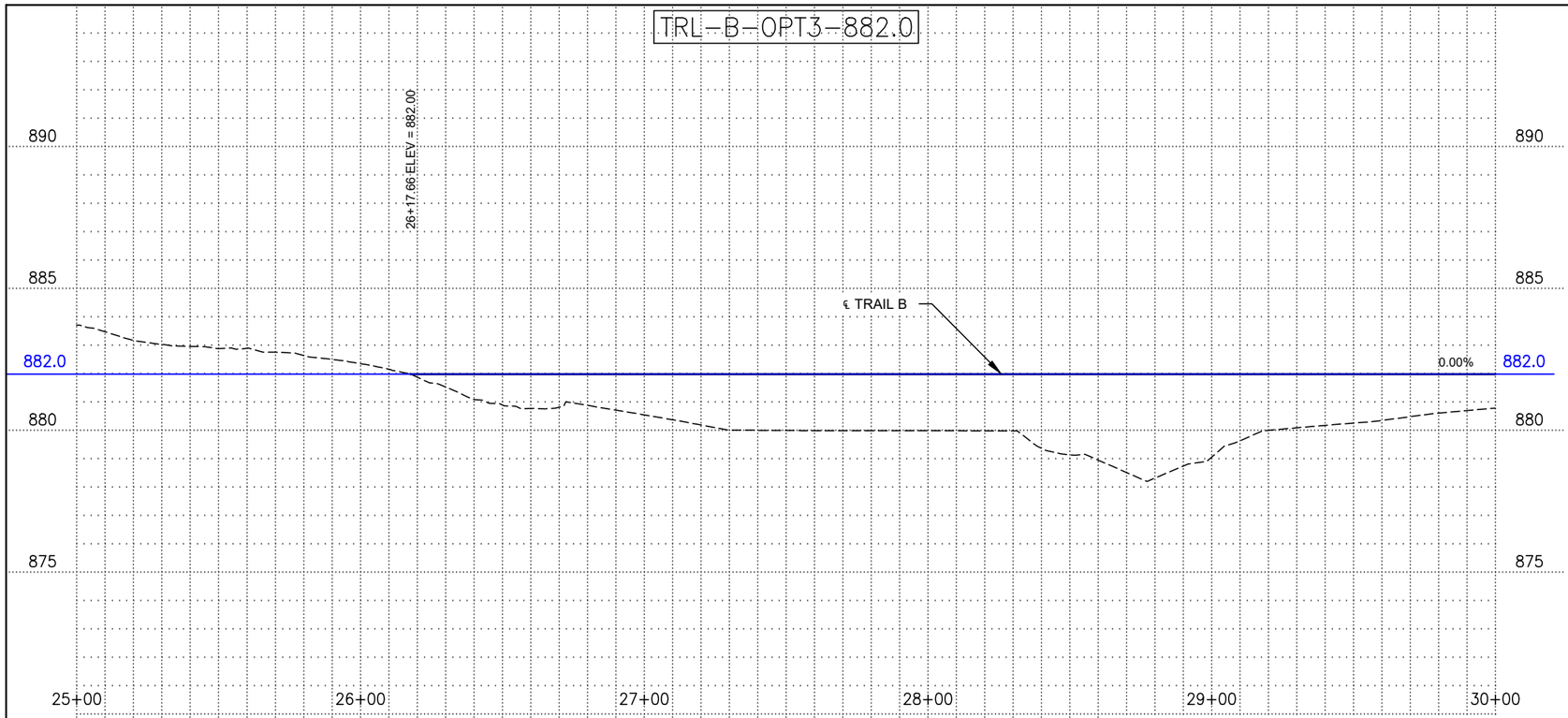

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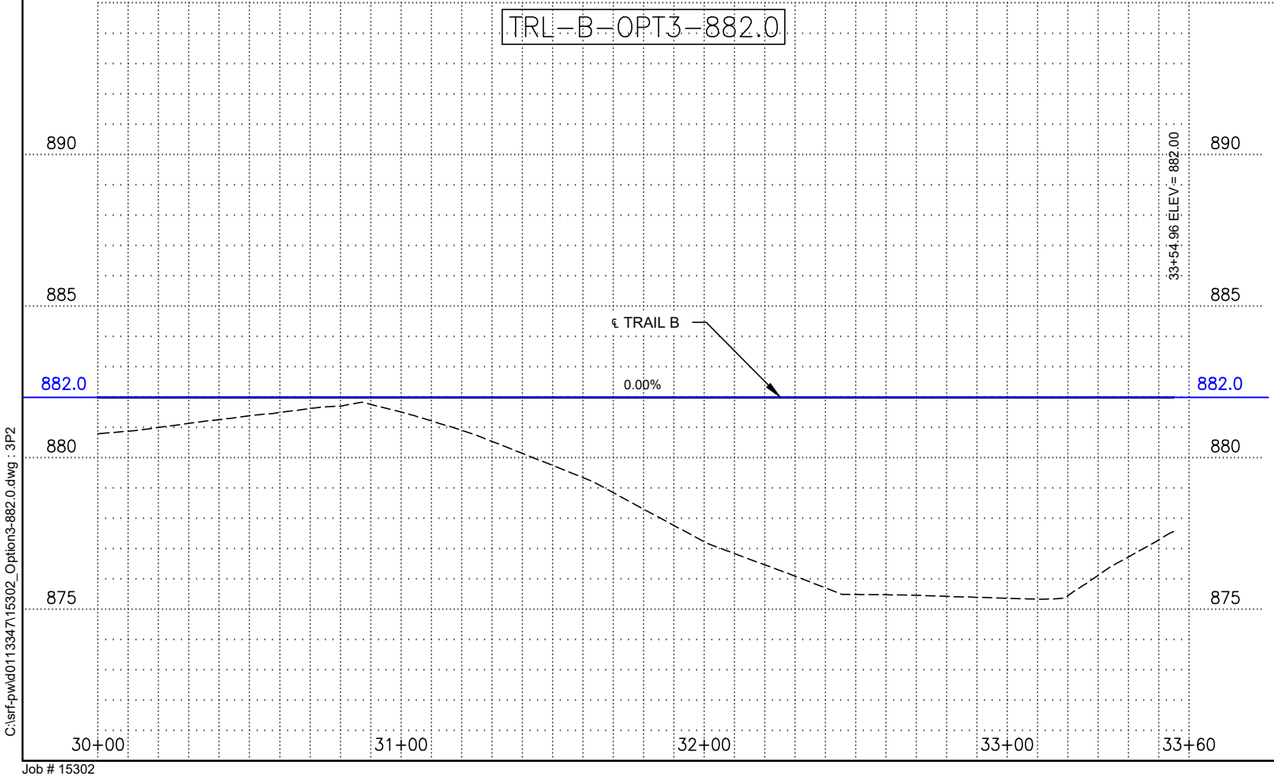

0 5 10
SCALE IN FEET
VERTICAL

0 25 50
SCALE IN FEET
HORIZONTAL

SRF

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Job # 15302
6/29/2022 - 9:34AM

APPENDIX E

MCES Facilities

Q:\METROPOLITAN COUNCIL ENVIRONMENTAL SERVICES\GRASS LAKE-LONG LAKE SEWER REH-15P013B\GRASS LAKE-LONG LAKE SEWER REH-15P013B\XREFS\X-C-SL-GIS.DWG
PLOTTED: 4/02/19 10:52 PM
MODIFIED: MH DETAILS

NO	DATE	BY	REMARKS
	MM/DD/YY		ISSUED FOR BIDDING

REVISIONS

NO	DATE	BY	REMARKS

REVISIONS

DESIGNED AMJ
DRAWN PRW
CHECKED WJJ

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.

SIGNATURE:
TYPED OR PRINTED NAME: SIGNED BY
DATE MM/DD/YY REG NO ######

Foth
Foth Infrastructure & Environment, LLC
Eagle Point II
8550 Hudson Boulevard North, Suite 105
Lake Elmo, MN 55042
Phone: 651-288-8550 Fax: 651-288-8551

PROJECT 808861

FILE NAME X-C-SL-GIS

GRASS LAKE/LONG LAKE INTERCEPTOR REHABILITATION

SNAIL LAKE

C4.2

X OF X

APPENDIX F

Geotechnical Report

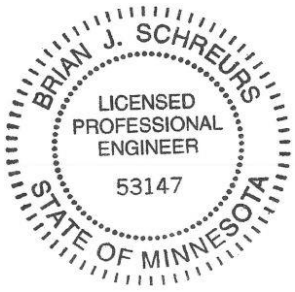
Geotechnical Evaluation Report

Snail Lake Regional Park Trail Improvements
Snail Lake Regional Park – Wetland A
South of Snail Lake Road
Shoreview, Minnesota

Prepared for

Ramsey County Parks and Recreation

Professional Certification:
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.



Brian J. Schreurs, PE
Project Engineer
License Number: 53147
April 4, 2022

BRAUN INTERTEC
The Science You Build On.

Project B2201410

Braun Intertec Corporation

Braun Intertec Corporation
11001 Hampshire Avenue S
Minneapolis, MN 55438

Phone: 952.995.2000
Fax: 952.995.2020
Web: braunintertec.com

April 4, 2022 Project B2201410

Mr. B. Gus Blumer
Ramsey County Parks and Recreation
2015 North Van Dyke Street
Maplewood, MN 55120

Re: Geotechnical Evaluation
Snail Lake Regional Park Trail Improvements
Snail Lake Regional Park – Wetland A
South of Snail Lake Road
Shoreview, Minnesota

Dear Mr. Blumer:

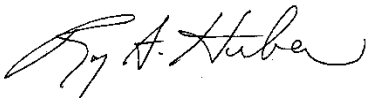
We are pleased to present this Geotechnical Evaluation Report for the Snail Lake Regional Park Trail Improvements project located on the east side of Wetland A in Shoreview, Minnesota. The following report provides the results of our evaluation and should be read in its entirety. .

Thank you for making Braun Intertec your geotechnical consultant for this project. If you have questions about this report, or if there are other services that we can provide in support of our work to date, please contact Brian Schreurs at 952.995.2256 (bschreurs@braunintertec.com) or Ray Huber at 952.995.2260 (rhuber@braunintertec.com).

