Geotechnical Evaluation Report

Bottineau Ridge Phase II Apartments
Northwest Quadrant of Intersection of Arbor Lakes Parkway and Hemlock Avenue
Maple Grove, Minnesota

Prepared for

Duffy Development, Inc.

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.

Dec 16 2016 12:30 PM

Daniel B. Mahrt, PE
Associate Principal – Principal Engineer
License Number 42729
December 16, 2016

DANIEL MAHRT LICENSED PROFESSIONAL ENGINEER 42729 STATE OF MINNESOTA

Mahrt, Dan
Dec 16 2016 12:31 PM

Project B1611164

Braun Intertec Corporation

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December 16, 2016 Project B1611164

Mr. John Duffy
Duffy Development, Inc.
11900 Wayzata Boulevard, Suite 216
Minnetonka, MN 55305

Re: Geotechnical Evaluation
Bottineau Ridge Phase II Apartments
Northwest Quadrant of Intersection of Arbor Lakes Parkway and Hemlock Avenue
Maple Grove, Minnesota

Dear Mr. Duffy:

We are pleased to present this Geotechnical Evaluation Report for the Phase II of the Bottineau Ridge Apartment complex.

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 Dan Mahrt at 651.487.7031 (dmahrt@braunintertec.com).

Sincerely,

BRAUN INTERTEC CORPORATION

Dec 16 2016 12:31 PM

Daniel B. Mahrt, PE
Associate Principal – Principal Engineer

Mark L. Jenkins, PE
Senior Engineer

Table of Contents

Table of Contents (continued)

Description **Page**

A. Introduction

A.1. Project Description

This Geotechnical Evaluation Report addresses the proposed design and construction of Phase II of the Bottineau Ridge Apartments, located in the northwest corner of the intersection of Arbor Lakes Parkway and Hemlock Avenue in Maple Grove, Minnesota. Figure 1 in the Appendix shows the layout of the borings on the site. Tables 1 and 2 provide project details.

Table 1. Building Description

Aspect	Description
Below grade levels	One below-grade parking level
Above grade levels	4
Lowest level floor elevation	Approximately 901 (provided)
Maximum Column loads (kips)	250 (Assumed)
Maximum Wall loads (kips per linear foot)	8 (Assumed)
Nature of construction	Below-grade concrete or masonry, wood-framed above grade
Cuts or fills	Southern portion of site is near planned final grades. Northern portion of the site will require up to about 5 feet of fill.
Tolerable building settlement	1 inch total, 2/3-inch differential (Assumed)
Comments	Future expansion plans include adding to the east side of the Phase II structure. Borings for the future expansion were not included in this evaluation.

Table 2. Site Aspects and Grading Description

Aspect	Description
Assumed Pavement loads	Light-duty: 50,000 ESALs*
	Heavy-duty: 150,000 ESALs*
Grade changes	Less than 3 feet (Assumed)

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

A.2. Site Conditions and History

The site is currently vacant, with sparse vegetation. Up to 8 inches of standing water was present in the central portion of the site when we completed the borings.

This area of Maple Grove has historically been mined for gravel. Braun Intertec has completed excavation observations and compaction testing supporting mine reclamation on this site and adjacent sites. Braun Intertec also completed a Geotechnical Evaluation Report for the Bottineau Ridge Phase I apartment building located south of the planned Phase II building (Braun Intertec Project SP-13-00212). As a part of the work on Bottineau Ridge Phase I, two soil borings were completed in the area of the Phase II development. Based on the results of those soil borings, and our previous work on this site, we anticipate that the northern portion of the site has not likely been mined, while the southern portion of the site may contain up to 15 feet of existing fill associated with mine reclamation.

Current grades within the building pad range from about 903 to 905 feet.

A.3. Purpose

The purpose of our geotechnical evaluation is to characterize subsurface geologic conditions at selected exploration locations and provide geotechnical recommendations for the design and construction of the new apartment facility.

A.4. Background Information and Reference Documents

We reviewed the following information:

- Site Plan dated April 27, 2016, prepared by Daniel K. Duffy Architects, Inc.
- Previous geotechnical report for Bottineau Phase I, prepared by Braun Intertec (project SP-13-00212) and dated March 6, 2013.
- "Summary Report" of excavation observations and compaction testing services at Seleen Pit, prepared by Braun Intertec (Project BN-04-03896), dated January 26, 2005.

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

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 dated November 21, 2016. 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. Duffy Development 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 six standard penetration test (SPT) borings, denoted as ST-101 to ST-106, to nominal depths of 10 to 25 feet below grade across the site.

- 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 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 the personnel performing the evaluation are not trained to provide environmental services or testing. We can provide these 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. 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 sheets in the Appendix include definitions of abbreviations used in Table 3.

Table 3. Subsurface Profile Summary*

Strata	Soil Type - ASTM Classification	Range of Penetration Resistances	Commentary and Details
Fill	SM, SC, SP-SM	11 to 44 BPF	▪ Generally moist. ▪ Thicknesses at boring locations varied from 4 to 12 feet.
Glacial deposits	GP, GM, SP, SP-SM, SM	3 to over 50 BPF	▪ General penetration resistance of 10 to 30 BPF.

Strata	Soil Type - ASTM Classification	Range of Penetration Resistances	Commentary and Details
	SC	8 to 18 BPF	▪ Variable amounts of gravel; may contain cobbles and boulders. ▪ Moist to waterbearing

*Abbreviations defined in the attached Descriptive Terminology sheets.

Based on our review of previous geotechnical and construction materials testing information, it appears that the southern portion of the site was mined for gravel. The fill present in the northern portion of the site was likely placed during reclamation of the mine. Based on the blow counts and the types of soils identified as fill, the fill that was noted in the borings appeared to be placed in a controlled manner.

