Geotechnical Engineering Report
Buckley Residential Development
Spiketon Road
Buckley, Washington

Prepared for: Evans Development West, LLC
P.O. Box 1744
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Attention: Mr. David Evans

Prepared by: *South Sound* Geotechnical Consulting
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November 23, 2015

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South Sound Geotechnical Consulting

November 23, 2015

Evans Development West, LLC
PO Box 1744
Wenatchee, WA 98807-1744

Attention: Mr. David Evans

Subject: Report of Geotechnical Engineering Services
Buckley Residential Development
Spiketon Road
Buckley - Pierce County, Washington
SSGC Project Number: 15087

Mr. Evans:

South Sound Geotechnical Consulting (SSGC) has prepared this geotechnical engineering report regarding the above referenced development. Our services have been completed in general conformance of our proposal (P15081) dated October 20, 2015 and authorized by you on October 23, 2015. The purpose of our services was to explore subsurface conditions on the project property to provide general geotechnical information regarding development for a sixty six lot residential plat. Our scope of services included completing nine (9) test pits on the site, laboratory testing, engineering analyses, and preparation of this report.

We appreciate the opportunity to work with you on this project. Please contact us if we can be of further assistance.

Respectfully,

South Sound Geotechnical Consulting

TIMOTHY H. ROBERTS
STATE OF WASHINGTON
43126
REGISTERED
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11-23-15

Timothy H. Roberts, P.E., R.G.
Member/Geotechnical Engineer

cc: AHBL, Inc – Ms. Lisa Klein

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EXECUTIVE SUMMARY

South Sound Geotechnical Consulting (SSGC) has completed a geotechnical evaluation to assist in design of the Buckley Residential Development on Spiketon Road in Buckley, Washington. The following information is intended only as a summary of geotechnical considerations for development of the site:

- Site Conditions: The site is undeveloped and generally level. The western approximate 2/3 is used as pasture, with the eastern 1/3 forested with isolated wetlands.

- Soil Conditions: An approximate 1 foot (+/-) topsoil layer covers the site. Native soils below the topsoil were consistent across the site and consisted of silty sand with gravel, cobbles, and occasional boulders. Near the surface this soil was loose grading to medium dense with depth.

- Groundwater: Seepage was observed in some of the test pits ranging in depth from about 2 to 7 feet. A permanent groundwater table was not observed to the maximum depth of the test pits at 10.5 feet. Groundwater levels will fluctuate throughout the year, but are not expected to adversely impact the planned development.

- Suitability of Soils for Structural Fill: Native soils will be difficult to use as structural fill due to their overall higher fines contents.

- Building Sites: Conventional spread footings founded on firm native soils or structural fill placed over firm soils are considered suitable for support of buildings. Footings on properly prepared native subgrades or structural fill can be designed for an allowable bearing pressure of 1,500 pounds per square foot (psf).

- Seismic Considerations: Site Class D would be used to classify the site per the 2012 International Building Code (IBC). This site is considered to have a low risk for liquefaction/dynamic settlement.

- Pavements: Conventional asphalt pavements are considered suitable. The pavement section (HMA and base course) should be placed on a minimum of 10 inches of granular compacted subbase fill.

- Stormwater Infiltration: Infiltration of storm runoff will be severely limited at this site. Native soils have relatively high fines contents that will restrict infiltration.

Executive summaries should not be used for design and/or construction purposes. The entire report must be read for a comprehensive understanding of the information and recommendations presented. Specific details are not included or fully developed in this executive summary.

PROJECT INFORMATION

The proposed development is on the approximate 18.6 acre property on the east side of Spiketon Road, south and east of the intersection with Mountain View Avenue. The property is rectangular with the long axis trending east-west. Preliminary plans provided to us by AHBL, Inc show improvements currently include up to 66 single-family residential lots with access roads. Conventional spread footing foundations are anticipated for the residential buildings. Access into the property will be provided from Spiketon Road. We understand roads will be asphalt paved. A tract in the southwest corner of the site is being considered for stormwater management.

SITE CONDITIONS

The western 2/3 of the property is pasture. The approximate eastern one-third portion is wooded with several identified wetlands. Overall, the property is generally level with only about 2 to 3 feet elevation change in the proposed development area. Areas of standing water on the surface were observed particularly in the northwest and southeast portions of the pasture area at the time of our fieldwork on November 13, 2015. A deep ditch is between Spiketon Road and the western side of the property.

SUBSURFACE CONDITIONS

Subsurface conditions on the site were characterized by excavating nine (9) test pits on November 13, 2015. Test pits were advanced to depths ranging from about 9 to 10.5 feet below surface grades. Approximate exploration locations are shown on Figure 1, Exploration Plan. A summary description of observed subgrade soils is provided below, with logs of the explorations provided in Appendix A.

Soil Conditions

Soil conditions across the site were fairly consistent in the test pits. A well developed topsoil layer was below the surface and ranged in thickness from about 8 inches to 1 foot. Native silty sand with some gravel and cobbles with occasional boulders was observed below the topsoil. This soil was usually loose near the surface and graded medium dense with depth. It continued to the bottom of the test pits.

Groundwater Conditions

Seepage was observed in several of the test pits at depths ranging from around 2 to 7 feet. A permanent groundwater table was not identified to the depths explored. Seasonal perched water layers should be anticipated. Groundwater levels will fluctuate due to seasonal precipitation patterns and on- and off-site drainage conditions, but should not adversely impact the planned development.

