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March 23, 2017

5957 GEOTECHNICAL RPT

WoodSpring Suites, LLC
8621 East 21st Street North, Suite 250
Wichita, KS 67206

Attention: Aaron Packard

SUBJECT: Geotechnical Investigation
Gresham WoodSpring Suites
NE Sandy Boulevard
Gresham, Oregon

At your request, GRI completed a geotechnical investigation for the proposed WoodSpring Suites project in Gresham, Oregon. The Vicinity Map, Figure 1, shows the general location of the site. The purpose of this investigation was to evaluate subsurface conditions at the site and develop conclusions and recommendations for site preparation, earthwork, and design and construction of foundations for the proposed WoodSpring Suites hotel. Our investigation included review of available subsurface information for the surrounding area, subsurface explorations, laboratory testing, and engineering analyses. This report describes the work accomplished and provides our conclusions and geotechnical recommendations for use in design and construction of the proposed hotel.

PROJECT DESCRIPTION

The project site is located adjacent to an existing Hampton Inn hotel and extends from US Highway Bancorp Columbia Center Terrace to NE Sandy Boulevard. We understand the project includes construction of a four-story, wood-framed hotel structure, associated drive lanes and parking areas, and landscaped areas. The Site Plan, Figure 2, shows the proposed location and configuration of the building with respect to Hampton Inn and the adjacent streets. We understand the new structure will be constructed at grade with a footprint of about 12,500 sq ft, and no pools or other underground facilities are planned. Information provided by the client indicates the building will be supported on continuous wall foundations with a maximum load of about 4,400 pounds per lineal foot.

We anticipate the finished floor elevation for the first floor will generally be consistent with adjacent street grades, and cuts and fills to establish grades across the site will not exceed 5 ft. The depth of excavation for utilities may approach about 10 ft. We understand parking areas, drive lanes, and a trash enclosure area will be constructed around the building. The drive lane and parking areas will be paved with asphalt concrete (AC) pavement, and the trash enclosure area will be paved with portland cement concrete (PCC). On-site stormwater facilities, such as swales and drywells, are also being considered for this project.

SITE DESCRIPTION

Surface Conditions and Topography

The project site encompasses about 2.5 acres and is bordered by NE Sandy Boulevard on the north; undeveloped land, Hampton Inn, and commercial buildings on the east; US Highway Bancorp Columbia Center Terrace on the south; and a parking lot on the west. The majority of the property is currently undeveloped land used for agricultural purposes; however, a residential structure is located in the northern half of the property. Our observations at the site indicate the ground surface gently slopes from south to north across the site.

Geology

The site is mantled with Quaternary alluvial deposits generally composed of silt underlain by gravel, cobbles, and boulders in a silt or coarse-grained sand matrix (Evarts and O'Connor, 2008). Relatively coarse-grained sedimentary deposits, locally referred to as the Troutdale Formation, underlie the Quaternary alluvial deposits. The Troutdale Formation consists of sand, gravel, cobbles, and boulders with varying amounts of cementation and is underlain by Columbia River Basalt at depth.

SUBSURFACE CONDITIONS

General

Subsurface materials and conditions at the site were investigated on February 28, 2017, with 10 test pits, designated TP-1 through TP-10. The test pits were advanced to depths of 3.5 to 10 ft below existing site grades at the approximate locations shown on Figure 2. Logs of the test pits are provided on Figures 1A through 5A, and photos of the test pits following excavation are provided on Figures 7A through 14A. The field and laboratory testing programs conducted to evaluate the physical engineering properties of the materials encountered in the test pits are described in Appendix A. The terms and symbols used to describe the soils encountered in the test pits are defined in Table 1A and on the attached legend.

Soils

The soils disclosed by the explorations are generally consistent with previous work completed by GRI in the area and indicate the project site is mantled with silt underlain by gravel and cobbles. We anticipate the thickness of the rooted zone and associated organic material at the ground surface is up to 6 in. over most of the site, but this material may be thicker in the vicinity of the brush and trees.

For the purpose of discussion, the soils disclosed by our investigation have been grouped into the following categories based on their physical characteristics and engineering properties:

1. **SILT**
2. **Silty GRAVEL and COBBLES**

The following paragraphs provide a detailed description of the soil units encountered in the explorations and a discussion of the groundwater conditions at the site.

1. SILT. Silt was encountered at the ground surface in all of the explorations and extends to depths of about 4.5 to 7 ft below existing site grades. The silt is generally brown and contains a variable amount of fine-grained sand ranging from some sand to sandy. The relative consistency of the silt is soft to medium stiff based on Torvane shear strength values ranging from 0.15 to 0.45 tsf and is typically medium stiff. The natural moisture content of the silt ranges from 22 to 32%. Atterberg limit test results indicate the silt has a liquid limit of 30% and a plasticity index of 4%, see Figure 6A. Test pit TP-8 was terminated in silt at a depth of about 3.5 ft.

2. Silty GRAVEL and COBBLES. Gravel and cobbles were encountered beneath silt in all of the explorations except test pit TP-8 and extended to the maximum depth explored of about 10 ft. The gravel and cobbles are generally subrounded to rounded, silty, and contain a variable amount of fine- to medium-grained sand ranging from a trace to some sand. Boulders on the order of 12 to 24 in. in diameter were encountered in the explorations at depths ranging from 5 to 8 ft below the ground surface. Our test pits for this project and our experience in the site's vicinity indicate this deposit usually contains scattered boulders in excess of 24 in. in diameter, zones that exhibit slight to moderate cementation, and lenses and layers of clayey, silty, and sandy soils. The relative density of the gravel and cobbles is medium dense to dense based on observations made during excavation. Test pits TP-1 through TP-7, TP-9, and TP-10 were terminated in gravel and cobbles at depths of about 7 to 10 ft below existing site grades.

Groundwater

Groundwater was not encountered in the test pits at the time of excavation. Our experience in the project vicinity and review of U.S. Geological Survey (USGS) groundwater data suggest the regional groundwater table occurs at depths greater than 35 ft below the ground surface. However, due to the shallow silt soils that mantle the site, it should be anticipated perched groundwater conditions may approach the ground surface during the wet, winter months and following periods of intense or prolonged precipitation.

Infiltration Testing

On February 28, 2017, two falling-head infiltration tests were conducted at depths of 3 and 7 ft below existing site grades in test pits TP-8 and TP-9, respectively. The infiltration tests were completed in general accordance with the City of Portland 2016 *Stormwater Management Manual* (SMM). Details regarding the infiltration testing methods are provided in Appendix A. The unfactored, field-measured infiltration rates recorded at specific depths within a specific soil unit are tabulated below.

Test Location	Depth of Infiltration Test, ft	Average Infiltration Rate, in./hr	Soil Classification
TP-8	3	0.5	Silty SAND
TP-9	7	5.0	Silty GRAVEL and COBBLES

CONCLUSIONS AND RECOMMENDATIONS

General

Subsurface explorations for this investigation indicate the site is mantled with up to 7 ft of medium-stiff silt underlain by dense silty gravel and cobbles. We anticipate the regional groundwater level typically occurs at depth in the gravel and cobble deposit. Boulders are locally present within the gravel and cobble deposit.