B.3. Groundwater

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 or Estimated Depth to Groundwater (ft)	Corresponding Groundwater Elevation (ft)
ST-101	903.5	17	886 ½
ST-102	903.6	16	888
ST-103	904.2	19	885 ½
ST-104	904.8	20	885

The soil borings indicate a layered soil profile that is conducive for encountering perched water conditions.

B.4. Laboratory Test Results

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

We performed moisture content (MC) tests (per ASTM D2216) on selected samples to aid in our classifications and estimations of the materials' engineering properties. The moisture content of the fill varied from approximately 3 to 10 percent, indicating that the material was dry of to near its probable optimum moisture content.

We performed tests to evaluate the percent of particles passing the #200 sieve (P200) (per ASTM D1140) to estimate the engineering properties of the granular material. The results of these tests indicated the soils encountered had P200s ranging from 6 to 36 percent. The tests indicated the samples classified as poorly-graded sand with silt (SP-SM) and clayey sand (SC), The Appendix includes graphical representations of the grain size analyses. The Log of Boring sheets list the results of P200 tests in the "Tests or Notes" column.

C. Recommendations

C.1. Design and Construction Discussion

Based on the results of our borings and our experiences on this site and adjacent sites, it is our opinion that the site is generally capable of accommodating the planned construction, supporting the building on conventional spread footings, with grade-supported slabs and bituminous pavements. As our records indicate portions of this site lie in an area that was not previously mined, we recommend that any existing fill encountered during construction be closely evaluated by a geotechnical engineer.

The near-surface subgrade soils typically consist of silty and clayey soils that are very susceptible to strength loss upon wetting, and disturbance from construction activities. Haul roads and staging areas will be particularly sensitive to disturbance and strength loss. Subexcavation and recompaction or replacement of the subgrade soils can be limited if the exposed grades are protected with imported crushed stone.

The existing, non-organic, debris-free, on-site soils are considered suitable for reuse as engineered fill below the proposed building pad. We do not recommend reusing existing fill that contains debris or organic material as structural fill.

In our judgment, the on-site soils are suitable for reuse as engineered fill, but will require moisture conditioning to achieve compaction. In the spring, and after periods of precipitation, the near-surface soils will likely be wet. To dry these soils, the contractor will need to perform extensive scarifying, which is easier to accomplish in the relatively drier months of June to September. If the contractor performs site grading in the spring or fall, on-site drying of these soils may not prove feasible and require importing drier soils. If time or space is not available to dry these soils, the contractor may need to import drier soils. We recommend discussing the reuse of these materials with potential contractors at the bidding stages of the project.

To account for potential rainfall during construction, we recommend maintaining construction grades to intercept surface water flow into the area and drain water from the area to an appropriate collection point. After grading, the contractor should compact the soil surface with a smooth drum roller to attempt to lower infiltration. After rain events, the contractor should limit construction traffic until the surface is dry enough that traffic will not mix accumulated surface water into lower portions of the soil.

C.2. Site Grading and Subgrade Preparation

C.2.a. Building Subgrade Excavations

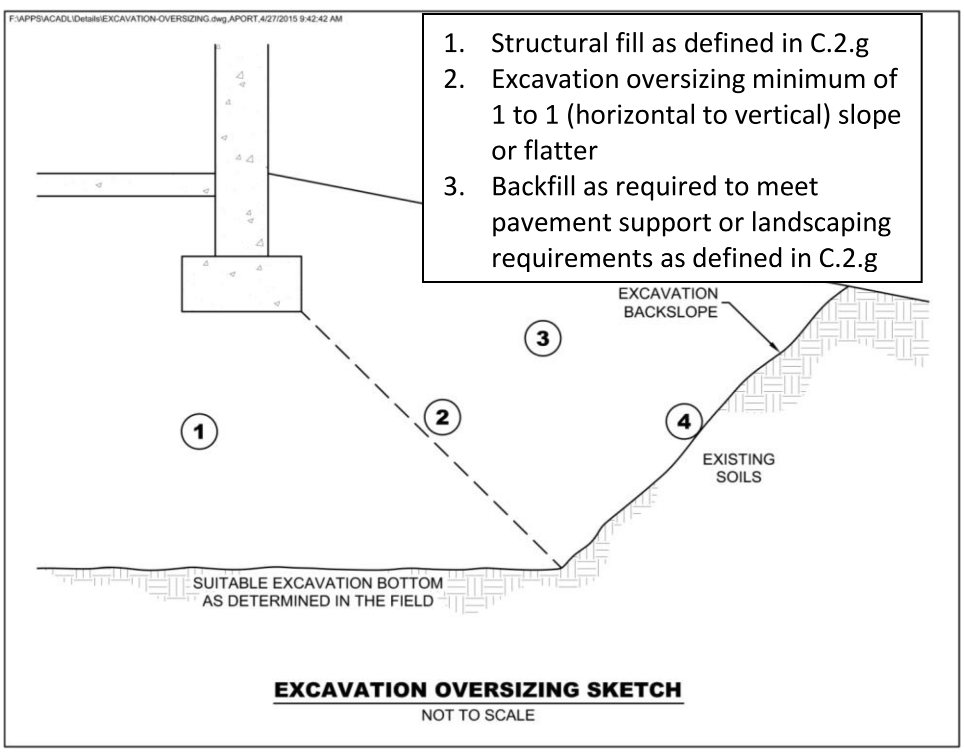
We recommend removing topsoil from below the proposed building and pavement areas. We anticipate the excavations will range from about 6 inches to 2 feet.