Geologic Setting

The USDA Soil Conservation Service "Soil Survey of Pierce County Area, Washington" (issued in 1979) maps native soils on the property as Buckley gravelly silt loam (0 to 3% slopes). This soil formed in Osceola mudflow deposits. Permeability is reported as low, with no erosion hazard. Native soils in the test pits appear to conform to the mapped soil type.

GEOTECHNICAL DESIGN CONSIDERATIONS

The planned development is considered feasible based on observed soil conditions in the explorations completed. In general, native soils will provide suitable support for conventional spread footing foundations and roads. Infiltration for stormwater control should not be relied upon for this site. Although site soils will infiltrate slowly, they are generally not considered feasible for infiltration due to the anticipated high fines (silt and clay) content of site soils.

Recommendations presented in the following sections should be considered general and may require modifications when earthwork and grading occur. Recommendations assume finish grades will be similar (or higher) than existing grades. They are based upon the subsurface conditions observed in the test pits and our current understanding of project plans. It should be noted that subsurface conditions across the site may vary from those depicted on the test pit logs and can change with time. Therefore, proper site preparation will depend upon the weather and soil conditions encountered at the time of construction. We recommend that SSGC review final plans and further assess subgrade conditions at the time of construction, as warranted.

General Site Preparation

Site grading and earthwork should include procedures to control surface water runoff. Grading the site without adequate drainage control measures may negatively impact site soils, resulting in increased export of impacted soil and import of fill materials, thereby potentially increasing the cost of the earthwork and subgrade preparation phases of the project.

We recommend the topsoil layer is stripped from building and pavement areas. Stripping depths are expected to be around 1 to 1.5 feet, but may locally be deeper. Building and pavement subgrades should consist of existing medium dense to dense granular fill or firm native soils.

General Subgrade Preparation

Exposed subgrades should consist of firm native silty sand following stripping. We recommend that exposed subgrades in building sites and pavement areas (roads and driveways) are proofrolled using a large roller (minimum 20 ton) or loaded dump truck to assess subgrade conditions. Proofrolling efforts should result in the upper 1 foot of subgrade soils achieving a compaction level of at least 95 percent of the maximum dry density (MDD) per the ASTM D1557 test method. Wet, loose, or soft subgrades should

be compacted or removed and replaced with structural fill. A representative of SSGC should be present to assess subgrade conditions during proofrolling.

Grading and Drainage

Positive drainage should be provided during construction and maintained throughout the life of the development. Standing water was observed on the surface in areas across the site. Allowing surface water into cuts, utility trenches, road subgrades, and building sites should be prevented. We recommend that earthwork activities occur in the drier seasons of the year.

Structural Fill Materials

The suitability of soil for use as structural fill will depend on the gradation and moisture content of the soil when it is placed. Soils with higher fines content (soil fraction passing the U.S. No. 200 sieve) will become sensitive with higher moisture content. It is often difficult to achieve adequate compaction if soil moisture is outside of optimum condition for soils that contain more than about 5 percent fines.

Site Soils: Native soils are not considered suitable for use as structural fill. The overall higher fines (silt and clay) contents make them moisture sensitive and will limit their use as structural fill. They would have to be treated (dried) to obtain optimal moisture content.

Import Fill Materials: We recommend import structural fill placed during dry weather periods consist of material which meets the specifications for *Gravel Borrow* as described in Section 9-03.14(1) of the 2014 Washington State Department of Transportation (WSDOT) Specifications for Road, Bridge, and Municipal Construction (Publication M 41-10). Gravel Borrow should be protected from disturbance if exposed to wet conditions after placement.

During wet weather, or for backfill on wet subgrades, import soil suitable for compaction in wetter conditions should be provided. Imported fill for use in wet conditions should generally conform to specifications for *Select Borrow* as described in Section 9-03.14(2), or *Crushed Surfacing* per Section 9-03.9(3) of the 2014 WSDOT M-41 manual, with the modification that a maximum of 5 percent by weight shall pass the U.S. No. 200 sieve for these soil types.

It should be noted that structural fill placement and compaction is weather-dependent. Delays due to inclement weather are common, even when using select granular fill. We recommend site grading and earthwork be scheduled for the drier months of the year.

Structural Fill Placement

We recommend structural fill is placed in lifts not exceeding about 10 to 12 inches in loose measure. It may be necessary to adjust lift thickness based on site and fill conditions during placement and

compaction. Structural fill should be compacted to attain the recommended levels presented in Table 1, Compaction Criteria.

Table 1. Compaction Criteria

Fill Application	Compaction Criteria*
Footing areas (below structures and retaining walls)	95 %
Upper 2 feet in pavement areas, slabs and sidewalks, and utility trenches	95 %
Below 2 feet in pavement areas, slabs and sidewalks, and utility trenches	92 %
Utility trenches or general fill in non-paved or -building areas	90 %

*Per the ASTM D 1557 test method.

Trench backfill within about 2 feet of utility lines should not be over-compacted to reduce the risk of damage to the line. In some instances the top of the utility line may be within 2 feet of the surface. Backfill in these circumstances should be compacted to a firm and unyielding condition.

