INSIGHT GEOLOGIC, INC.

March 13, 2020

Hatton Godat Pantier
3910 Martin Way East, Suite B
Olympia, Washington 98506
Attention: Jeff Pantier

Report
Geotechnical Investigation
Ticknor Farms – 4 Parcels
7927 Littlerock Road SW
Tumwater, Washington
Project No. 297-011-01

INTRODUCTION

Insight Geologic, Inc. is pleased to provide our report for the investigation of subsurface soil conditions at 7927 Littlerock Road SW in Tumwater, Washington. The location of the site is shown relative to surrounding physical features in the Vicinity Map, Figure 1. The combined parcels of the proposed project include Thurston County Tax Parcel No. 09070001000, 09070004000, 12708410100, and 12709320100, comprising approximately 292 acres. The project will include residential homesites as well as paved streets through the development.

SCOPE OF SERVICES

The purpose of our services was to evaluate subsurface conditions as they pertain to geotechnical parameters for the proposed project. The specific tasks performed are outlined below:

1. Provided for the location of subsurface utilities on the site by notifying the “One Call” system.
2. Conducted a site reconnaissance to evaluate and mark proposed test pit locations at the site and for track-mounted excavator access.
3. Excavated a series of twenty-four (24) exploratory test pits across the project site using a small, track-mounted excavator. The test pits were excavated to a depth of 8 feet below ground surface (bgs) and were backfilled at the end of the day.
4. Collected representative soil samples from the test pits for laboratory analysis.
5. Logged the soils exposed in the test pits in general accordance with ASTM D2487-06.
6. Provided for laboratory testing of the soils. We conducted gradation analyses to evaluate soil class, bearing capacity and to assist with stormwater infiltration calculations.

7. Prepared a report summarizing our field activities including our recommendations for site preparation and grading, bearing capacity, seismic class, temporary and final cut slopes, earth pressures, suitability of the on-site soils for use as fill, and initial infiltration rates.

FINDINGS

Surface Conditions

The project site is comprised of four parcels containing a total of 292 acres and is situated at an elevation of between approximately 150 and 202 feet above mean sea level. The site is bounded by Littlerock Road SW and Black Hills High School to the east, residential and undeveloped properties to the north and south, and the Burlington Northern railroad line to the west. The subject site is currently developed with two single-family residences, associated barns and out-buildings are located on the east side of the parcel. The property slopes gently from the southeast corner of the site to the northwest. A low ridge approximately 15 feet in height crosses the southern half of the central portion of the site. The majority of the site is agricultural fields. A wooded area is located in the northwest corner of the site.

Geology

Based on our review of available published geologic maps, Vashon age glacial recessional outwash deposits underlie the project site and surrounding area. This material is described as recessional sands and silt with minor gravel interbeds. This material was deposited within stream channels and deltaic environments, during the waning stages of the most recent glacial period in the Puget Sound and is not glacially consolidated.

Subsurface Explorations

We explored subsurface conditions at the site on March 4 and 5, 2020, by excavating twenty-four test pits in the locations as shown on the Site Plan, Figure 2. The test pits were excavated by Insight Geologic using a track-mounted excavator. A geologist from Insight Geologic monitored the explorations and maintained a log of the conditions encountered. The test pits were completed to the depth of 8 feet bgs. The soils were visually classified in general accordance with the system described in ASTM D2487-06. A copy of the explorations is contained in Attachment A.

Soil Conditions

Soil conditions at the site generally consisted of 1 to 1.5 feet of sod and dark brown topsoil, underlain by brown fine sand with silt (SP-SM) in a loose to medium dense and moist to wet condition to the base of the explorations. Three exceptions to this general description were noted. Soils in test pit TP-9 consisted of silty sand (SM) in a loose and moist condition. Soils in test pit TP-11 consisted of approximately 5 feet of well-graded gravel with sand (GW) in a moist and loose condition, overlying a 1-foot thick unit of silt with sand (ML) in a medium-stiff and moist condition, overlying poorly graded sand with gravel (SP) in a medium dense and moist condition. Test pit TP-11 was excavated at the top of a linear ridge approximately 10 to 15 feet high. Soils in test pits TP-20 to TP-24 encountered 1.5 to 4.5 feet of dark brown fine sand with silt (SP-SM) in a loose and moist condition, overlying the brown sand with silt encountered elsewhere on the site.

The soils encountered are generally consistent with Cagey loamy sand, Nisqually loamy fine sand, and Yelm fine sandy loam, which is mapped for the area. These soils are generally formed from glacial outwash and generally have restrictive layers occurring greater than 7 feet below grade. Percolation is generally moderately high to very high, with rates between 1.98 and 19.98 inches per hour, according to the U.S. Department of Agriculture Soil Survey. Soils associated with the esker deposit are mapped as Everett very gravelly sandy loam.

Groundwater Conditions

Groundwater was encountered in test pits TP-3 to TP-6, TP-9 and TP-19. These test pits are generally located in the central portion of the west half of the site and groundwater was encountered at a depth of between 4 and 7.5 feet bgs. No evidence of perched water was encountered within the explorations. Further evaluation of the existing groundwater wells on-site should be performed to more accurately determine winter groundwater levels at the site.

Laboratory Testing

We selected eleven soil samples for gradation analyses in general accordance with ASTM D422 to define soil class and obtain parameters for stormwater infiltration calculations. Our geotechnical laboratory test results contained in Attachment B.

STORMWATER INFILTRATION

We completed a stormwater infiltration rate evaluation in general accordance with the 2018 City of Tumwater Drainage Design and Erosion Control Manual (2018 Manual). The 2018 Manual uses a detailed method that utilizes the relationship between the D10, D60, and D90 results of the ASTM grain-size distribution analyses, along with site-specific correction factors to estimate long-term design infiltration rates.

Based on our gradation analyses, we estimate that the preliminary long-term design infiltration rate (F_{design}) for the proposed stormwater infiltration system is between 2.3 and 6.3 inches per hour, based on the location on the site and after applying the appropriate correction factors. Our calculations assumed that stormwater infiltration will occur at a depth of 2 feet bgs with winter high groundwater levels at depths of between 4 and 10 feet bgs, depending on the location. Lower infiltration rates may occur if winter groundwater monitoring determines that groundwater levels rise to a higher elevation during the winter season monitoring activities. In addition, infiltration rates can change depending on the final geometry of the infiltration facility. We recommend that the provided infiltration rates be evaluated after the geometry of the infiltration facility is determined. It may be possible to increase the design infiltration rate with additional testing. We have found that Pilot Infiltration Tests, or PITs, often can result in increased infiltration rates in fine-grained soils due to the nature of the testing and the correction factors allowed within the method. The results of our stormwater infiltration evaluation are presented in Table 1 and Attachment B.

Table 1. Design Infiltration Rates – ASTM Method

Exploration	Unit	Depth Range (feet)	D_{10} Value	D_{60} Value	D_{90} Value	Correction Factor Plugging	Correction Factor Geometry	Correction Factor Testing Methodology	Long-Term Design Infiltration Rate (Inches per hour)
TP-2	SP-SM	1.0 – 8.0	0.08	0.18	0.25	0.8	0.45	0.4	4.6
TP-7	SP-SM	1.0 – 8.0	0.09	0.22	0.34	0.8	0.45	0.4	6.3
TP-8	SP-SM	1.5 – 8.0	0.07	0.17	0.23	0.8	0.45	0.4	4.3
TP-9	SM	1.5 – 8.0	0.07	0.16	0.23	0.8	0.25	0.4	2.3
TP-16	SP-SM	1.0 – 8.0	0.08	0.18	0.23	0.8	0.45	0.4	5.6
TP-19	SP-SM	1.5 – 8.0	0.07	0.18	0.23	0.8	0.33	0.4	3.1
TP-21	SP-SM	1.0 – 4.0	0.08	0.17	0.23	0.8	0.45	0.4	5.2
TP-23	SP-SM	1.0 – 5.0	0.08	0.18	0.23	0.8	0.45	0.4	5.7

SEISMIC DESIGN CONSIDERATIONS

General

We understand that seismic design will likely be performed using the 2015 IBC standards. The following parameters may be used in computing seismic base shear forces:

Table 2. 2015 IBC Seismic Design Parameters

Spectral Response Accel. at Short Periods (S_S) = 1.31
Spectral Response Accel. at 1 Second Periods (S_1) = 0.55
Site Class = D
Site Coefficient (F_A) = 1.0
Site Coefficient (F_V) = 1.5

A full report for the seismic design parameters is presented in Attachment C.

Ground Rupture

Because of the location of the site with respect to the nearest known active crustal faults, and the presence of a relatively thick layer of glacial outwash deposits, it is our opinion that the risk of ground rupture at the site due to surface faulting is low.

Soil Liquefaction

Liquefaction refers to a condition where vibration or shaking of the ground, usually from earthquake forces, results in the development of excess pore water pressures in saturated soils, and a subsequent loss of stiffness in the soil occurs. Liquefaction also causes a temporary reduction of soil shear strength and bearing capacity, which can cause settlement of the ground surface above the liquefied soil layers. In general, soils that are most susceptible to liquefaction include saturated, loose to medium dense, clean to silty sands and non-plastic silts within 50 feet of the ground surface.

Based on our review of the *Liquefaction Susceptibility Map of Thurston County (Palmer, 2004)*, the project site is identified to have a low to moderate potential risk for soil liquefaction. Given the fine-grained nature of the soils and the high winter groundwater elevations, it is our opinion that the susceptibility for liquefaction at the site should be considered as moderate to high, depending on the time of year.

Seismic Compression

Seismic compression is defined as the accrual of contractive volumetric strains in unsaturated soils during strong shaking from earthquakes (Stewart et al., 2004). Loose to medium dense clean sands and non-plastic silts are particularly prone to seismic compression settlement. Seismic compression settlement is most prevalent on slopes, but it can also occur on flat ground. It is our opinion that the upper 6 to 10 feet of the soil profile at the site has a low risk for seismic compression settlement.

Seismic Settlement Discussion

Based on the materials encountered in our explorations, it is our preliminary opinion that seismic settlements (liquefaction-induced plus seismic compression) could potentially total a few inches at the site as the result of an IBC design level earthquake. We are available upon request to perform deep subsurface explorations and detailed seismic settlement estimates during the design phase.

Seismic Slope Instability

The maximum inclination of the site is generally less than 10 percent and we did not observe signs of slope instability during our site work. In our opinion, there is a low risk of seismic slope instability at the project site under current conditions.

Lateral Spreading

Lateral spreading involves the lateral displacement of surficial blocks of non-liquefied soil when an underlying soil layer liquefies. Lateral spreading generally develops in areas where sloping ground or large grade changes are present. Based on our understanding of the subsurface conditions, it is our opinion that there is a low risk for the development of lateral spreading as a result of an IBC design level earthquake.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our review, subsurface explorations, and engineering analyses, it is our opinion that the proposed development is feasible from a geotechnical standpoint. We recommend that the proposed structures be supported on shallow concrete foundations that are designed using an allowable soil bearing capacity of 2,000 pounds per square foot (psf) when founded within the sand with silt unit.

The soils encountered in our explorations are typically in a loose condition near the ground surface. To limit the potential for structure settlement, we recommend that shallow foundations and slabs-on-grade be established on a minimum 1-foot thick layer of compacted structural fill. Depending on final grading plans and the time of year earthwork is performed; it could be practical to reuse the on-site soils as structural fill under the foundations/slabs.

Earthwork

General

We anticipate that site development earthwork will include removal of the existing residential building and accessory structures, clearing and stripping of existing vegetation, preparing subgrades, excavating for utility trenches, installing ground improvements, and placing and compacting structural fill. We expect that the majority of site grading can be accomplished with conventional earthmoving equipment in proper working order.

Our explorations did not encounter appreciable amounts of debris or unsuitable soils associated with past site development. However, it is possible that concrete slabs, abandoned utility lines or other development features could be encountered during construction. The contractor should be prepared to deal with these conditions.

Clearing and Stripping

Clearing and stripping should consist of removing surface and subsurface deleterious materials including sod/topsoil, trees, brush, debris and other unsuitable loose/soft or organic materials. Stripping and clearing should extend at least 5 feet beyond all structures and areas to receive structural fill.

We estimate that a stripping depth of about 1 foot will be required to remove the surficial organic layer encountered located at the site. Deeper stripping depths may be required if additional unsuitable soils are exposed during stripping operations. We recommend that trees be removed by overturning so that the majority of roots are also removed. Depressions created by tree or stump removal should be backfilled with structural fill and properly compacted.

Subgrade Preparation

After stripping and excavating to the proposed subgrade elevation, and before placing structural fill or foundation concrete, the exposed subgrade should be thoroughly compacted to a firm and unyielding condition. The exposed subgrade should then be proof-rolled using loaded, rubber-tired heavy equipment. We recommend that Insight Geologic be retained to observe the proof-rolling prior to the placement of structural fill or foundation concrete. Areas of limited access that cannot be proof-rolled can be evaluated using a steel probe rod. If soft or otherwise unsuitable areas are revealed during proof-rolling or probing, that cannot be compacted to a stable and uniformly firm condition, we generally recommend that: 1) the subgrade soils be scarified (e.g., with a ripper or farmer's disc), aerated and recompacted; or 2) the unsuitable soils be overexcavated and replaced with structural fill.

Temporary Excavations and Groundwater Handling

Excavations deeper than 4 feet should be shored or laid back at a stable slope if workers are required to enter. Shoring and temporary slope inclinations must conform to the provisions of Title 296 Washington Administrative Code (WAC), Part N, "Excavation, Trenching and Shoring." Regardless of the soil type encountered in the excavation, shoring, trench boxes or sloped sidewalls were required under the Washington Industrial Safety and Health Act (WISHA). The contract documents should specify that the contractor is responsible for selecting excavation and dewatering methods, monitoring the excavations for safety and providing shoring, as required, to protect personnel and structures.

In general, temporary cut slopes should be inclined no steeper than about 1.5H:1V (horizontal: vertical). This guideline assumes that all surface loads are kept at a minimum distance of at least one-half the depth of the cut away from the top of the slope and that significant seepage is not present on the slope face. Flatter cut slopes were necessary where significant seepage occurs or if large voids are created during excavation. Some sloughing and raveling of cut slopes should be expected. Temporary covering with heavy plastic sheeting should be used to protect slopes during periods of wet weather.

We anticipate that groundwater may be encountered during construction within deeper utility trenches greater than 4 feet in depth along the western half of the site. The installation of deep utility trenches will be difficult, if not impossible, without an engineered dewatering system that will need to be developed for the site. Groundwater handling needs will generally be lower during the late summer and early fall months. We recommend that the contractor performing the work be made responsible for controlling and collecting groundwater encountered during construction.

Permanent Slopes

We do not anticipate that permanent slopes will be utilized for the proposed project. If permanent slopes are necessary, we recommend the slopes be constructed at a maximum inclination of 2H:1V. Where 2H:1V permanent slopes are not feasible, protective facings and/or retaining structures should be considered.

To achieve uniform compaction, we recommend that fill slopes be overbuilt and subsequently cut back to expose well-compacted fill. Fill placement on slopes should be benched into the slope face and include keyways. The configuration of the bench and keyway depends on the equipment being used. Bench excavations should be level and extend into the slope face. We recommend that a vertical cut of about 3 feet be maintained for benched excavations. Keyways should be about 1-1/2 times the width of the equipment used for grading or compaction.

Erosion Control

We anticipate that erosion control measures such as silt fences, straw bales and sand bags will generally be adequate during development. Temporary erosion control should be provided during construction activities and until permanent erosion control measures are functional. Surface water runoff should be properly contained and channeled using drainage ditches, berms, swales, and tightlines, and should not discharge onto sloped areas. Any disturbed sloped areas should be protected with a temporary covering until new vegetation can take effect. Jute or coconut fiber matting, excelsior matting or clear plastic sheeting is suitable for this purpose. Graded or disturbed slopes should be tracked in-place with the equipment running perpendicular to the slope contours so that the track marks provide a texture to help resist erosion. Ultimately, erosion control measures should be in accordance with local regulations and should be clearly described on project plans.

Wet Weather Earthwork

Some of the near-surface soils contain up to about 12 percent fines. When the moisture content of the soil is more than a few percent above the optimum moisture content, the soil will become unstable and it may become difficult or impossible to meet the required compaction criteria. Disturbance of near-surface soils should be expected if earthwork is completed during periods of wet weather.

The wet weather season in this area generally begins in October and continues through May. However, periods of wet weather may occur during any month of the year. If wet weather earthwork is unavoidable, we recommend that:

- The ground surface is sloped so that surface water is collected and directed away from the work area to an approved collection/dispersion point.
- Earthwork activities not take place during periods of heavy precipitation.
- Slopes with exposed soil be covered with plastic sheeting or otherwise protected from erosion.
- Measures are taken to prevent on-site soil and soil stockpiles from becoming wet or unstable. Sealing the surficial soil by rolling with a smooth-drum roller prior to periods of precipitation should reduce the extent that the soil becomes wet or unstable.
- Construction traffic is restricted to specific areas of the site, preferably areas that are surfaced with materials not susceptible to wet weather disturbance.
- A minimum 1-foot thick layer of 4- to 6-inch quarry spalls is used in high traffic areas of the site to protect the subgrade soil from disturbance.
- Contingencies are included in the project schedule and budget to allow for the above elements.

