Preliminary Geotechnical Evaluation Report

Proposed City of Oakdale Public Works Building
Granada Avenue N and 32nd Street N
Oakdale, Minnesota

Prepared for

City of Oakdale

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.

Christopher R. Kehl, PE
Vice President, Principal Engineer
License Number: 43459
October 8, 2020

CHRISTOPHER R. KEHL
LICENSED PROFESSIONAL ENGINEER
43459
STATE OF MINNESOTA

Project B2008003

Braun Intertec Corporation

BRAUN INTERTEC
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October 8, 2020 Project B2008003

City of Oakdale
c/o Mr. Matt Lysne
Hagen Christensen & McIlwain Architects, P.A.
4201 Cedar Avenue South
Minneapolis, MN 55407

Re: Preliminary Geotechnical Evaluation
Proposed City of Oakdale Public Works Building
Granada Avenue N and 32nd Street N
Oakdale, Minnesota

Dear Mr. Lysne:

We are pleased to present this Preliminary Geotechnical Evaluation Report for the proposed City of Oakdale Public Works Building in Oakdale, Minnesota.

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 Ryan Braun at 651.304.7074 (rbraun@braunintertec.com) or Chris Kehl 952.995.2386 (ckehl@braunintertec.com).

Sincerely,

BRAUN INTERTEC CORPORATION

Ryan M. Braun, EIT
Staff Engineer

Christopher R. Kehl, PE
Vice President, Principal Engineer

c: Mr. Brian Bachmeier, City of Oakdale

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BRAUN INTERTEC

A. Introduction

A.1. Project Description

This Preliminary Geotechnical Evaluation Report addresses the proposed design and construction of the proposed City of Oakdale Public Works Facility, located in Oakdale, Minnesota. The project will include the construction of a new slab-on-grade, two-story above grade public works facility with indoor storage and parking space with office space on the second story. The project also includes site improvements such as surface parking lots, fueling station, cold storage areas, material storage areas, new underground utilities and stormwater management features. Tables 1 and 2 provide project details.

Table 1. Building Description

Aspect	Provided/Assumed	Description
Below grade levels	Provided	None
Above grade levels	Provided	2
Finish level floor elevation (feet Mean Sea Level)	Provided	1003
Column loads (kips)	Provided	300
Wall loads (kips per linear foot)	Provided	5
Nature of construction	Provided	Spread footings with tip-up precast concrete panel walls and steel framing above grade
Other site aspects	Provided	Fuel station, cold storage, wash bay

Table 2. Site Aspects and Grading Description

Aspect	Description
Pavement type(s)	Flexible (bituminous) and Rigid (concrete)
Assumed pavement loads	Light-duty: Less than 50,000 ESALs* Cars only
	Heavy-duty: 250,000 ESALs* 200 cars, 20 loaded dump trucks per day

*Equivalent 18,000-lb single axle loads based on 20-year design.

The figure below shows an illustration of the proposed site layout.

Figure 1. Site Layout

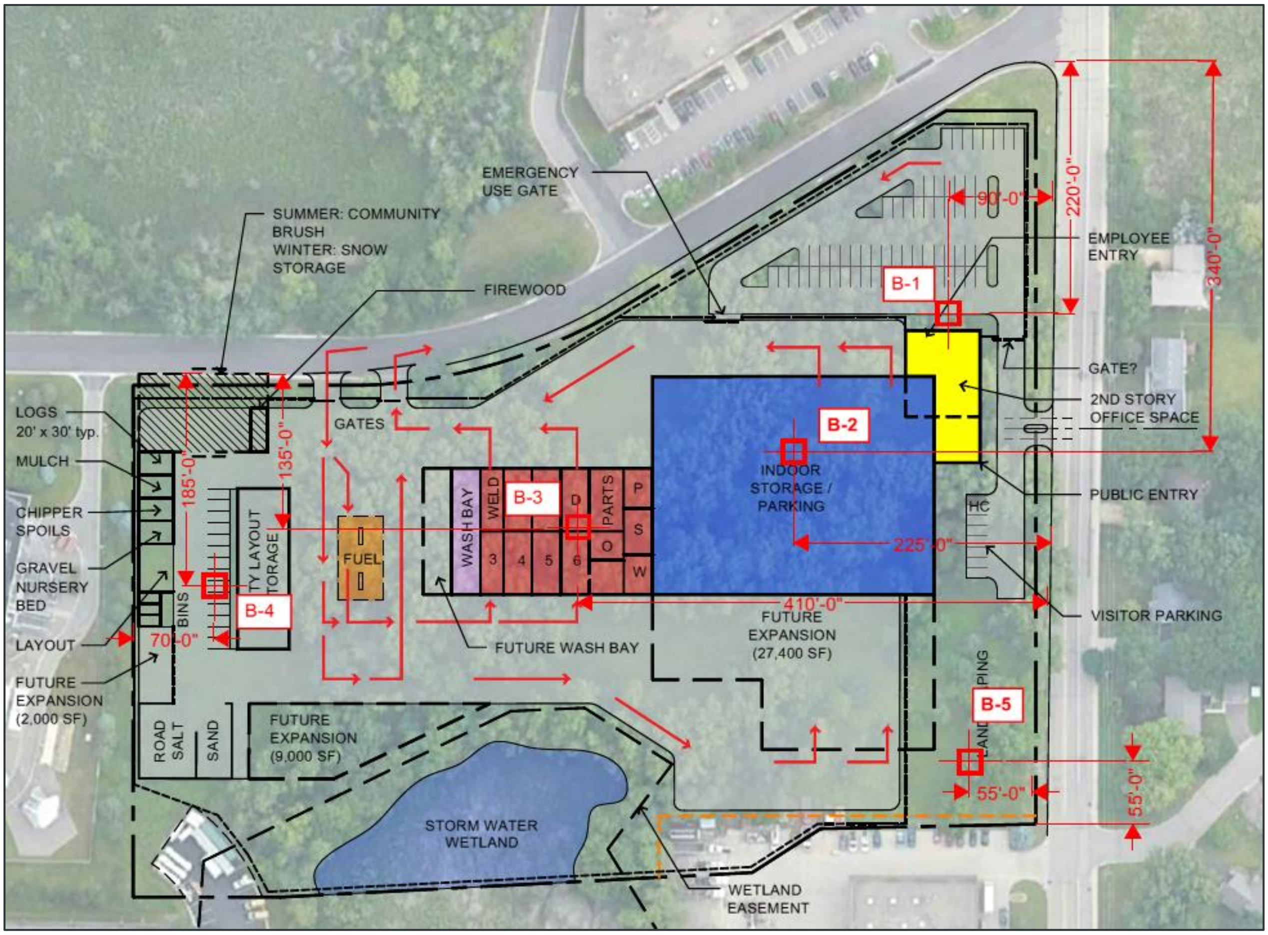


Figure provided by Hagen Christensen & McIlwain Architects, P.A. (HCM Architects) dated August 31, 2020.

A.2. Site Conditions and History

Currently, the site exists as an empty wooded field that is designated as a Brownfield Site, bordered by the Granada Business Park to the south, Granada Business Park 3rd Addition to the west, 32nd Street North to the north and Granada Avenue North to the east. Current grades range from 994 to 1010 feet Mean Sea Level (MSL) with the site generally sloping from the middle to the northwest and southeast. Photograph 1 below depicts the site more or less in its current condition with existing topography overlain.

Photograph 1. Aerial Photograph of the Site in 2019

Photograph provided by MnTOPO.

Based on available aerial imagery, it appears that no structure has ever been present on the property. Possible wetlands are illustrated in Photograph 2 below. Based on available information provided by Barr Engineering and 3M Company, the site has been used as a dump area for debris and chemicals. Depictions of some of the main dumping areas are shown on the soil boring figure in red and blue. Photograph 2 below depicts the site prior to the development of the surrounding buildings.

