Geotechnical Engineering Report

Olive Way Apartments
1662 E Olive Way
Seattle, King County, Washington

July 14, 2023

Terracon Project No. 81235014

Prepared for:

1661 Olive Way LP
Bellevue, WA

Prepared by:

Terracon Consultants, Inc.
Mountlake Terrace, Washington

July 14, 2023

1661 Olive Way LP
10900 NE 4th St #1440
Bellevue, WA 98004

Attn: Ed Segat – Development Manager
P: (425) 462-0700
E: ESegat@continentalproperties-inc.com

Re: Geotechnical Engineering Report
Olive Way Apartments
1661 East Olive Way
Seattle, King County, Washington
Terracon Project No. 81235014

Dear Mr. Segat:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. P81235036 dated March 1, 2023. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork, the design and construction of building foundations, floor slabs and excavation design for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Xiaoyi Tan

RICHARD D. LUARK
STATE OF WASHINGTON
29321
REGISTERED
PROFESSIONAL ENGINEER

Xiaoyi Tan, E.I.T.
Staff Engineer

Richard D. Luark, P.E., L.E.G.
Principal

REPORT TOPICS

Note: This report was originally delivered in a web-based format. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

REPORT SUMMARY

Topic [1]	Overview Statement [2]
Project Description	The proposed development will consist of demolishing the existing buildings and parking areas and construction of an eight-story apartment building with up to three levels of below grade parking. The development will require shoring to construct the below-grade portions of the building.
Geotechnical Characterization	Existing fill was observed up to about 5 feet below existing ground (bgs). Medium dense to dense weathered glacial deposits is anticipated to be up to about 7½ feet bgs. Very dense glacially consolidated soil to at least 46 feet bgs. Groundwater was measured via monitoring well between about 18 to 20½ feet bgs during the exploration and is anticipated to trend deeper to northwest.
Earthwork	The maximum excavation depth appears to be on the order of 33 feet below existing grades. Shoring will be required to support the construction of the below-grade portion of the building. Foundation bearing soils are glacially consolidated soils. The subgrade soils contain an appreciable fines content and will be moisture sensitive. Subgrades may become unstable when exposed to excessive moisture and/or disturbance.
Shallow Foundations	Shallow foundations will be sufficient at the base of the excavation. Bearing capacity values for spread footings and strip footing are present in **Shallow Foundation** section. Expected settlements: < 1-inch total, < ½-inch differential
Below-Grade Structures	The proposed structure will include two to three levels of below grade parking.
Retaining Walls	We anticipate interior retaining walls in the parking garage at the ramps between parking levels.
Shoring Design	A solider pile with tieback shoring system and/or soil nails with vertical elements appear feasible to support the excavation for the below grade portions of the building and foundations. The shoring system must be designed to support the surcharge loads from the Bonneville Apartments.
General Comments	This section contains important information about the limitations of this geotechnical engineering report.

1. If the reader is reviewing this report as a pdf, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.
2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.

Geotechnical Engineering Report

Olive Way Apartments
1661 East Olive Way
Seattle, King County, Washington

Terracon Project No. 81235014

July 14, 2023

INTRODUCTION

This report presents the results of the subsurface explorations and geotechnical engineering services performed for the proposed Olive Way Apartments to be located at 1661 East Olive Way in Seattle, King County, Washington. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Seismic considerations and hazards
- Foundation design and construction
- Floor slab design and construction
- Lateral earth pressures
- Excavation design
- Subsurface Drainage

The project description, site conditions, and our geotechnical conclusions and design recommendations are presented in the text of this report. Map the site and historical geotechnical and environmental boring locations are shown in the **Site Location** and **Historical Exploration Plan** sections, respectively. Supporting data including historical boring logs and result of laboratory testing are presented in the **Historical Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located at 1661 East Olive Way in Seattle, King County, Washington. Lot Size: ~0.58 acres Latitude: 47.61933° N Longitude: --122.32372° E See **Site Location**
Existing Improvements	■ One (1) two- to three-story building within the north portion of the site ■ Two (2) one- to two-story buildings with associated garage and deck parking daylight to the west within the south portion of the site

Item	Description
Current Ground Cover	Asphalt pavement and concrete sidewalk
Existing Topography	The site generally slopes down to the northwest from 306 to 295 feet in elevations.
Geology	Our review of geologic maps, existing subsurface information, and our past experiences with projects in the area indicates the geology consists of a fill unit of variable thickness overlaying weathered glacial deposits that are underlain by glacially consolidated soils. **Map reviewed**: *The geologic map of Seattle – a progress report 1:100,000-scale Quadrangle, Washington compiled by Kathy Goetz Troost, Derek B. Booth, Aaron P. Wisher, and Scott A. Shimel, 2005*

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	■ Preliminary Geotechnical Report "Preliminary Geotechnical Engineering Report, 1161 East Olive Way, Seattle, Washington" by Terracon Consultants, Inc., dated September 10, 2018 ■ Environmental Report "Limited Site Investigation, Olive Way, 1651 and 1661 E Olive Way, 12 and 127 Boylston Avenue East, Seattle King County, Washington", by Terracon Consultants, Inc., dated January 14, 2009. ■ Architectural Design Drawing by MG2 Architects (MG2), publish date of December 12, 2022 ■ Olive Way ALTA Survey by PACE, dated September 17, 2018
Project Description	The proposed development will consist of demolishing of the existing structures and construction of one apartment building with underground parking. The development will require shoring to support below-ground construction.
Proposed Structure	The project includes one seven- to eight-story building with two- to three-below grade levels. The footprint of the development is approximately 0.5 acres.
Building Construction	Wood frame over concrete podium construction
Finished Floor Elevation	Elevation 274.5 for P2, the lowest level.
Maximum Loads (Assumed)	■ Column: 800 kips ■ Wall: 12 kips per linear foot (klf) ■ Slabs: 250 pounds per square foot (psf)

Item	Description
Below-Grade Structures	Two to three below grade levels
Retaining Walls	We anticipate interior retaining walls in the parking garage at the ramps between parking levels.
Below-Grade Areas	Project will include up to three below grade levels and will require shoring to support construction for the below grade portion. The excavation depth will be up to about 33 feet bgs.
Applicable Building Code and Minimum Design Load Standard	City of Seattle Building Code – (SBC 2018) 2016 ASCE Standard ASCE/SEI 7-16 (ASCE 7-16)
Estimated Start of Construction	2024

GEOTECHNICAL CHARACTERIZATION

The following Terracon environmental boring logs, third-party exploration geotechnical boring logs, and corresponding laboratory test results, presented in **Historical Exploration Results** section, were used to develop a geotechnical characterization of the subsurface conditions:

- Three (3) onsite environmental borings ranging between 20½ and 46 feet bgs and four (4) environmental borings associated with monitoring wells ranging between 35 and 46½ feet bgs completed by Terracon
- Three (3) offsite geotechnical soil borings to the north ranging between 25 and 35 feet bgs completed by PanGeo
- Two (2) offsite geotechnical soil borings to the east and northeast ranging between 18 and 23 feet bgs completed by Hart Crowser (HC)
- Two (2) offsite geotechnical soil borings to the east and southeast ranging between 25 and 35 feet bgs completed by Geotech Consultants (GC)

The characterization forms the basis of our geotechnical recommendations based on our engineering evaluations of site preparation and foundation options. As noted in **General Comments**, the characterization is based upon widely spaced exploration points within and in the vicinity of the site, and variations are likely.