Sincerely,

BRAUN INTERTEC CORPORATION

Brian J. Schreurs, PE
Project Engineer



Ray A. Huber, PE
Vice President, Principal Engineer

Table of Contents

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Description **Page**

Appendix

A. Introduction

A.1. Project Description

This Geotechnical Evaluation Report addresses the proposed design and construction of the Snail Lake Trail Improvements being considered as part of the Ramsey County Park and Recreation (County) Feasibility Study. The focus of the trail improvements project is the corridor section along the east side of Wetland A where the trails experience flooding at various times of the year. The County has identified a potential boardwalk structure as the most likely means to make the trail connection, but with a desire to maintain as much at-grade trail as possible. The boardwalk structure will extend approximately 1,300 feet between two existing trail connection points on the east side of Wetland A between Dennison Avenue and Demar Avenue. The figure below shows an illustration of the proposed site layout.

Figure 1. Site Layout

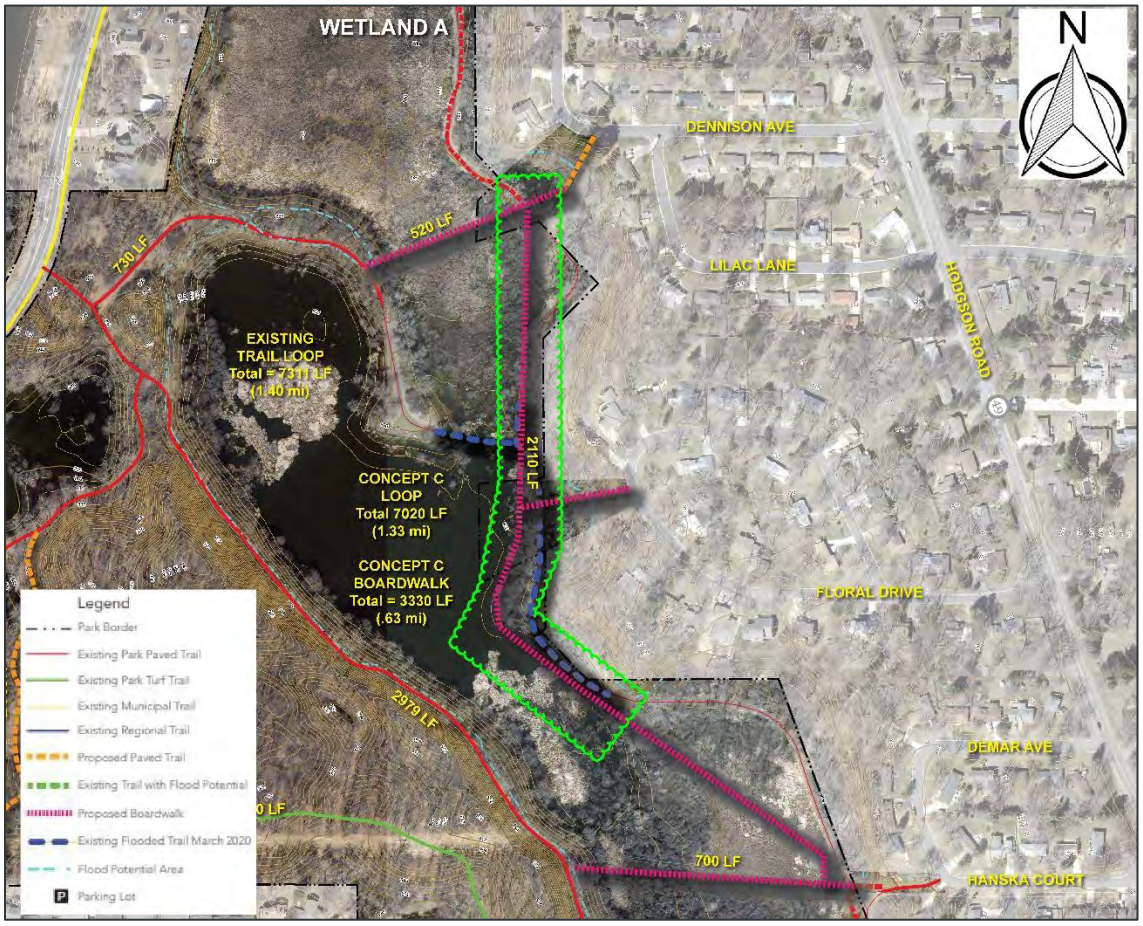


Figure taken from Ramsey County's website dated 6-8-2020.

A.2. Site Conditions and History

Currently, the site existing as an existing bituminous trail along the east side of Wetland A where segments of the trail remain inundated with water for a majority of the year. We have included a couple of historical aerial photographs to document some of the different stages of apparent flooding along the existing trail. Currently grades along the proposed boardwalk range in elevation between 873.8 feet above Mean Sea Level (MSL) and 882.6 feet above MSL.

Photograph 1. Aerial Photograph of the Site in 2012

Photograph provided by Google Earth.

Photograph 2. Aerial Photograph of the Site in 2019

Photograph provided by Google Earth.

A.3. Purpose

The purpose of our geotechnical evaluation was to characterize subsurface geologic conditions at selected exploration locations and evaluate their impact on the design and construction of the new boardwalk structure.

A.4. Background Information and Reference Documents

We reviewed the following information:

- Aerial photography and topographic maps from Google Earth and MnTOPO.
- Atlas C-7 Geologic Atlas of Ramsey County prepared by the Minnesota Geological Survey dated 1992.
- Communications with the County regarding the proposed improvements project.

We have described our understanding of the proposed construction and site to the extent others reported it to us. Depending on the extent of available information, we may have made assumptions based on our experience with similar projects. If we have not correctly recorded or interpreted the project details, the project team should notify us. New or changed information could require additional evaluation, analyses and/or recommendations.

A.5. Scope of Services

We performed our scope of services for the project in accordance with our Proposal for a Geotechnical Evaluation to Gus Blumer at the County, dated February 10, 2022. We were then authorized through a notice to proceed by the County on February 15, 2022. The following list describes the geotechnical tasks completed in accordance with our authorized scope of services.

- Reviewing the background information and reference documents previously cited.
- Staking and coordinating the clearing the exploration location of underground utilities through Gopher State One Call. We selected and staked the new exploration locations in the field. We acquired the surface elevations and locations with GPS technology using the State of Minnesota's permanent GPS base station network. The Soil Boring and Push Probe Location Sketch included in the Appendix shows the approximate locations of the borings and push probes.
- Performing five standard penetration test (SPT) borings, denoted as ST-1 to ST-5, each to a depth of 50 feet below the existing ground surface.

- Performing 12 swamp push probes at approximately 100-foot intervals along the proposed boardwalk alignment in areas inaccessible to our drill rig equipment. Each probe was advanced to a depth at which manual effort was no longer sufficient. Also, one push probe (P-1) location was changed to a SPT boring as we were able to access the planned exploration location with our drill rig.

- Performing laboratory testing on select samples to aid in soil classification and engineering analysis.

- Preparing this report containing a boring location sketch, logs of soil borings, a summary of the soils encountered, results of laboratory tests, and design and construction recommendations for the proposed boardwalk structure.

Our scope of services did not include environmental services or testing and our geotechnical personnel performing this evaluation are not trained to provide environmental services or testing. We can provide environmental services or testing at your request.

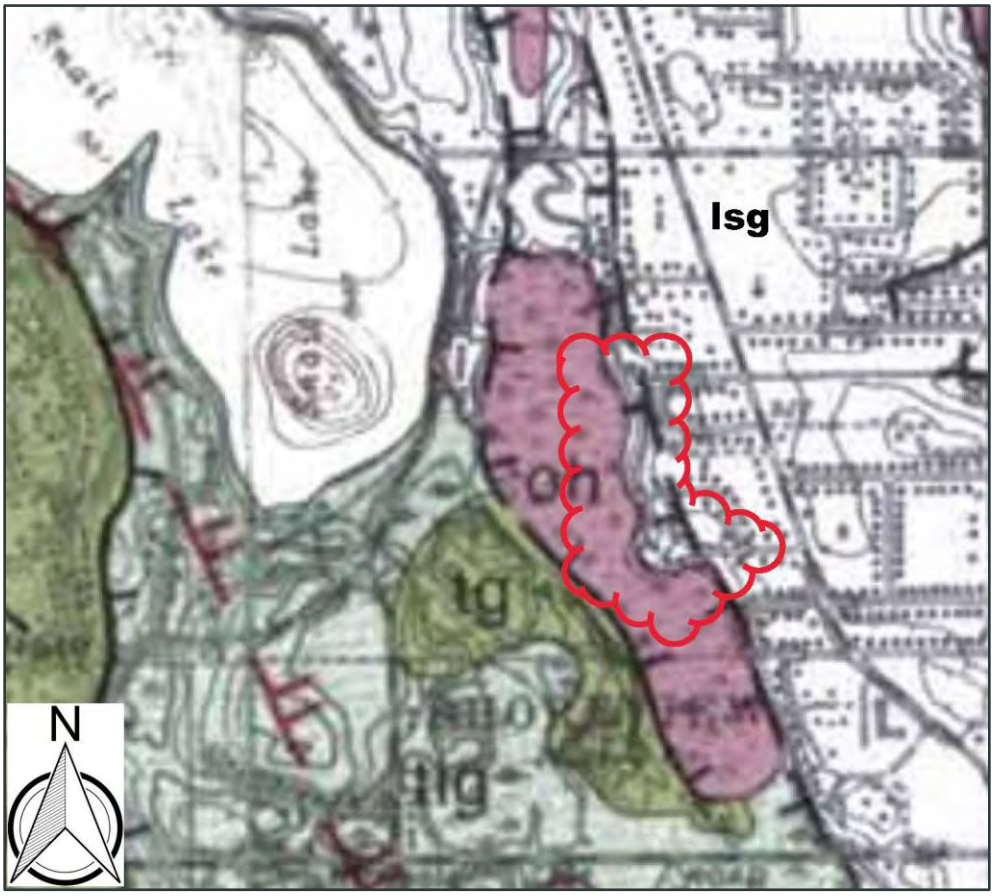
B. Results

B.1. Geologic Overview

We based the geologic origins used in this report on the soil types, laboratory testing, and available common knowledge of the geological history of the site. Because of the complex depositional history, geologic origins can be difficult to ascertain. We did not perform a detailed investigation of the geologic history for the site.

Our referenced documents suggest the area is underlain with organic sediment (map unit “oh”), sandy lake sediment (map unit “lsg”), and till (map units “tg” and “tlg”) beneath the sandy lake sediment near the southern portion of the site. The organic sediment includes peat, shallow lakes, and marshes. The sandy lake sediment generally consists of fine to medium sand; silt and clay; with scattered cobbles and boulders. The till ranges from loamy sand to clay and is beneath as much as 20 feet of sandy lake sediment.

