Exhibit 12.D.3

DRAFT GEOTECHNICAL REPORT

24TH STREET SE FINAL DESIGN

LAKE STEVENS, WASHINGTON

HWA Project No. 2017-039-21

October 16, 2017

Prepared for:

Lochner

&

City of Lake Stevens

by:

HWA GEOSCIENCES INC.

DRAFT

October 16, 2017
HWA Project No. 2017-039-21

Lochner
915 118th Avenue SE
Suite 130
Bellevue, Washington 98005

Attention: Jorge Garcia, P.E.

Subject: **DRAFT GEOTECHNICAL REPORT**
24th Street SE Final Design
Lake Stevens, Washington

Dear Jorge:

As requested, HWA GeoSciences Inc. (HWA) has performed geotechnical engineering evaluations for the proposed 24th Street SE Final Design Project in the City of Lake Stevens, Washington. This draft report includes the results of our field explorations, laboratory testing, and our geotechnical engineering analyses and recommendations completed to date. This report will be finalized upon receipt of your review comments.

We appreciate the opportunity to provide geotechnical engineering services for this project. If you have any questions regarding this report or require additional information or services, please contact the undersigned at your convenience.

Sincerely,

HWA GEOSCIENCES INC.

JoLyn Gillie, P.E.
Geotechnical Engineer

Enclosure: Draft Geotechnical Report

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TABLE OF CONTENTS

1. INTRODUCTION 1
    1.1 GENERAL 1
    1.2 PROJECT UNDERSTANDING 1
2. FIELD INVESTIGATION AND LABORATORY TESTING 2
    2.1 GEOTECHNICAL SUBSURFACE EXPLORATIONS 2
    2.2 LABORATORY TESTING 2
    2.3 PREVIOUS EXPLORATIONS 2
3. SITE CONDITIONS 2
    3.1 SURFACE CONDITIONS 2
    3.2 GENERAL GEOLOGIC CONDITIONS 3
    3.3 SUBSURFACE SOIL CONDITIONS 3
    3.4 GROUND WATER CONDITIONS 5
4. CONCLUSIONS AND RECOMMENDATIONS 5
    4.1 GENERAL 5
    4.2 SEISMIC CONSIDERATIONS 6
        4.2.1 Seismic Design Parameters 6
        4.2.2 Soil Liquefaction 7
    4.3 ROADWAY CONSTRUCTION 7
        4.3.1 Over-Excavation and Replacement 7
        4.3.2 Dewatering 8
    4.4 RETAINING WALLS 8
        4.4.1 Wetland Area Retaining Walls 8
        4.4.2 Wall Reconstruction at 20th Street SE 9
        4.4.3 Gravity Block and Structural Earth Wall Design Recommendations 9
        4.4.4 Global Stability 10
        4.4.5 Wall Embedment 10
        4.4.6 Wall Drainage 10
        4.4.7 Wall Subgrade Preparation 10
    4.5 POST CONSTRUCTION WETLAND WATER CONVEYANCE 10
        4.5.1 Small Diameter Culverts 10
        4.5.2 Box Culverts 11
        4.5.3 Bridge the Wetlands 11
    4.6 LUMINAIRE AND SIGNAL POLE FOUNDATIONS 11
    4.7 STORMWATER MANAGEMENT 11
        4.7.1 Stormwater Pond 11
        4.7.2 Feasibility of Using Infiltration for Stormwater Management 12
    4.8 GENERAL EARTHWORK 12
        4.8.1 Structural Fill 12
        4.8.2 Compaction 12
        4.8.3 Temporary Excavations 12
        4.8.4 Wet Weather Earthwork 13

DRAFT

5. CONDITIONS AND LIMITATIONS.....13
6. REFERENCES.....16

FIGURES (Following Text)

Figure 1	Vicinity Map
Figures 2A-2B	Site and Exploration Plan
Figure 3	Typical Road Detail

Appendix A: Logs of HWA Explorations

Figure A-1	Legend of Terms and Symbols Used on Exploration Logs
Figure A-2 to A-4	Logs of Borings BH-1 through BH-3
Figure A-5 to A-17	Logs of Test Pits TP-16 through TP-28

Appendix B: Laboratory Test Results

Figures B-1 to B-6	Particle-Size Analysis of Soils
Figure B-7	Liquid Limit, Plastic Limit and Plasticity Index of Soils

Appendix C: Field Explorations from Previous HWA Report for 24th Street SE

Figure C-1	Legend of Terms and Symbols Used on Exploration Logs
Figures C-2 to C-16	Logs of Test Pits TP-1 through TP-15
Figures C-17 to C-19	Grain Size Distributions for TP-1 through TP-15
Figure C-20	Plasticity Chart for TP-13 and TP-14

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DRAFT GEOTECHNICAL REPORT
24TH STREET SE FINAL DESIGN
LAKE STEVENS, WASHINGTON

1. INTRODUCTION

1.1 GENERAL

This report summarizes the results of the geotechnical engineering study performed by HWA GeoSciences Inc. (HWA) for the proposed 24th Street SE Final Design Project in Lake Stevens, Washington. Figure 1, Vicinity Map, and Figures 2A-2B, Site and Exploration Plan, show the approximate location of the project site. The proposed improvements will extend 24th Street SE westward from SR 9 and 91st Avenue SE southward from 20th Street.

HWA previously performed a site investigation and provided recommendations for preliminary design of the 24th Street SE alignment. The results were provided in our *Preliminary Geotechnical Report*, dated January 15, 2016. This report incorporates the results of the previous investigation and updates the recommendations based on the improvements proposed for this phase of the design.

HWA has also performed additional field work to provide information of support of final design. For this phase, our field work included drilling three machine-drilled borings, excavating thirteen test pits, and advancing eight hand-holes. Laboratory tests were conducted on selected soil samples to determine relevant engineering properties of the subsurface soils. Engineering analyses were conducted to develop recommendations for design of the proposed roadway, stormwater facilities and retaining structures.

1.2 PROJECT UNDERSTANDING

The City of Lake Stevens is planning to extend 24th Street SE approximately 1,400 feet westward from SR 9 to its crossing with 91st Avenue SE, which will be extended 900 feet southward from 20th Street SE to connect with the 24th Street SE extension. The proposed alignments are primarily wooded and sections of the alignment will cross several documented wetlands. Several walls will be needed along the alignment to retain the roadway cuts and fills within the proposed City right-of-way. At 20th Street SE, an existing Ecology Block wall along the west side of 91st Avenue SE will either be replaced or built in front of to construct the roadway embankment. About 100 feet south of 20th Street SE, the 91st Avenue SE alignment will cross the buried 48-inch diameter City of Everett water transmission lines. A storm water facility will be constructed for the improvements and is currently planned on the south side of the intersection of 24th Street SE and 91st Avenue SE.

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2. FIELD INVESTIGATION AND LABORATORY TESTING

2.1 GEOTECHNICAL SUBSURFACE EXPLORATIONS

Our geotechnical exploration program for the final design phase included drilling three borings, excavating thirteen test pits, advancing eight handholes, and performing six dynamic cone penetrometer (DCP) tests. The borings, designated BH-1 through BH-3, were drilled on August 23 and 24, 2017 and were advanced to depths ranging from 31.5 to 36.5 feet below the ground surface. The test pits, designated TP-16 through TP-28 (following the test pit numbering of the previous investigation), were excavated on September 13 and 14, 2017 and were advanced to depths ranging from 4.5 feet to 10 feet. The handholes and DCPs were performed on October 4 and 5, 2017, and ranged in depth from 1.8 feet to 9 feet. The locations of the explorations are shown on the Site and Exploration Plan, Figures 2A-2B. Field exploration methods are described in more detail in Appendix A which also contains summary of the logs for each exploration. The eight handhole and DCP explorations were completed recently, the results of which will be provided in a future version of this report.

2.2 LABORATORY TESTING

Laboratory tests were conducted at HWA's Bothell, Washington laboratory, on selected samples retrieved from the explorations to determine relevant index and engineering properties of the soils encountered at the site. The tests included visual classifications, natural moisture content, grain size distribution and Atterberg Limits. The tests were conducted in general accordance with appropriate American Society of Testing and Materials (ASTM) standards. The test results and a discussion of laboratory test methodology are presented in Appendix B, and/or displayed on the exploration logs in Appendix A, as appropriate.

2.3 PREVIOUS EXPLORATIONS

HWA performed a field exploration program for the preliminary phase of this project. The explorations included excavation of fifteen test pits along with Dynamic Cone Penetrometer (DCP) testing, which were conducted on October 12 through 14, 2015. The test pits, designated TP-1 through TP-15 were excavated with a small rubber-tracked backhoe by the City of Lake Stevens. These test pits were dug to depths ranging from 7 to 9 feet below ground surface. The locations of these explorations were selected in the field based on geomorphic variations and are indicated on the Site and Exploration Plan, Figures 2A-2B. The logs and test results from these explorations are provided in Appendix C.

3. SITE CONDITIONS

3.1 SURFACE CONDITIONS

The site is located on a plateau at an elevation of about 300 feet that rises above the river valleys to south and west of the project site. The site has gently rolling topography with vertical relief of

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about 10 to 20 feet in places. At the east end of the 24th Street SE alignment, surface runoff collects in the low areas forming wetlands. Most of the site is currently wooded; however, there are a few residential houses at the east end of 24th Street SE and at the north end of 91st Avenue SE. At 20th Street SE, there is an Ecology block wall about 10 feet tall located on the western edge of the proposed roadway prism for the 91st Avenue alignment, where the ground surface slopes steeply to the southwest.

3.2 GENERAL GEOLOGIC CONDITIONS

The project alignment is located within the Puget Lowland. The Puget Lowland has repeatedly been occupied by a portion of the continental glaciers that developed during the ice ages of the Quaternary period. During at least four periods, portions of the ice sheet advanced south from British Columbia into the lowlands of Western Washington. The southern extent of these glacial advances was near Olympia, Washington. Each major advance included numerous local advances and retreats, and each advance and retreat resulted in its own sequence of erosion and deposition of glacial lacustrine, outwash, till, and drift deposits. Between and following these glacial advances, sediments from the Olympic and Cascade Mountains accumulated in the Puget Lowland.

General geologic information for the site was obtained from the Geologic Map of the Snohomish Quadrangle, Snohomish County, Washington (Minard, 1985). The map indicates that the geology along the project corridor includes glacial till near the ground surface from the most recent continental glaciation, the Fraser Glaciation. Minard indicates patches of recessional outwash and advance outwash, consisting of predominantly sands and gravels, were observed near the ground surface to the west of the site.

3.3 SUBSURFACE SOIL CONDITIONS

Our interpretations of subsurface conditions are based on our exploration data, published geologic information, and our experience in the project vicinity. The exploration data indicate that the soils in the upland areas along the western portion of 24th Street SE and most of 91st Street SE consist of loose to medium dense, gravelly, sandy silt (Weathered Drift) and silty, sandy gravel to gravelly, sand (Recessional Outwash) over dense to very dense, Glacial Till. At the east end 24th Street SE, low lying wetland areas contain soft peat and/or clay to depths of 2 to 6 feet over water-bearing gravelly sand (Recessional Outwash). Upland areas along the center to eastern section of 24th Street SE are underlain with silty sand (Weathered Drift) over gravelly sand and sandy gravel (Recessional Outwash). At the northern approximately 100 feet of 91st Avenue SE, loose to medium dense fill materials overlie a buried topsoil layer above glacial soils consisting of Recessional Outwash and Glacial Till. In the area of the proposed stormwater pond, the borings encountered Glacial Till near the ground surface over a hard silt layer (Glaciolacustrine). Each of these soil units is described below with the youngest in origin described first.

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- **Fill:** Loose to medium dense fill soils were encountered over buried native organic materials (topsoil, charcoal or peat) in test pits TP-10, TP-12, TP-27 and TP-28. These soils extended from the ground surface to depths ranging from 1.25 to 5 feet below ground surface, and consisted of loose to medium dense, slightly gravelly to gravelly, silty sand with scattered rootlets. Refuse was present in test pit TP-12 located on the western edge of the upland area, at a depth of 3 to 4.5 feet. The fill materials were likely placed during activities associated with the adjacent residence.
- **Duff and Topsoil:** Loose forest litter (duff) and dark brown, sandy silt or silty sand with fine organics and abundant rootlets were encountered in the upper approximately 1 foot in each of the test pits in the upland areas.
- **Buried Topsoil:** Buried topsoil was observed below the fill in the test pits at the north end of the alignment. This layer was 1 to 2 feet thick and extended to a depth of 7 feet in TP-27 and a depth of 5 feet in TP-28.
- **Peat:** Very soft to soft peat was encountered at the ground surface (or below fill) in test pits within low-lying areas. This material consists of partly decomposed organics deposited since glacial retreat in anaerobic wetland environments. It has a very high moisture content and is highly compressible.
- **Clay:** Clay was encountered in TP-13 and TP-14. The clay layer in TP-13 was medium stiff to stiff and extended from a depth of 4 feet below ground surface to 6 feet below ground surface. The material was gray and contained partly decomposed straw. The clay layer in TP-14 was stiff to very stiff and extended from a depth of 1 foot below ground surface to 3.5 feet below ground surface. Scattered gravel was encountered in this layer.
- **Weathered Drift:** Loose to medium dense, silty sand to sandy silt with variable gravel content was encountered below the topsoil in upland areas along 24th Street SE. This material consists of soils mechanically, chemically, and biologically weathered from the underlying glacial materials.
- **Recessional Outwash:** Medium dense to dense, gravelly sand and sandy gravel were encountered below the fill, topsoil, peat, or weathered drift along the project alignment. These soils were interpreted as recessional outwash sands that was deposited by glacial meltwater streams as the ice sheet retreated during the last glaciation. The Recessional Outwash extended past the termination depth of most of the test pits in which it was encountered at the east end of the project. Along 91st Avenue SE, the recessional outwash was typically a 2- to 3-foot thick layer of silty, gravelly sand with abundant subrounded gravel particles.
- **Glacial Till:** Very dense, silty, gravelly sand was encountered in the western seven test pits (TP-1 through TP-7) and borings along 24th Street SE as well as all the test pits along 91st Avenue SE. This material was deposited as a deforming bed of material along the sole of the glacial ice as lodgment till. It consists of an unsorted mixture of clay, silt,

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sand and gravel, and is very dense, having been consolidated by the weight of over 3,000 feet of glacial ice. It is also known to contain scattered cobbles and boulders. This unit is locally referred to as "hardpan", because of its induration and an appearance similar to concrete.

- **Ice Contact Stratified Drift:** Ice-Contact Stratified Drift was encountered below the Glacial Till in test pit TP-21 near the middle of the 91st Street alignment and in BH-2 near the west end of 24th Street SE. The deposit consisted of laminated, silty fine sand. This deposit has stratified layers of silt and sand that form near the front of the glacial ice.
- **Glaciolacustrine:** Below the glacial till in each of the borings, glaciolacustrine was encountered. This layer consists of very stiff to hard, dark gray, silt and was deposited in slow moving melt waters such as a glacial lake. Similar to glacial till, it has low permeability.

3.4 GROUND WATER CONDITIONS

Ground water was not encountered in any of explorations west of the center of the 24th Street SE alignment at the time that they were conducted. The test pits and handholes in the eastern portion of the 24th Street SE alignment encountered ground water seepage at depths ranging from 2 to 8.3 feet, within the Recessional Outwash. Based on the soil conditions observed in the test pits and handholes, the observed water is believed to represent surface perched water that collects over the very dense and relatively impermeable glacial till soils. We expect that the level of the perched water will vary seasonally with rainfall. Our explorations were conducted near the end of a relatively dry summer. Therefore, we expect that the groundwater conditions observed at the time of our field explorations are lower than they would be during other times of the year.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 GENERAL

In general, the soils along the project alignment are adequate to support the proposed improvements with some mitigation in wetland areas. Along the alignment, the medium dense, recessional outwash, and dense to very dense, glacial till soils should be considered the bearing layer for roadway construction. The loose overlying soils in the upland areas should be removed and replaced with structural fill to provide a good base for the proposed roadway. The soft peat and clay in wetland areas will need to be over-excavated and replaced with structural fill to construct the roadway. While the wetland soils are shallow enough to feasibly over-excavate, ground water conditions may necessitate dewatering to facilitate construction of the roadway within or near existing wetlands.

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The glacial soils will be suitable to support retaining walls needed to limit the extents of cuts and fill along the alignments. Walls can consist of rockeries and gravity block walls for cuts and gravity block walls and structural earth walls for fill walls.

We understand there will be a wall at the southwest corner of the intersection of 91st Avenue SE and 20th Street SE. Construction of a structural earth wall would likely require shoring near the south edge of 20th Street SE to provide room for the reinforced soil zone. Therefore we consider the most suitable wall type for area to be a soldier pile wall.

The soils along the project alignment are highly moisture sensitive, and would best be worked in the dry season. Re-use of the recessional outwash soils as structural fill may be appropriate if construction is to take place during the dry summer months. However, if roadway construction is to extend into the wet weather months, we would recommend that the native soils not be reused as structural fill.

Roadway construction will require over-excavation and replacement of the soft soils within the delineated wetlands. Structural roadway fill placed within the wetlands will act as a dam and limit the ability of water to flow from one side of the proposed roadway to the other. This damming affect can be mitigated by incorporating culverts within the structural roadway fill to promote hydraulic conductivity across the wetlands being bisected by the roadway.

The stormwater pond can be located in the southwestern portion of the site. Stormwater infiltration does not appear feasible for the project alignment. Dense, relatively impermeable Glacial Till along the western portion and high ground water in the central to eastern sections make infiltration infeasible.

4.2 SEISMIC CONSIDERATIONS

4.2.1 Seismic Design Parameters

Earthquake loading for the proposed 24th Street SE improvements was developed in accordance with Section 3.4 of the AASHTO Guide Specifications for *LRFD Seismic Bridge Design, 2nd Edition*, 2011 (AASHTO, 2011 with 2012, 2014 and 2015 Interim Revisions) and WSDOT Design Memorandum (WSDOT, 2017). For seismic analysis, the Site Class is required to be established and is determined based on the average soil properties in the upper 100 feet below the ground surface. Based on available geotechnical information for the project corridor, the underlying soils represent AASHTO Site Class C.

Table 1 presents the seismic coefficients, associated with AASHTO Site Class C that were used for the geotechnical evaluations discussed in this report. These parameters are based upon a design event with a 7 percent probability of exceedance in 75 years (equal to a return period of 1,033 years). Ground motions for the site are based on probabilistic earthquake hazard mapping efforts including those conducted by the United States Geological Survey (Frankel, et al., 2002) and (Peterson, et al., 2014). The parameters provided include the 2014 update and were based on the design memorandum from WSDOT, dated January 8, 2017, and using the BridgeLink tool

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(BridgeLink, 2017) developed by WSDOT. Accordingly, a Seismic Design Category C, as given by AASHTO (AASHTO, 2011), should be used.

Table 1. Seismic Coefficients for Geotechnical Evaluations Using AASHTO

Site Class	Peak Horizontal Bedrock Acceleration PBA, (g)	Spectral Bedrock Acceleration at 0.2 sec S_s, (g)	Spectral Bedrock Acceleration at 1.0 sec S_1, (g)	Site Coefficients			Peak Horizontal Acceleration PGA, (g)
				F_{pga}	F_a	F_v	
C	0.347	0.785	0.232	1.200	1.200	1.500	0.416

4.2.2 Soil Liquefaction

The potential for soil liquefaction must be considered during the design of any soil-supported structure. Soil liquefaction is a phenomenon where loose, saturated, granular deposits temporarily lose strength and behave as a liquid in response to moderate to strong earthquake shaking. Primary factors controlling the development of liquefaction include the intensity and duration of strong ground motions, the characteristics of subsurface soils, in-situ stress conditions and the depth to ground water. Test-pit data shows the granular layers encountered below the water table are of a dense nature, indicating that liquefaction will likely not be a design consideration for this project.

4.3 ROADWAY CONSTRUCTION

In general, the soils along the project alignment are conducive to construction of the proposed roadway. We expect that roadway construction will require over excavation of the soft wetland soils, as well as fill and buried topsoil layers that overlie the glacial soils. We also expect that the loose, near-surface soils encountered in the upland areas will need to be over-excavated and replaced with structural fill to facilitate construction of the roadway and associated improvements. Roadway construction considerations are provided in the following sections.

4.3.1 Over-Excavation and Replacement

Based on test pit explorations, we anticipate the upland areas will generally require 2 to 3 feet of over-excavation to reach suitable subgrade material. We anticipate the low wetland areas will generally require 2 to 5 feet of over-excavation to completely remove the peat and reach suitable subgrade material. South of 20th Street SE, fill over buried topsoil should also be removed prior to constructing walls and embankments. All over-excavated areas should be replaced to grade with compacted structural fill. All over-excavated limits should extend a distance laterally from the edge of the proposed embankment or structures equal to the depth of over-excavation to ensure that proposed loads are distributed into competent material.

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4.3.2 Dewatering

Ground water was encountered near the ground surface within the wetland areas and at a depth of approximately 5 feet in the central and eastern upland areas. During the wet seasons, we expect that ground water rises above the ground surface in the wetland areas. Excavations and roadway construction in these areas will likely require dewatering. We expect that dewatering for the proposed roadway improvements can be accomplished with a series of sumps and pumps. As the observed ground water is perched on top of the relatively impermeable glacial till soils at depth, dewatering wells will not be an appropriate means of dewatering for this project.

In the wetland areas, we expect that the contractor will likely be required to construct water tight barriers on either side of the roadway during construction to ensure that the dewatering effort does not drain the adjacent wetlands.

4.4 RETAINING WALLS

Construction of the proposed roadway will require construction of retaining walls on one or both sides of the alignment. We anticipate that both cut and fill walls, with heights ranging from 2 to 8 feet will be required. Cut walls will likely be required in upland areas; while fill walls and/or embankments will likely be constructed in the low areas. Based on the soil conditions, we expect that cut walls will likely consist of rockery or gravity block walls. Whereas fill walls will likely consist of structural earth walls (SEW) or gravity block walls.

Embankment side slopes may be constructed in low areas in lieu of retaining walls. Side slopes should be no greater than 2H:1V (horizontal:vertical). Construction of sloped embankments in low lying wetland areas, however, will require more over-excavation and greater wetland impacts. Figure 3 shows the conceptual wetland-area retaining wall and embankment construction process. Retaining wall construction in wetland areas is discussed in the following section.