We anticipate excavations to reach the garage slab and foundation bearing elevations will terminate in fill. Once subgrade elevations are exposed, we recommend surface compacting the exposed fill with a vibratory smooth drum self-propelled roller with a minimum 42-inch diameter drum, capable of exerting a centrifugal force of at least 50,000 pounds. We recommend the surface compaction consist of a minimum of 6 passes of the compactor. Footing subgrade soils should be compacted with a large vibratory plate prior to placing formwork. The geotechnical engineer should observe the compaction efforts to determine if any areas are unstable and need further stabilization measures. Compaction testing should subsequently be performed to evaluate the compactive effort.

C.2.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 1 for an illustration of excavation oversizing.

Figure 1. Generalized Illustration of Oversizing



C.2.c. Excavated Slopes

Based on the borings, we anticipate on-site soils in excavations will consist of mixed soils. These soils are typically considered Type C Soil under OSHA (Occupational Safety and Health Administration) guidelines. OSHA guidelines indicate unsupported excavations in Type C soils should have a gradient no steeper than 1 1/2H: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.2.d. Excavation Dewatering

We recommend removing groundwater from the excavations. Project planning should include temporary sumps and pumps for excavations in low-permeability soils, such as clays. Dewatering of high-permeability soils (e.g., sands) from within the excavation with conventional pumps has the potential to loosen the soils, due to upward flow. A well contractor should develop a dewatering plan; the design team should review this plan.

C.2.e. Pavement and Exterior Slab Subgrade Preparation

We recommend the following steps for pavement and exterior slab subgrade preparation, understanding the site will have a grade change of 5 feet or less. Note that project planning may need to require additional subcuts to limit frost heave.

1. Strip unsuitable soils consisting of topsoil, organic soils, peat, 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 where accumulating water can be removed.

4. Scarify, moisture condition and surface compact the subgrade with at least 6 passes of a large roller with a minimum drum diameter of 3 ½ feet.

5. Place pavement fill to grade and compact in accordance with Section C.2.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.2.f.

C.2.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.2.g. Fill Materials and Compaction

Table 5 below contains our recommendations for fill materials.

Table 5. Fill Materials*

Locations To Be Used	Fill Classification	Possible Soil Type Descriptions	Gradation	Additional Requirements
▪ Below foundations ▪ Below interior slabs	Structural fill	SP, SW, SP-SM, SW-SM, SM, SC	100% passing 2-inch 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, SW, SP-SM, SW-SM, SM	100% passing 3-inch sieve < 20% passing #200 sieve	< 2% OC Plasticity Index (PI) < 4%
Pavements	Pavement fill	SP, SW, SP-SM, SW-SM, SM, SC	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

* Fill materials should satisfy applicable environmental requirements.

* 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 fill in loose lifts of approximately 8 to 10 inches thick. We recommend compacting fill in accordance with the criteria presented below in Table 6. The project documents should specify relative compaction of fill, based on the structure located above the fill, and vertical proximity to that structure.

Table 6. 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 foundations, slabs 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 fill.

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

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

C.2.h. Special Inspections of Soils

We recommend including the site grading and placement of fill within the building pad under the direction of Special Inspections, as provided in Chapter 17 of the International Building Code, which is adopted into the state building code. Special Inspection requires observation of soil conditions below fill or footings, evaluations to determine if excavations extend to the anticipated soils, and if fill materials meet requirements for type of fill and compaction condition of fill. A licensed geotechnical engineer should direct the Special Inspections of site grading and 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 fill, etc.) and compaction testing of the fill.

C.3. Spread Footings

Table 7 below contains our recommended parameters for foundation design.

Table 7. Recommended Spread Footing Design Parameters

Item	Description
Maximum net allowable bearing pressure (psf)	3,000
Minimum factor of safety for bearing capacity failure	3.0
Minimum width (inches)	18
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)	1
Differential settlement	Typically about 1/2 of total settlement*

* Actual differential settlement amounts will depend on final loads and foundation layout.