Soil Layer[1]	Layer Name	USCS	General Description
--	Surface	---	Based on Terracon on-site environmental soil borings and monitoring wells, about 2 to 3 inches asphalt, 6 inches concrete, bricks, or 2 inches topsoil were observed at the exploration locations.
1	**Existing Fill**	SM, GM	Medium dense silty sand or silty sandy gravel. The depth of the bottom of this unit ranged from about 2 to 5 feet bgs.

2	**Weathered Glacial Deposits**	SM	Medium dense to dense silty sand with variable gravel content. The depth of the bottom of this unit is anticipated to be about 7½ feet bgs.
3[2]	**Glacially Consolidated Soil**	SM, ML, SP	Very dense silty sand with variable gravel content/hard silt with variable sand content and was observed to depth of at least 46 feet bgs.

1. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.
2. All soil borings were terminated within this layer.

Groundwater Conditions

The water levels recorded in the boring logs, which can be found in **Historical Exploration Results** section, are summarized below:

Boring Number	Approximate Depth to Water Level (feet) while Drilling [1]	Approximate Depth to Water Level (feet) via Measurement [1,2]
B-2 (GC)	16	--
B-1 (HC)	3[3]	--
MW1	28.5	19.6
MW2	29.1	19.5
MW3	--	15.8
MW4	--	17.3

1. Below ground surface
2. Measured via monitoring well on December 21, 2018
3. Possibly perched groundwater

Groundwater was not observed in the remaining borings while drilling. However, this does not necessarily mean the borings terminated above groundwater, or the water levels summarized above are stable groundwater levels. Due to the low permeability of the soils (i.e. glacially consolidated soil) encountered in the borings, perched groundwater are often associated. In addition, a relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type. Four monitoring wells were installed following the boring exploration at MW1 through MW4.

On June 6, 2023, a Terracon representative visited the site and measure the groundwater levels in the four monitoring wells at the site. The measured groundwater results are summarized below:

Boring Number	Approximate Depth to Water Level (feet) via Measurement[1]	Approximate Elevation of Water Level (feet) [2]
MW1	20.6	274.4
MW2	18.5	276.5
MW3	19.5	280
MW4	18	286

1. Below ground surface
2. Interpolated from site topographic site plan

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

As mentioned in previous section, the information obtained from the subsurface exploration programs performed by Terracon and others are the basis for the subsurface conditions at the site. In general, the site is underlain by a viable thickness of existing fill and weathered glacial deposits, which are underlain by glacially consolidated soils. The glacially consolidated soils will be the bearing soil at the foundation level per the current design with a basement with finished floor elevation of 274.5 feet.

The site soils generally contain an appreciable fine content and could become moisture sensitive when exposed to excessive moisture and/or disturbance. The glacially consolidated native soils, when cut neat, are suitable for foundation loading; therefore, care should be taken by the contractor to minimized disturbance of subgrades. If possible, construction should be performed during drier months to reduce the potential of distributing the subgrade. Further discussions are provided in the **Earthwork** section.

The foundation level is planned to be within the very dense glacially consolidated soil (Layer 3), which is a suitable bearing stratum for foundation and floor slab loading in their native state. The **Shallow Foundations** section addresses support of the building bearing on Layer 3. The **Floor Slabs** section addresses slab-on-grade support of the building.

The anticipated shoring depths are about 22 to 34 feet bgs. A shoring system consisting of soldier piles with tiebacks, and/or soil nails with vertical elements appears feasible to provide the support of the excavation; however, the south shoring wall will be located adjacent to the existing Bonneville Apartments is recommended to consist of soldier pile shoring with tiebacks or interior

bracing if tieback easement cannot be obtained. Specific considerations for each shoring wall are provided in the **Excavation Design** section.

Based on the existing subsurface condition, the groundwater is anticipated to be at the elevation between about 274½ and 286 feet, which is above the bottom of the proposed excavation. In addition, perched groundwater may be encountered as the excavation progresses. However, due to the low permeability of the soils (i.e. glacially consolidated soils), groundwater encountered through the excavation sidewalls and excavation base can likely be managed through sumps and pumps. Additional recommendations are provided in the **Subsurface Drainage** section.

The **General Comments** section provides an understanding of the report limitations.

Specific conclusions and recommendations regarding these geotechnical considerations, as well as other geotechnical aspects of design and construction of foundation systems and other earthwork related phases of the project are outlined in the following sections. The recommendations contained in this report are based upon the results of field and laboratory testing, engineering analyses, and our current understanding of the proposed project. ASTM and Washington State Department of Transportation (WSDOT) specification codes cited herein respectively refer to the current manual published by the American Society for Testing & Materials and the current edition of the *Standard Specifications for Road, Bridge, and Municipal Construction, (M41-12)*.

SEISMIC CONSIDERATIONS

In 2022, the State of Washington amended the 2018 IBC to allow the Multi-Period Response Spectrum (MPRS) of ASCE 7-22 for determination of design ground motion values. The amendment requires use of the updated Site Class designations found in Chapter 20 of ASCE 7-22. The MPRS values were obtained from the ASCE 7-22 online tool (https://asce7hazardtool.online/) and are presented in the below table.

Description	Value
Site Class	C
Site Latitude	47.6193° N
Site Longitude	-122.3237° E
S_S	1.54
S_1	0.65
S_{MS}	1.72
S_{M1}	0.89
S_{DS}	1.14

Description	Value
S_{D1}	0.59
PGA_M	0.68

Surface-Fault Rupture

The hazard of damage from onsite fault rupture appears to be low based on review of the USGS Earthquake Hazards Program Quaternary Faults and Folds Database available online (https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=5a6038b3a1684561a9b0aadf88412fcf) accessed on June 2, 2023. The closest mapped fault is the Seattle fault zone, which lies approximately 3 miles to the south.

