Technical Memorandum

Received by Email
06-03-2021

TO: AJ Smith, Combined Construction, Inc.
Ryan Moore, PE, Vector Engineering, Inc.

FROM: Benjamin Ford, PE

DATE: May 28, 2021

RE: **Summary of Geotechnical Engineering Services**
Combined Construction Site Development
Mukilteo, Washington
Project No. 1937001.010.011

Introduction

This memorandum summarizes the results of geotechnical engineering services provided by Landau Associates, Inc. (LAI) in support of the Combined Construction Site Development project, located at 3701 South Road in Mukilteo, Washington (site; Figure 1). Services were provided in accordance with the scope outlined in LAI's August 5, 2020 proposal.

This memorandum has been prepared with information provided by Vector Engineering, Inc. (Vector; project civil engineer) and with data collected during LAI's field exploration and laboratory testing programs.

Project Understanding

Combined Construction, Inc. (CCI; project owner) proposes to construct an 80-foot (ft) by 154-ft metal warehouse in the northwest corner of the site. Other proposed site improvements include the addition of an underground stormwater management facility, paved parking, a fuel station, and a wash rack. Retaining walls, with a maximum height of 15 ft, will be constructed along the southern, western, and northern boundaries of the site. The proposed stormwater management facility will be installed in the northeast corner of the site and will consist of an open-bottom, below-grade vault. Stormwater that does not infiltrate will be conveyed to the City of Mukilteo's (City) stormwater system.

Site Conditions

The 1.71-acre site currently is developed with a warehouse and paved/gravel hardscape. The site is bordered by Evergreen Drive to the northeast, by South Road to the south, and by commercial development to the north and west. Site topography is generally flat with 50 percent slopes along the northwestern, western, and southern site boundaries. The slopes reach a maximum height of approximately 15 ft. Existing site features are shown on Figure 2.

Geologic Conditions

Geologic information for the site and the surrounding area was obtained from the *Distribution and Description of Geologic Units in the Mukilteo Quadrangle, Washington* (Minard 1982). Surficial deposits at the site are mapped as Vashon glacial till (Qvt), a non-sorted mixture of clay, silt, sand, gravel, and cobbles. Impermeability is commonly observed in glacial till, given its high clay content and compactness. The soils observed in LAI's January 2021 explorations were consistent with the mapped geology; however, undocumented fill also was observed in the explorations.

Subsurface Explorations

Site subsurface conditions were explored on January 6, 2021 by excavating four test pits (TP-1 through TP-4) at the approximate locations shown on Figure 2. The test pit excavations extended 4 to 11 ft below ground surface (bgs).

LAI personnel monitored the field explorations, collected representative soil samples, and maintained a detailed log of the subsurface soil and groundwater conditions observed. Each representative soil type was described using the soil classification system shown on Figure 3, in general accordance with ASTM International (ASTM) standard test method D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).* Summary logs of the explorations are presented on Figures 4 and 5.

Samples were transported to LAI's soils laboratory for further examination and classification. Natural moisture content determinations were performed on select soil samples in accordance with ASTM standard test method D2216, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.* The natural moisture content is shown as W = xx (i.e., percentage of dry weight) in the "Test Data" column on Figures 4 and 5. Grain size analyses were performed in accordance with ASTM standard test method D422, *Standard Test Method for Particle-Size Analysis of Soils.* Samples selected for grain size analysis are designated with a "GS" in the "Test Data" column on Figures 4 and 5. The results of the grain size analyses are presented on Figures 6 and 7.

Soil Conditions

The soils observed underlying existing surface conditions (i.e., topsoil or grass) were categorized into two general units:

- **Fill:** Fill was observed in all four test pits and consisted of sand with variable silt, gravel, and organic content. The fill was in a loose to medium dense, moist to wet condition and extended from ground surface to a maximum depth of 5 ft bgs. The fill encountered in test pit TP-1 included significant organic content. LAI interprets the fill observed in test pit TP-1 to be stripped material from previous grading activities. Test pit TP-4 was terminated in the fill unit.

- **Glacial till:** Glacial till was observed beneath the fill in test pits TP-1, TP-2, and TP-3 and consisted of sand with variable silt and gravel content in a medium dense to very dense/hard, moist condition. Test pits TP-1, TP-2, and TP-3 were terminated in this unit. The glacial till was consistent with ablation till, a unit with variable soil density.

Groundwater Conditions

Groundwater was not observed in LAI's January 2021 explorations; however, moist to wet soil conditions, indicative of a perched groundwater layer, were observed in test pit TP-4. The groundwater conditions reported herein are for the specific locations and date indicated and may not be representative of other locations and/or times. Groundwater conditions will vary depending on local subsurface conditions, weather conditions, and other factors. Site groundwater levels are expected to fluctuate seasonally, with maximum groundwater levels occurring during late winter and early spring.