In our opinion, structural loads for the proposed hotel can be supported by conventional spread and perimeter foundations established in the medium-stiff silt that mantles the site. The following sections of this report provide our conclusions and recommendations for design and construction of the hotel building.

Earthwork

General. The fine-grained soil that mantles the site is sensitive to moisture content, and perched groundwater may approach the ground surface during the wet, winter months. Therefore, it is our opinion earthwork can be completed most economically during the dry, summer months, typically extending from June to mid-October. It has been our experience that the moisture content of the upper few feet of silt soil will decrease during extended warm, dry weather. However, below this depth, the moisture content of the soil tends to remain relatively unchanged and well above the optimum moisture content for compaction. As a result, the contractor must use construction equipment and procedures that prevent disturbance and softening of the subgrade soils. To minimize disturbance of the moisture-sensitive silt soils, site grading can be completed using track-mounted, hydraulic excavators. The excavation should be finished using a smooth-edged bucket to produce a firm, relatively undisturbed surface. It may also be necessary to construct granular haul roads and work pads concurrently with excavation to minimize subgrade disturbance. If the subgrade is disturbed during construction, soft, disturbed soils should be overexcavated to firm soil and backfilled with structural fill.

If construction occurs during wet ground conditions, granular work pads will be required to protect the underlying silt subgrade and provide a firm working surface for construction activities. In our opinion, a 12- to 18-in.-thick granular work pad should be sufficient to prevent disturbance of the subgrade in areas traveled by lighter construction equipment and limited dump-truck traffic. Haul roads and other high-density traffic areas will require a minimum of 18 to 24 in. of fragmental rock, up to 6-in. nominal size, to reduce the risk of subgrade deterioration. The use of a geotextile fabric over the subgrade may reduce the need for maintenance during construction. In areas that will be paved, haul roads can also be constructed by placing a thickened section of crushed rock base (CRB) and subsequently spreading and grading the CRB after earthwork is complete.

Site Preparation. The ground surface within the building footprint, pavement areas, and walkways should be stripped of existing vegetation, surface organics, and loose surface soils. We anticipate stripping up to a depth of about 4 to 6 in. will likely be required across the majority of the site; however, deeper grubbing may be required to remove brush and tree roots. Excavations required to remove brush and trees should be backfilled with structural fill. Organic strippings should be disposed of off site or stockpiled on site for use in landscaped areas.

Following stripping or excavation to subgrade level, the exposed subgrade should be evaluated by a qualified geotechnical engineer or engineering geologist. Proof-rolling with a loaded dump truck may be part of this evaluation. Any soft areas or areas of unsuitable material disclosed by the evaluation should be overexcavated to firm material and backfilled with structural fill.

Cobble and Boulder Excavation. It should be anticipated excavation efforts will be moderate to difficult where cobbles and boulders are encountered. In this regard, we recommend the project plans, specifications, and bid items address the uncertainty associated with encountering cobbles and boulders in excavations at the site. We anticipate conventional excavation equipment, including large excavators equipped with rock teeth, can be used to complete the excavations for utilities and other improvements that extend into the gravel and cobble deposit. It should be anticipated 24-in.-diameter or larger boulders may be encountered at the site. Excavation of large boulders, if encountered, may require using a large excavator equipped with a hydraulic splitter. Alternative methods for breaking and fracturing large boulders, if encountered, could consist of non-explosive, expansive, silent cracking agents (Crackamite or similar). These expansive agents are placed in holes drilled into the rock. The expansive agents then swell and fracture the rock to facilitate removal.

Structural Fill. It is anticipated a relatively minor amount of structural fill will be required to establish grades across the site. In our opinion, imported granular material or recycled concrete would be most suitable for construction of the structural fills. Granular material, such as sand, sandy gravel, or fragmental rock with a maximum size of about 1 1/2 in., would be suitable structural fill material. Granular fill placed during wet conditions should be relatively clean and have less than about 5% passing the No. 200 sieve (washed analysis). Granular fill should be placed in 12-in.-thick (loose) lifts and compacted to at least 95% of the maximum dry density as determined by ASTM D 698, or until well keyed with a vibratory roller.

On-site, fine-grained soils and site strippings free of debris may be used as fill in landscaped areas. These materials should be placed at about 90% of the maximum dry density as determined by ASTM D 698. The moisture content of soils placed in landscaped areas is not as critical, provided construction equipment can effectively handle the materials.

Utility Excavations. In our opinion, there are three major considerations associated with the design and construction of new utilities.

1) Provide stable excavation side slopes or support for trench sidewalls to minimize loss of ground. Excavations that encounter boulders will likely require additional support and/or flatter slope inclinations.
2) Provide a safe working environment during construction.
3) Minimize post-construction settlement of the utility and ground surface.

The method of excavation and design of trench support are the responsibility of the contractor and subject to applicable local, state, and federal safety regulations, including the current Occupational Safety and Health Administration (OSHA) excavation and trench safety standards. The means, methods, and sequencing of construction operations and site safety are also the responsibility of the contractor. The information provided below is for the use of our client and should not be interpreted to mean we are assuming responsibility for the contractor's actions or site safety.

According to current OSHA regulations, the majority of the silt and gravel encountered in the explorations may be classified as Type B and C, respectively. In our opinion, trenches less than 4 ft deep in silt that do not encounter groundwater may be cut vertically and left unsupported during the normal construction sequence. Trenches should be excavated and backfilled in the shortest possible sequence. Excavations more than 4 ft deep or excavations that encounter gravel, cobbles, or boulders should be laterally supported or alternatively provided with side slopes of 1.5H:1V (Horizontal to Vertical) or flatter. In our opinion, adequate lateral support may be provided by common methods, such as the use of a trench shield or hydraulic shoring systems. Larger trench dimensions may result from excavation of boulders, if encountered.

We anticipate the groundwater level will typically occur below the anticipated maximum excavation depth; however, perched groundwater may approach the ground surface during intense or prolonged precipitation. Groundwater seepage, running soil conditions, unstable trench sidewalls, or soft trench subgrades, if encountered during construction, will require dewatering of the excavation and/or trench sidewall support. The impact of these conditions can be reduced by completing trench excavation during the summer months and limiting the depth of the trenches.

We anticipate groundwater inflow, if encountered, can generally be controlled by pumping from sumps. To facilitate dewatering, it will be necessary to overexcavate the trench bottom to permit installation of a granular working blanket. We estimate the required thickness of the granular working blanket will be on the order of 1 ft, or as required to maintain a stable trench bottom. The actual required depth of overexcavation will depend on the conditions exposed in the trench and the effectiveness of the contractor's dewatering efforts. The thickness of the granular blanket must be evaluated on the basis of field observations during construction. We recommend the use of relatively clean, free-draining material, such as 2- to 4-in.-minus crushed rock, for this purpose. A non-woven geotextile fabric should be placed beneath the granular blanket.