Figure 2. Site Surficial Geology



Surficial Geology map taken from the Ramsey County Geologic Atlas dated 1992.

B.2. Boring Results

The table below provides a summary of the soil boring results, in the general order we encountered the strata. Please refer to the Log of Boring sheets in the Appendix for additional details. The Descriptive Terminology sheet in the Appendix includes definitions of abbreviations used in in the table below.

For simplicity in this report, we define existing fill to mean existing, uncontrolled or undocumented fill.

Table 1. Subsurface Profile Summary

Strata	Soil Type - ASTM Classification	Range of N-Values	Commentary and Details
Topsoil fill	SM, SC	---	▪ Encountered at the surface of all borings except Boring P-1. ▪ Generally, slightly organic to organic and dark brown to black. ▪ Thicknesses at the boring locations varied from 1/2-foot to 2 feet. ▪ Moisture condition generally frozen (moist to wet when thawed).
Fill	SM	Weight of Hammer (WOH) to 6	▪ Encountered beneath the surficial topsoil in Borings ST-3, ST-4, and ST-5. ▪ Encountered to depths ranging from 2 1/2 to 12 feet below the existing ground surface. ▪ The fill encountered in Boring ST-4 was noted as slightly organic. ▪ Existing fill contained variable amounts of gravel.
Swamp deposits	PT, OH, OL	WOH to 6	▪ Not encountered in Boring ST-2. ▪ Encountered at the surface of Boring P-1 and beneath the topsoil or fill in Borings ST-1, ST-3, ST-4, and ST-5. ▪ Encountered at depth ranging from 2 1/2 to 31 feet below the existing ground surface. ▪ A layer of lacustrine sand was encountered beneath two layers of swamp deposits in Boring ST-3. ▪ Fibrous peat and organic silt with various fibers and shells.
Lacustrine	SP, SP-SM, SM, ML	WOH to 27	▪ Encountered in each boring beneath the topsoil, fill, or swamp deposits. ▪ Encountered to the termination depth of Borings ST-2, ST-3, and ST-5. ▪ General N-values ranged from 6 to 20, indicating loose to medium dense relative densities.
Glacial deposits	SP (outwash)	20 to 24	▪ Encountered beneath the lacustrine sands and silts to the termination depth of Borings P-1, ST-1, and ST-4. ▪ General N-values recorded in the sands indicate medium dense to dense relative densities. ▪ General N-values recorded in the clays indicate stiff to very stiff consistencies. ▪ Variable amounts of gravel; may contain cobbles and boulders.
	SM, CL (till)	9 to 37	

B.3. Push Probes

Based on our site reconnaissance, we were unable to access the majority of the boardwalk alignment with our drilling equipment. Therefore, we performed a series of hand operated push probes approximately every 100 feet along the proposed boardwalk alignment. The push probes were used to help quantify the extent of possible soft, loose, or poor soils (i.e., muck) present along the proposed boardwalk.

The attached figure shows the approximate location of each push probe (P). However, P-1 was performed as a standard penetration test (SPT) boring instead of a push probe due to the exploration location being located on the north side of the existing trail away from the low-lying wetland.

The table below provides the depths at which our push probes were advanced until refusal to advancement was met and the corresponding assumed bottom of apparent soft, loose, and poor soils (i.e., muck). We note that physical soil samples were not obtained with the push probes, thus, the extent of soft, loose, or muck soils is approximated based on probe resistance only.

Table 2. Push Probe Summary

Push Probe Location	Existing Surface Elevation[1] (feet above MSL)	Depth to Push Probe Refusal (feet)	Corresponding Assumed Bottom Elevation of Poor Soil[1] (feet above MSL)
P-2	874.0	12	862
P-3	874.4	6	868 1/2
P-4	873.9	4	870
P-5	873.8	16	857 1/2
P-6	874.1	22	852
P-7	874.3	29	845
P-8	875.7	12	863 1/2
P-9	877.3	6	871
P-10	877.8	16	861 1/2
P-11	878.8	27	851 1/2
P-12	879.7	26	853 1/2

[1]Bottom elevations were rounded to the nearest half-foot and should be considered approximate.

B.4. Groundwater

The table below summarizes the depths where we observed groundwater; the attached Log of Boring sheets in the Appendix also include this information and additional details.

Table 3. Groundwater Summary

Location	Existing Ground Surface Elevation (feet above MSL)	Estimated Depth to Groundwater (feet)	Corresponding Groundwater Elevation (feet above MSL)[1]
P-1	875.7	7	869
ST-1	878.1	11	867 1/2
ST-2	878.6	10	869
ST-3	876.5	5	871 1/2
ST-4	880.4	7	873 1/2
ST-5	882.6	7	875 1/2

[1]Groundwater elevations rounded up to the nearest half-foot.

At the time of our observation, the groundwater surface elevation appeared to range in elevation from 867 1/2 (Boring ST-1) to 875 1/2 (Boring ST-5) feet above MSL. Project planning should anticipate groundwater to fluctuate in relation to groundwater level or flooding of Wetland A adjacent to the project.

B.5. Laboratory Test Results

The boring logs in the Appendix show the results of the laboratory testing we performed, next to the tested sample depth.

B.5.a. Moisture Contents

We performed moisture content (MC) tests (per ASTM D2216) on selected samples to aid in our classifications and estimations of the materials' engineering properties. The moisture contents for the soils overall ranged from 4 to 134 percent. The Log of Boring Sheets attached in the Appendix present the results of the moisture content tests in the "MC" column.

B.5.b. Organic Contents

We performed organic content (OC) tests (per ASTM D2974) on selected samples to aid in our classifications and estimations of the materials' engineering properties. The organic contents of the materials tested ranged from 6, 13, and 27 percent which indicate the soils were organic, highly organic and peat according to MnDOT terminology. The Log of Boring sheets in the Appendix show the results of the organic content tests in the "Tests or Remarks" column.

B.5.c. Atterberg Limits

We performed Atterberg limits tests (per ASTM D4318) on selected samples for classification, evaluation of the soil's plasticity, and engineering properties. The results of the Atterberg limits tests indicated the soil tested had a liquid limit (LL) of 95 percent, plastic limit (PL) of 88 percent, and a plasticity index (PI) of 7 percent. The Log of Boring sheets list the results of the Atterberg limits test in the "Tests or Remarks" column.

B.5.d. Percent Passing the #200 Sieve Tests

We performed tests to evaluate the percent of particles passing the #200 sieve (P200) (per ASTM D1140) on selected samples to aid in our classifications and estimations of the materials' engineering properties. The results of these tests indicated the soils encountered had P200s ranging from 12 to 31 percent. The Log of Boring sheets list the results of P200 tests in the "Tests or Remarks" column.

C. Recommendations

C.1. Design and Construction Discussion

C.1.a. Pedestrian Boardwalk

The County has identified a Boardwalk structure as the most likely means to prevent the trail from being inundated with water from Wetland A. Based on the soils encountered, a majority of the proposed boardwalk alignment will likely need to be supported on an intermediate foundation system (I.e. helical piles). There are a couple of areas along the alignment near Borings ST-1 (and south) and ST-2 where the structure might be able to transition from an intermediate foundation system to being ground-supported. However, the final design information for the proposed boardwalk structure were not available at the time of this report.

We have assumed the grade changes (cuts and fills) at the abutments (north and south limits) of the boardwalk structure will be minimal (less than 2 feet). Also, we assume the planned boardwalk structure will elevated up to 5 feet above the existing ground surface or 100-year flood elevation.

C.1.b. Excavated Slopes

The on-site soils mostly appear to consist of soils meeting OSHA Type C requirements. In accordance with OSHA requirements, we recommend excavation side slopes be constructed to lie back at a horizontal to vertical slope of 1 1/2:1 (H:V) or flatter. However, in organic soils, or where saturated soils are present (including saturated sand seams), excavation side slopes may need to lie back at slopes of 5:1 (H:V) or flatter to prevent sloughing. OSHA requires an engineer to evaluate slopes or excavations over 20 feet in depth.

All excavations must comply with the requirements of OSHA 29 CFR, Part 1926, Subpart P, "Excavations and Trenches." This document states that excavation safety is the responsibility of the contractor. Reference to these OSHA requirements should be included in the project specifications.

C.1.c. Groundwater

Based on the proximity to the low-lying wetland area and the fluctuating groundwater level, we anticipate groundwater will likely be encountered during construction. We recommend removing groundwater from the excavations. Project planning should include temporary sumps and pumps for excavations in low-permeability soils, such as clays. Dewatering of high-permeability soils (e.g., sands) from within the excavation with conventional pumps has the potential to loosen the soils, due to upward flow. A well contractor should develop a dewatering plan; the design team should review this plan.

C.2. Helical Pile Foundations

The following sections provide our recommendations for a helical pile design and installation options for support of the new boardwalk bridge. Helical pile design is typically a design-build item and the recommendations provided within this report should be considered preliminary and confirmed by formal design by a licensed and experienced design-build contractor.

Prior to final design, we recommend further reviewing the feasibility of transitioning from an intermediate foundation system to a ground-supported trail near Borings ST-1 (and south) and ST-2. Recommendations for ground-supporting the trail in these areas can be provided as design progresses. Some additional subsurface exploration to in these areas may be required depending on the final length and configuration of the boardwalk structure.

C.2.a. General

Helical piles generally consist of hollow steel shafts (circular or square) to which a series of circular steel plates are attached. Because the shafts are structurally slender, helical piles derive most of their capacity through plate bearing. Once the size, number, and spacing of the plates have been determined, the piles are installed by screwing them into the ground using hydraulic rotary-powered equipment (much in the same manner as using an electric drill to install a screw into a wooden board). The elements are installed vertically until a specified torque and minimum depth are achieved.

C.2.b. Helical Pile Design and Construction Considerations

Due to the number of proprietary helical pile foundation systems, we recommend the project documents include performance-based specifications along with design-build contracting. The performance-based specifications should identify the required ultimate capacity, deflection tolerances, required safety factor, and any testing requirements. The project documents should specify an average bid length and preliminary helix configuration for competitive bidding. They should also include add-and-deduct pricing in case piles terminate longer or shorter than the bid length. We recommend requiring the contractor to have at least five years of experience in performing this work. The specifications should require the design engineer be licensed in Minnesota.

Therefore, the recommendations provided herein are primarily for bidding purposes. The final installation lengths will be governed by the field installation torque measurements during the installation of the helical piles and potentially a load test program as discussed below. We are happy to assist in establishing the performance-based specifications to help mitigate the exposed risk to both the owner and the bidding contractors.