4.4.1 Wetland Area Retaining Walls

Utilizing retaining walls for wetland-area roadway construction will likely limit wetland impacts in comparison to constructing embankment side slopes. We expect that SEW or gravity block walls will be used in wetland areas. We anticipate these walls may be 6 to 8 feet high.

Construction of wetland area retaining walls will require over-excavation of the native peat and replacement with structural fill. Dewatering will be required prior to placing structural fill and constructing the retaining wall. We expect that the contractor will likely be required to construct water tight barriers on either side of the roadway during construction to ensure that the dewatering effort does not drain the adjacent wetlands; and that localized sumps and pumps will be used to facilitate the dewatering process.

The retaining wall elements and structural fill will be founded in the recessional outwash layer after the peat is excavated. Water conveyance systems, such as culverts, can be incorporated into

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the retaining wall and structural fill system to facilitate water flow between the bisected portions of wetland areas.

4.4.2 Wall Reconstruction at 20th Street SE

The proposed alignment for the 91st Avenue SE extension expands the roadway embankment west of the existing Lock-Block wall that supports the access road to the pump station. This will require removal and reconstruction of the two existing modular block walls. One wall consists of smaller modular blocks typical of Keystone blocks, which supports the roadway embankment for 20th Street SE. The second wall consists of large modular Lock-Blocks typical of the Ultra-Block Walls. We anticipate that the wall construction will require reconstruction of all of the Lock-Block Wall and a portion of the Keystone block wall. Where the Keystone wall supports the existing 20th Street SE embankment, a shoring wall is likely to be needed to provide room for installation of the reinforced soil zone of a typical SEW. Therefore, it is likely to be more cost effective to design a portion of this wall as a soldier pile wall rather than build both a SEW and a robust shoring wall.

4.4.3 Gravity Block and Structural Earth Wall Design Recommendations

We anticipate that gravity block and SEW will consist of a proprietary wall system that the wall supplier will design for internal stability. The walls should be designed in accordance with AASHTO Standard Specifications for Highway Bridges. We recommend the walls be designed using the parameters presented in Table 2. For the Extreme Event I Limit State, the wall shall be designed for a horizontal seismic acceleration coefficient k_h of one-half the peak ground acceleration or 0.21 g and a vertical seismic acceleration coefficient k_v of 0.0 g (assuming the wall is free to move during a seismic event).

Table 2. Recommended Gravity Block and Structural Earth Wall Design Parameters

Soil Properties	Wall Backfill*	Retained Soil*	Foundation Soil
Unit Weight (pcf)	135	135	135
Friction Angle (deg)	34	34	36
Cohesion (psf)	0	0	0
		AASHTO Load Group 1	**AASHTO Load Group 2**
Allowable Bearing Capacity (tsf)		3000	4500
Acceleration Coefficient (g)			0.21

* *Gravel Borrow*, as specified in Section 9-03.14(1) of WSDOT Standard Specifications

* If geogrid reinforcing is to be used the gravel borrow should be limited to a maximum particle size of 1¼ inches.

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4.4.4 Global Stability

The dense to very dense, native glacial soils observed at the site will provide adequate global stability for the proposed walls under both static and seismic conditions.

4.4.5 Wall Embedment

We recommend the block and SEW walls be embedded at least 1.5 feet below the final ground surface.

4.4.6 Wall Drainage

A 6-inch-diameter perforated drain pipe should be installed behind the base of the walls such that it will collect and convey all ground water from behind the walls. The drain pipe should be sloped to drain and routed to an appropriate discharge location.

4.4.7 Wall Subgrade Preparation

Subgrade preparation is important to limit differential settlement of the walls and maintain global stability. All organic material should be removed from beneath the entire footprint of the structural earth walls prior to placing material. Loose or soft soil, defined as being penetrable more than 1 foot with a ½-inch diameter rod pushed in under a 150-lb load (T-probe pushed in by hand), should be removed and replaced with "Structural Backfill" or be suitably compacted.

We recommend the bottom of the retaining walls be placed on a 6-inch-thick leveling pad consisting of crushed surfacing base course (CSBC) compacted to 95 percent of Modified Proctor maximum dry density, as determined by ASTM D 1557. This leveling pad should be graded to establish the proper wall batter.

4.5 POST CONSTRUCTION WETLAND WATER CONVEYANCE

As previously noted, the proposed alignment will bisect multiple delineated wetlands. It is our understanding that the City of Lake Stevens desires to maintain hydraulic conductivity within the wetland areas to the maximum extent possible in order to limit wetland impacts. It is our understanding that surface runoff within the wetlands generally flows from north to south; flowing perpendicular to the proposed roadway.

There are several options to allow water to flow under the proposed roadway and maintain hydraulic conductivity to some extent. These options include installing a series of small diameter culverts in the structural roadway fill, installing larger box culverts, or constructing a bridge. Further details associated with each of these options are provided below.

4.5.1 Small Diameter Culverts

A series of small diameter 8- to 12-inch diameter culverts could be installed within the structural roadway fill to allow water to flow from north to south. These culverts would be orientated north-south on relatively tight spacing. Culvert openings would be integrated into the block

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facing if retaining walls are utilized. Installation of small diameter culverts would allow the most flexibility with respect to the final road grade. Installation of these culverts would be fairly cost effective and would allow some hydraulic conductivity across the roadway.

4.5.2 Box Culverts

Larger box culverts could be installed within the wetland areas to allow water to flow from one side of the roadway to the other. Installation of the box culverts would channelize the flow of water to the locations of the structures. The box culverts would likely be founded on spread footings bearing on the medium dense to dense, recessional outwash soils. Installation of box culverts would provide greater hydraulic conductivity and conductivity for wildlife than the use of small diameter culverts.

4.5.3 Bridge the Wetlands

Bridge structures could be used to carry the proposed roadway over the wetlands with very limited impact to the flow of water. The bridge structures would likely be constructed on relatively shallow driven piles or spread footing bearing on the very dense glacial till soils. Although construction of bridge structures over the wetlands would be the least impactful to the wetland flow characteristics, this option would be significantly more costly that the other two options.

4.6 LUMINAIRE AND SIGNAL POLE FOUNDATIONS

It is our understanding that the proposed roadway will require lighting and possibly signalization improvements along the corridor. We expect that the foundations associated with these improvements will likely consist of WSDOT standard plan foundations. Based on the soils encountered in our explorations, we expect that standard plan foundations for luminaries and signal poles will be appropriate for this project. Allowable lateral bearing pressures for design of these foundations are expected to be 1,500 psf but should be evaluated on a case by case basis once actual locations are determined.

Several of the test pits exhibited sidewall caving starting at 2 to 3 feet below the existing ground surface. It is likely caving will occur when excavating the luminaire foundations. Prospective contractors should be prepared to case or shore the luminaire and signal pole foundation excavations to prevent caving of the native soils.

4.7 STORMWATER MANAGEMENT

4.7.1 Stormwater Pond

The current location of the stormwater pond indicates it will be primarily in the upland area at the west end of 24th Street SE. The borings indicate that pond will be excavated in glacial soils consisting of Ice-Contact Stratified Drift over glaciolacustrine deposits. No ground water was encountered during the borings; however, saturated zones within the glacial deposits are likely.

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During excavation of the stormwater pond, we anticipate that zones of seepage will be encountered. Perched ground water could collect within the pond and seep through saturated lenses from the adjacent wetlands east of the pond. The resulting perched water level is likely to be similar in elevation to the water levels in the wetlands east of the pond.

4.7.2 Feasibility of Using Infiltration for Stormwater Management

Low permeablility materials generally exist within 3 feet of the ground surface. Given the presence of low permeability glacial soils near the ground surface we do not recommend using infiltration for stormwater management at this site.

4.8 GENERAL EARTHWORK

4.8.1 Structural Fill

The existing site fill and native soils are highly variable in consistency and are moisture sensitive. If construction is completed during the dry summer months, some of the excavated native material may be suitable for re-use as structural fill. If roadway construction is expected to extend into the wet weather months of October through June, we recommend that imported structural fill be used. Imported structural fill should consist of clean, free-draining, granular soils free from organic matter or other deleterious materials. Such materials should meet the gradation and quality requirements as specified for "Gravel Borrow" in Section 9-03.14(1) of the WSDOT *Standard Specifications* (WSDOT, 2016).

4.8.2 Compaction

Structural fill and CSBC should be moisture conditioned and compacted to the requirements specified in Section 2-03.3(14)C, Method C, of the WSDOT *Standard Specifications* (WSDOT, 2016); except the standard of compaction achieved should not be less than 95% of the maximum dry density (MDD) determined for the fill material by test method ASTM D1557 (Modified Proctor). Subgrade compaction should conform to the requirements of Section 2-06.3(1) of the WSDOT *Standard Specifications*.

Achievement of proper density of a compacted fill depends on the size and type of compaction equipment, the number of passes, thickness of the layer being compacted, and soil moisture-density properties. In areas where limited space restricts the use of heavy equipment, smaller equipment can be used, but the soil must be placed in thin enough layers to achieve the required compaction. Generally, loosely compacted soils result from poor construction techniques and/or improper moisture content. Soils with high fines contents are particularly susceptible to becoming too wet, and coarse-grained materials easily become too dry, for proper compaction.

4.8.3 Temporary Excavations

Maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the contractor. In accordance with Part N of Washington Administrative Code

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(WAC) 296-155, latest revisions, all temporary cuts in excess of 4 feet in height must be either sloped or shored prior to entry by personnel. The existing fill, wetland, and recessional outwash soils are generally classified as Type C soils, per WAC 296-155. Where shoring is not used, temporary cuts in Type C soils should be sloped no steeper than 1½H:1V (horizontal:vertical). The existing glacial till, ice-contact stratified drift, and glaciolacustrine soils are generally classified as Type A soils, per WAC 296-155. Where shoring is not used, temporary cuts in Type A soils should be sloped no steeper than 3/4H:1V (horizontal:vertical).

4.8.4 Wet Weather Earthwork

General recommendations relative to earthwork performed in wet weather or in wet conditions are presented below. These recommendations should be incorporated into the contract specifications.

- Earthwork should be performed in small areas to minimize exposure to wet weather. Excavation of unsuitable and/or softened soil should be followed promptly by placement and compaction of clean structural fill. The size and type of construction equipment used may need to be limited to prevent soil disturbance.
- For wet weather conditions, the allowable fines content of the structural fill should be reduced to no more than 5 percent by weight of the portion of the fill material passing the ¾-inch sieve. The fines should be non-plastic.
- The ground surface within the construction area should be graded to promote surface water run-off and to prevent ponding.
- Within the construction area, the ground surface should be sealed on completion of each shift by a smooth drum vibratory roller, or equivalent, and under no circumstances should soil be left uncompacted and exposed to moisture infiltration.
- Bales of straw and/or geotextile silt fences should be strategically located to control erosion and the movement of soil.

5. CONDITIONS AND LIMITATIONS

We have prepared this report for the City of Lake Stevens and Lochner for use in design of this project. This report should be provided in its entirety to prospective contractors for bidding and estimating purposes; however, the conclusions and interpretations presented in this report should not be construed as our warranty of the subsurface conditions. Experience has shown that soil and ground water conditions can vary significantly over small distances. Inconsistent conditions can occur between explorations and may not be detected by a geotechnical study. If, during future site operations, subsurface conditions are encountered which vary appreciably from those described herein, HWA should be notified for review of the recommendations of this report, and revision of such if necessary.

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We recommend HWA be retained to review the plans and specifications to verify that our recommendations have been interpreted and implemented as intended. Sufficient geotechnical monitoring, testing, and consultation should be provided during construction to confirm the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should conditions revealed during construction differ from those anticipated, and to verify that the geotechnical aspects of construction comply with the contract plans and specifications.

Within the limitations of scope, schedule and budget, HWA attempted to execute these services in accordance with generally accepted professional principles and practices in the fields of geotechnical engineering and engineering geology in the area at the time the report was prepared. No warranty, express or implied, is made. The scope of our work did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or ground water at this site.

HWA does not practice or consult in the field of safety engineering. We do not direct the contractor's operations, and cannot be responsible for the safety of personnel other than our own on the site. As such, the safety of others is the responsibility of the contractor(s). The contractor(s) should notify the owner if it is considered that any of the recommended actions presented herein are unsafe.

DRAFT

We appreciate the opportunity to provide geotechnical services on this project. Should you have any questions or comments, or if we may be of further service, please do not hesitate to call.

Sincerely,

HWA GEOSCIENCES INC.

Zakeyo Ngoma, P.E.
Geotechnical Engineer

JoLyn Gillie, P.E.
Principal Geotechnical Engineer

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6. REFERENCES

AASHTO, 2011, Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition, Washington D.C.

Booth, D.B., Cox, B.F., Troost, K.A. and Wisher, A.P. 2007. *Geologic Map of King County*. University of Washington. Seattle, Washington. Scale 1:100,000.

BridgeLink, 2017, http://www.wsdot.wa.gov/eesc/bridge/software

Frankel, et al., 2002, *Documentation for the 2002 Update of the National Seismic Hazard Maps,* USGS Open File Report, 02-420.

Minard P.J., 1985, *Geologic Map of the Snohomish Quadrangle*, U.S. Geological Survey Miscellaneous Filed Studies Map MF-1745, scale 1:24,000.

Washington State Department of Ecology, November 2014, *Stormwater Management Manual for Western Washington,* Water Quality Program, Publication Number 12-10-030.

Petersen, M.D., Moschetti, M.P., Powers, P.M., Mueller, C.S., Haller, K.M., Frankel, A.D., Zeng, Yuehua, Rezaeian, Sanaz, Harmsen, S.C., Boyd, O.S., Field, Ned, Chen, Rui, Rukstales, K.S., Luco, Nico, Wheeler, R.L., Williams, R.A., and Olsen, A.H., 2014, Documentation for the 2014 update of the United States national seismic hazard maps: *U.S. Geological Survey Open-File Report 2014–1091*, 243 p., https://dx.doi.org/10.3133/ofr20141091.

WSDOT, 2015, *Geotechnical Design Manual*, Washington State Department of Transportation.

WSDOT, 2016, *Standard Specifications for Road, Bridge, and Municipal Construction,* Washington State Department of Transportation.

WSDOT, Memo to Designers ,2017, "*AASHTO Guide Specifications for LRFD Seismic Bridge Design Amendments*" dated January 8, 2017

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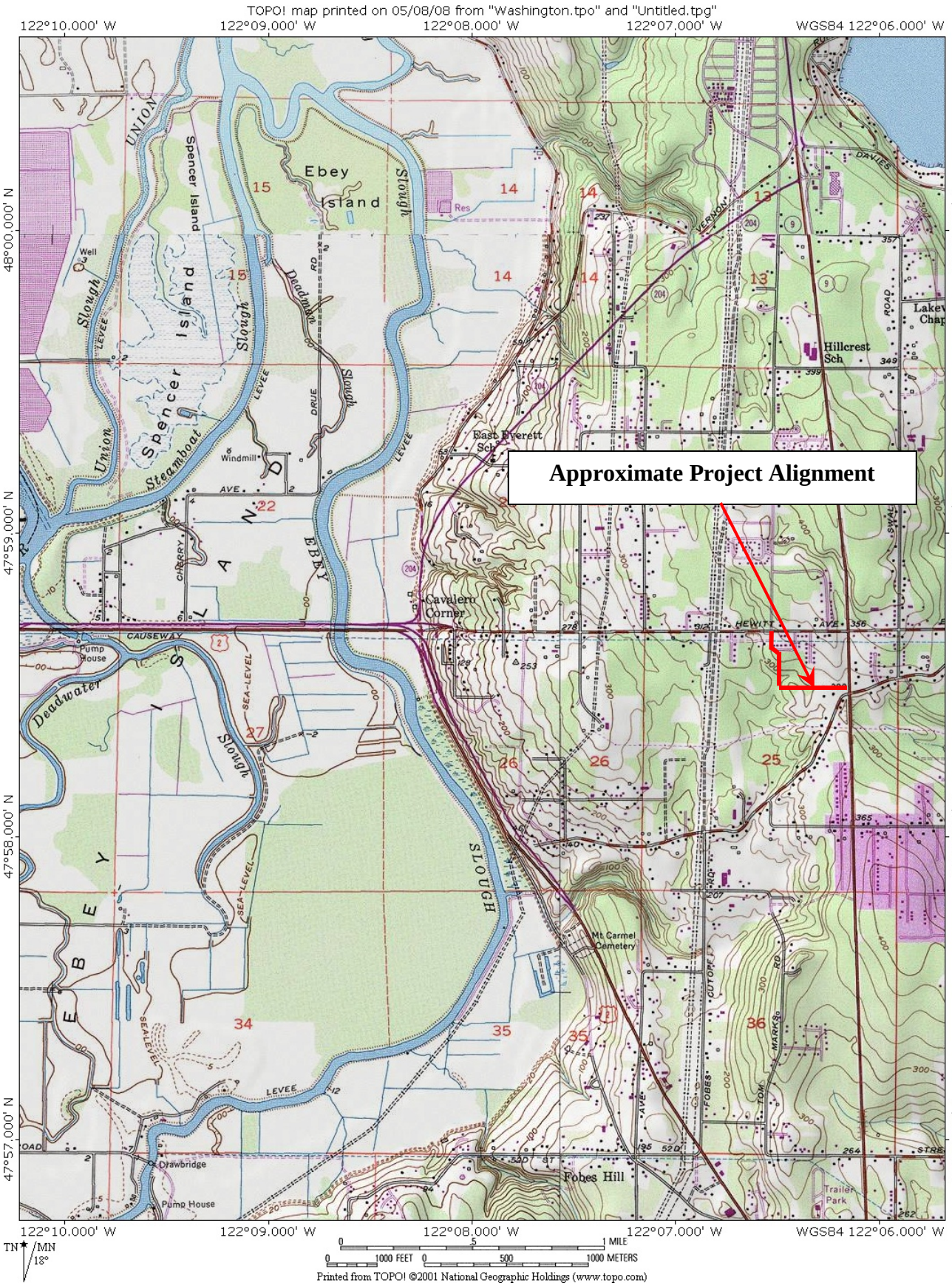


VICINITY MAP

24TH STREET SE PROJECT
FINAL DESIGN
LAKE STEVENS, WASHINGTON

FIGURE NO.
1

PROJECT NO.
2015-098

HWA GEOSCIENCES INC.

MATCHLINE SEE FIGURE 2B

91ST AVE SE

24TH STREET SE

SR 9

TP-18
TP-17
TP-16
TP-1
TP-2
TP-3
TP-4
TP-5
TP-6
TP-7
TP-8
TP-9
TP-10
TP-11
TP-12
TP-13
TP-14
TP-15

HH-1
HH-2
HH-3
HH-4
HH-5
HH-6
HH-7
HH-8

BH-1
BH-2
BH-3

DUAL 599
DUAL 599
DUAL 476

APN: 00457000002102
CITY OF LAKE STEVENS
9126 S. LAKE STEVENS RD.

APN: 00457000002201
CITY OF LAKE STEVENS
9208 S. LAKE STEVENS RD.

PROVISIONAL FLAGGED WETLAND

APN: 00457000002304
NORDIN INVESTMENTS LLC
2404 S. LAKE STEVENS RD.

APN: 00457000002401
NORDIN INVESTMENTS LLC
2326 S. LAKE STEVENS RD.

APN: 00457000002503
NORDIN INVESTMENTS LLC
UNKNOWN ADDRESS

APN: 00457100005101
S. GOOD
2415 SOUTH LAKE STEVENS RD.

LEGEND

BH-3 — BORE HOLE DESIGNATION AND APPROXIMATE LOCATION FOR CURRENT STUDY

HH-4 — HAND HOLE DESIGNATION AND APPROXIMATE LOCATION FOR CURRENT STUDY

TP-8 — TEST PIT DESIGNATION AND APPROXIMATE LOCATION FOR PREVIOUS 24TH STREET STUDY (2015)

TP-27 — TEST PIT DESIGNATION AND APPROXIMATE LOCATION FOR CURRENT STUDY

N

0' 50' 100' 200'
SCALE: 1"=100'

HWA GEOSCIENCES INC.

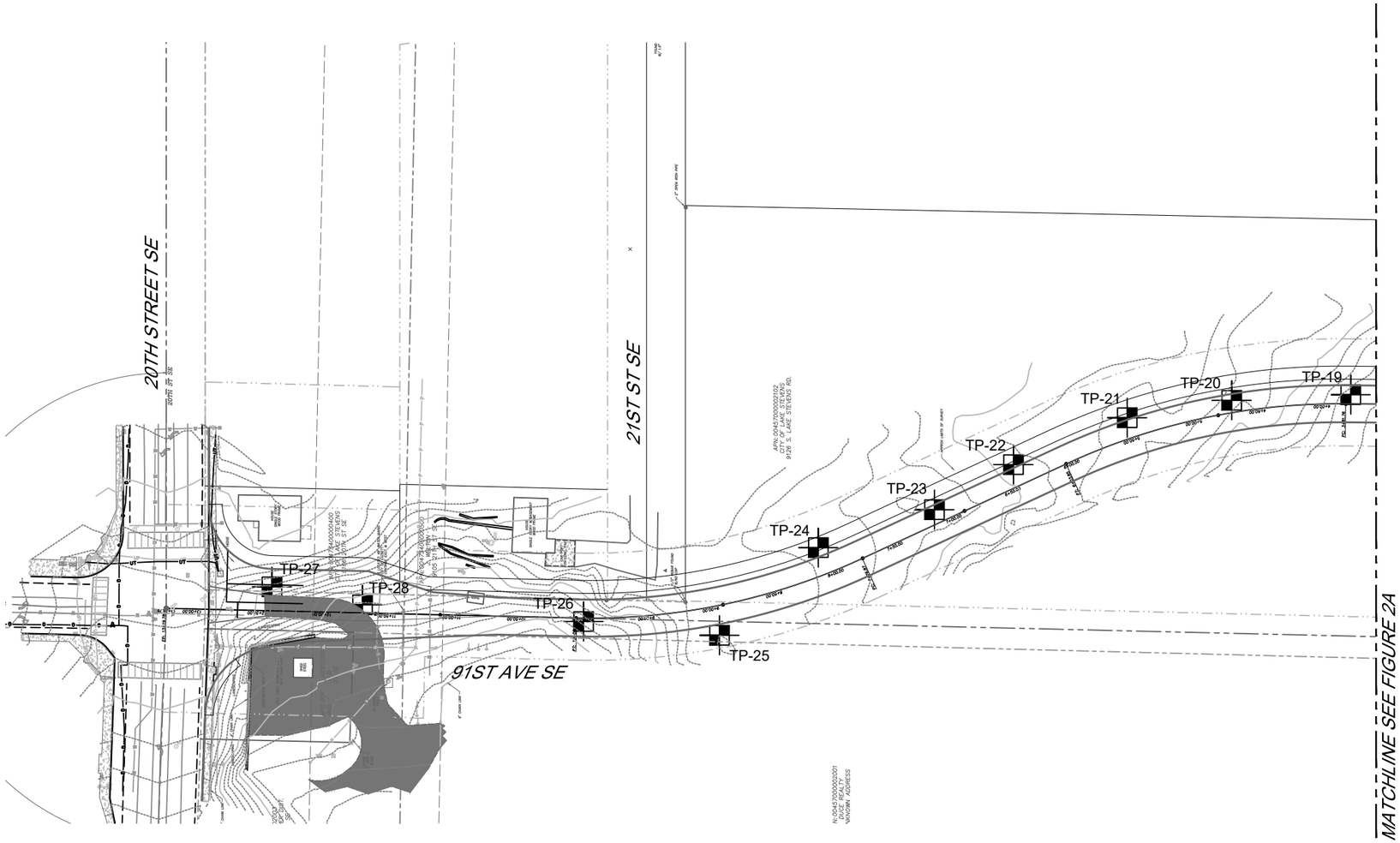
24TH STREET SE PROJECT
FINAL DESIGN
LAKE STEVENS, WASHINGTON

SITE AND
EXPLORATION PLAN

DRAWN BY: BFM
CHECK BY: JG
DATE 10.05.2017

FIGURE NO. 2A
PROJECT NO. 2017-039-21

S:\2017 PROJECTS\2017-039-21 24TH STREET FINAL DESIGN\CAD\HWA 2017-039-21.DWG <Fig 2A> Plotted: 10/16/2017 7:49 PM



LEGEND

BH-3 — BORE HOLE DESIGNATION AND APPROXIMATE LOCATION FOR CURRENT STUDY

HH-4 — HAND HOLE DESIGNATION AND APPROXIMATE LOCATION FOR CURRENT STUDY

TP-8 — TEST PIT DESIGNATION AND APPROXIMATE LOCATION FOR PREVIOUS 24TH STREET STUDY (2015)

TP-27 — TEST PIT DESIGNATION AND APPROXIMATE LOCATION FOR CURRENT STUDY

0' 50' 100' 200'
SCALE: 1"=100'

HWA GEOSCIENCES INC.