All utility trench excavations within building and pavement areas should be backfilled with relatively clean, granular material, such as sand, sandy gravel, or crushed rock of up to 1 1/2-in. maximum size and having less than 5% passing the No. 200 sieve (washed analysis). The bottom of the excavation should be thoroughly cleaned to remove loose materials, and the utilities should be underlain by a minimum 6-in. thickness of bedding material. The granular backfill material should be compacted to at least 95% of the maximum dry density as determined by ASTM D698 in the upper 5 ft of the trench and at least 92% of this density below a depth of 5 ft. The use of hoe-mounted, vibratory-plate compactors is usually most efficient for this purpose. Flooding or jetting as a means of compacting the trench backfill should not be permitted.

Foundation Support

We understand the building will be supported by continuous foundations, and the maximum footing load will be about 4,400 pounds per lineal foot. In our opinion, continuous foundations constructed in accordance with the following design criteria will be suitable for support of the structural loads.

All footings should be established in the medium-stiff, native silt that mantles the site. The base of all new footings should be established at a minimum depth of 18 in. below the lowest adjacent finished grade and the footing width should not be less than 18 in. for continuous foundations. Excavations for all foundations should be made with a smooth-edged bucket, and all footing subgrades should be observed by a geotechnical engineer. Soft or otherwise unsuitable material encountered at foundation subgrade level should be overexcavated and backfilled with granular structural fill. Our experience indicates subgrade soils are easily disturbed by excavation and construction activities. In this regard, we recommend installing a minimum 3-in.-thick layer of compacted crushed rock in the bottom of all footing excavations. Relatively clean, 3/4-in.-minus crushed rock is suitable for this purpose. Additionally, cobbles or boulders that protrude above the base of the footing excavation should be removed and replaced with 3/4-in-minus crushed rock, as discussed above.

Footings established in accordance with these criteria can be designed on the basis of an allowable soil bearing pressure of 2,000 psf. This value applies to the total of dead load and/or frequently applied live loads and can be increased by one-third for the total of all loads: dead, live, and wind or seismic. We estimate the total settlement of spread footings designed in accordance with the recommendations presented above will be less than 1 in. for footings supporting wall loads of up to 4,400 pounds per lineal foot. Differential settlements between adjacent, comparably loaded footings should be less than half the total settlement. Our experience indicates these settlements will occur rapidly, with the majority of the settlement occurring during construction.

Horizontal shear forces can be resisted partially or completely by frictional forces developed between the base of the footings and the underlying soil and by soil passive resistance. The total frictional resistance between the footing and the soil is the normal force times the coefficient of friction between the soil and the base of the footing. We recommend an ultimate value of 0.35 for the coefficient of friction for footings cast on granular material. The normal force is the sum of the vertical forces (dead load plus real live load). If additional lateral resistance is required, passive earth pressures against embedded footings can be computed on the basis of an equivalent fluid having a unit weight of 250 pcf. This design passive-earth pressure would be applicable only if the footing is cast neat against undisturbed soil, or if backfill for the footings is placed as granular structural fill. This value also assumes the ground surface in front of the foundation is horizontal, i.e., does not slope downward away from the toe of the footing.

Subdrainage / Floor Support

We anticipate the finished floor elevation for the hotel will be established near or above the adjacent final site grades. To provide a capillary break and reduce the risk of damp floors, slab-on-grade floors that are established at or above adjacent final site grades should be underlain by a minimum of 8 in. of free-draining, clean, angular rock. This material should consist of angular rock such as 1½- to ¾-in. crushed rock, with less than 2% passing the No. 200 sieve (washed analysis), and should be placed in one lift and compacted to at least 95% of the maximum dry density as determined by ASTM D 698, or until well-keyed. To improve workability, the drain rock can be capped with a 2-in.-thick layer of compacted, ¾-in.-minus crushed rock. In our opinion, it is appropriate to assume a coefficient of subgrade reaction, k, of 175 pci to characterize the subgrade support for point loads with 8 in. of compacted crushed rock beneath the floor slab.

In areas where floor coverings will be provided or moisture-sensitive materials will be stored, it would be appropriate to also install a vapor-retarding membrane. The membrane should be installed as recommended by the manufacturer. In addition, a foundation drain should be installed around the building perimeter to collect water that could potentially infiltrate beneath the foundations. Collected water should discharge to an approved storm drain.

It is anticipated the finished floor elevation for the building will be established near or above the adjacent site grades. However, if structures such as floors are established below the final site grades, the structure should be provided with a subdrainage system. A subdrainage system will reduce the buildup of hydrostatic pressures on the floor slab and the risk of groundwater entering through embedded walls and floor slabs. GRI should be contacted if embedded structures are being considered.

Seismic Considerations

Based on our review of the 2012 *International Building Code* (IBC) and 2014 *Oregon Structural Specialty Code*, which incorporate recommendations from the ASCE 7-10, *Minimum Design Loads for Building and Other Structures*, and the results of our subsurface investigations, we recommend using Site Class C to evaluate the seismic design of the structure. The 2012 IBC and ASCE 7-10 seismic hazard levels are based on a Risk-Targeted Maximum Considered Earthquake (MCE_R). The ground motions associated with the probabilistic MCE_R represent a targeted risk level of 1% in 50 years probability of building collapse in the direction of maximum horizontal response. In general, these risk-targeted ground motions are developed by applying adjustment factors of directivity and risk coefficients to the 2% probability of exceedance in 50 years, or a 2,475-year return period hazard level, ground motions developed from the 2008 USGS probabilistic seismic hazard maps. The risk-targeted probabilistic values are also subject to a deterministic limit. The maximum horizontal direction spectral response accelerations were obtained from the USGS Seismic Design Maps for the coordinates of 45.5453° N latitude and 122.4790° W longitude. The S_S and S_1 parameters identified for the site are 0.98 and 0.40 g, respectively. These bedrock spectral ordinates are adjusted for Site Class, with the short- and long-period site coefficients, F_a and F_v, based on subsurface conditions or a site-specific response analysis. The short- and long-period site coefficients, F_a and F_v, are 1.00 and 1.40, respectively, for Site Class C. The design-level response spectrum is calculated as two-thirds of the Site Class-adjusted, MCE_R-level spectrum.

In terms of potential seismic-related hazards in the area, we anticipate the risk of liquefaction, lateral spreading, settlement, or ground subsidence is low for the site. The risk of damage by a tsunami and/or seiche and slope instability at the site is absent. The nearest mapped fault is the Grant Butte Fault, which is located about 3.7 miles south of the site. Unless occurring on a previously unmapped or unknown fault, the risk of fault rupture at the site is low.

Pavement Design

We anticipate the paved areas around the proposed structure will be subjected primarily to automobile and light-truck traffic, with occasional heavy-truck traffic. We anticipate the majority of the site will be paved with AC pavement; however, areas subjected to repeated heavy-truck traffic, such as trash enclosure areas, may be paved with PCC pavement. Traffic estimates for the roadways and parking areas are presently unknown.

Based on our experience with similar projects and subgrade soil conditions, we recommend the following pavement sections.