Photograph 2. Aerial Photograph of the Site in 1964

Photograph provided by Minnesota Historical Aerial Photographs Online.

A.3. Purpose

The purpose of our preliminary geotechnical evaluation will be to characterize subsurface geologic conditions at selected boring locations, evaluate their impact on the project, and provide geotechnical recommendations for the design and construction of proposed public works facility.

A.4. Background Information and Reference Documents

We reviewed the following information:

- Existing topographic maps prepared by MnTOPO and Washington County GIS.
- Existing soil borings, trench test pits and well record logs on the property prepared or provided by Barr Engineering.

- Communications with Jennifer Brekken, Barr Engineering, and Kevin Madson, 3M Company, regarding the existing contaminants on site that may be encountered in the soil borings.

- Communications with Matt Lysne, HCM Architects, regarding the proposed design and construction of the proposed public works facility.

In addition to the provided sources, we have used several publicly available sources of information.

- Current and historic aerial photos from Minnesota Historical Aerial Photographs Online for information on site history.

- Geologic Atlas of Washington County, Minnesota – Surficial Geology map prepared and published by the Minnesota Geological Survey, dated 2016 for geological information of native soils.

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 QTB126227 to the City of Oakdale, dated September 2, 2020. 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 exploration location of underground utilities. The design team selected and we staked the new exploration 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 5 standard penetration test (SPT) borings, denoted as ST-1001 to ST-1005, to nominal depths of 24 1/2 feet below grade across the site.

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

- Preparing this preliminary report containing a boring location sketch, logs of soil borings, a summary of the soils encountered, results of laboratory tests, and recommendations for structure and pavement subgrade preparation and the design of foundations, floor slabs, exterior slabs, utilities, stormwater improvements and 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, in-situ and 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. Previous Geotechnical Information

Barr Engineering (Barr) performed numerous rounds of soil borings and test trenches on this site between 1981 and 2005. Select soil borings logs are attached. Other logs were omitted as they were too shallow, off the site, or did not contain applicable information. The previous investigations encountered similar soil and groundwater conditions as our soil borings with the exception of previous Boring W45 which encountered a layer of peat that was not encountered in our borings. Some of the borings were taken much deeper with bedrock encountered at a depth of 83 feet. Note also that Boring W41 shows a surface elevation 5 feet below current elevations as shown in topographic information which may indicate that additional fill may have been placed on the site in the subsequent 40 years.

Also, many of Barr's previous borings were targeted to evaluate the contaminated or debris-laden areas, so greater understanding of the content and extents of the material can be understood by reviewing their reports.

B.3. Boring Results

Table 3 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 Table 3.

Table 3. Subsurface Profile Summary*

Strata	Soil Type - ASTM Classification	Range of Penetration Resistances	Commentary and Details
Topsoil fill	SM	---	▪ Predominantly SM. ▪ Dark brown to black. ▪ Thicknesses at boring locations varied from 2 to 4 feet. ▪ Moisture condition generally moist.
Fill	SP-SM, SM	4 to 16 Blows per Foot (BPF)	▪ Moisture condition generally moist. ▪ Thicknesses at boring locations varied from 4 to 7 feet. ▪ Existing fill may contain variable amounts of debris or contaminates. ▪ Possible cobbles and boulders.
Glacial deposits	SM	6 to 48 BPF	▪ Possible cobbles and boulders. ▪ Variable amounts of gravel; may contain cobbles and boulders. ▪ Moisture condition generally moist.

*Abbreviations defined in the attached Descriptive Terminology sheet.

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

B.4. Groundwater

Groundwater was encountered in 5 of the 11 soil borings contained in this report. Table 4 summarizes the depths where we observed groundwater; the attached Log of Boring sheets in the Appendix also include this information and additional details.

Table 4. Groundwater Summary

Location	Surface Elevation	Measured Depth to Groundwater (ft)	Corresponding Groundwater Elevation (ft)
ST-1005	1005.1	15	990 1/2
W41 (1981)	998.9	9 1/2	989 1/2
W45 (1984)	995.1	3	992 1/2
W47 (1984)	1004.0	11	993
W49 (1984)	1007.8	19	989

Based on the information, the groundwater surface elevation appeared to be about elevation 989 to 993 feet MSL. Given the age of some of the information and limited duration of our observations, additional evaluation with piezometers are recommended to accurately establish water levels. Project planning should expect groundwater will fluctuate seasonally and annually.

B.5. Laboratory Test Results

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

The moisture content (ASTM D 2216) of the selected samples varied from approximately 4 to 16 percent, indicating that the material was slightly below or near its probable optimum moisture content.

Our mechanical analyses (ASTM C 117) indicated that the selected sample contained 6 percent silt and clay by weight.

C. Preliminary Recommendations

C.1. Design and Construction Foundation Discussion

The soil borings performed, and many of the other soil borings provided to us, indicate a soil profile favorable for supporting the building on conventional spread footings. However, areas of unsuitable soils (fill, debris or organic soils) are present on site that would need to be removed and replaced with suitable fill soil (soil correction) within building pads. These materials, after further evaluation, may be able to be left in place below pavements provided the near surface soils are suitable to support pavement loads. If, because of contamination cost or risk reasons, it is determined spread footings are not cost effective, alternative foundation approaches including aggregate piers, helical anchors or even driven piles could be considered for building support. The four options are further discussed below.

C.1.a. Standard Soil Correction

Spread footing foundations bearing on the native silty sand soils can support the proposed structures, after performing typical subgrade preparation. Typical subgrade preparation includes removing existing topsoil or organic soils, fill, debris, structures and any very loose or soft soils directly below the footings. The soil correction would require the removal of unsuitable soils and replacement back to finish grade with engineered fill material. On-site, non-organic, debris-free material can be used for this soil correction.

Some deep corrections encounter groundwater. While typical practice is to remove the water through pumping, it is possible to place a coarse free-draining sand below the water table, with an experienced contractor and full-time observation, if water cannot be removed.

C.1.b. Deep and Alternate Foundation System

Based on the known contaminated soils and buried debris on site, we understand alternates to excavating and exporting the contaminated soils may be desired. In order to further define these recommendations, additional investigation will be required.

C.1.b.1. Aggregate Piers

We recommend performing ground improvements with aggregate piers as one substitute to a soil correction, commonly known by trade names such as: Geopier, Vibro Piers, Vibro Stone Columns, etc. This approach can be used in just a portion of the building where deep fill or contamination preclude soil corrections while the rest of the building is supported on spread footings. The approach reduces the potential for detrimental settlement associated with the existing fill to occur, provides adequate bearing capacity, eliminates the need for deep excavations and export of contaminated soils, and reduces the volume of subgrade soils disturbed at this site.

Different contractors use varying techniques to construct aggregate piers but generally consist of excavating soil from a hole with an auger or vibrating a probe into the ground, and then building a column of clean, open-graded aggregate. The contractor constructs the pier by placing the aggregate in lifts from the bottom of the pier and compacting each lift before placing aggregate for the subsequent lift. Grout may be added in organic layers. The vibratory energy, and sometimes ramming action, causes the aggregate to interlock, forming a stiff pier that provides soil reinforcement and increases shear resistance.

Aggregate piers will be needed below foundations, but dependent on soil conditions may not be needed under floor slabs. The aggregate piers should extend through unsuitable soils to bear on the underlying alluvial and glacial soils. Some soils are brought to the surface with this approach. They may be challenged by advancing through debris.

The aggregate pier designer will determine the allowable soil bearing capacity of footings bearing upon rammed aggregate piers. However, aggregate piers are typically able to support net allowable bearing pressures of 4,000 to 5,000 pounds per square foot (PSF). This value includes a safety factor of at least 3.0 with regard to bearing capacity failure. Aggregate piers supporting footings typically limit total and differential settlement of spread footing foundations to less than 1 inch and 1/2 inch, respectively.