Conclusions and Recommendations

In LAI's opinion, the observed subsurface conditions will provide adequate support of shallow foundations and pavement sections, provided the following geotechnical recommendations are incorporated into the project design. The following key points should be considered when developing project plans and specifications:

- **Unsuitable foundation material:** The undocumented fill observed in test pits TP-1, TP-2, and TP-3 includes loose, organic-rich material that may not provide suitable support for structure or retaining wall foundations. The project plans and specifications should include an allowance for removal of 3 to 5 ft of undocumented fill and replacement with structural fill. If not removed from areas designated for development, undocumented fill could cause foundation cracking or premature pavement wear.

  Following stripping activities and prior to placement of structural fill, an LAI representative should visit the site to evaluate prepared subgrades and confirm sufficient removal of unsuitable foundation material.

- **Sloping ground:** Retaining walls are proposed along the western site boundary. To achieve global stability, the retaining walls should be embedded a minimum of 2 ft where sloping ground is present. This recommendation is based on the assumption that slopes are 2 horizontal to 1 vertical (2H:1V) or flatter. Global stability should be verified during final design.

- **Site soil:** Site soils noted as "SP-SM" on the test pit logs may be suitable for reuse as structural fill. These soils are moisture sensitive and contain up to 15 percent fines. The contractor should be prepared to moisture condition reused site soils and to segregate them from organic-rich fill.

- **Stormwater infiltration:** The eastern and western portions of the site are underlain by glacially consolidated till. Though infiltration may be feasible in the medium dense sand in the western portion of the site, it is not recommended, as stormwater could be carried along

impermeable soil layers, toward slope faces and ground surface. In LAI's opinion, onsite stormwater infiltration is not feasible.

Seismic Design Considerations

LAI understands that seismic design will be completed using *2018 International Building Code standards* (ICC 2017). The parameters in Table 1 can be used to compute seismic base shear forces.

Table 1. *2018 International Building Code* Seismic Design Parameters

Spectral response acceleration at short periods (S_S) = 1.381g
Spectral response acceleration at 1-second periods (S_1) = 0.493g
Site class = D
Site coefficient (F_a) = 1.0
Site coefficient (F_v) = 1.807[(a)]

(a) When using the coefficient F_v = 1.807, adhere to Exception 2 requirements for a ground motion hazard analysis. See Section 11.4.8 of the American Society of Civil Engineers' *Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE/SEI 7-16).*
F_a, F_v = acceleration (0.2-second period) and velocity (1.0-second period) site coefficients, respectively
g = force of gravity
S_s, S_1 = 0.2-second and 1.0-second period spectral accelerations, respectively

Based on the subsurface conditions observed in LAI's explorations, there is a low risk that seismically induced soil liquefaction will occur at the site. The site is located within 2,500 ft of the southern Whidbey Island fault zone. The fault may have moved within the last 15,000 years, but the risk of ground rupture due to surface faulting is low.

Foundation Support

Shallow foundations should be constructed on glacial till soil or on structural fill extending to such soil. The design parameters in Table 2 should be used in conjunction with the complete recommendations in this memorandum.

Table 2. Summary of Design Parameters for Shallow Foundations

Allowable soil bearing pressure = 2,500 psf
Friction coefficient (factored) = 0.35
Passive earth pressure = 300 pcf
Minimum foundation width = 18 inches (continuous), 24 inches (isolated)
Maximum foundation width (for settlement considerations) = 10 ft (continuous), 15 ft (isolated)

ft = feet
pcf = pounds per cubic foot
psf = pounds per square foot

When developing foundation design parameters, LAI assumed that shallow foundations would be established on medium dense to dense subgrades prepared as recommended herein. Prior to placement of structural fill, LAI should evaluate prepared subgrades to confirm that unsuitable foundation material has been removed.

The allowable soil bearing pressure in Table 2 applies to long-term dead and live loads, exclusive of the weight of the footing and any overlying backfill. The bearing pressure can be increased by one-third for transient loads, such as those induced by wind and seismic forces.

For frost protection, perimeter footings should be embedded at least 12 inches below the lowest adjacent grade, where the ground is flat. Interior footings should be embedded at least 6 inches below the nearest adjacent grade. LAI estimates that continuous and isolated foundations will settle 1 inch or less if constructed as recommended. Differential settlement between similarly loaded foundation elements is estimated to be on the order of ½ inch or less. Settlement is expected to occur as building loads are applied during construction.

An allowable coefficient of sliding resistance of 0.35, applied to vertical dead loads only, can be used to compute frictional resistance acting on the base of footings. This coefficient includes a factor of safety of 1.5 on the calculated ultimate value.

The passive resistance of properly compacted structural fill placed against the sides of foundations can be considered equivalent to a fluid with a density of 300 pounds per cubic foot (pcf). The foundation passive earth pressure has been reduced by a factor of 1.5 to limit deflections to less than 2 percent of the embedded depth. The passive earth pressure and friction components can be combined, provided the passive component does not exceed two-thirds of the total. The top foot of soil should be excluded from the calculation, unless the foundation perimeter will be covered by slab-on-grade or pavement. Passive resistance should be omitted where sloping ground is present.