We recommend fill procedures include maintaining grades that promote drainage and do not allow collection of water within fill areas. The contractor should protect compacted fill subgrades from disturbance during wet weather. If rain occurs during structural fill placement, the exposed fill surface should be allowed to dry prior to placement of additional fill. Alternatively, the wet soil can be removed. We recommend consideration be given to protecting haul routes and other high traffic areas on native soils with free-draining granular fill material (i.e. sand and gravel containing less than 5 percent fines) or quarry spalls to reduce the potential for disturbance to the subgrade during inclement weather. Structural fill should not consist of frozen material.

Earthwork Procedures

Conventional earthmoving equipment should be suitable for earthwork at this site. Earthwork will be difficult during periods of wet weather or if elevated soil moisture is present. If soils are stockpiled for future use and wet weather is anticipated, the stockpile should be protected with securely anchored plastic sheeting. If on-site soils become unusable, it may become necessary to import clean, granular soils to complete wet weather site work.

Wet or disturbed subgrade soils should be over-excavated to expose firm, non-yielding, non-organic soils and backfilled with compacted structural fill. We recommend the earthwork portion of this project be completed during extended periods of dry weather. If earthwork is completed during the wet season (typically late October through May) it may be necessary to take extra measures to protect subgrade soils.

If earthwork takes place during freezing conditions, we recommend the exposed subgrade be allowed to thaw and is re-compacted prior to placing subsequent lifts of structural fill. Alternatively, the frozen soil can be removed to unfrozen soil and replaced with structural fill.

A qualified geotechnical engineer and materials testing firm should be retained during the construction phase of the project to observe earthwork operations and to perform necessary tests and observations during subgrade preparation, placement and compaction of structural fill, and backfilling of excavations.

Temporary Cut Slopes

We anticipate that site grades will not be raised (fill) or lowered (cut) significantly from existing grades. Therefore, most excavation activities are anticipated to include temporary excavations for utility line placement. The contractor is responsible for designing and constructing stable, temporary excavations (including utility trenches) as required maintaining stability of both the excavation sides and bottoms. Excavations should be sloped or shored following local and federal regulations, including current OSHA/WISHA excavation and trench safety standards. Site soils should be considered OSHA Type C. The contractor should be prepared to shore and dewater deeper excavations.

Foundations

Foundations can be placed on firm (medium dense) native soils or on a zone of structural fill above competent native soils that have been prepared as described in this report. The following recommendations have been prepared for conventional spread footing foundations.

Bearing Capacity (net allowable):	1,500 pounds per square foot (psf) for footings supported on native soils or structural fill prepared as described in this report.
Footing Width (Minimum):	18 inches (Strip) 24 inches (Column)
Embedment Depth (Minimum):	18 inches (Exterior) 12 inches (Interior)
Settlement:	Total: < 1 inch Differential: < 1/2 inch (over 40 feet)
Allowable Lateral Passive Resistance:	275 psf/ft* (below 18 inches)
Allowable Coefficient of Friction:	0.35*

*These values include a factor of safety of approximately 1.5.

The net allowable bearing pressures presented above may be increased by one-third to resist transient, dynamic loads such as wind or seismic forces. Lateral resistance to footings should be ignored in the upper 12-inches from exterior finish grade.

Foundation Construction Considerations

All foundation subgrades should be free of water and loose soil prior to placing concrete, and should be prepared as recommended in this report. Concrete should be placed soon after excavating and compaction to reduce disturbance to bearing soils. Should soils at foundation level become excessively dry, disturbed, saturated, or frozen, the affected soil should be removed prior to placing concrete. We recommend that SSGC observe all foundation subgrades prior to placement of concrete.

Foundation Drainage

Site soils will not drain readily as indicated by standing water observed over portions of the site. Footing drains are recommended around all structures. We recommend footing drains include a perforated rigid plastic drain pipe at least 4-inches in diameter is placed adjacent the bottom of the footing. The pipe should be encased in a minimum 12-inch wide zone of free draining granular soil (containing less than 5 percent material passing the US No. 200 sieve) with the free-draining granular soil zone (encapsulated in filter fabric). Drain lines should be sloped to provide flow to an approved storm water receptor. The granular fill should extend to within 6 inches of finish grade, where it should be capped with compacted low permeable fill containing sufficient fines to reduce infiltration of surface water into the drainage zone. Cleanouts are recommended for maintenance of the drain system.

On-Grade Floor Slabs

On-grade floor slabs should be placed on subgrades and/or structural fill prepared as described in this report. We recommend a modulus subgrade reaction of 175 pounds per square inch per inch (psi/in) for native soils.

We recommend a capillary break is provided between the prepared subgrade and bottom of slab. Capillary break material should be a minimum of 6 inches thick and consist of compacted clean, free-draining, well graded course sand and gravel. The capillary break material should contain less than 5 percent fines, based on that soil fraction passing the U.S. No. 4 sieve. Alternatively, a clean angular gravel such as No. 7 aggregate per Section 9-03.1(4) C of the 2014 WSDOT (M41-10) manual could be used for this purpose.

We recommend positive separations and/or isolation joints are provided between slabs and foundations, columns or utility lines to allow independent movement, where needed. Backfill in interior trenches beneath slabs should be compacted in accordance with recommendations presented in this report.