Structural Fill Materials

General

Material used for structural fill should be free of debris, organic material and rock fragments larger than 3 inches. The workability of material for use as structural fill will depend on the gradation and moisture content of the soil. As the amount of fines increases, soil becomes increasingly more sensitive to small changes in moisture content and adequate compaction becomes more difficult or impossible to achieve.

On-Site Soil

We anticipate that the majority of the on-site soils encountered during construction will consist of sand with silt or silty sand, located at or near the surface of the site. It is our opinion, that this material is a suitable source for structural fill during a limited portion of the year. We anticipate that thin lifts (6-inches thick or less) will likely be needed to obtain structural fill compaction specifications. During the winter and spring months, it is likely that the moisture content of the material will be over optimum, and as a result, adequate compaction will be difficult or impossible to achieve. On-site materials used as structural fill should be free of roots, organic matter and other deleterious materials and particles larger than 3 inches in diameter.

Select Granular Fill

Select granular fill should consist of imported, well-graded sand and gravel or crushed rock with a maximum particle size of 3 inches and less than 5 percent passing a U.S. Standard No. 200 sieve based on the minus ¾-inch fraction. Organic matter, debris or other deleterious material should not be present. In our experience, “gravel borrow” as described in Section 9-03.14(1) of the 2020 WSDOT

Standard Specifications is typically a suitable source for select granular fill during periods of wet weather, provided that the percent passing a U.S. Standard No. 200 sieve is less than 5 percent based on the minus ¾-inch fraction.

Structural Fill Placement and Compaction

General

Structural fill should be placed on an approved subgrade that consists of uniformly firm and unyielding inorganic native soils or compacted structural fill. Structural fill should be compacted at a moisture content near optimum. The optimum moisture content varies with the soil gradation and should be evaluated during construction.

Structural fill should be placed in uniform, horizontal lifts and uniformly densified with vibratory compaction equipment. The maximum lift thickness will vary depending on the material and compaction equipment used but should generally not exceed the loose thicknesses provided in Table 3. Structural fill materials should be compacted in accordance with the compaction criteria provided in Table 4.

Table 3. Recommended Uncompacted Lift Thickness

Compaction Equipment	Recommended Uncompacted Fill Thickness (inches)	
	Granular Materials Maximum Particle Size ≤ 1 1/2 inch	Granular Materials Maximum Particle Size > 1 1/2 inch
Hand Tools (Plate Compactors and Jumping Jacks)	4 – 8	Not Recommended
Rubber-tire Equipment	10 – 12	6 – 8
Light Roller	10 – 12	8 – 10
Heavy Roller	12 – 18	12 – 16
Hoe Pack Equipment	18 – 24	12 – 16

Note: The above table is intended to serve as a guideline and should not be included in the project specifications.

Table 4. Recommended Compaction Criteria in Structural Fill Zones

Fill Type	Percent Maximum Dry Density Determined by ASTM Test Method D 1557 at ±3% of Optimum Moisture		
	0 to 2 Feet Below Subgrade	> 2 Feet Below Subgrade	Pipe Zone
Imported or On-site Granular, Maximum Particle Size < 1-1/4-inch	95	95	-----
Imported or On-site Granular, Maximum Particle Size >1-1/4-inch	N/A (Proof-roll)	N/A (Proof-roll)	-----
Trench Backfill[1]	95	92	90

Note: [1]Trench backfill above the pipe zone in nonstructural areas should be compacted to at least 85 percent.

Shallow Foundation Support

General

We recommend that the proposed structures be founded on continuous wall or isolated column footings, bearing on a minimum 1-foot thick overexcavation and replacement with compacted structural fill where underlying soils are not able to be compacted as structural fill. The structural fill zone should extend to a horizontal distance equal to the overexcavation depth on each side of the footing. The actual overexcavation depth will vary, depending on the conditions encountered.

We recommend that a representative from Insight Geologic observe the foundation surfaces before overexcavation, and before placing structural fill. Our representative should confirm that adequate bearing surfaces have been prepared and that the soil conditions are as anticipated. Unsuitable foundation bearing soils should be recompacted or removed and replaced with compacted structural fill, as recommended by the geotechnical engineer.

Bearing Capacity and Footing Dimensions

We recommend an allowable soil bearing pressure of 2,000 psf for shallow foundations that are supported as recommended. This allowable bearing pressure applies to long-term dead and live loads exclusive of the weight of the footing and any overlying backfill. The allowable soil bearing pressure can be increased by one-third when considering total loads, including transient loads such as those induced by wind and seismic forces.

Perimeter footings should be embedded at least 12 inches below the lowest adjacent grade where the ground is flat. Interior footings should be embedded a minimum of 6 inches below the nearest adjacent grade.

Settlement

We estimate that the total settlement of footings that are designed and constructed as recommended should be less than 1 inch. We estimate that differential settlement should be ½ inch or less between comparably loaded isolated footings or along 50 feet of continuous footing. We anticipate that the settlement will occur essentially as loads are applied during construction.

Subsurface Drainage

It is our opinion, that foundation footing drains and underslab drains are likely unnecessary for the proposed structures. The site soils are moderate to very well-draining, and it is unlikely that subsurface drains would produce water.

Lateral Load Resistance

Lateral loads on shallow foundation elements may be resisted by passive resistance on the sides of footings and by friction on the base of footings. Passive resistance may be estimated using an equivalent fluid density of 300 pounds per cubic foot (pcf), assuming that the footings are backfilled with structural fill. Frictional resistance may be estimated using 0.25 for the coefficient of base friction.

The lateral resistance values provided above incorporate a factor of safety of 1.5. The passive earth pressure and friction components can be combined, provided that the passive component does not exceed two-thirds of the total. The top foot of soil should be neglected when calculating passive resistance, unless the foundation perimeter area is covered by a slab-on-grade or pavement.

Slabs-On-Grade

Slabs-on-grade should be established on a minimum 1-foot thick section of structural fill extending to an approved bearing surface. A modulus of vertical subgrade reaction (subgrade modulus) can be used to design slabs-on-grade. The subgrade modulus varies 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. We recommend a modulus value of 200 pounds per cubic inch (pci) for design of on-grade floor slabs with floor loads up to 500 psf. We are available to provide alternate subgrade modulus recommendations during design, based on specific loading information.

We recommend that slabs-on-grade in interior spaces be underlain by a minimum 4-inch thick capillary break layer to reduce the potential for moisture migration into the slab. The capillary break material should consist of well-graded sand and gravel or crushed rock containing less than 5 percent fines based on the fraction passing the ¾-inch sieve. The 4-inch thick capillary break layer can be included when calculating the minimum 1-foot thick structural fill section beneath the slab. If dry slabs are required (e.g., where adhesives are used to anchor carpet or tile to the slab), a waterproofing liner should be placed below the slab to act as a vapor barrier.

Conventional Retaining Walls

General

The following sections provide general guidelines for retaining wall design on this site. Since the site is fairly level, we do not anticipate that retaining walls will be necessary. However, we should be contacted during the design phase to review retaining wall plans and provide supplemental recommendations, if needed.

Drainage

Positive drainage is imperative behind any retaining structure. This can be accomplished by using a zone of free-draining material behind the wall with perforated pipes to collect water seepage. The drainage material should consist of coarse sand and gravel containing less than 5 percent fines based on the fraction of material passing the ¾-inch sieve. The wall drainage zone should extend horizontally at least 12 inches from the back of the wall. If a stacked block wall is constructed, we recommend that a barrier such as a non-woven geotextile filter fabric be placed against the back of the wall to prevent loss of the drainage material through the wall joints.

A perforated smooth-walled rigid PVC pipe, having a minimum diameter of 4 inches, should be placed at the bottom of the drainage zone along the entire length of the wall. Drainpipes should discharge to a tightline leading to an appropriate collection and disposal system. An adequate number of cleanouts should be incorporated into the design of the drains in order to provide access for regular maintenance. Roof downspouts, perimeter drains or other types of drainage systems should not be connected to retaining wall drain systems.

Design Parameters

We recommend an active lateral earth pressure of 37 pcf (equivalent fluid density) for a level backfill condition. This assumes that the top of the wall is not structurally restrained and is free to rotate. For restrained walls that are fixed against rotation (at-rest condition), an equivalent fluid density of 56 pcf can be used for the level backfill condition. For seismic conditions, we recommend a uniform lateral pressure of 14H psf (where H is the height of the wall) be added to the lateral pressures. This seismic pressure assumes a peak ground acceleration of 0.32 g. Note that if the retaining system is designed as a braced system but is expected to yield a small amount during a seismic event, the active earth pressure condition may be assumed and combined with the seismic surcharge.

The recommended earth pressure values do not include the effects of surcharges from surface loads or structures. If vehicles are to be operated within a distance equal to one-half the height of the wall, a traffic surcharge should be added to the wall pressure. The traffic surcharge can be approximated by the equivalent weight of an additional 2 feet of backfill behind the wall. Other surcharge loads, such as construction equipment, staging areas, and stockpiled fill, should be considered on a case-by-case basis.

DOCUMENT REVIEW AND CONSTRUCTION OBSERVATION

We recommend that we be retained to review the portions of the plans and specifications that pertain to earthwork construction and stormwater infiltration. We recommend that monitoring, testing and consultation be performed during construction to confirm that the conditions encountered are consistent with our explorations and our stated design assumptions. Insight Geologic would be pleased to provide these services upon request.

REFERENCES

International Code Council, International Building Code, 2015.

Seismic Compression of As-compacted Fill Soils with Variable Levels of Fines Content and Fines Plasticity, Department of Civil and Environmental Engineering, University of California, Los Angeles, July 2004.

Washington State Department of Transportation (WSDOT), Standard Specifications for Road, Bridge and Municipal Construction Manual, 2020.

LIMITATIONS

We have prepared this geotechnical investigation report for the exclusive use of Hatton Godat Pantier and their authorized agents for the proposed Ticknor Farms development project located at 7927 Littlerock Road SW in Tumwater, Washington.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions, expressed or implied, should be understood.

Please refer to Attachment D titled “Report Limitations and Guidelines for Use” for additional information pertaining to use of this report.

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We appreciate the opportunity to be of service to you on this project. Please contact us if you have questions or require additional information.

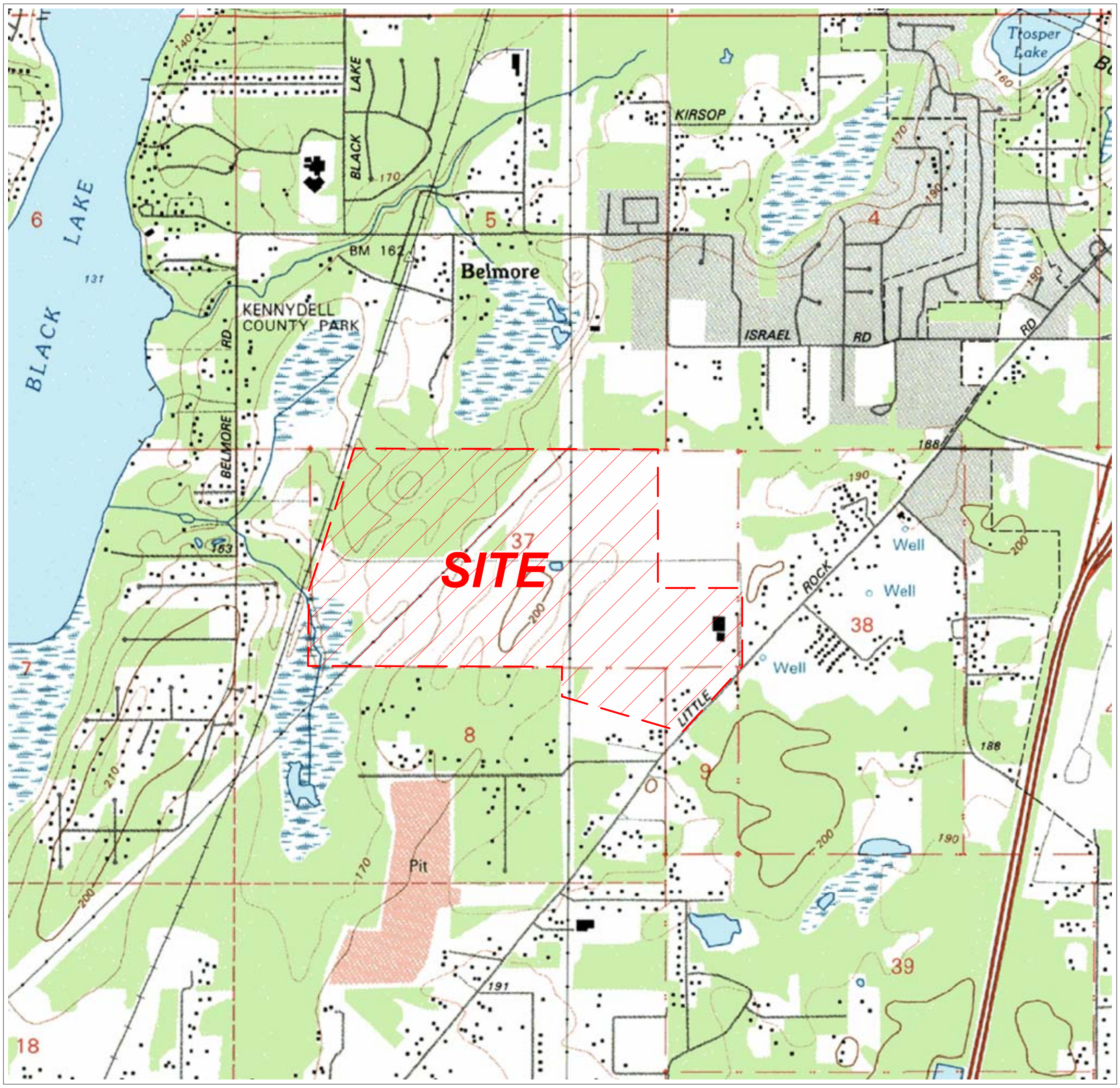
Respectfully Submitted,
INSIGHT GEOLOGIC, INC.

William E. Halbert, L.E.G., L.HG.
Principal

State of Washington
Engineering Geologist
816
Licensed Geologist
William E. Halbert

Attachments

FIGURES



MAYTOWN, WASHINGTON
7.5 MINUTE QUADRANGLE
Year 1990

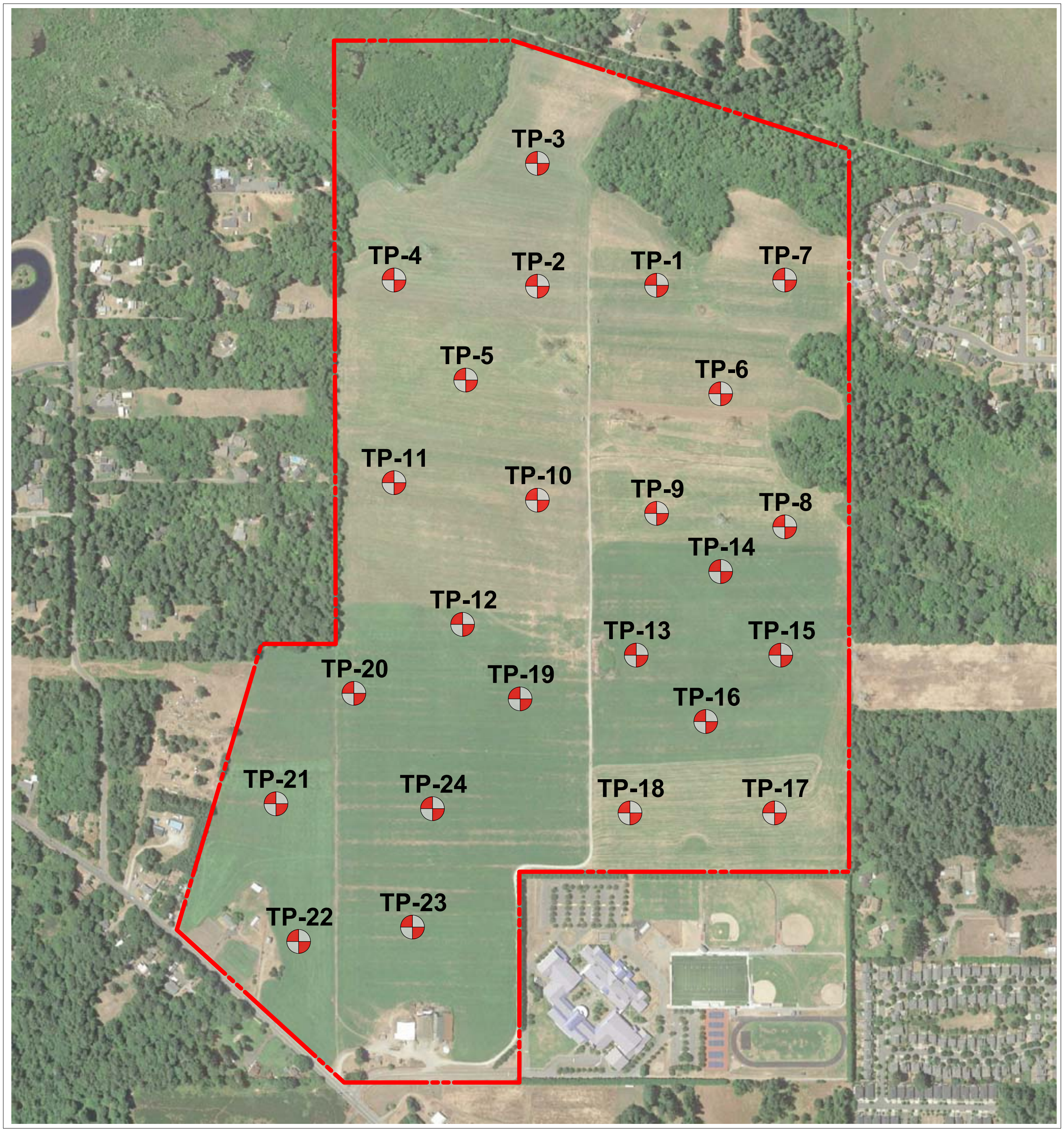
SCALE: 1: 24000

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Figure 1
Vicinity Map



SOURCE: GOOGLE EARTH

LEGEND:

TP-1 APPROXIMATE TEST PIT LOCATION

APPROXIMATE PROJECT BOUNDARY

SCALE: 1"=800'

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Figure 2

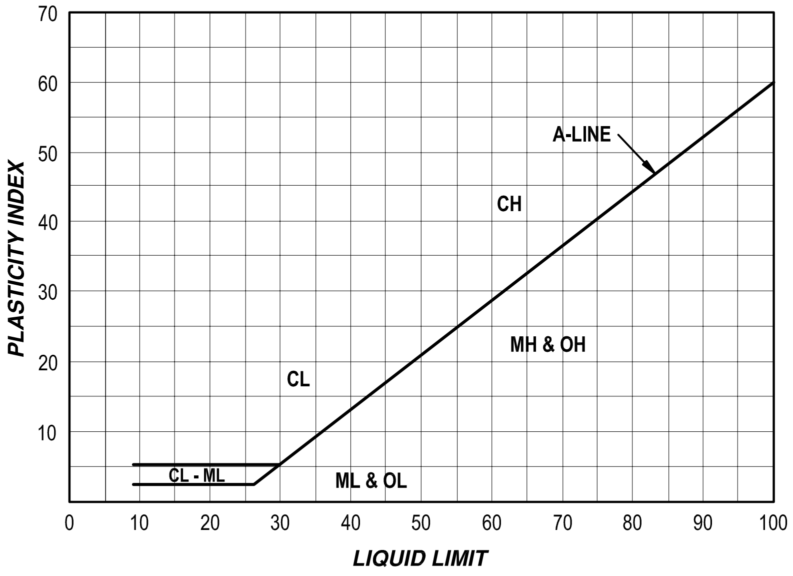
Site Plan

ATTACHMENT A

EXPLORATION LOGS

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		GROUP NAME
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL <5% FINES	▨	**GW**	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			▨	**GP**	POORLY GRADED GRAVEL
		GRAVEL WITH FINES >12% FINES	▨	**GM**	SILTY GRAVEL
			▨	**GC**	CLAYEY GRAVEL
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SAND <5% FINES	▨	**SW**	WELL-GRADED SAND, FINE TO COARSE SAND
			▨	**SP**	POORLY GRADED SAND
		SAND WITH FINES >12% FINES	▨	**SM**	SILTY SAND
			▨	**SC**	CLAYEY SAND
FINE GRAINED SOILS MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50	INORGANIC	▨	**ML**	SILT
			▨	**CL**	CLAY
		ORGANIC	▨	**OL**	ORGANIC SILT, ORGANIC CLAY
	SILTS AND CLAYS LIQUID LIMIT 50 OR MORE	INORGANIC	▨	**MH**	SILT OF HIGH PLASTICITY, ELASTIC SILT
			▨	**CH**	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	▨	**OH**	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			▨	**PT**	PEAT



SOIL MOISTURE MODIFIERS:
DRY - ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH
MOIST - DAMP, BUT NO VISIBLE WATER
WET - VISIBLE FREE WATER OR SATURATED, USUALLY SOIL IS OBTAINED BELOW WATER TABLE

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS		TYPICAL DESCRIPTION
▨	**CC**	CEMENT CONCRETE
▨	**AC**	ASPHALT CONCRETE
▨	**CR**	CRUSHED ROCK / QUARRY SPALLS
▨	**TS**	TOPSOIL/SOD/DUFF

GROUNDWATER EXPLORATION SYMBOLS

▽	MEASURED GROUNDWATER LEVEL IN EXPLORATION, WELL, OR PIEZOMETER
▼	GROUNDWATER OBSERVED AT TIME OF EXPLORATION
≡	PERCHED WATER OBSERVED AT TIME OF EXPLORATION
▼	MEASURED FREE PRODUCT IN WELL OR PIEZOMETER

STRATIGRAPHIC CONTACT

——	APPROXIMATE CONTACT BETWEEN SOIL STRATA OR GEOLOGIC UNIT
– – –	APPROXIMATE LOCATION OF SOIL STRATA CHANGE WITHIN GEOLOGIC SOIL UNIT
⟋	APPROXIMATE GRADUAL CHANGE BETWEEN SOIL STRATA OR GEOLOGIC SOIL UNIT
- - -	APPROXIMATE GRADUAL CHANGE OF SOIL STRATA WITHIN GEOLOGIC SOIL UNIT

LABORATORY / FIELD TEST CLASSIFICATIONS

%F	PERECENT FINES	**MD**	MOISTURE CONTENT AND DRY DENSITY
AL	ATTERBERG LIMITS	**OC**	ORGANIC COMPOUND
CA	CHEMICAL ANALYSIS	**PM**	PERMEABILITY OR HYDRAULIC CONDUCTIVITY
CP	LABORATORY COMPACTION TEST	**PP**	POCKET PENETROMETER
CS	CONSOLIDATION TEST	**SA**	SIEVE ANALYSIS
DS	DIRECT SHEAR	**TX**	TRIAXIAL COMPRESSION
HA	HYDROMETER ANALYSIS	**UC**	UNCONFINED COMPRESSION
MC	MOISTURE CONTENT	**VS**	VANE SHEAR

SAMPLER SYMBOLS

■	2.4 INCH I.D. SPLIT BARREL	◫	SHELBY TUBE
◧	DIRECT-PUSH	☰	PISTON
◨	STANDARD PENETRATION TEST	☒	BULK OR GRAB

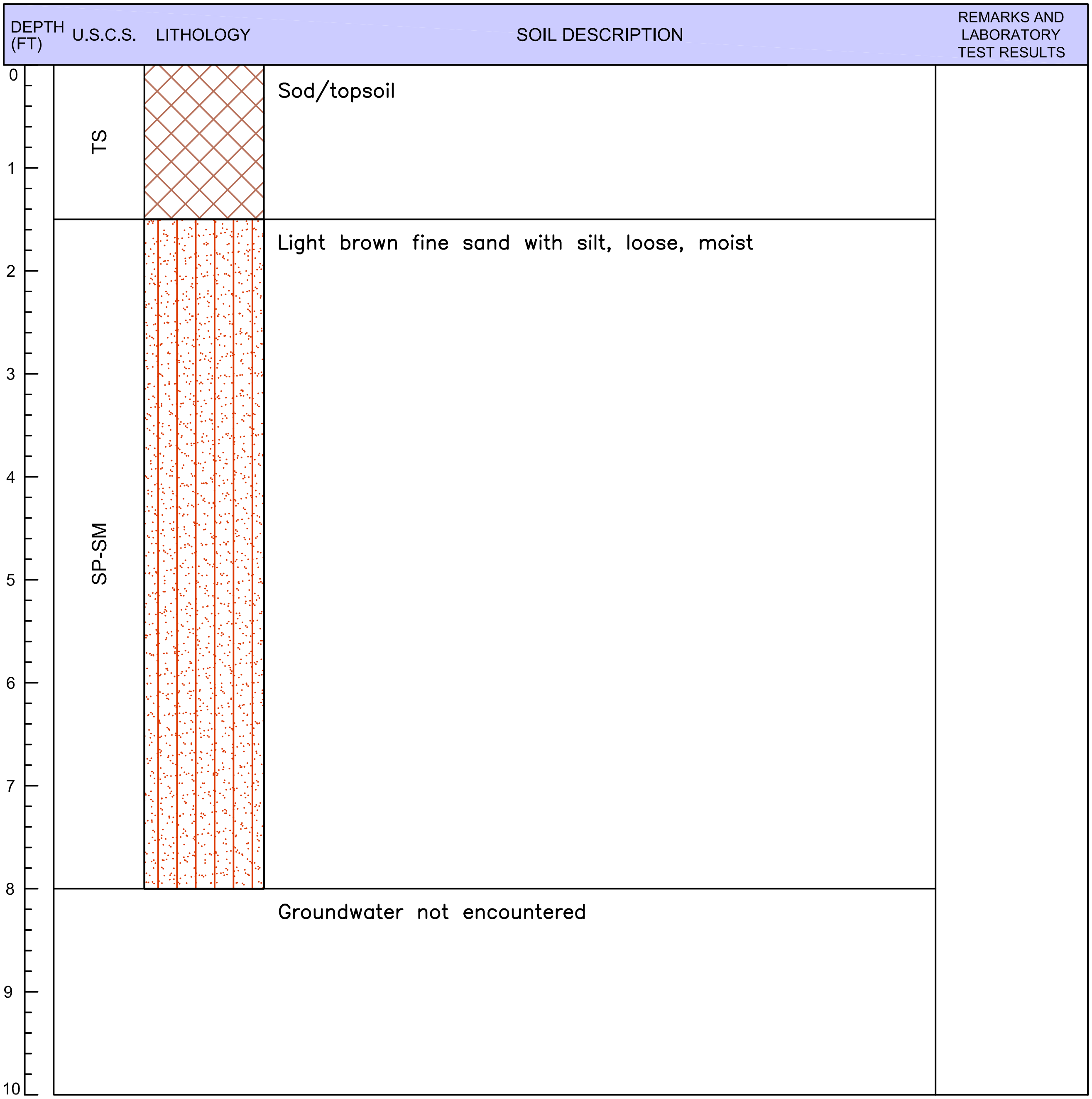
SHEEN CLASSIFICATIONS

NS	NO VISIBLE SHEEN
SS	SLIGHT SHEEN
MS	MODERATE SHEEN
HS	HEAVY SHEEN
NT	NOT TESTED

INSIGHT GEOLOGIC, INC.

Key to Exploration Logs

TP-1



Sod/topsoil

Light brown fine sand with silt, loose, moist

Groundwater not encountered

LEGEND:

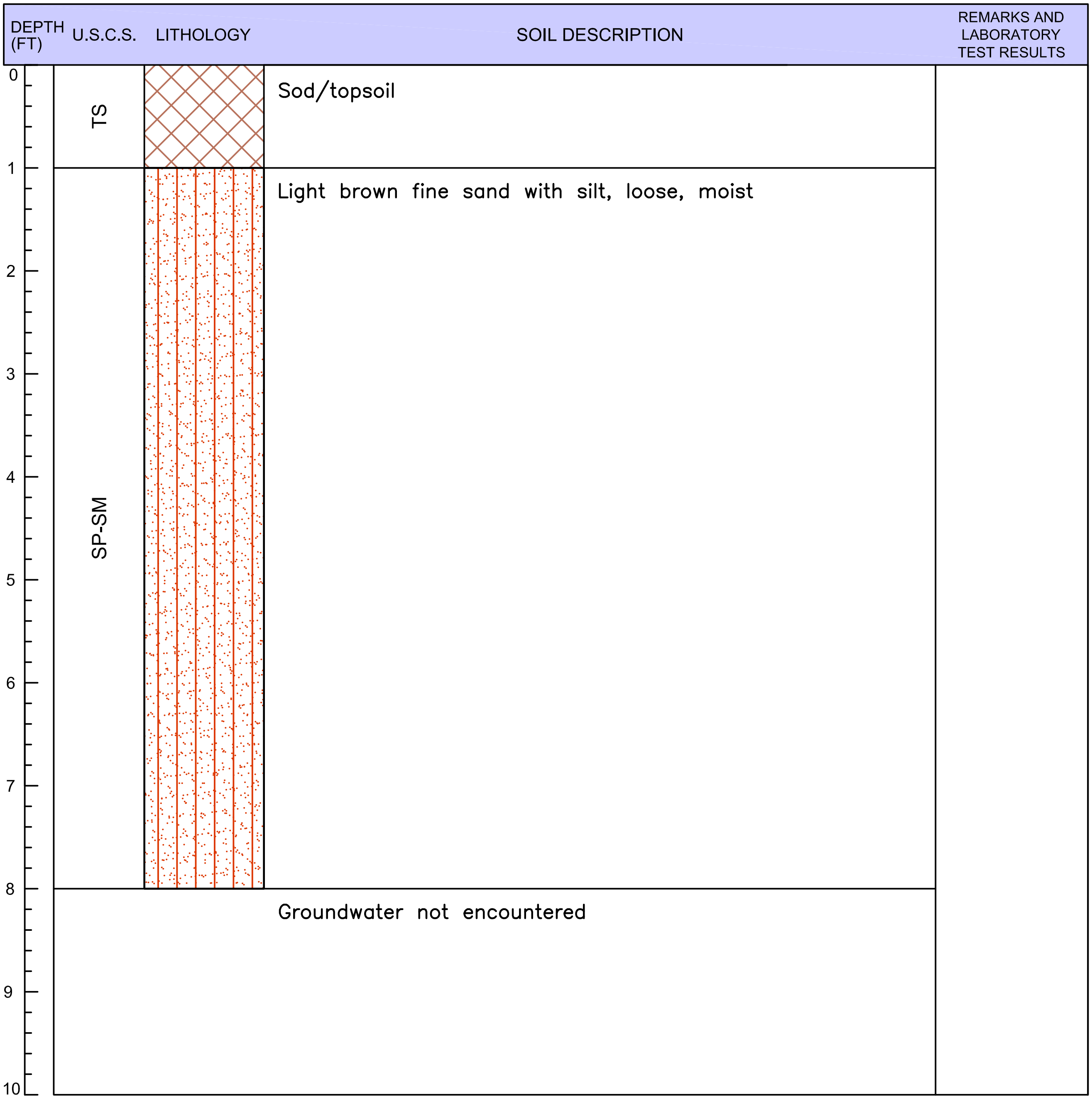
PROJECT NO.: 297-011-01
DATE: MARCH 4, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS
TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-1

TP-2



Sod/topsoil

Light brown fine sand with silt, loose, moist

Groundwater not encountered

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 4, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

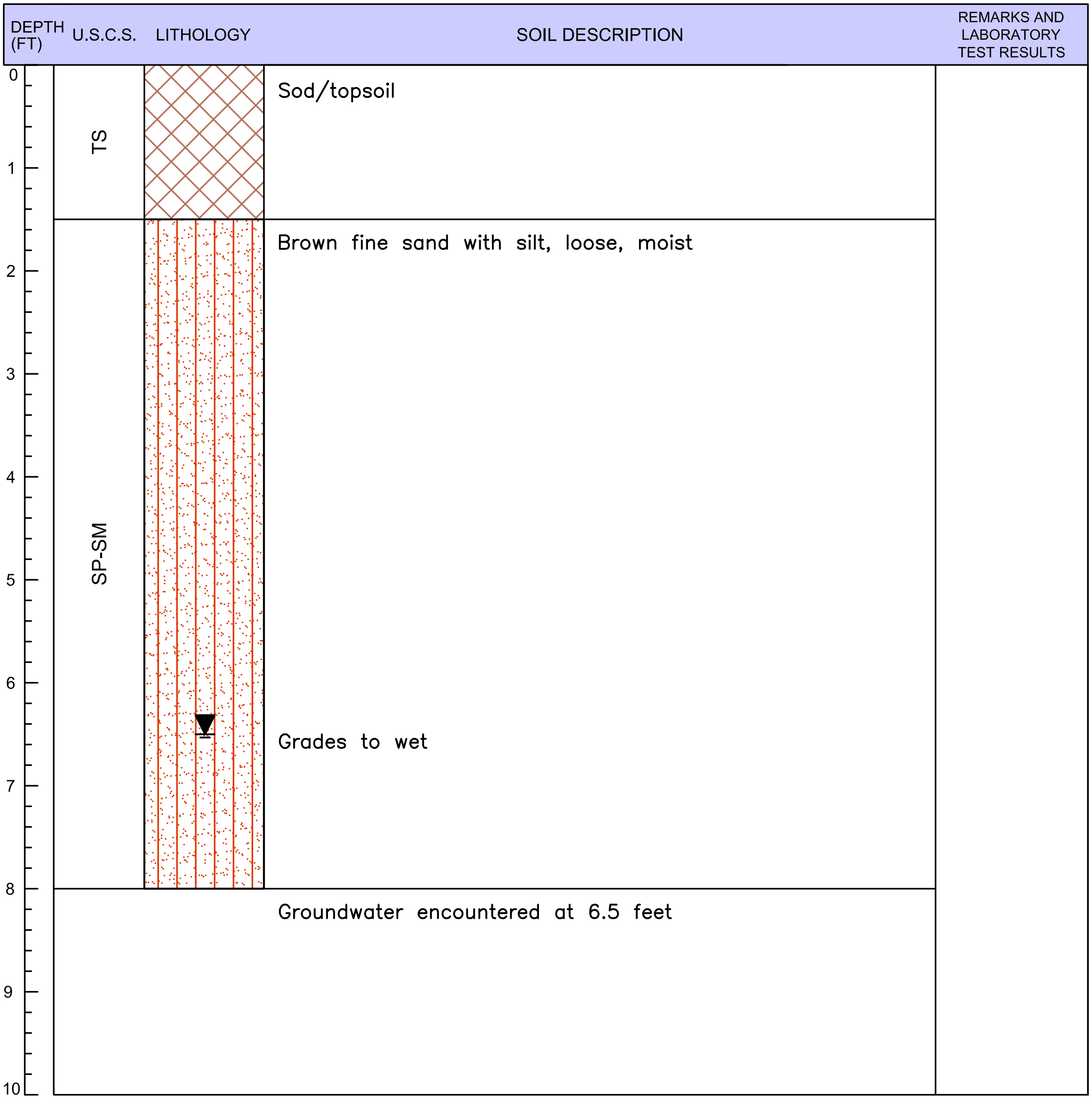
TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-2