C.1.b.2. Helical Pile

Another viable alternate to a soil correction is installing helical piles. Helical piles are hollow-tube, steel shafts with metal plates welded to them that are screwed into the ground, until they meet a specified torque. We recommend requiring the helical piles to extend at least 5 feet below existing fill. While they can be advanced through “light” debris, they may not be advanced through concrete, steel, wood, etc. To facilitate installation in gravel- or debris-laden soils, the contractor may need to “open up” or “sea shell”.

Helical anchors are similar to aggregate piers in that:

- Can be used in combination with spread footings.
- May be used to support the floor if needed.

However, they differ in that:

- Do not bring any soil to the surface.
- Are designed by using a pile cap rather than a spread footing.

C.1.b.3. Driven Pile

Driven pile can used and the pile would develop capacity quickly in the dense soils on site. However, as they do not "settle" like a conventional footing it becomes more difficult to use them in combination with spread footings.

C.2. Additional Considerations

C.2.a. Reuse of On-Site Soils

The existing, non-organic, debris-free, fill and native soils are suitable for reuse as engineered fill below the proposed building pad. The existing fill may contain debris or organic material. While we did not encounter debris in our borings, we understand there is buried debris on site and we do not recommend reusing existing fill that contains debris or organic material as structural fill. The project team should reuse any on-site soils in accordance with the approved environmental response action plan (RAP) for the project.

C.2.b. Groundwater

We observed limited groundwater in the borings. Where we observed groundwater, it was below the anticipated excavation depths for construction. Some of the soils, such as silty sands, clayey sands and clay, will collect water from precipitation or if water drains to the site. We generally recommend the contractor remove any water that collects in work areas before performing further work, in accordance with the RAP.

C.2.c. Miscellaneous Structures on Site

There are a variety of structures to be constructed typical to this type of development that will require specific recommendations once greater detail is provided and additional soil exploration is performed. Some of these items include:

- Fuel tank – Groundwater is shallow enough that groundwater levels should be determined to evaluate the potential for buoyancy on the tanks.

- Fuel tank canopy – There should not be any special challenges in resisting the uplift and overturning forces from wind. Usually these loads are accommodated through soil above the foundation that may result in greater embedment or helical anchors.

- Salt storage – The large piles can result in large and broad loading of the soils; generally the soils appear to have enough strength this should not cause an issue.

- Cold storage and pavements – The soils appear to generally be capable of supporting loads, however they are quite frost susceptible. Keeping soils dry and accommodating seasonal movement will be important considerations.

C.2.d. Additional Geotechnical Evaluation

We do not consider this preliminary geotechnical evaluation sufficient to provide detailed geotechnical design recommendations for the building. Additional exploration to more broadly evaluate the site and delineate poor soils is needed.

C.3. Site Grading and Subgrade Preparation

C.3.a. Building Subgrade Excavations

We recommend removing unsuitable materials from within the building pad and oversizing areas. We define unsuitable materials as existing fill, frozen materials, organic soils, existing structures, existing utilities and associated backfill, vegetation and soft/loose soils. Table 5 shows the anticipated excavation depths and bottom elevations for each of the borings in relation to the proposed finish floor elevation (FFE) of 1003 feet Mean Sea Level (MSL).

Table 5. Building Excavation Depths

Location	Approximate Surface Elevation (ft MSL)	Anticipated Excavation Depth (ft)	Anticipated Bottom Elevation (ft MSL)	Anticipated Depth Below FFE 1003 (ft)
ST-1001	1007.5	4	1003 1/2	---
ST-1002	1004.5	4	1000 1/2	2 1/2
ST-1003	1003.2	4	999	4
ST-1004	1005.2	7	998	5
ST-1005	1005.1	4	1001	2
W41	998.9*	0	999	4

*Based on site grades, filling may have occurred since this boring was performed.

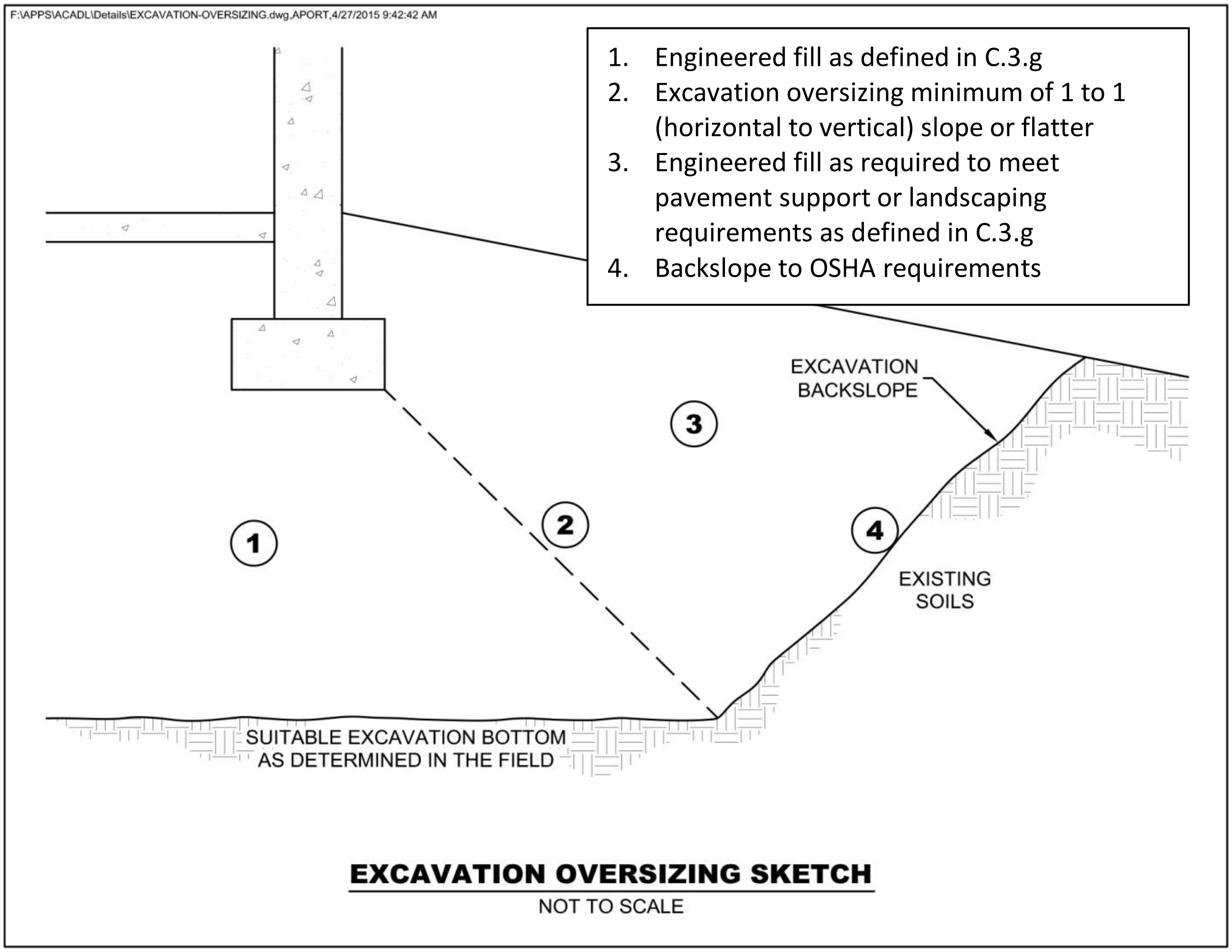
Excavation depths will vary between the borings. Portions of the excavations may also extend deeper than indicated by the borings. A geotechnical representative should observe the excavations to make the necessary field judgments regarding the suitability of the exposed soils.