SITES AND PROPERTIES
LAKE STEVENS, WASHINGTON

SITE AND
EXPLORATION PLAN

DRAWN BY: BFM
CHECK BY: JG
DATE 10.05.2017

FIGURE NO. 2B
PROJECT NO. 2017-039-21

S:\2017 PROJECTS\2017-039-21 24TH STREET FINAL DESIGN\CAD\HWA 2017-039-21.DWG <Fig 2B> Plotted: 10/16/2017 7:52 PM

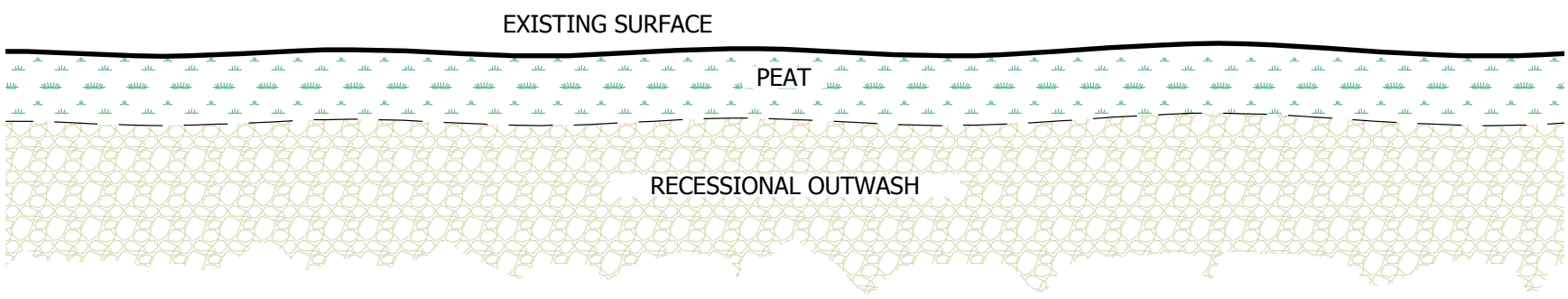
TYPICAL SOIL CROSS-SECTION DETAIL NOTES:

- PEAT = A soft, highly organic soil, consisting of partly decomposed vegetable matter.
- RECESSIONAL OUTWASH = A clean to slightly silty, fine to medium sand with varying amounts of gravel.
- Provided soil profile is general. Actual soil depths may vary significantly over relatively short distances.

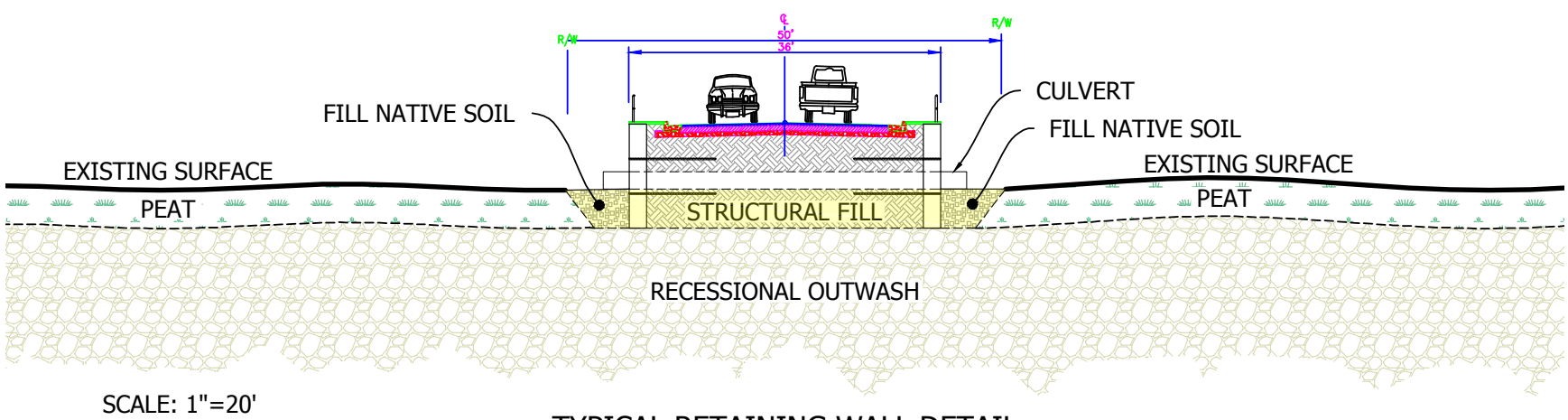
GENERAL CONSTRUCTION STEPS FOR RETAINING WALL AND EMBANKMENT:

- Excavate peat in the wet
- Seal and dewater excavation footprint.
- Construct retaining wall (or embankment) and structural fill section. Install water conveyance systems and utilities during this stage.
- Construct roadway surface and pedestrain features.
- Discontinue dewatering and remove watertight shoring to facilitate water flow through roadway prism.

APPROXIMATE AREA OF SOIL REMOVAL

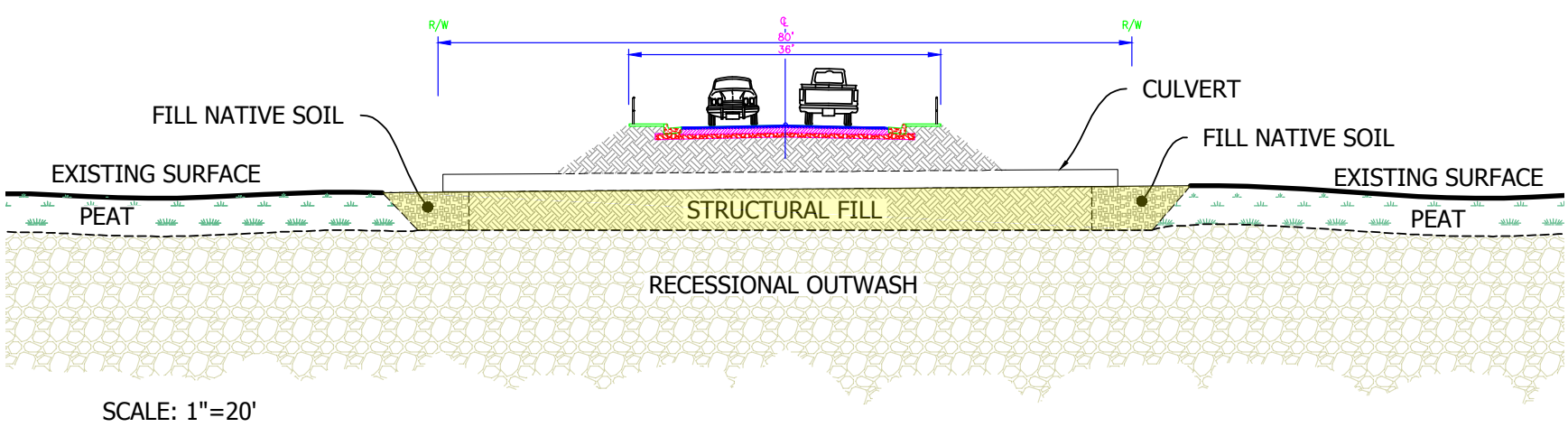


TYPICAL SOIL DETAIL



SCALE: 1"=20'

TYPICAL RETAINING WALL DETAIL



SCALE: 1"=20'

TYPICAL EMBANKMENT DETAIL

BASE MAP PROVIDED BY:

HWA GEOSCIENCES INC.	24th STREET SE PROJECT FINAL DESIGN LAKE STEVENS, WASHINGTON	TYPICAL ROAD DETAIL	DRAWN BY EFK CHECK BY CJ DATE: 01.13.15	FIGURE # 3 PROJECT # 2015-098

S:\2015 PROJECTS\2015-098-21 24TH STREET SE LAKE STEVENS\CAD 2015-098\HWA 2015-098 RM.DWG, <Layout2> Plotted: 1/13/2016 6:04 PM

APPENDIX A

HWA EXPLORATION LOGS

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APPENDIX A

HWA EXPLORATIONS

HWA GeoSciences Inc. (HWA) conducted three geotechnical borings in support of the design of the 24th Street SE Final Design Project. The three borings were conducted within the right of way easement of the City of Lake Stevens. These borings were drilled by Holocene Drilling, Inc. of Puyallup, Washington, on August 23 and 24, 2017. On August 23, a limited access CME-850 track-mounted drill rig was used to drill borings BH-2 and BH-3. On August 24, a limited access Dietrich D-50 track-mounted drill rig was used to drill boing BH-1. All borings were drilled using hollow stem augers and an automatic hammer.

In each of the borings, Standard Penetration Test (SPT) sampling was performed using a 2-inch outside diameter split-spoon sampler driven by a 140-pound manual rope and cathead hammer. During the SPT, samples were obtained by driving the sampler 18 inches into the soil with the hammer free-falling 30 inches. The numbers of blows required for each 6 inches of penetration were recorded. The Standard Penetration Resistance ("N-value") of the soil is calculated as the number of blows required for the final 12 inches of penetration. This resistance, or N-value, provides an indication of relative density of granular soils and the relative consistency of cohesive soils; both indicators of soil strength.

HWA also logged the excavation of thirteen test pits with the right of way easement of the City of Lake Stevens. These test pits were excavated by the City on September 13 and 14, 2017. A limited access Yanmar Vic 55 rubber tracked excavator equipped with a 2-foot wide bucket was used to excavate the test pits.

A geotechnical engineer from HWA logged the explorations and recorded pertinent information, including sample depths, stratigraphy, soil engineering characteristics, and ground water occurrence. Soil samples obtained from the exploration were classified in the field and representative portions were placed in plastic bags. These soil samples were then taken to our Bothell, Washington, laboratory for further examination and testing.

The stratigraphic contacts shown on the exploration log represent the approximate boundaries between soil types; actual transitions may be more gradual. The soil and groundwater conditions depicted are only for the specific date and location reported and, therefore, are not necessarily representative of other locations and times.

The locations of the boreholes and test pits were determined approximately in the field by pacing and taping distances from existing site features and are shown on the Site and Exploration Plan, Figure 2A-2B. A legend of the terms and symbols used on the exploration logs is presented in Figure A-1. Summary logs of the borehole and test pit explorations are presented in Figures A-2 through A-17.

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RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALUE

COHESIONLESS SOILS			COHESIVE SOILS		
Density	N (blows/ft)	Approximate Relative Density(%)	Consistency	N (blows/ft)	Approximate Undrained Shear Strength (psf)
Very Loose	0 to 4	0 - 15	Very Soft	0 to 2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Medium Dense	10 to 30	35 - 65	Medium Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	over 50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	over 30	>4000

USCS SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP DESCRIPTIONS	
Coarse Grained Soils	Gravel and Gravelly Soils	Clean Gravel (little or no fines)	GW	Well-graded GRAVEL
			GP	Poorly-graded GRAVEL
	More than 50% of Coarse Fraction Retained on No. 4 Sieve	Gravel with Fines (appreciable amount of fines)	GM	Silty GRAVEL
			GC	Clayey GRAVEL
	Sand and Sandy Soils	Clean Sand (little or no fines)	SW	Well-graded SAND
More than 50% Retained on No. 200 Sieve Size			SP	Poorly-graded SAND
	50% or More of Coarse Fraction Passing No. 4 Sieve	Sand with Fines (appreciable amount of fines)	SM	Silty SAND
			SC	Clayey SAND
Fine Grained Soils	Silt and Clay	Liquid Limit Less than 50%	ML	SILT
			CL	Lean CLAY
			OL	Organic SILT/Organic CLAY
50% or More Passing No. 200 Sieve Size	Silt and Clay	Liquid Limit 50% or More	MH	Elastic SILT
			CH	Fat CLAY
			OH	Organic SILT/Organic CLAY
Highly Organic Soils			PT	PEAT

TEST SYMBOLS

%F	Percent Fines
AL	Atterberg Limits: PL = Plastic Limit, LL = Liquid Limit
CBR	California Bearing Ratio
CN	Consolidation
DD	Dry Density (pcf)
DS	Direct Shear
GS	Grain Size Distribution
K	Permeability
MD	Moisture/Density Relationship (Proctor)
MR	Resilient Modulus
PID	Photoionization Device Reading
PP	Pocket Penetrometer Approx. Compressive Strength (tsf)
SG	Specific Gravity
TC	Triaxial Compression
TV	Torvane Approx. Shear Strength (tsf)
UC	Unconfined Compression

SAMPLE TYPE SYMBOLS

- 2.0" OD Split Spoon (SPT) (140 lb. hammer with 30 in. drop)
- Shelby Tube
- 3-1/4" OD Split Spoon with Brass Rings
- Small Bag Sample
- Large Bag (Bulk) Sample
- Core Run
- Non-standard Penetration Test (3.0" OD split spoon)

GROUNDWATER SYMBOLS

- Groundwater Level (measured at time of drilling)
- Groundwater Level (measured in well or open hole after water level stabilized)

COMPONENT DEFINITIONS

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
Gravel	3 in to No 4 (4.5mm)
Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No 4 (4.5mm)
Sand	No. 4 (4.5 mm) to No. 200 (0.074 mm)
Coarse sand	No. 4 (4.5 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.074mm)

COMPONENT PROPORTIONS

PROPORTION RANGE	DESCRIPTIVE TERMS
< 5%	Clean
5 - 12%	Slightly (Clayey, Silty, Sandy)
12 - 30%	Clayey, Silty, Sandy, Gravelly
30 - 50%	Very (Clayey, Silty, Sandy, Gravelly)
Components are arranged in order of increasing quantities.	

NOTES: Soil classifications presented on exploration logs are based on visual and laboratory observation. Soil descriptions are presented in the following general order:

Density/consistency, color, modifier (if any) GROUP NAME, additions to group name (if any), moisture content. Proportion, gradation, and angularity of constituents, additional comments. (GEOLOGIC INTERPRETATION)

Please refer to the discussion in the report text as well as the exploration logs for a more complete description of subsurface conditions.

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.

HWA GEOSCIENCES INC.

24TH STREET SE PROJECT
FINAL DESIGN
LAKE STEVENS, WASHINGTON

LEGEND OF TERMS AND SYMBOLS USED ON EXPLORATION LOGS

PROJECT NO.: 2017-039-21 FIGURE: A-1

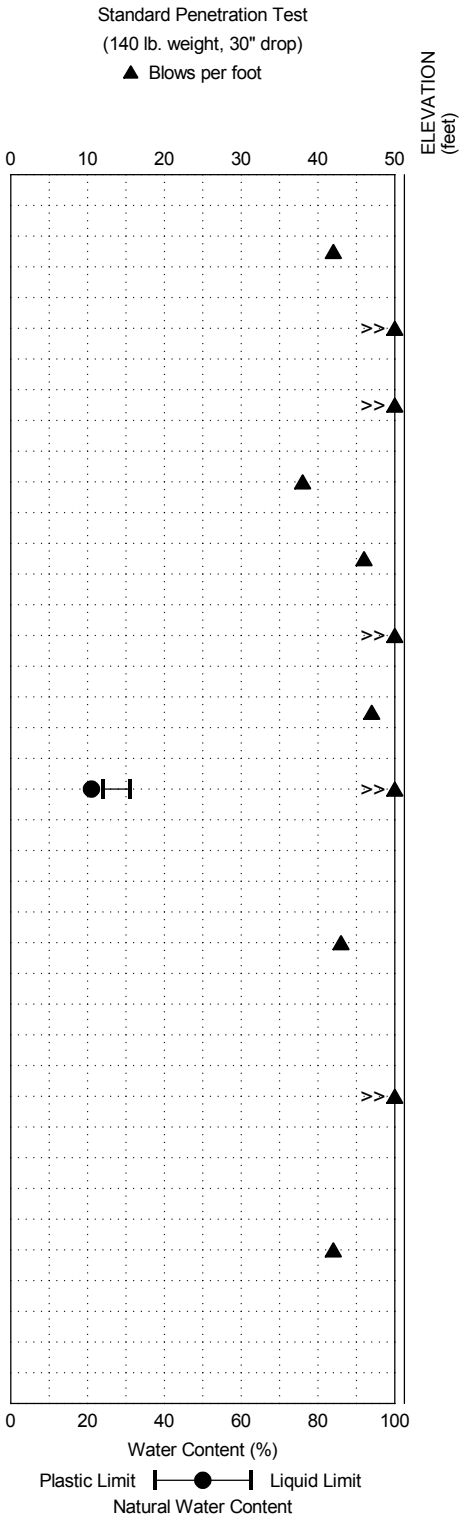
DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Track-mounted Dietrich D50, 3 1/4" HSA
SAMPLING METHOD: SPT w/ Autohammer
LOCATION: See Figures 2A-2B

DATE STARTED: 8/24/2017
DATE COMPLETED: 8/24/2017
LOGGED BY: S. Miller

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)
0	SP SM	Loose, brown, gravel and SAND, moist, with abundant roots and bark. **(TOPSOIL/DUFF)**			
	ML SM	Gravelly drilling at 1.5 ft. Subrounded coarse gravel in cuttings.		S-1	14-20-22
5	ML SM	Dense, light gray to tan and brown, gravelly SAND to sandy SILT, moist, rust mottling throughout. **(GLACIAL TILL)** Diamict appearance at 3.5 ft		S-2	50/6"
		Very dense, gray and brown, gravelly, sandy SILT to silty SAND, varies, moist. broken gravel in sampler. Till-like appearance. Faint rust mottling.		S-3	36-39-50/5"
10	ML	Gravelly drilling from 5' to 7.5'. Very dense, tan, gray and brown, slightly gravelly to gravelly, sandy SILT, moist. Faint rust mottling. Till-like appearance.		S-4	7-16-22
		Hard, dark gray, massive SILT, moist. Faint bedding. **(GLACIOLACUSTRINE)** Crumbles easily.		S-5	16-19-27
15		Crumbles more easily.		S-6	18-26-26
		Faint lamination/bedding observed.		S-7	16-20-27
20				S-8	14-27-29
25		Becomes more moist.		S-9	13-18-25
		Cuttings appear more moist and stick together in clumps.			
30				S-10	13-24-31
35				S-11	12-18-24
40		Boring terminated at 36.5'. No ground water seepage observed during drilling.			