C.2.c. Helical Pile Axial Resistance

We performed a preliminary analysis based on the provided loads and observed soil conditions using HeliCAP Design Software by Chance Foundations. Helical piles for support of the boardwalk bridge are recommended to be installed through the fill, organics, and loose sand, silt and soft clay to bear within the underlying medium dense to dense native sands. Note the entire lead section of each anchor, including all bearing helix plates, should extend into or penetrate the bearing stratum.

Due to the presence of organic deposits or little to no resistance soil being present along the alignment, portions of the upper zone should be considered as unbraced pile length; thus, buckling should be factored into the helical pile design. The designer will also need to address any lateral or overturn loading requirements as part of their design.

We performed a preliminary analysis to determined ultimate bearing capacities that should be divided by an appropriate safety factor based on the level of field quality control. We recommend using a safety factor of 2.0 with the level of field quality control discussed herein.

Based on the recommended safety factor of 2.0 and the results of our analysis, we anticipate that the helical piles can be designed for the allowable resistances shown in the table below. If higher resistances are beneficial to a more economic foundation design, we can assist in evaluating longer, higher capacity piles. Consideration should also be given to using galvanized piles to resist corrosion from the potential of organic soils and shallow groundwater. We assumed a helical pile with three helices with diameters of 10-, 12-, and 14-inches as this is a commonly available helical pile design in the local market.

The table below provides a summary of the recommended helical pile configuration for bidding purposes.

Table 4. Estimated Helical Pile Lengths and Correlating Geotechnical Resistances

Boring	Helix Configuration (inches)	Existing Ground Surface Elevation (feet above MSL)	Analyzed Tip Elevation (feet above MSL)	Approximate Anchor Length (feet)	Estimated Ultimate Axial Resistance (kips)
ST-1	10-, 12-, 14-	878.1	838	40	105
			833	45	160
			828	50	200
ST-2	10-, 12-, 14-	878.6	838	40	65
			833	45	90
			828	50	130
ST-3	10-, 12-, 14-	876.5	836	40	30
			831	45	45
			826	50	65
ST-4	10-, 12-, 14-	880.4	840	40	60
			835	45	85
			830	50	100
ST-5	10-, 12-, 14-	882.6	842	40	50
			837	45	60
			832	50	80

C.2.d. Wet Sands Considerations

Our preliminary analysis indicated that a helical pile with a tip-elevation ranging from 826 to 842 feet above MSL and helix configuration of 10-, 12-, 14-inches results in an ultimate, compression resistance ranging from 30 to 200 kips. However, helical piles have the tendency to "run", or not meet the required torque at the design depth, in wet sands. Therefore, we recommend evaluating the torque versus depth profile on the first installed pile. If the pile does not meet the required torque at the design depth, we recommend extending it deeper until it meets the installation requirements.

Performing a static load test allows for developing site-specific torque correlations that may reduce the additional installed lengths associated with wet sands. The project team should determine the potential additional costs of installing the additional piles deeper based on the initially installed pile and torque profile from the initial pile installation and compare the cost to the cost of a static load test to develop site-specific torque correlations. Since helical piles tend to run in wet sands, the standard torque correlations may under-predict the axial resistance of the helical pile. If a static load test is performed, we also recommend using a safety factor of 2.0.

We recommend the bid documents carry line items for additional per foot fees for piles that extend deeper than design and for performing static load tests to identify these costs prior to selecting a contractor.

C.2.e. Pile Settlement

Helical piles are proprietary systems and actual depths between different installers and materials will fluctuate. We recommend using a performance-based specification for installers using the ultimate capacity and a specified settlement of less than about 1 inch.

C.2.f. Corrosion Protection

Organic soils can cause detrimental corrosion to the shafts of the helical anchors. Due to the presence of organic soils along the alignment, we recommend using galvanized steel for the anchor shafts to minimize the effects of corrosion. We also recommend having discussions with the selected anchor installer regarding corrosion protection. An additional step to reduce the potential for corrosion is to grout the anchor shafts during installation. Grouting the helical pile shafts during installation will also increase the shaft stiffness and reduce the potential for columnar buckling.

If the installer does not grout the helical pile shafts, we recommend including some loss in the anchor shafts over time due to corrosion in the anchor capacity calculations.

C.2.g. Helical Pile Design and Quality Control

The helical pile designer should provide a design that clearly states the size and configuration of the helical pile elements, the required minimum depth of embedment, and the required minimum installation torque value to achieve the design capacity with an adequate safety factor. The structural engineer and the geotechnical engineer should review the design submittal to verify it meets the expectations set forth herein and as established by the structural engineer.

Helical piles are a Special Inspection item in accordance with Chapter 17 of the IBC and require continuous observations by a third-party Special Inspector working under a geotechnical engineer. The observations should include installed length, torque, confirmation of the materials, and confirmation of installation techniques. With full time observations and torque measurements, we recommend a safety factor of 2.5 be used for the helical pile design. If static load testing is performed, the safety factor can be reduced to 2.0.

C.2.h. Calibration

The torque specified for construction should be based on a performance-based calibration table prepared by the helical pile manufacturer or installer. The design torque should also consider the equipment used to install the piles.

D. Procedures

D.1. Penetration Test Borings

We drilled the penetration test borings with a rubber tire ATV-mounted core and auger drill equipped with hollow-stem auger. We performed the borings in general accordance with ASTM D6151 taking penetration test samples at 2 1/2- or 5-foot intervals in general accordance to ASTM D1586. The boring logs show the actual sample intervals and corresponding depths.

We sealed penetration test boreholes meeting the Minnesota Department of Health (MDH) Environmental Borehole criteria with an MDH-approved grout.

D.2. Manual Exploration – Manual Push Probes

In areas not accessible to our drill rig equipment, we completed manual push probes at approximately 100-foot intervals along the boardwalk alignment. The push probes consist of manually advancing a series of 3/8-inch threaded rods. We advanced the probes in 3- to 6-foot sections to a depth at which manual effort was no longer sufficient and apparent push probe refusal was reached.

D.3. Exploration Logs

D.3.a. Log of Boring Sheets

The Appendix includes Log of Boring sheets for our penetration test borings. The logs identify and describe the penetrated geologic materials, and present the results of penetration resistance tests performed.

We inferred strata boundaries from changes in the penetration test samples and the auger cuttings. Because we did not perform continuous sampling, the strata boundary depths are only approximate. The boundary depths likely vary away from the boring locations, and the boundaries themselves may occur as gradual rather than abrupt transitions.

D.3.b. Geologic Origins

We assigned geologic origins to the materials shown on the logs and referenced within this report, based on: (1) a review of the background information and reference documents cited above, (2) visual classification of the various geologic material samples retrieved during the course of our subsurface exploration, (3) penetration resistance testing performed for the project, (4) laboratory test results, and (5) available common knowledge of the geologic processes and environments that have impacted the site and surrounding area in the past.

D.4. Material Classification and Testing

D.4.a. Visual and Manual Classification

We visually and manually classified the geologic materials encountered based on ASTM D2488. When we performed laboratory classification tests, we used the results to classify the geologic materials in accordance with ASTM D2487. The Appendix includes a chart explaining the classification system we used.

D.4.b. Laboratory Testing

The exploration logs in the Appendix note the results of the laboratory tests performed on geologic material samples. We performed the tests in general accordance with ASTM procedures.

D.5. Groundwater Measurements

The drillers checked for groundwater while advancing the penetration test borings, and again after auger withdrawal. We then backfilled the boreholes as noted on the boring logs.

E. Qualifications

E.1. Variations in Subsurface Conditions

E.1.a. Material Strata

We developed our evaluation, analyses and recommendations from a limited amount of site and subsurface information. It is not standard engineering practice to retrieve material samples from exploration locations continuously with depth. Therefore, we must infer strata boundaries and thicknesses to some extent. Strata boundaries may also be gradual transitions, and project planning should expect the strata to vary in depth, elevation and thickness, away from the exploration locations.

Variations in subsurface conditions present between exploration locations may not be revealed until performing additional exploration work, or starting construction. If future activity for this project reveals any such variations, you should notify us so that we may reevaluate our recommendations. Such variations could increase construction costs, and we recommend including a contingency to accommodate them.

E.1.b. Groundwater Levels

We made groundwater measurements under the conditions reported herein and shown on the exploration logs, and interpreted in the text of this report. Note that the observation periods were relatively short, and project planning can expect groundwater levels to fluctuate in response to rainfall, flooding, irrigation, seasonal freezing and thawing, surface drainage modifications and other seasonal and annual factors.

E.2. Continuity of Professional Responsibility

E.2.a. Plan Review

We based this report on a limited amount of information, and we made a number of assumptions to help us develop our recommendations. We should be retained to review the geotechnical aspects of the designs and specifications. This review will allow us to evaluate whether we anticipated the design correctly, if any design changes affect the validity of our recommendations, and if the design and specifications correctly interpret and implement our recommendations.

E.2.b. Construction Observations and Testing

We recommend retaining us to perform the required observations and testing during construction as part of the ongoing geotechnical evaluation. This will allow us to correlate the subsurface conditions exposed during construction with those encountered by the borings and provide professional continuity from the design phase to the construction phase. If we do not perform observations and testing during construction, it becomes the responsibility of others to validate the assumption made during the preparation of this report and to accept the construction-related geotechnical engineer-of-record responsibilities.

