Purchasing Division
Finance Department

Room 120
411 West First Street
Duluth, Minnesota 55802

☎ 218-730-5340
✉ purchasing@duluthmn.gov

Addendum No. 1
Solicitation 26-99071
Palm Street Smart Pond

This addendum serves to notify all bidders of the following changes to the solicitation documents:

1. Insert the attached document, labeled 'Geotechnical Evaluation Report', into the Bid Package.

Please acknowledge receipt of this Addendum by checking the acknowledgement box within the www.bidexpress.com solicitation.

Posted: **January 14, 2026**

Geotechnical Evaluation Report

Palm Street Pond and Storm Sewer Alignment
Blackman Avenue and Palm Street
Duluth, Minnesota

Prepared for the

City of Duluth

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.

Andrew J. Hillerud, PE
Project Engineer
License Number: 59434
September 5, 2024

ANDREW J. HILLERUD
59434

Project B2406482

Braun Intertec Corporation

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Braun Intertec Corporation
4511 West First Street, Suite 4
Duluth, MN 55807

Phone: 218.624.4967
Fax: 952.995.2020
Web: braunintertec.com

September 5, 2024 Project B2406482

Brad Scott, PE
City of Duluth
411 West 1st Street, Room 107
Duluth, MN 55802

Re: Geotechnical Evaluation
Palm Street Pond and Storm Sewer Alignment
Blackman Avenue and Palm Street
Duluth, Minnesota

Dear Mr. Scott:

We are pleased to present this Geotechnical Evaluation Report for the Palm Street Stormwater Improvement project in Duluth, Minnesota.

Thank you for making Braun Intertec Corporation 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 David Morrison at 218.624.4967 (dmorrison@braunintertec.com).

Sincerely,

BRAUN INTERTEC CORPORATION

Andrew J. Hillerud, PE
Project Engineer

Joseph C. Butler, PE
Associate Director, Senior Engineer

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A. Introduction

A.1. Project Description

This Geotechnical Evaluation Report addresses improvements to the existing stormwater pond located at the corner of Blackman Avenue and Palm Street in Duluth, Minnesota. The project will include construction of new retaining walls surrounding the stormwater pond. We understand the retaining walls will be cast-in-place concrete walls supported on either spread footing foundations or sheet piles or sheet pile walls with a steel cap. The project will also include installing new stormwater sewer utilities along Clearwood Drive to provide an outlet for the pond, and new bituminous pavement along portions of East Palm Street, South Blackman Avenue, and Clearwood Drive. Table 1 below provides additional project details and Figure 1 shows an illustration of the proposed project layout. The new pavement areas are shown in on the sketch in dark gray.

Table 1. Site Aspects and Grading Description

Aspect	Description
Utility Depths	Storm Sewer – approximately 2 to 19 feet deep
Pavement type	Bituminous
Assumed Average Daily Traffic	East Palm Street and South Blackman Avenue – Less than 250 (Assumed) Clearwood Drive – Less than 100 (Assumed)
Grade changes along roadways	Less than 1 foot (Assumed)

Figure 1. Project Layout

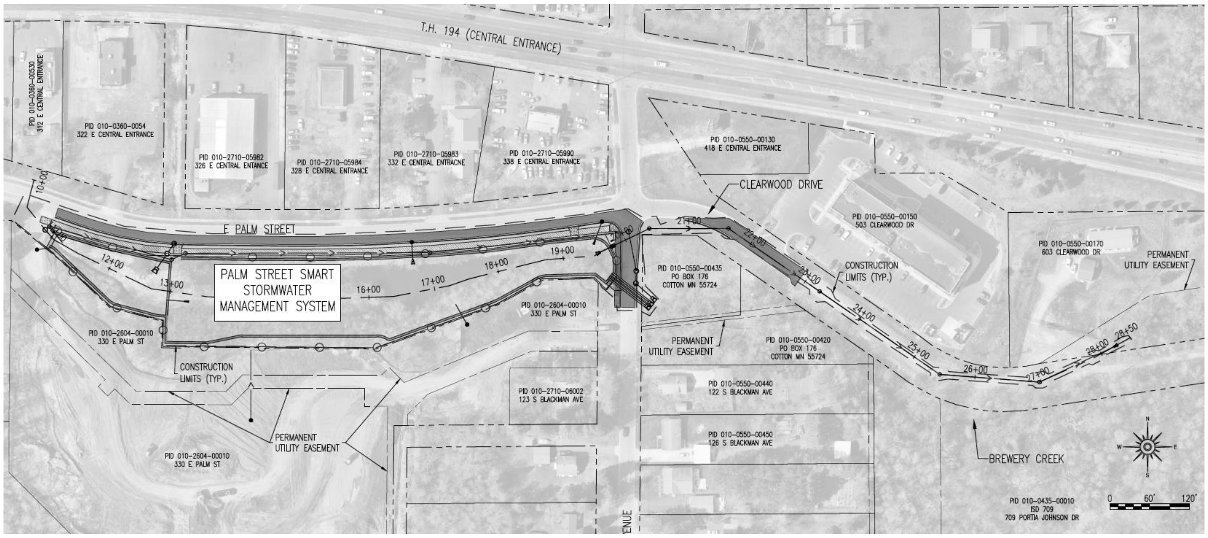
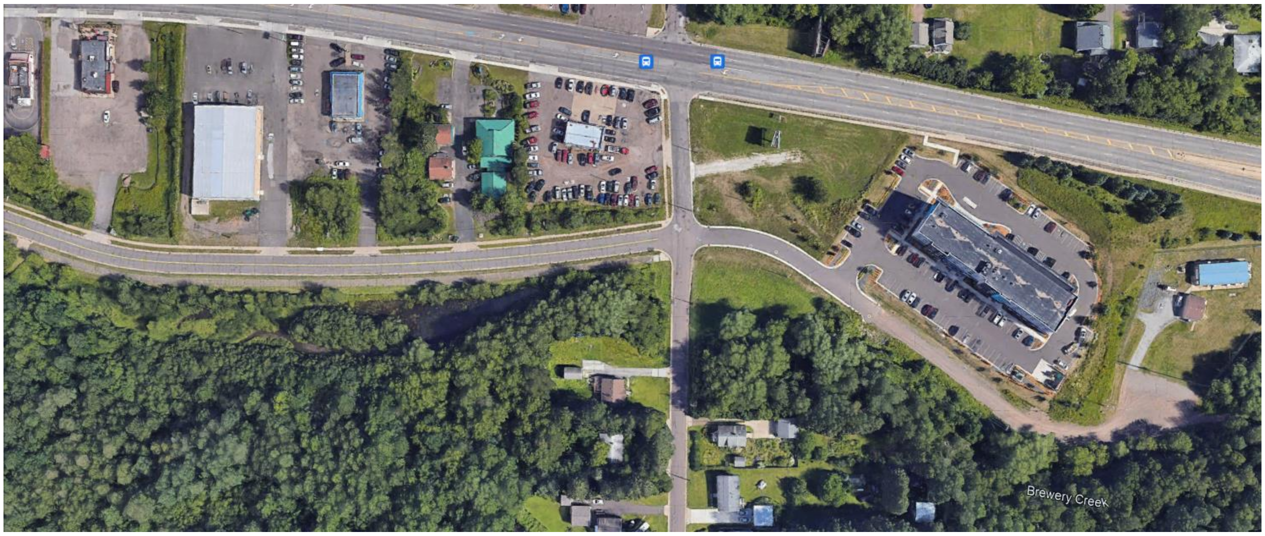


Figure provided by the City of Duluth dated April 9, 2024.

A.2. Site Conditions

The figure below shows the approximate existing conditions of the site. Based on the elevations measured at our exploration locations, current grades range from about 1206 1/2 to 1226. Generally, the site slopes downward to the east.

Figure 2. Approximate Existing Site Conditions



Photograph provided by Google Earth®.