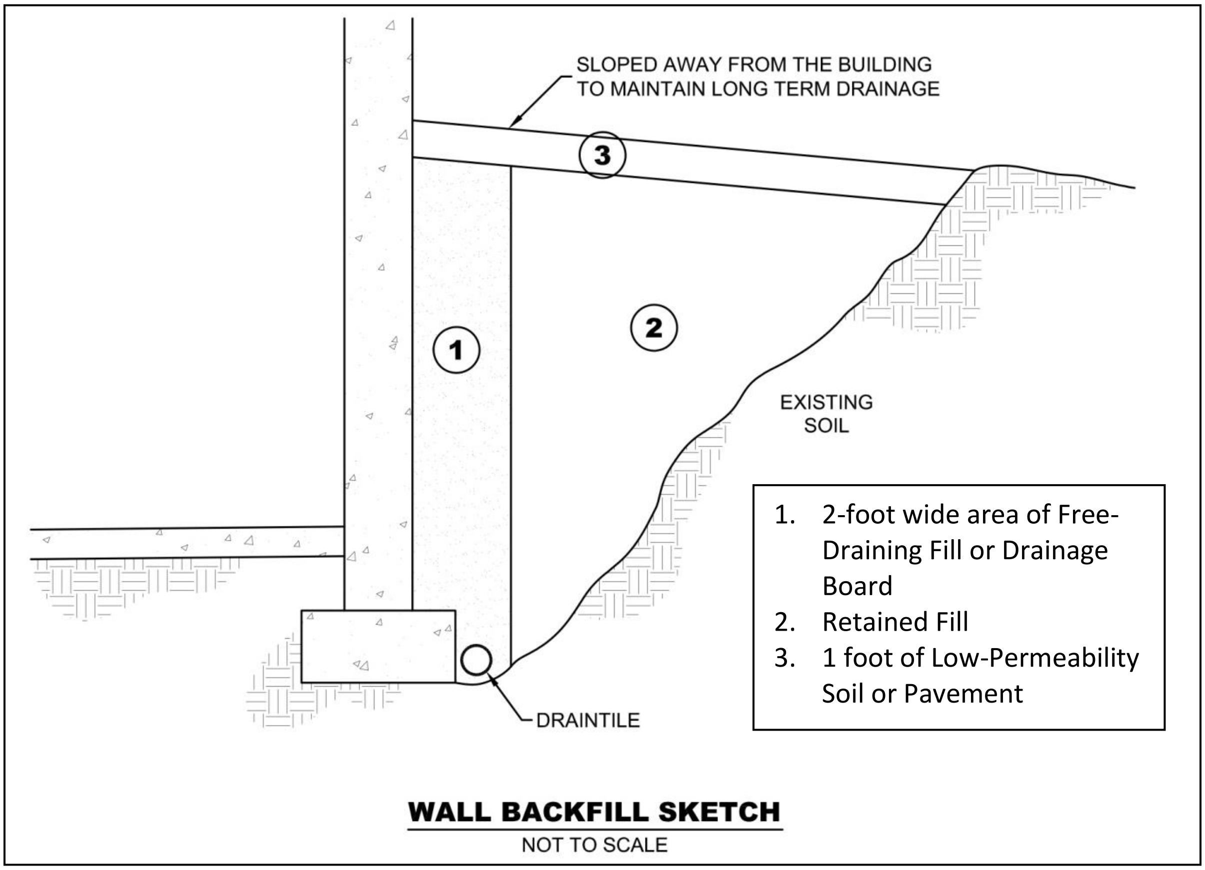
C.4. Below-Grade Walls

C.4.a. Drainage Control

We recommend installing drain tile to remove water behind the below-grade walls, at the location shown in Figure 2. The below-grade wall drainage system should also incorporate free-draining fill or a drainage board placed against the wall and connected to the drain tile.

Even with the use of free-draining fill, we recommend general waterproofing of below-grade walls that surround occupied or potentially occupied areas because of the potential cost impacts related to seepage after construction is complete.

Figure 2. Generalized Illustration of Wall Backfill



The materials listed in the sketch should meet the definitions in Section C.2.g. Low-permeability material is capable of directing water away from the wall, like clay, topsoil or pavement. The project documents should indicate if the contractor should brace the walls prior to filling and allowable unbalanced fill heights.

As shown in Figure 2, we recommend Zone 2 consist of retained fill, and this material will control lateral pressures on the wall. However, we are also providing design parameters for using other fill material. If final design uses non-sand material for fill, project planning should account for the following items:

- Other fill material may result in higher lateral pressure on the wall.
- Other fill material may be more difficult to compact.

- Post-construction consolidation of other fill material may result in settlement-related damage to the structures or slabs supported on the fill. Post-construction settlement of other fill material may also cause drainage towards the structure. The magnitude of consolidation could be up to about 3 percent of the wall fill thickness.

C.4.b. 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.

Table 8 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 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 the fill of walls.

Table 8. Recommended Below-Grade Wall Design Parameters – Drained Conditions

Retained Soil	Wet Unit Weight, pcf	Friction Angle, degrees	Active Lateral Coefficient/ Equivalent Fluid Pressure* (pcf)	At-Rest Lateral Coefficient/ Equivalent Fluid Pressure* (pcf)	Passive Lateral Coefficient/ Equivalent Fluid Pressure* (pcf)
SP, SP-SM	120	32	0.31/37	0.47/56	3.25/391
SM, SC	120	28	0.36/43	0.53/64	2.77/332

* 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.

Sliding resistance between the bottom of the footing and the soil can also resist lateral pressures. We recommend assuming a sliding coefficient equal to 0.33 between the concrete and soil.

The values presented in this section are un-factored.

C.5. Interior Slabs

C.5.a. Subgrade Modulus

The anticipated floor subgrade is fill consisting of silty and clayey sands. We recommend using a modulus of subgrade reaction, k, of 150 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, 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

C.6.a. General

Silty and clayey sands will underlie all or some of the exterior slabs, as well as pavements. We consider silty and clayey sands to be 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.

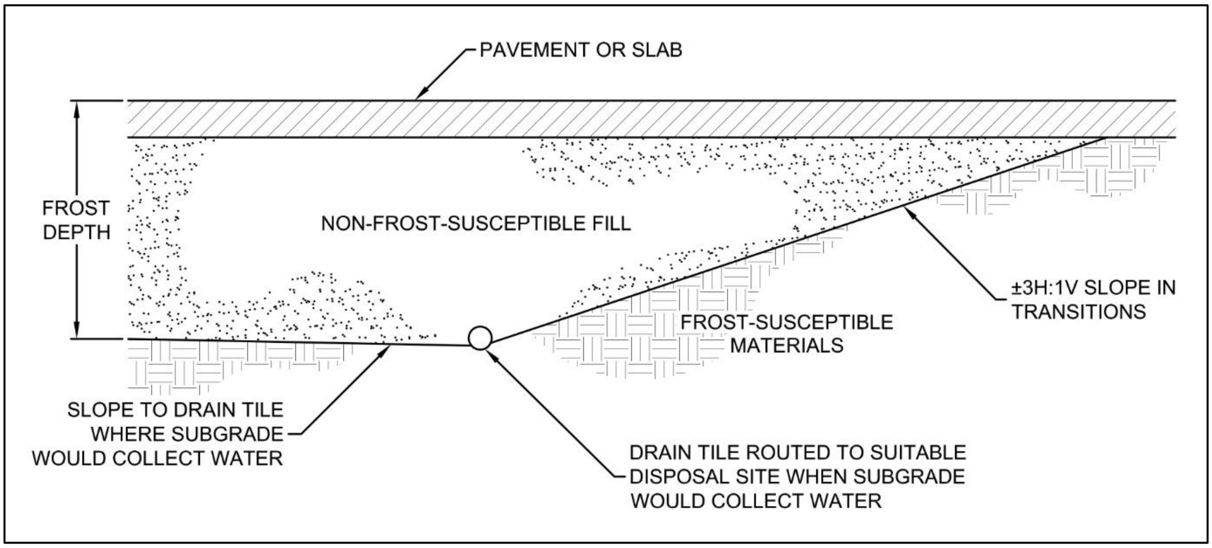
Even small amounts of frost-related differential movement at walkway joints or cracks can create tripping hazards. Project planning can explore several subgrade improvement options to address this condition.