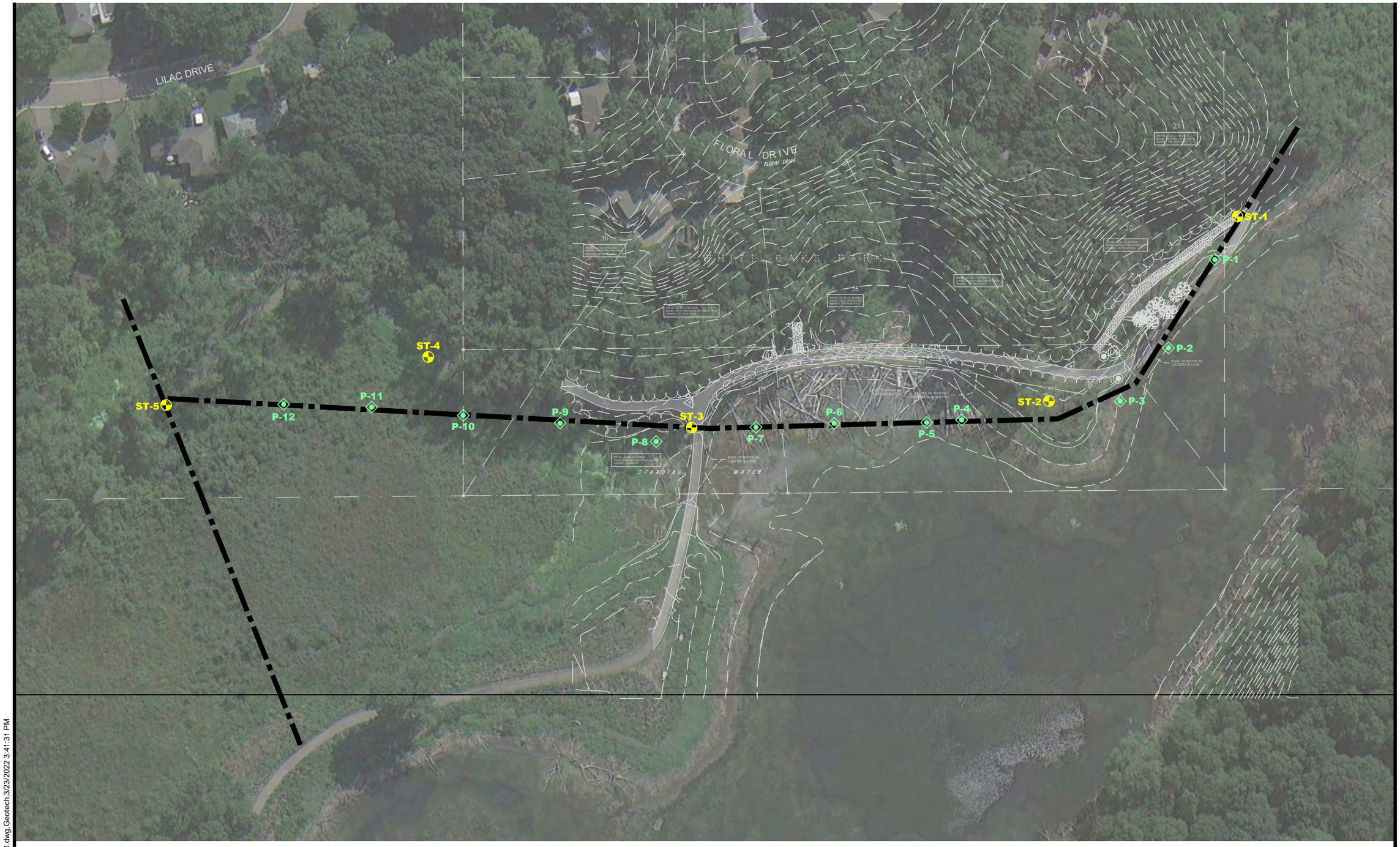
E.3. Use of Report

This report is for the exclusive use of the addressed parties. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

E.4. Standard of Care

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

Appendix



DENOTES APPROXIMATE LOCATION OF STANDARD PENETRATION TEST BORING

DENOTES APPROXIMATE LOCATION OF PUSH PROBE SOIL BORING

50' 0 100'

SCALE: 1"= 100'

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BRAUN INTERTEC
The Science You Build On.

11001 Hampshire Avenue S
Minneapolis, MN 55438
952.995.2000
braunintertec.com

Drawing Information

Project No:	B2201410
Drawing No:	B2201410
Drawn By:	JAG
Date Drawn:	3/2/22
Checked By:	BJS
Last Modified:	3/23/22

Project Information

Snail Lake Regional Park
Trail Improvements

Wetland A, South of
Snail Lake Road

Shoreview, Minnesota

Soil Boring Location Sketch

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2201410
Geotechnical Evaluation
Snail Lake Regional Park Trail Improvements
Wetland A, South of Snail Lake Road
Shoreview, Minnesota

BORING: **P-1**

LOCATION: See attached sketch

NORTHING: 200397 EASTING: 569172

DRILLER: M. Takada | LOGGED BY: B. Schreurs | START DATE: 03/15/22 | END DATE: 03/15/22

SURFACE ELEVATION: 875.7 ft | RIG: 7507 | METHOD: 3 1/4" HSA | SURFACING: Grass | WEATHER: Sunny

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
868.7	▽	ORGANIC SILT (OL), contains lenses of Peat, and Sand, dark brown and gray, frozen (moist when thawed) (SWAMP DEPOSIT) *Moist at 2 feet*		1-2-1 (3) 15"		104	
			5	1-1-2 (3*) 0"			*No sample recovery
7.0 864.7		SILTY SAND (SM), fine to medium-grained, trace Gravel, brown and gray, wet, loose to medium dense (LACUSTRINE)		3-3-3 (6) 12"		26	
			10	3-9-7 (16) 14"			
11.0 862.7		POORLY GRADED SAND (SP), fine-grained, gray, wet, loose (LACUSTRINE)		4-4-4 (8*) 0"			*No sample recovery
13.0 861.2		SANDY LEAN CLAY (CL), trace Gravel, gray, wet, stiff (GLACIAL TILL)		4-5-5 (10) 18"			
14.5		END OF BORING Boring immediately backfilled	15				Water observed at 6.0 feet while drilling.
			20				
			25				
			30				

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2201410
Geotechnical Evaluation
Snail Lake Regional Park Trail Improvements
Wetland A, South of Snail Lake Road
Shoreview, Minnesota

BORING: **ST-1**

LOCATION: See attached sketch

NORTHING: 200373 EASTING: 569218

DRILLER: M. Takada | LOGGED BY: B. Schreurs | START DATE: 03/15/22 | END DATE: 03/15/22

SURFACE ELEVATION: 878.1 ft | RIG: 7507 | METHOD: 3 1/4" HSA | SURFACING: Grass | WEATHER: Sunny

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
876.1		CLAYEY SAND (SC), slightly organic, trace Gravel, dark brown to brown, moist (TOPSOIL)					
2.0		ORGANIC SILT (OL), contains lenses of Sand, and Gravel, dark brown and gray, moist (SWAMP DEPOSIT)		2-2-2 (4) 15"		39	OC=6%
873.1			5	1-3-4 (7) 12"			
5.0		SILTY SAND (SM), fine to medium-grained, little Gravel, gray, moist, loose (LACUSTRINE)					
871.1				3-4-5 (9) 18"		15	
7.0	▽	SANDY LEAN CLAY (CL), trace Gravel, brown to gray, moist, stiff to very stiff (GLACIAL TILL)	10	4-6-7 (13) 18"			
		Gray at 12 feet		5-5-8 (13) 18"		17	
862.1			15	2-5-11 (16) 18"			
16.0		SILTY SAND (SM), fine to medium-grained, little Gravel, brown to gray, wet, medium dense to dense (GLACIAL TILL)		4-9-14 (23) 18"			
		Gray at 20 feet	20	9-8-13 (21) 16"			
			25	2-4-8 (12) 15"			
			30	4-7-7 (14) 16"			

Continued on next page

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2201410
Geotechnical Evaluation
Snail Lake Regional Park Trail Improvements
Wetland A, South of Snail Lake Road
Shoreview, Minnesota

BORING: **ST-1**

LOCATION: See attached sketch

NORTHING: 200373 EASTING: 569218

DRILLER: M. Takada LOGGED BY: B. Schreurs START DATE: 03/15/22 END DATE: 03/15/22

SURFACE ELEVATION: 878.1 ft RIG: 7507 METHOD: 3 1/4" HSA SURFACING: Grass WEATHER: Sunny

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
		SILTY SAND (SM), fine to medium-grained, little Gravel, brown to gray, wet, medium dense to dense (GLACIAL TILL)	35	7-10-10 (20) 12"			
			40	20-17-15 (32) 5"			
			45	15-18-14 (32) 12"			
			50	12-17-20 (37) 10"			
827.1							
51.0		END OF BORING Boring immediately backfilled with bentonite grout					Water observed at 11.0 feet while drilling.
			55				
			60				

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Project Number B2201410
Geotechnical Evaluation
Snail Lake Regional Park Trail Improvements
Wetland A, South of Snail Lake Road
Shoreview, Minnesota

BORING: **ST-2**

LOCATION: See attached sketch

NORTHING: 200576	EASTING: 569019		
DRILLER: M. Takada	LOGGED BY: B. Schreurs	START DATE: 03/15/22	END DATE: 03/16/22
SURFACE ELEVATION: 878.6 ft	RIG: 7507	METHOD: 3 1/4" HSA	SURFACING: Grass	WEATHER: Sunny

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
877.6		CLAYEY SAND (SC), slightly organic, trace roots, and Gravel, dark brown, frozen (moist when thawed) (TOPSOIL)					
1.0		POORLY GRADED SAND with SILT (SP-SM), fine to medium-grained, trace Gravel, occasional lenses of Silty Sand, brown, moist to wet, loose to medium dense (LACUSTRINE)		3-6-6 (12) 14"		4	
			5	5-6-6 (12) 16"		7	P200=12%
				5-6-6 (12) 16"			
	▽	*Wet at 10 feet*	10	4-4-4 (8) 16"			
866.6							
12.0		POORLY GRADED SAND (SP), fine-grained, brown, wet, loose to medium dense (LACUSTRINE)		4-3-3 (6) 18"			
			15	5-5-5 (10) 16"			
				5-6-7 (13) 15"			
			20	4-4-5 (9) 16"			
855.6							
23.0		SANDY SILT (ML), brown, wet, loose (LACUSTRINE)					
			25	5-5-5 (10) 16"			
850.6							
28.0		POORLY GRADED SAND (SP), fine-grained, contains lenses of Silt, brown, wet, loose to medium dense (LACUSTRINE)					
			30	4-3-4 (7) 8"			

Continued on next page

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See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2201410
Geotechnical Evaluation
Snail Lake Regional Park Trail Improvements
Wetland A, South of Snail Lake Road
Shoreview, Minnesota

BORING: **ST-2**

LOCATION: See attached sketch

NORTHING: 200576 EASTING: 569019

DRILLER: M. Takada | LOGGED BY: B. Schreurs | START DATE: 03/15/22 | END DATE: 03/16/22