Liquefaction

Liquefaction is the phenomenon where saturated soils develop high pore water pressures during seismic shaking and lose their strength characteristics. This phenomenon generally occurs in areas of high seismicity, where groundwater is shallow, and loose granular soils or relatively non-plastic fine-grained soils are present. As the site soils at the building foundation level are glacially consolidated, therefore the hazard of liquefaction is considered to be negligible.

EARTHWORK

Earthwork is anticipated to include clearing and grubbing, demolition and excavation of existing building foundations, and a shored excavation to support construction of below-grade portion of the proposed structure. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavements.

Demolition Consideration

The existing two-story parking garage onsite borders the Bonneville Apartments to the south. The Bonneville Apartments does not have a basement level, but steps down to the south and west. The existing onsite parking garage at the south end of the site includes one below-grade level with daylight to the east. During the site reconnaissance, we observed that the foundations of the Bonneville Apartments eastern building is offset from our site; however, a trash closure area is partially located within our site and need to be re-located during the demolition. The Bonneville Apartments western building is near the project's south property line; however, the foundations extend down to below the existing site grades as the western building has a daylight basement level. Our understanding of the Bonneville Apartments is based on a review of the building plans obtained from the City of Seattle.

Site Preparation

All prepared subgrades should be observed by Terracon prior to casting of building foundations or placement of capillary break for slab on grade floors. In their existing, undisturbed state, the native soils are suitable for foundation loading. The contractor should exercise care to minimize disturbance of native subgrades. Subgrades deemed deficient should be addressed by the contractor per Terracon's recommendations. Maintaining the condition of the subgrade after observation by Terracon will be the responsibility of the contractor. A layer of concrete referred to as a "mud mat" or "rat slab" is recommended at the base of the foundation excavation to protect the subgrade from disturbance. Alternatively, a layer of clean crushed rock can be utilized to protect the foundation subgrades from disturbance.

Existing Fill

As noted in **Geotechnical Characterization**, borings in the vicinity of our site encountered existing fill to depths of about 2 to 5 feet bgs. Based on the existing site topography, current and proposed development, existing fill is anticipated to be encountered within our site and be removed with the building footprint as part of the planned excavation.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill. Structural fill is material used to backfill around foundations to achieve design grades for slab on grade floors and for backfilling behind cast in place retaining walls. Earthen materials used for structural and common fill should meet the following material property requirements:

Fill Type	Recommended Materials	Acceptable Location for Placement
Structural Fill	Type 21 (1) *(1-1/4-inch Minus Crushed Rock)*[1] Type 17 *(Select Backfill)* [1] Type 22 *(3/4 inch minus clean Crushed Gravel)*[1]	Beneath and adjacent to structural slabs, adjacent to foundations, building appurtenances, and pavement subgrades
Lean Concrete[2]	28-day unconfined compressive strength of at least 150 psi	Beneath the foundations and structural slabs
Free-Draining Granular Fill	Type 13 *(2-1/2-inch Crushed Rock)* Type 21 (1) *(1-1/4-inch Minus Crushed Rock)*[1] Type 22 *(3/4 inch minus clean Crushed Gravel)*[1]	Backfilling in wet weather, drainage layers for walls, sump drains, footing drains[3]

1. Seattle (SDOT) Standard Specifications
2. Lean concrete should contain a minimum of 150lbs per cubic foot of cementitious material and achieve a 28-day unconfined compressive strength of at least 150 psi.
3. Minimum particle size must be greater than drainpipe perforations.

Other earthen materials may be suitable for use in addition to the options presented in the table above. All materials should be approved by Terracon prior to use.

Fill Compaction Requirements

Structural and common fill should meet the following compaction requirements.

Item	Structural and Free-Draining Fill	Lean Concrete
Maximum Lift Thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used	24 inches[2]
Minimum Compaction Requirements [1]	95% of max. below foundations and floor slabs and within 1 foot of finished pavement subgrade 92% of max. above foundations and more than 1 feet below finished pavement subgrade	N/A
Water Content Range [1]	Typically within 2% of optimum	N/A

Utility Trench Backfill

All trenches should be wide enough to allow for compaction around the haunches of the pipe. Or material such as pea gravel (provided this is allowed by the pipe manufacturer) should be used below the spring line of the pipes to eliminate the need for mechanical compaction in this portion of the trenches. If water is encountered in the excavations, it should be removed prior to fill placement.

Placement and compaction of recommended materials for utility trench backfill should be in accordance with the recommendations presented herein for **Earthwork**. In our opinion, the initial lift thickness should not exceed one foot unless recommended by the manufacturer to protect utilities from damage by compacting equipment. Light, hand-operated compaction equipment in conjunction with thinner fill lift thicknesses may be utilized on backfill placed above utilities if damage resulting from heavier compaction equipment is of concern.

Flexible connections for utilities that pass through building foundations are recommended to reduce potential stress associated with differential settlement that may occur between the building foundation and the improvements located outside of the building footprint.

Grading and Drainage

Site grades should be established such that surface water is directed away from foundation and pavement subgrades to prevent an increase in the water content of the soils. Adequate positive

drainage diverting water from structures, open cuts, and slopes should be established to prevent erosion, ground loss, and instability. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping, final grades should be verified to document effective drainage has been achieved. Where paving or flatwork abuts the structure a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Earthwork Construction Considerations

The excavation for the proposed below-grade portion is anticipated to be accomplished with conventional construction equipment although the very dense nature of the glacially consolidated soils may result in slower excavation production. Construction traffic over the completed subgrades should be avoided. Use of concrete “mud mat or rat slab” placed in a thin lift following preparation of subgrades is encouraged. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over, or adjacent to, construction areas should be removed. Earthwork should be performed during drier months to reduce the potential for subgrade disturbances from wet weather. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed per Terracon’s observation and field recommendations during construction.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, “Excavations” and its appendices, and in accordance with any applicable local, and/or state regulations. Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts should be monitored under the observation of Terracon. Observations, at a minimum, should include the following:

- Installation of shoring including solider pile installation
- Tieback and soil nail installation and testing
- Lagging and subsurface drainage installation
- Subgrade preparation for shallow foundations, floor slabs, and any pavement areas
- Backfilling around foundations
- Removal and replacement of unsuitable soils and replacement with structural fill or lean concrete, if encountered

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by Terracon prior to placement of additional lifts. Each lift of fill should be tested for density and water content.