A vapor retarder should be considered beneath concrete slabs that will be covered with moisture sensitive or impervious coverings (such as tile, wood, etc.), or when the slab will support equipment sensitive to moisture. We recommend that the slab designer refer to ACI 302 and/or ACI 360 for procedures and limitations regarding the use and placement of vapor retarders.

Seismic Considerations

Seismic parameters and values in Table 2 are recommended based on the 2012 International Building Code (IBC).

Table 2. Seismic Parameters

PARAMETER	VALUE
2012 International Building Code (IBC) Site Classification[1]	E
Site Latitude	N 47.153057°
Site Longitude	W 122.025456°
S_s Spectral Acceleration for a Short Period	1.183
S_1 Spectral Acceleration for a 1-Second Period	0.443g
F_a Site Coefficient for a Short Period	1.027
F_v Site Coefficient for a 1-Second Period	1.557

[1] Note: In general accordance with *2012 International Building Code*, Section 1613.3.2 for risk categories I,II,III. IBC Site Class is based on the specified characteristics of the upper 100 feet of the subsurface profile. S_s, S_1, F_a, and F_v values based on the USGS US Seismic Design Maps website using referenced site latitude and longitude. The 2012 IBC requires a site soil profile determination extending to a depth of 100 feet for seismic site classification. Test pits completed on the site do not satisfy the required 100 foot soil profile determination. The recommended seismic site class considers a stiff soil profile continues below the maximum depth of the explorations and is based on the referenced maps in this report and other geotechnical information of the area.

Liquefaction

Soil liquefaction is a condition where loose, typically granular soils located below the groundwater surface lose strength during ground shaking, often associated with earthquakes. The Pierce County "Potential Seismic Hazard Areas" map indicates the site is in a potential liquefaction and/or dynamic settlement hazard area. It is our opinion the site has a moderate to high risk of liquefaction/dynamic settlement based on the overall granular nature of native soils and high groundwater table. Although additional seismic studies would be necessary to fully assess the potential impact, seismic induced differential settlements on the order of 3 to 6 inches (and locally more) could occur during a design level earthquake. We are available to provide additional studies regarding seismic hazards, as requested.

Pavements

We anticipate conventional asphalt pavements will be used for roads and driveways. Subgrades for pavement areas should be prepared as described in the site and subgrade preparation and structural fill sections of this report. Subgrade soils below pavements should be compacted to at least 95 percent of the maximum dry density (ASTM D 1557) within at least one foot of the base of the section. Subgrades below pavement sections should also be graded or crowned to promote drainage and not allow for ponding of water beneath the section. If drainage is not provided and ponding occurs, the subgrade soils could become saturated, lose strength, and result in premature distress to the pavement. In addition, the pavement surfacing should also be graded to promote drainage and reduce the potential for ponding of water on the pavement surface.

Pavement section design has been prepared and is based on AASHTO design guidelines and the following assumed design parameters:

- 20-year life span;
- Estimated design life Equivalent Single Axle Loads (18 kips) of 260,000;
- Estimated subgrade CBR of 4;
- Terminal serviceability of 2.0; and,
- Level of reliability 85 percent.

Minimum recommended pavement sections for conventional pavement areas include:

Table 3. Preliminary Pavement Sections

Traffic Area	Preliminary Recommended Minimum Pavement Section Thickness (inches)			
	Asphalt Concrete Surface[1]	Aggregate Course[2]	Granular Subbase[3]	Total
Main Access Ways	3	6	10	19
Driveways	2	6	-	8

[1] 1/2 –inch nominal aggregate hot-mix asphalt per WSDOT 9-03.8(1)
[2] Crushed Top or Base course per WSDOT 9-03.9(3)
[3] Gravel Borrow per WSDOT 9-03.14(1) or better

The above recommended pavement sections should only be considered for preliminary design purposes. Final pavement sections should be based on actual traffic design loads. The estimated CBR value may not be suitable depending on final road subgrades which could affect the preliminary pavement sections. When traffic loads and final pavement subgrade elevations are known, SSGC should review and verify or

modify the preliminary pavement sections. Geotextile fabrics or geogrids could be considered to reduce the amount of granular subbase in the pavement section.

Pavement Maintenance

The performance and lifespan of pavements can be significantly impacted by future maintenance. The above pavement sections represent minimum recommended thicknesses and, as such, periodic maintenance should be completed. Proper maintenance will slow the rate of pavement deterioration, and will improve pavement performance and life. Preventive maintenance consists of both localized maintenance (crack and joint sealing and patching) and global maintenance (surface sealing). Added maintenance measures should be anticipated over the lifetime of the pavement section if any existing fill or topsoil is left in-place beneath pavement sections.