SURFACE ELEVATION: 878.6 ft | RIG: 7507 | METHOD: 3 1/4" HSA | SURFACING: Grass | WEATHER: Sunny

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
		POORLY GRADED SAND (SP), fine-grained, contains lenses of Silt, brown, wet, loose to medium dense (LACUSTRINE)	35	3-5-7 (12) 8"			
840.6							
38.0		SANDY SILT (ML), brown, wet, medium dense (LACUSTRINE)	40	5-6-7 (13) 12"			
835.6							
43.0		POORLY GRADED SAND (SP), fine-grained, contains lenses of Silt, brown, wet, medium dense (LACUSTRINE)	45	8-10-12 (22) 10"			
			50	9-12-15 (27) 12"			
827.6							
51.0		END OF BORING Boring immediately backfilled with bentonite grout	55				Water observed at 10.0 feet while drilling.
			60				

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See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2201410
Geotechnical Evaluation
Snail Lake Regional Park Trail Improvements
Wetland A, South of Snail Lake Road
Shoreview, Minnesota

BORING: **ST-3**
LOCATION: See attached sketch
NORTHING: 200961 EASTING: 568991
DRILLER: M. Takada LOGGED BY: B. Schreurs START DATE: 03/16/22 END DATE: 03/16/22
SURFACE ELEVATION: 876.5 ft RIG: 7507 METHOD: 3 1/4" HSA SURFACING: Grass WEATHER:

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
875.7		CLAYEY SAND (SC), slightly organic to organic, black, frozen (moist when thawed) (TOPSOIL FILL)					
0.8							
874.0		FILL: SILTY SAND (SM), fine-grained, gray, moist		1-2-2 (4) 8"		40	
2.5	▽	ORGANIC SILT (OH), contains lenses of Peat, trace fibers, and shells, dark brown, black and gray, moist to wet (SWAMP DEPOSIT) *Wet at 5 feet*	5	0-0-0 WOH/18" 10"		134	LL=95, PL=88, PI=7 OC=13%
869.5							
7.0		POORLY GRADED SAND (SP), fine-grained, contains lenses of Silty Sand, gray, wet, very loose (LACUSTRINE)		0-0-1 (1) 10"			
			10	0-0-0 WOH/18" 6"			
				1-0-0 WOH/12" 16"			
			15	1-1-1 (2) 12"		21	P200=3%
				0-1-1 (2) 14"			
857.5							
19.0		PEAT (PT), contains lenses of Sand, dark brown, gray and black, wet (SWAMP DEPOSIT)	20	0-0-1 (1) 16"		200	OC=27%
851.5			25	2-3-3 (6) 18"			
25.0		ORGANIC SILT (OL), contains lenses of Sand, dark brown, gray and black, wet (SWAMP DEPOSIT)					
			30	2-3-2 (5) 10"		65	
845.5		POORLY GRADED SAND (SP), fine-grained, occasional lenses of Silt, brown, wet, loose to medium dense (LACUSTRINE)					
31.0							

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Project Number B2201410
Geotechnical Evaluation
Snail Lake Regional Park Trail Improvements
Wetland A, South of Snail Lake Road
Shoreview, Minnesota

BORING: **ST-3**

LOCATION: See attached sketch

NORTHING: 200961 EASTING: 568991

DRILLER: M. Takada | LOGGED BY: B. Schreurs | START DATE: 03/16/22 | END DATE: 03/16/22

SURFACE ELEVATION: 876.5 ft | RIG: 7507 | METHOD: 3 1/4" HSA | SURFACING: Grass | WEATHER:

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
		POORLY GRADED SAND (SP), fine-grained, occasional lenses of Silt, brown, wet, loose to medium dense (LACUSTRINE)	35	2-4-8 (12) 10"			
			40	6-8-10 (18) 12"			
			45	7-9-11 (20) 14"			
			50	6-11-15 (26) 10"			
825.5							
51.0		END OF BORING Boring immediately backfilled with bentonite grout					Water observed at 5.0 feet while drilling.
			55				
			60				

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See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2201410
Geotechnical Evaluation
Snail Lake Regional Park Trail Improvements
Wetland A, South of Snail Lake Road
Shoreview, Minnesota

BORING: **ST-4**
LOCATION: See attached sketch
NORTHING: 201245 EASTING: 569067
DRILLER: M. Takada LOGGED BY: B. Schreurs START DATE: 03/16/22 END DATE: 03/17/22
SURFACE ELEVATION: 880.4 ft RIG: 7507 METHOD: 3 1/4" HSA SURFACING: Grass WEATHER: Overcast, 36-54°F

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
879.9							
0.5		CLAYEY SAND (SC), slightly organic, trace roots, and Gravel, dark brown, frozen (moist when thawed) (TOPSOIL FILL)					
		FILL: SILTY SAND (SM), fine to medium-grained, slightly organic, little Gravel, dark brown and gray, moist		9-3-2 (5) 3"			
876.4							
4.0		ORGANIC SILT (OL), contains lenses of Silty Sand, dark brown and gray, moist (SWAMP DEPOSIT)	5	1-2-2 (4) 8"		39	
873.4							
7.0	▽	POORLY GRADED SAND (SP), fine-grained, grayish brown, wet, loose to medium dense (LACUSTRINE)		2-3-3 (6) 8"			
			10	1-2-3 (5) 6"			
				4-3-4 (7) 12"			
			15	4-5-7 (12) 10"			
				5-7-12 (19) 10"			
861.4							
19.0		SILTY SAND (SM), contains lenses of Silt, brown to gray, wet, loose to medium dense (LACUSTRINE)	20	6-7-7 (14) 10"		23	P200=31%
		Gray at 25 feet	25	1-4-5 (9) 12"			
		Layer of LEAN CLAY encountered at 30 feet	30	3-4-5 (9) 18"		24	

Continued on next page

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See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2201410
Geotechnical Evaluation
Snail Lake Regional Park Trail Improvements
Wetland A, South of Snail Lake Road
Shoreview, Minnesota

BORING: **ST-4**

LOCATION: See attached sketch

NORTHING: 201245 EASTING: 569067

DRILLER: M. Takada | LOGGED BY: B. Schreurs | START DATE: 03/16/22 | END DATE: 03/17/22

SURFACE ELEVATION: 880.4 ft | RIG: 7507 | METHOD: 3 1/4" HSA | SURFACING: Grass | WEATHER: Overcast, 36-54°F

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
		SILTY SAND (SM), contains lenses of Silt, brown to gray, wet, loose to medium dense (LACUSTRINE)					
		Layer of LEAN CLAY encountered at 35 feet	35	3-6-7 (13) 18"			
842.4							
38.0		POORLY GRADED SAND (SP), fine to medium-grained, trace Gravel, gray, wet, medium dense (GLACIAL OUTWASH)	40	5-8-12 (20) 12"			
			45	7-10-11 (21) 10"			
			50	7-10-14 (24) 8"			
829.4							
51.0		END OF BORING					Water observed at 7.0 feet while drilling.
		Boring immediately backfilled with bentonite grout	55				
			60				

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See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2201410
Geotechnical Evaluation
Snail Lake Regional Park Trail Improvements
Wetland A, South of Snail Lake Road
Shoreview, Minnesota

BORING: **ST-5**

LOCATION: Offset 25 feet north of staked location. See attached sketch.

NORTHING: 201528 EASTING: 569015

DRILLER: M. Takada | LOGGED BY: B. Schreurs | START DATE: 03/17/22 | END DATE: 03/17/22

SURFACE ELEVATION: 882.6 ft | RIG: 7507 | METHOD: 3 1/4" HSA | SURFACING: Grass | WEATHER: Overcast, 43°F

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
881.6		CLAYEY SAND (SC), slightly organic, trace roots, and Gravel, dark brown, frozen (wet when thawed) (TOPSOIL FILL)					
1.0		FILL: SILTY SAND (SM), fine to medium-grained, little Gravel, brown, wet		5-4-2 (6) 8"		13	
			5	1-1-1 (2) 6"			
	▽			0-0-0 WOH/18" 14"		18	
			10	1-1-1 (2) 6"			
870.6							
12.0		PEAT (PT), black, wet (SWAMP DEPOSIT)		4-5-7 (12) 16"			
869.6							
13.0		POORLY GRADED SAND (SP), fine-grained, occasional lenses of Silt, grayish brown, wet, loose to medium dense (LACUSTRINE)	15	1-4-4 (8) 8"			
				5-5-5 (10) 8"			
			20	1-3-3 (6) 14"			
			25	1-4-5 (9) 12"			
			30	4-4-4 (8) 10"			

Continued on next page

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2201410
Geotechnical Evaluation
Snail Lake Regional Park Trail Improvements
Wetland A, South of Snail Lake Road
Shoreview, Minnesota

BORING: **ST-5**

LOCATION: Offset 25 feet north of staked location. See attached sketch.

NORTHING: 201528	EASTING: 569015		
DRILLER: M. Takada	LOGGED BY: B. Schreurs	START DATE: 03/17/22	END DATE: 03/17/22
SURFACE ELEVATION: 882.6 ft	RIG: 7507	METHOD: 3 1/4" HSA	SURFACING: Grass	WEATHER: Overcast, 43°F

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
		POORLY GRADED SAND (SP), fine-grained, occasional lenses of Silt, grayish brown, wet, loose to medium dense (LACUSTRINE)					
35				5-6-8 (14) 10"			
40				6-6-8 (14) 10"			
45				7-9-10 (19) 10"			
50				8-12-10 (22) 8"			
831.6							
51.0		END OF BORING Boring immediately backfilled with bentonite grout					Water observed at 7.0 feet while drilling.
55							
60							

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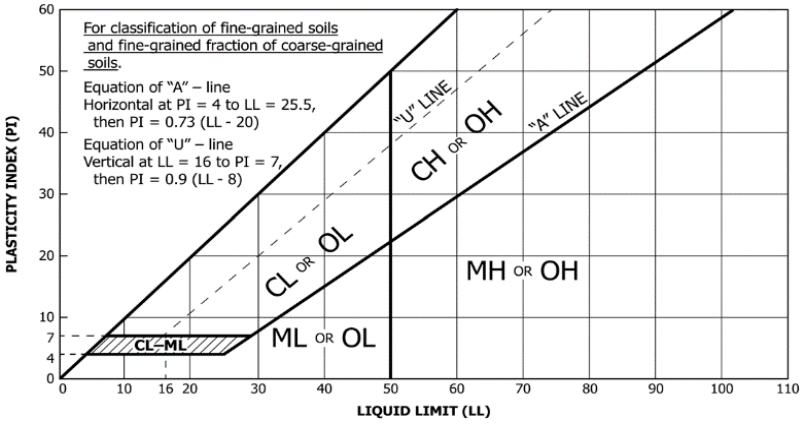
Descriptive Terminology of Soil