Slabs-On-Grade

Slabs-on-grade should be installed on a uniformly firm, unyielding subgrade that consists of sand and/or gravel. A modulus of vertical subgrade reaction (subgrade modulus) can be used to design slabs-on-grade. The subgrade modulus will vary based on the dimensions of the slab and the magnitude of applied loads on the slab surface; slabs with larger dimensions and loads are influenced by soils to a greater depth. LAI recommends using a subgrade modulus of 200 pounds per cubic inch to design on-grade floor slabs. This subgrade modulus is for a 1-ft by 1-ft square plate and is not the overall modulus of a larger area.

Interior slabs-on-grade should include a vapor barrier and a capillary break layer, designed and installed in accordance with industry standards.

Site Drainage

Because the site is underlain by low-permeability glacial till, LAI recommends that perimeter foundation footing drains are included in the project design.

Retaining Wall Design

Cast-in-place or mechanically stabilized earth walls, up to 15 ft tall, may be used to retain soils along the southern, western, and northern site boundaries. When developing design parameters, LAI assumed level backslope conditions. Walls installed above sloping ground should include a minimum embedment depth of 2 ft. This recommendation is based on the assumption that slopes are 2H:1V or flatter. During final design, retaining walls should be evaluated for global stability. The soil parameters in Table 3 can be used to design retaining walls.

Table 3. Retaining Wall Design Parameters

Allowable soil bearing pressure = 2,500 psf
Friction coefficient (factored) = 0.35
Passive resistance (factored) = 300 pcf[(a)]
Active earth pressure = 35 pcf
At-rest earth pressure = 55 pcf
Active surcharge coefficient = 0.28
At-rest surcharge coefficient = 0.44
Seismic active earth pressure (horizontal backslope) = 13*H psf

(a) Passive resistance should not be included where sloping ground is present at the face of retaining walls.
H = height of wall
pcf = pounds per cubic foot
psf = pounds per square foot

The nature and density of soil behind the wall, the amount of lateral wall movement that occurs as backfill is placed, and the inclination of the backfill surface contribute to the lateral soil pressure acting on walls. Soil pressures can be reduced by restraining wall movement. LAI recommends using an equivalent fluid density of 35 pcf to design yielding walls (walls with tops that are allowed to rotate at least 0.001 times the wall height). An equivalent fluid density of 55 pcf should be used to design restrained walls (walls not allowed to rotate at least 0.001 times the wall height).

For seismic loading conditions, a rectangular earth pressure, equal to 13H pounds per square foot, where H is the height of the wall, should be added to the active earth pressure provided above. This seismic earth pressure is based on the Mononobe-Okabe theory and one-half of the peak ground surface acceleration. If the wall is designed for an at-rest condition but will be free to move in seismic conditions, the seismic surcharge pressure and active pressure (rather than the at-rest pressure) should be combined. These recommended soil pressures are based on the assumption that material

behind the wall will consist of structural fill or undisturbed native soil that extends a horizontal distance equal to the wall height.

The lateral soil pressures provided above do not include traffic/building surcharges, the effects of sloping backfill, or hydrostatic pressure. Design of yielding walls should include a uniformly distributed lateral pressure, 0.28 times the uniform surcharge pressure; design of non-yielding walls should include a uniformly distributed lateral pressure, 0.44 times the uniform surcharge pressure.

Lateral resistance and foundation support values for retaining wall footings should comply with the recommendations in the "Foundation Support" section.

Drainage systems should be constructed to collect water and prevent the buildup of hydrostatic pressure. LAI recommends that a zone of free-draining backfill, at least 18 inches wide, is included at the back of the wall. Free-draining backfill should meet the requirements for Gravel Backfill for Walls in Section 9-03.12(2) of the Washington State Department of Transportation's 2021 *Standard Specifications for Road, Bridge, and Municipal Development* (*2021 WSDOT Standard Specifications*). The free-draining backfill zone should extend to within 1 ft of the top of the wall. A perforated, rigid, smooth-walled drainpipe with a minimum diameter of 4 inches should be placed along the base of the wall and should extend the length of the wall. The drainpipe should be sloped to drain to an approved discharge location.

Pavement Design

Pavement sections should be constructed on a subgrade prepared as recommended herein. When developing the recommendations in Table 4, LAI assumed a 20-year design life and a maximum equivalent single-axle load of 50,000 for the standard-duty pavement section and 500,000 for the heavy-duty section.

Table 4. Recommended Asphalt Pavement Design Section

Pavement Section Type	Asphalt Concrete Pavement Thickness	Crushed Surfacing Base Course Thickness	Subbase
Standard duty (parking)	2 inches	6 inches	Compacted Fill Soils
Heavy duty (drive lanes)	3 inches	8 inches	Compacted Fill Soils

Base course material should be compacted to at least 95 percent of the maximum dry density, determined in accordance with ASTM standard test method D1557, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).* Compacted base course should meet the requirements for Crushed Surfacing Base Course in Section 9-03.9(3) of the *2021 WSDOT Standard Specifications.* To facilitate fine grading of the surface, the upper 2 inches of crushed surfacing could consist of Crushed Surfacing Top Course. Prevention of

road-base saturation is essential for pavement durability; efforts should be made to limit the amount of water entering the base course.

Asphalt concrete should be Class B aggregate material or hot-mix asphalt class ½ inch and PG58H-22 binder, conforming to the requirements in Section 5-04 of the *2021 WSDOT Standard Specifications.* The asphalt should be compacted to at least 91 percent of the Rice density.