TP-3



DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
	TS	▨	Sod/topsoil	
	SP-SM	▒	Brown fine sand with silt, loose, moist ▼ Grades to wet	
			Groundwater encountered at 6.5 feet	

LEGEND:

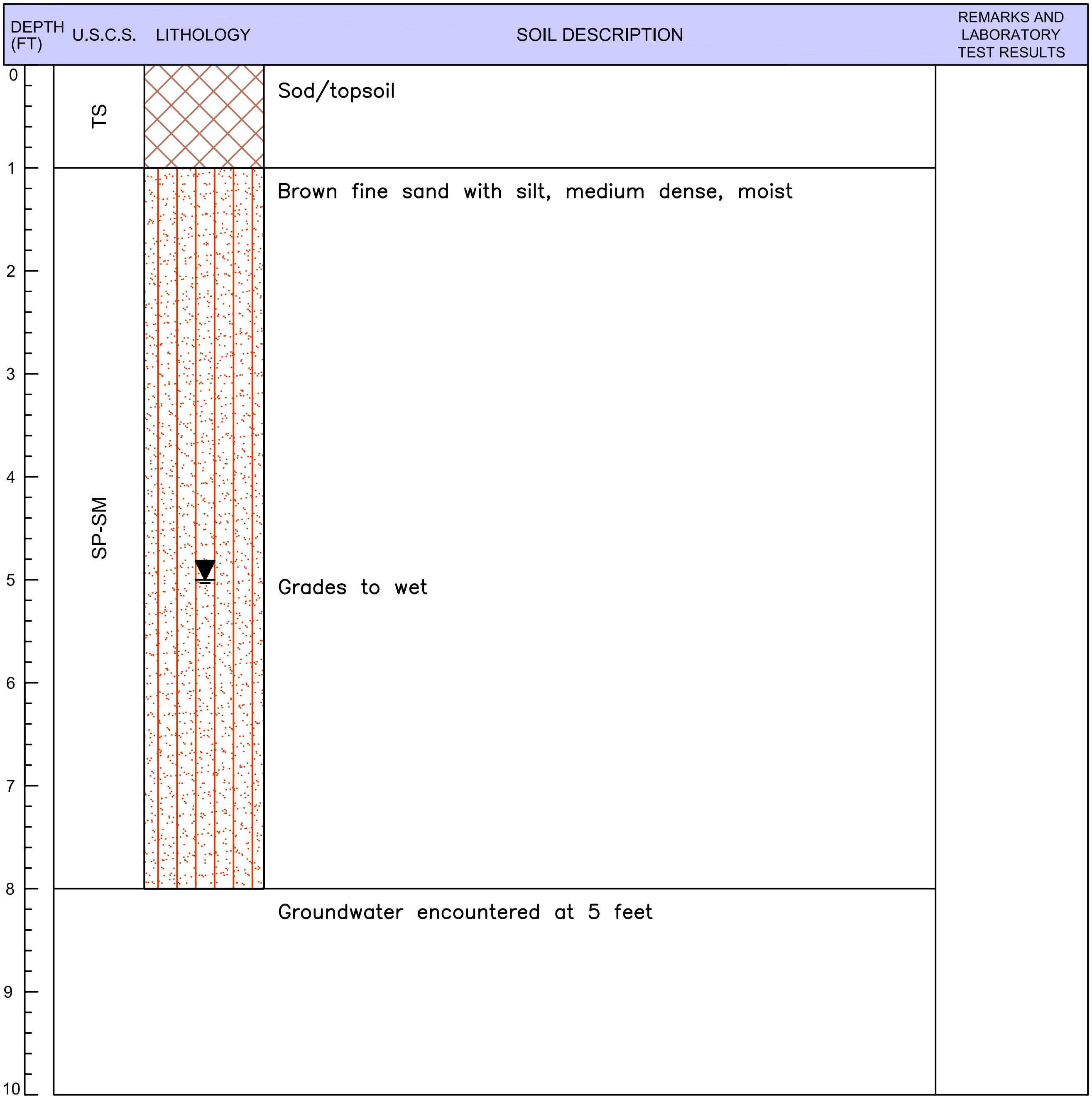
PROJECT NO.: 297-011-01
DATE: MARCH 4, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS
TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-3

TP-4



DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0	TS	▨	Sod/topsoil	
1	SP-SM		Brown fine sand with silt, medium dense, moist	
5		▼	Grades to wet	
8			Groundwater encountered at 5 feet	
10				

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 4, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

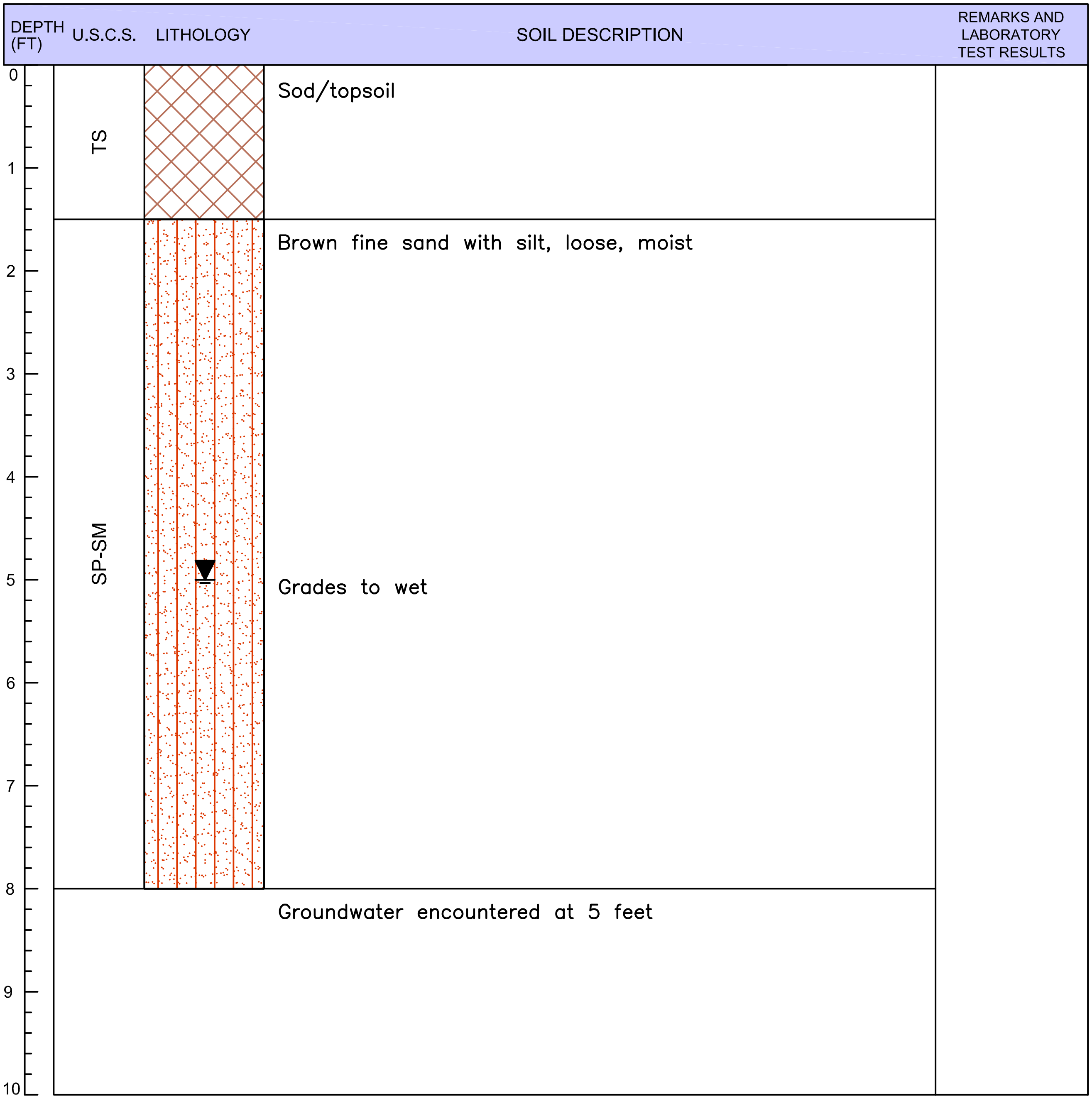
TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-4

TP-5



DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
	TS	▨	Sod/topsoil	
	SP-SM	▨	Brown fine sand with silt, loose, moist Grades to wet	
			Groundwater encountered at 5 feet	

LEGEND:

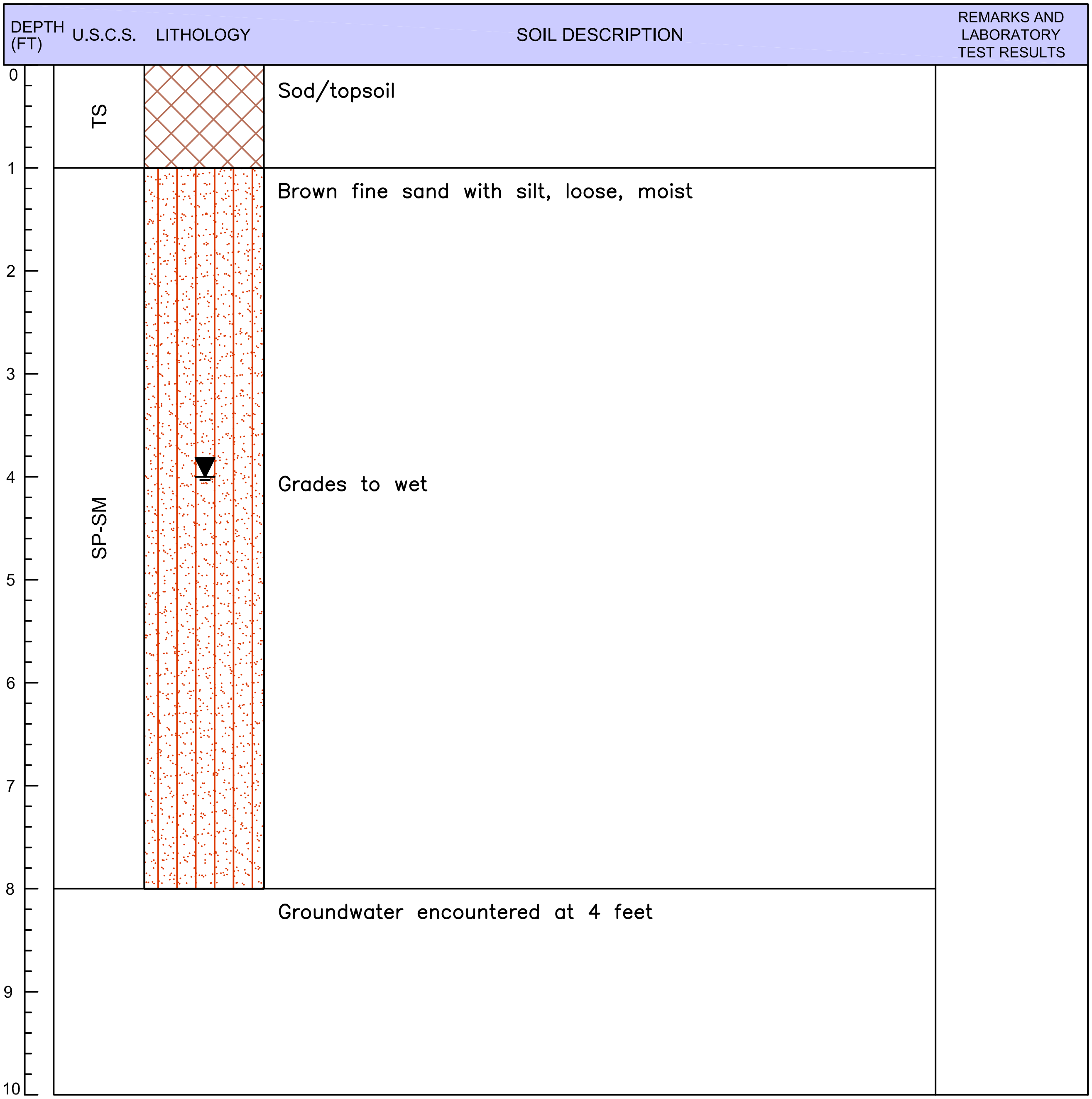
PROJECT NO.: 297-011-01
DATE: MARCH 4, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS
TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-5

TP-6



Sod/topsoil

Brown fine sand with silt, loose, moist

Grades to wet

Groundwater encountered at 4 feet

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 4, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-6

TP-7

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0	TS	▨	Sod/topsoil	
1	SP-SM	▥	Light brown fine sand with silt, loose, moist	
2				
3				
4				
5				
6				
7				
8			Groundwater not encountered	
9				
10				

LEGEND:

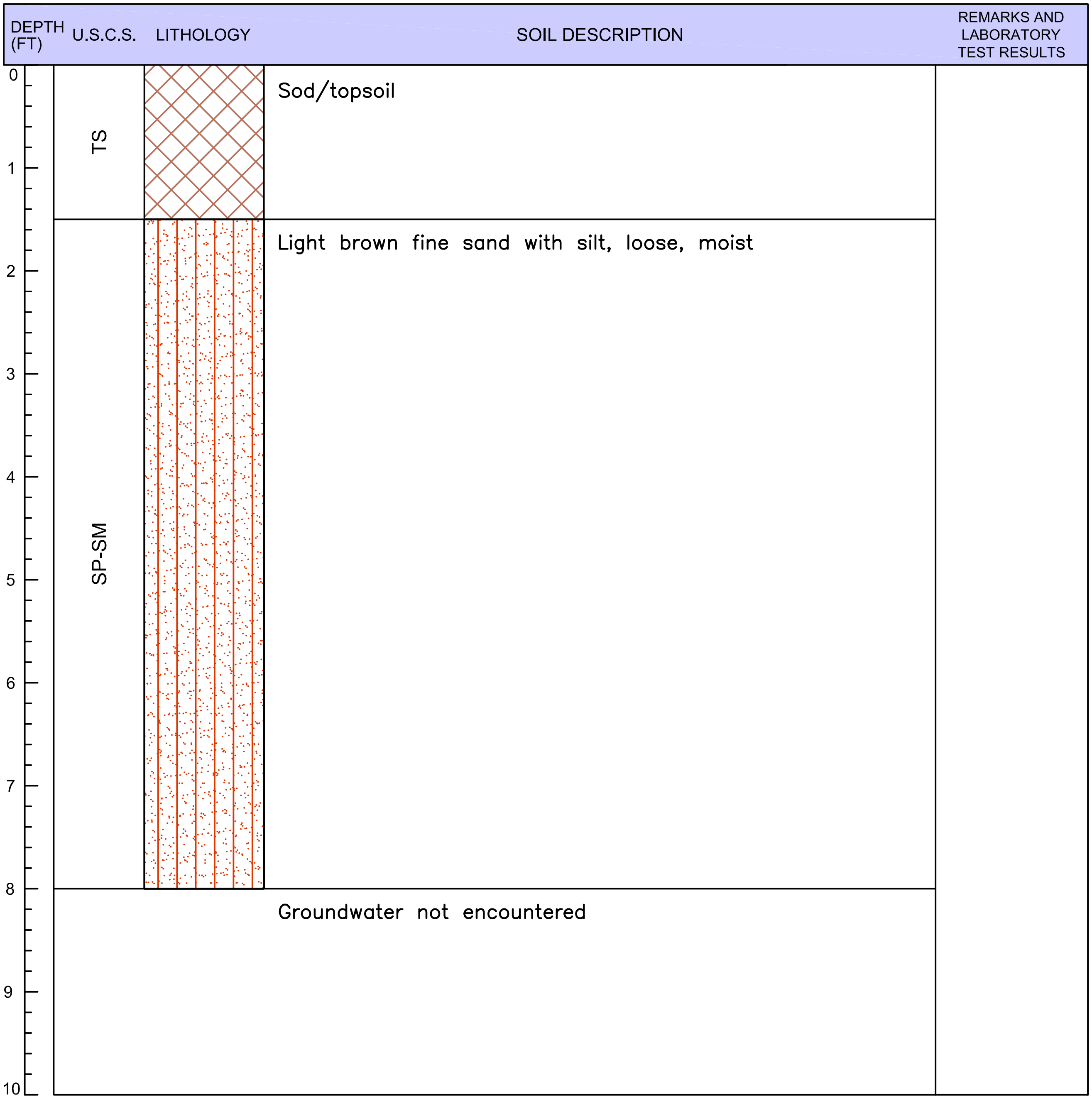
PROJECT NO.: 297-011-01
DATE: MARCH 4, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS
TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-7

TP-8



Sod/topsoil

Light brown fine sand with silt, loose, moist

Groundwater not encountered

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 4, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