In areas of foundation excavations, the bearing subgrade should be evaluated by Terracon. In the event that unanticipated conditions are encountered, Terracon should recommend mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Terracon into the construction phase of the project provides the continuity to maintain Terracon's evaluation of subsurface conditions, including assessing variations and associated design changes.

Wet Weather Earthwork

The near-surface soils have variable fines content based on our visual observations and lab testing and are considered moisture sensitive. The soils will exhibit moderate erosion potential and may be transported by running water. Silt fences and other best-management practices will be necessary to control erosion and sediment transport during construction.

The suitability of soils used for structural fill depends primarily on their grain-size distribution and moisture content when they are placed. As the fines content (the soil fraction passing the U.S. No. 200 Sieve) increases, soils become more sensitive to small changes in moisture content. Soils containing more than about 5 percent fines (by weight) cannot be consistently compacted to a firm, unyielding condition when the moisture content is more than 2 percentage points above or below optimum. Optimum moisture content is the moisture content at which the maximum dry density for the material is achieved in the laboratory by the ASTM D1557 test procedure.

If inclement weather or in situ soil moisture content prevents the use of on-site material as structural fill, we recommend use of materials specified in **Fill Material Types** for free-draining granular fill.

Stockpiled soils should be protected with polyethylene sheeting anchored to withstand local wind conditions and preservation of the soil's moisture content.

SHALLOW FOUNDATIONS

If the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable for shallow foundations within the glacially consolidated deposits.

Design Parameters – Compressive Loads

Description	Spread Footing	Strip Footing
Net Allowable Bearing Pressure [1,2] ■ ≤8 feet ■ 8 feet < Footing Width ≤ 12 feet ■ ≥12 feet	8 ksf 10 ksf 12 ksf	6 ksf for all
Minimum Dimensions	24 inches	18 inches
Minimum Embedment Below Finished Grade [3]	18 inches	
Approximate Static Total Settlement from Foundation Loads for Condition Specified [4]	<1 inch	
Estimated Static Differential Settlement from Foundation Loads [4]	About 2/3 of total settlement	
Ultimate Passive Pressure [5,6] ■ **Compacted Structural Fill**	400 pcf (equivalent fluid unit weight)	
Ultimate Coefficient of Sliding Friction [7]	0.6	

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. These bearing pressures can be increased by 1/3 for transient loads unless those loads have been factored to account for transient conditions. Assumes that exterior grades are relatively level adjacent to the structure.
2. Values provided are for maximum loads noted in **Project Description**.
3. For frost protection and to reduce the effects of seasonal moisture variations in the subgrade soils. For perimeter footing and footings beneath unheated areas. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.
4. Differential settlements are as measured over a span of 50 feet. We should review the settlement estimates after the foundation plan has been prepared by the structural engineer.
5. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face.
6. Passive resistance in the upper 2 feet of the soil profile should be neglected.
7. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Should be neglected for foundations subject to net uplift conditions.

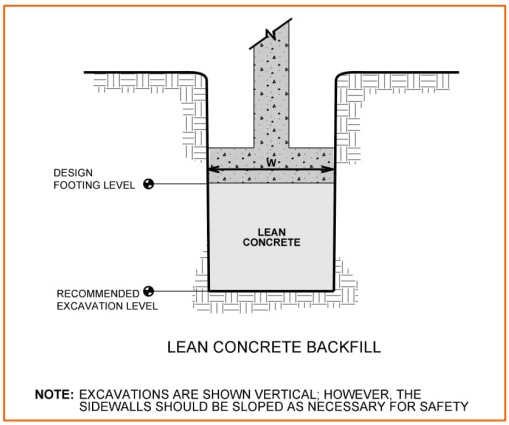
Foundation Construction Considerations

As noted in **Earthwork**, the footing excavations should be evaluated under the observation of the Geotechnical Engineer. Foundation subgrades shall consist of native very dense glacially consolidated soil or lean concrete placed over native very dense to glacially consolidated soil.

The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance.

Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

If unsuitable bearing soils are encountered at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. This is illustrated on the sketch below.



The subgrade soils at the base of the footings are anticipated to be silty, therefore disturbances of the subgrade soils from foot traffic during placement of formwork and rebar to cast the footing excavation are suitable, the contractor should consider over-excavating the footings by several inches and backfilling with lean concrete or crushed rock to preserve the subgrade condition.

FLOOR SLABS

Design parameters for floor slabs assume the requirements for **Earthwork** have been followed. Specific attention should be given to have positive drainage away from the structure along with positive drainage of the aggregate base beneath the floor slab.

Floor Slab Design Parameters

Item	Description
Floor Slab Support [1]	Minimum 6 inches of free draining coarse granular soil such as City of Seattle Type 22 (3/4-inch Crushed Gravel)[3] or similar approved material. Compacted to at least 95% of ASTM D 1557)

Item	Description
Estimated Modulus of Subgrade Reaction [2]	150 pounds per square inch per inch (psi/in) for point loads

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Values of modulus of subgrade reaction are estimated for subgrade conditions where non-yielding, native soils are present.
3. Seattle (SDOT) Standard Specifications

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut control joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual. Joints or cracks should be sealed with a water-proof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

Floor Slab Construction Considerations

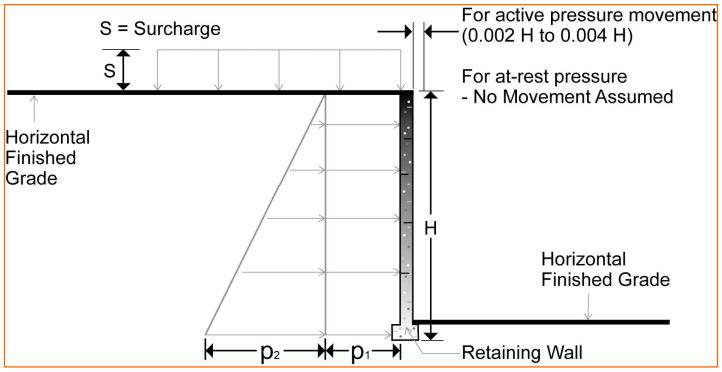
Finished subgrades should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

The Geotechnical Engineer should approve the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel, and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

LATERAL EARTH PRESSURES

Backfilled Walls Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being retained. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of retaining walls that allow wall movement such as cantilever walls, gravity walls, and MSE walls. The "at-rest" condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