RECOMMENDED PAVEMENT SECTIONS

	CRB Thickness, in.	AC Thickness, in.
Areas Subject to Occasional Heavy-Truck Traffic	12	4
Areas Subject to Primarily Automobile Traffic and Parking	8	3
	CRB Thickness, in.	**PCC Thickness, in.**
Areas Subject to Repeated Heavy-Truck Traffic (trash enclosure areas)	6	6

A woven geotextile fabric should be placed beneath the crushed rock base.

The recommended pavement sections should be considered minimum thicknesses, and it should be assumed some maintenance will be required over the life of the pavement (15 to 20 years). The sections are based on the assumption pavement construction will be accomplished during the dry season and after construction of the building has been completed. If wet-weather pavement construction is considered, it will likely be necessary to increase the thickness of CRB to support construction equipment and protect the subgrade from disturbance. The indicated sections are not intended to support extensive construction traffic, such as dump trucks and concrete trucks. Pavements subject to construction traffic may require repair.

For the above-indicated sections, drainage is an essential aspect of pavement performance. We recommend paved areas be provided with positive drainage to remove surface water and water within the base course. This will be particularly important in cut sections or at low points within the paved areas, such as at catch basins. Effective methods to prevent saturation of the base course materials include providing weep holes in the sidewalls of catch basins, subdrains in conjunction with utility excavations, and separate trench-drain systems. To provide quality materials and construction practices, we recommend the pavement work conform to the current Oregon Department of Transportation *Standard Specifications for Construction*.

Prior to placing base course materials, all pavement areas should be proof-rolled with a fully loaded, 10-cy dump truck. Any soft areas detected by the proof-rolling should be overexcavated to firm ground and backfilled with compacted structural fill.

Provided the pavement section is installed in accordance with the recommendations provided above, it is our opinion the site access areas will support infrequent traffic by an emergency vehicle having a gross vehicle weight (GVW) of up to 75,000 lbs. For the purposes of this evaluation, *infrequent* can be defined as once a month or less.

On-Site Disposal of Stormwater

The unfactored, field-measured infiltration rates for the silt and gravel and cobbles soils are approximately 0.5 and 5 in./hr, respectively. Table 2-2 in the 2016 SMM specifies a minimum factor of safety of 2 for infiltration design based on encased, falling-head infiltration tests. Therefore, we recommend reducing the field infiltration rates by at least 50% to meet the requirements of the 2016 SMM and account for the reduction in the rate of infiltration over time due to clogging. Based on the field infiltration rates, it is our opinion the near-surface soils do not meet the requirements for on-site stormwater disposal; however, deeper stormwater facilities may be feasible in the gravel and cobble deposit at this site.

DESIGN REVIEW AND CONSTRUCTION SERVICES

We welcome the opportunity to review and discuss construction plans and specifications for this project as they are being developed. In addition, GRI should be retained to review all geotechnical-related portions of the plans and specifications to evaluate whether they are in conformance with the recommendations provided in our report. To observe compliance with the intent of our recommendations, design concepts, and the plans and specifications, we are of the opinion that all construction operations dealing with earthwork and foundation construction should be observed by a GRI representative. Our construction-phase services will allow for timely design changes if site conditions are encountered that are different from those described in our report. If we do not have the opportunity to confirm our interpretations, assumptions, and analyses during construction, we cannot be responsible for the application of our recommendations to subsurface conditions different from those described in this report.

LIMITATIONS

This report has been prepared to aid the architect and engineer in the design of this project. The scope is limited to the specific project and location described herein, and our description of the project represents our understanding of the significant aspects of the project relevant to the earthwork and design and construction of the foundations and floors. In the event any changes in the design and location of the project elements as outlined in this report are planned, we should be given the opportunity to review the changes and modify or reaffirm the conclusions and recommendations of this report in writing.

The conclusions and recommendations submitted in this report are based on the data obtained from the explorations made at the locations indicated on Figure 2 and other sources of information discussed in this report. In the performance of subsurface investigations, specific information is obtained at specific locations at specific times. However, it is acknowledged that variations in soil conditions may exist between exploration locations. This report does not reflect any variations that may occur between these explorations. The nature and extent of variation may not become evident until construction. If, during construction, subsurface conditions differ from those encountered in the explorations, we should be advised at once so we can observe and review these conditions and reconsider our recommendations where necessary.

Submitted for GRI,

Renews 06-2018

A. Wesley Spang, PhD, PE, GE Principal	Nicholas M. Hatch, PE Project Engineer	Christopher M. Landau, EIT Engineering Staff

Reference:

Evarts, R.C., and O'Connor, J.E., 2008, Geologic map of the Camas Quadrangle, Clark County, Washington, and Multnomah County, Oregon: U.S. Geological Survey Scientific Investigations Map 3017, scale 1:24,000.

APPENDIX A

Field Explorations and Laboratory Testing

APPENDIX A

FIELD EXPLORATIONS AND LABORATORY TESTING

FIELD EXPLORATIONS

Subsurface materials and conditions at the site were investigated on February 28, 2017, with 10 test pits, designated TP-1 through TP-10. The test pits were advanced to depths of 3.5 to 10 ft at the approximate locations shown on the Site Map, Figure 2. The test pits were excavated using a John Deere 85D track-mounted excavator provided and operated by Scott Lee Excavating, Inc., of Battle Ground, Washington. The field exploration work was coordinated and documented by an experienced geotechnical engineer from GRI, who maintained a log of the materials and conditions disclosed during the course of the work.

Disturbed grab samples were obtained from the test pit sidewalls at approximate 2- to 3-ft intervals of depth. Samples obtained from the test pits were examined in the field, and representative portions were saved in plastic jars or bags for further examination and physical testing in our laboratory. At the time of sampling, Torvane shear strength values were obtained in test pit sidewalls where the material consisted of fine-grained soils. Upon completion of the test pit excavations, the excavations were backfilled with excavation spoils.

Logs of the test pits are provided on Figures 1A through 5A. Each log presents a descriptive summary of the various types of materials encountered in the test pits and notes the depths at which the materials and/or characteristics of the materials change. To the right of the descriptive summary, the numbers and types of samples are indicated. Farther to the right, Torvane shear strength values are shown graphically along with the natural moisture contents, the Atterberg limits, and the fines contents (percent passing the No. 200 sieve), where applicable. The terms and symbols used to describe the materials encountered in the test pits are defined in Tables 1A and the attached legend. Pictures of the test pits were taken following completion and are provided on Figures 7A through 14A.

Infiltration Testing

Falling-head infiltration testing was completed at the site on February 28, 2017, in general conformance with the City of Portland *2016 Stormwater Management Manual* (SMM) using the encased falling-head method outlined in Section 2.3.6 of the SMM. Table 2-2 in the SMM specifies a minimum factor of safety of 2 for infiltration design based on encased falling-head infiltration tests. Infiltration testing was completed at depths of 3 and 7 ft in test pits TP-8 and TP-9, respectively. The test pits were excavated to the selected depths using a John Deere 85G excavator. At the base of the test pit, a 6-in.-inner-diameter (I.D.) PVC pipe was embedded into the soil and filled with water to a height of approximately 1 ft above the test depth. After soaking, infiltration testing was conducted by re-establishing the water level in the PVC pipe to the target height and recording the drop in water level over 1 hr or until the water completely drained, whichever occurred first. The infiltration tests were repeated until consecutive tests showed little or no change in infiltration rate. The unfactored, field-measured infiltration rates recorded at specific depths within a specific soil unit are tabulated below.