Construction Considerations

The following key points should be considered when preparing for project construction:

- **Stripping:** Approximately 12 inches of surface material (i.e., topsoil) should be stripped from areas designated for development (i.e., the proposed locations of footings, slabs-on-grade, and pavement sections). Up to 5 ft of stripping may be required in areas where undocumented fill is present. Topsoil is not considered suitable for reuse as structural fill.
- **Subgrade preparation:** Before structural fill, formwork, or pavement base course is placed, the prepared subgrade should be proof-rolled in the presence of a qualified geotechnical engineer, who is familiar with the site and can check for soft/disturbed areas. Areas of limited access can be evaluated with a steel T-probe. If probing or proof-rolling reveals loose and/or disturbed subgrades, the upper 1 ft of subgrade should be scarified; moisture conditioned; and compacted to a firm, unyielding condition. Alternatively, unsuitable soils can be overexcavated and replaced with compacted structural fill.
- **Utility trench excavation and backfill:** LAI anticipates that utility trenches will be excavated in medium dense to dense fill or glacial till soils. Caving may occur in fill soils. A heavy-duty hydraulic excavator should be able to reach the required trench depths. A smooth-bladed bucket should be used to remove loose and/or disturbed soil from the trench bottom. The final trench bottom should be firm and free of roots, topsoil, lumps of silt and clay, and organic and inorganic debris.
- **Site soil:** Fill and glacial till soils have a fines content of 17 percent or less and are considered moisture sensitive. Site soils noted as “SP-SM” on the test pit logs may be suitable for reuse as structural fill with proper moisture conditioning. Soil described as “Fill” on the test pit logs includes significant organic content and is not considered suitable for reuse as structural fill. Earthwork should be avoided during heavy and/or extended periods of precipitation.
- **Import structural fill:** Select Borrow, as described in Section 9-03.14(2) of the *2021 WSDOT Standard Specifications,* is a suitable source of import structural fill. During periods of wet weather, the fines content should not exceed 5 percent, based on the minus ¾-inch fraction.
- **Fill placement and compaction:** Structural fill should be placed on an approved subgrade that consists of uniformly firm, unyielding, inorganic native soils or of compacted structural fill that extends to such soils. Structural fill should be placed and compacted in accordance with the requirements in Section 2-03.3(14)C, Method C of the *2021 WSDOT Standard Specifications.* Method A is appropriate for non-structural areas, such as landscaping. Each layer of structural fill should be compacted to at least 95 percent of the maximum dry density, determined in accordance with ASTM standard test method D1557. Alternatively, the maximum dry density

can be determined using the methods described in Section 2-03.3(14)D of the *2021 WSDOT Standard Specifications.*

- **Construction dewatering:** Zones of perched groundwater may be encountered above the glacial till unit. Temporary excavations should be dewatered to allow construction to be completed in the dry. Where groundwater seepage is encountered, conventional sumps and pumps should be sufficient to dewater excavations. The contractor should be responsible for the design, monitoring, and maintenance of dewatering systems.
- **Temporary slopes:** Temporary excavations should be completed in accordance with the requirements in Section 2-09 of the *2021 WSDOT Standard Specifications.* The contractor should be responsible for actual excavation configurations and the maintenance of safe working conditions, including temporary excavation stability. Temporary excavations in excess of 4 ft should be shored or sloped in accordance with the requirements outlined in Safety Standards for Construction Work, Part N (Washington Administrative Code Chapter 296-155). The soil likely to be exposed in construction excavations should be considered Type C, with a maximum allowable excavation inclination of 1½H:1V. All applicable local, state, and federal safety codes should be followed.
- **Permanent slopes:** Permanent cut and fill slopes should be no steeper than 2H:1V. This design recommendation does not apply to stormwater pond slopes, which are typically 3H:1V or flatter.
- **Stormwater infiltration:** In LAI's opinion, onsite stormwater infiltration is infeasible. Detention and release of stormwater are recommended.

Use of This Technical Memorandum

Landau Associates has prepared this technical memorandum for the exclusive use of Combined Construction, Inc. and Vector Engineering, Inc. for specific application to the Combined Construction Site Development project in Mukilteo, Washington. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Reuse of the information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that, within the limitations of scope, schedule, and budget, its services have been provided in a manner consistent with that level of skill and care ordinarily exercised by members of the profession currently practicing in the same locality, under similar conditions as this project. Landau Associates makes no other warranty, either express or implied.

Closing

We trust that this memorandum provides you with sufficient information to proceed with the project. If you have questions or comments, please contact the undersigned at (360) 791-3178 or bford@landauinc.com.

LANDAU ASSOCIATES, INC.

Benjamin Ford, PE
Associate

LGL/BJF/mcs
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Attachments: Figure 1. Vicinity Map
Figure 2. Site and Exploration Location Plan
Figure 3. Soil Classification System and Key
Figures 4 and 5. Logs of Test Pits TP-1 through TP-4
Figures 6 and 7. Grain Size Distribution

References

ASCE. 2016. *Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE/SEI 7-16)*. American Society of Civil Engineers, Structural Engineering Institute.