A.3. Purpose

The purpose of our geotechnical evaluation is to characterize subsurface geologic conditions at selected exploration locations, evaluate their impact on the project, and provide geotechnical recommendations for the design and construction of the stormwater pond walls and new stormwater sewer along Clearwood Drive.

A.4. Background Information and Reference Documents

We reviewed the following information:

- A proposal request from Brad Scott, PE, with the City of Duluth.
- Preliminary construction plans for the Palm Street Permanent Stormwater Management System Improvements project, prepared by the City of Duluth, undated.
- A boring location figure prepared by LHB, Inc.

- A Geologic Map of Minnesota, prepared by Howard C. Hobbs and Joseph E. Goebel, 1982.
- Aerial photographs of the project areas using Google Earth®.

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 QTB196933 to Mr. Scott dated June 7, 2024, and authorized on June 14, 2024 with PO 24-0104. 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 clearing the boring locations of underground utilities. LHB, Inc. selected and we staked the boring locations. We acquired the surface elevations and locations with GPS technology using the State of Minnesota's permanent GPS base station network. The Soil Boring Location Sketch included in the Appendix shows the approximate locations of the borings.

- Performing 14 standard penetration test (SPT) borings, denoted as ST-2, ST-4, ST-7, ST-9, ST-12, ST-14, and ST-16 through ST-24, to nominal depths of 20 to 25 feet below grade.

- Performing 10 flight auger borings, denoted as FA-1, FA-3, FA-5, FA-6, FA-8, FA-10, FA-11, FA-13, FA-15, and FA-16, to nominal depths of 20 feet below grade, or refusal. FA-10 was not completed due to inaccessibility.

- Coring the bedrock if encountered at 2 boring locations. Bedrock was not encountered in our borings.

- 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 recommendations for utility and pavement subgrade preparation, installation of utilities, lateral earth pressures for retaining walls, and design of bituminous pavements.

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.

B.2. Boring Results

Table 2 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 sheets in the Appendix include definitions of abbreviations used in Table 2.

Table 2. Subsurface Profile Summary*

Strata	Soil Type - ASTM Classification	Range of Penetration Resistances	Commentary and Details
Topsoil and Topsoil fill	SM	---	▪ Encountered in Borings ST-2, ST-4, ST-7, ST-9, ST-12, ST-14, and ST-17 through ST-21. ▪ Predominantly black to dark brown SM. ▪ Thicknesses at boring locations varied from 1/2 to 3 feet. ▪ Moisture condition generally moist.
Fill	SP-SM, SM, SC		▪ Encountered in Borings ST-2, ST-4, ST-7, ST-9, ST-12, ST-14, and ST-17 through ST-20, ST-22, ST-23, and ST-24. ▪ General penetration resistance of 7 to 15 BPF.

Strata	Soil Type - ASTM Classification	Range of Penetration Resistances	Commentary and Details
			▪ Moisture condition generally moist or wet. ▪ Extended to depths ranging from 1 1/2 to 14 feet. ▪ A portion or all of the existing fill soils in Borings ST-9, ST-12, ST-19, and ST-24 contained traces of roots and organic material.
Lacustrine	SM, ML, SC	4 to 19 BPF	▪ Encountered below the fill soils in Boring ST-2, ST-4, ST-7, ST-9, ST-12, ST-14, and ST-17. ▪ General penetration resistance of 5 to 10 BPF indicting the lacustrine soils are medium or loose. ▪ Moisture condition generally moist or wet.
Glacial deposits	GP, SP, SP-SM, SM, ML	5 to Greater than 50 BPF	▪ Encountered below the topsoil, fill, and lacustrine soils in Borings ST-2, ST-4, ST-7, ST-9, ST-12, ST-14, and ST-17 through ST-20, ST-22, ST-23, and ST-24. ▪ Layers of glacial outwash and glacial till. ▪ General penetration resistance of the gravel, sand, and silt soils was 10 to 25 BPF indicating they are loose to medium dense. ▪ General penetration resistance of the clayey soil was 7 to 15 BPF indicating they are medium to stiff. ▪ Variable amounts of gravel; may contain cobbles and boulders. ▪ Moisture condition generally moist or wet
	SC, CL	5 to 29 BPF	

*Abbreviations defined in the attached Descriptive Terminology sheets.

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

B.3. Groundwater

Table 3 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	Surface Elevation	Observed Depth to Groundwater (ft)	Corresponding Groundwater Elevation (ft)
FA-1	1225.7	Not Measured	---
ST-2	1224.9	13 1/2	1211 1/2
FA-3	1224.2	Not Measured	---
ST-4	1223.4	8	1215 1/2

Location	Surface Elevation	Observed Depth to Groundwater (ft)	Corresponding Groundwater Elevation (ft)
FA-5	1222.7	Not Measured	---
FA-6	1222.9	Not Measured	---
ST-7	1222.7	5 1/2	1217 1/2
FA-8	1222.2	Not Measured	---
ST-9	1219.7	11	1209
FA-10	1222.9	Not Completed	---
FA-11	1222.5	Not Measured	---
ST-12	1221.1	4	1217 1/2
FA-13	1221.2	Not Measured	---
ST-14	1222.7	7 1/2	1215 1/2
FA-15	1223.6	Not Measured	---
FA-16	1221.4	Not Measured	---
ST-17	1224	Not Observed	---
ST-18	1225.4	18 1/2	1207
ST-19	1222.4	11 1/2	1211
ST-20	1221.0	12	1209
ST-21	1218.6	11 1/2	1207 1/2
ST-22	1213.3	15 1/2	1198
ST-23	1209.3	10	1200
ST-24	1206.8	6 1/2	1200 1/2

*Depth to groundwater in flight auger (FA-#) borings was not measured.

Project planning should anticipate seasonal and annual fluctuations of groundwater.

B.4. Laboratory Test Results

The boring logs show the results of moisture content and percent passing a #200 sieve testing we performed, next to the tested sample depth.

C. Recommendations

C.1. Design and Construction Discussion

C.1.a. Utility and Pavement Support

Based on the anticipated utility invert depths and our soil borings, it appears the utility subgrades will consist of poorly graded gravel with sand, silty sand, clayey sand, sandy lean clay or sandy silt.

These soils appear suitable for support of the utilities; however, they are susceptible to disturbance, especially the lacustrine soils. Furthermore, the sandy silt and fine-grained silty sand soils are extremely susceptible to disturbance. Subgrade stabilization and dewatering will be necessary on portions of the project to facilitate installation of the utilities. Care will need to be taken to minimize the disturbance of susceptible soils.

The borings indicate the roadway subgrade soils will consist of existing silty sand and clayey sand fill soils. The non-organic soils are suitable for the pavement subgrades but are considered marginal since they will become unstable when wet and will require moisture conditioning for proper compaction. They are also frost susceptible and require thicker pavement sections.

C.1.b. Reuse of On-Site Soils and Construction Disturbance

The existing, non-organic, debris-free, soils are suitable for reuse as fill and backfill for the utilities and roadways. If encountered, we do not recommend reusing black existing fill that contains organic material below the utilities or roadways.

The wet lacustrine soils, especially the sandy silt and fine-grained silty sand soils, near the utility bearing depth are extremely sensitive to moisture and disturbance during placement and, therefore, in our opinion very difficult to re-use as backfill and fill, unless they are segregated during excavation and dried.

We generally recommend backfilling over wet excavation bottoms with coarse sand or gravel having less than 50 percent of the particles by weight passing a number 40 sieve, and less than 5 percent of the particles passing a number 200 sieve (P200).

We recommend any imported material brought to the site for use as engineered backfill and fill be free of any debris, construction related or otherwise, free of vegetation and organic material, and consist of granular soils containing less than 20 percent passing the 200 sieve.

C.1.c. Site Retaining Walls

For retaining walls supported on spread footings, we recommend topsoil, organic soil, existing fill soil, and any soft or very loose soils be completely removed from below the proposed walls and their oversize areas. Based on the borings completed around the existing pond, topsoil and existing fill depths ranged from 6 to 11 1/2 feet deep. Structural fill can then be placed to proposed grades. After soil corrections, the prepared subgrade soils can support the walls.