Stormwater and Infiltration Characteristics

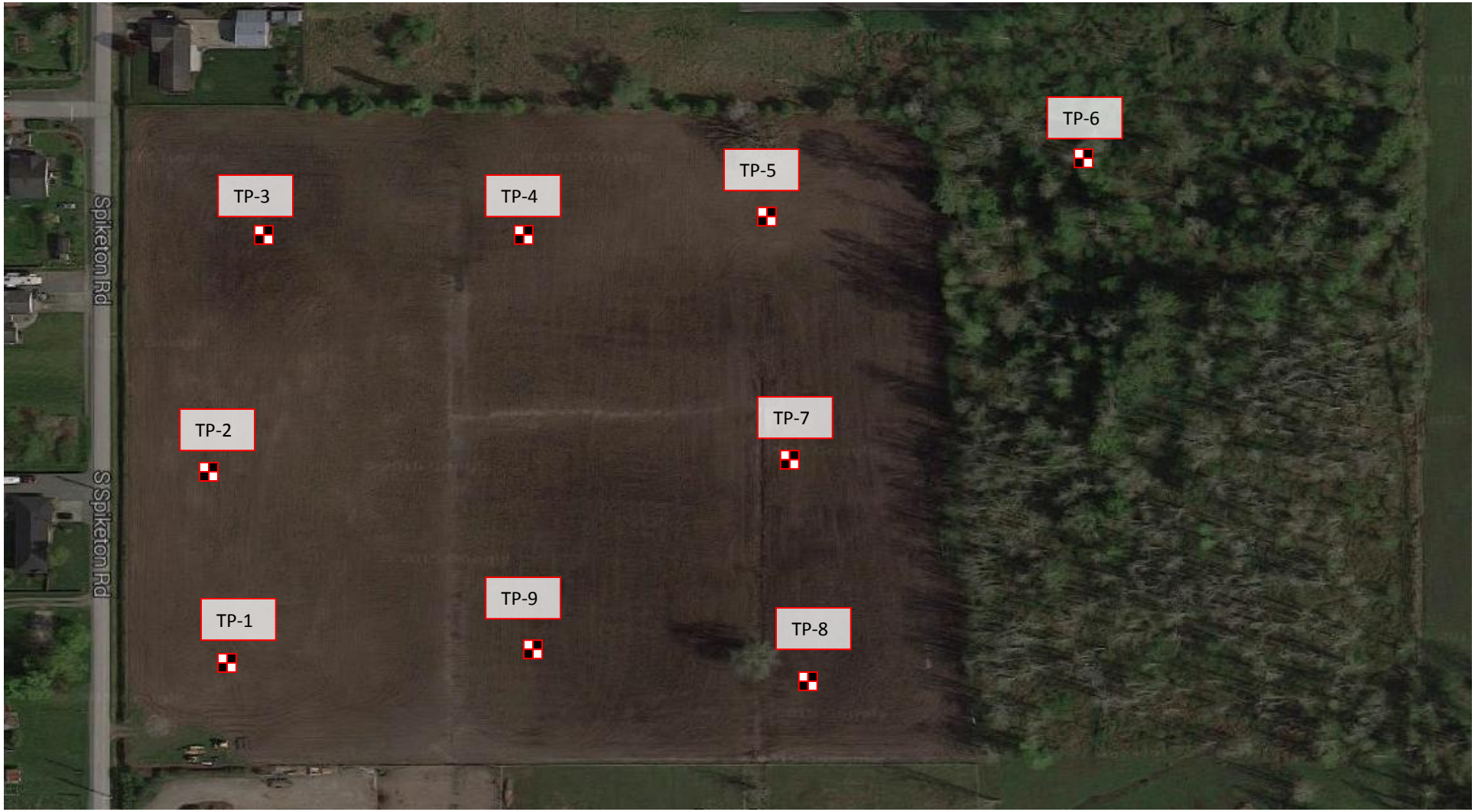
A storm tract is proposed in the southwestern corner of the development. Soils across the site appeared fairly consistent. Gradation results show that fine (silt and clay) content of site soils is about 30 percent or higher. These amounts of fines will limit infiltration potential. Based solely on the gradation results, potential infiltration rates of less than ¼-inch per hour would be anticipated for site soils. Additional on-site infiltration tests would be required to further assess infiltration feasibility and design infiltration rates.

REPORT CONDITIONS

This report has been prepared for the exclusive use of Evans Development West, LLC and their agents as discussed and has been prepared in accordance with generally accepted geotechnical engineering practices in the area. No warranties, either express or implied, are intended or made. Should changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless SSGC reviews the changes and either verifies or modifies the conclusions of this report in writing.

The analysis and recommendations presented in this report are based upon the data obtained from the subsurface explorations completed at the indicated locations and from other information as discussed. This report does not reflect variations of subsurface conditions that may occur between explorations, across the site, or due to the modifying effects of construction or weather. If variations appear or design plans change, we should be notified so that further evaluation and supplemental recommendations can be provided, as warranted.

The scope of services for this project does not include any environmental or biological assessment of the site. Other environmental studies should be completed if the owner is concerned about the potential for contamination or pollution.



Legend

TP-1

Approximate Test Pit Location

Base map from Google Maps.

No Scale

South Sound Geotechnical Consulting
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(253) 973-0515

Figure 1 – Site Plan

Buckley Residential Development
Spiketon Rd - Buckley, WA

SSGC Project #15087

Appendix A

Field Exploration Procedures and Test Pit Logs

Field Exploration Procedures

Assessing subgrade conditions for this project included nine (9) test pits completed on November 13, 2015. Approximate exploration locations are shown on the Exploration Plan (Figure 1). Ground surface elevation referenced on the logs was inferred from Google Earth and USGS 7.5-minute quadrangle maps.

Test pits were excavated by a private excavation contractor subcontracted to SSGC. Soil samples were collected during excavation and stored in moisture tight containers. Explorations were backfilled with excavated soils and tamped when completed. Please note backfill in the explorations will likely settle with time. Should test pits be discovered in building or pavement areas, the backfilled material should be re-excavated and re-compacted, or replaced with structural fill.