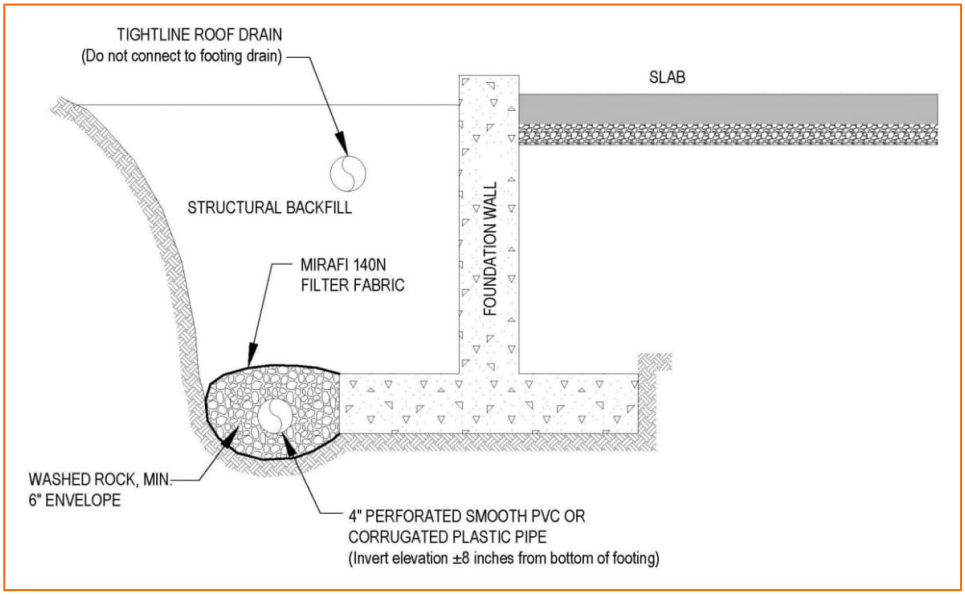
Lateral Earth Pressure Design Parameters			
Earth Pressure Condition [1]	**Coefficient for Backfill Type** [2]	**Uniform Pressure** [3, 4, 5] **p_1 (psf)**	**Effective Fluid Pressures (psf)** [2, 4, 5]
Active (Ka)	0.28	(0.28)S	(35)H
At-Rest (Ko)	0.44	(0.44)S	(55)H
Passive (Kp)	3.5	---	(440)H
Seismic [6]	---	(7)H – Active (12)H – At-Rest	---

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, compacted to at least 95 percent of the ASTM D 1557 maximum dry density.
3. Uniform surcharge, where S is surcharge pressure (psf).
4. Loading from heavy compaction equipment is not included.
5. No safety factor is included in these values.
6. Values are in addition to static earth pressures

Backfill placed against structures should consist of granular soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.

Backfilled Wall Foundation Drains

We recommend backfilled walls include **foundation drains** to collect exterior seepage water. This drain should consist of a 4-inch diameter perforated pipe within an envelope of washed rock, extending at least 6 inches on all sides of the pipe. The washed rock should conform to SDOT Type 5, 1-inch Washed Gravel or equivalent approved material. The washed rock envelope should be wrapped with filter fabric (such as Mirafi 140N, or equal) to reduce the migration of fines from the surrounding soil. Ideally, the drain invert would be installed no more than 8 inches above or below the base of the perimeter footings. These recommendations are summarized in the figure below. Subsurface drainage against shoring walls should be designed in accordance with the recommendations in **Subsurface Drainage** section of this report.



Design Parameters – Wall Cast Against Shoring

We recommend permanent basement walls constructed flush against shoring walls be designed to withstand a uniform rectangular lateral pressure equal to 25H, is psf, where H equals the wall height in feet and should include a seismic load acting over the height of the wall equal to 8H psf. The upper 0.2H of the pressure diagram can be truncated to zero at the top. Where permanent basement walls are adjacent to streets, we recommend a uniform surcharge load equal to 100 psf acting over the upper 15 feet of the wall height. For other surcharges, such as adjacent

building loads (i.e., to the south), please consult with Terracon for the appropriate design surcharge load during the shoring design.

Basement walls cast against the shoring walls with multiple floors are best represented by an "apparent" earth pressure condition due to the lateral movements of the walls being restrained by the floors. During seismic loading, 80 percent of the calculated moment can be applied to basement walls as a result of the stiffer, horizontal floors carrying a higher portion of the seismic load.

Permanent basement walls cast against shoring walls should be provided with drainage as described in **Subsurface Drainage** section to prevent the buildup of hydrostatic pressure.

EXCAVATION DESIGN

Based on the soil conditions observed at the exploration locations and the proposed basement floor slab elevation, a soil nail with vertical elements and a soldier pile with one or multiple row(s) tieback shoring system both appear to be feasible for shoring to temporarily support the excavation during construction of the excavation. Dewatering can likely be managed through sumps and pumps if perched and reginal groundwaters encountered as the excavation progress. The shoring required to support the excavation is typically used as back forms for the permanent basement walls.

Terracon should be included in discussions with the design team regarding design of temporary shoring systems for this project. The following design and construction parameters are provided for preliminary planning purposes.

Soil Nails

The basic concept of soil nailing is to reinforce and strengthen the existing ground by installing closely spaced steel bars commonly referred to as "nails" into a slope or excavation as construction proceeds from the top, downward. This produces a reinforced zone that is itself stable and helps to support the un-reinforced ground behind it. The nails are considered passive as tension is applied as they resist the deformation of the adjacent soil. The nail reinforcement improves stability in two ways. First, soil nailing reduces the driving force along the potential failure surfaces. Second, in frictional soil, nailing increases the normal force and hence the soil shear resistance along potential failure surfaces. If required, vertical elements typically consisting of closely spaced steel beams or pipes placed in augered holes and backfilled with lean concrete can be installed to improve face stability and temporary conditions during nail installation.

Based on the subsurface conditions encountered during our site investigation, the site consists of fill soils over weathered glacial deposits overlying glacially consolidated soils. The following parameters are recommended for design of soil nail walls:

Soil Layers 1 and 2 (Existing Fill and Weathered Glacial Deposits)
Friction Angle: 33 degrees
Cohesion: 50 psf
Moist Unit Weight: 125 pcf
Ultimate Pullout Strength (minimum 6-inch diameter soil nail): 3 kip/ft.
Allowable Pullout Strength (minimum 6-inch diameter soil nail): 1.5 kip/ft.

Soil Layer 3 (Glacially Consolidated Soil)
Friction Angle: 38 degrees
Cohesion: 100 psf
Moist Unit Weight: 130 pcf
Ultimate Pullout Strength (minimum 6-inch diameter soil nail): 6 kip/ft.
Allowable Pullout Strength (minimum 6-inch diameter soil nail): 3 kip/ft.