Based on Standards ASTM D2487/2488
(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])	$C_u \geq 4$ and $1 \leq C_c \leq 3$[D]	GW	Well-graded gravel[E]
			$C_u < 4$ and/or ($C_c < 1$ or $C_c > 3$)[D]	GP	Poorly graded gravel[E]
		Gravels with Fines (More than 12% fines[C])	Fines classify as ML or MH	GM	Silty gravel[E F G]
			Fines Classify as CL or CH	GC	Clayey gravel[E F G]
	Sands (50% or more coarse fraction passes No. 4 sieve)	Clean Sands (Less than 5% fines[H])	$C_u \geq 6$ and $1 \leq C_c \leq 3$[D]	SW	Well-graded sand[I]
			$C_u < 6$ and/or ($C_c < 1$ or $C_c > 3$)[D]	SP	Poorly graded sand[I]
		Sands with Fines (More than 12% fines[H])	Fines classify as ML or MH	SM	Silty sand[F G I]
			Fines classify as CL or CH	SC	Clayey sand[F G 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 / Liquid Limit – not dried <0.75	OL	Organic clay[K L M N] / 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 / Liquid Limit – not dried <0.75	OH	Organic clay[K L M P] / 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. $C_u = D_{60} / D_{10}$ $C_c = (D_{30})^2 / (D_{10} \times D_{60})$
E. If soil contains ≥ 15% sand, add "with sand" to group name.
F. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
G. If fines are organic, add "with organic fines" to group name.
H. 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
I. If soil contains ≥ 15% gravel, add "with gravel" to group name.
J. If Atterberg limits plot in hatched area, soil is CL-ML, silty clay.
K. If soil contains 15 to < 30% 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.



Laboratory Tests

DD	Dry density, pcf	**q_p**	Pocket penetrometer strength, tsf
WD	Wet density, pcf	**q_U**	Unconfined compression test, tsf
P200	% Passing #200 sieve	**LL**	Liquid limit
MC	Moisture content, %	**PL**	Plastic limit
OC	Organic content, %	**PI**	Plasticity index

Particle Size Identification

Boulders..... over 12"
Cobbles..... 3" to 12"
Gravel
  Coarse..... 3/4" to 3" (19.00 mm to 75.00 mm)
  Fine..... No. 4 to 3/4" (4.75 mm to 19.00 mm)
Sand
  Coarse..... No. 10 to No. 4 (2.00 mm to 4.75 mm)
  Medium..... No. 40 to No. 10 (0.425 mm to 2.00 mm)
  Fine..... No. 200 to No. 40 (0.075 mm to 0.425 mm)
Silt..... No. 200 (0.075 mm) to .005 mm
Clay..... < .005 mm

Relative Proportions[L, M]

trace..... 0 to 5%
little..... 6 to 14%
with..... ≥ 15%

Inclusion Thicknesses

lens..... 0 to 1/8"
seam..... 1/8" to 1"
layer..... over 1"

Apparent Relative Density of Cohesionless Soils

Very loose ..... 0 to 4 BPF
Loose ..... 5 to 10 BPF
Medium dense..... 11 to 30 BPF
Dense..... 31 to 50 BPF
Very dense..... over 50 BPF

Consistency of Cohesive Soils	Blows Per Foot	Approximate Unconfined Compressive Strength
Very soft	0 to 1 BPF	< 0.25 tsf
Soft	2 to 4 BPF	0.25 to 0.5 tsf
Medium	5 to 8 BPF	0.5 to 1 tsf
Stiff	9 to 15 BPF	1 to 2 tsf
Very Stiff	16 to 30 BPF	2 to 4 tsf
Hard	over 30 BPF	> 4 tsf

Moisture Content:

Dry: Absence of moisture, dusty, dry to the touch.
Moist: Damp but no visible water.
Wet: Visible free water, usually soil is below water table.

Drilling Notes:

Blows/N-value: Blows indicate the driving resistance recorded for each 6-inch interval. The reported N-value is the blows per foot recorded by summing the second and third interval in accordance with the Standard Penetration Test, ASTM D1586.

Partial Penetration: If the sampler could not be driven through a full 6-inch interval, the number of blows for that partial penetration is shown as #/x" (i.e. 50/2"). The N-value is reported as "REF" indicating refusal.

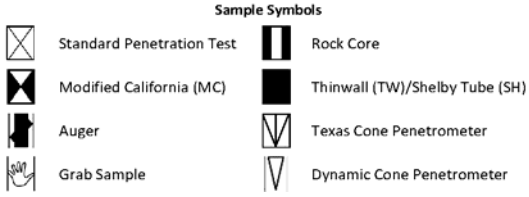
Recovery: Indicates the inches of sample recovered from the sampled interval. For a standard penetration test, full recovery is 18", and is 24" for a thinwall/shelby tube sample.

WOH: Indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WOR: Indicates the sampler penetrated soil under weight of rods alone; hammer weight and driving not required.

Water Level: Indicates the water level measured by the drillers either while drilling (▽), at the end of drilling (▼), or at some time after drilling (▼).

Sample Symbols



5/2021

APPENDIX G

Cost Estimates

				Engineer's Estimate - Snail Lake Trail Feasibility Study							
NOTES	ITEM DESCRIPTION	UNIT	UNIT PRICE	OPTION 1A		OPTION 1B		OPTION 1C		OPTION 1D	
				QUANTITY	AMOUNT	QUANTITY	AMOUNT	QUANTITY	AMOUNT	QUANTITY	AMOUNT
	TRAIL & BOARDWALK CONSTRUCTION:										
(3)	CLEAR & GRUB TREE	ACRE	$6,000.00	0.07	$420.00	0.07	$420.00	0.07	$420.00		
	COMMON EXCAVATION (CUT)	CU YD	$20.00	70	$1,400.00	70	$1,400.00	70	$1,400.00		
	COMMON EMBANKMENT (FILL)	CU YD	$20.00	1050	$21,000.00	190	$3,800.00	410	$8,200.00		
(2)	BITUMINOUS PAVEMENT & AGGREGATE	LIN FT	$60.00	1700	$102,000.00	1385	$83,100.00	1513	$90,780.00	780	$46,800.00
(5)	BOARDWALK	LIN FT	$1,200.00			315	$378,000.00	188	$225,600.00	620	$744,000.00
(1)	WETLAND IMPACTS	ACRE	$10,000.00	0.38	$3,800.00	0.15	$1,500.00	0.22	$2,200.00		
(4)	TEMPORARY EASEMENTS FOR CONSTRUCTION	SQ FT	$5.00	2490	$12,450.00						
(7)	CROSS CULVERTS & MCES MANHOLE RECONSTRUCTION	LUMP SUM	$20,000.00	2	$40,000.00			1	$20,000.00		
	TRAIL & BOARDWALK CONSTRUCTION SUBTOTAL:			$181,070.00		$468,220.00		$348,600.00		$790,800.00	
(6)	TURF ESTABLISHMENT & EROSION CONTROL		10%		$19,000.00		$47,000.00		$35,000.00		$80,000.00
	GENERAL CONTINGENCY		25%		$46,000.00		$118,000.00		$88,000.00		$198,000.00
	TRAIL & BOARDWALK CONSTRUCTION TOTAL:			$246,070.00		$633,220.00		$471,600.00		$1,068,800.00	
	COMPENSATORY STORAGE REQUIRED (1:1 RATIO):			**980**		**120**		**340**			
	MITIGATION OPTION			**A**		**A**		**A**			
(3)	CLEAR & GRUB TREE	ACRE	$6,000.00	0.07	$420.00	0.07	$420.00	0.07	$420.00		
	COMMON EXCAVATION (CUT)	CU YD	$20.00	2440	$48,800.00	2440	$48,800.00	2440	$48,800.00		
	COMPENSATORY STORAGE TOTAL:			$49,220.00		$49,220.00		$49,220.00			
	ONSITE WETLAND IMPACT MITIGATION REQUIRED (1:2 RATIO):			**0.76**		**0.30**		**0.44**			
(1)	WETLAND CREATION	ACRE	$10,000.00	0.76	$7,600.00	0.76	$7,600.00	0.76	$7,600.00		
(1)	WETLAND IMPACTS (PERMANENT)	ACRE	$10,000.00								
(1)	WETLAND IMPACTS (TEMPORARY)	ACRE	$10,000.00	0.02	$200.00	0.02	$200.00	0.02	$200.00		
	ONSITE WETLAND IMPACT MITIGATION TOTAL:			$7,800.00		$7,800.00		$7,800.00			
	OFFSITE WETLAND IMPACT MITIGATION:										
(8)	OUTSTANDING WETLAND IMPACTS (PERMANENT)	ACRE	$80,000.00			-0.46	-$36,800.00	-0.32	-$25,600.00		
TOTAL ESTIMATED OPTION COST (CONSTRUCTION + MITIGATION)				**$303,090.00**		**$653,440.00**		**$503,020.00**		**$1,068,800.00**	
FINAL DESIGN & CONSTRUCTION ADMINISTRATION (25%)				**$75,780.00**		**$163,360.00**		**$125,760.00**		**$267,200.00**	
TOTAL ESTIMATED PROJECT COST				**$378,870.00**		**$816,800.00**		**$628,780.00**		**$1,336,000.00**	

NOTES:

(1) PER DELINEATED WETLANDS FOR RAPID STABILIZATION AND FINAL SEEDING
(2) FOR 10 FOOT BIT TRAIL (3 INCH DEPTH) OVER 11 FOOT AGG BASE (6 INCH DEPTH)
(3) PER ESTIMATED TREE LINES FROM AERIAL IMAGERY
(4) FOR TEMPORARY GRADING IMPACTS TO PRIVATE PARCELS EAST OF EXISTING TRAIL
(5) FOR 9 FOOT CLEAR WIDTH, NON-VEHICLE RATED TIMBER BOARDWALK ON HELICAL PILES WITH 4.5 FOOT TALL RAILS WHEN DROPOFF EXCEEDS 30 INCHES
(6) CONTINGENCY FOR SITE PROTECTION DURING CONSTRUCTION AND FINAL SEEDING OF FINISHED SLOPES
(7) CONTINGENCY FOR CROSS CULVERT REPLACEMENT AND/OR MCES SANITARY SEWER STRUCTURE RECONSTRUCTION
(8) POSITIVE VALUES ARE IMPACTS TO BE MITIGATED OFFSITE VIA CREDITS. UNIT PRICE LISTED IS 2019 AVERAGE COST PER CREDIT FOR BSA 7. BLANK OR NEGATIVE VALUES SUGGEST THAT MITIGATION CAN BE ACHIEVED ONSITE WITH SOME OPTIONS CREATING EXCESS.