The contractor should use equipment and techniques to minimize soil disturbance. If soils become disturbed or are wet, we recommend excavation, replacement and recompaction.

C.3.b. Excavation Oversizing

When removing unsuitable materials below structures or pavements, we recommend the excavation extend outward and downward at a slope of 1H:1V (horizontal:vertical) or flatter. See Figure 2 for an illustration of excavation oversizing.

Figure 2. Generalized Illustration of Oversizing



C.3.c. Excavated Slopes

Based on the borings, we anticipate on-site soils in excavations will consist mainly of silty sand. These soils are typically considered Type B Soil under OSHA (Occupational Safety and Health Administration) guidelines. OSHA guidelines indicate unsupported excavations in Type B soils should have a gradient no steeper than 1H:1V. Slopes constructed in this manner may still exhibit surface sloughing. OSHA requires an engineer to evaluate slopes or excavations over 20 feet in depth.

An OSHA-approved qualified person should review the soil classification in the field. Excavations must comply with the requirements of OSHA 29 CFR, Part 1926, Subpart P, “Excavations and Trenches.” This document states excavation safety is the responsibility of the contractor. The project specifications should reference these OSHA requirements.

C.3.d. Excavation Dewatering

Groundwater is anticipated to be below excavation depths however, water may collect in excavations from precipitation or surface runoff. The contractor should assume any collected water within excavations should be immediately removed to facilitate construction and proper backfilling. We would assume conventional sumps could control the water in most excavations.

C.3.e. Pavement and Exterior Slab Subgrade Preparation

We recommend the following steps for pavement and exterior slab subgrade preparation. Note that project planning may need to require additional subcuts to limit frost heave.

1. Strip unsuitable soils consisting of topsoil, organic soils, vegetation, existing structures and pavements from the area, within 3 feet of the surface of the proposed pavement grade.
2. Have a geotechnical representative observe the excavated subgrade to evaluate if additional subgrade improvements are necessary.
3. Slope subgrade soils to areas of sand or drain tile to allow the removal of accumulating water.
4. Surface compact the subgrade with several passes of a large self-propelled vibratory, drum roller.
5. Place pavement engineered fill to grade and compact in accordance with Section C.3.g to bottom of pavement and exterior slab section. See Section C.6 for additional considerations related to frost heave.
6. Proofroll the pavement or exterior slab subgrade as described in Section C.3.f.

To improve long-term pavement performance, we recommend incorporating 12 inches of non-frost susceptible engineered fill in paved areas, in addition to the recommendations above, as a sand subbase. Section C.6 provides recommended pavement design sections with and without the sand subbase. Note, we recommend sloping subgrade soils to promote drainage and removal of accumulated water.

C.3.f. Pavement Subgrade Proofroll

After preparing the subgrade 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.3.g. Engineered Fill Materials and Compaction

Table 6 below contains our recommendations for engineered fill materials.

Table 6. Engineered Fill Materials*

Locations To Be Used	Engineered Fill Classification	Possible Soil Type Descriptions	Gradation	Additional Requirements
Below building footprint and oversizing area	Structural fill	SP, SP-SM, SM	100% passing 2-inch sieve < 25% passing #200 sieve	< 2% Organic Content (OC)
▪ Drainage layer ▪ Non-frost-susceptible	▪ Free-draining ▪ Non-frost-susceptible fill	GP, GW, SP, SW	100% passing 1-inch sieve < 50% passing #40 sieve < 5% passing #200 sieve	< 2% OC
Behind below-grade walls, beyond drainage layer	Retained fill	SP, SP-SM, SM	100% passing 3-inch sieve < 20% passing #200 sieve	< 2% OC
Pavements	Pavement fill	SP, SP-SM, SM	100% passing 3-inch sieve	< 2% OC PI < 15%
Below landscaped surfaces, where subsidence is not a concern	Non-structural fill	Any	100% passing 6-inch sieve	< 10% OC

*Engineered fill materials should satisfy the approved Response Action Plan (RAP) or applicable environmental regulations.

*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.

We recommend spreading engineered fill in loose lifts of approximately 12 inches thick. We recommend compacting engineered fill in accordance with the criteria presented below in Table 7. 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 7. 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, ML, SM)
Below building footprint and oversizing zones	98	±3	-1 to +3
Within 3 feet of pavement subgrade	100	±3	-1 to +3
More than 3 feet below pavement subgrade	95	±3	±3
Below landscaped surfaces	90	±5	±4
Adjacent to below-grade wall	95*	±3	-1 to +3

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

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

C.3.h. Special Inspections of Soils

We recommend including the site grading and placement of engineered fill within the building pad under the requirements of Special Inspections, as provided in Chapter 17 of the International Building Code, which is part of the Minnesota State Building Code. Special Inspection requires observation of soil conditions below engineered fill or footings, evaluations to determine if excavations extend to the anticipated soils, and if engineered fill materials meet requirements for type of engineered fill and compaction condition of engineered fill. A licensed geotechnical engineer should direct the Special Inspections of site grading and engineered fill placement. The purpose of these Special Inspections is to evaluate whether the work is in accordance with the approved Geotechnical Report for the project. Special Inspections should include evaluation of the subgrade, observing preparation of the subgrade (surface compaction or dewatering, excavation oversizing, placement procedures and materials used for engineered fill, etc.) and compaction testing of the engineered fill.

C.4. Spread Footings

Table 8 below contains our preliminary recommended parameters for foundation design.

Table 8. Preliminary Recommended Spread Footing Design Parameters

Item	Description
Maximum net allowable bearing pressure (psf)	4,000 to 6,000
Minimum factor of safety for bearing capacity failure	3.0
Minimum embedment below final exterior grade for heated structures (inches)	42
Minimum embedment below final exterior grade for unheated structures or for footings not protected from freezing temperatures during construction (inches)	60
Total estimated settlement (inches)	Less than 1 inch
Differential settlement	Typically about 1/2 of total settlement*

*Actual differential settlement amounts will depend on final loads and foundation layout. We can evaluate differential settlement based on final foundation plans and loadings.

C.5. Interior Slabs

C.5.a. Subgrade Modulus

The anticipated floor subgrade is debris free engineered fill or native silty sand. We recommend using a modulus of subgrade reaction, k, of 250 pounds per square inch per inch of deflection (pci) to design the slabs. If the slab design requires placing 6 inches of compacted crushed aggregate base immediately below the slab, the slab design may increase the k-value by 50 pci. We recommend that the aggregate base materials be free of bituminous. In addition to improving the modulus of subgrade reaction, an aggregate base facilitates construction activities and is less weather sensitive.

C.5.b. Moisture Vapor Protection

Excess transmission of water vapor could cause floor dampness, certain types of floor bonding agents to separate, or mold to form under floor coverings. If project planning includes using floor coverings or coatings, such as in offices, bathrooms, etc., we recommend placing a vapor retarder or vapor barrier immediately beneath the slab. We also recommend consulting with floor covering manufacturers regarding the appropriate type, use and installation of the vapor retarder or barrier to preserve warranty assurances.

C.6. Frost Protection and Exterior Slabs

C.6.a. General

Silty sand will underlie all or some of the exterior slabs, as well as pavements. We consider these soils moderately to highly frost susceptible. Soils of this type can retain moisture and heave upon freezing. In general, this characteristic is not an issue unless these soils become saturated, due to surface runoff or infiltration, or are excessively wet in situ. Once frozen, unfavorable amounts of general and isolated heaving of the soils and the surface structures supported on them could develop. This type of heaving could affect design drainage patterns and the performance of exterior slabs and pavements, as well as any isolated exterior footings and piers.