For sheet pile supported and sheet pile walls, we did not encounter refusal to advance or apparent bedrock in our borings. Based on the borings, we anticipate the soils adjacent the sheet pile and site retaining walls will consist of poorly graded sand with silt, silty sand, and clayey sand fill, silty sand and sandy silt lacustrine soils, and glacial poorly graded sand, silty sand, and clayey sand soils.

While installing sheet piles, the glacial soils that will be penetrated are generally more dense and stiffer than the existing fill and lacustrine soils, which may slow down production. Cobbles may also be encountered while penetrating the glacial soils.

C.2. Utility Installation

C.2.a. Excavations

It is our opinion that the soils encountered by the borings can be excavated using a typical open-cut method with a backhoe. At the anticipated excavation depths, the soils in the sidewalls of the excavations will be Type C soils under the Department of Labor Occupational Safety and Health Administration (OSHA) guidelines.

The sandy silt and fine-grained silty sand soils encountered in the borings will likely be very fluid during excavation and may cause the sidewalls to slough very flat.

C.2.b. Excavation Subgrades

Bedding in the sandy silts and fine-grained silty sand soils will require stabilization as indicated below.

Based on the anticipated utility invert depths and our soil borings, it appears the utility subgrades will consist of poorly graded gravel with sand, silty sand, clayey sand, sandy lean clay or sandy silt. These soils appear adequate for support of the utilities.

Most of the soils at the utility bearing depths will be wet and are susceptible to disturbance. The sandy silts and fine-grained silty sands, and areas with wet, disturbed subgrades or subgrades that are allowed to become wet will require bedding with rock and potentially rock wrapped in fabric as described below.

C.2.c. Subgrade Stabilization

Boring ST-9 encountered wet sandy silt and silt soils near the anticipated utility invert depths. Stabilizing aggregate, potentially wrapped in fabric will be required to stabilize the silt to facilitate construction of the utilities. Stabilization may also be required in other areas with silty and clayey utility subgrade soils if they are disturbed, are wet, or are allowed to become wet.

For stabilization, we recommend 6 to 12 inches of coarse sand or gravel having less than 50 percent of the particles by weight passing a number 40 sieve, and less than 5 percent of the particles passing a number 200 sieve. Alternately, 1 1/2-inch crushed rock (or Class 2 Ballast) could be used.

C.2.d. Excavation Dewatering

Project planning should include temporary sumps and pumps for utility trench excavations in low-permeability soils, such as the onsite silty sand, clayey sand, and sandy lean clay soils. Dewatering of the sandy silts will be very difficult and will require specialty equipment.

C.2.e. Selecting Excavation Backfill

The onsite soils will require draying to facility adequate compaction. In addition, these soils are susceptible to disturbance and will be difficult to compact if they are not near their optimum moisture contents.

The sandy silt and fine-grained silty sand soils are extremely sensitive to disturbance and will be very difficult to compact. We recommend the sandy silt and fine-grained silty sand soils be segregated and dried prior to using them as backfill

On-site sandy soils that do not contain debris, black soils or organic material may be used as backfill material.

C.2.f. Placement and Compaction of Backfill

We recommend spreading backfill and fill in loose lifts of 12 inches prior to compacting. We recommend compacting backfill and fill in accordance with the criteria presented below in Table 4.
The relative compaction of utility backfill should be evaluated based on the structure below which it is installed, and vertical proximity to that structure.

Table 4. Compaction Recommendations Summary

Area of Backfill Placement	Relative Compaction, percent (ASTM D698 – Standard Proctor)	Moisture Content Variance from Optimum, percentage points	
		< 12% Passing #200 Sieve (typically SP, SP-SM)	> 12% Passing #200 Sieve (typically SM, SC, CL, ML)
Within 1:1 oversize zone of pavements, within 3 feet of subgrade elevations	100	±3	-1 to +3
Within 1:1 oversize zone of pavements, more than 3 feet of subgrade elevations	95	±3	-1 to +3

C.2.g. Corrosion Potential

Based on our experience, the soils encountered by most of the borings are moderately corrosive to metallic conduits, but only marginally corrosive to concrete. We recommend bedding the utilities in sandy soil free of any clay lumps or constructing the utilities with non-corrosive materials. Some of the borings encountered sandy soils. We consider these soils non- to slightly corrosive to metallic conduits.

C.3. Pavement Reconstruction

C.3.a. Subgrade Preparation

We recommend the following steps for pavement subgrade preparation, understanding the reconstructed roadways will have a grade change of 1 foot or less.

1. Strip unsuitable soils consisting of black organic soils within 3 feet of the bottom of the proposed aggregate base layer (top of pavement subgrade). The existing fill soils encountered in Boring ST-9 contained traces of roots and organic material.

2. Have a geotechnical representative observe the excavated subgrade to evaluate if additional subgrade improvements are necessary.

3. Scarify, moisture condition and surface compact the subgrade with at least 5 passes of a large roller with a minimum drum diameter of 3 1/2 feet.

4. Place pavement engineered fill to grade and compact in accordance with Section C.3.c. to bottom of pavement.

5. Proofroll the pavement subgrade as described in Section C.3.d.

To improve long-term pavement performance, we recommend incorporating at least 12 inches of sand containing less than 7 percent fines passing the #200 sieve in paved areas, in addition to the recommendations above, as a sand subbase. Note, we recommend sloping subgrade soils to promote drainage and removal of accumulated water.

C.3.b. Selecting Excavation Backfill and Additional Required Fill

On-site soils that are free of black, organic, or foreign materials and debris can be reused as backfill. Soils with less than 12 percent silt and clay should be used for backfill placed below water or on wet subgrades, or immediately below the aggregate base section.

C.3.c. Placement and Compaction of Backfill and Fill

We recommend compacting fill and backfill material within the pavement subgrades to a minimum of 100 percent of their standard Proctor maximum dry density. At depths greater than 3 feet below the street subgrade, the minimum compaction requirement may be decreased to 95 percent of standard Proctor maximum dry density. Fill and backfill soils should be placed at moisture contents as indicated in Table 4 above.

C.3.d. Pavement Subgrade Proofroll

After preparing the subgrades as described above and prior to the placement of the aggregate base, we recommend proofrolling the subgrade soils with a fully loaded tandem-axle truck. We also recommend having a geotechnical representative observe the proofroll. Areas that fail the proofroll likely indicate soft or weak areas that will require additional soil correction work to support pavements.

The contractor should correct areas that display excessive yielding or rutting during the proofroll, as determined by the geotechnical representative. Possible options for subgrade correction include moisture conditioning and recompaction, subcutting and replacement with soil or crushed aggregate, chemical stabilization and/or geotextiles. We recommend performing a second proofroll after the aggregate base material is in place, and prior to placing bituminous or concrete pavement.

C.4. Pavements

C.4.a. Design Sections

Our scope of services for this project did not include laboratory tests on subgrade soils to determine an R-value for pavement design. Based on our experience with similar silty sand and clayey sand soils anticipated at the pavement subgrade elevation, we recommend pavement design assume an R-value of 20.

Note the contractor may need to perform limited removal of unsuitable or less suitable soils to achieve this value. Table 5 provides recommended pavement sections, based on the soils support and traffic loads.

Table 5. Recommended Bituminous Pavement Section

Use	Roadway Section
Minimum asphalt thickness	4 Inches
Minimum aggregate base thickness	8 Inches
Minimum Granular Subbase	12 inches

C.4.b. Bituminous Pavement Materials

Appropriate mix designs are critical to the performance of flexible pavements. We can provide recommendations for pavement material selection during final pavement design.

C.4.c. Subgrade Drainage

We recommend installing perforated drainpipes throughout pavement areas at low points. The contractor should place drainpipes in small trenches, extended at least 8 inches below the granular subbase layer, or below the aggregate base material where no subbase is present.