Test pit logs in this appendix indicate the observed lithology of soils and other materials in the explorations at the time of excavation. Average soil contact depths are shown where contacts were observed to be gradational. Our logs also indicate the approximate depth to groundwater (when observed at the time of excavation). Static groundwater levels may vary from the depths indicated. Soil descriptions on the logs are based on the Unified Soil Classification System.

Test Pit TP-1

Depth (feet)	Material Description
0 – 1	**Topsoil:** SILT with some sand and organics: Soft, wet, dark brown.
1 – 5	Silty SAND with gravel and cobbles: Loose to medium dense, moist, mottled gray/orange. (Sample S-1 @ 2 feet)
5 – 10	Silty SAND with gravel and cobbles: Medium dense, moist, light gray/brown. (Grades wet at about 8 feet)

Test pit completed at approximately 10 feet on 11/13/15.
No groundwater observed at time of excavation.
No caving observed at time of excavation.
Approximate surface elevation: 730 feet

Test Pit TP-2

Depth (feet)	Material Description
0 – 1	**Topsoil:** SILT with some sand and organics: Soft, wet, dark brown.
1 – 10	Silty SAND with gravel and cobbles: Medium dense, moist to wet, light brown. (Grades light gray/brown @ 3 feet) (Grades wet at about 8 feet)

Test pit completed at approximately 10 feet on 11/13/15.
Seepage observed ear surface and at about 6 feet at time of excavation.
No caving observed at time of excavation.
Approximate surface elevation: 731 feet

Test Pit TP-3

Depth (feet)	Material Description
0 – 0.75	**Topsoil:** SILT with some sand and organics: Soft, wet, dark brown.
0.75 – 4.5	Silty SAND with gravel and cobbles: Loose to medium dense, moist, mottled gray/orange. (Sample S-1 @ 3 feet)
4.5 – 10.5	Silty SAND with gravel and cobbles: Medium dense, moist, light gray/brown. (More silt and clay at about 7 feet)

Test pit completed at approximately 10.5 feet on 11/13/15.
No groundwater observed at time of excavation.
No caving observed at time of excavation.
Approximate surface elevation: 732 feet

Test Pit TP-4

Depth (feet)	Material Description
0 – 0.75	**Topsoil:** SILT with some sand and organics: Soft, wet, dark brown.
0.75 – 9	Silty SAND with gravel and cobbles: Loose to medium dense, moist, mottled gray/orange. (Grades light gray/brown at 4 feet)(Sample S-1 @ 8 feet)

Test pit completed at approximately 9 feet on 11/13/15.
No groundwater observed at time of excavation.
Slight caving observed below about 5 feet.
Approximate surface elevation: 733 feet

Test Pit TP-5

Depth (feet)	Material Description
0 – 0.75	**Topsoil:** SILT with some sand and organics: Soft, wet, dark brown.
0.75 – 10	Silty SAND with gravel, cobbles, and occasional boulder: Loose grading to medium dense, moist to wet, mottled gray/orange. (Grades light gray/brown at 4 feet)

Test pit completed at approximately 10 feet on 11/13/15.
Slight seepage observed at about 5 and 7 feet at time of excavation.
No caving observed at time of excavation.
Approximate surface elevation: 733 feet

Test Pit TP-6

Depth (feet)	Material Description
0 – 0.75	**Topsoil:** SILT with some sand and organics: Soft, wet, dark brown.
0.75 - 9	Silty SAND with gravel, cobbles, and occasional boulder: Loose grading to medium dense, moist to wet, gray. (Sample S-1 @ 4 feet)
	Test pit completed at approximately 9 feet on 11/13/15. Seepage observed near surface and at about 7 feet at time of excavation. No caving observed at time of excavation. Approximate surface elevation: 733 feet

Test Pit TP-7

Depth (feet)	Material Description
0 – 1	**Topsoil:** SILT with some sand and organics: Soft, wet, dark brown.
1 – 9	Silty SAND with gravel, cobbles, and occasional boulder: Loose grading to medium dense, moist to wet, mottled gray/orange. (Grades light gray brown at 3 feet)
	Test pit completed at approximately 9 feet on 11/13/15. Seepage observed at about 2.5 feet at time of excavation. No caving observed at time of excavation Approximate surface elevation: 734 feet

Test Pit TP-8

Depth (feet)	Material Description
0 – 0.75	**Topsoil:** SILT with some sand and organics: Soft, wet, dark brown.
0.75 – 10	Silty SAND with gravel, cobbles, and occasional boulder: Loose grading to medium dense, moist to wet, light gray brown. (Sample S-1 @ 2 feet)

Test pit completed at approximately 10 feet on 11/13/15.
Seepage observed at about 3 feet at time of excavation.
No caving observed at time of excavation.
Approximate surface elevation: 733 feet

Test Pit TP-9

Depth (feet)	Material Description
0 – 1	**Topsoil:** SILT with some sand and organics: Soft, wet, dark brown.
1 – 9	Silty SAND with gravel, cobbles, and occasional boulder: Loose grading to medium dense, moist to wet, light gray brown.