Note that general runoff and infiltration from precipitation are not the only sources of water that can saturate subgrade soils and contribute to frost heave. Roof drainage and irrigation of landscaped areas in close proximity to exterior slabs, pavements, and isolated footings and piers, contribute as well.

C.6.b. Frost Heave Mitigation

To address most of the heave related issues, we recommend setting general site grades and grades for exterior surface features to direct surface drainage away from buildings, across large paved areas and away from walkways. Such grading will limit the potential for saturation of the subgrade and subsequent heaving. General grades should also have enough “slope” to tolerate potential larger areas of heave, which may not fully settle after thawing.

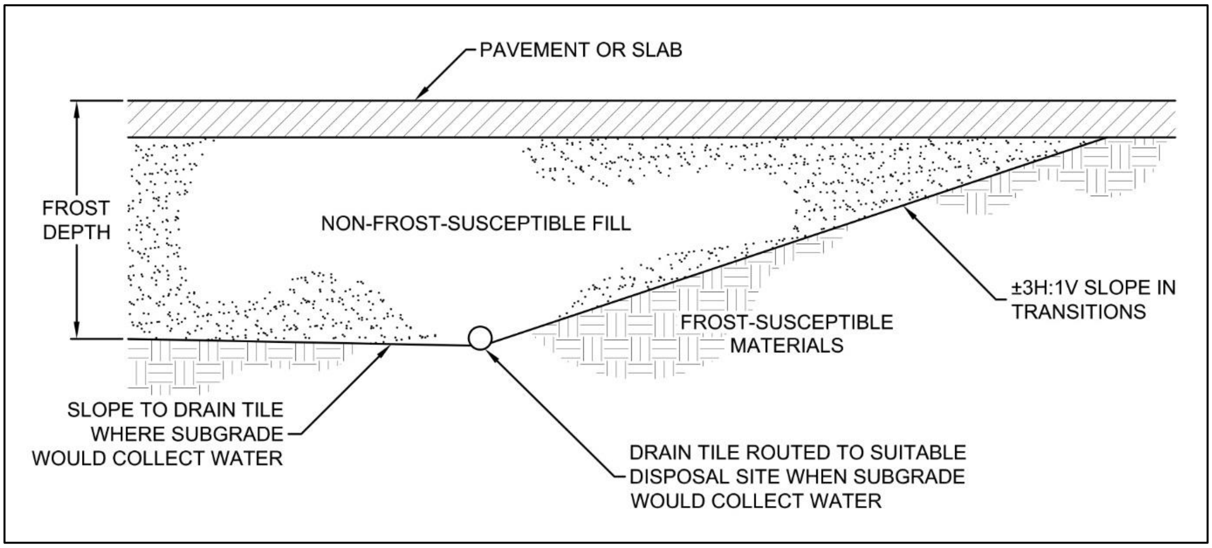
Even small amounts of frost-related differential movement at walkway joints or cracks can create tripping hazards. Project planning can explore several subgrade improvement options to address this condition.

One of the more conservative subgrade improvement options to mitigate potential heave is removing any frost-susceptible soils present below the exterior slab areas down to a minimum depth of 3 feet below subgrade elevations. We recommend filling the resulting excavation with non-frost-susceptible fill. We also recommend sloping the bottom of the excavation toward one or more collection points to remove any water entering the engineered fill. This approach will not be effective in controlling frost heave without removing the water.

An important geometric aspect of the excavation and replacement approach described above is sloping the banks of the excavations to create a more gradual transition between the unexcavated soils considered frost susceptible and the engineered fill in the excavated area, which is not frost susceptible. The slope allows attenuation of differential movement that may occur along the excavation boundary. We recommend slopes that are 3H:1V, or flatter, along transitions between frost-susceptible and non-frost-susceptible soils.

Figure 3 shows an illustration summarizing some of the recommendations.

Figure 3. Frost Protection Geometry Illustration



Another option is to limit frost heave in critical areas, such as doorways and entrances, via frost-depth footings or localized excavations with sloped transitions between frost-susceptible and non-frost-susceptible soils, as described above.

Over the life of slabs and pavements, cracks will develop and joints will open up, which will expose the subgrade and allow water to enter from the surface and either saturate or perch atop the subgrade soils. This water intrusion increases the potential for frost heave or moisture-related distress near the crack or joint. Therefore, we recommend implementing a detailed maintenance program to seal and/or fill any cracks and joints. The maintenance program should give special attention to areas where dissimilar materials abut one another, where construction joints occur and where shrinkage cracks develop.

C.7. Pavements

C.7.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 fill soils and native silty sand soils anticipated at the pavement subgrade elevation, we recommend pavement design assume an R-value of 40. Note the contractor may need to perform limited removal of unsuitable or less suitable soils to achieve this value. Table 9 provides recommended pavement sections, based on the soils support and traffic loads.

We based the concrete pavement designs on a modulus of subgrade reaction (k) of 250 pci.

Table 9. Recommended Bituminous and Concrete Pavement Sections

Layer	Minimum Thickness (inches)	
	On-Site Soil (SM) Subgrade	**With Optional Sand Subgrade**
	Light Duty Pavement (Parking Stalls - Up to 50,000 ESALs)	
Asphalt Pavement	3 1/2	3 1/2
Aggregate Base	8	6
Sand Section	---	12
	Heavy Duty Pavement (Drive Lanes/Heavy Equipment Areas - Up to 250,000 ESALs)	
Asphalt Pavement	4	4
Aggregate Base	10	8
Sand Section	---	12
	Concrete Pavement (Fuel Station)	
Concrete	6	
Aggregate Base	4	

C.7.b. Concrete Pavements

We assumed the concrete pavement sections in Table 9 will have edge support. We recommend placing an aggregate base below the pavement to provide a suitable subgrade for concrete placement, reduce faulting and help dissipate loads. Appropriate mix designs, panel sizing, jointing, doweling and edge reinforcement are critical to performance of rigid pavements. We recommend you contact your civil engineer to determine the final design or consult with us for guidance on these items.

C.7.c. 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.7.d. Subgrade Drainage

We recommend installing perforated drainpipes throughout pavement areas at low points, around catch basins, and behind curb in landscaped areas. We also recommend installing drainpipes along pavement and exterior slab edges where exterior grades promote drainage toward those edge areas. 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.7.e. Performance and Maintenance

We based the above pavement designs on a 20-year performance life for bituminous and a 35-year life for concrete. 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 exterior slabs and 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 exterior slabs and 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.8. Utilities

C.8.a. Subgrade Stabilization

Earthwork activities associated with utility installations located inside the building area should adhere to the recommendations in Section C.2.g.

For exterior utilities, we anticipate the soils at typical invert elevations will be suitable for utility support. However, if construction encounters unfavorable conditions such as soft clay, organic soils or perched water at invert grades, the unsuitable soils may require some additional subcutting and replacement with sand or crushed rock to prepare a proper subgrade for pipe support. Project design and construction should not place utilities within the 1H:1V oversizing of foundations.

C.8.b. Corrosion Potential

Based on our experience, the soils encountered by the borings are moderately corrosive to metallic conduits, but only marginally corrosive to concrete. We recommend specifying non-corrosive materials or providing corrosion protection, unless project planning chooses to perform additional tests to demonstrate the soils are not corrosive.

C.9. Stormwater

We estimated infiltration rates for some of the soils we encountered in our soil borings, as listed in Table 10. These infiltration rates represent the long-term infiltration capacity of a practice and not the capacity of the soils in their natural state. Field testing, such as with a double-ring infiltrometer (ASTM D3385), may justify the use of higher infiltration rates. However, we recommend adjusting field test rates by the appropriate correction factor, as provided for in the Minnesota Stormwater Manual or as allowed by the local watershed. We recommend consulting the Minnesota Stormwater Manual for stormwater design.