C.4.d. Performance and Maintenance

We based the above pavement designs on a 20-year performance life for bituminous. This is the amount of time before we anticipate the pavement will require reconstruction. This performance life assumes routine maintenance, such as seal coating and crack sealing. The actual pavement life will vary depending on variations in weather, traffic conditions and maintenance.

It is common to place the non-wear course of bituminous and then delay placement of wear course. For this situation, we recommend evaluating if the reduced pavement section will have sufficient structure to support construction traffic.

Many conditions affect the overall performance of the pavements. Some of these conditions include the environment, loading conditions and the level of ongoing maintenance. With regard to bituminous pavements in particular, it is common to have thermal cracking develop within the first few years of placement, and continue throughout the life of the pavement. We recommend developing a regular maintenance plan for filling cracks in pavements to lessen the potential impacts for cold weather distress due to frost heave or warm weather distress due to wetting and softening of the subgrade.

C.5. Retaining Walls

The following comments and recommendations may be used in retaining wall design and construction, however, final design responsibility will rest with the wall design engineer. Retaining wall designers should be informed of site features and utilities that would influence their design. Our scope of services did not include global stability analysis. If desired, we can provide global stability analysis of the proposed walls.

We understand the retaining walls will be cast-in-place walls supported on spread footings or drive sheet piles bearing in native soils. Alternately, the retaining walls may be sheet pile walls bearing in native soils with a steel cap. The followings sections provide recommendations for these types of retaining walls.

C.5.a. Excavation and Subgrade Preparation for Walls Supported on Spread Footings

To prepare the area for a cast-in-place wall supported on spread footings, the site should be cut to grade and any topsoil, organic soil, existing fill soil, and very loose or soft soils observed below the wall and its reinforced zone be removed and replaced. Dewatering as described in Section C.2.d. above will be required during excavation.

Table 6 shows the anticipated excavation depths and bottom elevations for each of the SPT boring locations performed adjacent the pond.

Table 6. Spread Footing Supported Retaining Wall Excavation Depths

Location	Approximate Surface Elevation (ft)	Anticipated Excavation Depth (ft)	Anticipated Bottom Elevation (ft)
ST-2	1224.9	11 1/2	1213
ST-4	1223.4	6 1/2	1216 1/2
ST-7	1222.7	10	1212 1/2
ST-9	1219.7	8	1211 1/2
ST-12	1221.1	9	1212
ST-14	1222.7	6 1/2	1216

However, further direction regarding soil correction depths and suitable subgrade soils should be provided by the retaining wall designer. The soil borings indicate the walls will likely bear on sandy silt and silty sands that are susceptible to disturbance.

Contractors should use techniques which would limit the disturbance. Provisions to subcut and replace soils with crushed aggregate base should be anticipated to provide a stable working platform.

We also recommend for excavations that extend below the wall elevation be extended laterally beyond the edges of the proposed footings a minimum of 1 foot for each vertical foot below the footing at that location (i.e., 1:1 lateral oversizing). If MSE walls are used, we recommend the lateral oversizing extend outward and downward from the back of the lateral reinforcement behind the wall.

If the existing fill soils are not corrected below the footings, the wall design should expect walls placed on existing fill to have a greater amount of post-construction settlement, both differential and total settlements, than walls placed on new fill or native soils.

C.5.b. Drainage

Drainage behind the walls is critical. Unless a drainage composite is placed against the backs of the retaining walls, we recommend that fill placed within 2 horizontal feet of the walls consist of sand having less than 7 percent silts and clays passing the #200 sieve. If “clear” gravel only is used for drainage, a fabric separator may be needed to keep sand from washing into the gravel. Water within this zone should be removed and routed away from the wall and its foundation zone.

Wall fill not capped with slabs or pavement should be capped with a low-permeability soil to limit the infiltration of surface drainage into the fill. Grades should also be sloped to divert water away from the walls and the reinforced zone. We recommend the wall designer be consulted if water is introduced to the area of the wall.

C.5.c. Net Allowable Bearing Pressure for Spread Footings

We anticipate foundations for the proposed retaining wall will bear on native sandy silt, silty sand soils sandy structural fill soil.

For wall design purposes, we recommend foundations bearing on these materials be designed to exert a maximum soil bearing pressure of 1,500 pounds per square foot (psf). All foundation subgrades should be reviewed by a geotechnical engineer.

We anticipate total settlement of the wall will not exceed 1 inch; however, we recommend additional settlement analysis be performed as part of final wall design.

C.5.d. Selection, Placement and Compaction of Fill

Table 7 below contains our recommendations for retaining wall engineered fill materials.

Table 7. Retaining Wall Engineered Fill Materials*

Locations To Be Used	Engineered Fill Classification	Possible Soil Type Descriptions	Gradation	Additional Requirements
Below retaining wall footings**	Structural fill	GP, GW, SP, SW, SP-SM, SW-SM, SM, SC, CL, ML	100% passing 3-inch sieve	< 2% Organic Content (OC)
▪ Drainage layer ▪ Non-frost-susceptible	▪ Free-draining ▪ Non-frost-susceptible fill	GP, GW, SP, SW, SP-SM, SW-SM	100% passing 1-inch sieve < 50% passing #40 sieve < 7% passing #200 sieve	< 2% OC
Behind retaining walls, beyond drainage layer	Retained fill	SP, SW, SP-SM, SW-SM, SM, SC, CL	100% passing 3-inch sieve	< 2% OC Plasticity Index (PI) < 20%
Below landscaped surfaces	Non-structural fill	Any	100% passing 6-inch sieve	< 10% OC

* More select soils comprised of coarse sands with < 5% passing #200 sieve may be needed to accommodate work occurring in periods of wet or freezing weather.

**See Section C.1.b. for additional information for selection of appropriate backfill soils.

We recommend spreading engineered fill in loose lifts of approximately 8 to 12 inches thick. We recommend compacting engineered fill in accordance with the criteria presented below in Table 8. The project documents should specify relative compaction of engineered fill, based on the structure located above the engineered fill, and vertical proximity to that structure.

Table 8. Compaction Recommendations Summary

Reference	Relative Compaction, percent (ASTM D698 – Standard Proctor)	Moisture Content Variance from Optimum, percentage points	
		< 12% Passing #200 Sieve (typically SP, SP-SM)	> 12% Passing #200 Sieve (typically CL, SC, SM, ML)
Below foundations and oversizing zones	98	±3	-1 to +3
Below landscaped surfaces	90	±5	±4
Adjacent to below-grade walls	95*	±3	-1 to +3

*Increase compaction requirement to meet compaction required for structure supported by this engineered fill.

We recommend fill be placed on level surfaces. Therefore, any fill placed on or against sloping ground should begin from the bottom of the slope where a level surface can be established and properly 'keyed' into the slope. Keys should consist of a level bench excavated to a convenient width for the equipment used. This will provide a more stable fill condition and reduce the potential for slip surface to occur along the existing soil/new fill interface.

The project documents should not allow the contractor to use frozen material as engineered fill or to place engineered fill on frozen material. Frost should not penetrate under foundations during construction.

We recommend a walk-behind compactor be used to compact the fill placed within about 5 feet of the retaining walls. Further away than that, a self-propelled compactor can be used.

We recommend performing density tests in engineered fill to evaluate if the contractors are effectively compacting the soil and meeting project requirements.

C.5.e. Sheet Pile Considerations

As noted above in Section C.1.c., our borings did not encounter refusal to advance or apparent bedrock. However, while installing sheet piles, the glacial soils that will be penetrated are generally more dense and stiffer than the existing fill and lacustrine soils, which may slow down production. Cobbles may also be encountered while penetrating the glacial soils.

C.5.f. Configuring and Resisting Lateral Loads

Below-grade wall design can use active earth pressure conditions, if the walls can rotate slightly. If the wall design cannot tolerate rotation, then design should use at-rest earth pressure conditions. Rotation up to 0.002 times the wall height is generally required for walls supporting sand. Rotation up to 0.02 times the wall height is required when wall supports clay.