OTHER TESTS

GROUNDWATER



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24TH STREET SE PROJECT
FINAL DESIGN
LAKE STEVENS, WASHINGTON

BORING:
BH-1

PROJECT NO.: 2017-039-21 FIGURE: A-2

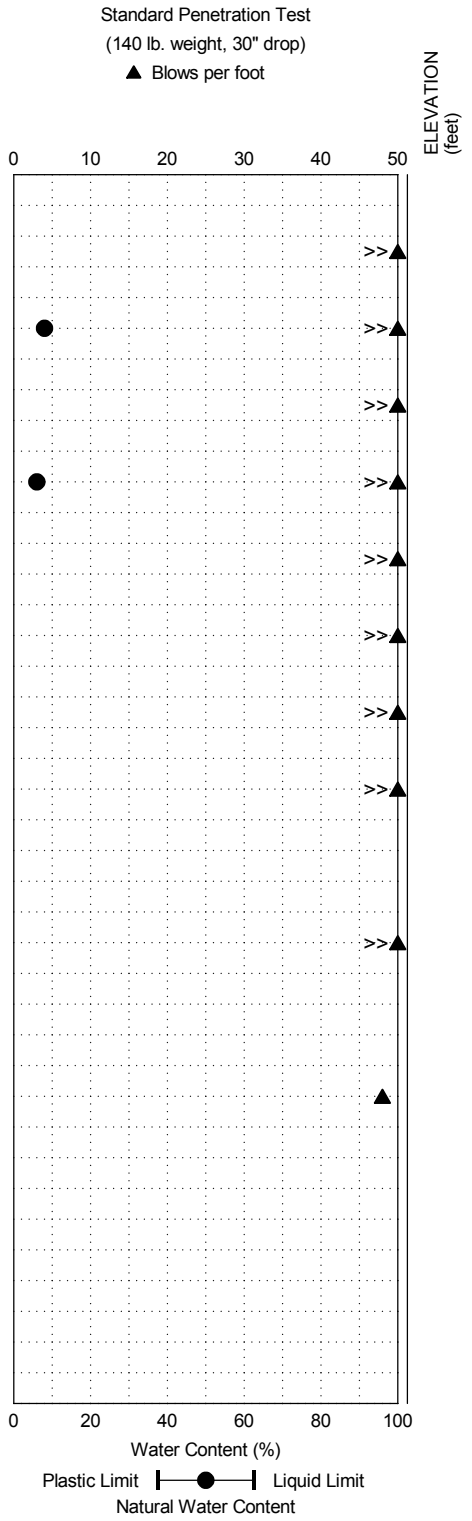
DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Track-mounted CME-850, 3 1/4" HSA
SAMPLING METHOD: SPT w/ Autohammer
LOCATION: See Figures 2A-2B

DATE STARTED: 8/23/2017
DATE COMPLETED: 8/23/2017
LOGGED BY: J. Gillie/S. Miller

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)
0	GP	Dense, dark brown, rounded to sub rounded GRAVEL, moist. **(RECESSIONAL OUTWASH)**			
	SM	Very dense, light olive brown, rust mottling, silty, gravelly SAND, moist with broken gravel. **(GLACIAL TILL)**		S-1	16-29-42
5		Hammer bouncing at bottom of sample, likely driving on rock. Very dense, light yellow brown, gravelly, silty SAND, band of heavy rust mottling at top of top of sample, decreasing silt content with depth.		S-2	19-50/6"
	SM	Gravelly drilling to 7.5'.		S-3	50/5"
10		Very dense, dark gray, gravelly, silty SAND, moist, with thin 1/8-1/4" laminations and broken gravel. Stratified with 1-inch lens of wet, brown, sandy silt observed in Sample at 10'.		S-4	50/5"
		Becomes slightly gravelly, with pockets of medium sand, very moist.		S-5	20-36-41
15		Trace gravel observed in sample at 15 feet. Lenses of fine to medium sand throughout.		S-6	17-27-31
		Becomes slightly gravelly with lenses of fine to medium sand lenses.		S-7	21-45-34
20	ML	Hard, dark gray, massive SILT, moist, tiny pocket of fine sand. **(GLACIOLACUSTRINE)**		S-8	14-22-37
25		Hard, dark gray, massive SILT, moist.		S-9	16-25-28
30		Hard, dark gray, massive SILT, moist, with increasing moisture content and plasticity with depth.		S-10	14-21-27
35		Boring terminated at 31.5'. No ground water seepage observed during drilling.			
40					

OTHER TESTS

GROUNDWATER



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24TH STREET SE PROJECT
FINAL DESIGN
LAKE STEVENS, WASHINGTON

BORING:
BH-2

PROJECT NO.: 2017-039-21 FIGURE: A-3

DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Track-mounted CME-850, 3 1/4" HSA
SAMPLING METHOD: SPT w/ Autohammer
LOCATION: See Figures 2A-2B

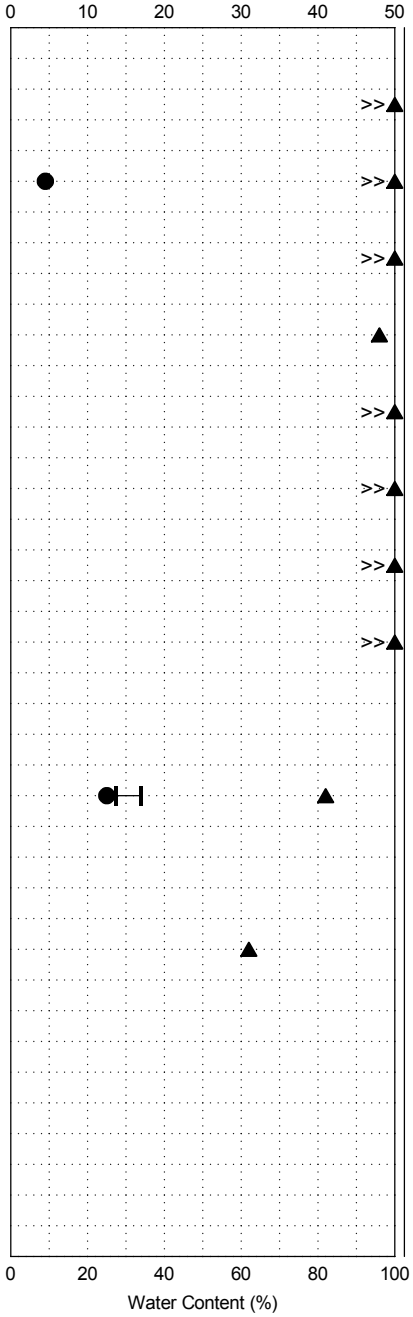
DATE STARTED: 8/23/2017
DATE COMPLETED: 8/23/2017
LOGGED BY: J. Gille/S. Miller

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE / SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)
0	SM	Brown, loose, silty SAND w/ gravel, dry.		
		(TOPSOIL/DUFF)		
	SM	Very dense, olive gray, silty SAND, moist. Broken rock at top w/ black and brown topsoil in upper 6".	S-1	16-32-32
5		**(GLACIAL TILL)** Very dense, olive brown, SAND, moist, with slight rust mottling, compact appearance, diamicton.	S-2	12-15-50
		Becomes more sandy, more moist.	S-3a S-3b	11-22-50/4"
	ML SM	Very dense, olive brown, gravelly, very silty SAND to sandy SILT, moist.		
10	ML	Hard, dark gray, massive SILT, moist. **(ICE CONTACT STRATIFIED DRIFT)**	S-4	11-21-27
	SM	Very dense, olive gray, silty SAND, moist to wet.	S-5	50/5"
15		Very dense, olive brown to olive gray, gravelly, very silty SAND, moist, diamict appearance?.	S-6	50/5"
	ML SM	Hard, dark gray, gravelly, very sandy SILT, moist, with faint laminations. Hard drilling, chattering while advancing.	S-7	30-50/5"
20	ML	Hard, dark gray, massive SILT, moist. **(GLACIOLACUSTRINE)**	S-8	10-26-27
25			S-9	11-17-24
30			S-10	11-14-17
35				
40				

Boring terminated at 31.5'.
No ground water seepage observed during drilling.

GROUNDWATER

Standard Penetration Test
(140 lb. weight, 30" drop)
▲ Blows per foot



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24TH STREET SE PROJECT
FINAL DESIGN
LAKE STEVENS, WASHINGTON

BORING:
BH-3

PROJECT NO.: 2017-039-21 FIGURE: A-4

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/13/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		GP	Loose, dark yellow-brown, sandy GRAVEL to gravelly SAND, dry. With abundant roots and thin layer of subrounded to rounded gravel and cobbles. **(TOPSOIL)**				
		SM	Medium dense, yellow-brown, silty, gravelly SAND, moist. With minor roots and rootlets. **(RECESSIONAL OUTWASH)**		S-1	6	
		SM	Very dense, olive-gray, silty, gravelly SAND, moist. Horizontal rust bands, faint laminations and friable in the upper 1'. **(GLACIAL TILL)**		S-2		
5					S-3	6	
			Test pit terminated at 5 feet below ground surface. Minor caving in the upper 2.5 feet. No groundwater seepage observed at the time of exploration.				
10							
15							

TEST PIT PHOTO

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24TH STREET SE PROJECT
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LOG OF TEST PIT
TP-16

PROJECT NO.: 2017-039-21 FIGURE: A-5

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/13/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		GP	Loose, dark yellow-brown, sandy GRAVEL to gravelly SAND, dry. With abundant roots. **(TOPSOIL)**				
		SM	Medium dense, yellow-brown, silty, gravelly SAND, moist. With minor roots and rootlets. **(RECESSIONAL OUTWASH)**		S-1		
		SM			S-2	5	
		SM	Very dense, light olive-gray, silty, gravelly SAND, moist. Weathered. **(GLACIAL TILL)**		S-3		
					S-4	6	
5			Very dense, olive-gray, silty, gravelly SAND, moist.				
			Test pit terminated at 4.5 feet below ground surface. No caving. No groundwater seepage observed at the time of exploration.				
10							
15							

TEST PIT PHOTO

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HWA GEOSCIENCES INC.

24TH STREET SE PROJECT
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LOG OF TEST PIT
TP-17

PROJECT NO.: 2017-039-21 FIGURE: A-6

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/13/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		GW GM	Loose, dark yellow-brown, slightly silty, sandy GRAVEL to gravelly SAND, dry. With abundant roots. **(TOPSOIL)**				
		SM	Medium dense, yellow-brown, silty, gravelly SAND, moist. With roots and rootlets. **(RECESSIONAL OUTWASH)**		S-1	5	
5		SM	Very dense, rust mottled, olive-gray, silty, gravelly SAND, moist. **(GLACIAL TILL)**		S-2		
10			Test pit terminated at 6 feet below ground surface. No caving. No groundwater seepage observed at the time of exploration.				
15							

TEST PIT PHOTO

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HWA GEOSCIENCES INC.

24TH STREET SE PROJECT
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LOG OF TEST PIT
TP-18

PROJECT NO.: 2017-039-21 FIGURE: A-7

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/13/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		SM	Loose, dark brown, silty, gravelly SAND, dry. With roots and rootlets. **(TOPSOIL)**				
		SM	Medium dense, yellow-brown, silty, gravelly SAND, moist. With roots and rootlets. **(RECESSIONAL OUTWASH)**		S-1	28	
5		SM	Very dense, olive-gray, silty, gravelly SAND, moist. **(GLACIAL TILL)**		S-2	8	
10			Test pit terminated at 6 feet below ground surface. No caving. No groundwater seepage observed at the time of exploration.				
15							

TEST PIT PHOTO

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24TH STREET SE PROJECT
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LOG OF TEST PIT
TP-19

PROJECT NO.: 2017-039-21 FIGURE: A-8

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/13/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		SM	Loose, dark brown, silty, gravelly SAND, dry. With abundant roots and rootlets. **(TOPSOIL)**				
		SM	Medium dense, yellow-brown, silty, gravelly SAND, moist. With scattered subrounded and rounded cobbles. **(RECESSIONAL OUTWASH)**		S-1	12	
5		SM	Very dense, olive-gray, silty, gravelly SAND, moist. **(GLACIAL TILL)**		S-2		
			Test pit terminated at 6.5 feet below ground surface. No caving. No groundwater seepage observed at the time of exploration.				
10							
15							

TEST PIT PHOTO

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24TH STREET SE PROJECT
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LAKE STEVENS, WASHINGTON

LOG OF TEST PIT
TP-20

PROJECT NO.: 2017-039-21 FIGURE: A-9

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/13/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		SM	Loose, dark brown, silty, gravelly SAND, dry. With roots and rootlets. **(TOPSOIL)**				
		SM	Medium dense, yellow-brown, silty, gravelly SAND, moist. **(RECESSIONAL OUTWASH)**		S-1	11	
					S-2	11	
		SM	Very dense, rust mottled, olive-gray, silty, gravelly SAND, moist. **(GLACIAL TILL)**				
5		SM	Very dense, rust mottled, olive-gray, silty fine SAND, moist. Laminated. **(ICE CONTACT STRATIFIED DRIFT)**		S-3	14	
			Test pit terminated at 7.5 feet below ground surface. No caving. No groundwater seepage observed at the time of exploration.				
10							
15							

TEST PIT PHOTO

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HWA GEOSCIENCES INC.

24TH STREET SE PROJECT
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LAKE STEVENS, WASHINGTON

LOG OF TEST PIT
TP-21

PROJECT NO.: 2017-039-21 FIGURE: A-10

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/13/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		SM	Loose, dark brown, silty, gravelly SAND, dry. With minor roots and rootlets. **(TOPSOIL)**				
		SM	Medium dense, yellow-brown, silty, gravelly SAND, moist. With minor roots and rootlets. **(RECESSIONAL OUTWASH)**		S-1	7	
5		SM	Very dense, rust mottled, olive-gray, silty, gravelly SAND, moist. **(GLACIAL TILL)**		S-2	9	
10			Test pit terminated at 7.5 feet below ground surface. No caving. No groundwater seepage observed at the time of exploration.				
15							

TEST PIT PHOTO

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

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24TH STREET SE PROJECT
FINAL DESIGN
LAKE STEVENS, WASHINGTON

LOG OF TEST PIT
TP-22

PROJECT NO.: 2017-039-21 FIGURE: A-11

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/13/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		SM	Loose, dark brown, silty, gravelly SAND, dry. With abundant roots and rootlets. **(TOPSOIL)**				
		SM	Medium dense, yellow-brown, silty, gravelly SAND, moist. With abundant roots and rootlets. **(RECESSIONAL OUTWASH)**				
					S-1	8	
5		SM	Very dense, olive-gray, silty, gravelly SAND, moist. **(GLACIAL TILL)**				
					S-2		
10			Test pit terminated at 6 feet below ground surface. No caving. No groundwater seepage observed at the time of exploration.				
15							

TEST PIT PHOTO

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

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24TH STREET SE PROJECT
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LAKE STEVENS, WASHINGTON

LOG OF TEST PIT
TP-23

PROJECT NO.: 2017-039-21 FIGURE: A-12

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/14/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		SM	Loose, dark brown, silty, gravelly SAND, dry. With abundant roots and rootlets. White 2" PVC pipe at north limit of test pit running east-to-west and buried only 6" below ground surface.				
		SM	**(TOPSOIL)**		S-1	20	
			Medium dense, yellow-brown, silty, gravelly SAND, moist. With minor roots and rootlets. **(RECESSIONAL OUTWASH)**				
		SM	Very dense, rust mottled, olive-gray, silty, gravelly SAND, moist. **(GLACIAL TILL)**		S-2		
5							
10							
15							

Test pit terminated at 6 feet below ground surface.
No caving.
No groundwater seepage observed at the time of exploration.

TEST PIT PHOTO

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

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24TH STREET SE PROJECT
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LOG OF TEST PIT
TP-24

PROJECT NO.: 2017-039-21 FIGURE: A-13

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/14/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		SM	Loose, dark brown, silty, gravelly SAND, dry. With abundant roots and rootlets. **(TOPSOIL)**				
		SM	Medium dense, yellow-brown, silty, gravelly SAND, moist. With abundant roots and rootlets. **(RECESSIONAL OUTWASH)**		S-1	8	
		SM	Very dense, rust mottled, olive-gray, silty, gravelly SAND, moist. **(GLACIAL TILL)**		S-2		
5							
10							
15							

Test pit terminated at 6.5 feet below ground surface.
No caving.
No groundwater seepage observed at the time of exploration.

TEST PIT PHOTO

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

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24TH STREET SE PROJECT
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LOG OF TEST PIT
TP-25

PROJECT NO.: 2017-039-21 FIGURE: A-14

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/14/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		GM	Loose, dark brown, silty, sandy GRAVEL, dry. With abundant roots and rootlets. **(TOPSOIL)**				
		GM	Medium dense, yellow-brown, silty, sandy, GRAVEL, moist. With abundant roots and rootlets. **(RECESSIONAL OUTWASH)**		S-1	7	
5		SM	Very dense, rust mottled, olive-gray, silty, gravelly SAND, moist. **(GLACIAL TILL)**		S-2		
10			Test pit terminated at 6 feet below ground surface. No caving. No groundwater seepage observed at the time of exploration.				
15							

TEST PIT PHOTO

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24TH STREET SE PROJECT
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LOG OF TEST PIT
TP-26

PROJECT NO.: 2017-039-21 FIGURE: A-15

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/14/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		SM	Loose, dark brown, silty, gravelly SAND, dry. With abundant roots and rootlets. **(TOPSOIL)**		S-1		
		SM	Medium dense, olive-gray to light olive-brown, silty, gravelly SAND, moist. **(FILL)**		S-2	5	
5			Medium dense, dark brown, silty, gravelly SAND, moist. Occasional cobbles and minor organics. **(BURIED TOPSOIL)**		S-3		
		GM	Medium dense, yellow-brown, silty, sandy, GRAVEL, moist. **(RECESSIONAL OUTWASH)**		S-4	7	
10		SM	Very dense, olive-gray, silty, gravelly SAND, moist. **(GLACIAL TILL)**		S-5		
15			Test pit terminated at 10 feet below ground surface. No caving. No groundwater seepage observed at the time of exploration.				

TEST PIT PHOTO

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LOG OF TEST PIT
TP-27

PROJECT NO.: 2017-039-21 FIGURE: A-16

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar Rubber Tracked Excavator

LOCATION: See Figures 2A-2B
DATE COMPLETED: 9/14/17
LOGGED BY: Z. Ngoma

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTUE CONTENT (%)	OTHER TESTS
0		SM	Loose, dark brown, silty, gravelly SAND, dry. With abundant roots and rootlets. **(TOPSOIL)**				
		SM	Medium dense, olive-gray to light olive-brown, silty, gravelly SAND, moist. **(FILL)**		S-1		
			Medium dense, dark brown, silty, gravelly SAND, moist. Occasional cobbles and minor organics. **(BURIED TOPSOIL)**		S-2		
5		SM	Medium dense, yellow-brown, silty, gravelly SAND, moist. **(RECESSIONAL OUTWASH)**				
		SM	Very dense, olive-gray, silty, gravelly SAND, moist. **(GLACIAL TILL)**		S-3	8	
10			Test pit terminated at 10 feet below ground surface. No caving. No groundwater seepage observed at the time of exploration.				
15							

TEST PIT PHOTO

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24TH STREET SE PROJECT
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LOG OF TEST PIT
TP-28

PROJECT NO.: 2017-039-21 FIGURE: A-17

APPENDIX B

LABORATORY TEST RESULTS

DRAFT

APPENDIX B

LABORATORY INVESTIGATION

Representative soil samples obtained from the explorations were placed in plastic bags to prevent loss of moisture and transported to our Bothell, Washington, laboratory for further examination and testing. Laboratory tests were conducted on selected soil samples to characterize relevant engineering and index properties of the site soils. The laboratory testing program was performed in general accordance with appropriate ASTM Standards, as outlined below.

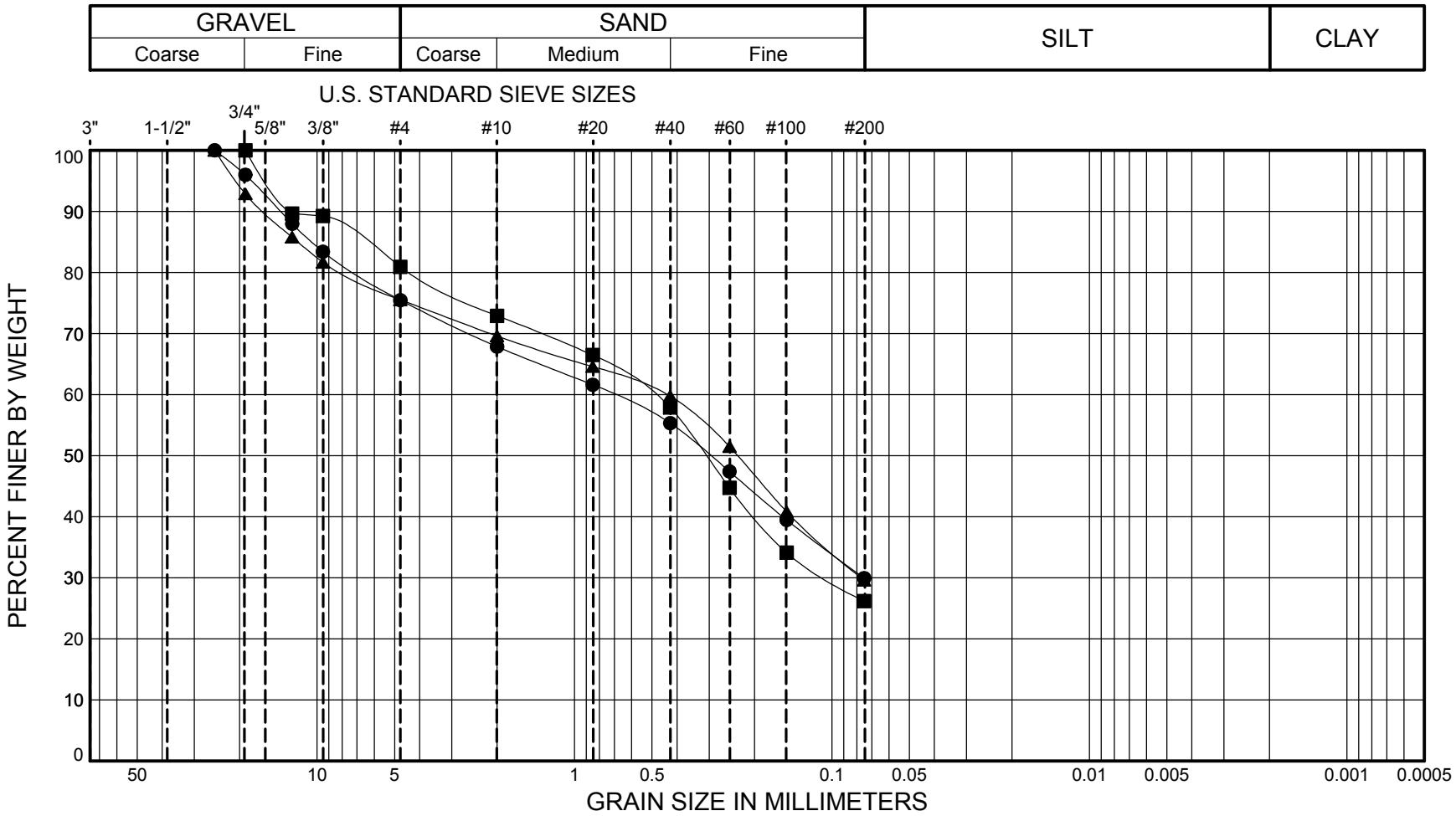
MOISTURE CONTENT OF SOIL: The moisture content of selected soil samples (percent by dry mass) was determined in general accordance with ASTM D 2216. The results are shown at the sampled intervals on the appropriate summary logs in Appendix A.

PARTICLE SIZE ANALYSIS OF SOILS: Selected granular samples were tested to determine the particle size distribution of material in accordance with ASTM D 422 (wash sieve or wash sieve and hydrometer methods). The results are summarized on the attached Particle-Size Distribution reports (Figures B-1 through B-6, Appendix B), which also provide information regarding the classification of the samples and the moisture content at the time of testing.

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ATTERBERG LIMITS): Selected samples were tested using method ASTM D 4318, one-point method. The results are reported on the attached Liquid Limit, Plastic Limit, and Plasticity Index report, Figure B-7.

LABORATORY COMPACTION CHARACTERISTICS OF SOIL (PROCTOR TEST): Selected samples were tested using method ASTM D 1557 (Modified Proctor) Method C. The test was performed on the portion of the sample passing ¾", as required by the test procedure. The maximum dry density and optimum moisture content result have been corrected for the amount of over-sized material using method ASTM 4718. The test results are summarized on the attached Laboratory Compaction Characteristics of Soil report, Figure B-8.