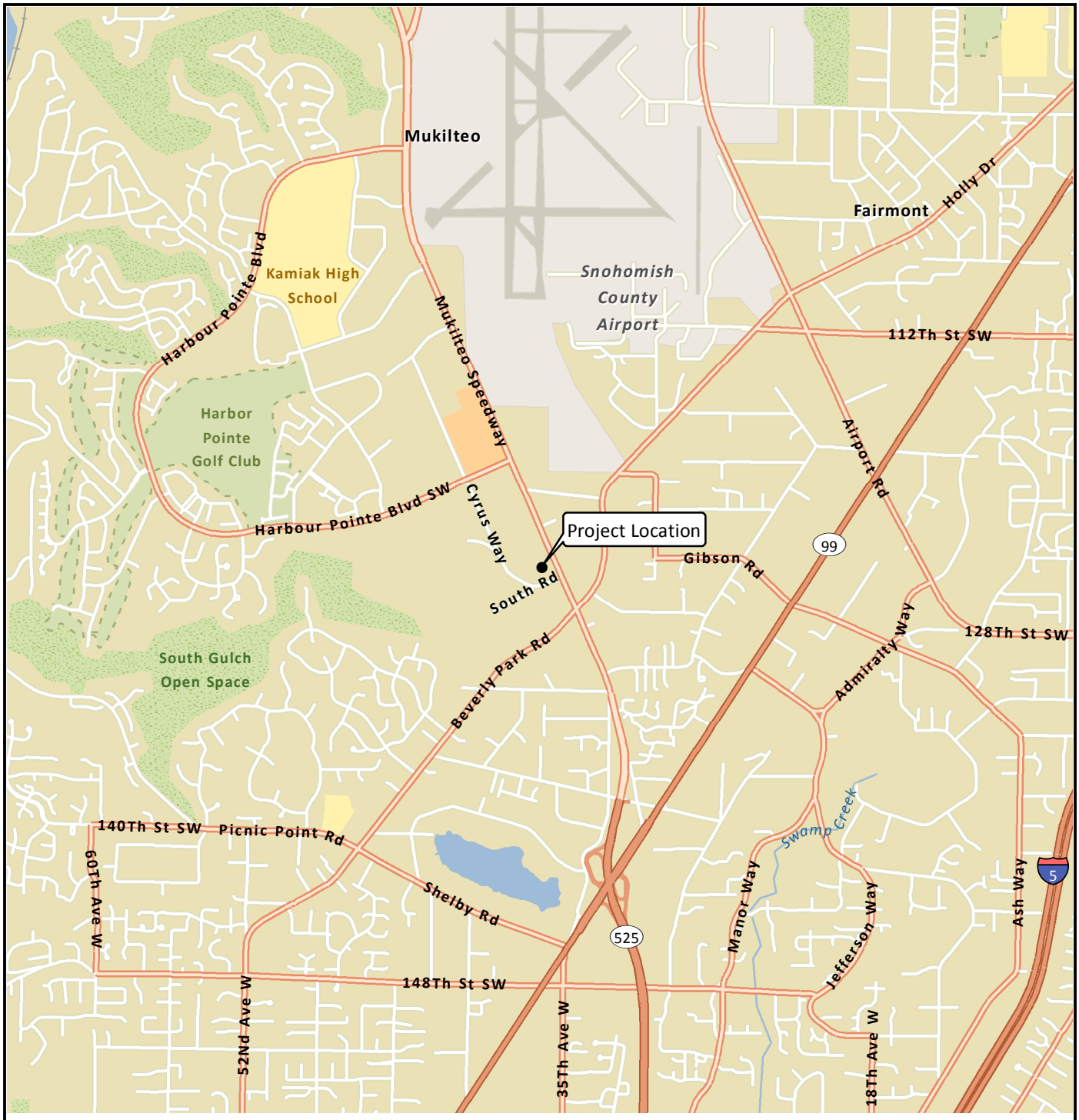
ASTM. 2017. Annual Book of ASTM Standards. In: *Soil and Rock (I)*. West Conshohocken, PA: ASTM International.

ICC. 2017. *2018 International Building Code*. International Code Council. August 31.

LNI. 2020. Construction Work. Chapter 296-155 WAC; Part N. Excavation, Trenching, and Shoring. Washington State Department of Labor and Industries. Effective October.

Minard, J.P. 1982. *Distribution and Description of Geologic Units in the Mukilteo Quadrangle, Washington*. United States Geological Survey.

WSDOT. 2020. *M41-10: Standard Specifications for Road, Bridge, and Municipal Construction*. 2021 Edition. Washington State Department of Transportation. September 9.