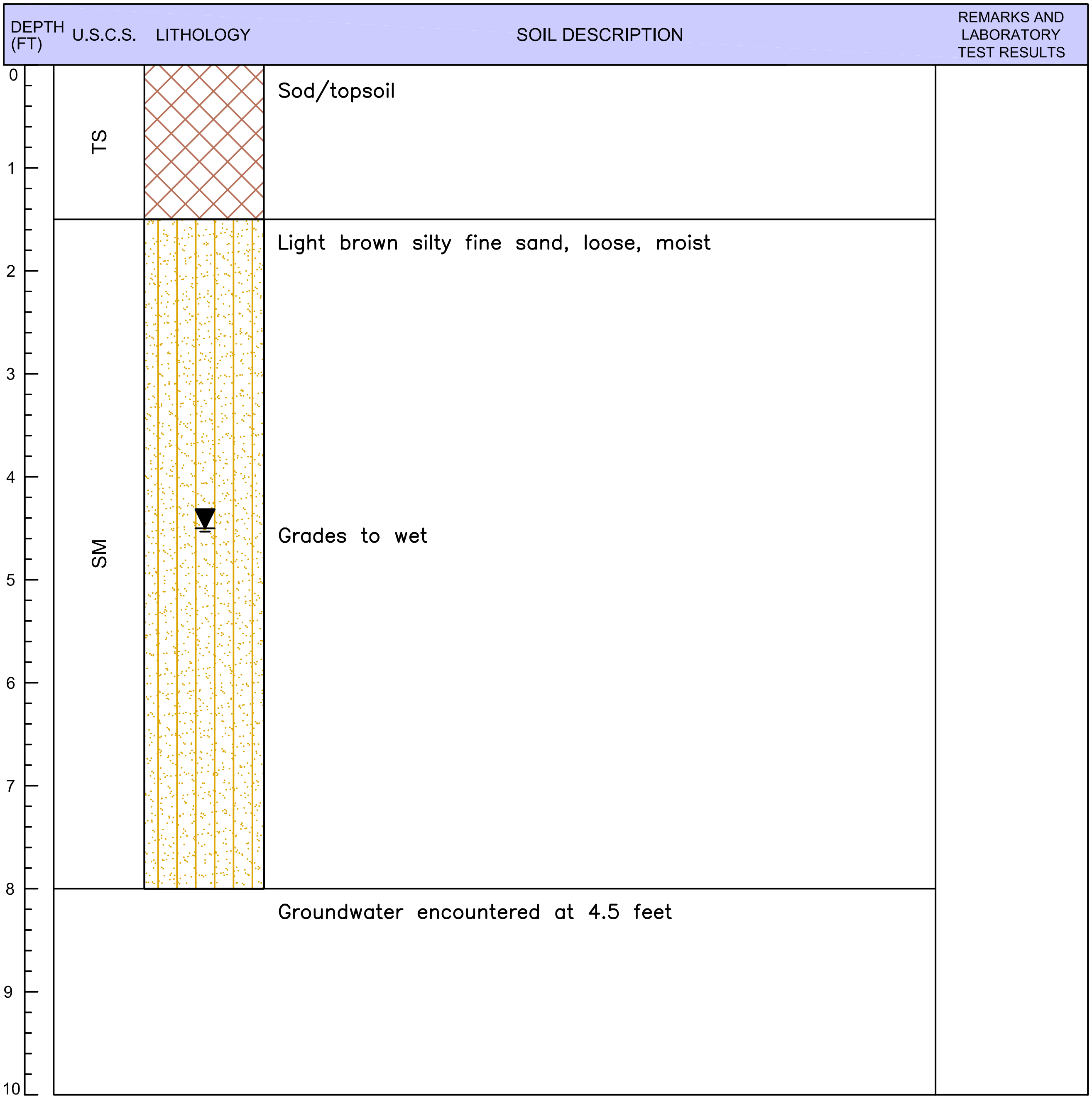
TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-8

TP-9



DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0	TS	▨	Sod/topsoil	
	SM		Light brown silty fine sand, loose, moist	
		▼	Grades to wet	
8			Groundwater encountered at 4.5 feet	

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 4, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-9

TP-10

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0 1	TS		Sod/topsoil	
2 3 4 5 6 7	SP-SM		Brown fine sand with silt, loose, moist	
8 9 10			Groundwater not encountered	

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 4, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-10

TP-11

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0	TS	▨	Sod/topsoil	
1 2 3 4 5	GW	▦	Brown fine to coarse gravel with medium to coarse sand, medium dense, moist	
6	ML	▥	Light brown silt with fine sand, medium stiff, moist	
7	SP	░	Brown fine to coarse sand with fine to coarse gravel, medium dense, moist	
8 9 10			Groundwater not encountered	

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 4, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-11

TP-12

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0–1	TS	▨	Sod/topsoil	
1–8	SP-SM	▥	Brown fine sand with silt, loose, moist	
8–10			Groundwater not encountered	

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

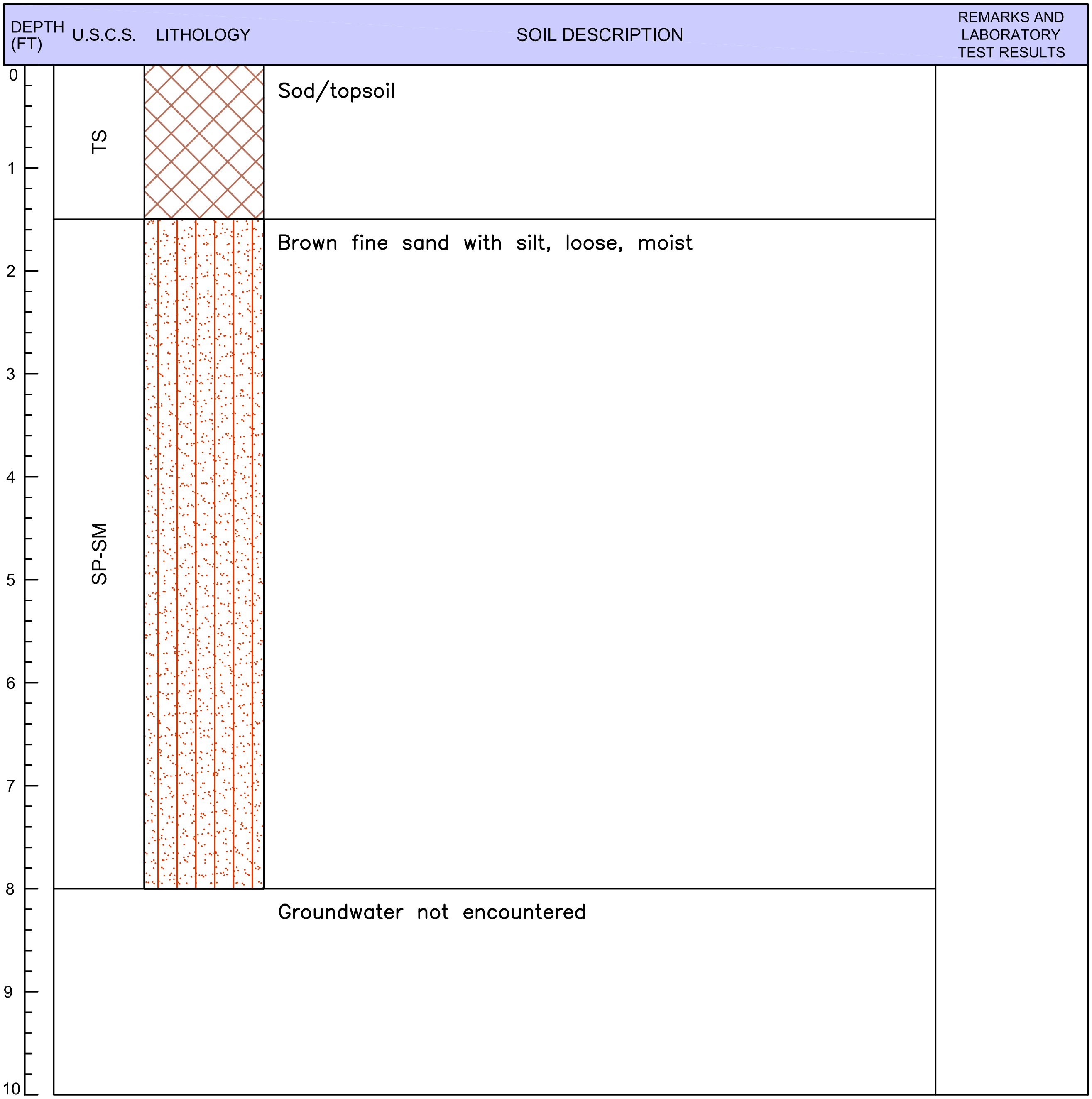
TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-12

TP-13



DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
	TS	▨	Sod/topsoil	
	SP-SM	▨	Brown fine sand with silt, loose, moist	
			Groundwater not encountered	

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-13

TP-14

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0	TS	▨	Sod/topsoil	
2	SP-SM	▨	Brown fine sand with silt, loose, moist	
8			Groundwater not encountered	
10				

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-14

TP-15

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0	TS	▨	Sod	
1	SP-SM	░	Dark brown fine sand with silt, loose, moist Grades to brown	
8			Groundwater not encountered	
10				

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-15

TP-16

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0	TS	▨	Sod/topsoil	
1	SP-SM	░	Brown fine sand with silt, loose, moist	
8			Groundwater not encountered	
10				

LEGEND:
PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS
TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-16

TP-17

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0	TS	▨	Sod/topsoil	
1	SP-SM	░	Brown fine sand with silt, loose, moist	
2				
3				
4				
5				
6				
7				
8			Groundwater not encountered	
9				
10				

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-17

TP-18

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0 1	TS	▨	Sod/topsoil	
2 3 4 5 6 7	SP-SM	▨	Brown fine sand with silt, loose, moist	
8 9 10			Groundwater not encountered	

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-18

TP-19

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0 1	TS	▨	Sod/topsoil	
2 3 4 5 6 7	SP-SM	▥ ▼	Brown fine sand with silt, loose, moist Grades to wet	
8 9 10			Groundwater encountered at 7.5 feet	

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS
TUMWATER, WASHINGTON

TP-20

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0–1	TS	▨	Sod	
1–8	SP-SM	▨	Dark brown fine sand with silt, loose, moist Grades to brown	
8			Groundwater not encountered	

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

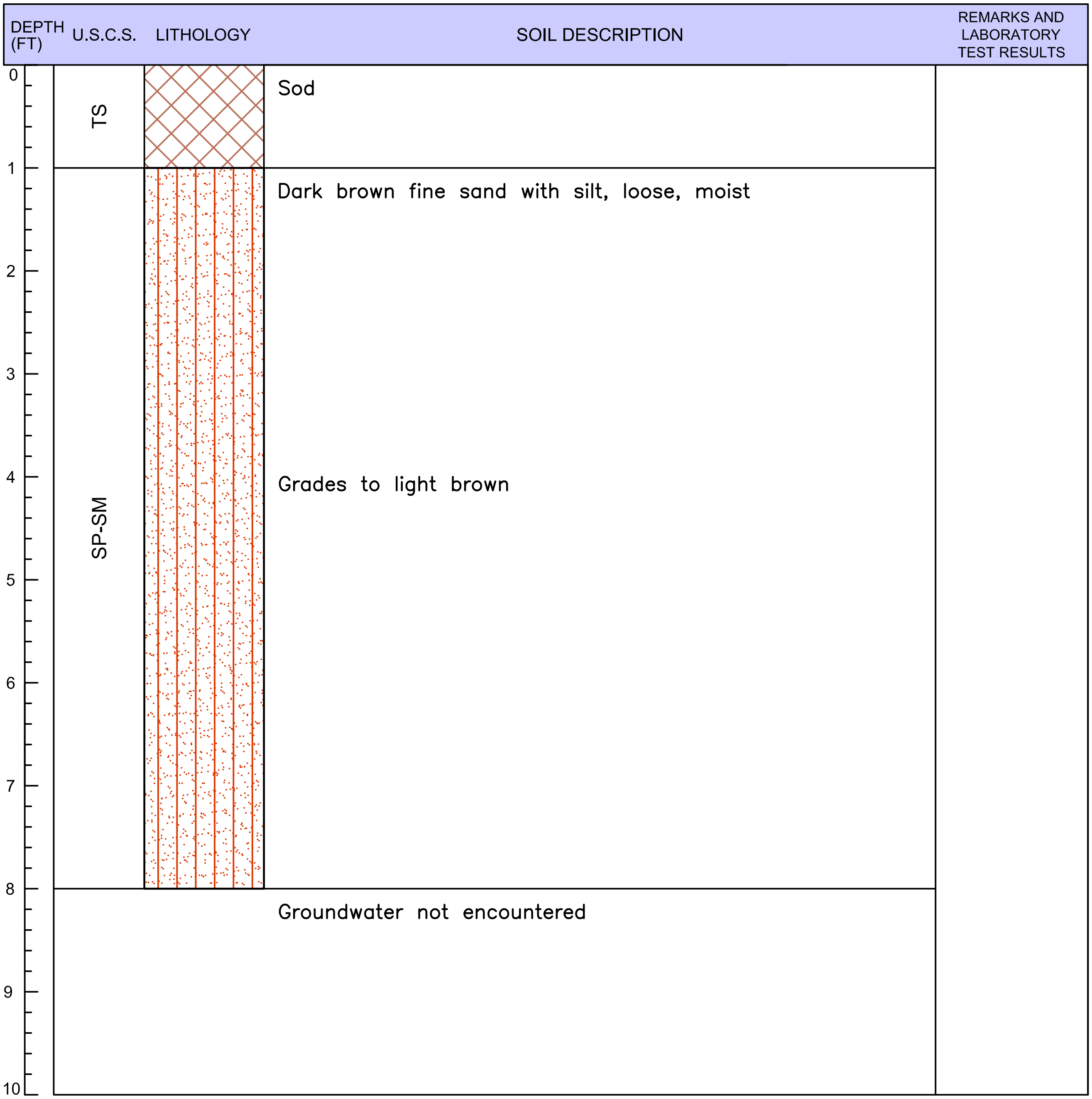
TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-20

TP-21



DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0	TS		Sod	
1	SP-SM		Dark brown fine sand with silt, loose, moist	
4			Grades to light brown	
8			Groundwater not encountered	

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

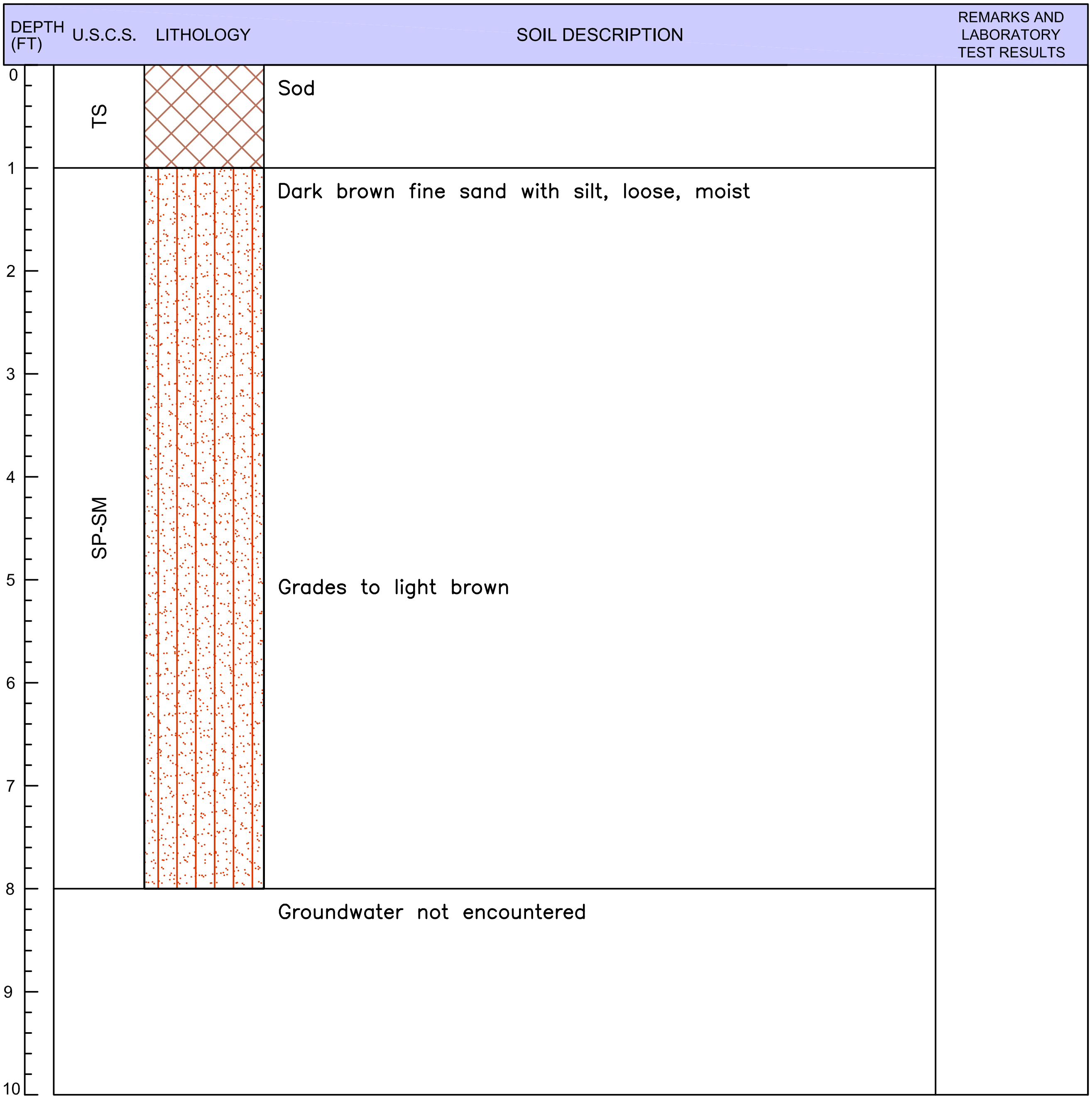
TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-21