DRAFT



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	BH-2	S-2	5.0 - 6.0	(SM) Light olive-brown, silty SAND with gravel	8				24.5	45.5	29.9
■	BH-2	S-4	10.0 - 10.5	(SM) Gray, silty SAND with gravel	6				19.1	54.8	26.2
▲	BH-3	S-2	5.0 - 6.5	(SM) Grayish-brown, silty SAND with gravel	9				24.5	45.9	29.6

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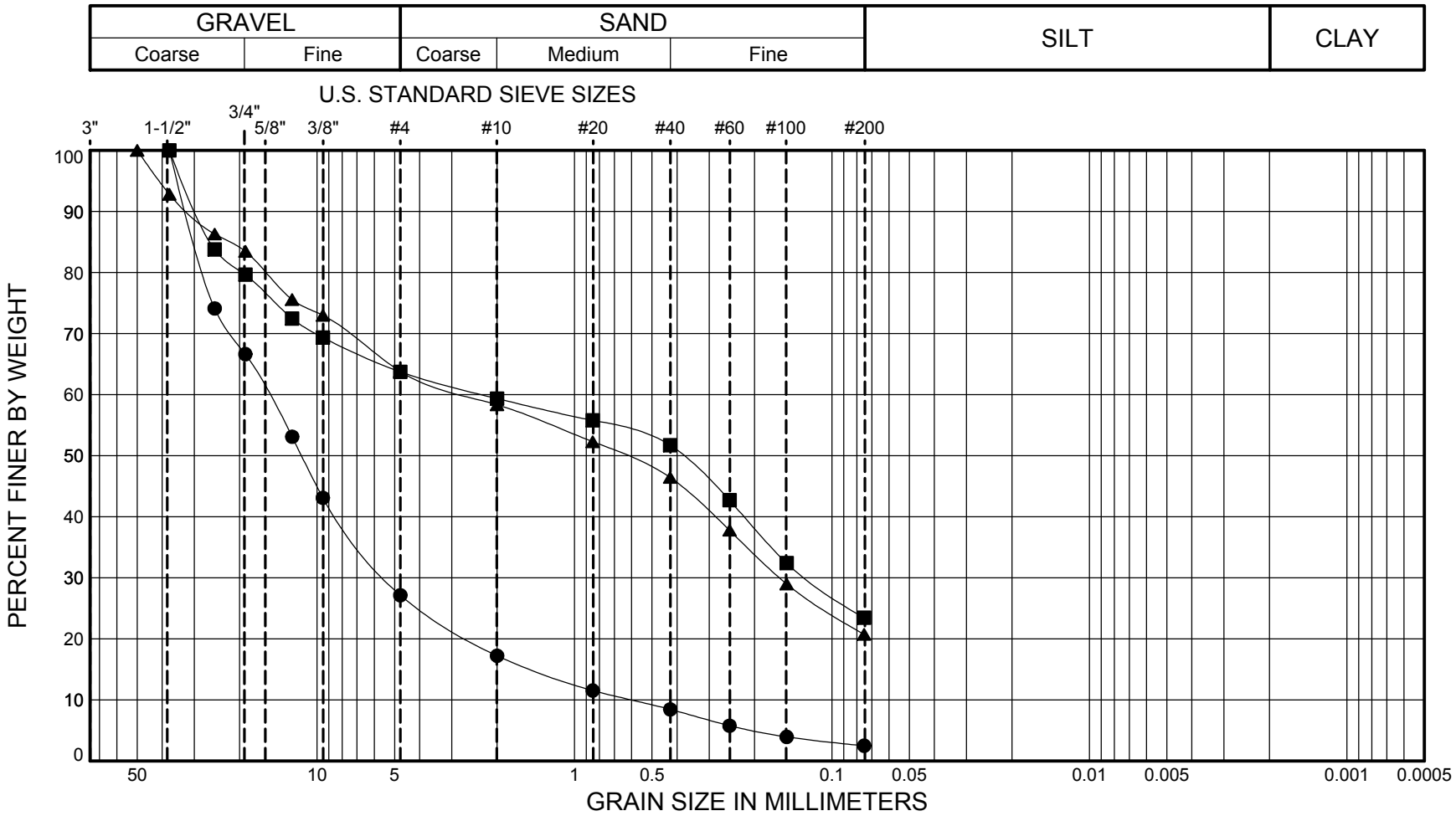
PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2017-039-21 FIGURE: B-1



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	TP-16	S-1	2.5 - 3.0	(GP) Yellowish-brown, poorly graded GRAVEL with sand	6				72.9	24.6	2.5
■	TP-16	S-3	4.5 - 5.0	(SM) Gray, silty SAND with gravel	6				36.3	40.3	23.4
▲	TP-17	S-2	2.0 - 2.5	(SM) Light olive-brown, silty SAND with gravel	5				36.2	43.1	20.7

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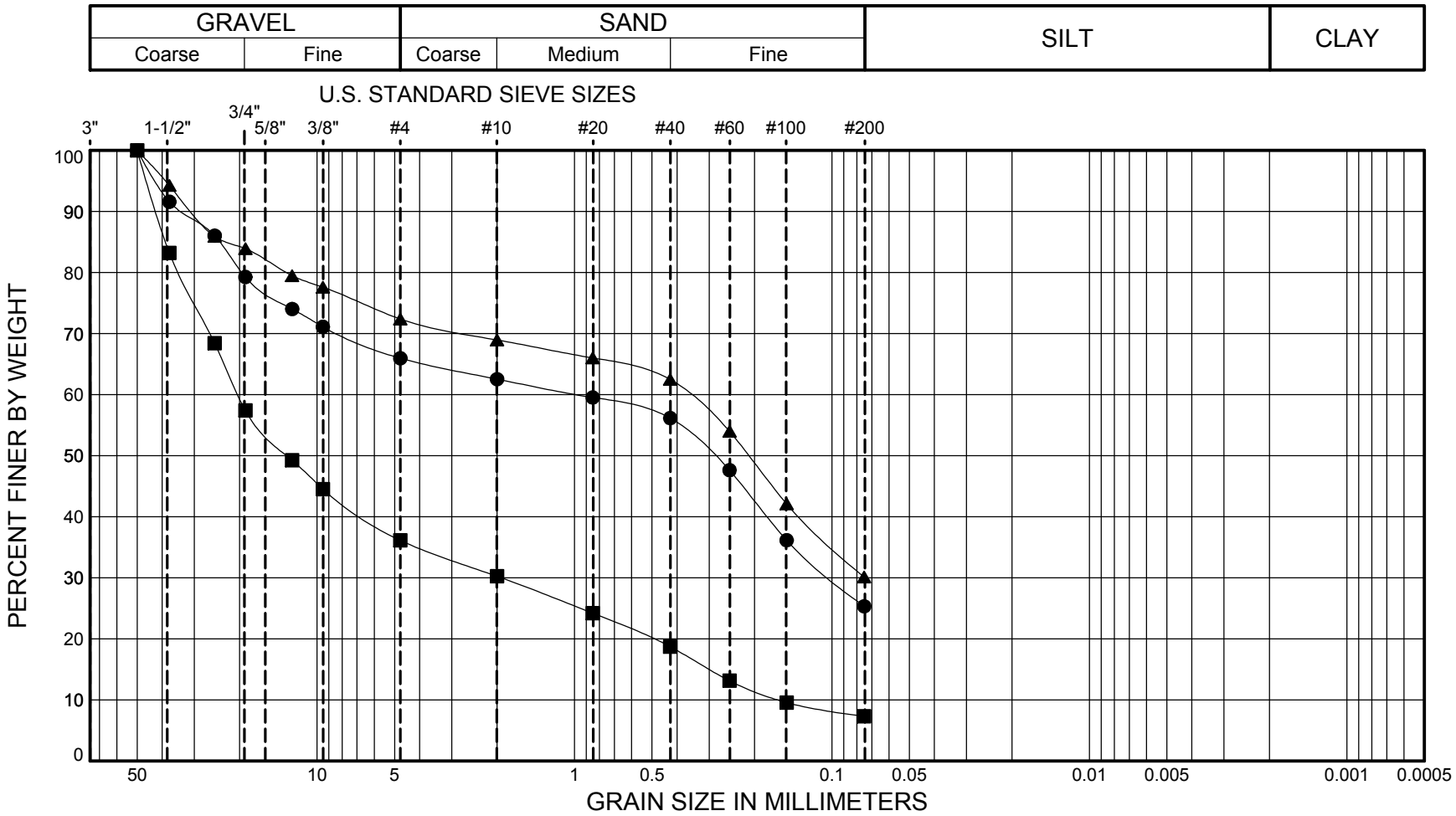
PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2017-039-21 FIGURE: B-2



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	TP-17	S-4	4.0 - 4.5	(SM) Light olive-brown, silty SAND with gravel	6				34.0	40.6	25.3
■	TP-18	S-1	2.5 - 3.0	(GW-GM) Yellowish-brown, well-graded GRAVEL with silt and sand	5				63.9	28.8	7.3
▲	TP-19	S-2	5.5 - 6.0	(SM) Dark gray, silty SAND with gravel	8				27.6	42.3	30.1

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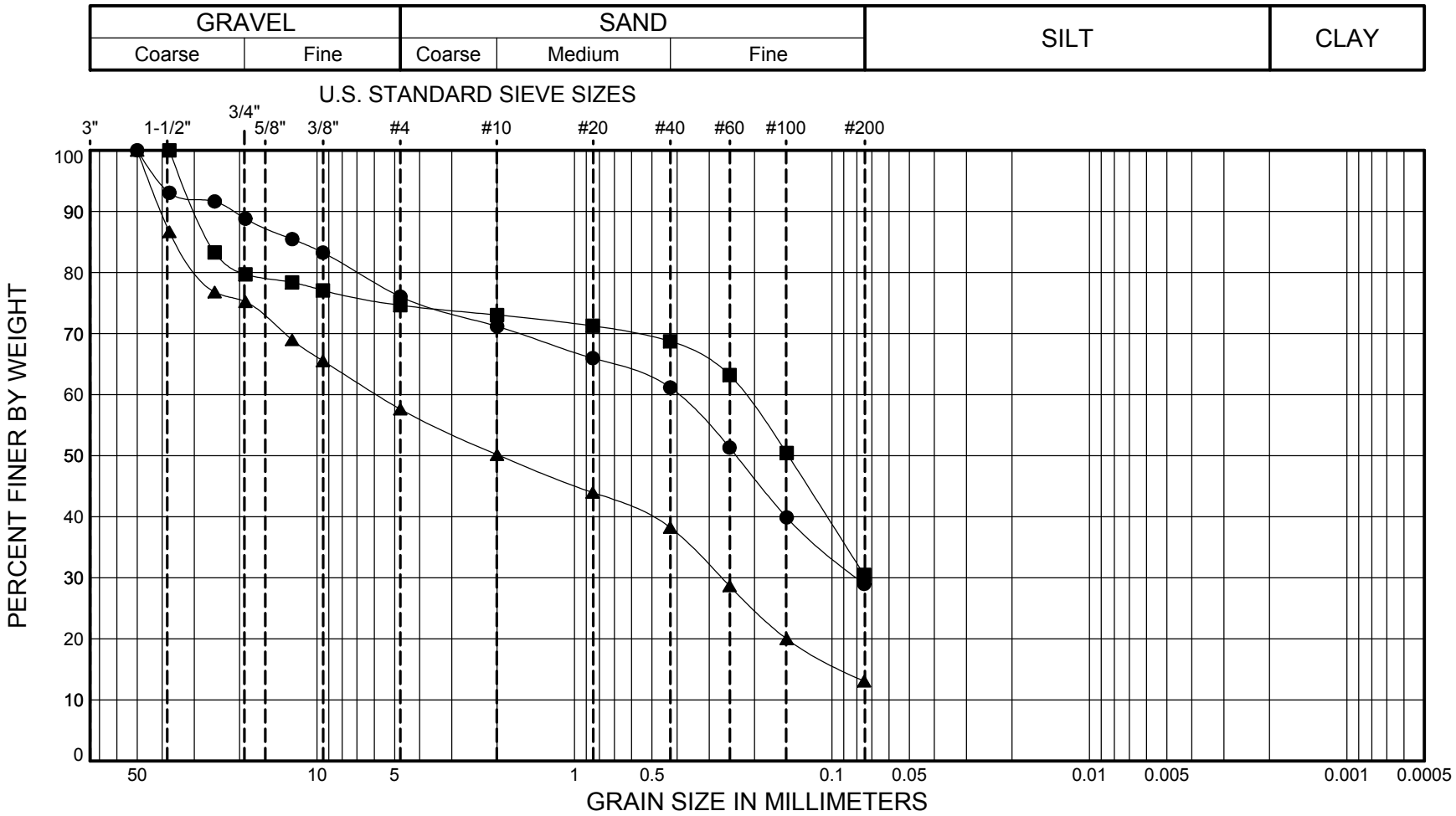
PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2017-039-21 FIGURE: B-3



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	TP-21	S-2	2.5 - 3.0	(SM) Gray, silty SAND with gravel	11				24.0	47.0	29.0
■	TP-21	S-3	6.0 - 6.5	(SM) Gray, silty SAND with gravel	14				25.4	44.1	30.5
▲	TP-22	S-1	1.5 - 2.0	(SM) Brownish-yellow, silty SAND with gravel	7				42.4	44.6	13.0

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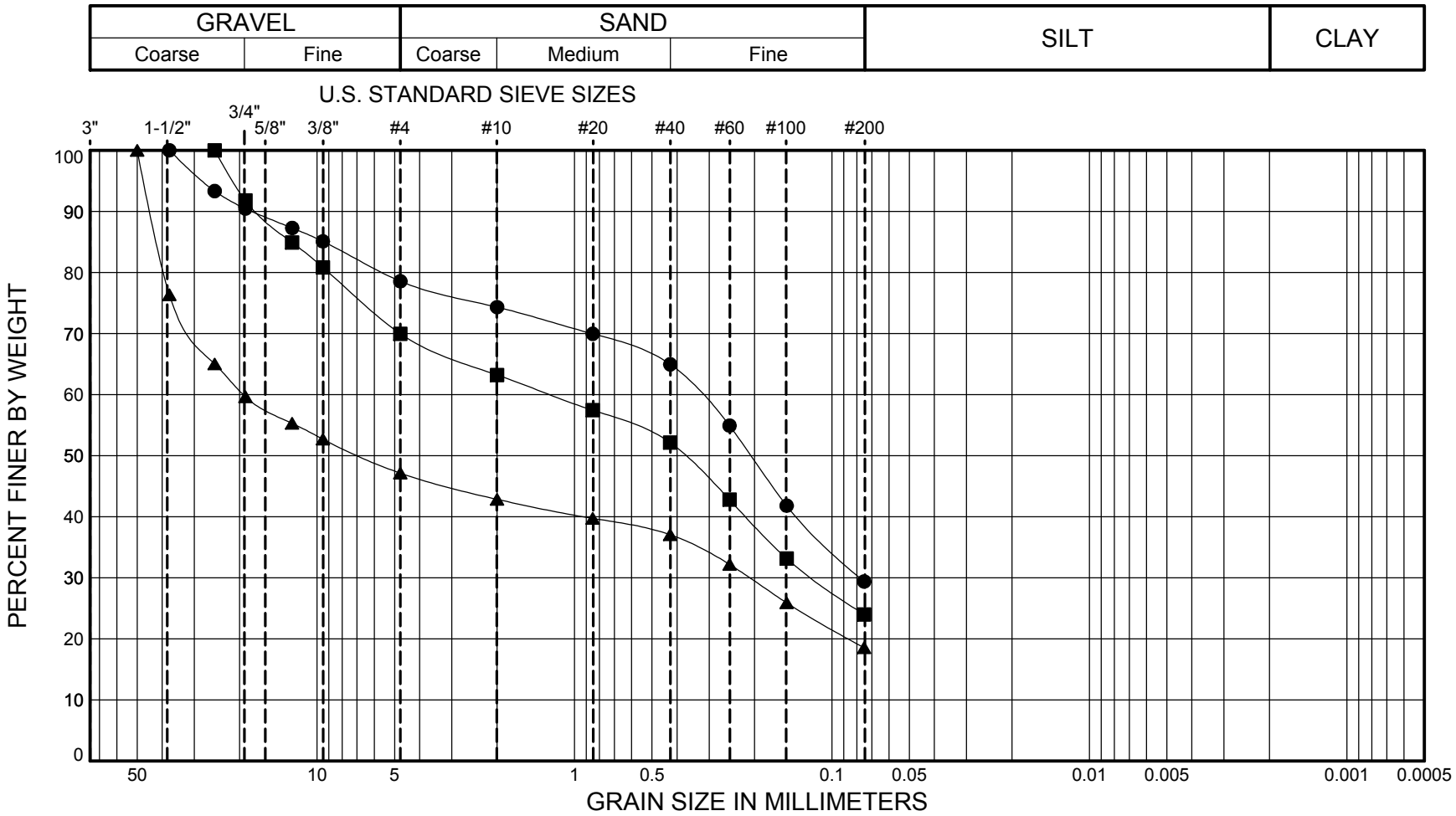
PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2017-039-21 FIGURE: B-4



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	TP-22	S-2	4.0 - 4.5	(SM) Light olive-brown, silty SAND with gravel	9				21.4	49.2	29.4
■	TP-23	S-1	3.5 - 4.0	(SM) Brownish-yellow, silty SAND with gravel	8				30.0	46.0	24.0
▲	TP-26	S-1	3.0 - 3.5	(GM) Brownish-yellow, silty GRAVEL with sand	7				52.9	28.6	18.5

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24TH STREET SE PROJECT
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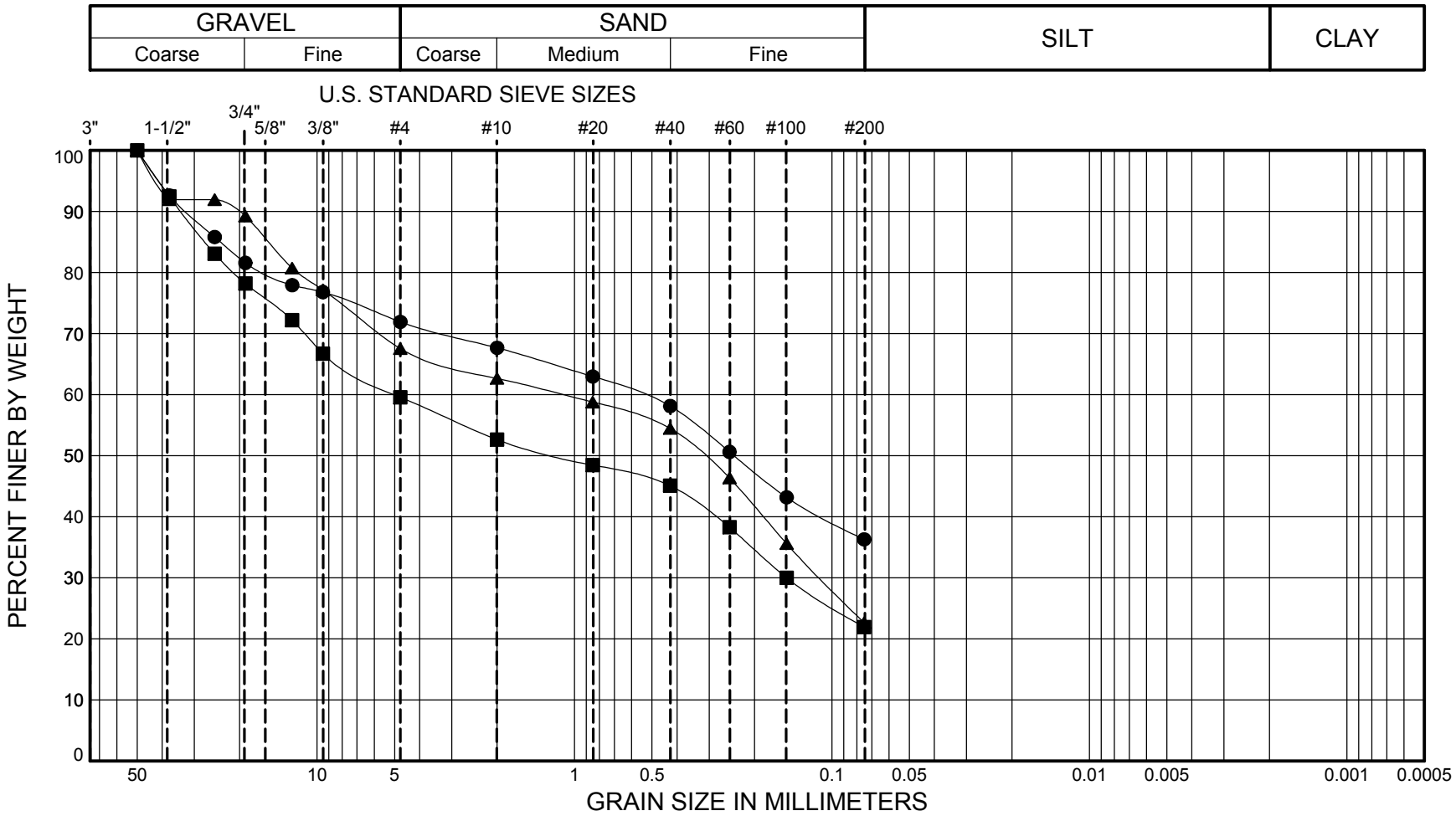
LAKE STEVENS, WASHINGTON

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2017-039-21 FIGURE: B-5



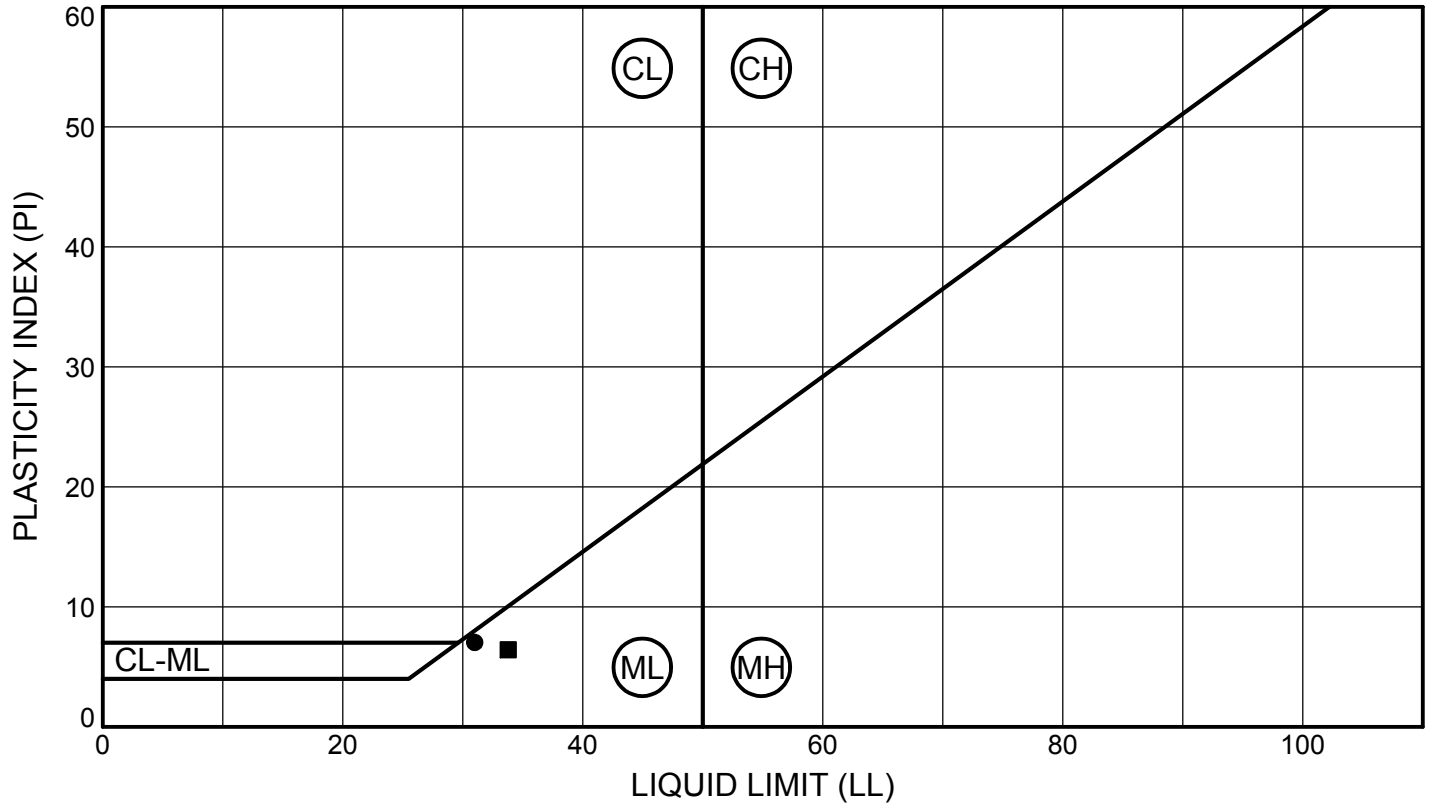
SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	TP-27	S-2	2.5 - 3.0	(SM) Light yellowish-brown, silty SAND with gravel	5				28.1	35.6	36.3
■	TP-27	S-4	7.0 - 7.5	(GM) Brownish-yellow, silty GRAVEL with sand	7				40.4	37.6	21.9
▲	TP-28	S-3	7.5 - 8.0	(SM) Grayish-brown, silty SAND with gravel	8				32.5	44.9	22.6

HWA GEOSCIENCES INC.