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 5 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 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 excavation fill, 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 and Exterior Slabs

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 soils anticipated at the pavement subgrade elevation, we recommend pavement design assume an R-value of 30. 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.

Table 9. Recommended Bituminous Pavement Sections

Use	Light Duty	Heavy Duty
Minimum asphalt thickness (inches)	3 ½	4
Minimum concrete thickness (inches)	5	6
Minimum aggregate base thickness (inches)	8 (for bituminous pavement) 6 (for concrete pavement)	10 (for bituminous pavement) 6 (for concrete pavement)

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

We recommend specifying crushed aggregate base meeting the requirements of Minnesota Department of Transportation (MnDOT) Specification 3138 for Class 5. We recommend that the bituminous wear and non-wear courses meet the requirements of Specifications 2360, with the following designations:

- Wear: SPWEA240B or SPWEB240B
- Non-wear: SPNWA230B or SPNWB230B

In the above mixes, aggregate A (as in SPWE**A**240B), a 1/2-inch maximum size, will provide a surface with less visible aggregate than B (3/4-inch maximum size).

We recommend asphalt grade B (as in SPWEA240B), or 58-28. Additional resistance to rutting, scuffing and dimpling can be obtained with a 64-28/E grade asphalt. A PG 58-34/C asphalt grade will provide additional resistance to cold-weather cracking.

We recommend compacting the aggregate base to meet the requirements of MnDOT Specification 2211.3.D.2.c (Penetration Index Method for the dynamic cone penetrometer (DCP)). We recommend compacting bituminous pavements to at least 92 percent of their maximum theoretical (Rice) density.

We recommend specifying concrete for pavements that has a minimum 28-day compressive strength of 4,000 psi, and a modulus of rupture (M_r) of at least 600 psi. We also recommend Type I cement meeting the requirements of ASTM C 150. We recommend specifying 5 to 7 percent entrained air for exposed concrete to provide resistance to freeze-thaw deterioration, and a water/cement ratio of 0.45 or less for concrete exposed to deicers.

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 footprint should adhere to the recommendations in Section C.2.

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.9. 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 ATV-mounted core and auger drill equipped with hollow-stem auger. We performed the borings in general accordance with ASTM D1586 taking penetration test samples at 2 1/2- or 5-foot intervals. 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 also collected bulk samples of auger cuttings at selected locations for laboratory testing.

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 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 in accordance with ASTM D2488. The Appendix includes a chart explaining the classification system.

D.3.b. Laboratory Testing

The exploration logs in the Appendix note most of the results of the laboratory tests performed on geologic material samples. The remaining laboratory test results follow the exploration logs. We performed the tests in general accordance with ASTM or AASHTO 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

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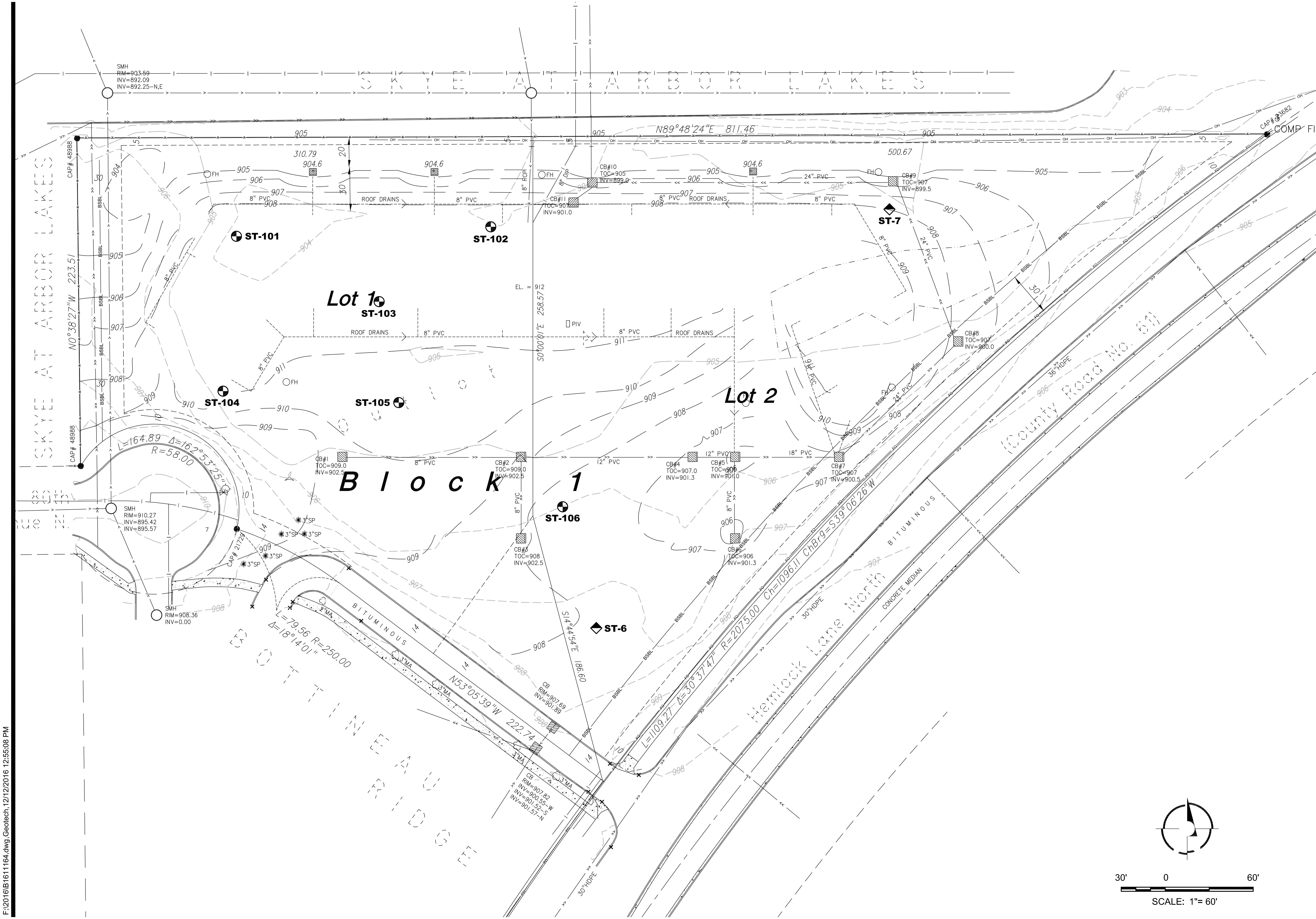