TP-22



LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-22

TP-23

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0	TS	▩	Sod	
1	SP-SM	▥	Dark brown fine sand with silt, loose, moist	
2				
3				
4				
5			Grades to brown	
6				
7				
8			Groundwater not encountered	
9				
10				

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS
TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Exploration Log TP-23

TP-24

DEPTH (FT)	U.S.C.S.	LITHOLOGY	SOIL DESCRIPTION	REMARKS AND LABORATORY TEST RESULTS
0	TS	▨	Sod	
1	SP-SM	▨	Dark brown fine sand with silt, loose, moist	
4			Grades to brown	
8			Groundwater not encountered	
10				

LEGEND:

PROJECT NO.: 297-011-01
DATE: MARCH 5, 2020
TOTAL DEPTH: 8 FEET
DRILLING EQUIPMENT: EXCAVATOR
LOGGED BY: KEVIN VANDEHEY

TICKNOR FARMS

TUMWATER, WASHINGTON

ATTACHMENT B

LABORATORY ANALYSES RESULTS

Gradation Analysis Summary Data

Job Name:	Ticknor Farms	**Sample Location:**	TP-2
Job Number:	297-011-01	**Sample Name:**	TP-2 1.0' - 8.0'
Date Tested:	3/6/20	**Depth:**	1 - 8 Feet
Tested By:	Andrew Johnson		

Moisture Content (%) 13.8%

Sieve Size	**Percent Passing**
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	100.0
3/8 in. (9.5-mm)	100.0
No. 4 (4.75-mm)	100.0
No. 10 (2.00-mm)	99.9
No. 20 (.850-mm)	99.7
No. 40 (.425-mm)	99.2
No. 60 (.250-mm)	89.3
No. 100 (.150-mm)	44.1
No. 200 (.075-mm)	10.7

Size Fraction	**Percent by Weight**
Coarse Gravel	0.0
Fine Gravel	0.0
Coarse Sand	0.1
Medium Sand	0.7
Fine Sand	88.5
Fines	10.7
Total	**100.0**

LL	- -
PL	- -
PI	- -
D_{10}	0.08
D_{30}	0.12
D_{60}	0.18
D_{90}	0.25
Cc	1.07
Cu	2.40

ASTM Classification

Group Name: **Poorly Graded Sand with Silt**

Symbol: **SP-SM**

INSIGHT GEOLOGIC, INC.

Gradation Analysis Summary Data

Job Name: Ticknor Farms
Job Number: 297-011-01
Date Tested: 3/6/20
Tested By: Andrew Johnson

Sample Location: TP-7
Sample Name: TP-7 1.0' - 8.0'
Depth: 1 - 8 Feet

Moisture Content (%) 11.8%

Sieve Size	Percent Passing
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	100.0
3/8 in. (9.5-mm)	100.0
No. 4 (4.75-mm)	100.0
No. 10 (2.00-mm)	99.9
No. 20 (.850-mm)	99.6
No. 40 (.425-mm)	98.2
No. 60 (.250-mm)	72.7
No. 100 (.150-mm)	25.8
No. 200 (.075-mm)	5.2

Size Fraction	Percent by Weight
Coarse Gravel	0.0
Fine Gravel	0.0
Coarse Sand	0.1
Medium Sand	1.7
Fine Sand	93.0
Fines	5.2
Total	**100.0**

LL	- -
PL	- -
PI	- -
D_{10}	0.09
D_{30}	0.16
D_{60}	0.22
D_{90}	0.34
Cc	1.29
Cu	2.44

ASTM Classification
Group Name: **Poorly Graded Sand with Silt**
Symbol: **SP-SM**

INSIGHT GEOLOGIC, INC.

Gradation Analysis Summary Data

Job Name: Ticknor Farms
Job Number: 297-011-01
Date Tested: 3/6/20
Tested By: Andrew Johnson

Sample Location: TP-8
Sample Name: TP-8 1.5' - 8.0'
Depth: 1.5 - 8 Feet

Moisture Content (%) 16.6%

Sieve Size	Percent Passing
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	100.0
3/8 in. (9.5-mm)	100.0
No. 4 (4.75-mm)	100.0
No. 10 (2.00-mm)	99.9
No. 20 (.850-mm)	99.8
No. 40 (.425-mm)	99.5
No. 60 (.250-mm)	95.1
No. 100 (.150-mm)	51.2
No. 200 (.075-mm)	11.9

Size Fraction	Percent by Weight
Coarse Gravel	0.0
Fine Gravel	0.0
Coarse Sand	0.1
Medium Sand	0.5
Fine Sand	87.5
Fines	11.9
Total	**100.0**

LL - -
PL - -
PI - -

D_{10} 0.07
D_{30} 0.11
D_{60} 0.17
D_{90} 0.23

Cc 0.96
Cu 2.30

ASTM Classification
Group Name: **Poorly Graded Sand with Silt**
Symbol: **SP-SM**

INSIGHT GEOLOGIC, INC.

Gradation Analysis Summary Data

Job Name: Ticknor Farms
Job Number: 297-011-01
Date Tested: 3/6/20
Tested By: Andrew Johnson

Sample Location: TP-9
Sample Name: TP-9 1.5' - 8.0'
Depth: 1.5 - 8 Feet

Moisture Content (%) 30.0%

Sieve Size	Percent Passing
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	100.0
3/8 in. (9.5-mm)	100.0
No. 4 (4.75-mm)	100.0
No. 10 (2.00-mm)	100.0
No. 20 (.850-mm)	99.9
No. 40 (.425-mm)	99.5
No. 60 (.250-mm)	95.7
No. 100 (.150-mm)	57.3
No. 200 (.075-mm)	12.4

Size Fraction	Percent by Weight
Coarse Gravel	0.0
Fine Gravel	0.0
Coarse Sand	0.0
Medium Sand	0.4
Fine Sand	87.1
Fines	12.4
Total	**100.0**

LL - -
PL - -
PI - -

D_{10} 0.07
D_{30} 0.10
D_{60} 0.16
D_{90} 0.23

Cc 0.87
Cu 2.22

ASTM Classification
Group Name: **Silty Sand**
Symbol: **SM**

Insight Geologic, Inc.

Gradation Analysis Summary Data

Job Name: Ticknor Farms
Job Number: 297-011-01
Date Tested: 3/6/20
Tested By: Andrew Johnson

Sample Location: TP-11
Sample Name: TP-11 1.0' - 5.5'
Depth: 1 - 5.5 Feet

Moisture Content (%) 4.5%

Sieve Size	**Percent Passing**
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	60.1
3/8 in. (9.5-mm)	37.0
No. 4 (4.75-mm)	24.7
No. 10 (2.00-mm)	16.2
No. 20 (.850-mm)	10.4
No. 40 (.425-mm)	6.8
No. 60 (.250-mm)	5.5
No. 100 (.150-mm)	5.0
No. 200 (.075-mm)	3.1

Size Fraction	**Percent by Weight**
Coarse Gravel	39.9
Fine Gravel	35.3
Coarse Sand	8.5
Medium Sand	9.4
Fine Sand	3.7
Fines	3.1
Total	**100.0**

LL - -
PL - -
PI - -

D_{10} 0.80
D_{30} 6.50
D_{60} 19.00
D_{90} 31.00

Cc 2.78
Cu 23.75

ASTM Classification
Group Name: **Well Graded Gravel with Sand**
Symbol: **GW**

Gradation Analysis Summary Data

Job Name: Ticknor Farms
Job Number: 297-011-01
Date Tested: 3/6/20
Tested By: Andrew Johnson

Sample Location: TP-11
Sample Name: TP-11 5.5' - 6.5'
Depth: 5.5 - 6.5 Feet

Moisture Content (%) 41.3%

Sieve Size	Percent Passing
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	100.0
3/8 in. (9.5-mm)	100.0
No. 4 (4.75-mm)	99.8
No. 10 (2.00-mm)	99.2
No. 20 (.850-mm)	98.4
No. 40 (.425-mm)	97.3
No. 60 (.250-mm)	96.2
No. 100 (.150-mm)	94.6
No. 200 (.075-mm)	78.1

Size Fraction	Percent by Weight
Coarse Gravel	0.0
Fine Gravel	0.2
Coarse Sand	0.6
Medium Sand	2.0
Fine Sand	19.2
Fines	78.1
Total	**100.0**

LL - -
PL - -
PI - -

D_{10} 0.12
D_{30} 0.00
D_{60} 0.00
D_{90} 0.00

Cc - -
Cu 0.00

ASTM Classification
Group Name: **Silt with Sand**
Symbol: **ML**

INSIGHT GEOLOGIC, INC.

Gradation Analysis Summary Data

Job Name: Ticknor Farms
Job Number: 297-011-01
Date Tested: 3/6/20
Tested By: Andrew Johnson

Sample Location: TP-11
Sample Name: TP-11 6.5' - 8.0'
Depth: 6.5 - 8 Feet

Moisture Content (%) 4.0%

Sieve Size	Percent Passing
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	93.3
3/8 in. (9.5-mm)	70.9
No. 4 (4.75-mm)	56.1
No. 10 (2.00-mm)	46.1
No. 20 (.850-mm)	30.5
No. 40 (.425-mm)	11.0
No. 60 (.250-mm)	6.5
No. 100 (.150-mm)	5.6
No. 200 (.075-mm)	2.9

Size Fraction	Percent by Weight
Coarse Gravel	6.7
Fine Gravel	37.2
Coarse Sand	10.0
Medium Sand	35.2
Fine Sand	8.0
Fines	2.9
Total	**100.0**

LL - -
PL - -
PI - -

D_{10} 0.40
D_{30} 0.84
D_{60} 6.00
D_{90} 17.00

Cc 0.29
Cu 15.00

ASTM Classification
Group Name: **Poorly Graded Sand with Gravel**
Symbol: **SP**

Insight Geologic, Inc.

Gradation Analysis Summary Data

Job Name: Ticknor Farms
Job Number: 297-011-01
Date Tested: 3/6/20
Tested By: Andrew Johnson

Sample Location: TP-16
Sample Name: TP-16 1.0' - 8.0'
Depth: 1 - 8 Feet

Moisture Content (%) 13.9%

Sieve Size	Percent Passing
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	100.0
3/8 in. (9.5-mm)	100.0
No. 4 (4.75-mm)	100.0
No. 10 (2.00-mm)	100.0
No. 20 (.850-mm)	99.9
No. 40 (.425-mm)	99.5
No. 60 (.250-mm)	93.2
No. 100 (.150-mm)	41.8
No. 200 (.075-mm)	7.1

Size Fraction	Percent by Weight
Coarse Gravel	0.0
Fine Gravel	0.0
Coarse Sand	0.0
Medium Sand	0.5
Fine Sand	92.4
Fines	7.1
Total	**100.0**

LL - -
PL - -
PI - -

D_{10} 0.08
D_{30} 0.13
D_{60} 0.18
D_{90} 0.23

Cc 1.17
Cu 2.25

ASTM Classification
Group Name: **Poorly Graded Sand with Silt**
Symbol: **SP-SM**

INSIGHT GEOLOGIC, INC.

Gradation Analysis Summary Data

Job Name: Ticknor Farms
Job Number: 297-011-01
Date Tested: 3/6/20
Tested By: Andrew Johnson

Sample Location: TP-19
Sample Name: TP-19 1.5' - 8.0'
Depth: 1.5 - 8 Feet

Moisture Content (%) 27.7%

Sieve Size	Percent Passing
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	100.0
3/8 in. (9.5-mm)	100.0
No. 4 (4.75-mm)	100.0
No. 10 (2.00-mm)	99.9
No. 20 (.850-mm)	99.8
No. 40 (.425-mm)	99.4
No. 60 (.250-mm)	95.9
No. 100 (.150-mm)	45.7
No. 200 (.075-mm)	11.9

Size Fraction	Percent by Weight
Coarse Gravel	0.0
Fine Gravel	0.0
Coarse Sand	0.1
Medium Sand	0.5
Fine Sand	87.5
Fines	11.9
Total	**100.0**

LL - -
PL - -
PI - -

D_{10} 0.07
D_{30} 0.12
D_{60} 0.18
D_{90} 0.23

Cc 1.14
Cu 2.57

ASTM Classification
Group Name: **Poorly Graded Sand with Silt**
Symbol: **SP-SM**

Insight Geologic, Inc.

Gradation Analysis Summary Data

Job Name: Ticknor Farms
Job Number: 297-011-01
Date Tested: 3/6/20
Tested By: Andrew Johnson

Sample Location: TP-21
Sample Name: TP-21 1.0' - 4.0'
Depth: 1 - 4 Feet

Moisture Content (%) 19.4%

Sieve Size	Percent Passing
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	100.0
3/8 in. (9.5-mm)	100.0
No. 4 (4.75-mm)	100.0
No. 10 (2.00-mm)	99.9
No. 20 (.850-mm)	99.8
No. 40 (.425-mm)	99.5
No. 60 (.250-mm)	96.0
No. 100 (.150-mm)	52.7
No. 200 (.075-mm)	8.2

Size Fraction	Percent by Weight
Coarse Gravel	0.0
Fine Gravel	0.0
Coarse Sand	0.1
Medium Sand	0.4
Fine Sand	91.3
Fines	8.2
Total	**100.0**

LL - -
PL - -
PI - -

D_{10} 0.08
D_{30} 0.11
D_{60} 0.17
D_{90} 0.23

Cc 0.90
Cu 2.15

ASTM Classification
Group Name: **Poorly Graded Sand with Silt**
Symbol: **SP-SM**

INSIGHT GEOLOGIC, INC.

Gradation Analysis Summary Data

Job Name:	Ticknor Farms	**Sample Location:**	TP-23
Job Number:	297-011-01	**Sample Name:**	TP-23 1.0' - 5.0'
Date Tested:	3/6/20	**Depth:**	1 - 5 Feet
Tested By:	Andrew Johnson		

Moisture Content (%) 19.9%

Sieve Size	**Percent Passing**
3.0 in. (75.0)	100.0
1.5 in. (37.5)	100.0
3/4 in. (19.0)	100.0
3/8 in. (9.5-mm)	100.0
No. 4 (4.75-mm)	100.0
No. 10 (2.00-mm)	99.9
No. 20 (.850-mm)	99.7
No. 40 (.425-mm)	99.3
No. 60 (.250-mm)	94.6
No. 100 (.150-mm)	43.7
No. 200 (.075-mm)	6.7

Size Fraction	**Percent by Weight**
Coarse Gravel	0.0
Fine Gravel	0.0
Coarse Sand	0.1
Medium Sand	0.6
Fine Sand	92.6
Fines	6.7
Total	**100.0**

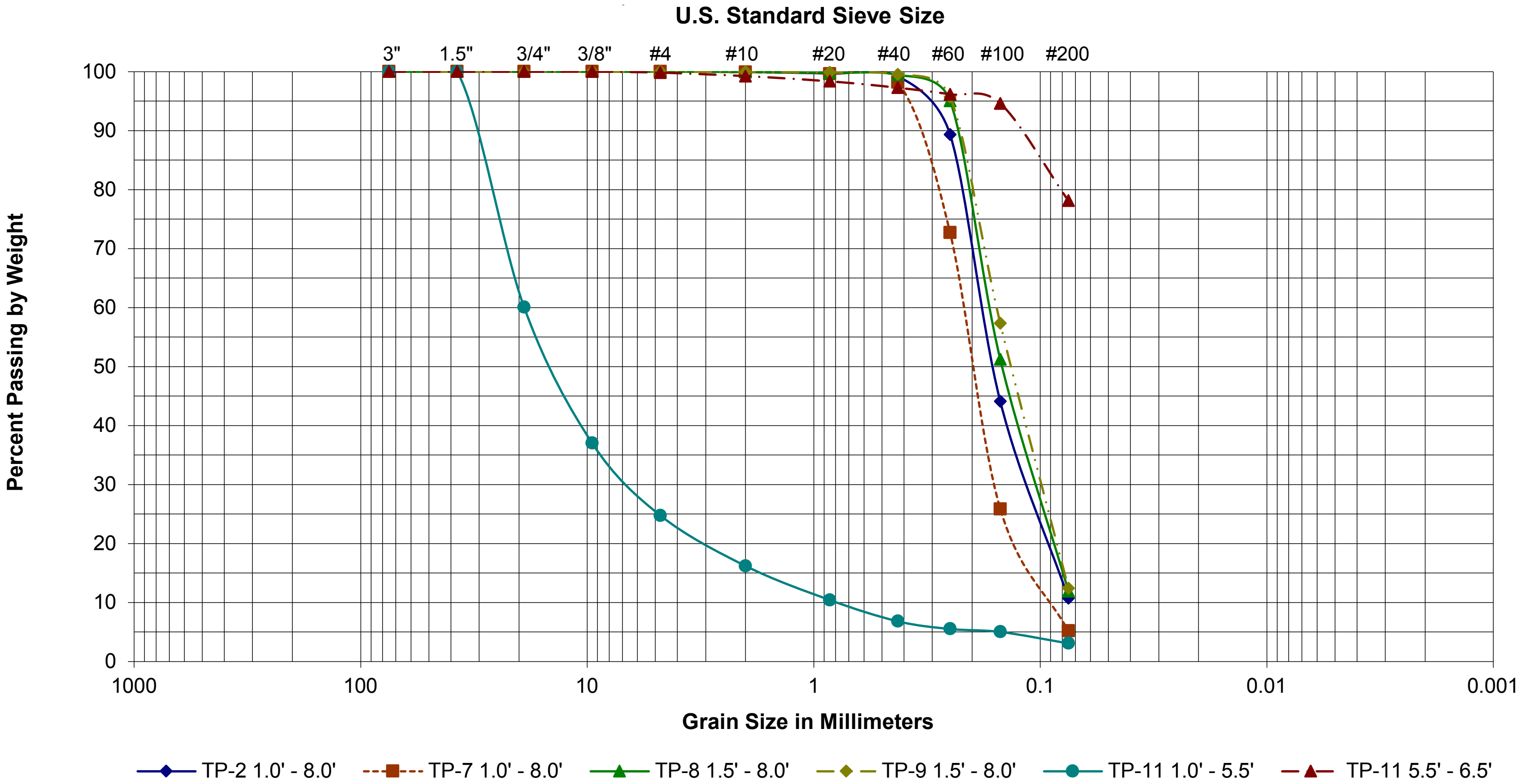
LL	- -
PL	- -
PI	- -
D_{10}	0.08
D_{30}	0.13
D_{60}	0.18
D_{90}	0.23
Cc	1.17
Cu	2.25

ASTM Classification

Group Name: **Poorly Graded Sand with Silt**

Symbol: **SP-SM**

INSIGHT GEOLOGIC, INC.