The actual adhesion value will depend on the materials and installation methods and should be confirmed by testing. Larger diameter drill holes and/or secondary grouting may be required to achieve the recommended pullout capacity. Installation methods should be the responsibility of the contractor. The location and presence of existing features should be checked during the design as these may affect the location and lengths of the soil nails.

Vertical elements may be used to provide cantilever support where utilities or adjacent structures prevent installation of soil nails in the upper portion of the shoring wall. The vertical elements should be designed using the recommendations presented in the soldier pile sections of this report. The allowable passive resistance can be represented as an equivalent fluid weight of 400 pcf above the groundwater table and 200 pcf below and can be assumed to act over three times the concrete pile diameter or pile spacing, whichever is less.

We recommend that soil nail shoring be designed in general accordance with local standard of practice and soil surcharge pressures from slopes, construction loads, and traffic be included.

Soil Nail Shoring Installation

Cased holes may be required to prevent caving and loss of ground within any surficial fill and sandy zones within the glacially overridden deposits. The soil nail grout should be pumped into the soil nail holes by tremie methods in order to force grout up from the bottom of the hole and to provide a continuously grouted soil nail.

A minimum of two sacrificial, 200 percent verification tests should be performed in each soil type to be nailed in order to evaluate the ultimate soil friction capacity and the load deformation performance of the soil nail. Verification testing should be accomplished as soon as each soil type is encountered and prior to installation of production nails. The location of the verification tests should be selected by the contractor and approved by the engineer of record. The drilling method, hole diameter, and depth of soil nail should be identical to the production soil nails. Additionally, 5 percent of production soil nails should be proof tested to 150 percent of design load to confirm the design capacity and appropriate construction methods.

Soldier Piles

Soldier piles for shoring are typically set in drilled holes and backfilled with lean or structural concrete. Soldier pile installation may involve casing the holes and/or drilling with a mud slurry to cut-off groundwater seepage. Passive earth pressures acting on the embedded portion of the soldier piles resist horizontal loads on the shoring system. We recommend using an allowable equivalent fluid unit weight of 400 pcf above the groundwater table and 200 pcf below for passive resistance. The passive earth pressure will act over three times the diameter of the concreted soldier pile section or the pile spacing, whichever is less. The active earth pressures act over the concreted pile diameter below the base of the excavation. Solder pile shoring should be designed in accordance with the earth pressures presented in **Figure 1 – Shoring Earth Pressure Diagram**.

Surcharge pressures associated with adjacent buildings or heavy construction equipment such as pump truck outrigger loads and mobile cranes, should be calculated based on the methods presented in **Figure 2 – Lateral Pressures for Surcharges**. Alternatively, other industry recognized procedures can be utilized to calculate lateral surcharge pressures from adjacent buildings and construction equipment.

Vertical capacity of the soldier piles may be provided by a combination of end bearing and side friction below the base of the excavation. The piles can be designed for an allowable end bearing resistance of 40 ksf with an allowable side friction of 2 ksf. Factors of safety of 3 and 2 have been applied to the allowable end bearing and side friction, respectively.

Tieback Anchors

For tieback anchors, the anchor portion of the tieback should be located sufficiently far behind the excavation shoring to stabilize the excavation face. The no “load” zone limit is the area behind the soldier pile equal to a lateral distance from the base of the excavation equal to the exposed wall height (H in feet) divided by five, or five feet, whichever is greater, and a line sloping up and back at 60 degrees from horizontal.

The selection of the tieback materials and installation methods should be the responsibility of the contractor. The actual adhesion values will depend on the materials and installation method and should be confirmed by testing. For 6-inch diameter, gravity grouted tiebacks, the allowable design pullout capacity of 1.5 kips/ft is recommended for the fill and weathered glacial soils (Layers 1 and 2), and 3 kips/ft for the design for anchors in glacially consolidated soils (Layer 4). For pressure-grouted anchors, this value can typically be increased by a factor of 1.5 to 2 times; however, we recommend a maximum allowable pullout capacity of 4 kips/ft for design for the tieback bonded zone. We recommend all tieback anchors be proof tested to at least 133% of the design capacity prior to locking off at the specified post-tensioned design load. Prior to installation of production anchors, two verification tests to 200% of the design pull out capacity are recommended for each soil type in order to confirm the design anchor capacity.

A minimum anchor spacing of four feet center to center is recommended for tieback anchors. The anchor holes should be drilled at an angle of 15 to 45 degrees down from horizontal. A minimum anchor bond of 10 feet is recommended. The location and presence of existing features such as utilities should be checked during the design as these may affect the location and length of tieback anchors.

Lagging

We recommend timber lagging, or some other form of protection, be installed in all areas between the soldier piles. Prompt and careful installation of lagging would reduce potential loss of ground. We recommend that the following minimum lagging board thickness based on Hem-Fir No. 2 or better, as shown in the following table:

Recommended Lagging Thickness[1] Per Span (inches)						
Depth (feet)	**5 feet**	**6 feet**	**7 feet**	**8 feet**	**9 feet**	**10 feet**
0 to 25	2	3	3	4	4	4
25 to 100	3	3	3	4	4	5

1. Rough Cut.

We recommend that the lagging be installed in 4 to 6-foot lifts to prevent soil failure, sloughing, and loss of ground. Proper installation of lagging is critical to provide safe working conditions. We recommend that any voids between the lagging and soil be backfilled promptly. However, the backfill should not allow potential hydrostatic pressure to build-up behind the wall. Drainage behind the wall must be maintained.

Soldier Pile Shoring Installation

The contractor should be required to prevent caving and loss of ground in all soldier pile drill holes. The shoring contractor will need to use methods to minimize caving and sloughing of the drill holes, such as the use of augercast methods or installation of casing. If more than one foot of water is present in the bottom of the hole, placement of concrete from the bottom of the hole will be required.

When drilling tieback anchor holes, casing may be required to prevent caving and loss of ground. The anchor grout should be pumped into the anchor zone by tremie methods in order to remove water from the hole and to provide a continuous grouted anchor.

Voids behind the lagging should be backfilled immediately with a permeable granular soil material or lean concrete. The excavation height prior to lagging installation should not exceed 5 feet to maintain stability of the cut face.