Test Location	Depth of Infiltration Test, ft	Average Infiltration Rate, in./hr	Soil Classification
TP-8	3	0.5	Silty SAND
TP-9	7	5.0	Silty GRAVEL and COBBLES

After the infiltration testing was completed, disturbed samples of the material were collected and examined in the field, and representative portions were saved in airtight jars for further examination and physical testing in our laboratory.

LABORATORY TESTING

General

The samples obtained from the test pits were examined in our laboratory, where the physical characteristics of the samples were noted, and the field classifications were modified where necessary. At the time of classification, the natural moisture content of each sample was determined. Additional testing included Torvane shear strength, grain size analysis, and Atterberg limits. A summary of the laboratory test results have been provided in Table 2A. The following sections describe the testing program in more detail.

Natural Moisture Content

Natural moisture content determinations were made in general conformance with ASTM D2216. The results are summarized on Figures 1A through 5A and in Table 2A.

Torvane Shear Strength

The approximate undrained shear strengths of relatively undisturbed fine-grained soil samples were determined using a Torvane shear device. The Torvane is a hand-held apparatus with vanes that are inserted into the soil. The torque required to fail the soil in shear around the vanes is measured using a calibrated spring. The results of the Torvane shear tests are summarized on Figures 1A through 5A.

Grain Size Analysis

Washed Sieve Method. To assist in classification of the soils, samples of known dry weight were washed over a No. 200 sieve. The material retained on the sieve is oven-dried and weighed. The percentage of material passing the No. 200 sieve is then calculated. The results are summarized in Figures 1A through 5A and in Table 2A.

Atterberg Limits

Atterberg limits determinations were performed on a representative sample of the silt in general conformance with ASTM D4318. The test results are shown on the test pit logs, Figures 1A through 5A, and the Plasticity Chart, Figure 6A. The results are also summarized in Table 2A.

Table 1A: GUIDELINES FOR CLASSIFICATION OF SOIL

Description of Relative Density for Granular Soil

Relative Density	Standard Penetration Resistance (N-values), blows per foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	over 50

Description of Consistency for Fine-Grained (Cohesive) Soils

Consistency	Standard Penetration Resistance (N-values), blows per foot	Torvane or Undrained Shear Strength, tsf
Very Soft	0 - 2	less than 0.125
Soft	2 - 4	0.125 - 0.25
Medium Stiff	4 - 8	0.25 - 0.50
Stiff	8 - 15	0.50 - 1.0
Very Stiff	15 - 30	1.0 - 2.0
Hard	over 30	over 2.0

Grain-Size Classification

Boulders:
$>$12 in.

Cobbles:
3 - 12 in.

Gravel:
$^1/_4$ - $^3/_4$ in. (fine)
$^3/_4$ - 3 in. (coarse)

Sand:
No. 200 - No. 40 sieve (fine)
No. 40 - No. 10 sieve (medium)
No. 10 - No. 4 sieve (coarse)

Silt/Clay:
pass No. 200 sieve

Modifier for Subclassification

Adjective	Primary Constituent SAND or GRAVEL	Primary Constituent SILT or CLAY
	Percentage of Other Material (by weight)	
trace:	5 - 15 (sand, gravel)	5 - 15 (sand, gravel)
some:	15 - 30 (sand, gravel)	15 - 30 (sand, gravel)
sandy, gravelly:	30 - 50 (sand, gravel)	30 - 50 (sand, gravel)
trace:	$<$5 (silt, clay)	*Relationship of clay and silt determined by plasticity index test*
some:	5 - 12 (silt, clay)	
silty, clayey:	12 - 50 (silt, clay)	

Table 2A

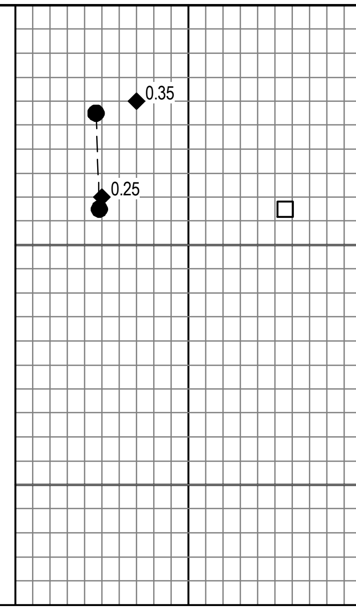
SUMMARY OF LABORATORY RESULTS

Sample Information						Atterberg Limits			
Location	Sample	Depth, ft	Elevation, ft	Moisture Content, %	Dry Unit Weight, pcf	Liquid Limit, %	Plasticity Index, %	Fines Content, %	Soil Type
TP-1	S-1	2.0	--	23	--	--	--	--	SILT
	S-2	4.0	--	24	--	--	--	78	SILT
TP-2	S-1	2.0	--	28	--	--	--	--	Sandy SILT
	S-2	4.0	--	28	--	--	--	--	Sandy SILT
TP-3	S-1	2.0	--	27	--	--	--	--	Sandy SILT
	S-2	4.0	--	28	--	--	--	--	Sandy SILT
TP-4	S-1	2.0	--	32	--	--	--	--	Sandy SILT
	S-2	4.0	--	27	--	--	--	--	Sandy SILT
TP-5	S-1	2.0	--	27	--	--	--	--	Sandy SILT
	S-2	4.0	--	27	--	--	--	--	Sandy SILT
TP-6	S-1	2.0	--	28	--	--	--	--	Sandy SILT
	S-2	4.0	--	28	--	30	4	62	Sandy SILT
TP-7	S-1	2.0	--	25	--	--	--	--	Sandy SILT
	S-2	4.0	--	28	--	--	--	--	Sandy SILT
TP-8	S-1	3.0	--	27	--	--	--	66	Sandy SILT
TP-9	S-1	2.0	--	26	--	--	--	--	Sandy SILT
	S-2	4.0	--	28	--	--	--	--	Sandy SILT
TP-10	S-1	2.0	--	22	--	--	--	--	Sandy SILT
	S-2	4.0	--	23	--	--	--	--	Sandy SILT

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO. / SAMPLE TYPE	● MOISTURE CONTENT, % □ FINES CONTENT, % ├─┤ LIQUID LIMIT, % / PLASTIC LIMIT, % (0 – 50 – 100)	COMMENTS AND ADDITIONAL TESTS

TP-1 **Surface Elevation:** Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO.
	SILT, some fine-grained sand, brown, medium stiff, 6-in.-thick heavily rooted zone at ground surface		S-1
	---soft to medium stiff below 4 ft		S-2
5	Silty GRAVEL and COBBLES, trace to some fine- to coarse-grained sand, dense, subrounded to rounded, contains boulders	4.5	
	---24-in.-diameter boulder encountered at 7 ft		S-3
10	(2/28/2017) Groundwater not encountered	10.0	