24TH STREET SE PROJECT
FINAL DESIGN
LAKE STEVENS, WASHINGTON

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2017-039-21 FIGURE: B-6



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION	% MC	LL	PL	PI	% Fines
●	BH-1	S-8	20.0 - 21.5	(ML) Gray, SILT	21	31	24	7	
■	BH-3	S-9	25.0 - 26.5	(ML) Gray, SILT	25	34	27	7	

HWA GEOSCIENCES INC.

24TH STREET SE PROJECT
FINAL DESIGN
LAKE STEVENS, WASHINGTON

LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS
METHOD ASTM D4318

PROJECT NO.: 2017-039-21 FIGURE: B-7

LABORATORY COMPACTION CHARACTERISTICS OF SOIL

HWA GEOSCIENCES INC.

CLIENT: *H. W. Lochner, Inc.*

PROJECT: *24th Street Final Design* **SAMPLE ID:** *Combined*

PROJECT NO: *2017-034* Sampled By: *ZN* Tested By: *DW*

Date Sampled: Date Received: *9/20/2017* Date Tested: *9/28/2017*

MATERIAL TYPE OR DESCRIPTION:
Light brown, silty SAND with gravel (SM)

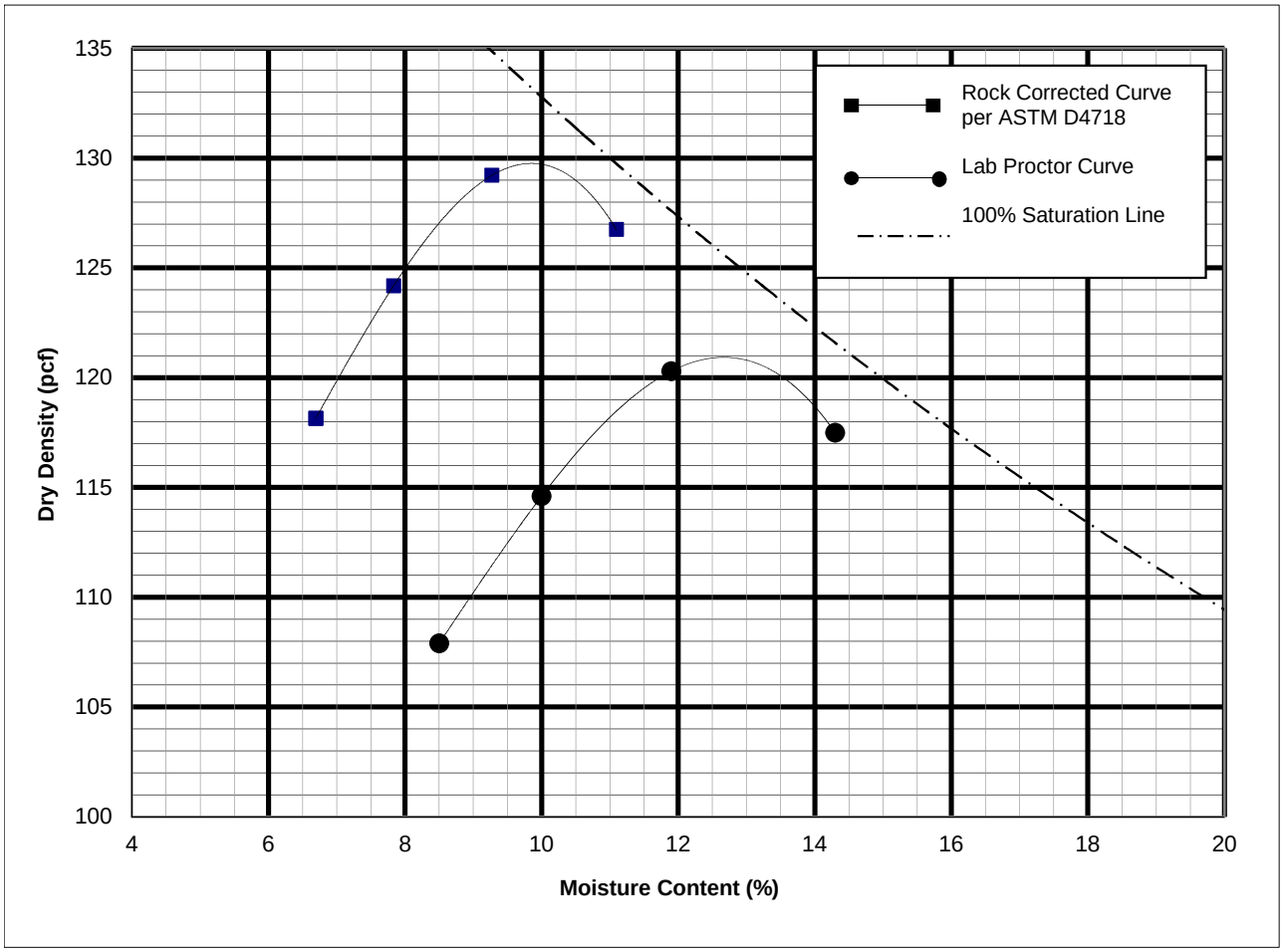
MATERIAL SOURCE, SAMPLE LOCATION AND DEPTH:
Combination of test pit samples from 0-3 feet.

Designation: [ ] ASTM D 698 [X] ASTM D 1557 Natural Moisture Content: *10* %

Method: [ ] A [ ] B [X] C Oversize: *24.1* % retained on: *3/4* in.

Preparation: [ ] Dry [X] Moist Rammer: [X] Auto [ ] Manual Assumed S.G.: *2.7*

Test Data					
Dry Density (pcf)	*107.9*	*114.6*	*120.3*	*117.5*	
Moisture Content (%)	*8.5*	*10.0*	*11.9*	*14.3*	



Data Summary*	
Percent Oversize	***24.1%***
Max. Dry Density (pcf)*	***129.8***
Optimum Moisture (%)*	***9.9***

Test Values At Other Oversize Percentages						
0.0%	5.0%	10.0%	15.0%	20.0%	25.0%	30.0%
121.0	*122.7*	*124.5*	*126.3*	*128.2*	*130.2*	*132.2*
12.7	*12.1*	*11.5*	*10.9*	*10.4*	*9.8*	*9.2*

* values corrected for oversize material per ASTM D4718, using assumed Specific Gravity shown and oversize moisture content of 1%

Reviewed By: *Steve Greene* **FIGURE** *B-8*

This report applies only to the items tested, and may be reproduced in full, with written approval of HWA GEOSCIENCES INC.

APPENDIX C

FIELD EXPLORATIONS FROM PREVIOUS HWA REPORT FOR 24TH STREET SE

DRAFT

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALUE

COHESIONLESS SOILS			COHESIVE SOILS		
Density	N (blows/ft)	Approximate Relative Density(%)	Consistency	N (blows/ft)	Approximate Undrained Shear Strength (psf)
Very Loose	0 to 4	0 - 15	Very Soft	0 to 2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Medium Dense	10 to 30	35 - 65	Medium Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	over 50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	over 30	>4000

USCS SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP DESCRIPTIONS	
Coarse Grained Soils	Gravel and Gravelly Soils	Clean Gravel (little or no fines)	GW	Well-graded GRAVEL
			GP	Poorly-graded GRAVEL
	More than 50% of Coarse Fraction Retained on No. 4 Sieve	Gravel with Fines (appreciable amount of fines)	GM	Silty GRAVEL
			GC	Clayey GRAVEL
	Sand and Sandy Soils	Clean Sand (little or no fines)	SW	Well-graded SAND
More than 50% Retained on No. 200 Sieve Size			SP	Poorly-graded SAND
	50% or More of Coarse Fraction Passing No. 4 Sieve	Sand with Fines (appreciable amount of fines)	SM	Silty SAND
			SC	Clayey SAND
Fine Grained Soils	Silt and Clay	Liquid Limit Less than 50%	ML	SILT
			CL	Lean CLAY
			OL	Organic SILT/Organic CLAY
50% or More Passing No. 200 Sieve Size	Silt and Clay	Liquid Limit 50% or More	MH	Elastic SILT
			CH	Fat CLAY
			OH	Organic SILT/Organic CLAY
Highly Organic Soils			PT	PEAT

TEST SYMBOLS

%F	Percent Fines
AL	Atterberg Limits: PL = Plastic Limit, LL = Liquid Limit
CBR	California Bearing Ratio
CN	Consolidation
DD	Dry Density (pcf)
DS	Direct Shear
GS	Grain Size Distribution
K	Permeability
MD	Moisture/Density Relationship (Proctor)
MR	Resilient Modulus
PID	Photoionization Device Reading
PP	Pocket Penetrometer Approx. Compressive Strength (tsf)
SG	Specific Gravity
TC	Triaxial Compression
TV	Torvane Approx. Shear Strength (tsf)
UC	Unconfined Compression

SAMPLE TYPE SYMBOLS

- 2.0" OD Split Spoon (SPT) (140 lb. hammer with 30 in. drop)
- Shelby Tube
- 3-1/4" OD Split Spoon with Brass Rings
- Small Bag Sample
- Large Bag (Bulk) Sample
- Core Run
- Non-standard Penetration Test (3.0" OD split spoon)

GROUNDWATER SYMBOLS

- Groundwater Level (measured at time of drilling)
- Groundwater Level (measured in well or open hole after water level stabilized)

COMPONENT DEFINITIONS

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
Gravel	3 in to No 4 (4.5mm)
Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No 4 (4.5mm)
Sand	No. 4 (4.5 mm) to No. 200 (0.074 mm)
Coarse sand	No. 4 (4.5 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.074mm)

COMPONENT PROPORTIONS

PROPORTION RANGE	DESCRIPTIVE TERMS
< 5%	Clean
5 - 12%	Slightly (Clayey, Silty, Sandy)
12 - 30%	Clayey, Silty, Sandy, Gravelly
30 - 50%	Very (Clayey, Silty, Sandy, Gravelly)
Components are arranged in order of increasing quantities.	

NOTES: Soil classifications presented on exploration logs are based on visual and laboratory observation. Soil descriptions are presented in the following general order:

Density/consistency, color, modifier (if any) GROUP NAME, additions to group name (if any), moisture content. Proportion, gradation, and angularity of constituents, additional comments. (GEOLOGIC INTERPRETATION)

Please refer to the discussion in the report text as well as the exploration logs for a more complete description of subsurface conditions.

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.

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LEGEND OF TERMS AND SYMBOLS USED ON EXPLORATION LOGS

PROJECT NO.: 2015-098-21 FIGURE: C-1

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: W end of alignment
DATE COMPLETED: 10/12/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE / SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff & Topsoil.			
		SM	Loose, light yellow brown, gravelly, silty, SAND, dry. Abundant roots to 1.5 feet. **(WEATHERED DRIFT)**	S-1		
2		SM	Medium dense, light yellow brown, gravelly, silty, SAND, dry. Non-plastic.	S-2		
4		SM	Dense, olive gray, slightly gravelly, silty, fine to medium SAND, dry.	S-3		
		SM	Very dense, gray, silty, gravelly, fine to medium SAND, moist. Scattered cobbles. Diamicton. **(GLACIAL TILL)**	S-4		
6						
8			Test pit terminated at 7 feet. No ground water seepage. Minor caving from 0.5 to 2.5 feet.			
10						
12						
14						

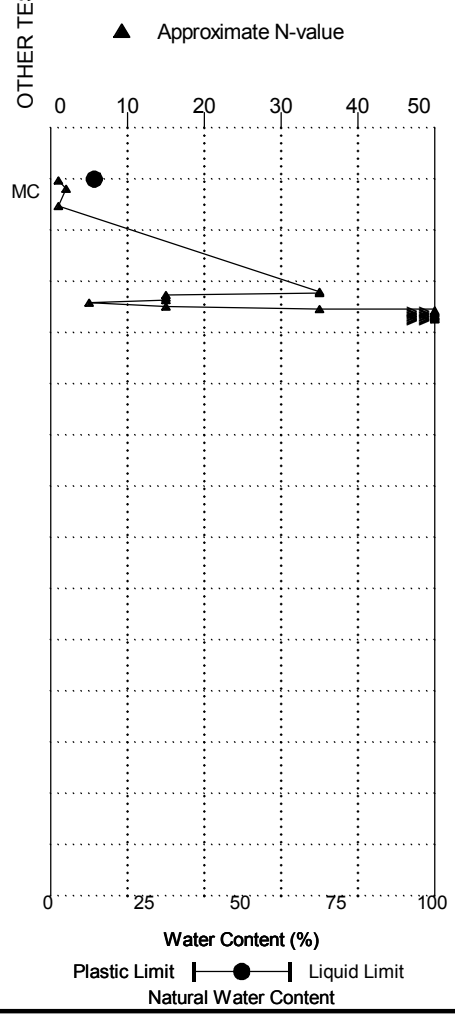


PHOTO OF TEST PIT

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 1

PROJECT NO.: 2015-098 FIGURE: C-2

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: 2nd TP from W end, on ridge
DATE COMPLETED: 10/12/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil. Abundant rootlets. Scattered roots to 4.5 feet.				
1		GM	Loose, dark yellow brown, slightly sandy, silty, fine to coarse GRAVEL, dry. Non-plastic. **(WEATHERED DRIFT)**		S-1		GS
2		GM	Medium dense, yellow brown, slightly sandy to sandy, very silty, fine to coarse GRAVEL, dry. Abundant cobbles.		S-2		
3		GP GM	Dense, olive gray, clean to slightly silty, fine to coarse sandy, fine to coarse GRAVEL, dry.				
4		SM	**(RECESSIONAL OUTWASH)**				
5			Very dense, gray, fine to coarse gravelly, silty, fine to medium SAND, dry grading to damp. Diamicton. Boulder at 6 feet. **(GLACIAL TILL)**		S-3		
8					S-4		
9			Test pit terminated at 9 feet. No ground water seepage. Minor caving from 3 to 4.5 feet.				
10							
12							
14							

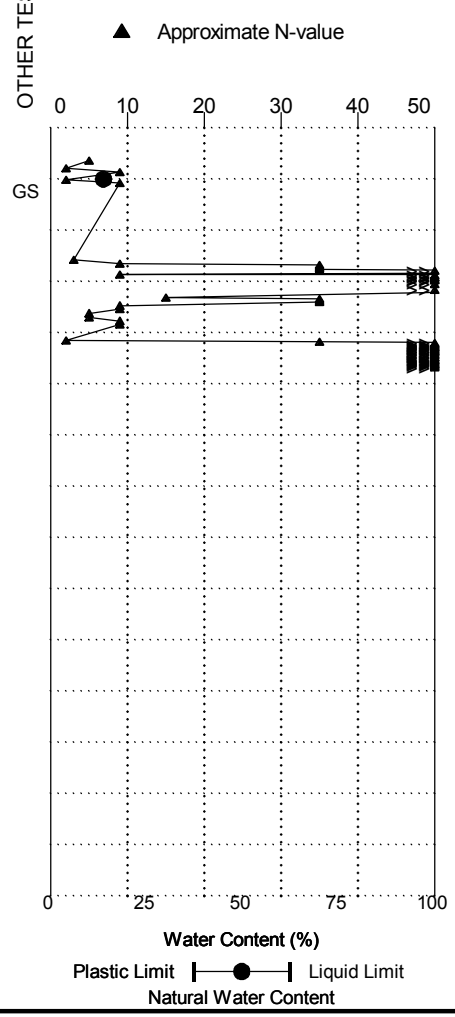


PHOTO OF TEST PIT

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HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 2

PROJECT NO.: 2015-098 FIGURE: C-3

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: W side of low area E of TP-2 ridge
DATE COMPLETED: 10/12/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil.				
		SM	Loose grading to medium dense, reddish brown, gravelly, silty, fine to medium SAND, moist.		S-1		
2		GM	**(WEATHERED DRIFT)**				
		SM	Dense, rust-mottled light gray, silty, fine to medium sandy, GRAVEL,damp.		S-2	GS	
4			Very dense, gray, gravelly, silty, fine to medium SAND, moist. Diamicton. **(GLACIAL TILL)**		S-3		
6		SM	Very hard digging below 5.5 feet; scraping with bucket teeth.		S-4		
8			Test pit terminated at 7 feet. No ground water seepage. No caving.				
10							
12							
14							

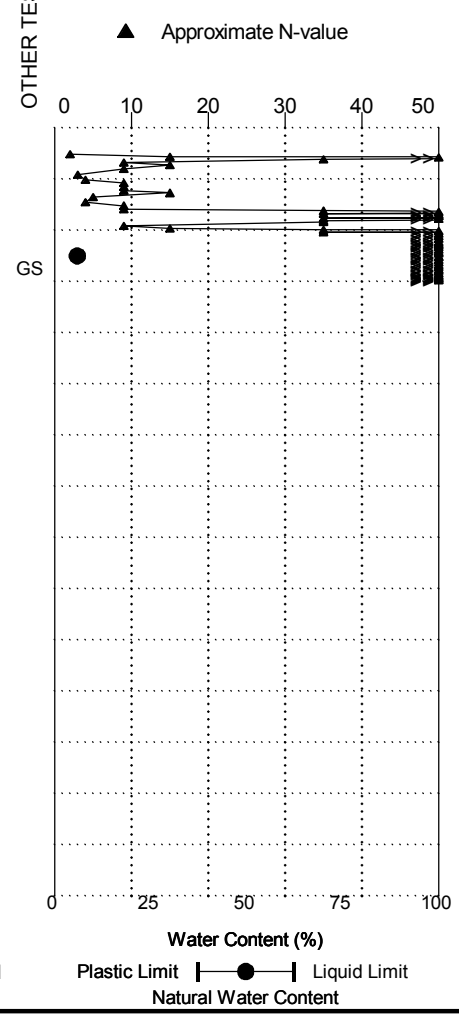

PHOTO OF TEST PIT

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HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 3

PROJECT NO.: 2015-098 FIGURE: C-4

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: East side of low area E of TP-2 ridge
DATE COMPLETED: 10/12/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil.				
		GM	Loose grading to medium dense, slightly sandy, silty, GRAVEL, damp. Abundant roots to approx. 1.5 feet. **(WEATHERED DRIFT)**		S-1		
2		GP GM	Dense grading to very dense, dark olive gray, slightly silty, fine to coarse sandy, fine to coarse GRAVEL, damp. **(RECESSIONAL OUTWASH)**		S-2		
4		SM	Very dense, gray, gravelly, very silty, fine to medium SAND, damp grading to moist. Scattered cobbles. Diamicton. **(GLACIAL TILL)**		S-3		
6					S-4		
8			Test pit terminated at 7 feet. No ground water seepage. No caving.				
10							
12							
14							

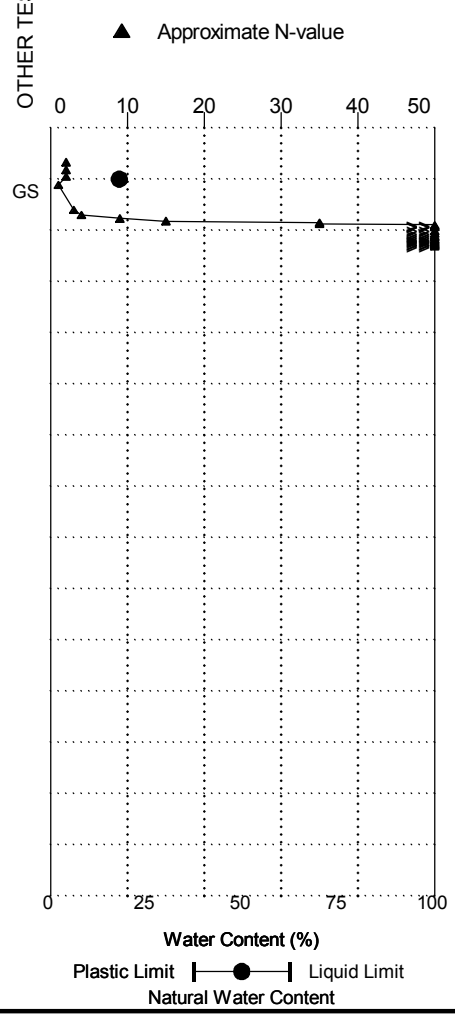

PHOTO OF TEST PIT

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HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 4