Monitoring of Temporary Shoring

Any time an excavation is made below the level of existing buildings, utilities, or other structures, there is risk of damage even if a well-designed shoring system has been planned. We recommend, therefore, that a systematic program of observations be conducted on adjacent facilities and structures. The monitoring program should include measurements of the horizontal and vertical movements of the adjacent structures and the shoring system itself. At least two reference lines should be established adjacent to the excavation at horizontal distances back from the excavation at the curb lines and center of the adjacent streets. Monitoring of the shoring system should include measurements of horizontal movements at the top of every other soldier pile. If local wet areas are noted within the excavation, additional monitoring points may be recommended by Terracon.

The measuring system used for shoring monitoring should have an accuracy of at least 0.01-feet. All reference points on the existing structures should be installed and readings taken prior to commencing the excavation. All reference points should be read prior to and during critical stages of construction. The frequency of readings will depend on the results of previous readings and the rate of construction. As a minimum, readings should be taken about once a week throughout construction until the basement walls and floor slabs are completed up to grade. All readings should be reviewed by Terracon.

SUBSURFACE DRAINAGE

We recommend that the walls and parking garage slab are positively drained to collect and convey any groundwater seepage that may be present. The drainage system should consist of a

combination of free-draining structural fill, wall drainage, footing drains, and a sump collection system.

Wall Drains

Basement walls poured flush against the shoring should be provided with drainage by placing 100 percent coverage of geocomposite drain against the shoring wall. The geocomposite drain should be tied into the foundation drains. It is important to provide a good connection between the wall drain and the foundation drains. The detail of the wall/footing drain connection will depend on the type of shoring, basement wall type, and perimeter footing. Drainage behind walls cast in open excavations can consist of geocomposite drainage as discussed above or a minimum of a 2-foot wide zone of well-graded, clean sand and gravel fill with less than 5 percent passing the No. 200 sieve. If a moisture-free wall is desired, a waterproof barrier, such as plastic or bentonite panels, should be placed over the geocomposite drain prior to casting or shotcreting the basement walls.

For backfill retaining walls such as interior ramp walls, subsurface drainage should be designed in accordance with the recommendations in **Lateral Erath Pressure** section of this report.

Foundation Drains

We recommend that the building be encircled with a perimeter foundation drain to collect exterior seepage water. This drain should consist of a 4-inch diameter perforated pipe within an envelope of washed rock, extending at least 6 inches on all sides of the pipe. The washed rock should conform SDOT Type 5, 1-inch Washed Gravel or equivalent approved material. The washed rock envelope should be wrapped with a non-woven needle-punched geotextile separator fabric to reduce the migration of fines from the surrounding soil. Ideally, the drain invert would be installed no more than 8 inches above or below the base of the perimeter footings. The perimeter foundation drain should not be connected to roof downspout drains and should be constructed to discharge into the site storm water system or other appropriate outlet.

Under-slab Drainage System

Due to the groundwater table above or near the footing subgrade elevations especially within northern portion of the site, an under-slab drainage system is recommended to provide permanent dewatering and prevent buildup of hydrostatic pressure below floor slab. We recommend that the under-slab drainage be spaced no greater than 30 feet on center, have a minimum slope of 0.25 percent, and the pipe invert be at least 12 inches below the finish floor slab. The perimeter footing drainage will act as an under-slab drain; therefore, the first interior under slab drain can be offset a maximum of 30 feet from the perimeter footing drain.

The under-slab drainpipe should be bedded in at least 4 inches and surrounded by at least 6 inches of drainage material consisting of ¾-inch washed drain rock. We recommend use of

nonwoven filter fabric (Mirafi 140N or equivalent) to wrap the entire pipe and rock assembly. Cleanouts are recommended for the under-slab drainage system.

Sumps

If gravity flow is not possible, the below slab and wall drainage system should drain to a sump for pumping. The steady state or long-term ground water flow rate should be evaluated during construction and the permanent drainage system sized for that flow. For design, we recommend a steady state groundwater flow rate of 5 gallons per minute (gpm).

The 5 gpm steady state groundwater flow rate should be verified once the excavation is completed. If a sump system is used, a backup pump with emergency power is recommended in case of mechanical breakdown. The subsurface drainage system should be vented to the atmosphere in case of mechanical or electrical failure. As a minimum, we recommend that the sump and drainpipe clean outs be vented to the atmosphere to prevent the buildup of hydrostatic pressure below the floor slab.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from the site explorations. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

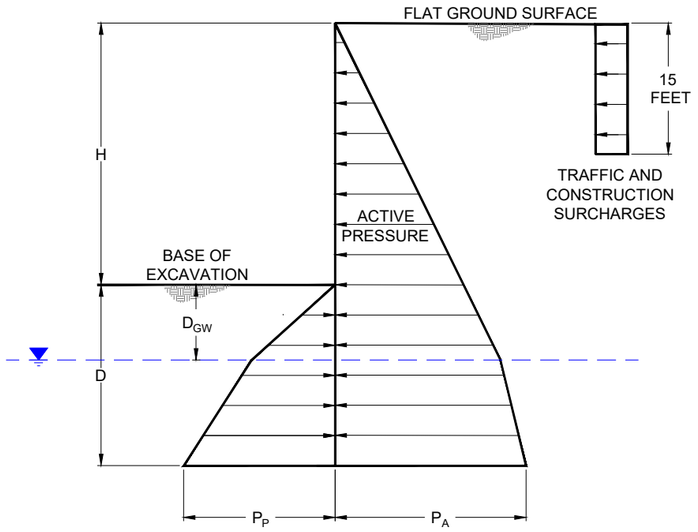
Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

FIGURES

Contents:

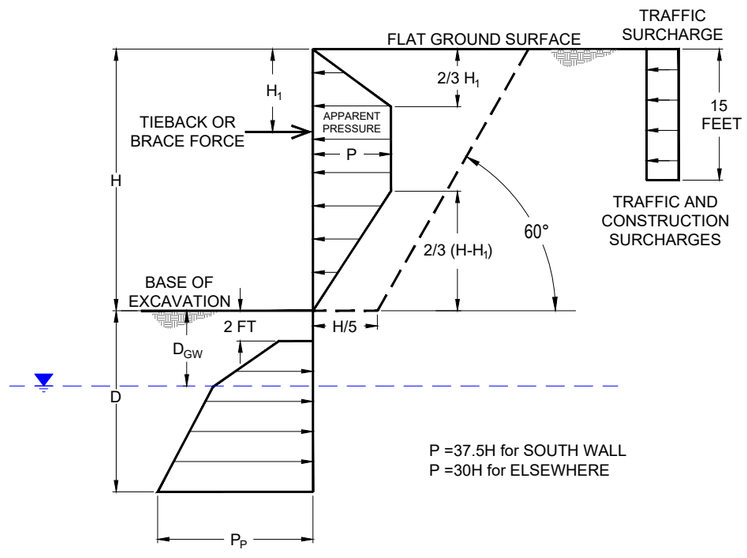
LATERAL EARTH PRESSURE DIAGRAM FOR CANTILEVER SOLDIER PILES AND VERTICAL ELEMENTS