Test pit completed at approximately 9 feet on 11/13/15.
Seepage observed at about 2.5 feet at time of excavation.
No caving observed at time of excavation.
Approximate surface elevation: 732 feet

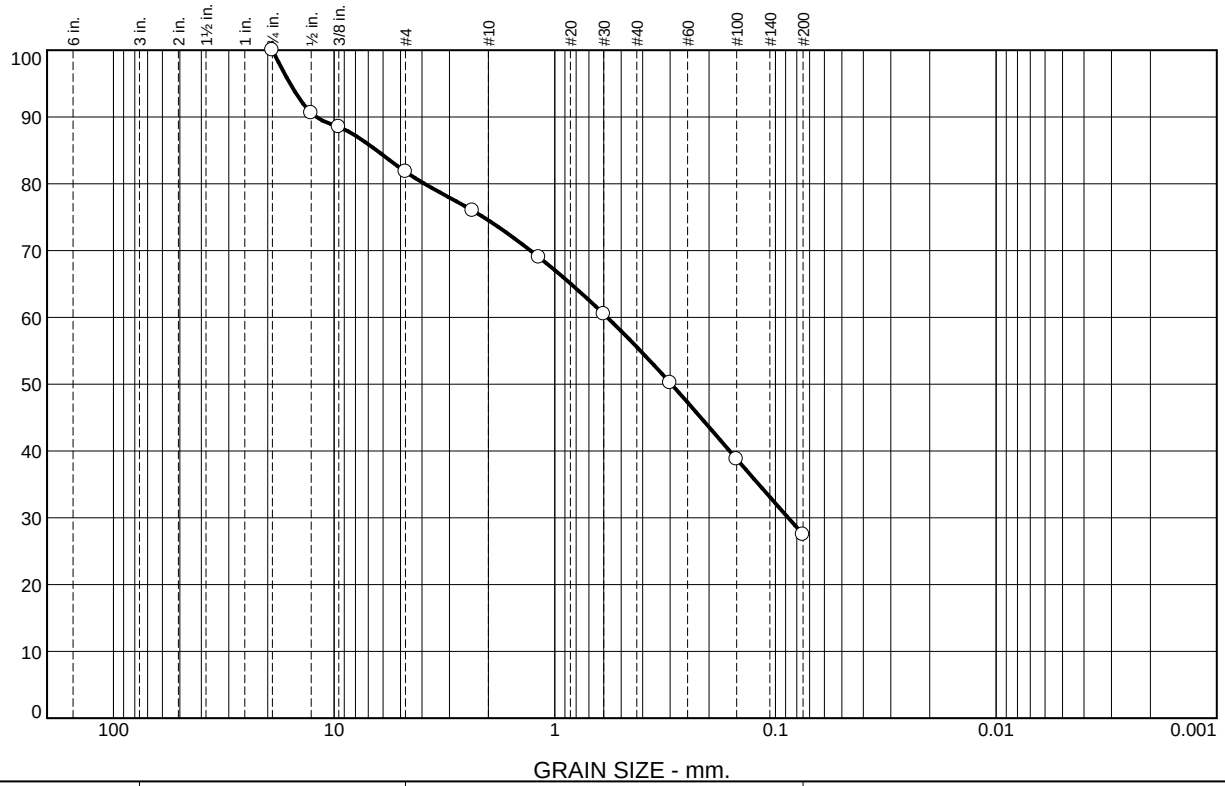
Appendix B

Laboratory Testing

Laboratory Testing

Select soil samples were tested to assess grain size distribution (gradation). Construction Testing Laboratories (CTL) of Puyallup, Washington performed the tests. Results of the laboratory testing are included in this appendix.

Particle Size Distribution Report ASTM C-117,C136



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	18	7	19	28	28	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100		
1/2"	91		
3/8"	88		
#4	82		
#8	76		
#16	69		
#30	60		
#50	50		
#100	39		
#200	28		

* (no specification provided)

Material Description

Grab Sample
Sampled at 6'

Atterberg Limits

PL= LL= PI=

Classification

USCS= AASHTO=

Remarks

Report: #2

Sampled by: Client

Source of Sample: TP-1 S-2
Sample Number: 15-1339

Date: 11-13-15

Construction Testing Laboratories
400 Valley Ave. NE, Suite #102
Puyallup WA, 98372 Tel. (253) 383-8778

Client: South Sound Geotechnical Consulting
Project: Spiketon Road (JO#15087)
Project No: 5982 **Figure**