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Base Dwg Provided By:

SOIL BORING LOCATION SKETCH

GEOTECHNICAL EVALUATION
BOTTINEAU RIDGE II
NORTHWEST QUADRANT OF ARBOR LAKES PARKWAY AND HEMLOCK AVENUE
MAPLE GROVE, MINNESOTA

Project No:	B1611164
Drawing No:	B1611164
Scale:	1"= 60'
Drawn By:	JAG
Date Drawn:	11/25/16
Checked By:	DBM
Last Modified:	12/12/16
Sheet: of	Fig:

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LOG OF BORING

Braun Project B1611164 GEOTECHNICAL EVALUATION REPORT Bottineau Ridge II NWQ of Arbor Lakes Parkway & Hemlock Avenue Maple Grove, Minnesota	BORING: ST-101 LOCATION: See attached sketch.

DRILLER: M. Nolden	METHOD: 3 1/4" HSA, Autohammer	DATE: 12/2/16	SCALE: 1" = 4'

Elev. feet 903.5	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	P200 %	Tests or Notes
903.0	0.5	FILL	FILL: Silty Sand, fine-grained, dark brown, moist. (Topsoil)					
		FILL	FILL: Poorly Graded Sand with Silt, brown, moist.	11		3	6	
899.5	4.0	FILL	FILL: Silty Sand, medium-grained, trace Gravel, brown, moist.	16				
				44				
				33				
891.5	12.0	GP	POORLY GRADED GRAVEL, coarse-grained, brown, wet to waterbearing, medium dense to dense. (Glacial Outwash)	33				
				26				
					▽			An open triangle in the water level (WL) column indicates the depth at which groundwater was observed while drilling.
				44				
				38				
877.5	26.0		END OF BORING. Groundwater observed at 17 feet while drilling. Boring then backfilled with cuttings.					

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\AX PROJECTS\2016\11164.GPJ BRAUN_V8_CURRENT.GDT 12/16/16 11:32

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LOG OF BORING

Braun Project B1611164
GEOTECHNICAL EVALUATION REPORT
Bottineau Ridge II
NWQ of Arbor Lakes Parkway & Hemlock Avenue
Maple Grove, Minnesota

BORING: **ST-102**

LOCATION: See attached sketch.

DRILLER: M. Nolden	METHOD: 3 1/4" HSA, Autohammer	DATE: **12/2/16**	SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 903.6	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	P200 %	Tests or Notes
903.1	0.5	FILL	FILL: Silty Sand, fine-grained, dark brown, moist. (Topsoil)					
		FILL	FILL: Clayey Sand, brown, moist.	28		9	36	
				19				
896.6	7.0	SP-SM	POORLY GRADED SAND with SILT, Poorly Graded Sand with Silt, medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Outwash)	26				
				19				
892.6	11.0	SP-SM	POORLY GRADED SAND with SILT, coarse-grained, trace Gravel, moist to waterbearing, medium. (Glacial Outwash)	16				
				17	▽			
				13				
880.6	23.0	GP	POORLY GRADED GRAVEL, coarse-grained, brown, waterbearing, medium dense. (Glacial Outwash)	20				
877.6	26.0		END OF BORING. Groundwater observed at 16 feet while drilling. Boring then backfilled with cuttings.					

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LOG OF BORING

BRAUN INTERTEC

Braun Project B1611164
GEOTECHNICAL EVALUATION REPORT
Bottineau Ridge II
NWQ of Arbor Lakes Parkway & Hemlock Avenue
Maple Grove, Minnesota

BORING: **ST-103**

LOCATION: See attached sketch.

DRILLER: M. Nolden | METHOD: 3 1/4" HSA, Autohammer | DATE: **12/2/16** | SCALE: **1" = 4'**

Elev. feet 904.2	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	P200 %	Tests or Notes
903.9	0.3	FILL	FILL: Silty Sand, fine-grained, dark brown, moist. (Topsoil)					
		FILL	FILL: Clayey Sand, brown, moist.	20		10	33	
				24				
897.2	7.0	SC	CLAYEY SAND, with Gravel, brown, moist, loose to medium dense. (Glacial Outwash)	8				
				18				
892.2	12.0	SM	SILTY SAND, fine-grained, gray, wet, very loose. (Glacial Outwash)	3				
890.2	14.0	GM	SILTY GRAVEL, coarse-grained, brown, wet to waterbearing, loose to dense. (Glacial Outwash)	9				
					∇			
				12				
				44				
878.2	26.0		END OF BORING. Groundwater at 19 feet while drilling. Boring then backfilled with cuttings.					