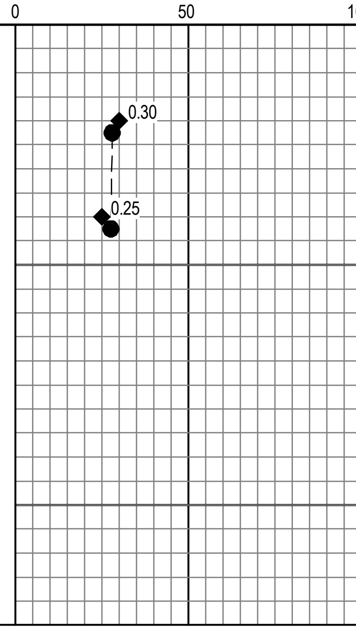


◆ TORVANE SHEAR STRENGTH, TSF

Logged By: C. Landau **Excavated by:** Scott Lee Excavating, Inc. **Equipment:** John Deere 85D Track-Mounted Excavator
Date Started: 2/28/17 **Coordinates:** Not Available **Note:** See Legend for Explanation of Symbols

TP-2 **Surface Elevation:** Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO.
	SILT, some fine-grained sand, brown, medium stiff, 6-in.-thick heavily rooted zone at ground surface		
	---sandy below 2 ft		S-1
	---soft to medium stiff below 4 ft		S-2
5	Silty GRAVEL and COBBLES, trace to some fine- to coarse-grained sand, dense, subrounded to rounded, contains boulders ---13-in.-diameter boulder encountered at 6 ft	5.0	
	(2/28/2017) Groundwater not encountered	9.0	
10			



◆ TORVANE SHEAR STRENGTH, TSF

Logged By: C. Landau **Excavated by:** Scott Lee Excavating, Inc. **Equipment:** John Deere 85D Track-Mounted Excavator
Date Started: 2/28/17 **Coordinates:** Not Available **Note:** See Legend for Explanation of Symbols

GRI TP LOG (LAT/LONG)-2 PP-NO ELEV GRI DATA TEMPLATE.GDT 3/16/17

GRI

TEST PITS

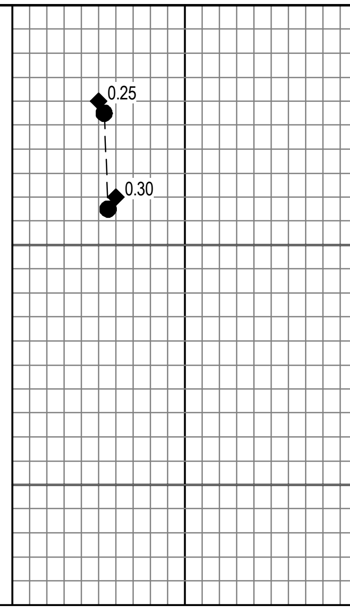
MAR. 2017 JOB NO. 5957 FIG. 1A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO. / SAMPLE TYPE	● MOISTURE CONTENT, % ☐ FINES CONTENT, % LIQUID LIMIT, % PLASTIC LIMIT, % (0 – 50 – 100)	COMMENTS AND ADDITIONAL TESTS

TP-3

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO.
	SILT, some fine-grained sand, brown, soft to medium stiff, 6-in.-thick heavily rooted zone at ground surface		
	---sandy below 2 ft		S-1
	---medium stiff below 4 ft		S-2
5			
	Silty GRAVEL and COBBLES, trace to some fine- to coarse-grained sand, dense, subrounded to rounded, contains boulders ---14-in.-diameter boulder encountered at 7 ft	6.0	S-3
10	(2/28/2017) Groundwater not encountered	10.0	



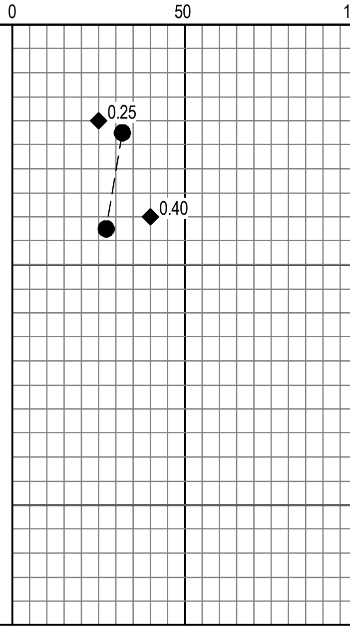
Logged By: C. Landau **Excavated by:** Scott Lee Excavating, Inc. **Equipment:** John Deere 85D Track-Mounted Excavator

Date Started: 2/28/17 **Coordinates:** Not Available **Note:** See Legend for Explanation of Symbols

TP-4

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO.
	SILT, some fine-grained sand, brown, soft to medium stiff, 6-in.-thick heavily rooted zone at ground surface		
	---sandy below 2 ft		S-1
	---medium stiff below 4 ft		S-2
5	Silty GRAVEL and COBBLES, trace to some fine- to coarse-grained sand, dense, subrounded to rounded, contains boulders	5.0	S-3
	---19-in.-diameter boulder encountered at 8 ft		
10	(2/28/2017) Groundwater not encountered	10.0	



Logged By: C. Landau **Excavated by:** Scott Lee Excavating, Inc. **Equipment:** John Deere 85D Track-Mounted Excavator

Date Started: 2/28/17 **Coordinates:** Not Available **Note:** See Legend for Explanation of Symbols

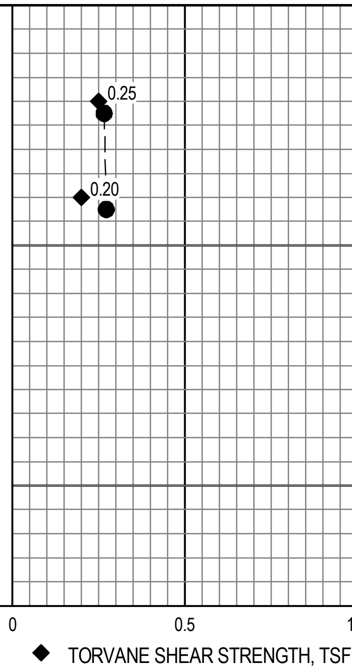
GRI

TEST PITS

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO.	SAMPLE TYPE	● MOISTURE CONTENT, % □ FINES CONTENT, % ├─┤ LIQUID LIMIT, % / PLASTIC LIMIT, % (0 – 50 – 100)	COMMENTS AND ADDITIONAL TESTS

TP-5 **Surface Elevation:** Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO.
	SILT, some fine-grained sand, brown, soft to medium stiff, 6-in.-thick heavily rooted zone at ground surface		
	---sandy below 2 ft		S-1
	---soft below 4 ft		S-2
5	Silty GRAVEL and COBBLES, trace to some fine- to coarse-grained sand, dense, subrounded to rounded, contains boulders	5.0	
	---16-in.-diameter boulder encountered at 6 ft	7.0	
	(2/28/2017)		
	Groundwater not encountered		
10			