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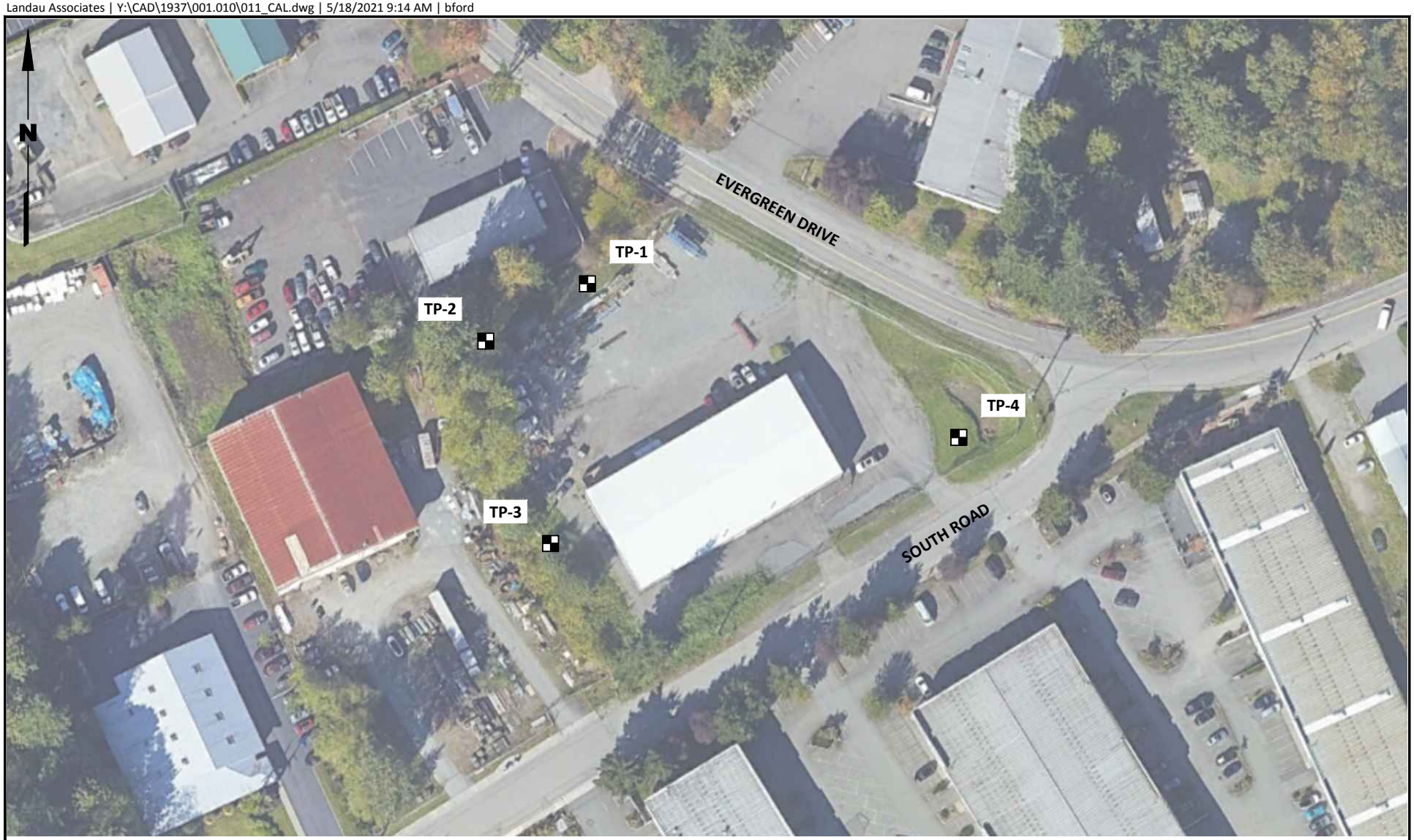
Combined Construction Site Development Mukilteo, Washington	**Vicinity Map**	Figure 1



Legend

TP-1 Approximate Test Pit Location and Designation

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Google Imagery 2020

0 100 200

Scale in Feet

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Combined Construction Site Development Mukilteo, Washington

Site and Exploration Location Plan

Figure 2

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS [2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
	> 15% and ≤ 30% - "gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 15% - "with gravel," "with sand," "with silt," etc.
	≤ 5% - "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

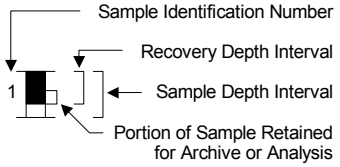
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	2.50-inch O.D., 2.00-inch I.D. WSDOT
h	3.00-inch O.D., 2.375-inch I.D. Mod. California
i	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Vibrocore (Rotosonic/Geoprobe)
5	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Groundwater

▽ Approximate water level at time of drilling (ATD)

▼ Approximate water level at time after drilling/excavation/well

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Combined Construction Site Development Mukilteo, Washington

Soil Classification System and Key

Figure 3

TP-1

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Excavator Ground Elevation (ft): Logged By: DSB	
0						ML	6 inches of topsoil and sod	Groundwater not encountered.
2		S-1				SP-SM	Brown, fine to coarse SAND with gravel, silt, and organics (loose, moist) **(FILL)**	
4								
6		S-2				SM	Gray, very silty, fine SAND (dense, moist) **(GLACIAL TILL)**	
8								
10								
12								
14								

Test Pit Completed 01/06/21
Total Depth of Test Pit = 6.0 ft.