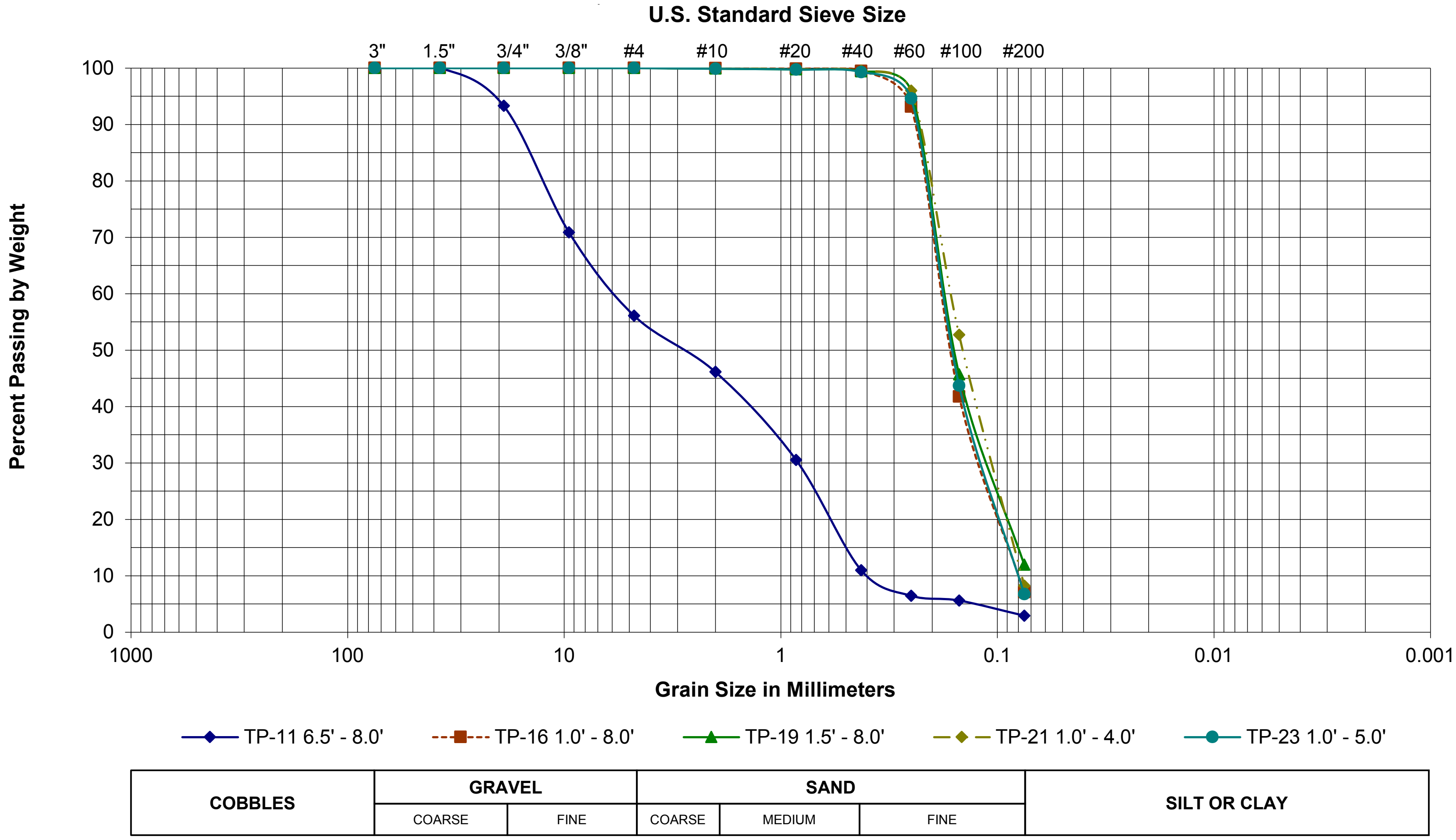
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

TICKNOR FARMS

TUMWATER, WASHINGTON

INSIGHT GEOLOGIC, INC.

Graph 1
Gradation Analysis Results



TICKNOR FARMS

TUMWATER, WASHINGTON

Insight Geologic, Inc.

Graph 2
Gradation Analysis Results

Simple Method for Determining Infiltration Rate
for
Ticknor Farms
Tumwater, Washington
297-011-01

TP-2

Equation 1 - Saturated Potential Hydraulic Conductivity

Soil Layer	Soil Classification	D_{10}	D_{60}	D_{90}	f_{fines}	K_{sat}
Layer 1	SP-SM	0.08	0.18	0.25	0.11	63.4

Ksat = $2835*10^{(-1.57 +1.90D10 +0.015D60 -0.013D90 -2.08ffines)}$

Where:

Ksat: Saturated Potential Hydraulic Conductivity, ft/day

Dn: Particle size for which "n" percent of particles by weight are smaller, mm.

ffines: Fraction of soil by weight passing the number 200 sieve, gm/gm.

Equation 2 - Equivalent Potential Hydraulic Conductivity for Layers of Soils in One Hole

"d" Hole Depth	"dn" Layer Thickness	d_n/K_{sat}	SUM d_n/K_{sat}	K_{equiv}
96	96	1.5	1.5	63.4

Kequiv = d / SUM(Dn/Kn)

Where:

d: Total depth of soil column between base of facility and groundwater table, in

dn: Thickness of layer "n" in soil column, in

Kn: Saturated potential hydraulic conductivity (Ksat) of layer "n", ft/day.

Detailed Method for Determining Infiltration Rate
for
Ticknor Farms
Tumwater, Washington
TP-2

Equation 3 - Correction Factor Geometry

$D_{water\ table}$	W_{pond}	$CF_{geometry}$
8.0	80.00	0.45

$Cf_{geometry}$ = 4 Dwt/Wpond +0.05

Where:

$D_{water\ table}$: Depth to seasonal high water table, feet
W_{pond}: Width of pond feet
$CF_{geometry}$: Between 0.25 and 1.0

Equation 4 - Facility Design Infiltration Rate

Kequiv	$CF_{Testing}$	$CF_{Plugging}$	$CF_{geometry}$	f_{design} (ft/day)	f_{design} (in/hr)
63.38	0.40	0.80	0.45	9.1	4.6

f_{design} = K_{equiv} * ($CF_{testing}$*$Cf_{plugging}$*$CF_{geometry}$)

Where:

K_{equiv}: Saturated Hydraulic Conductivity Equivalent (ft/day)
$Cf_{Testing}$: Testing Methodology
$Cf_{Plugging:}$ Degree of long-term maintenance and performance
$Cf_{geometry}$: Facility Geometry
f_{design}: Maximum infiltration rate allowed by Method is 20.0 in/hr

Simple Method for Determining Infiltration Rate

for
Ticknor Farms
Tumwater, Washington
297-011-01

TP-7

Equation 1 - Saturated Potential Hydraulic Conductivity

Soil Layer	Soil Classification	D_{10}	D_{60}	D_{90}	f_{fines}	K_{sat}
Layer 1	SP-SM	0.09	0.22	0.34	0.05	88.0

Ksat = $2835*10^{(-1.57 +1.90D10 +0.015D60 -0.013D90 -2.08ffines)}$

Where:

Ksat: Saturated Potential Hydraulic Conductivity, ft/day

Dn: Particle size for which "n" percent of particles by weight are smaller, mm.

ffines: Fraction of soil by weight passing the number 200 sieve, gm/gm.

Equation 2 - Equivalent Potential Hydraulic Conductivity for Layers of Soils in One Hole

"d" Hole Depth	"dn" Layer Thickness	d_n/K_{sat}	SUM d_n/K_{sat}	K_{equiv}
96	96	1.1	1.1	88.0

Kequiv = **d / SUM(Dn/Kn)**

Where:

d: Total depth of soil column between base of facility and groundwater table, in

dn: Thickness of layer "n" in soil column, in

Kn: Saturated potential hydraulic conductivity (Ksat) of layer "n", ft/day.

Detailed Method for Determining Infiltration Rate

for

Ticknor Farms

Tumwater, Washington

TP-7

Equation 3 - Correction Factor Geometry

$D_{\text{water table}}$	W_{pond}	CF_{geometry}
8.0	80.00	0.45

Cf_{geometry} = **4 Dwt/Wpond +0.05**

Where:

$D_{\text{water table}}$:	**Depth to seasonal high water table, feet**
W_{pond}:	**Width of pond feet**
CF_{geometry}:	**Between 0.25 and 1.0**

Equation 4 - Facility Design Infiltration Rate

Kequiv	CF_{Testing}	CF_{Plugging}	CF_{geometry}	f_{design} (ft/day)	f_{design} (in/hr)
87.96	0.40	0.80	0.45	12.7	6.3

f_{design} = **K_{equiv} * (CF_{testing}*Cf_{plugging}*CF_{geometry})**

Where:

K_{equiv}:	**Saturated Hydraulic Conductivity Equivalent (ft/day)**
Cf_{Testing}:	**Testing Methodology**
$Cf_{\text{Plugging:}}$	**Degree of long-term maintenance and performance**
Cf_{geometry}:	**Facility Geometry**
f_{design}:	**Maximum infiltration rate allowed by Method is 20.0 in/hr**

Simple Method for Determining Infiltration Rate

for

Ticknor Farms

Tumwater, Washington

297-011-01

TP-8

Equation 1 - Saturated Potential Hydraulic Conductivity

Soil Layer	Soil Classification	D_{10}	D_{60}	D_{90}	f_{fines}	K_{sat}
Layer 1	SP-SM	0.07	0.17	0.23	0.12	59.6

Ksat = $2835*10^{(-1.57 +1.90D10 +0.015D60 -0.013D90 -2.08ffines)}$

Where:

Ksat: **Saturated Potential Hydraulic Conductivity, ft/day**

Dn: **Particle size for which "n" percent of particles by weight are smaller, mm.**

ffines: **Fraction of soil by weight passing the number 200 sieve, gm/gm.**

Equation 2 - Equivalent Potential Hydraulic Conductivity for Layers of Soils in One Hole

"d" Hole Depth	"dn" Layer Thickness	d_n/K_{sat}	SUM d_n/K_{sat}	K_{equiv}
96	96	1.6	1.6	59.6

Kequiv = **d / SUM(Dn/Kn)**

Where:

d: **Total depth of soil column between base of facility and groundwater table, in**

dn: **Thickness of layer "n" in soil column, in**

Kn: **Saturated potential hydraulic conductivity (Ksat) of layer "n", ft/day.**

Detailed Method for Determining Infiltration Rate
for
Ticknor Farms
Tumwater, Washington
TP-8

Equation 3 - Correction Factor Geometry		
$D_{\text{water table}}$	W_{pond}	CF_{geometry}
8.0	80.00	0.45

Cf_{geometry} = **4 Dwt/Wpond +0.05**

Where:

$D_{\text{water table}}$: **Depth to seasonal high water table, feet**
W_{pond}: **Width of pond feet**
CF_{geometry}: **Between 0.25 and 1.0**

Equation 4 - Facility Design Infiltration Rate					
Kequiv	CF_{Testing}	CF_{Plugging}	CF_{geometry}	f_{design} (ft/day)	f_{design} (in/hr)
59.59	0.40	0.80	0.45	8.6	4.3

f_{design} = **K_{equiv} * (CF_{testing}*Cf_{plugging}*CF_{geometry})**

Where:

K_{equiv}: **Saturated Hydraulic Conductivity Equivalent (ft/day)**
Cf_{Testing}: **Testing Methodology**
Cf_{Plugging}: **Degree of long-term maintenance and performance**
Cf_{geometry}: **Facility Geometry**
f_{design}: **Maximum infiltration rate allowed by Method is 20.0 in/hr**

Simple Method for Determining Infiltration Rate
for
Ticknor Farms
Tumwater, Washington
297-011-01

TP-9

Equation 1 - Saturated Potential Hydraulic Conductivity

Soil Layer	Soil Classification	D_{10}	D_{60}	D_{90}	f_{fines}	K_{sat}
Layer 1	SM	0.07	0.16	0.23	0.12	57.7

Ksat = **$2835*10^{(-1.57 +1.90D10 +0.015D60 -0.013D90 -2.08ffines)}$**

Where:

Ksat: **Saturated Potential Hydraulic Conductivity, ft/day**

Dn: **Particle size for which "n" percent of particles by weight are smaller, mm.**

ffines: **Fraction of soil by weight passing the number 200 sieve, gm/gm.**

Equation 2 - Equivalent Potential Hydraulic Conductivity for Layers of Soils in One Hole

"d" Hole Depth	"dn" Layer Thickness	d_n/K_{sat}	SUM d_n/K_{sat}	K_{equiv}
96	96	1.7	1.7	57.7

Kequiv = **d / SUM(Dn/Kn)**

Where:

d: **Total depth of soil column between base of facility and groundwater table, in**

dn: **Thickness of layer "n" in soil column, in**

Kn: **Saturated potential hydraulic conductivity (Ksat) of layer "n", ft/day.**

Detailed Method for Determining Infiltration Rate

for

Ticknor Farms

Tumwater, Washington

TP-9

Equation 3 - Correction Factor Geometry		
$D_{water\ table}$	W_{pond}	$CF_{geometry}$
2.5	80.00	0.25

$Cf_{geometry}$ = **4 Dwt/Wpond +0.05**

Where:

$D_{water\ table}$: **Depth to seasonal high water table, feet**

W_{pond}: **Width of pond feet**

$CF_{geometry}$: **Between 0.25 and 1.0**

Equation 4 - Facility Design Infiltration Rate					
Kequiv	$CF_{Testing}$	$CF_{Plugging}$	$CF_{geometry}$	f_{design} (ft/day)	f_{design} (in/hr)
57.66	0.40	0.80	0.25	4.6	2.3

f_{design} = **K_{equiv} * ($CF_{testing}$*$Cf_{plugging}$*$CF_{geometry}$)**

Where:

K_{equiv}: **Saturated Hydraulic Conductivity Equivalent (ft/day)**

$Cf_{Testing}$: **Testing Methodology**

$Cf_{Plugging}$: **Degree of long-term maintenance and performance**

$Cf_{geometry}$: **Facility Geometry**

f_{design}: **Maximum infiltration rate allowed by Method is 20.0 in/hr**

Simple Method for Determining Infiltration Rate
for
Ticknor Farms
Tumwater, Washington
297-011-01

TP-16

Equation 1 - Saturated Potential Hydraulic Conductivity

Soil Layer	Soil Classification	D_{10}	D_{60}	D_{90}	f_{fines}	K_{sat}
Layer 1	SP-SM	0.08	0.18	0.23	0.07	77.0

Ksat = $2835*10^{(-1.57 +1.90D10 +0.015D60 -0.013D90 -2.08ffines)}$

Where:

Ksat: **Saturated Potential Hydraulic Conductivity, ft/day**

Dn: **Particle size for which "n" percent of particles by weight are smaller, mm.**

ffines: **Fraction of soil by weight passing the number 200 sieve, gm/gm.**

Equation 2 - Equivalent Potential Hydraulic Conductivity for Layers of Soils in One Hole

"d" Hole Depth	"dn" Layer Thickness	d_n/K_{sat}	SUM d_n/K_{sat}	K_{equiv}
96	96	1.2	1.2	77.0

Kequiv = **d / SUM(Dn/Kn)**

Where:

d: **Total depth of soil column between base of facility and groundwater table, in**

dn: **Thickness of layer "n" in soil column, in**

Kn: **Saturated potential hydraulic conductivity (Ksat) of layer "n", ft/day.**

Detailed Method for Determining Infiltration Rate
for
Ticknor Farms
Tumwater, Washington
TP-16