PROJECT NO.: 2015-098 FIGURE: C-5

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: On a ridge
DATE COMPLETED: 10/12/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil. Depth varies from 0.5 to 1.5 feet.				
		SM	Loose grading to medium dense, brown grading to yellow brown, gravelly, silty, fine to mediumSAND, moist.		S-1		MC
2		GM	Abundant roots to 1.5 feet. **(WEATHERED DRIFT)**		S-2		GS
4			Dense, rust-mottled light gray, silty, fine to medium sandy, GRAVEL, damp. Scattered cobbles. Diamicton. **(GLACIAL TILL)** Grades to very dense and olive brown with some rust mottling. Not difficult to dig.				
6					S-3		
8							
10			Test pit terminated at 8.5 feet. No ground water seepage. No caving.				
12							
14							

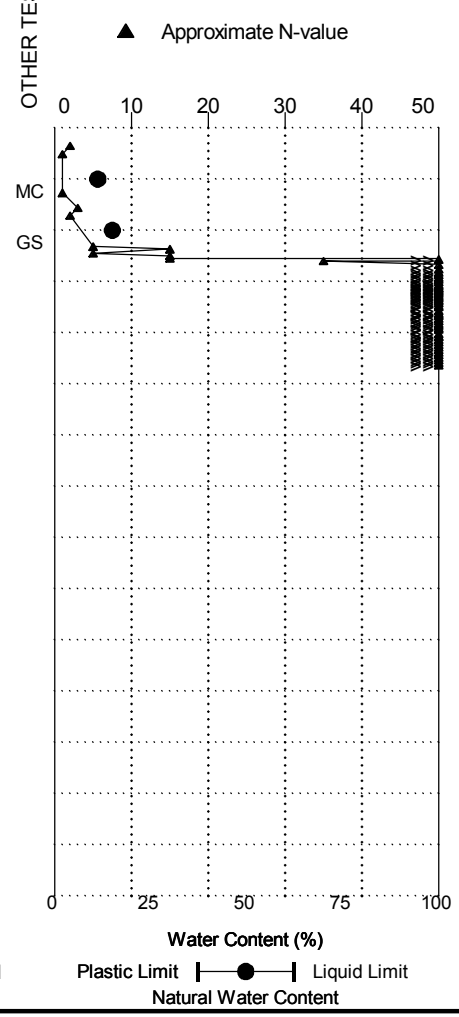

PHOTO OF TEST PIT

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 5

PROJECT NO.: 2015-098 FIGURE: C-6

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: On a ridge
DATE COMPLETED: 10/12/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil.				
		ML SM	Loose, reddish brown, slightly gravelly, sandy SILT, damp. Roots to 1.5 feet. **(WEATHERED DRIFT)**		S-1		MC
2		SM	Dense, rust-mottled light gray, gravelly, very silty, fine to medium SAND, moist. Scattered cobbles. Diamicton. **(GLACIAL TILL)**		S-2		
4			Becomes very dense and olive brown with minor rust mottling. Harder digging.		S-3		GS
6							
8					S-4		
10			Test pit terminated at 8 feet. No ground water seepage. No caving.				
12							
14							

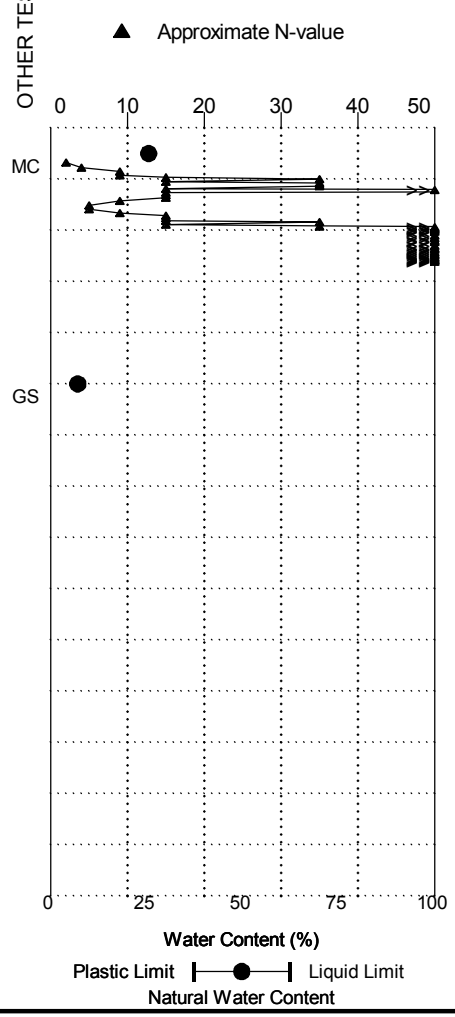

PHOTO OF TEST PIT

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HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 6

PROJECT NO.: 2015-098 FIGURE: C-7

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: Ridge, just W of western wetland
DATE COMPLETED: 10/13/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE / SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil. Abundant roots.			
		SM	Loose, yellow brown, slightly gravelly, very silty, fine to medium SAND, dry. Scattered cobbles. Abundant roots to 2.5 feet. **(WEATHERED DRIFT)**	S-1, S-2	GS	
2		SM	Medium dense grading to dense, olive gray with olive brown, gravelly, very silty, fine to medium SAND, moist.			
4		SM	Dense grading to very dense, gray, gravelly, silty, fine to coarse SAND, moist. Diamicton. **(GLACIAL TILL)**	S-3		
6			More gravelly from 7 to 7.5 feet.	S-4		
8			Test pit terminated at 8 feet. No ground water seepage. No caving.			
10						
12						
14						

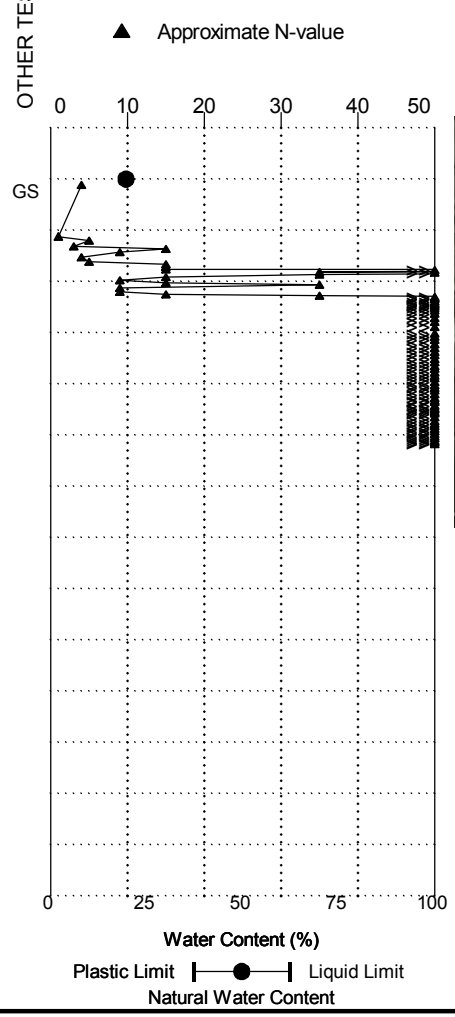

PHOTO OF TEST PIT

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 7

PROJECT NO.: 2015-098 FIGURE: C-8

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: W side of western wetland
DATE COMPLETED: 10/13/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0		PT	Very soft, dark brown, PEAT, wet. Scattered partly decomposed wood. **(PEAT)**		S-1		
2		PT	Becomes brown.		S-2		
4		ML	Loose grading to medium dense, gray, sandy SILT grading to silty, fine to medium SAND, wet.		S-3		
		SM	**(RECESSIONAL OUTWASH)**		S-4		
6		SM SP	Dense, rust-mottled olive brown, silty, fine to medium SAND, moist.				
8			Medium dense, rust-mottled olive brown, clean, gravelly, fine to medium SAND, wet. Lens of sandy GRAVEL at 6 to 6.5 feet.				
10			Test pit terminated at 9 feet. Minor ground water seepage at 4.5 feet; heavy below 5.5 feet. Heavy caving, from 5 to 9 feet.				
12							
14							

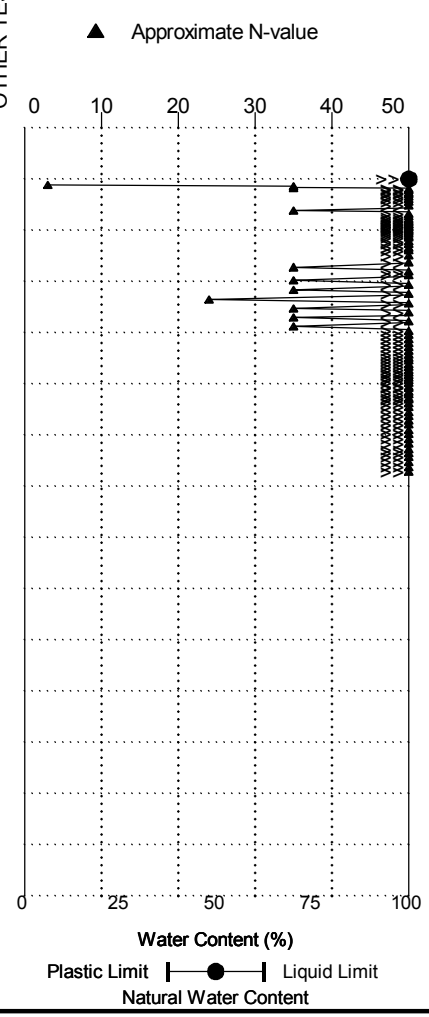

PHOTO OF TEST PIT

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 8

PROJECT NO.: 2015-098 FIGURE: C-9

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: W edge of upland, E of western wetland
DATE COMPLETED: 10/13/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil.				
		SM	Loose, reddish brown grading to dark yellow-brown, silty, fine to medium SAND, moist. Scattered gravel and charcoal. Abundant roots.		S-1		
2		SM	**(WEATHERED DRIFT)**				
			Medium dense, light olive brown, silty, fine to medium SAND, moist. Scattered gravel. **(RECESSIONAL OUTWASH)**		S-2		
4					S-3		
6		GW GM	Medium dense grading to dense, olive gray with rust mottling, slightly silty, sandy, fine to coarse GRAVEL, wet. Abundant cobbles.		S-4		
8							
10			Test pit terminated at 8 feet. Moderate ground water seepage at 5 feet. Moderate caving, 5 to 8 feet.				
12							
14							

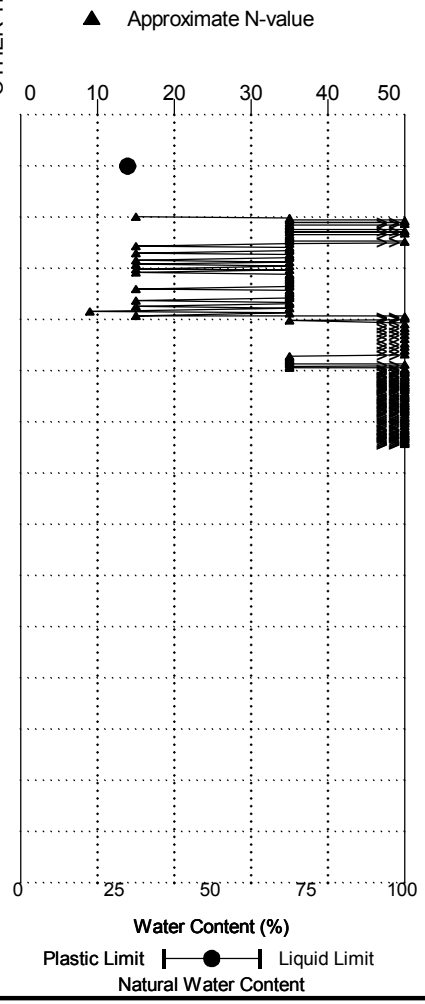

PHOTO OF TESTPIT

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP- 9

PROJECT NO.: 2015-098 FIGURE: C-10

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: Upland; 50 ft E of TP-9
DATE COMPLETED: 10/13/15
LOGGED BY: B. Thurber

DEPTH (feet)	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE / SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0	SM	Loose, brown, slightly gravelly, silty, fine to medium SAND, moist. Scattered roots. **(FILL)**	S-1		
	GM	Charcoal layer up to 3 inches thick, over:	S-2		
2	SM	Medium dense, light gray, silty, fine to medium sandy, fine GRAVEL, moist. **(RECESSIONAL OUTWASH, scorched by fire)**	S-3	GS	
4		Medium dense grading to dense, light olive brown, silty, fine gravelly, fine to medium SAND, moist.			
	GM	**(RECESSIONAL OUTWASH)** Medium dense to dense, dark brown, silty, sandy, fine GRAVEL, moist. Non-organic.	S-4		
6	SP	Medium dense to dense, brown, clean, fine to medium SAND, moist.	S-5		
8		Test pit terminated at 8.5 feet. Moderate ground water seepage at 8.3 feet. No caving.			
10					
12					
14					

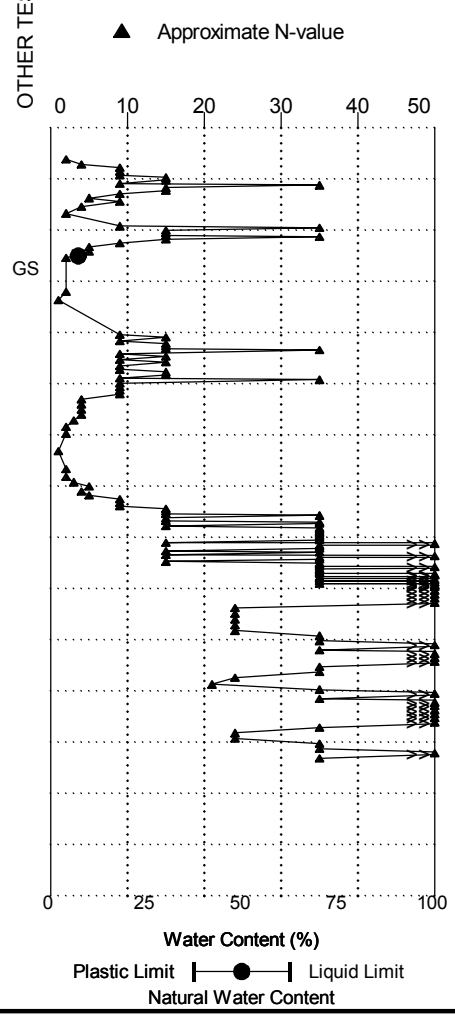

PHOTO OF TEST PIT

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP-10

PROJECT NO.: 2015-098 FIGURE: C-11

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: Wetland W of house
DATE COMPLETED: 10/13/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE / SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0		PT	Very soft, dark brown, PEAT, moist. Scattered partly decomposed wood. **(PEAT)**			
2		SM	Loose grading to medium dense, olive gray and olive brown, silty, fine to coarse gravelly, fine to medium SAND, moist. Scattered cobbles. **(RECESSIONAL OUTWASH)**	S-1		
4						
		GW	Medium dense, clean, fine to coarse sandy, fine to coarse GRAVEL, wet. Water bearing.	S-2		
6		SM	Medium dense, gray, silty, gravelly, fine to medium SAND, wet.			
		SP SM	Medium dense, olive brown, clean to slightly silty, fine to medium SAND, wet. Slightly gravelly below approx. 7 feet.	S-3		
8						
10						
12						
14						

Test pit terminated at 8.5 feet.
Moderate ground water seepage at 5.2 feet, east end.
Minor ground water seepage at 3.5 feet, west end.
Heavy caving from 2.5 to 7 feet.

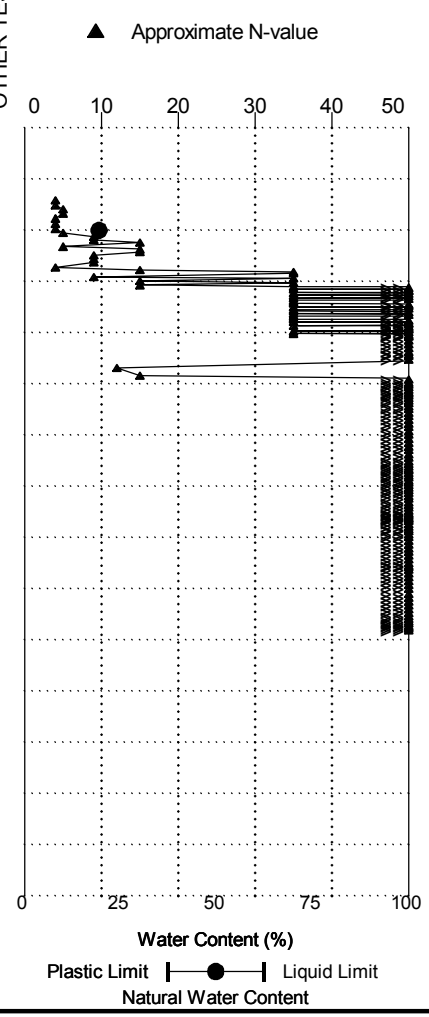

PHOTO OF TEST PIT

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HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP-11

PROJECT NO.: 2015-098 FIGURE: C-12

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: W edge of rise by house
DATE COMPLETED: 10/13/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0		GM	Loose, brown, silty, fine to medium sandy, GRAVEL, damp. Scattered roots. **(FILL)**		S-1		GS
2		GM	Becomes yellow brown, dry.				
4		SM	Loose, brown, silty, gravelly, fine to medium SAND, dry, with Garbage: Steel, glass and glass bottles, sheet metal, tire. **(FILL with REFUSE)**				
		PT	Charcoal layers over Soft, dark brown, PEAT, wet. **(PEAT)**		S-2		
6		SM	Medium dense to dense, gray and olive gray, clayey, silty, fine to coarse gravelly, fine to medium SAND, wet. **(RECESSIONAL OUTWASH)**		S-3		
8					S-4		
10			Test pit terminated at 9 feet. Minor ground water seepage at 6 feet. Moderate caving from 4.5 to 6 feet.				
12							
14							

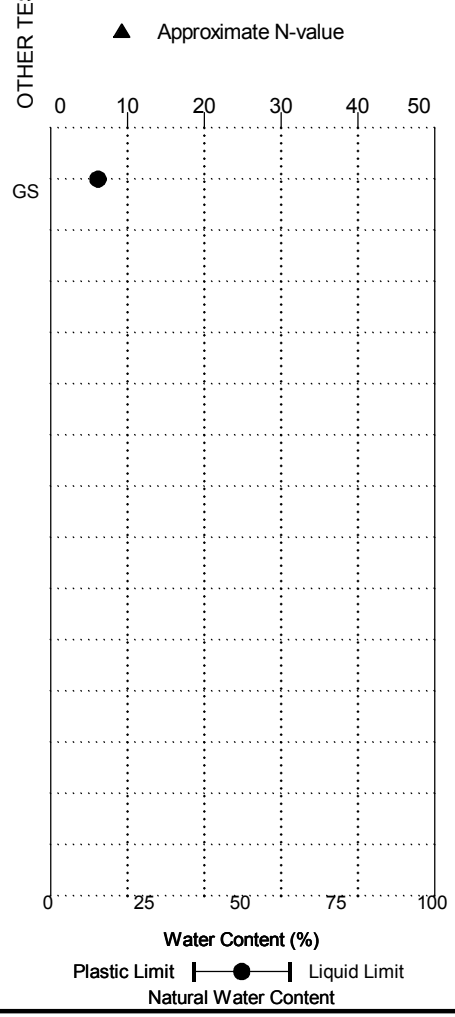

PHOTO OF TEST PIT

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HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP-12

PROJECT NO.: 2015-098 FIGURE: C-13

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: N of driveway, edge of upland
DATE COMPLETED: 10/14/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil.				
		CL	Stiff, brown, silty CLAY, moist. Scattered gravel.		S-1		AL
2		CL	Very stiff, rust-mottled olive gray, silty CLAY, moist. Scattered gravel.		S-2 S-3		
4		GM	Dense, light brown, silty, sandy, fine to coarse GRAVEL, wet.				
		GM	**(RECESSIONAL OUTWASH)** Becomes olive brown, and slightly silty to clean.				
6							
8					S-4		
10							
12							
14							

Test pit terminated at 8 feet.
Heavy ground water seepage below 2 feet.
Moderate caving within gravel while digging.
Heavy caving when to 6 feet, surface to 6 feet.

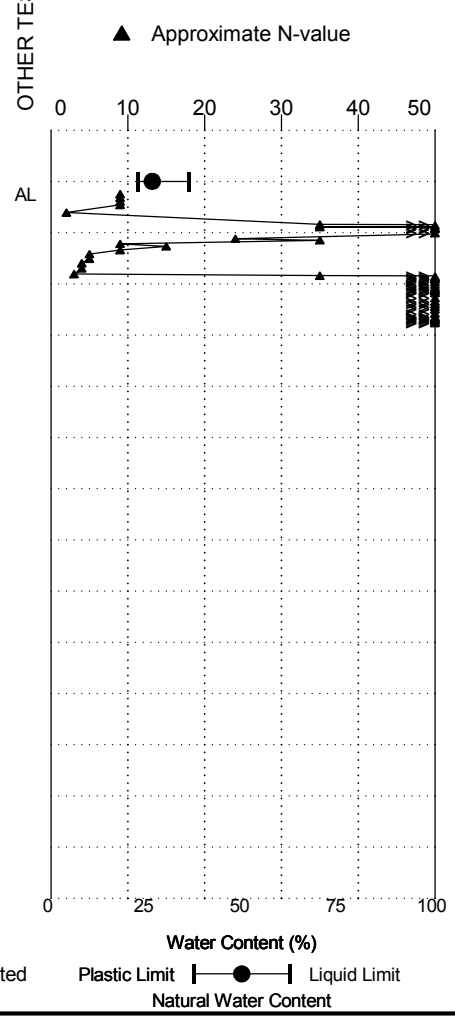

PHOTO OF EAST SIDE OF PIT

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP-14

PAGE: 1 of 1

PROJECT NO.: 2015-098 FIGURE: C-14

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: N of driveway, edge of upland
DATE COMPLETED: 10/14/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose Duff and Topsoil.				
		CL	Stiff, brown, clayey SILT, moist. Scattered gravel.		S-1		AL
2		ML	Very stiff, rust-mottled olive gray, clayey SILT, moist. Scattered gravel.		S-2		
		CL			S-3		
		ML					
4		GM	Dense, light brown, silty, sandy, fine to coarse GRAVEL, wet. **(RECESSIONAL OUTWASH)**				
		GM	Becomes olive brown, and slightly silty to clean.				
6							
8					S-4		
10							
12							
14							

Test pit terminated at 8 feet.
Heavy ground water seepage below 2 feet.
Moderate caving within gravel while digging.
Heavy caving when to 6 feet, surface to 6 feet.