TP-2

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Excavator Ground Elevation (ft): Logged By: DSB	
0						SP-SM	Brown, fine to coarse SAND with gravel, silt, and organics (loose, moist) **(FILL)**	Groundwater not encountered.
2		S-1		W = 13 GS			-Grades to without organics	
4								
6						SP-SM	Gray-brown, fine to coarse SAND with gravel and silt (medium dense, moist) **(GLACIAL TILL)**	
8		S-2		W = 8 GS				
10		S-3		W = 10 GS			-Grades to gray	
12								
14								

Test Pit Completed 01/06/21
Total Depth of Test Pit = 11.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Test Pits

Figure 4

TP-3

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Excavator Ground Elevation (ft): Logged By: DSB	
0						SM	Brown, silty, fine to coarse SAND (medium dense, moist) **(FILL)**	Groundwater not encountered.
2		S-1		W = 14 GS				
4						SP-SM	Gray, fine to coarse SAND with silt (medium dense, moist) **(GLACIAL TILL)**	
6								
8		S-2		W = 11 GS				
10								
12								
14								

Test Pit Completed 01/06/21
Total Depth of Test Pit = 11.0 ft.

TP-4

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Excavator Ground Elevation (ft): Logged By: DSB	
0						ML	6 inches of topsoil and sod (stiff, moist) **(FILL)**	Groundwater not encountered.
2		S-1		W = 19 GS		SP-SM	Light brown, gravelly, fine to coarse SAND with silt (medium dense, moist)	
4		S-2				SP-SM	Dark brown, fine to coarse SAND with gravel, silt, and organics (medium dense, moist to wet)	
6								
8								
10								
12								
14								

Test Pit Completed 01/06/21
Total Depth of Test Pit = 4.0 ft.

Notes:
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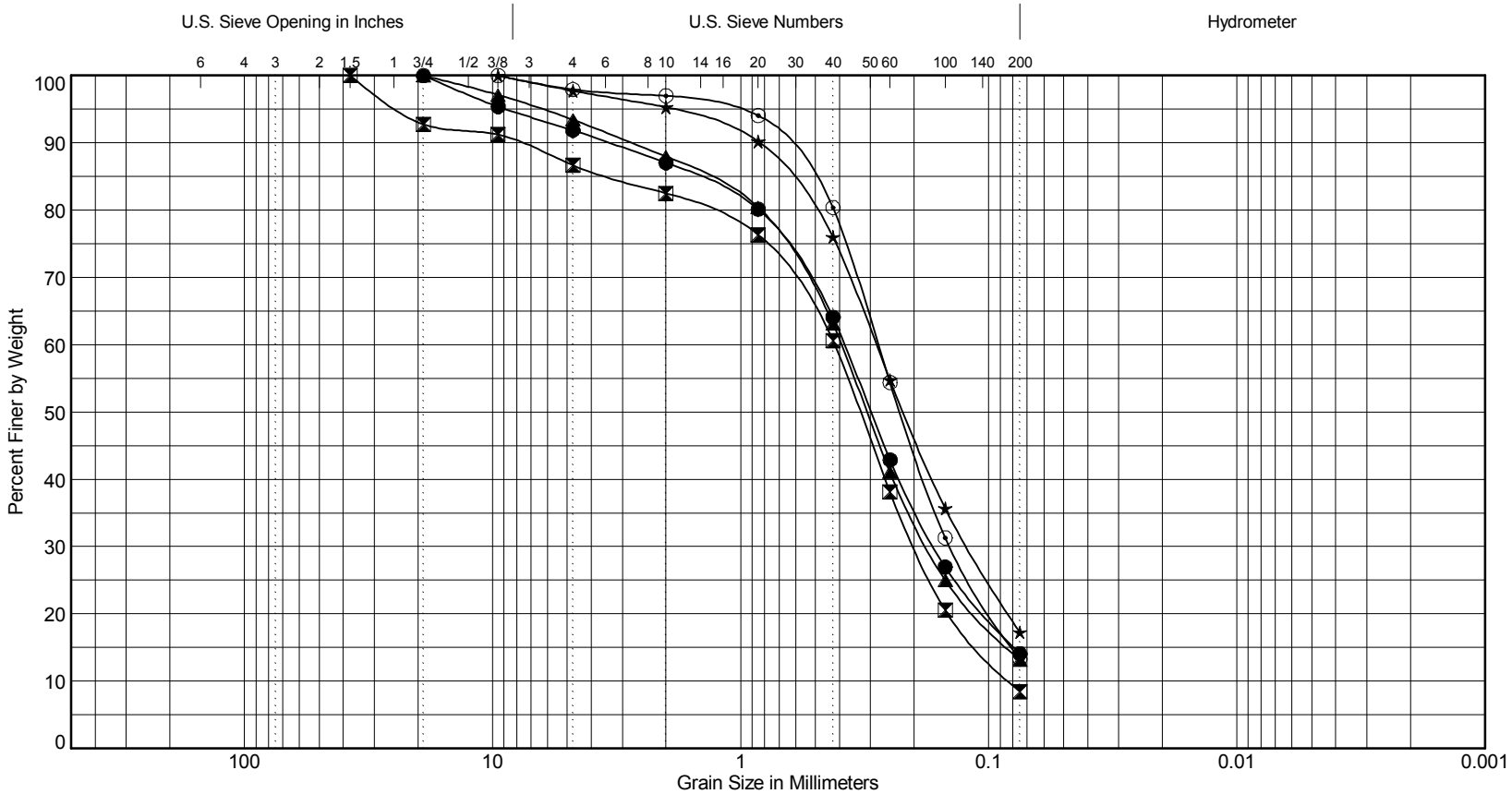
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TP-2	S-1	0	13	Fine to coarse SAND with gravel and silt	SP-SM
⧗	TP-2	S-2	5.0	8	Fine to coarse SAND with gravel and silt	SP-SM
▲	TP-2	S-3	10.0	10	Fine to coarse SAND with gravel and silt	SP-SM
★	TP-3	S-1	0	14	Silty, fine to coarse SAND	SM
⊙	TP-3	S-2	4.0	11	Fine to coarse SAND with silt	SP-SM