Table 10. Estimated Design Infiltration Rates Based on Soil Classification

Soil Type	Infiltration Rate * (inches/hour)
Silty sands, silty gravelly sands	0.45

*From Minnesota Stormwater Manual. Rates may differ at individual sites. Given the dense nature of the till we suspect it may be lower.

Fine-grained soils (silts and clays), topsoil or organic matter that mixes into or washes onto the soil will lower the permeability. The contractor should maintain and protect infiltration areas during construction. Furthermore, organic matter and silt washed into the system after construction can fill the soil pores and reduce permeability over time. Proper maintenance is important for long-term performance of infiltration systems.

This geotechnical evaluation does not constitute a review of site suitability for stormwater infiltration or evaluate the potential impacts, if any, from infiltration of large amounts of stormwater.

C.10. Equipment Support

The recommendations included in the report may not be applicable to equipment used for the construction and maintenance of this project. We recommend evaluating subgrade conditions in areas of shoring, scaffolding, cranes, pumps, lifts and other construction equipment prior to mobilization to determine if the exposed materials are suitable for equipment support, or require some form of subgrade improvement. We also recommend project planning consider the effect that loads applied by such equipment may have on structures they bear on or surcharge – including pavements, buried utilities, below-grade walls, etc. We can assist you in this evaluation.

D. Procedures

D.1. Penetration Test Borings

We drilled the penetration test borings with an all-terrain 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. We collected thin-walled tube samples in general accordance with ASTM D1587 at selected depths. 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. We will forward a sealing record for those boreholes to the Minnesota Department of Health Well Management Section.

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 and other in-situ 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 and other in-situ 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 or allowed them to remain open for an extended period of observation, 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

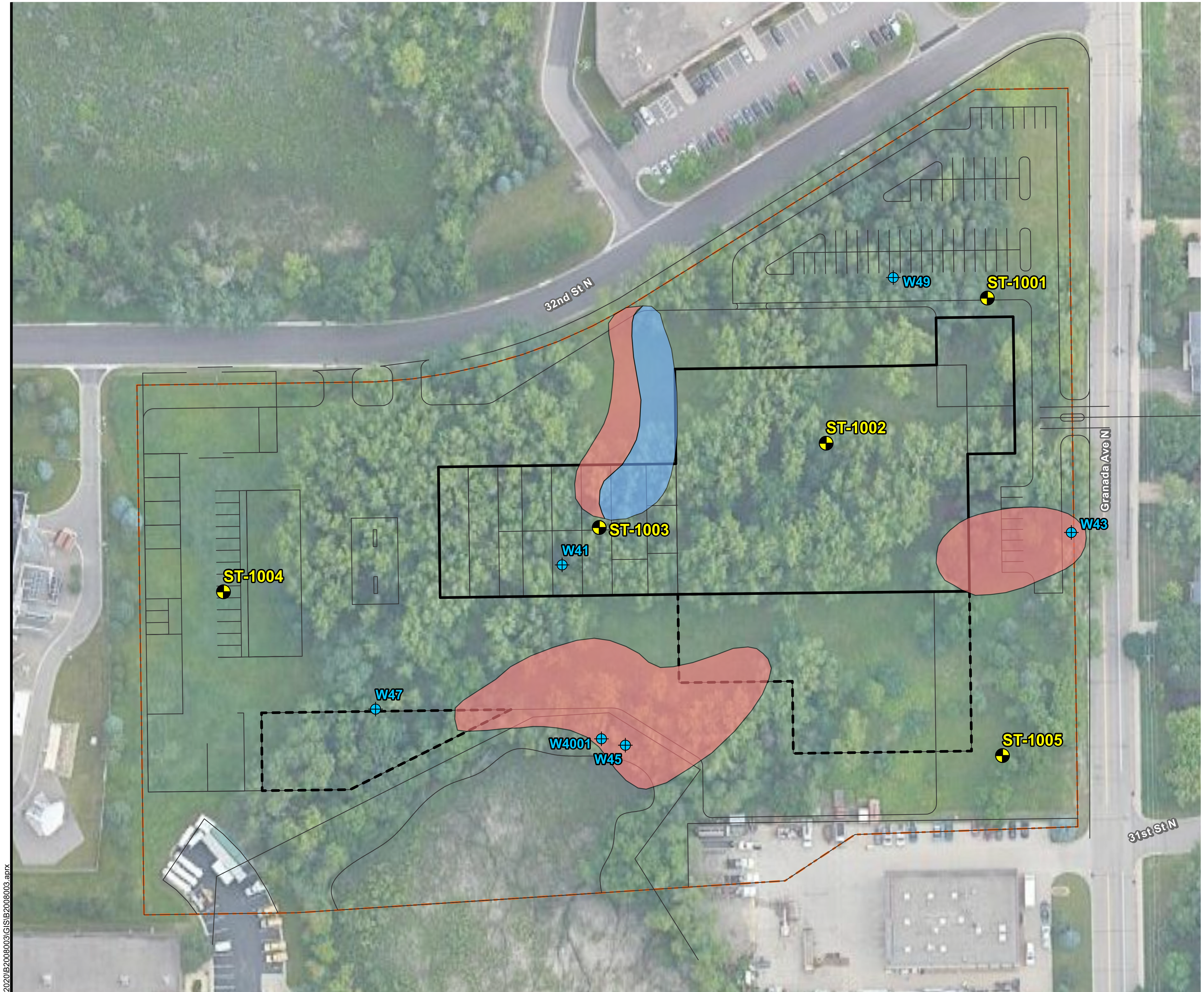
This report is for the exclusive use of the addressed parties. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

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

BRAUN INTERTEC



Location of Standard Penetration Test Boring

Historical Sample Locations Monitoring Well sealed, apprx.

Class I Area

Class II Areas

Proposed Building

Proposed Building Expansion

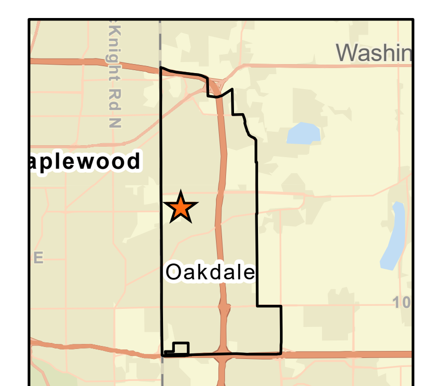
Site Plan (20200615)

Site Boundary

N

0 40 80 Feet

Scale 1" = 80'



F:\2020\B2008003\GIS\B2008003.aprx

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Data & Imagery Provided By

OpenStreetMap, Esri, MetroGIS Metropolitan Council, County of Washington

Drawing Information

Project No: B2008003

Drawing No: BoringSketch

Drawn By: CMF

Drawn Drawn: 9/18/2020

Checked By: CK

Last Modified: 10/1/2020

Project Information

Proposed City of Oakdale Public Works Building

Granada Ave N and 32nd St N

Oakdale, Minnesota

Boring Location Sketch

Figure 1

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2008003
Geotechnical Evaluation
Proposed City of Oakdale Public Works Building
Granada Avenue North and 32nd Street North
Oakdale, Minnesota

BORING:	**ST-1001**		
LOCATION: See attached sketch			
NORTHING:	190555	EASTING:	463339
START DATE:	09/25/20	END DATE:	09/25/20
SURFACING:	Grass	WEATHER:	