Tested By: R Rowden **Checked By:** C Pedersen

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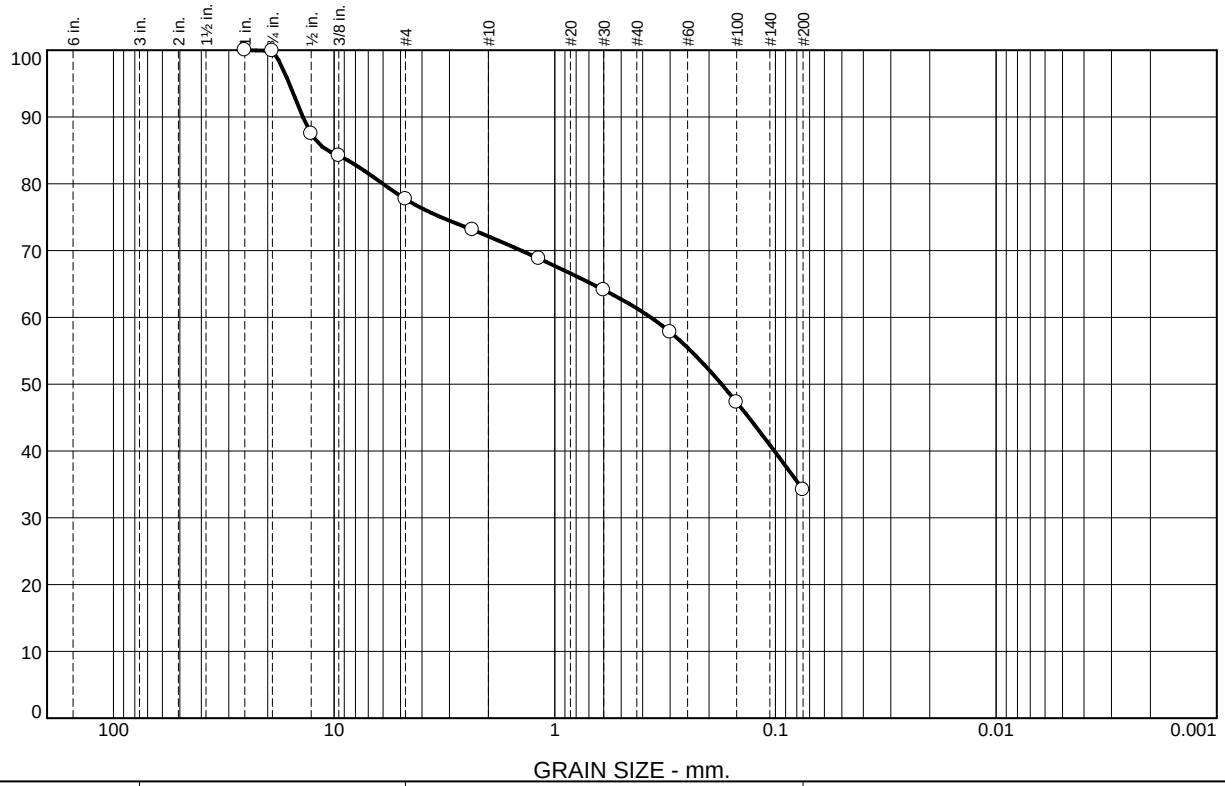
Particle Size Distribution Report ASTM C-117,C136



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	22	6	11	27	34	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100		
3/4"	100		
1/2"	88		
3/8"	84		
#4	78		
#8	73		
#16	69		
#30	64		
#50	58		
#100	47		
#200	34		

* (no specification provided)

Material Description

Grab Sample
Sampled at 2'

Atterberg Limits

PL= LL= PI=

Classification

USCS= AASHTO=

Remarks

Report: #1

Sampled by: Client

Source of Sample: TP-1 S-2
Sample Number: 15-1340

Date: 11-13-15

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Client: South Sound Geotechnical Consulting
Project: Spiketon Road (JO#15087)
Project No: 5982 **Figure**

Tested By: R Rowden **Checked By:** C Pedersen

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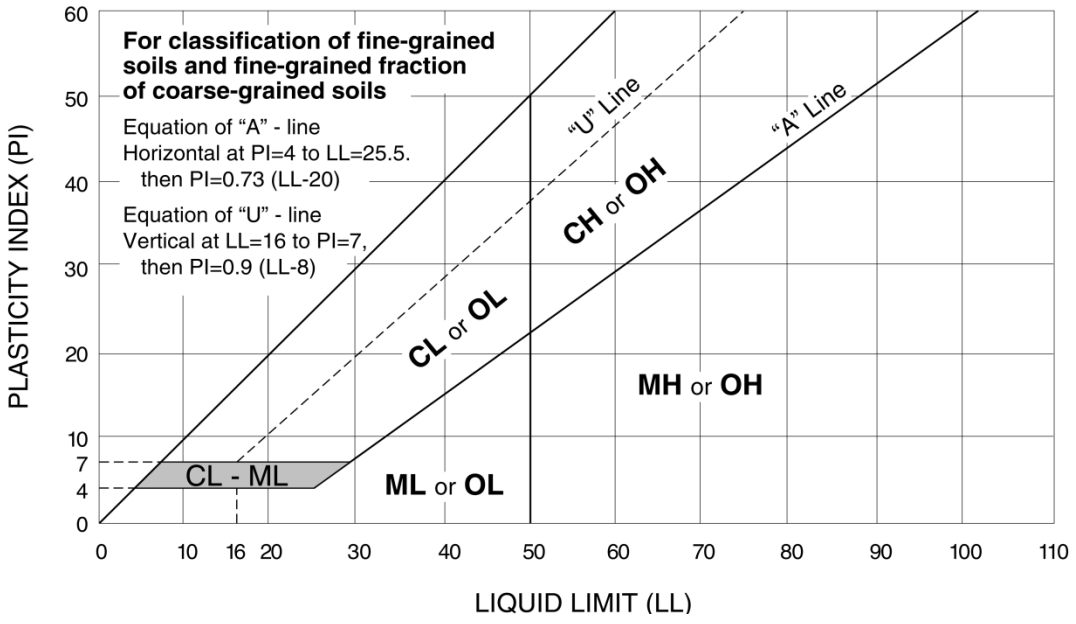
UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.