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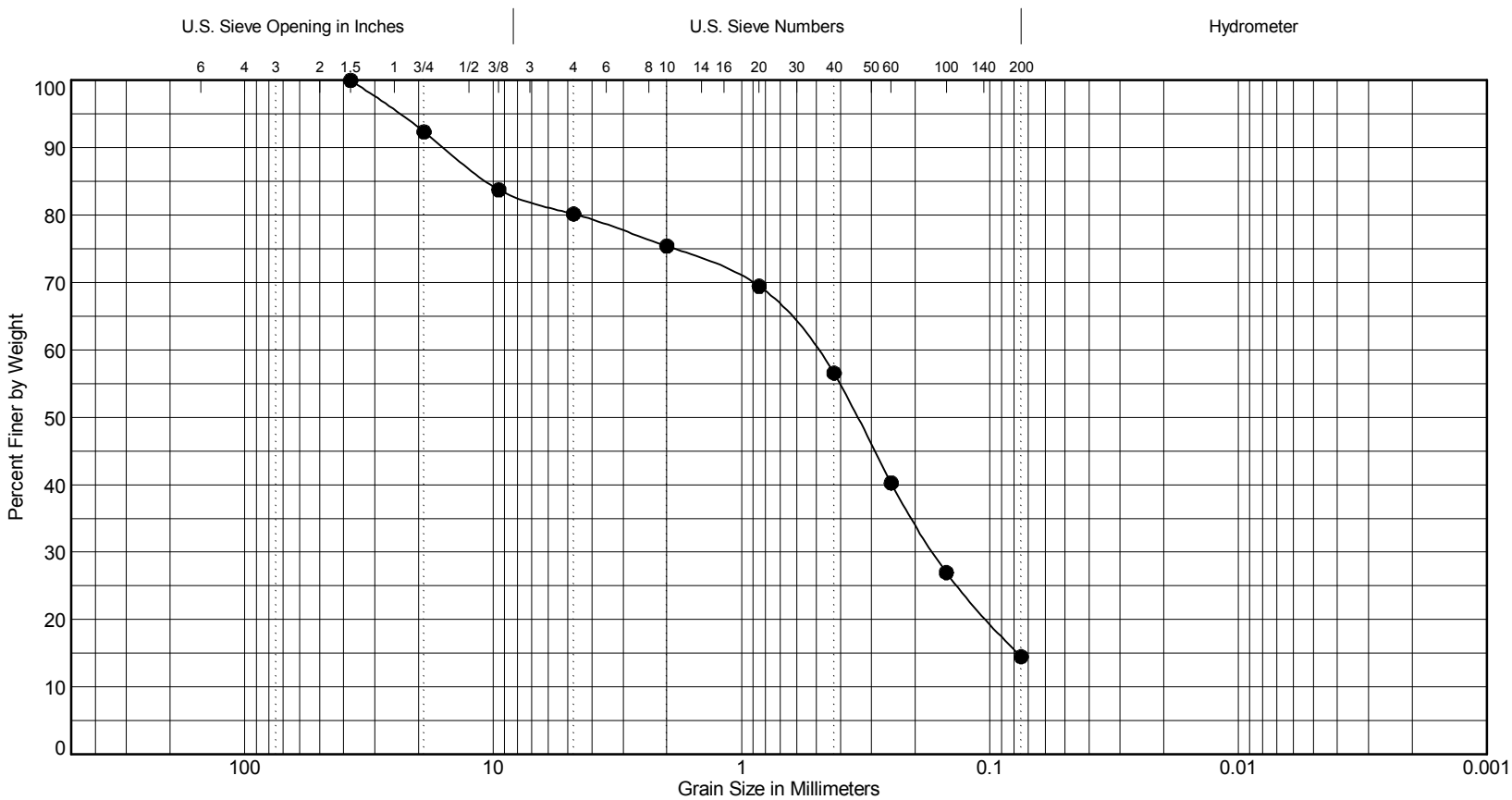
Grain Size Distribution

Figure
6



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TP-4	S-1	0	19	Gravelly, fine to coarse SAND with silt	SP-SM

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Grain Size Distribution

Figure
7