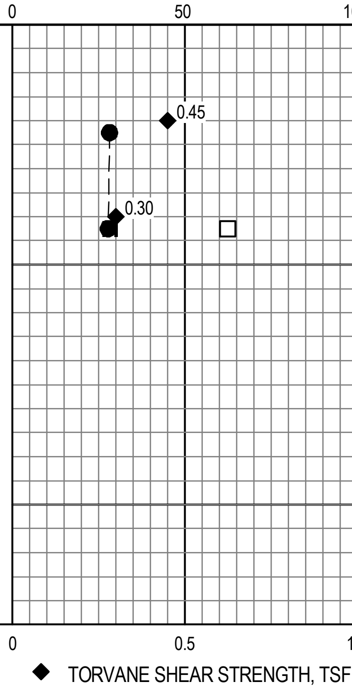


Logged By: C. Landau **Excavated by:** Scott Lee Excavating, Inc. **Equipment:** John Deere 85D Track-Mounted Excavator

Date Started: 2/28/17 **Coordinates:** Not Available **Note:** See Legend for Explanation of Symbols

TP-6 **Surface Elevation:** Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO.
	SILT, some fine-grained sand, brown, medium stiff, 6-in.-thick heavily rooted zone at ground surface		
	---sandy below 2 ft		S-1
			S-2
5			
	Silty GRAVEL and COBBLES, trace to some fine- to coarse-grained sand, dense, subrounded to rounded, contains boulders	7.0	
	---12-in.-diameter boulder encountered at 8 ft		
10	(2/28/2017)	10.0	
	Groundwater not encountered		



Logged By: C. Landau **Excavated by:** Scott Lee Excavating, Inc. **Equipment:** John Deere 85D Track-Mounted Excavator

Date Started: 2/28/17 **Coordinates:** Not Available **Note:** See Legend for Explanation of Symbols

GRI TP LOG (LAT/LONG)-2 PP-NO ELEV GRI DATA TEMPLATE.GDT 3/16/17

GRI

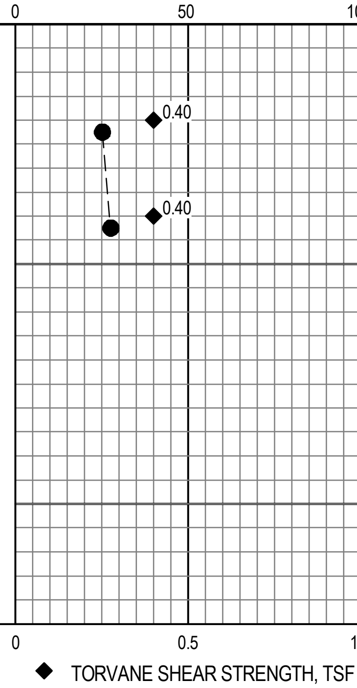
TEST PITS

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO. SAMPLE TYPE	● MOISTURE CONTENT, % ☐ FINES CONTENT, % LIQUID LIMIT, % PLASTIC LIMIT, % (0 50 100)	COMMENTS AND ADDITIONAL TESTS

TP-7

Surface Elevation: Not Available

Depth, ft	Classification of Material	Sample No.
0–7.0	SILT, some fine-grained sand, brown, medium stiff, 6-in.-thick heavily rooted zone at ground surface ---sandy below 2 ft	S-1, S-2
7.0–9.0	Silty GRAVEL and COBBLES, trace to some fine- to coarse-grained sand, dense, subrounded to rounded, contains boulders, 12-in.-diameter boulder encountered at 7 ft	
9.0	(2/28/2017) Groundwater not encountered	



◆ TORVANE SHEAR STRENGTH, TSF

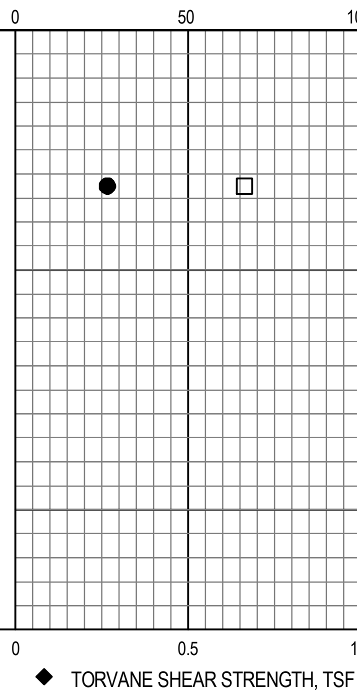
Logged By: C. Landau | **Excavated by:** Scott Lee Excavating, Inc. | **Equipment:** John Deere 85D Track-Mounted Excavator

Date Started: 2/28/17 | **Coordinates:** Not Available | **Note:** See Legend for Explanation of Symbols

TP-8

Surface Elevation: Not Available

Depth, ft	Classification of Material	Sample No.
0–3.5	Sandy SILT, brown, medium stiff, fine-grained sand, 6-in.-thick heavily rooted zone at ground surface	S-1
3.5	(2/28/2017) Groundwater not encountered	



◆ TORVANE SHEAR STRENGTH, TSF

Logged By: C. Landau | **Excavated by:** Scott Lee Excavating, Inc. | **Equipment:** John Deere 85D Track-Mounted Excavator

Date Started: 2/28/17 | **Coordinates:** Not Available | **Note:** See Legend for Explanation of Symbols

GRI TP LOG (LAT/LONG)-2 PP-NO ELEV GRI DATA TEMPLATE.GDT 3/16/17

GRI

TEST PITS

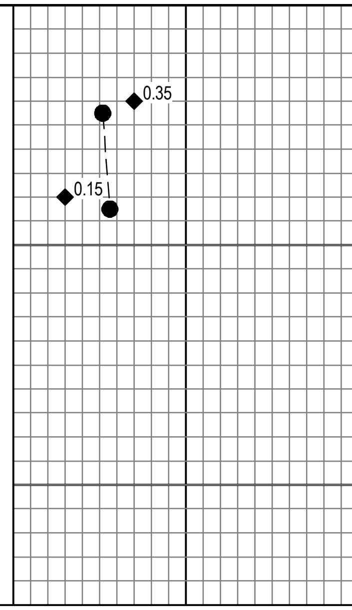
MAR. 2017 JOB NO. 5957 FIG. 4A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO. / SAMPLE TYPE	● MOISTURE CONTENT, % ☐ FINES CONTENT, % LIQUID LIMIT, % PLASTIC LIMIT, % (0 – 50 – 100)	COMMENTS AND ADDITIONAL TESTS

TP-9

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO.
	SILT, some fine-grained sand, brown, medium stiff, 6-in.-thick heavily rooted zone at ground surface		
	---sandy below 2 ft		S-1
	---soft below 4 ft		S-2
5	Silty GRAVEL and COBBLES, trace to some fine- to coarse-grained sand, dense, subrounded to rounded, contains boulders ---12-in.-diameter boulder encountered at 6 ft	5.0	S-3
	(2/28/2017) Groundwater not encountered	7.0	
10			