(See Descriptive Terminology sheet for explanation of abbreviations)

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LOG OF BORING

Braun Project B1611164
GEOTECHNICAL EVALUATION REPORT
Bottineau Ridge II
NWQ of Arbor Lakes Parkway & Hemlock Avenue
Maple Grove, Minnesota

BORING: **ST-104**

LOCATION: See attached sketch.

DRILLER: M. Nolden | METHOD: 3 1/4" HSA, Autohammer | DATE: **12/2/16** | SCALE: **1" = 4'**

Elev. feet 904.8	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	P200 %	Tests or Notes
902.8	2.0	FILL	FILL: Poorly Graded Sand with Silt, medium-grained, brown, moist. (Topsoil)					
897.8	7.0	FILL	FILL: Poorly Graded Sand with Silt, medium-grained, brown, moist.	20		8	11	
				17				
886.8	18.0	SM	SILTY SAND, coarse-grained, with Gravel, brown, moist, dense. (Glacial Outwash)	50/3"				
				50/4"				
				88				
				43				
878.8	26.0	GP	POORLY GRADED GRAVEL, coarse-grained, brown, waterbearing, medium dense to dense. (Glacial Outwash)	28	▽			
				35				
			END OF BORING. Groundwater observed at 20 feet while drilling. Boring then backfilled with cuttings.					

(See Descriptive Terminology sheet for explanation of abbreviations)

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LOG OF BORING

Braun Project B1611164
GEOTECHNICAL EVALUATION REPORT
Bottineau Ridge II
NWQ of Arbor Lakes Parkway & Hemlock Avenue
Maple Grove, Minnesota

BORING: **ST-105**

LOCATION: See attached sketch.

DRILLER: M. Nolden	METHOD: 3 1/4" HSA, Autohammer	DATE: **12/2/16**	SCALE: **1" = 4'**

Elev. feet 904.9	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	P200 %	Tests or Notes
904.6	0.3	FILL	FILL: Silty Sand, fine- to medium-grained, dark brown, moist. (Topsoil)					
900.9	4.0	FILL	FILL: Clayey Sand, trace Gravel, brown, moist.	17		10	33	
897.9	7.0	SM	SILTY SAND, medium-grained, brown, moist, medium dense. (Glacial Outwash)	14				
893.9	11.0	SP	POORLY GRADED SAND, fine- to medium-grained, brown, moist, loose to medium dense. (Glacial Outwash)	25 7				
			END OF BORING. Groundwater not observed while drilling. Boring then backfilled with cuttings.					

(See Descriptive Terminology sheet for explanation of abbreviations)

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LOG OF BORING

Braun Project B1611164 GEOTECHNICAL EVALUATION REPORT Bottineau Ridge II NWQ of Arbor Lakes Parkway & Hemlock Avenue Maple Grove, Minnesota	BORING: ST-106 LOCATION: See attached sketch.
DRILLER: M. Nolden / METHOD: 3 1/4" HSA, Autohammer	DATE: 12/2/16 / SCALE: 1" = 4'

Elev. feet 905.8	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	P200 %	Tests or Notes
905.5	0.3	FILL	FILL: Silty Sand, fine-grained, dark brown, moist. (Topsoil)					
		FILL	FILL: Clayey Sand, brown, moist.					
				19		9	28	
901.8	4.0	SM	SILTY SAND, medium-grained, brown, moist, medium dense. (Glacial Outwash)					
				22				
				20				
				24				
894.8	11.0		END OF BORING. Groundwater not observed while drilling. Boring immediately backfilled with cuttings.					

(See Descriptive Terminology sheet for explanation of abbreviations)

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LOG OF BORING

Braun Project SP-13-00212
Geotechnical Evaluation
Hemlock Apartment Building
NW of Arbor Lakes Parkway & Hemlock Avenue
Maple Grove, Minnesota

BORING: **ST-6**

LOCATION: See attached sketch.

DRILLER: J. Chermak	METHOD: 3 1/4" HSA, Autohammer	DATE: **1/28/13**	SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 907.4	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
906.8	0.6	FILL	FILL: Silty Sand, trace of roots, dark brown, moist.			Frozen to 4 feet.
904.4	3.0	FILL	FILL: Silty Sand, fine- to medium-grained, trace of Gravel, reddish-brown, moist.			
				30		
893.4	14.0	FILL	FILL: Silty Sand, fine- to medium-grained, trace of Gravel, mixed and layered dark brown and brown with reddish-brown, moist.	10		
				29		
				28		
				26		
886.4	21.0	SP	POORLY GRADED SAND, fine- to medium-grained, trace of Gravel, brown, moist, medium dense to dense. (Glacial Outwash)	*		*50 blows for 4"
				25		
			END OF BORING. Water not observed while drilling. Water not observed to cave-in depth of 12 feet immediately after withdrawal of auger. Boring then backfilled.			

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LOG OF BORING

Braun Project SP-13-00212 **Geotechnical Evaluation** **Hemlock Apartment Building** **NW of Arbor Lakes Parkway & Hemlock Avenue** **Maple Grove, Minnesota**	BORING: **ST-7** LOCATION: See attached sketch.