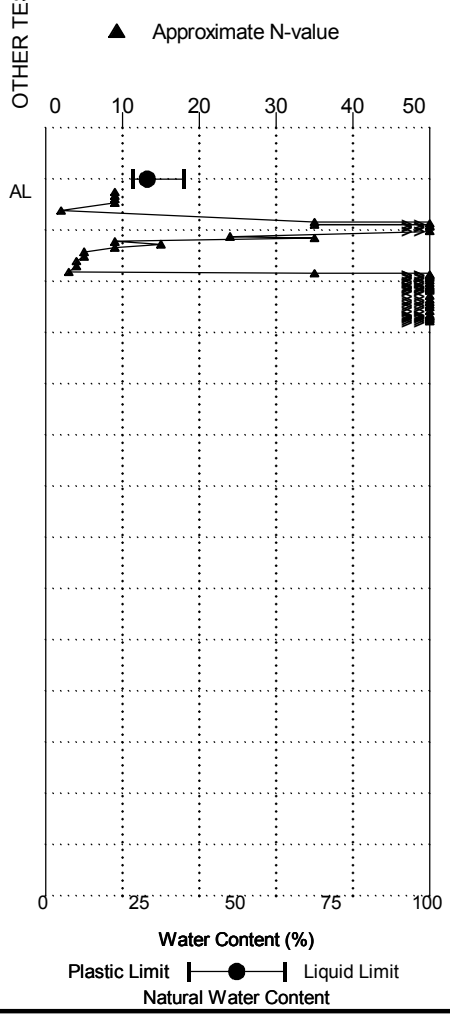

PHOTO OF TEST PIT

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HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP-14

PROJECT NO.: 2015-098 FIGURE: C-15

EXCAVATION COMPANY: City of Lake Stevens
EXCAVATING EQUIPMENT: Yanmar ViC55 trackhoe
SURFACE ELEVATION: ± Feet

LOCATION: E end of alignment, nearS Lk Stevens R
DATE COMPLETED: 10/14/15
LOGGED BY: B. Thurber

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	OTHER TESTS
0			Loose, dark brown, slightly organic, gravelly, silty SAND, moist. Scattered roots. **(TOPSOIL)**				
1		SW SM	Loose grading to medium dense, reddish brown grading to rust-mottled yellow brown, slightly silty, fine to medium SAND, moist. Scattered gravel. **(WEATHERED DRIFT)**		S-1		GS
2		SM			S-2		
4		GW GM	Medium dense to dense, rust-mottled yellow brown and olive gray, slightly silty, fine to coarse gravelly, fine to medium SAND, moist. Scattered cobbles. **(RECESSIONAL OUTWASH)**		S-3		
6		SP	Medium dense to dense, slightly silty, sandy, fine to coarse GRAVEL, moist. Scattered cobbles. Medium dense, olive gray, clean, fine to medium SAND, wet.		S-4		
8		GW	Dense, olive brown, clean, fine to coarse sandy, fine to coarse GRAVEL, wet.		S-5		
10			Test pit terminated at 9 feet. Minor ground water seepage at 5.5 feet; heavy below 7.5 feet. No caving.				
12							
14							

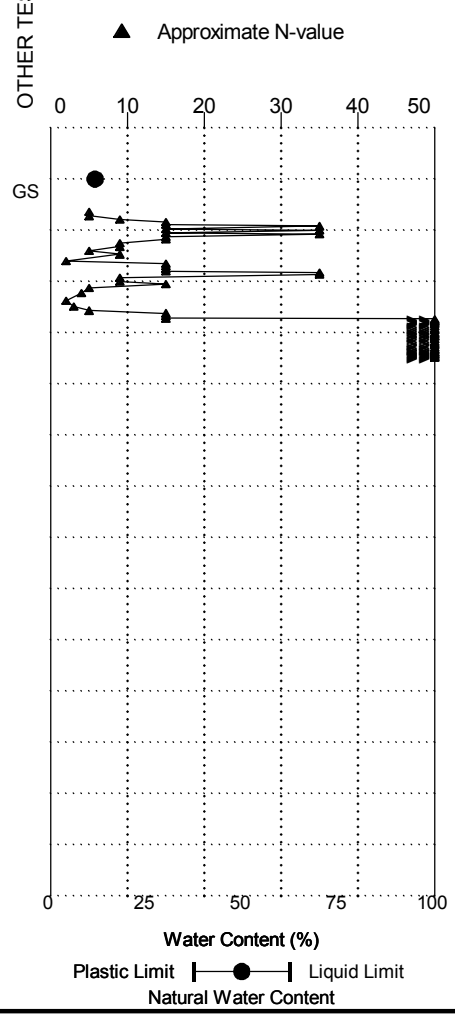

PHOTO OF TEST PIT

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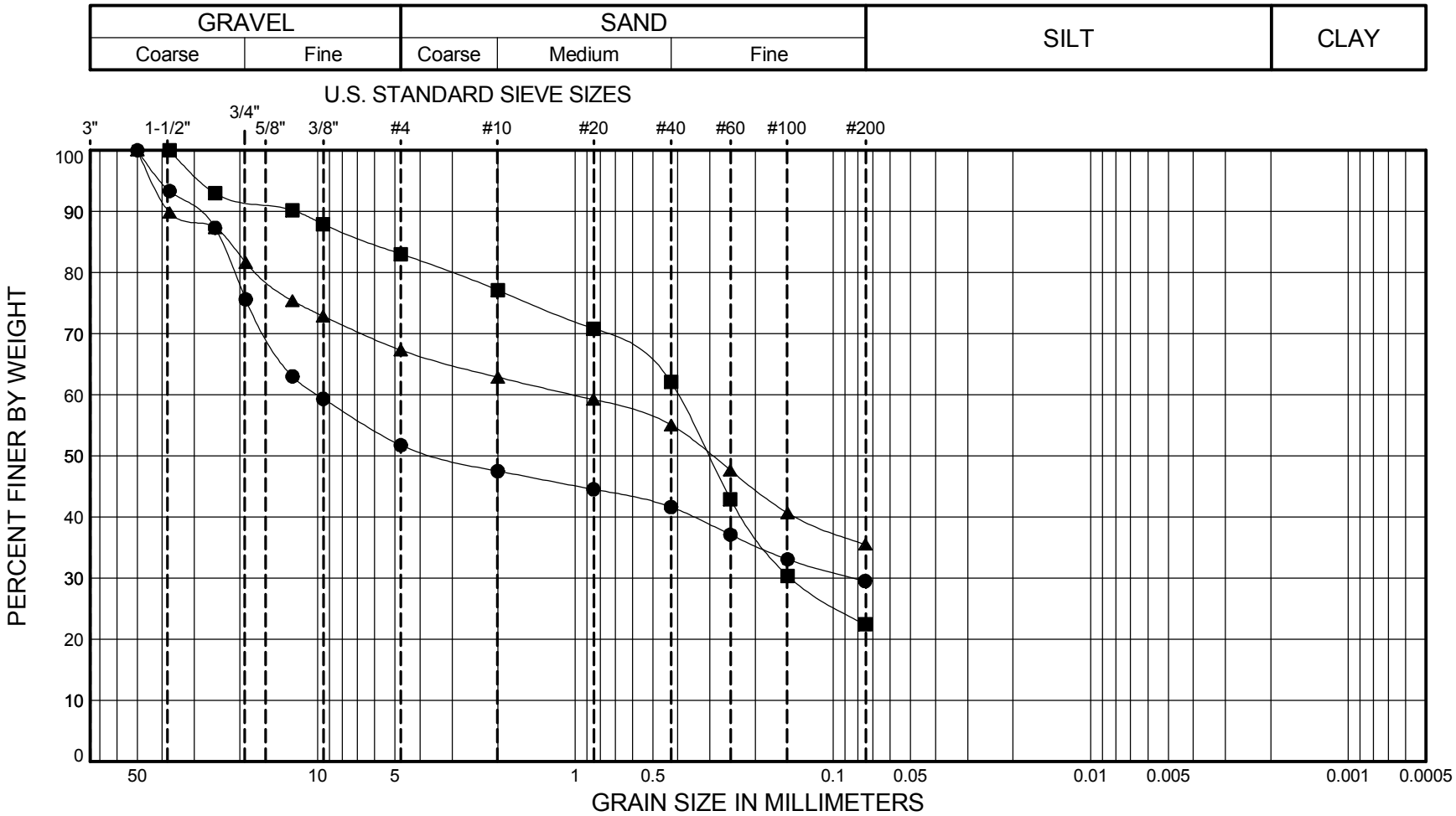
HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

LOG OF TEST PIT
TP-15

PAGE: 1 of 1

PROJECT NO.: 2015-098 FIGURE: C-16



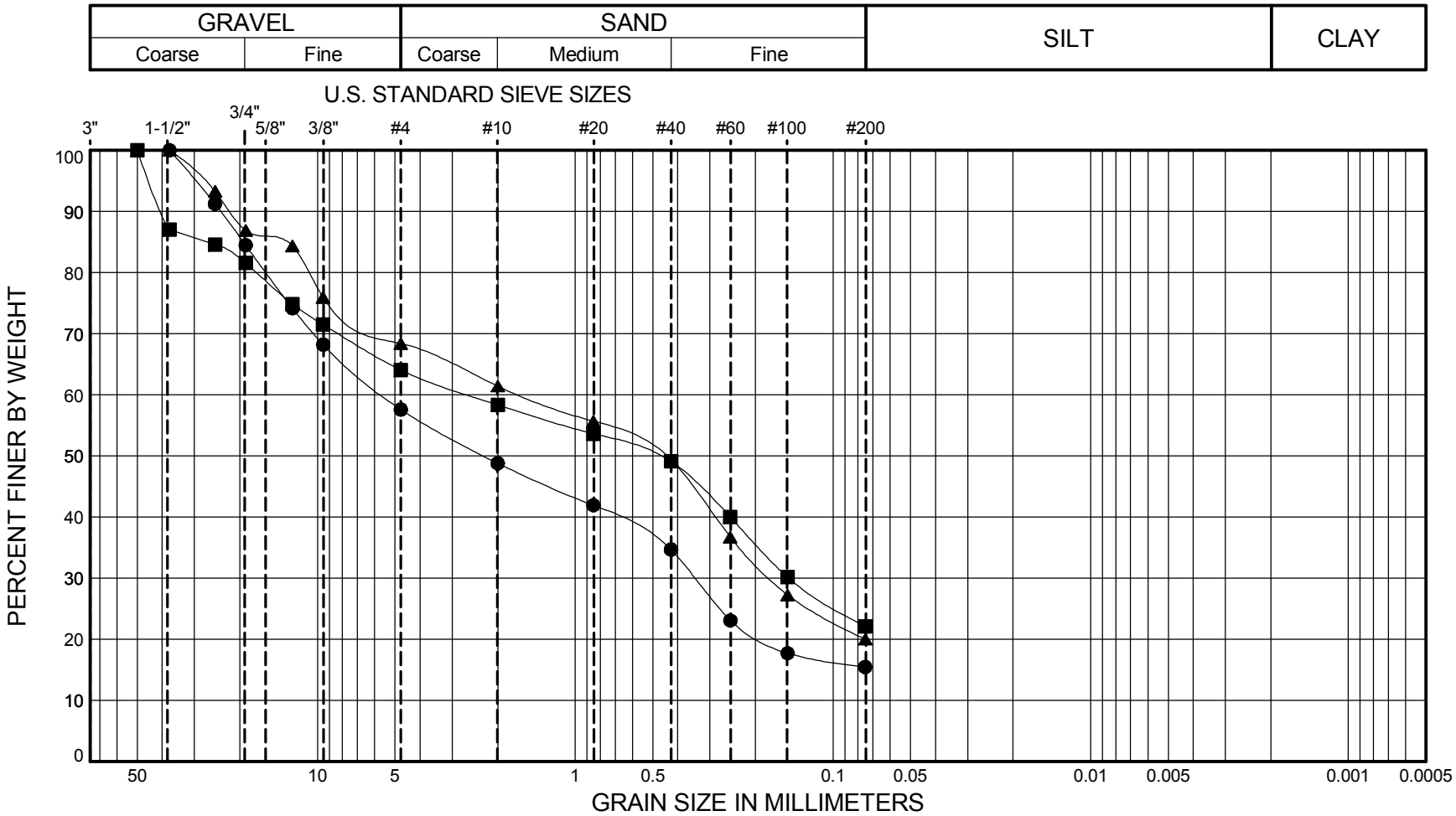
SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	TP- 2	S-1	1.0 - 1.5	(GM) Brown, silty GRAVEL with sand	14				48.3	22.2	29.5
■	TP- 3	S-2	2.5 - 3.0	(SM) Olive brown, silty SAND with gravel	6				17.0	60.6	22.4
▲	TP- 4	S-1	1.0 - 1.5	(GM) Brown, silty GRAVEL with sand	18				32.7	31.8	35.5

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2015-098 FIGURE: C-17



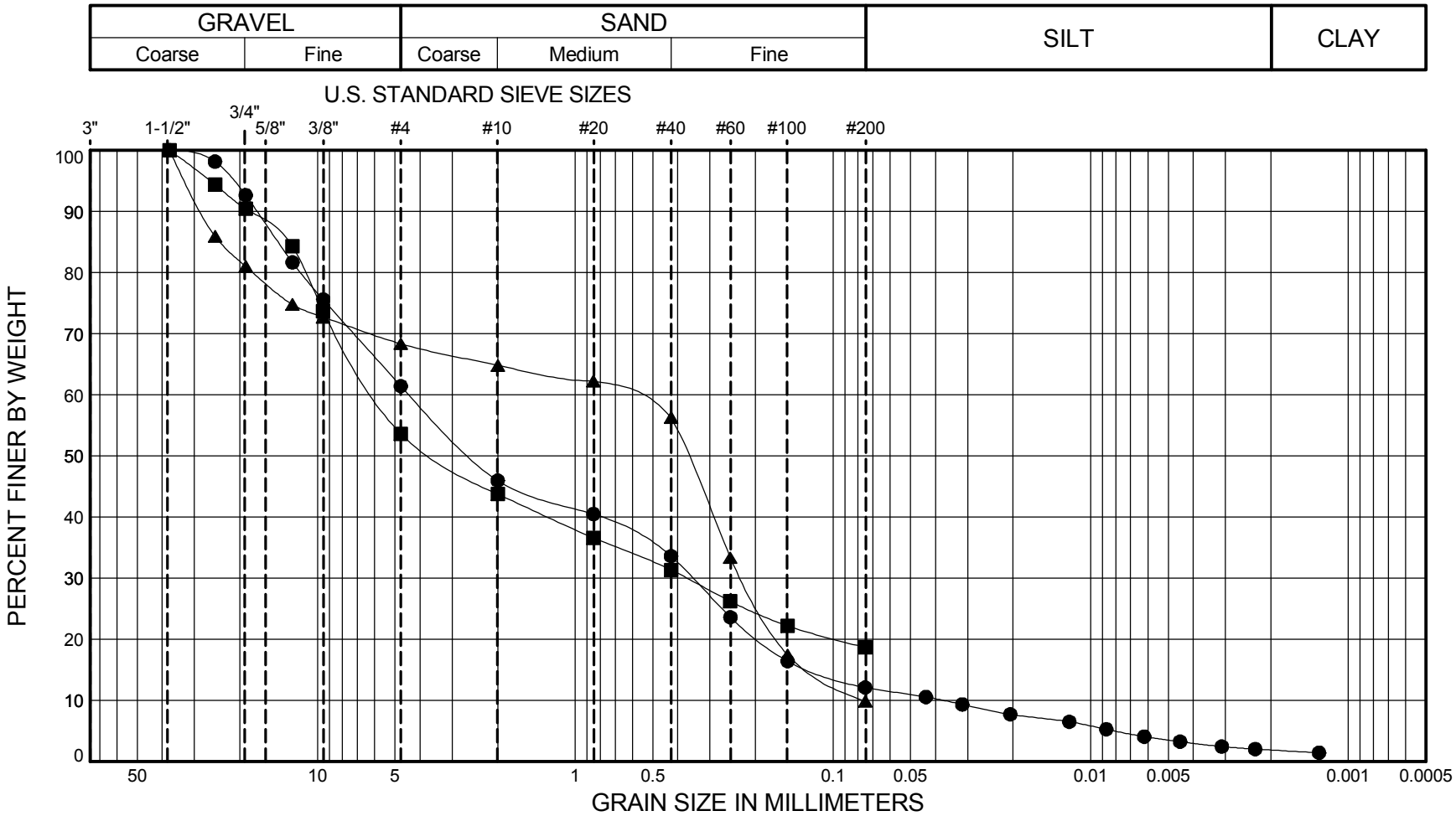
SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	TP- 5	S-2	2.0 - 3.0	(GM) Brown, silty GRAVEL with sand	15				42.4	42.1	15.4
■	TP- 6	S-3	5.0 - 5.5	(SM) Yellowish brown, silty SAND with gravel and cobbles	7				36.0	41.9	22.1
▲	TP- 7	S-1	1.0 - 1.5	(SM) Dark yellowish brown, silty SAND with gravel and cobbles	20				31.6	48.4	20.0

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2015-098 FIGURE: C-18



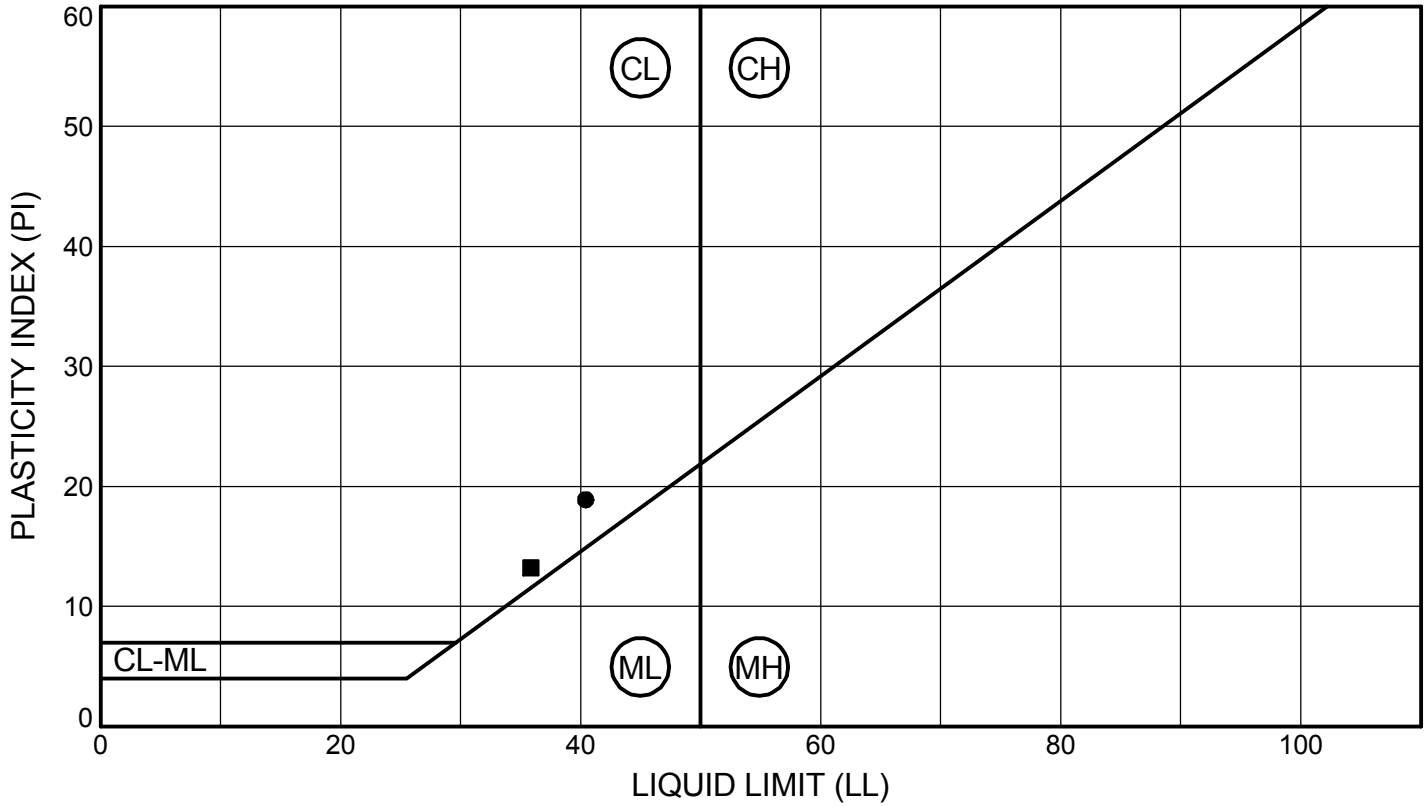
SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	TP-10	S-3	2.5 - 3.0	(SM) Olive brown, silty SAND with gravel	7				38.6	49.3	12.1
■	TP-12	S-1	1.0 - 2.0	(GM) Dark brown, silty GRAVEL with sand	12				46.4	35.0	18.7
▲	TP-15	S-1	1.0 - 1.5	(SW-SM) Dark yellowish brown, well graded SAND with silt and gravel	11				31.7	58.4	9.9

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2015-098 FIGURE: C-19



SYMBOL	SAMPLE	CLASSIFICATION	% MC	LL	PL	PI	% Fines
●	TP-13S-2	(CL) Olive gray, lean Clay	33	40	22	18	
■	TP-14S-1	(CL) Grayish brown, lean CLAY	26	36	23	13	

HWA GEOSCIENCES INC.

24th Street SE Extension
Lake Stevens, Washington

PLASTICITY CHART

PROJECT NO.: 2015-098 FIGURE: C-20