Table 9 presents our recommended lateral coefficients and equivalent fluid pressures for wall design of active, at-rest and passive earth pressure conditions. The table also provides recommended wet unit weights and internal friction angles.

Designs should also consider the slope of any engineered fill and dead or live loads placed behind the walls within a horizontal distance that is equal to the height of the walls. Our recommended values assume the wall design provides drainage so water cannot accumulate behind the walls. The construction documents should clearly identify what soils the contractor should use for engineered fill of walls.

Table 9. Recommended Below-Grade Wall Design Parameters – Drained Conditions

Retained Soil	Wet Unit Weight (pcf)	Friction Angle (degrees)	Fluid Pressure, Active Case (pcf)	Fluid Pressure, At-Rest Case (pcf)	Fluid Pressure, Passive Case (pcf)
SP, SP-SM	115	32	35	55	370
SM, ML	110	30	40	55	330
SC, CL	110	26	45	65	280

* Based on Rankine model for soils in a region behind the wall extending at least 2 horizontal feet beyond the bottom outer edges of the wall footings and then rising up and away from the wall at an angle no steeper than 60 degrees from horizontal.

The values presented in this section are un-factored.

C.5.g. Global Factor of Safety

In addition to other applicable stability and performance demonstrations, we recommend retaining wall design documents or submittals contain demonstrations of global stability with a minimum factor of safety against global failure of 1.5 or greater.

D. Procedures

D.1. Penetration Test Borings

We drilled the penetration test borings with a floatation tire carrier-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. Exploration Logs

D.2.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. The logs also present the results of laboratory tests performed on penetration test samples, and groundwater measurements.

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.2.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.3. Material Classification and Testing

D.3.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.3.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.4. Groundwater Measurements

The drillers checked for groundwater while advancing the penetration test borings, and again after auger withdrawal. We then filled 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

F:\2024\B2406482\CAD\B2406482.dwg,Geotech,7/18/2024 9:56:25 AM

● **DENOTES APPROXIMATE LOCATION OF STANDARD PENETRATION TEST BORING**

75' 0 150'

SCALE: 1"=150'

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4511 W 1st Street, Suite 4
Duluth, MN 55807
218.624.4967
braunintertec.com

Drawing Information

Project No:
B2406482

Drawing No:
B2406482

Drawn By:	MMH
Date Drawn:	7/18/24
Checked By:	DM
Last Modified:	7/18/24

Project Information

Palm Street Pond

Blackman Avenue and
Palm Street

Duluth, Minnesota

Soil Boring Location Sketch

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**FA-1**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154651	EASTING:	581426
START DATE:	07/01/24	END DATE:	07/01/24
SURFACING:	Soil	WEATHER:	Cloudy, 80°

DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud

SURFACE ELEVATION:	1225.7 ft	RIG: 75012	METHOD: 3 1/4" HSA	

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
		Auger advanced without sampling					
		5					
		10					
		15					
		20					
		25					
		30					
		35					
1189.7 36.0		END OF BORING Boring immediately backfilled with bentonite grout					

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**ST-2**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154628	EASTING:	581519
START DATE:	07/22/24	END DATE:	07/22/24
SURFACING:	Soil	WEATHER:	Cloudy, 80°

DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud		
SURFACE ELEVATION:	1224.9 ft	RIG:	75012	METHOD:	3 1/4" HSA

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	qp tsf	MC %	Tests or Remarks
		SILTY SAND (SM), fine-grained, with roots, dark brown, moist (TOPSOIL FILL)		AU			
1224.5 0.4		FILL: SILTY SAND (SM), fine-grained, trace Gravel, brown and dark brown, moist	5	4-7-11 (18) 12" 6-5-5 (10) 9" 2-4-3 (7) 5"			
1215.9 9.0		SANDY SILT (ML), brown, wet, very loose (LACUSTRINE)	10	1-2-2 (4) 9"			
1213.4 11.5		SILTY SAND (SM), fine-grained, brown, wet, loose (LACUSTRINE)		3-5-5 (10) 7"			
1210.9 14.0	▽ ▼	CLAYEY SAND (SC), with Silt, little Gravel, brown, wet, medium (GLACIAL TILL)	15	2-2-3 (5) 10"			
1206.9 18.0		SILTY SAND (SM), fine-grained, with Gravel, brown, wet, loose to medium dense (GLACIAL TILL)	20 25 30	6-9-10 (19) 8" 4-6-4 (10) 5" 4-6-7 (13) 7"			
1191.9 33.0		POORLY GRADED SAND with SILT (SP-SM), fine to medium-grained, brown, wet, very dense (GLACIAL OUTWASH)	35	4-27-21 (48) 9"			
1188.9 36.0		END OF BORING Boring immediately backfilled with bentonite grout					Water observed at 13.5 feet while drilling. Water observed at 15.0 feet at end of drilling.

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**FA-3**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154623	EASTING:	581616
START DATE:	07/22/24	END DATE:	07/22/24
SURFACING:	Soil	WEATHER:	Cloudy, 80°

DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud
SURFACE ELEVATION:	1224.2 ft	RIG: 75012	METHOD: 3 1/4" HSA

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
		Auger advanced without sampling					
1188.2 36.0		END OF BORING Boring immediately backfilled with bentonite grout					

Depth scale: 5, 10, 15, 20, 25, 30, 35

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482 **Geotechnical Evaluation** **Palm Street Pond** **Blackman Avenue and Palm Street** **Duluth, Minnesota**	BORING: **ST-4** LOCATION: Captured with submeter GPS. DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet) NORTHING: 154622 EASTING: 581724
DRILLER: M. Heinzen LOGGED BY: A. Hillerud	START DATE: 07/23/24 END DATE: 07/23/24
SURFACE ELEVATION: 1223.4 ft RIG: 75012 METHOD: 3 1/4" HSA	SURFACING: Soil WEATHER: Cloudy, 80°

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
1223.0		SILTY SAND (SM), fine-grained, with roots, dark brown, moist (TOPSOIL FILL)	■	AU			
0.4 1219.4		FILL: SILTY SAND (SM), fine-grained, trace Gravel, brown and dark brown, moist	⊠	7-8-8 (16) 14"			
4.0 1216.9		FILL: SILTY SAND (SM), fine to coarse-grained, with Gravel, brown, moist	5 ⊠	5-7-9 (16) 10"			
6.5 1214.4	▽	SILTY SAND (SM), fine-grained, brown, wet, loose (LACUSTRINE)	⊠	7-3-2 (5) 9"			
9.0 1205.4	▼	CLAYEY SAND (SC), with Silt, with Gravel, brown, wet, medium dense to very stiff (GLACIAL TILL)	10 ⊠ ⊠ 15 ⊠	4-3-2 (5) 8" 3-2-3 (5) 10" 7-9-7 (16) 0"			
18.0 1190.4		SILTY SAND (SM), fine to medium-grained, little Gravel, brown, wet, medium dense to loose (GLACIAL TILL)	20 ⊠ 25 ⊠ 30 ⊠	8-10-11 (21) 0" 7-6-5 (11) 12" 1-2-3 (5) 10"			
33.0 1187.4		CLAYEY SAND (SC), with Gravel, brown, moist, very stiff (GLACIAL TILL)	35 ⊠	8-12-12 (24) 8"			
36.0		END OF BORING Boring immediately backfilled with bentonite grout					Water observed at 8.0 feet while drilling. Water observed at 15.0 feet at end of drilling.