DRILLER:	B. Kammermeier	LOGGED BY:	R. Braun		
SURFACE ELEVATION:	1007.5 ft	RIG:	7506	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 Depth	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
1007.3 / 0.2		SILTY SAND (SM), fine to medium-grained, trace roots, black, moist (TOPSOIL FILL)					
1003.5 / 4.0		FILL: SILTY SAND (SM), fine to medium-grained, trace Gravel, brown, moist		5-7-9 (16) 15"		10	
983.0 / 24.5		SILTY SAND (SM), fine to medium-grained, trace Gravel, brown, moist, medium dense to dense (GLACIAL TILL)	5	8-9-10 (19) 18"		8	
				5-11-13 (24) 16"			
			10	17-24-24 (48)			
				7-13-18 (31)			
			15	4-7-10 (17) 20"			
			20	9-11-13 (24) 21"			
				8-10-14 (24) 20"			Water not observed while drilling.
		END OF BORING Boring immediately grouted	25				
			30				

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2008003
Geotechnical Evaluation
Proposed City of Oakdale Public Works Building
Granada Avenue North and 32nd Street North
Oakdale, Minnesota

BORING:	**ST-1002**		
LOCATION:	See attached sketch		
NORTHING:	190436	EASTING:	463202
DRILLER:	B. Kammermeier	LOGGED BY:	R. Braun
START DATE:	09/25/20	END DATE:	09/25/20
SURFACE ELEVATION:	1004.5 ft	RIG:	7506
METHOD:	3 1/4" HSA	SURFACING:	Dirt/grass
WEATHER:			

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
1004.3 / 0.2		SILTY SAND (SM), fine to medium-grained, trace roots, black, moist (TOPSOIL FILL)						
1000.5 / 4.0		FILL: POORLY GRADED SAND with SILT (SP-SM), fine to medium-grained, trace Gravel, brown, moist		X	10-8-6 (14) 17"		4	P200=6%
980.0 / 24.5		SILTY SAND (SM), fine to medium-grained, trace Gravel, brown, moist, medium dense to dense (GLACIAL TILL)	5	X	11-15-24 (39) 19"		5	
				X	6-14-16 (30) 20"			
			10	X	12-19-22 (41) 20"			
				X	6-17-24 (41) 14"			
			15	X	5-11-14 (25) 21"			
			20	X	8-10-17 (27) 21"			
				X	7-13-17 (30) 10"			Water not observed while drilling.
		END OF BORING Boring immediately grouted	25					
			30					

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2008003 **Geotechnical Evaluation** **Proposed City of Oakdale Public Works Building** **Granada Avenue North and 32nd Street North** **Oakdale, Minnesota**	BORING: **ST-1003**		
	LOCATION: See attached sketch		
	NORTHING: 190368	EASTING: 463010	
DRILLER: B. Kammermeier	LOGGED BY: R. Braun	START DATE: 09/25/20	END DATE: 09/25/20
SURFACE ELEVATION: 1003.2 ft	RIG: 7506	METHOD: 3 1/4" HSA	SURFACING: Dirt/weeds
		WEATHER:	

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample depth	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
1002.9 / 0.3		SILTY SAND (SM), fine to medium-grained, trace roots, black, moist (TOPSOIL FILL)					
999.2 / 4.0		FILL: SILTY SAND (SM), fine to medium-grained, trace Gravel, brown, moist		8-6-7 (13) 15"		7	
978.7 / 24.5		SILTY SAND (SM), fine to medium-grained, trace Gravel, brown to gray, moist, loose to medium dense (GLACIAL TILL)	5	3-4-4 (8) 16"		9	
				5-6-6 (12) 16"			
			10	7-10-12 (22) 18"			
				5-10-10 (20) 18"			
			15	6-6-8 (14) 17"			
			20	5-10-11 (21) 18"			
				4-6-9 (15) 16"			
		END OF BORING Boring immediately grouted	25				Water not observed while drilling.
			30				

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2008003
Geotechnical Evaluation
Proposed City of Oakdale Public Works Building
Granada Avenue North and 32nd Street North
Oakdale, Minnesota

BORING:	ST-1004		
LOCATION: See attached sketch			
NORTHING:	190320	EASTING:	462693
DRILLER: B. Kammermeier	LOGGED BY: R. Braun		
START DATE:	09/25/20	END DATE:	09/25/20
SURFACE ELEVATION: 1005.2 ft	RIG: 7506	METHOD: 3 1/4" HSA	
SURFACING:	Long grass	WEATHER:	

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample Depth	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
1004.9 / 0.3		SILTY SAND (SM), fine to medium-grained, trace roots, black, moist (TOPSOIL FILL)					
		FILL: SILTY SAND (SM), fine to medium-grained, trace Gravel, brown, moist		4-3-4 (7) 16"		16	
			5	3-2-2 (4) 16"		12	
998.2 / 7.0		SILTY SAND (SM), fine to medium-grained, trace Gravel, brown, moist, medium dense (GLACIAL TILL)		7-7-9 (16) 17"			
			10	5-10-9 (19) 20"			
				5-9-13 (22) 19"			
			15	7-9-10 (19) 21"			
			20	5-7-10 (17) 19"			
				5-10-12 (22) 14"			
980.7 / 24.5		END OF BORING Boring immediately grouted	25				Water not observed while drilling.
			30				

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2008003
Geotechnical Evaluation
Proposed City of Oakdale Public Works Building
Granada Avenue North and 32nd Street North
Oakdale, Minnesota

BORING:	**ST-1005**		
LOCATION: See attached sketch			
NORTHING:	190170	EASTING:	463345
DRILLER: B. Kammermeier	LOGGED BY: R. Braun	START DATE: 09/25/20	END DATE: 09/25/20
SURFACE ELEVATION: 1005.1 ft	RIG: 7506	METHOD: 3 1/4" HSA	
SURFACING: Long 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
1004.8 / 0.3		SILTY SAND (SM), fine to medium-grained, trace roots, black, moist (TOPSOIL FILL)					
1001.1 / 4.0		FILL: SILTY SAND (SM), fine to medium-grained, trace Gravel, brown, moist	X	7-6-6 (12) 19"		16	
		SILTY SAND (SM), fine to medium-grained, trace Gravel, brown, moist to wet, loose to dense (GLACIAL TILL)	X	7-5-7 (12) 21"		9	
			X	7-14-18 (32) 18"			
			X	5-10-14 (24) 20"			
			X	6-9-6 (15) 21"			
	▽	*Wet at 15 feet*	X	4-7-3 (10) 19"			
			X	7-9-12 (21) 17"			
980.6 / 24.5			X	1-2-4 (6) 20"			Water observed at 15.0 feet while drilling.
		END OF BORING Boring immediately grouted					

LOG OF BORING

BARR ENGINEERING CO
MINNEAPOLIS, MINNESOTA

PROJECT 3M/Oakdale
DATE STARTED 3/30/81
DATE COMPLETED 3/30/81
FIELD ENGINEER J. Willard (BEC)
CREW CHIEF P. Francis (SEC)

INITIAL GWL 9.5
____ HRS. GWL ____
____ HRS. GWL ____

BORING NO. 41
ELEVATION 998.9±.1

DEPTH (feet)	BLOWS PER 6"	SAMPLE TYPE	RECOVERY (In.)	PROFILE	DESCRIPTION OF MATERIALS AND REMARKS
					Clayey sand, very fine to medium grained, fairly well to poorly graded, quartz, 5% rock fragments and feldspar, increasing to 10%, trace fine gravel, 100% rock fragments and feldspar, moist, wet to saturated at 9.5', brown. (Alluvium)
5	7 / 12 / 17	SS	10		
10	5 / 8 / 11	SS	11		
15	5 / 7 / 9	SS	13		
					EOB 3/30/81

REMARKS: 2.0' PVC Standing

Sheet 1 of 1

BARR ENGINEERING CO
MINNEAPOLIS, MINNESOTA

LOG OF BORING

PROJECT 3M Oakdale Remedial Investigation — BORING NO. 45
DATE STARTED 1/6/84
DATE COMPLETED 1/7/84 — INITIAL GWL 3' — ELEVATION 995.1
FIELD ENGINEER J. Willard - BEC — 60 HRS. GWL 2'
CREW CHIEF D. Ruchti - BET — ___ HRS. GWL ___