Equation 3 - Correction Factor Geometry		
$D_{\text{water table}}$	W_{pond}	CF $_{\text{geometry}}$
8.0	80.00	0.45

Cf_{geometry} = **4 Dwt/Wpond +0.05**

Where:

$D_{\text{water table}}$: **Depth to seasonal high water table, feet**
W_{pond}: **Width of pond feet**
CF_{geometry}: **Between 0.25 and 1.0**

Equation 4 - Facility Design Infiltration Rate					
Kequiv	CF $_{\text{Testing}}$	CF $_{\text{Plugging}}$	CF $_{\text{geometry}}$	f $_{\text{design}}$ (ft/day)	f $_{\text{design}}$ (in/hr)
77.02	0.40	0.80	0.45	11.1	5.5

f_{design} = **K_{equiv} * (CF_{testing}*Cf_{plugging}*CF_{geometry})**

Where:

K_{equiv}: **Saturated Hydraulic Conductivity Equivalent (ft/day)**
Cf_{Testing}: **Testing Methodology**
$Cf_{\text{Plugging:}}$ **Degree of long-term maintenance and performance**
Cf_{geometry}: **Facility Geometry**
f_{design}: **Maximum infiltration rate allowed by Method is 20.0 in/hr**

Simple Method for Determining Infiltration Rate
for
Ticknor Farms
Tumwater, Washington
297-011-01

TP-19

Equation 1 - Saturated Potential Hydraulic Conductivity

Soil Layer	Soil Classification	D_{10}	D_{60}	D_{90}	f_{fines}	K_{sat}
Layer 1	SP-SM	0.07	0.18	0.23	0.12	58.6

Ksat =	**$2835*10^{(-1.57 +1.90D10 +0.015D60 -0.013D90 -2.08ffines)}$**
Where:	
Ksat:	**Saturated Potential Hydraulic Conductivity, ft/day**
Dn:	**Particle size for which "n" percent of particles by weight are smaller, mm.**
ffines:	**Fraction of soil by weight passing the number 200 sieve, gm/gm.**

Equation 2 - Equivalent Potential Hydraulic Conductivity for Layers of Soils in One Hole

"d" Hole Depth	"dn" Layer Thickness	d_n/K_{sat}	SUM d_n/K_{sat}	K_{equiv}
96	96	1.6	1.6	58.6

Kequiv =	**d / SUM(Dn/Kn)**
Where:	
d:	**Total depth of soil column between base of facility and groundwater table, in**
dn:	**Thickness of layer "n" in soil column, in**
Kn:	**Saturated potential hydraulic conductivity (Ksat) of layer "n", ft/day.**

Detailed Method for Determining Infiltration Rate

for

Ticknor Farms

Tumwater, Washington

TP-19

Equation 3 - Correction Factor Geometry		
$D_{\text{water table}}$	W_{pond}	CF_{geometry}
5.5	80.00	0.33

Cf_{geometry} = 4 Dwt/Wpond +0.05

Where:

$D_{\text{water table}}$:	Depth to seasonal high water table, feet
W_{pond}:	Width of pond feet
CF_{geometry}:	Between 0.25 and 1.0

Equation 4 - Facility Design Infiltration Rate					
Kequiv	CF_{Testing}	CF_{Plugging}	CF_{geometry}	f_{design} (ft/day)	f_{design} (in/hr)
58.58	0.40	0.80	0.33	6.1	3.0

f_{design} = K_{equiv} * (CF_{testing}*Cf_{plugging}*CF_{geometry})

Where:

K_{equiv}:	Saturated Hydraulic Conductivity Equivalent (ft/day)
Cf_{Testing}:	Testing Methodology
$Cf_{\text{Plugging:}}$	Degree of long-term maintenance and performance
Cf_{geometry}:	Facility Geometry
f_{design}:	Maximum infiltration rate allowed by Method is 20.0 in/hr

Simple Method for Determining Infiltration Rate
for
Ticknor Farms
Tumwater, Washington
297-011-01
TP-21

Equation 1 - Saturated Potential Hydraulic Conductivity

Soil Layer	Soil Classification	D_{10}	D_{60}	D_{90}	f_{fines}	K_{sat}
Layer 1	SP-SM	0.08	0.17	0.23	0.08	72.7

Ksat = **$2835*10^{(-1.57 +1.90D10 +0.015D60 -0.013D90 -2.08ffines)}$**

Where:

Ksat: **Saturated Potential Hydraulic Conductivity, ft/day**

Dn: **Particle size for which "n" percent of particles by weight are smaller, mm.**

ffines: **Fraction of soil by weight passing the number 200 sieve, gm/gm.**

Equation 2 - Equivalent Potential Hydraulic Conductivity for Layers of Soils in One Hole

"d" Hole Depth	"dn" Layer Thickness	d_n/K_{sat}	SUM d_n/K_{sat}	K_{equiv}
96	96	1.3	1.3	72.7

Kequiv = **d / SUM(Dn/Kn)**

Where:

d: **Total depth of soil column between base of facility and groundwater table, in**

dn: **Thickness of layer "n" in soil column, in**

Kn: **Saturated potential hydraulic conductivity (Ksat) of layer "n", ft/day.**

Detailed Method for Determining Infiltration Rate
for
Ticknor Farms
Tumwater, Washington
TP-21

Equation 3 - Correction Factor Geometry

$D_{\text{water table}}$	W_{pond}	CF $_{\text{geometry}}$
8.0	80.00	0.45

Cf_{geometry} = 4 Dwt/Wpond +0.05

Where:

$D_{\text{water table}}$:	Depth to seasonal high water table, feet
W_{pond}:	Width of pond feet
CF_{geometry}:	Between 0.25 and 1.0

Equation 4 - Facility Design Infiltration Rate

Kequiv	CF $_{\text{Testing}}$	CF $_{\text{Plugging}}$	CF $_{\text{geometry}}$	f $_{\text{design}}$ (ft/day)	f $_{\text{design}}$ (in/hr)
72.72	0.40	0.80	0.45	10.5	5.2

f_{design} = K_{equiv} * (CF_{testing}*Cf_{plugging}*CF_{geometry})

Where:

K_{equiv}:	Saturated Hydraulic Conductivity Equivalent (ft/day)
Cf_{Testing}:	Testing Methodology
$Cf_{\text{Plugging:}}$	Degree of long-term maintenance and performance
Cf_{geometry}:	Facility Geometry
f_{design}:	Maximum infiltration rate allowed by Method is 20.0 in/hr

Simple Method for Determining Infiltration Rate

for

Ticknor Farms

Tumwater, Washington

297-011-01

TP-23

Equation 1 - Saturated Potential Hydraulic Conductivity

Soil Layer	Soil Classification	D_{10}	D_{60}	D_{90}	f_{fines}	K_{sat}
Layer 1	SP-SM	0.08	0.18	0.23	0.07	78.5

Ksat = **$2835*10^{(-1.57 +1.90D10 +0.015D60 -0.013D90 -2.08ffines)}$**

Where:

Ksat: **Saturated Potential Hydraulic Conductivity, ft/day**

Dn: **Particle size for which "n" percent of particles by weight are smaller, mm.**

ffines: **Fraction of soil by weight passing the number 200 sieve, gm/gm.**

Equation 2 - Equivalent Potential Hydraulic Conductivity for Layers of Soils in One Hole

"d" Hole Depth	"dn" Layer Thickness	d_n/K_{sat}	SUM d_n/K_{sat}	K_{equiv}
96	96	1.2	1.2	78.5

Kequiv = **d / SUM(Dn/Kn)**

Where:

d: **Total depth of soil column between base of facility and groundwater table, in**

dn: **Thickness of layer "n" in soil column, in**

Kn: **Saturated potential hydraulic conductivity (Ksat) of layer "n", ft/day.**

Detailed Method for Determining Infiltration Rate
for
Ticknor Farms
Tumwater, Washington
TP-23

Equation 3 - Correction Factor Geometry		
$D_{water\ table}$	W_{pond}	$CF_{geometry}$
8.0	80.00	0.45

$Cf_{geometry}$ = 4 Dwt/Wpond +0.05

Where:

$D_{water\ table}$:	Depth to seasonal high water table, feet
W_{pond}:	Width of pond feet
$CF_{geometry}$:	Between 0.25 and 1.0

Equation 4 - Facility Design Infiltration Rate					
Kequiv	$CF_{Testing}$	$CF_{Plugging}$	$CF_{geometry}$	f_{design} (ft/day)	f_{design} (in/hr)
78.51	0.40	0.80	0.45	11.3	5.7

f_{design} = $K_{equiv} * (CF_{testing} * Cf_{plugging} * CF_{geometry})$

Where:

K_{equiv}:	Saturated Hydraulic Conductivity Equivalent (ft/day)
$Cf_{Testing}$:	Testing Methodology
$Cf_{Plugging}$:	Degree of long-term maintenance and performance
$Cf_{geometry}$:	Facility Geometry
f_{design}:	Maximum infiltration rate allowed by Method is 20.0 in/hr

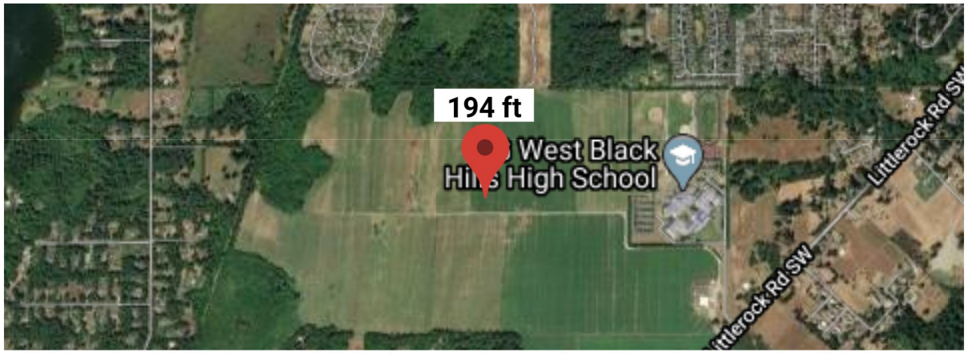
ATTACHMENT C

SEISMIC DESIGN PARAMETERS

Hazards by Location

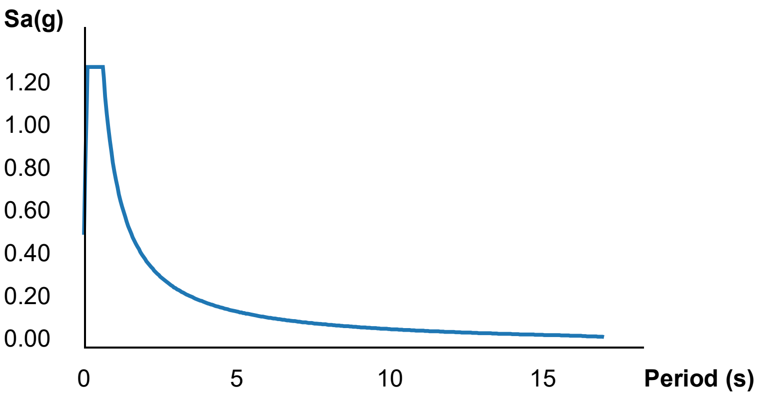
Search Information

Coordinates:	46.97838790376429, -122.95694084167484
Elevation:	194 ft
Timestamp:	2020-03-09T20:52:08.415Z
Hazard Type:	Seismic
Reference Document:	IBC-2015
Risk Category:	II
Site Class:	D

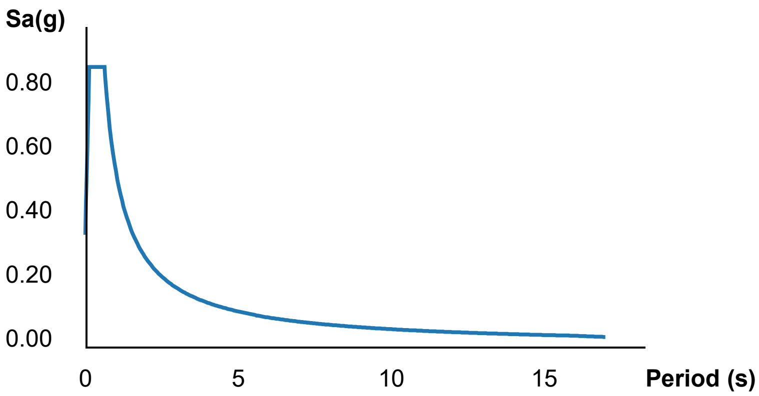


Map data ©2020 Imagery ©2020 , Landsat / Copernicus, Maxar Technologies, U.S. Geological Survey, USDA Fa Report a map error

MCER Horizontal Response Spectrum



Design Horizontal Response Spectrum



Basic Parameters

Name	Value	Description
S_S	1.308	MCE_R ground motion (period=0.2s)
S_1	0.546	MCE_R ground motion (period=1.0s)
S_{MS}	1.308	Site-modified spectral acceleration value
S_{M1}	0.818	Site-modified spectral acceleration value
S_{DS}	0.872	Numeric seismic design value at 0.2s SA
S_{D1}	0.546	Numeric seismic design value at 1.0s SA

ATTACHMENT D

REPORT LIMITATIONS AND GUIDELINES FOR USE

ATTACHMENT D

REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This attachment provides information to help you manage your risks with respect to the use of this report.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES, PERSONS AND PROJECTS

This report has been prepared for the exclusive use of Hatton Godat Pantier (Client) and their authorized agents. This report may be made available to regulatory agencies for review. This report is not intended for use by others, and the information contained herein is not applicable to other sites.

Insight Geologic Inc. structures our services to meet the specific needs of our clients. For example, a geotechnical or geologic study conducted for a civil engineer or architect may not fulfill the needs of a construction contractor or even another civil engineer or architect that are involved in the same project. Because each geotechnical or geologic study is unique, each geotechnical engineering or geologic report is unique, prepared solely for the specific client and project site. Our report is prepared for the exclusive use of our Client. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with whom there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted geotechnical practices in this area at the time this report was prepared. This report should not be applied for any purpose or project except the one originally contemplated.

A GEOTECHNICAL ENGINEERING OR GEOLOGIC REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

Insight Geologic, Inc. considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless Insight Geologic specifically indicates otherwise, do not rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

If important changes are made after the date of this report, Insight Geologic should be given the opportunity to review our interpretations and recommendations and provide written modifications or confirmation, as appropriate.

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[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org .

SUBSURFACE CONDITIONS CAN CHANGE

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by manmade events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or ground water fluctuations. Always contact Insight Geologic before applying a report to determine if it remains applicable.

MOST GEOTECHNICAL AND GEOLOGIC FINDINGS ARE PROFESSIONAL OPINIONS

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Insight Geologic reviewed field and laboratory data and then applied our professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

GEOTECHNICAL ENGINEERING REPORT RECOMMENDATIONS ARE NOT FINAL

Do not over-rely on the preliminary construction recommendations included in this report. These recommendations are not final, because they were developed principally from Insight Geologic’s professional judgment and opinion. Insight Geologic’s recommendations can be finalized only by observing actual subsurface conditions revealed during construction. Insight Geologic cannot assume responsibility or liability for this report's recommendations if we do not perform construction observation.

Sufficient monitoring, testing and consultation by Insight Geologic should be provided during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork activities are completed in accordance with our recommendations. Retaining Insight Geologic for construction observation for this project is the most effective method of managing the risks associated with unanticipated conditions.

A GEOTECHNICAL ENGINEERING OR GEOLOGIC REPORT COULD BE SUBJECT TO MISINTERPRETATION

Misinterpretation of this report by other design team members can result in costly problems. You could lower that risk by having Insight Geologic confer with appropriate members of the design team after submitting the report. Also retain Insight Geologic to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering or geologic report. Reduce that risk by having Insight Geologic participate in pre-bid and pre-construction conferences, and by providing construction observation.

DO NOT REDRAW THE EXPLORATION LOGS

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, but recognize that separating logs from the report can elevate risk.

GIVE CONTRACTORS A COMPLETE REPORT AND GUIDANCE

Some owners and design professionals believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering or geologic report, but preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with Insight Geologic and/or to conduct additional study to obtain the specific types of information they need or prefer. A pre-bid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might an owner be in a position to give contractors the best information available, while requiring them to at least share the financial responsibilities stemming from unanticipated conditions. Further, a contingency for unanticipated conditions should be included in your project budget and schedule.

CONTRACTORS ARE RESPONSIBLE FOR SITE SAFETY ON THEIR OWN CONSTRUCTION PROJECTS

Our geotechnical recommendations are not intended to direct the contractor’s procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and to adjacent properties.

READ THESE PROVISIONS CLOSELY

Some clients, design professionals and contractors may not recognize that the geoscience practices (geotechnical engineering or geology) are far less exact than other engineering and natural science disciplines. This lack of understanding can create unrealistic expectations that could lead to disappointments, claims and disputes. Insight Geologic includes these explanatory “limitations” provisions in our reports to help reduce such risks. Please confer with Insight Geologic if you are unclear how these “Report Limitations and Guidelines for Use” apply to your project or site.

GEOTECHNICAL, GEOLOGIC AND ENVIRONMENTAL REPORTS SHOULD NOT BE INTERCHANGED

The equipment, techniques and personnel used to perform an environmental study differ significantly from those used to perform a geotechnical or geologic study and vice versa. For that reason, a geotechnical engineering or geologic report does not usually relate any environmental findings, conclusions or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Similarly, environmental reports are not used to address geotechnical or geologic concerns regarding a specific project.