DRILLER: J. Chermak	METHOD: 3 1/4" HSA, Autohammer	DATE: **1/28/13**	SCALE: **1" = 4'**

Elev. feet 905.1	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
904.6	0.5	FILL	FILL: Silty Sand, trace of roots, dark brown, moist.			Frozen to 4 feet.
901.1	4.0	FILL	FILL: Silty Sand, fine- to medium-grained, trace of Gravel, dark brown, moist.	*		*50 blows for 1" (set)
893.1	12.0	SM	SILTY SAND, trace of Gravel, reddish-brown, moist, medium dense to dense. (Glacial Till)	21 30 23		
890.5	14.6	SP	POORLY GRADED SAND, fine- to medium-grained, trace of Gravel, reddish-brown, moist, dense. (Glacial Outwash)	46		
			END OF BORING. Water not observed while drilling. Water not observed to cave-in depth of 12 feet immediately after withdrawal of auger. Boring then backfilled.	*		*50 blows for 1" (set) suspected boulder or cobbles

(See Descriptive Terminology sheet for explanation of abbreviations)

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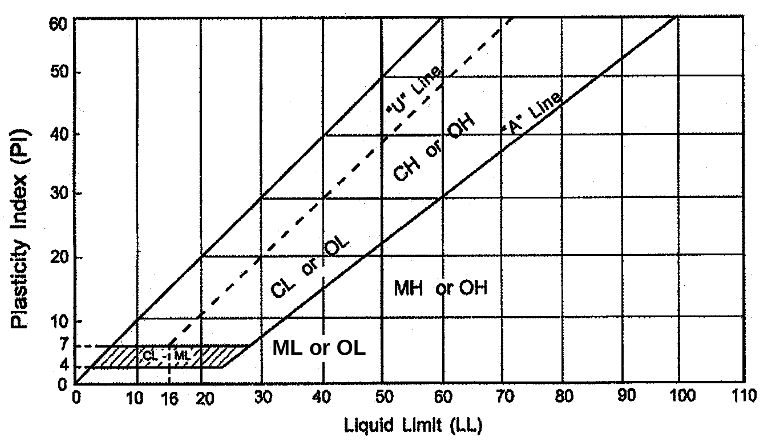
Descriptive Terminology of Soil

Standard D 2487
Classification of Soils for Engineering Purposes
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [a]				Soils 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 [e]	$C_u \geq 4$ and $1 \leq C_c \leq 3$ [c]	GW	Well-graded gravel [d]
			$C_u < 4$ and/or $1 > C_c > 3$ [c]	GP	Poorly graded gravel [d]
		Gravels with Fines More than 12% fines [e]	Fines classify as ML or MH	GM	Silty gravel [d f g]
			Fines classify as CL or CH	GC	Clayey gravel [d f g]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines [i]	$C_u \geq 6$ and $1 \leq C_c \leq 3$ [c]	SW	Well-graded sand [h]
			$C_u < 6$ and/or $1 > C_c > 3$ [c]	SP	Poorly graded sand [h]
		Sands with Fines More than 12% [i]	Fines classify as ML or MH	SM	Silty sand [f g h]
			Fines classify as CL or CH	SC	Clayey sand [f g h]
Fine-grained Soils 50% or more passed 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]
				OL	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]
				OH	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 (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60}/D_{10}$ $C_c = \frac{(D30)^2}{D_{10} \times D_{60}}$
d. If soil contains ≥15% sand, add "with sand" to group name.
e. 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
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. If soil contains ≥15% gravel, add "with gravel" to group name.
i. Sand 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
j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
k. If soil contains 10 to 29% plus No. 200, add "with sand" or "with gravel" whichever is predominant.
l. If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.
m. If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
n. PI ≥ 4 and plots on or above "A" line.
o. PI < 4 or plots below "A" line.
p. PI plots on or above "A" lines.
q. PI plots below "A" line.



Laboratory Tests

DD	Dry density, pcf	**OC**	Organic content, %
WD	Wet density, pcg	**S**	Percent of saturation, %
MC	Natural moisture content, %	**SG**	Specific gravity
LL	Liquid limit, %	**C**	Cohesion, psf
PL	Plastic limits, %	**Ø**	Angle of internal friction
PI	Plasticity index, %	**qu**	Unconfined compressive strength, psf
P200	% passing 200 sieve	**qp**	Pocket penetrometer strength, tsf

Particle Size Identification

Boulders................. over 12"
Cobbles .... 3" to 12"
Gravel
  Coarse .... 3/4" to 3"
  Fine................ No. 4 to 3/4"
Sand
  Coarse .... No. 4 to No. 10
  Medium.......... No. 10 to No. 40
  Fine................ No. 40 to No. 200
Silt .... <No. 200, PI< 4 or below "A" line
Clay .... <No. 200, PI ≥ 4 and on or about "A" line

Relative Density of Cohesionless Soils

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

Consistency of Cohesive Soils

Very soft................ 0 to 1 BPF
Soft .... 2 to 3 BPF
Rather soft .... 4 to 5 BPF
Medium .... 6 to 8 BPF
Rather stiff .... 9 to 12 BPF
Stiff .... 13 to 16 BPF
Very stiff................. 17 to 30 BPF
Hard....................... over 30 BPF

Drilling Notes

Standard penetration test borings were advanced by 3 1/4" or 6 1/4" ID hollow-stem augers, unless noted otherwise. Jetting water was used to clean out auger prior to sampling only where indicated on logs. All samples were taken with the standard 2" OD split-tube samples, except where noted.

Power auger borings were advanced by 4" or 6" diameter continuous flight, solid-stern augers. Soil classifications and strata depths were inferred from disturbed samples augered to the surface, and are therefore, somewhat approximate.

Hand auger borings were advanced manually with a 1 1/2" or 3 1/4" diameter auger and were limited to the depth from which the auger could be manually withdrawn.

BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments, and added to get BPF. Where they differed significantly, they are reported in the following form: 2/12 for the second and third 6" increments, respectively.

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

WR: WR indicates the sampler penetrated soil under weight of rods alone; hammer weight, and driving not required.

TW: TW indicates thin-walled (undisturbed) tube sample.

Note: All tests were run in general accordance with applicable ASTM standards.