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**FA-5**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154622	EASTING:	581812
DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud
START DATE:	07/23/24	END DATE:	07/23/24
SURFACE ELEVATION:	1222.7 ft	RIG:	75012
METHOD:	3 1/4" HSA		
SURFACING:	Soil	WEATHER:	Cloudy, 80°

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
		Auger advanced without sampling					
1189.7 33.0		END OF BORING Boring immediately backfilled with bentonite grout					

Depth scale: 5, 10, 15, 20, 25, 30, 35

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**FA-6**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154626	EASTING:	581925
START DATE:	07/23/24	END DATE:	07/23/24
SURFACING:	Soil	WEATHER:	Cloudy, 80°

DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud
SURFACE ELEVATION:	1222.9 ft	RIG: 75012	METHOD: 3 1/4" HSA

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
		Auger advanced without sampling					
1189.9 33.0		END OF BORING Boring immediately backfilled with bentonite grout					

Depth scale: 5, 10, 15, 20, 25, 30, 35

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**ST-7**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154632	EASTING:	582023
START DATE:	07/23/24	END DATE:	07/23/24
SURFACING:	Soil	WEATHER:	Cloudy, 80°

DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud		
SURFACE ELEVATION:	1222.7 ft	RIG:	75012	METHOD:	3 1/4" HSA

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	qₚ tsf	MC %	Tests or Remarks
1222.3 0.4		SILTY SAND (SM), with roots, dark brown, moist (TOPSOIL FILL)		AU			
1218.7 4.0		FILL: SILTY SAND (SM), fine-grained, little Gravel, brown, moist		5-2-3 (5) 8"			
1212.7 10.0	▽	FILL: POORLY GRADED SAND with SILT (SP-SM), fine to medium-grained, little Gravel, brown, moist to wet	5	4-4-12 (16) 9" 4-5-8 (13) 14"			
1208.7 14.0		SILTY SAND (SM), fine to medium-grained, little Gravel, brown, wet, medium dense (LACUSTRINE)	10	8-19-17 (36) 0" 7-6-6 (12) 8"			
1204.7 18.0		SILTY SAND (SM), fine-grained, brown, wet, loose (LACUSTRINE)	15	4-5-4 (9) 12"			
1194.7 28.0		SANDY SILT (ML), brown, wet, loose (LACUSTRINE)	20 25	3-3-5 (8) 10" 4-6-4 (10) 12"			
1190.7 32.0		SILTY SAND (SM), fine-grained, brown, wet, medium dense (LACUSTRINE)	30	7-9-10 (19) 9"			
1188.7 34.0		CLAYEY SAND (SC), with Silt, with Gravel, brown, moist, very stiff (GLACIAL TILL)		9-13-12 (25) 2"			Water observed at 5.5 feet while drilling.
		END OF BORING Boring immediately backfilled with bentonite grout	35				

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**FA-8**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154647	EASTING:	582150
DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud
START DATE:	07/23/24	END DATE:	07/23/24
SURFACE ELEVATION:	1222.2 ft	RIG:	75012
METHOD:	3 1/4" HSA		
SURFACING:	Soil	WEATHER:	Cloudy, 80°

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
1189.2 33.0		Auger advanced without sampling					
		END OF BORING Boring immediately backfilled with bentonite grout					

5
10
15
20
25
30
35

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**ST-9**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154611	EASTING:	582246
DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud
START DATE:	07/23/24	END DATE:	07/23/24
SURFACE ELEVATION:	1219.7 ft	RIG:	75012
METHOD:	3 1/4" HSA	SURFACING:	Soil
WEATHER:	Cloudy, 80°		

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
1219.4 0.3		SILTY SAND (SM), fine-grained, with roots, dark brown, moist (TOPSOIL FILL)		AU			
		FILL: CLAYEY SAND (SC), little Gravel, trace roots, trace organic, dark brown and grayish brown, moist		2-3-4 (7) 7"		16	P200=36%
			5	3-2-2 (4) 9"			
				2-1-2 (3) 7"			
1211.7 8.0		SANDY SILT (ML), with Clay, brown, wet, loose (LACUSTRINE)	10	3-3-4 (7) 13"			
	▼			2-3-3 (6) 12"			
1205.7 14.0	▽	SILTY SAND (SM), fine-grained, little Gravel, brown, moist, medium dense (GLACIAL TILL)	15	2-7-8 (15) 9"			
			20	5-6-11 (17) 10"			
1196.7 23.0		SILTY SAND (SM), fine to coarse-grained, with Gravel, brown, wet, medium dense (GLACIAL TILL)	25	4-9-10 (19) 7"			
			30	7-10-9 (19) 10"			
1188.7 31.0		END OF BORING Boring immediately backfilled with bentonite grout	35				Water observed at 14.0 feet while drilling. Water observed at 11.0 feet at end of drilling.

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**FA-11**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154524	EASTING:	581967
START DATE:	07/25/24	END DATE:	07/25/24
SURFACING:	Soil	WEATHER:	Cloudy, 80°

DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud		
SURFACE ELEVATION:	1222.5 ft	RIG:	75012	METHOD:	3 1/4" HSA

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
		Auger advanced without sampling					
1189.5 33.0		END OF BORING Boring immediately backfilled with bentonite grout					

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**ST-12**
LOCATION: Captured with submeter GPS.	
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)	
NORTHING: 154505	EASTING: 581882
START DATE: 07/25/24	END DATE: 07/25/24
SURFACING: Soil	WEATHER: Cloudy, 80°

DRILLER: M. Heinzen	LOGGED BY: A. Hillerud		
SURFACE ELEVATION: 1221.1 ft	RIG: 75012	METHOD: 3 1/4" HSA	

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
1218.1		SILTY SAND (SM), fine-grained, with roots, dark brown, moist (TOPSOIL FILL)		AU 4-4-4 (8) 9"			
3.0 1215.1	▽	FILL: CLAYEY SAND (SC), little Gravel, trace roots, trace organic, dark brown and brown, wet		3-4-5 (9) 9"			
6.0 1207.1		SILTY SAND (SM), fine-grained, brown, wet, very loose to loose (LACUSTRINE)		4-2-2 (4) 12" 0-2-4 (6) 6" 2-2-2 (4) 9"			
14.0 1203.1		POORLY GRADED SAND with SILT (SP-SM), fine to medium-grained, little Gravel, brown, wet, medium dense (GLACIAL OUTWASH)		8-6-5 (11) 4"			
18.0 1190.1		SILTY SAND (SM), fine-grained, with Gravel, brown, moist, medium dense to dense (GLACIAL TILL)		9-7-10 (17) 9" 8-13-22 (35) 10" 16-17-20 (37) 8"			
31.0		END OF BORING Boring immediately backfilled with bentonite grout					Water observed at 4.0 feet while drilling.

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482 **Geotechnical Evaluation** **Palm Street Pond** **Blackman Avenue and Palm Street** **Duluth, Minnesota**	BORING: **FA-13**		
	LOCATION: Captured with submeter GPS.		
	DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)		
	NORTHING: 154502	EASTING: 581764	
DRILLER: M. Heinzen	LOGGED BY: A. Hillerud	START DATE: 07/25/24	END DATE: 07/25/24
SURFACE ELEVATION: 1221.2 ft RIG: 75012 METHOD: 3 1/4" HSA		SURFACING: Soil	WEATHER: Cloudy, 80°

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
		Auger advanced without sampling					
1190.2 31.0		END OF BORING Boring immediately backfilled with bentonite grout					

Depth scale: 5, 10, 15, 20, 25, 30, 35

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**ST-14**		
LOCATION:			
DATUM:	NAD 1983 HARN Adj MN St Louis North (US Feet)		
NORTHING:	154497	EASTING:	581677
DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud
START DATE:	07/24/24	END DATE:	07/29/24
SURFACE ELEVATION:	1222.7 ft	RIG:	75012
METHOD:	3 1/4" HSA	SURFACING:	Soil
WEATHER:	Cloudy, 80°		

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
1222.2 0.5		SILTY SAND (SM), fine-grained, with roots, dark brown, moist (TOPSOIL FILL)		AU			
1216.2 6.5		FILL: SILTY SAND (SM), fine-grained, little Gravel, brown, moist		4-4-3 (7) 6" 4-4-4 (8) 8"			
1213.7 9.0	▽	SILTY SAND (SM), fine-grained, brown, wet, loose (LACUSTRINE)		2-3-4 (7) 12"			
1211.2 11.5		CLAYEY SAND (SC), with Silt, little Gravel, brown, moist, very stiff (GLACIAL TILL)		3-5-11 (16) 10"			
1190.7 32.0	▼	SILTY SAND (SM), fine-grained, little Gravel, brown, moist, medium dense to very dense (GLACIAL TILL)		11-11-14 (25) 10" 8-11-12 (23) 10" 9-18-47 (65) 9" 5-7-11 (18) 10" 9-11-13 (24) 4"			
1188.7 34.0		SILTY SAND (SM), fine-grained, little Gravel, brown, moist, medium dense to very dense (GLACIAL TILL)		10-12-4 (16) 8"			
		END OF BORING Boring immediately backfilled with bentonite grout					Water observed at 7.5 feet while drilling. Water observed at 29.0 feet at end of drilling.