				Engineer's Estimate - Snail Lake Trail Feasibility Study							
NOTES	ITEM DESCRIPTION	UNIT	UNIT PRICE	OPTION 2A		OPTION 2B		OPTION 2C		OPTION 2D	
				QUANTITY	AMOUNT	QUANTITY	AMOUNT	QUANTITY	AMOUNT	QUANTITY	AMOUNT
	TRAIL & BOARDWALK CONSTRUCTION:										
(3)	CLEAR & GRUB TREE	ACRE	$6,000.00	0.19	$1,140.00	0.02	$120.00	0.02	$120.00		
	COMMON EXCAVATION (CUT)	CU YD	$20.00	30	$600.00	30	$600.00	30	$600.00		
	COMMON EMBANKMENT (FILL)	CU YD	$20.00	3620	$72,400.00	180	$3,600.00	1080	$21,600.00		
(2)	BITUMINOUS PAVEMENT & AGGREGATE	LIN FT	$60.00	1700	$102,000.00	630	$37,800.00	904	$54,240.00	171	$10,260.00
(5)	BOARDWALK	LIN FT	$1,200.00			1059	$1,270,800.00	781	$937,200.00	1210	$1,452,000.00
(1)	WETLAND IMPACTS	ACRE	$10,000.00	0.62	$6,200.00	0.10	$1,000.00	0.22	$2,200.00		
(4)	TEMPORARY EASEMENTS FOR CONSTRUCTION	SQ FT	$5.00	5190	$25,950.00						
(7)	CROSS CULVERTS & MCES MANHOLE RECONSTRUCTION	LUMP SUM	$20,000.00	2	$40,000.00			1	$20,000.00		
	TRAIL & BOARDWALK CONSTRUCTION SUBTOTAL:			$248,290.00		$1,313,920.00		$1,035,960.00		$1,462,260.00	
(6)	TURF ESTABLISHMENT & EROSION CONTROL		10%		$25,000.00		$132,000.00		$104,000.00		$147,000.00
	GENERAL CONTINGENCY		25%		$63,000.00		$329,000.00		$259,000.00		$366,000.00
	TRAIL & BOARDWALK CONSTRUCTION TOTAL:			$336,290.00		$1,774,920.00		$1,398,960.00		$1,975,260.00	
	COMPENSATORY STORAGE REQUIRED (1:1 RATIO):			**3590**		**150**		**1050**			
	MITIGATION OPTION			**A & B**		**B**		**A**			
(3)	CLEAR & GRUB TREE	ACRE	$6,000.00	0.09	$540.00	0.02	$120.00	0.07	$420.00		
	COMMON EXCAVATION (CUT)	CU YD	$20.00	3590	$71,800.00	1190	$23,800.00	2440	$48,800.00		
	COMPENSATORY STORAGE TOTAL:			$72,340.00		$23,920.00		$49,220.00			
	ONSITE WETLAND IMPACT MITIGATION REQUIRED (1:2 RATIO):			**1.24**		**0.20**		**0.44**			
(1)	WETLAND CREATION	ACRE	$10,000.00	1.01	$10,100.00	0.25	$2,500.00	0.76	$7,600.00		
(1)	WETLAND IMPACTS (PERMANENT)	ACRE	$10,000.00								
(1)	WETLAND IMPACTS (TEMPORARY)	ACRE	$10,000.00	0.27	$2,700.00	0.02	$200.00	0.02	$200.00		
	ONSITE WETLAND IMPACT MITIGATION TOTAL:			$12,800.00		$2,700.00		$7,800.00			
	OFFSITE WETLAND IMPACT MITIGATION:										
(8)	OUTSTANDING WETLAND IMPACTS (PERMANENT)	ACRE	$80,000.00	0.23	$18,400.00	-0.05	-$4,000.00	-0.32	-$25,600.00		
TOTAL ESTIMATED OPTION COST (CONSTRUCTION + MITIGATION)				**$439,830.00**		**$1,797,540.00**		**$1,430,380.00**		**$1,975,260.00**	
FINAL DESIGN & CONSTRUCTION ADMINISTRATION (25%)				**$109,960.00**		**$449,390.00**		**$357,600.00**		**$493,820.00**	
TOTAL ESTIMATED PROJECT COST				**$549,790.00**		**$2,246,930.00**		**$1,787,980.00**		**$2,469,080.00**	

NOTES:

(1) PER DELINEATED WETLANDS FOR RAPID STABILIZATION AND FINAL SEEDING
(2) FOR 10 FOOT BIT TRAIL (3 INCH DEPTH) OVER 11 FOOT AGG BASE (6 INCH DEPTH)
(3) PER ESTIMATED TREE LINES FROM AERIAL IMAGERY
(4) FOR TEMPORARY GRADING IMPACTS TO PRIVATE PARCELS EAST OF EXISTING TRAIL
(5) FOR 9 FOOT CLEAR WIDTH, NON-VEHICLE RATED TIMBER BOARDWALK ON HELICAL PILES WITH 4.5 FOOT TALL RAILS WHEN DROPOFF EXCEEDS 30 INCHES
(6) CONTINGENCY FOR SITE PROTECTION DURING CONSTRUCTION AND FINAL SEEDING OF FINISHED SLOPES
(7) CONTINGENCY FOR CROSS CULVERT REPLACEMENT AND/OR MCES SANITARY SEWER STRUCTURE RECONSTRUCTION
(8) POSITIVE VALUES ARE IMPACTS TO BE MITIGATED OFFSITE VIA CREDITS. UNIT PRICE LISTED IS 2019 AVERAGE COST PER CREDIT FOR BSA 7. BLANK OR NEGATIVE VALUES SUGGEST THAT MITIGATION CAN BE ACHIEVED ONSITE WITH SOME OPTIONS CREATING EXCESS.

				Engineer's Estimate - Snail Lake Trail Feasibility Study							
NOTES	ITEM DESCRIPTION	UNIT	UNIT PRICE	OPTION 3A		OPTION 3B		OPTION 3C		OPTION 3D	
				QUANTITY	AMOUNT	QUANTITY	AMOUNT	QUANTITY	AMOUNT	QUANTITY	AMOUNT
	TRAIL & BOARDWALK CONSTRUCTION:										
(3)	CLEAR & GRUB TREE	ACRE	$6,000.00	0.51	$3,060.00	0.01	$60.00	0.04	$240.00		
	COMMON EXCAVATION (CUT)	CU YD	$20.00	10	$200.00	10	$200.00	10	$200.00		
	COMMON EMBANKMENT (FILL)	CU YD	$20.00	7680	$153,600.00	150	$3,000.00	2460	$49,200.00		
(2)	BITUMINOUS PAVEMENT & AGGREGATE	LIN FT	$60.00	1700	$102,000.00	138	$8,280.00	871	$52,260.00	138	$8,280.00
(5)	BOARDWALK	LIN FT	$1,200.00			1556	$1,867,200.00	765	$918,000.00	1250	$1,500,000.00
(1)	WETLAND IMPACTS	ACRE	$10,000.00	0.81	$8,100.00	0.04	$400.00	0.21	$2,100.00		
(4)	TEMPORARY EASEMENTS FOR CONSTRUCTION	SQ FT	$5.00	9080	$45,400.00						
(7)	CROSS CULVERTS & MCES MANHOLE RECONSTRUCTION	LUMP SUM	$20,000.00	2	$40,000.00			1	$20,000.00		
	TRAIL & BOARDWALK CONSTRUCTION SUBTOTAL:			$352,360.00		$1,879,140.00		$1,042,000.00		$1,508,280.00	
(6)	TURF ESTABLISHMENT & EROSION CONTROL		10%		$36,000.00		$188,000.00		$105,000.00		$151,000.00
	GENERAL CONTINGENCY		25%		$89,000.00		$470,000.00		$261,000.00		$378,000.00
	TRAIL & BOARDWALK CONSTRUCTION TOTAL:			$477,360.00		$2,537,140.00		$1,408,000.00		$2,037,280.00	
	COMPENSATORY STORAGE REQUIRED (1:1 RATIO):			**7670**		**140**		**2450**			
	MITIGATION OPTION			**A, B, D & E**		**B**		**A & C**			
(3)	CLEAR & GRUB TREE	ACRE	$6,000.00	0.86	$5,160.00	0.02	$120.00	0.07	$420.00		
	COMMON EXCAVATION (CUT)	CU YD	$20.00	8260	$165,200.00	1190	$23,800.00	2730	$54,600.00		
	COMPENSATORY STORAGE TOTAL:			$170,360.00		$23,920.00		$55,020.00			
	ONSITE WETLAND IMPACT MITIGATION REQUIRED (1:2 RATIO):			**1.62**		**0.08**		**0.42**			
(1)	WETLAND CREATION	ACRE	$10,000.00	1.06	$10,600.00	0.25	$2,500.00	0.78	$7,800.00		
(1)	WETLAND IMPACTS (PERMANENT)	ACRE	$10,000.00	0.15	$1,500.00			0.02	$200.00		
(1)	WETLAND IMPACTS (TEMPORARY)	ACRE	$10,000.00	1.33	$13,300.00	0.02	$200.00	0.32	$3,200.00		
	ONSITE WETLAND IMPACT MITIGATION TOTAL:			$25,400.00		$2,700.00		$11,200.00			
	OFFSITE WETLAND IMPACT MITIGATION:										
(8)	OUTSTANDING WETLAND IMPACTS (PERMANENT)	ACRE	$80,000.00	0.56	$44,800.00	-0.17	-$13,600.00	-0.36	-$28,800.00		
TOTAL ESTIMATED OPTION COST (CONSTRUCTION + MITIGATION)				**$717,920.00**		**$2,550,160.00**		**$1,445,420.00**		**$2,037,280.00**	
FINAL DESIGN & CONSTRUCTION ADMINISTRATION (25%)				**$179,480.00**		**$637,540.00**		**$361,360.00**		**$509,320.00**	
TOTAL ESTIMATED PROJECT COST				**$897,400.00**		**$3,187,700.00**		**$1,806,780.00**		**$2,546,600.00**	

NOTES:

(1) PER DELINEATED WETLANDS FOR RAPID STABILIZATION AND FINAL SEEDING
(2) FOR 10 FOOT BIT TRAIL (3 INCH DEPTH) OVER 11 FOOT AGG BASE (6 INCH DEPTH)
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