DEPTH (feet)	BLOWS PER 6"	SAMPLE TYPE	RECOVERY (Inches)	PIEZOMETER CONSTRUCTION	PROFILE	DESCRIPTION OF MATERIALS AND REMARKS
		A				Silty sand, wire, fine to medium grained, dark brown. (Fill)
5	2 2 2	SS				Peat, wet, 10YR 2/1, black. (Swamp Deposits)
						Clayey silt, trace medium sand, wet, 10YR 3/2, very dark grayish brown. (Alluvium)
10	5 4 5	SS				
						EOH 1/6/84

REMARKS:

Sheet 1 of 1

LOG OF BORING

BARR ENGINEERING CO
MINNEAPOLIS, MINNESOTA

PROJECT 3M Oakdale Remedial Investigation
BORING NO. 47
DATE STARTED 1/9/84
DATE COMPLETED 1/10/84
INITIAL GWL 11
ELEVATION 1004.0
FIELD ENGINEER J. Willard - BEC
22 HRS. GWL 12
CREW CHIEF D. Ruchti - BET
HRS. GWL

DEPTH (feet)	BLOWS PER 6"	SAMPLE TYPE	RECOVERY (Inches)		PROFILE	DESCRIPTION OF MATERIALS AND REMARKS
						Silty sand, trace coarse sand, trace organics (roots), fine grained, moist, 7.5YR 4/4 dark brown. (Alluvuim)
5	4 9 9	SS				
10	5 9 12	SS				A little clay, trace fine gravel, wet.
15	8 19 20	SS				
20	6 10 12	SS				
						EOH 1/9/94

REMARKS:

Sheet 1 of 1

BARR ENGINEERING CO
MINNEAPOLIS, MINNESOTA

LOG OF BORING

PROJECT: 3M Oakdale Remedial Investigation
BORING NO.: 49
DATE STARTED: 1/6/84
DATE COMPLETED: 1/9/84
FIELD ENGINEER: J. Willard - BEC
CREW CHIEF: D. Ruchti - BET
INITIAL GWL: 19.0
18 HRS. GWL: 12.5
____ HRS. GWL: ____
ELEVATION: 1007.8

DEPTH (feet)	BLOWS PER 6"	SAMPLE TYPE	RECOVERY (Inches)		PROFILE	DESCRIPTION OF MATERIALS AND REMARKS
						Silty sand, some clay, fine to medium grained, moist 7.5YR 3/4 dark brown. (Alluvium)
5	8 10 14	SS				
10	10 14 21	SS				
15	8 12 15	SS				Trace gravel.
20	5 12 13	SS				Silty sand, trace clay decreasing to no clay at depth, trace gravel and coarse sand, wet, 10YR 3/3 dark brown. (Alluvium)
						10YR 3/2 very dark grayish brown.
25	4 7 12	SS				
30	7 10	SS				10YR 4/2 dark grayish brown.

REMARKS:

BARR ENGINEER'NG CO
MINNEAPOLIS, MINNESOTA

LOG OF BORING

PROJECT 3M Oakdale Remedial Investigation
BORING NO. 49
DATE STARTED 1/6/84
DATE COMPLETED 1/9/84
INITIAL GWL
ELEVATION 1007.8
FIELD ENGINEER J. Willard - BEC
___ HRS. GWL
CREW CHIEF D. Ruchti - BET
___ HRS. GWL

DEPTH (feet)	BLOWS PER 6"	SAMPLE TYPE	RECOVERY (Inches)		PROFILE	DESCRIPTION OF MATERIALS AND REMARKS
	19					EOH 1/6/84

REMARKS:

Sheet 2 of 2

BARR ENGINEERING CO
MINNEAPOLIS, MINNESOTA

LOG OF BORING

PROJECT: 3M Oakdale Remedial Investigation
BORING NO. 4001
DATE STARTED: 3/30/84
DATE COMPLETED: 4/3/84
INITIAL GWL: ____
ELEVATION: 995.4
FIELD ENGINEER: B. Rohr - BEC
____ HRS. GWL ____
CREW CHIEF: D. Ruchti - BET
____ HRS. GWL ____

DEPTH (feet)	BLOWS PER 6"	SAMPLE TYPE	RECOVERY (Inches)	PIEZOMETER CONSTRUCTION	PROFILE	DESCRIPTION OF MATERIALS AND REMARKS
	18, 15, 14	SS				Silty sand, some clay, rubbish, some layers of clayey silt and sandy silt, mixed rubbish including some apparently burned material, wet, clay layers mottled, variable color 10YR 3/1 very dark gray and 10YR 2/2 very dark brown. (Fill)
5	25, 25, 4	SS				
	6, 6, 7	SS				
10	3, 5, 5	SS				
	200/3"	SS				
15	9, 6, 4	SS				
	12, 17, 20	SS				
20	12, 14, 15	SS				Sand to sandy gravel, trace fines, medium to coarse grained, mostly rock fragments including angular limestone chips, fairly uniform, wet to saturated. (Alluvium)
	5, 14, 14	SS				
25	90, 40, 42	SS				
	46, 32, 21	SS				
30	28, 36	SS				

REMARKS:

BARR ENGINEERING CO
MINNEAPOLIS, MINNESOTA

LOG OF BORING

PROJECT 3M Oakdale Remedial Investigation
BORING NO. 4001
DATE STARTED 3/30/84
DATE COMPLETED 4/30/84
INITIAL GWL ____
ELEVATION 995.4
FIELD ENGINEER B. Rohr - BEC
____ HRS. GWL ____
CREW CHIEF D. Ruchti - BET
____ HRS. GWL ____

DEPTH (feet)	BLOWS PER 6"	SAMPLE TYPE	RECOVERY (Inches)	PIEZOMETER CONSTRUCTION	PROFILE	DESCRIPTION OF MATERIALS AND REMARKS
	25					
	25 32 72					
35	8 16 20					
	17 20 20					
						Sandy silt, trace gravel, fine to medium grained sand, slightly moist to dry, 2.5Y 4/2 dark grayish brown. (Till)
40	17 22 35					
	10 19 21					Trace clay, 10YR 4/3 dark brown.
45	14 14 17					
	17 19 24					
50	15 22 29					10YR 4/4 dark yellowish brown.
	20 47 37					Mottled brown and gray.
						Silt, trace clay, moist, 10YR 3/1 very dark gray. (Alluvium)
55	52 25 83					EOH 4/2/84

REMARKS:

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Descriptive Terminology of Soil

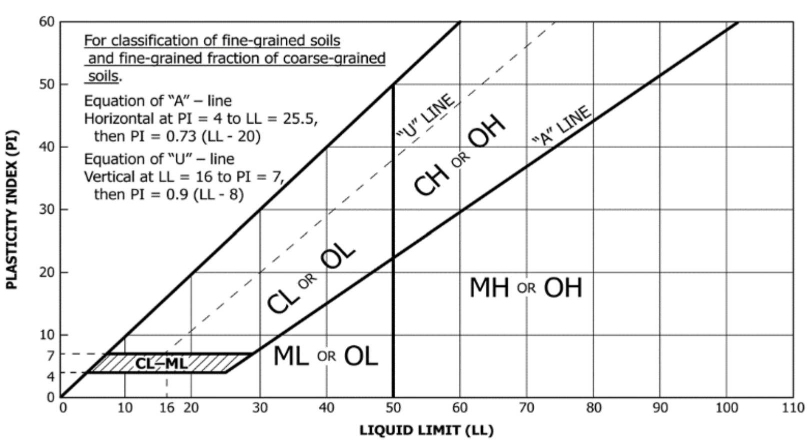
Based on Standards ASTM D2487/2488
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: 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.



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 (▼).

Laboratory Tests

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