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**FA-15**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154510	EASTING:	581568
DRILLER: M. Heinzen	LOGGED BY: A. Hillerud		
START DATE:	07/24/24	END DATE:	07/24/24
SURFACE ELEVATION: 1223.6 ft	RIG: 75012	METHOD: 3 1/4" HSA	
SURFACING:	Soil	WEATHER:	Cloudy, 80°

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
		Auger advanced without sampling					
1189.6 34.0		END OF BORING Boring immediately backfilled with bentonite grout					

Depth scale: 5, 10, 15, 20, 25, 30, 35

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482 **Geotechnical Evaluation** **Palm Street Pond** **Blackman Avenue and Palm Street** **Duluth, Minnesota**	BORING: **FA-16**		
	LOCATION: Captured with submeter GPS.		
	DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)		
	NORTHING: 154548	EASTING: 581475	
DRILLER: M. Heinzen	LOGGED BY: A. Hillerud	START DATE: 07/25/24	END DATE: 07/25/24
SURFACE ELEVATION: 1221.4 ft	RIG: 75012	METHOD: 3 1/4" HSA	
		SURFACING: Spo;	WEATHER: Cloudy, 80°

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
		Auger advanced without sampling					
1189.4 32.0		END OF BORING Boring immediately backfilled with bentonite grout					

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	ST-17		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154658	EASTING:	582328
DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud
START DATE:	07/26/24	END DATE:	07/26/24
SURFACE ELEVATION:	1224.0 ft	RIG:	75012
METHOD:	3 1/4" HSA		
SURFACING:	Soil	WEATHER:	Cloudy, 80°

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
1223.6 0.4		SILTY SAND (SM), fine-grained, with roots, dark brown, moist (TOPSOIL FILL)		AU			
1220.0 4.0		FILL: SILTY SAND (SM), fine-grained, little Gravel, brown, moist		9-6-7 (13) 10"			
1217.5 6.5		CLAYEY SAND (SC), brown, moist, medium (LACUSTRINE)		4-2-3 (5) 7"			
1215.0 9.0		SILTY SAND (SM), fine-grained, little Gravel, brown, moist, loose (LACUSTRINE)		8-5-5 (10) 8"			
1212.5 11.5		SANDY SILT (ML), with Silt, little Gravel, brown, moist, loose (LACUSTRINE)		3-4-4 (8) 12"			
1198.0 26.0		SANDY LEAN CLAY (CL), with Silt, little Gravel, brown, moist, medium to very stiff (GLACIAL TILL)		8-3-4 (7) 9" 7-5-6 (11) 9" 5-6-7 (13) 18" 7-7-11 (18) 16"			Water not observed while drilling.
		END OF BORING Boring immediately backfilled with bentonite grout					

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482 **Geotechnical Evaluation** **Palm Street Pond** **Blackman Avenue and Palm Street** **Duluth, Minnesota**	BORING: **ST-18** LOCATION: Captured with submeter GPS. DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet) NORTHING: 154634 EASTING: 582432
DRILLER: M. Heinzen LOGGED BY: A. Hillerud	START DATE: 07/26/24 END DATE: 07/26/24
SURFACE ELEVATION: 1225.4 ft RIG: 75012 METHOD: 3 1/4" HSA	SURFACING: Soil WEATHER: Cloudy, 80°

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
~~1225.0~~ 0.4			SILTY SAND (SM), fine-grained, with roots, dark brown, moist (TOPSOIL FILL)		AU			
		▨	FILL: SILTY SAND (SM), fine-grained, little Gravel, brown and dark brown, moist	☒	9-11-13 (24) 9"		11	P200=41%
		▨		5 ☒	5-6-7 (13) 8"			
		▨		☒	3-4-7 (11) 7"			
1213.9		▨		10 ☒	4-5-9 (14) 2"			
11.5		🟩	CLAYEY SAND (SC), with Silt, little Gravel, brown, moist to wet, stiff (GLACIAL TILL)	☒	7-5-6 (11) 16"			
		🟩		15 ☒	4-6-7 (13) 18"		13	P200=64%
	▽	🟩						
		🟩		20 ☒	11-7-8 (15) 16"			
	▼	🟩						
1199.4		🟩		25 ☒	24-2-9 (11) 10"			
26.0			END OF BORING Boring immediately backfilled with bentonite grout					Water observed at 18.5 feet while drilling. Water observed at 23.0 feet at end of drilling.
				30				
				35				

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**ST-19**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154586	EASTING:	582517
DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud
START DATE:	07/29/24	END DATE:	07/29/24
SURFACE ELEVATION:	1222.4 ft	RIG:	75012
METHOD:	3 1/4" HSA		
SURFACING:	Soil	WEATHER:	Cloudy, 80°

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Depth	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
~~1222.0~~ 0.4		SILTY SAND (SM), fine-grained, with roots, dark brown, moist (TOPSOIL FILL)			AU			
		FILL: SILTY SAND (SM), fine-grained, with Gravel, trace roots, dark brown and brown, moist			7-4-2 (6) 10"			
			5		2-2-8 (10) 7"			
					5-6-5 (11) 3"			
			10		3-2-1 (3) 6"			
1210.9 11.5	▽	SILTY SAND (SM), fine to coarse-grained, with Gravel, brown, wet, loose to medium dense (GLACIAL TILL)			2-6-4 (10) 3"			
	▼		15		2-2-6 (8) 0"			
			20		8-5-5 (10) 0"			
			25		4-4-8 (12) 3"			
1196.4 26.0		END OF BORING Boring immediately backfilled with bentonite grout	30 35					Water observed at 11.5 feet while drilling. Water observed at 15.5 feet at end of drilling.

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
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BORING:	**ST-20**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154528	EASTING:	582601
DRILLER: M. Heinzen	LOGGED BY: A. Hillerud	START DATE: 07/29/24	END DATE: 07/29/24
SURFACE ELEVATION: 1221.0 ft	RIG: 75012	METHOD: 3 1/4" HSA	
SURFACING:	Soil	WEATHER:	Cloudy, 80°

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	qp tsf	MC %	Tests or Remarks
		SILTY SAND (SM), fine-grained, with roots, dark brown, moist (TOPSOIL FILL)		AU			
1219.0 2.0		FILL: SILTY SAND (SM), fine to medium-grained, with Gravel, brown and dark brown, moist		4-4-4 (8) 7"			
				1-3-3 (6) 5"			
				5-4-3 (7) 7"		8	P200=21%
				5-5-6 (11) 5"			
	▽			7-7-18 (25) 6"			
1207.0 14.0	▼	SILTY SAND (SM), fine to coarse-grained, with Gravel, brown, wet, medium dense to dense (GLACIAL TILL)		11-11-14 (25) 7"			
				13-17-32 (49) 9"			
				13-15-16 (31) 12"			
1195.0 26.0		END OF BORING Boring immediately backfilled with bentonite grout					Water observed at 12.0 feet while drilling. Water observed at 15.0 feet at end of drilling.