0 0.5 1.0

◆ TORVANE SHEAR STRENGTH, TSF

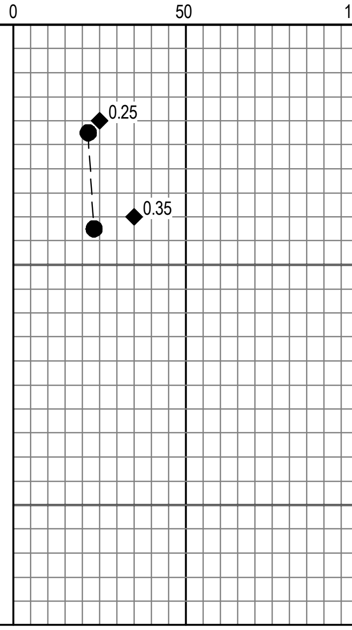
Logged By: C. Landau **Excavated by:** Scott Lee Excavating, Inc. **Equipment:** John Deere 85D Track-Mounted Excavator

Date Started: 2/28/17 **Coordinates:** Not Available **Note:** See Legend for Explanation of Symbols

TP-10

Surface Elevation: Not Available

DEPTH, FT	CLASSIFICATION OF MATERIAL	DEPTH, FT	SAMPLE NO.
	SILT, some fine-grained sand, brown, soft to medium stiff, 6-in.-thick heavily rooted zone at ground surface		
	---sandy below 2 ft		S-1
	---medium stiff below 4 ft		S-2
5			
	Silty GRAVEL and COBBLES, trace to some fine- to coarse-grained sand, dense, subrounded to rounded, contains boulders, 24-in.-diameter boulder encountered at 6 ft	6.0	S-3
10	(2/28/2017) Groundwater not encountered	9.0	



0 0.5 1.0

◆ TORVANE SHEAR STRENGTH, TSF

Logged By: C. Landau **Excavated by:** Scott Lee Excavating, Inc. **Equipment:** John Deere 85D Track-Mounted Excavator

Date Started: 2/28/17 **Coordinates:** Not Available **Note:** See Legend for Explanation of Symbols

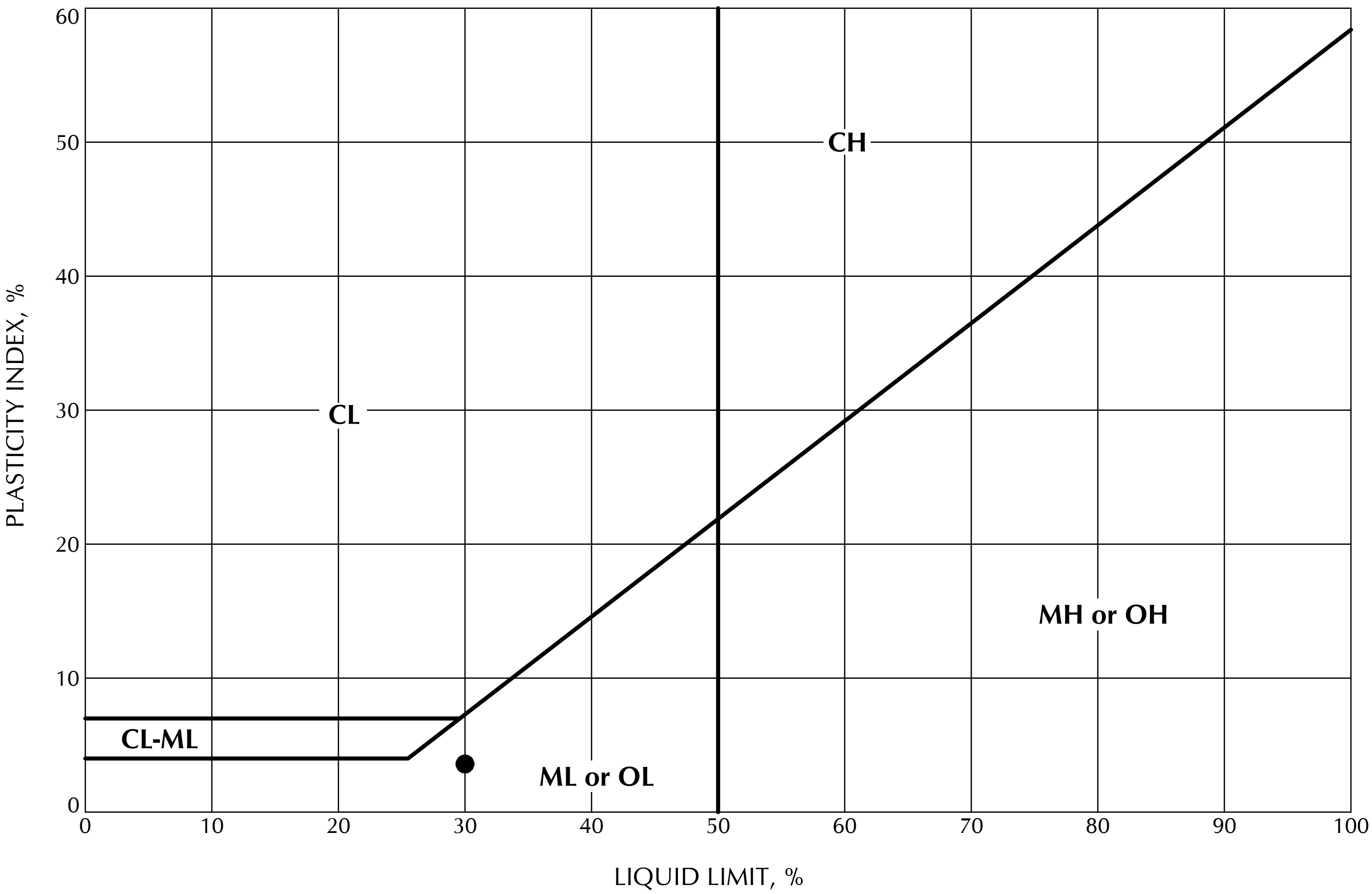
GRI

TEST PITS

MAR. 2017 JOB NO. 5957 FIG. 5A

GROUP SYMBOL	UNIFIED SOIL CLASSIFICATION FINE-GRAINED SOIL GROUPS
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
ML	INORGANIC CLAYEY SILTS TO VERY FINE SANDS OF SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY

GROUP SYMBOL	UNIFIED SOIL CLASSIFICATION FINE-GRAINED SOIL GROUPS
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
MH	INORGANIC SILTS AND CLAYEY SILT
CH	INORGANIC CLAYS OF HIGH PLASTICITY



	Location	Sample	Depth, ft	Classification	LL	PL	PI	MC, %
●	TP-6	S-2	4.0	Sandy SILT, brown, fine-grained sand	30	26	4	28

ATTERBERG-PLASTICITY 1 PER PAGE GRI DATA TEMPLATE.GDT 3/14/17

GRI

PLASTICITY CHART

MAR. 2017 JOB NO. 5957 FIG. 6A