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
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Duluth, Minnesota

BORING:	**ST-21**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154467	EASTING:	582687
START DATE:	07/29/24	END DATE:	07/29/24
SURFACING:	Soil	WEATHER:	Cloudy, 80°

DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud		
SURFACE ELEVATION:	1218.6 ft	RIG:	75012	METHOD:	3 1/4" HSA

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	qp tsf	MC %	Tests or Remarks
		SILTY SAND (SM), fine-grained, with roots, black, moist (TOPSOIL)		AU			
1218.2 0.4		SILTY SAND (SM), fine-grained, little Gravel, brown, moist, loose to medium dense (GLACIAL TILL)	⊠	3-3-4 (7) 15"			
			⊠	3-4-2 (6) 12"			
1212.1 6.5		SILTY SAND (SM), fine to coarse-grained, with Gravel, brown, moist to wet, dense to medium dense (GLACIAL TILL)	⊠	8-27-21 (48) 10"			
			⊠	19-20-18 (38) 12"			
	▽		⊠	9-12-13 (25) 12"			
			⊠	6-6-12 (18) 10"		17	P200=12%
1200.6 18.0	▼	SILT (ML), trace Sand, brown, moist, medium dense (GLACIAL TILL)	⊠	5-6-8 (14) 12"			
			⊠	46-50/4" (REF) 0"			
1193.2 25.4		END OF BORING Boring immediately backfilled with bentonite grout					Water observed at 11.5 feet while drilling. Water observed at 20.0 feet at end of drilling.

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**ST-22**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154430	EASTING:	582780
DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud
START DATE:	07/29/24	END DATE:	07/29/24
SURFACE ELEVATION:	1213.3 ft	RIG:	75012
METHOD:	3 1/4" HSA		
SURFACING:	Soil	WEATHER:	Cloudy, 80°

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Depth	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
1211.8 1.5		FILL: SILTY SAND (SM), fine to medium-grained, with Gravel, brown, moist			AU			
		SILTY SAND (SM), fine to medium-grained, with Gravel, with Cobbles, brown, moist, loose to medium dense (GLACIAL TILL)		☒	5-6-7 (13) 8"			
			5	☒	6-7-7 (14) 8"		8	P200=29%
				☒	14-9-28 (37) 4"			
			10	☒	4-4-3 (7) 5"			
				☒	8-17-14 (31) 12"			
	▽		15	☒	8-12-9 (21) 6"			
1195.8 17.5	▼	POORLY GRADED GRAVEL (GP), with Sand, brown, wet, dense to very dense (GLACIAL TILL)						
			20	☒	12-19-21 (40) 12"			
			25	☒	36-34-31 (65) 4"			
1187.3 26.0		END OF BORING Boring immediately backfilled with bentonite grout	30 35					Water observed at 15.5 feet while drilling. Water observed at 19.0 feet at end of drilling.

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING: **ST-23**

LOCATION: Captured with submeter GPS.

DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)

NORTHING:	154428	EASTING:	582868
DRILLER: M. Heinzen	LOGGED BY: A. Hillerud	START DATE: 07/29/24	END DATE: 07/29/24
SURFACE ELEVATION: 1209.3 ft	RIG: 75012	METHOD: 3 1/4" HSA	
SURFACING:	Soil	WEATHER:	Cloudy, 80°

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	qₚ tsf	MC %	Tests or Remarks
1205.3 4.0		FILL: SILTY SAND (SM), fine to medium-grained, with Gravel, brown, moist		AU 4-5-5 (10) 7"			
1202.8 6.5		POORLY GRADED GRAVEL (GP), with Sand, brown, moist, loose (GLACIAL TILL)		7-7-12 (19) 6"			
1200.3 9.0		POORLY GRADED GRAVEL (GP), with Sand, gray, moist, very dense (GLACIAL TILL)		24-32-34 (66) 4"			
1183.3 26.0	▽ ▼	POORLY GRADED GRAVEL (GP), with Sand, brown, moist to wet, very dense (GLACIAL TILL)		50/5" (REF) 2" 21-23-22 (45) 8" 9-27-39 (66) 8" 50/5" (REF) 2" 32-31-19 (50) 10"			
		END OF BORING Boring immediately backfilled with bentonite grout					Water observed at 10.0 feet while drilling. Water observed at 17.0 feet at end of drilling.

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2406482
Geotechnical Evaluation
Palm Street Pond
Blackman Avenue and Palm Street
Duluth, Minnesota

BORING:	**ST-24**		
LOCATION: Captured with submeter GPS.			
DATUM: NAD 1983 HARN Adj MN St Louis North (US Feet)			
NORTHING:	154455	EASTING:	582963
DRILLER:	M. Heinzen	LOGGED BY:	A. Hillerud
START DATE:	07/29/24	END DATE:	07/29/24
SURFACE ELEVATION:	1206.8 ft	RIG:	75012
METHOD:	3 1/4" HSA	SURFACING:	Soil
WEATHER:	Cloudy, 80°		

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
1200.8		FILL: SILTY SAND (SM), fine to medium-grained, with Gravel, brown, moist to wet *Roots at 5 feet*	■ ⊠ ⊠	AU 4-3-4 (7) 6" 3-8-13 (21) 5"			
6.0 1195.3	▽	FILL: SILTY SAND (SM), fine to coarse-grained, with Gravel, brown, wet	⊠ ⊠	8-6-6 (12) 5" 19-41-48 (89) 0"			
11.5 1188.8		CLAYEY SAND (SC), with Silt, little Gravel, brown, moist, very stiff (GLACIAL TILL)	⊠ ⊠	11-11-18 (29) 12" 15-11-15 (26) 12"			
18.0 1180.8	▼	SILTY SAND (SM), fine-grained, with Gravel, brown, moist, dense to very dense (GLACIAL TILL)	⊠ ⊠	13-17-21 (38) 12" 41-37-39 (76) 14"			
26.0		END OF BORING Boring immediately backfilled with bentonite grout					Water observed at 6.5 feet while drilling. Water observed at 25.5 feet at end of drilling.

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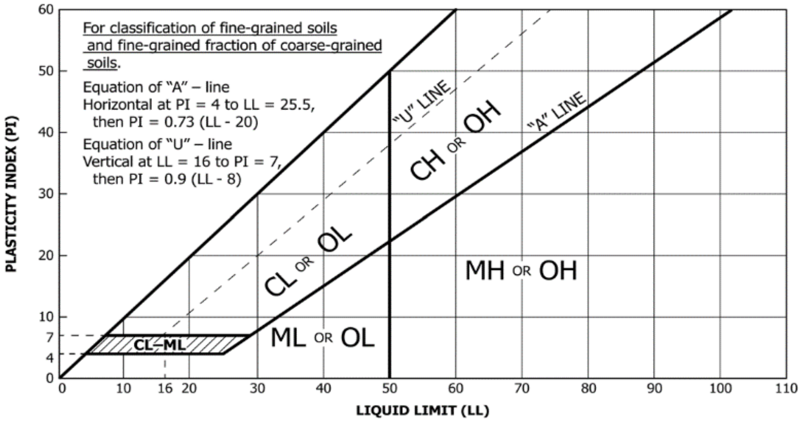
Descriptive Terminology of Soil

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	$\frac{\text{Liquid Limit – oven dried}}{\text{Liquid Limit – not dried}} < 0.75$	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	$\frac{\text{Liquid Limit – oven dried}}{\text{Liquid Limit – not dried}} < 0.75$	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. $C_u = D_{60} / D_{10}$ $\quad C_c = (D_{30})^2 / (D_{10} \; x \; D_{60})$
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

☒	Standard Penetration Test	◫	Rock Core
⧗	Modified California (MC)	■	Thinwall (TW)/Shelby Tube (SH)
◆	Auger	⧩	Texas Cone Penetrometer
✋	Grab Sample	▽	Dynamic Cone Penetrometer