P_P=400D (DRAINED)
P_P=400D_{GW}+200(D-D_{GW}) (SUBMERGED)
P_A=30(H+D) (DRAINED)
P_A=30(H+D_{GW})+15(D-D_{GW}) (SUBMERGED)

TRAFFIC/CONSTRUCTION SURCHARGES:
TRAFFIC SURCHARGE = 60 PSF
CONSTRUCTION SURCHARGE = 120 PSF

LATERAL EARTH PRESSURE DIAGRAM FOR SOLDIER PILE WALLS WITH ONE LEVEL OF TIEBACKS

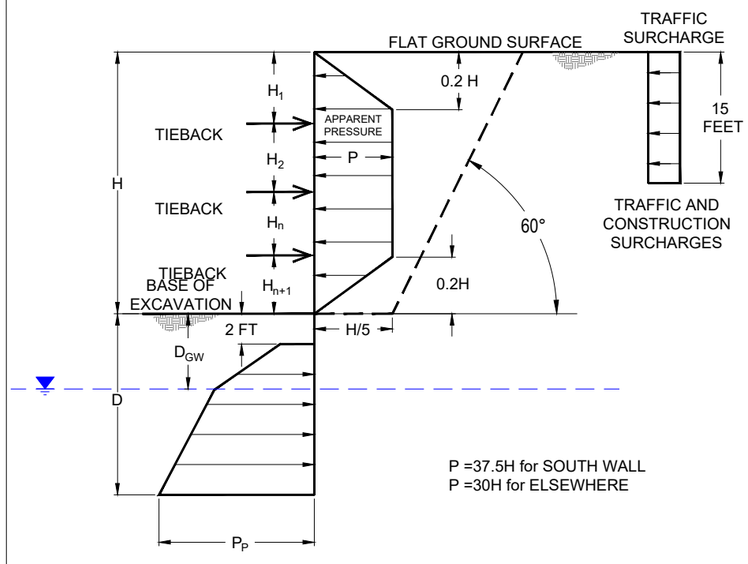


P =37.5H for SOUTH WALL
P =30H for ELSEWHERE

P_P=400D (DRAINED)
P_P=400D_{GW}+200(D-D_{GW}) (SUBMERGED)

TRAFFIC/CONSTRUCTION SURCHARGES:
TRAFFIC SURCHARGE = 60 PSF
CONSTRUCTION SURCHARGE = 120 PSF

LATERAL EARTH PRESSURE DIAGRAM FOR SOLDIER PILE WALLS WITH MULTIPLE ROWS OF TIEBACKS



P =37.5H for SOUTH WALL
P =30H for ELSEWHERE

P_P=400D (DRAINED)
P_P=400D_{GW}+200(D-D_{GW}) (SUBMERGED)

TRAFFIC/CONSTRUCTION SURCHARGES:
TRAFFIC SURCHARGE = 60 PSF
CONSTRUCTION SURCHARGE = 120 PSF

NOTES:

1. ALL EARTH PRESSURES ARE IN UNITS OF POUNDS PER SQUARE FOOT.
2. MINIMUM RECOMMENDED SOLDIER PILE EMBEDMENT (D) IS 10 FEET.
3. PASSIVE PRESSURES ARE ALLOWABLE VALUES AND INCLUDE A 1.5 FACTOR OF SAFETY.
4. PASSIVE PRESSURE ACTS OVER 3 TIMES THE CONCRETED DIAMETER OF THE SOLDIER PILE FOR OR THE PILE SPACING, WHICHEVER IS LESS.
5. 40 KSF ALLOWABLE END BEARING FOR SOLDIER PILE EMBEDDED AT LEAST 10 FEET IN TO HARD/DENSE GLACIALLY CONSOLIDATED SOILS.
6. 2 KSF ALLOWABLE SIDE FRICTION FOR THE PORTION OF THE SOLDIER PILE EMBEDDED BELOW THE BASE OF THE EXCAVATION.
7. EARTH AND SURCHARGE PRESSURES ACT OVER THE FACE OF WALL ABOVE THE BASE OF THE EXCAVATION.
8. ACTIVE PRESSURE ACTS OVER ONE PILE DIAMETER BELOW THE EXCAVATION FOR CANTILEVER SOLDIER PILES.
9. ADDITIONAL SURCHARGE FROM FOOTINGS, LARGE STOCKPILES, HEAVY EQUIPMENT, ETC., MUST BE ADDED TO THESE PRESSURES. REFER TO FIGURE 2 FOR METHODS TO CALCULATE LATERAL LOADS FROM ADJACENT SURCHARGES.
10. DIAGRAMS ARE NOT TO SCALE.

EARTH PRESSURE LEGEND:

P_P = ALLOWABLE PASSIVE PRESSURE
H = TOTAL HEIGHT OF EXCAVATION, FEET
H_1 = DEPTH TO UPPERMOST TIEBACK, FEET
H_n = HEIGHT BETWEEN TIEBACK, FEET
H_{n+1} = DISTANCE FROM BASE OF THE EXCAVATION TO LOWERMOST TIEBACK, FEET
D = EMBEDMENT DEPTH, FEET
D_{GW} = EMBEDMENT DEPTH TO GROUNDWATER TABLE, FEET

Project Mngr:	RDL
Drawn By:	AMP
Checked By:	RDL
Approved By:	RDL
Project No.	81235014
Scale:	NOT TO SCALE
File No.	Figure 1 .dwg
Date:	June, 2023

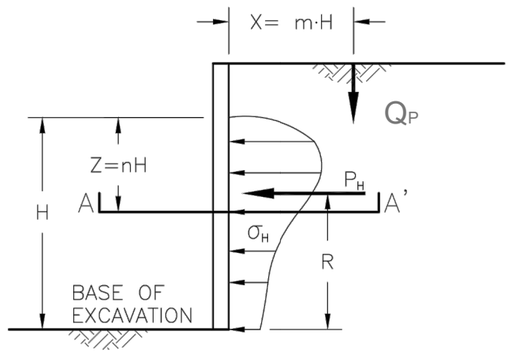
Terracon
Consulting Engineers and Scientists
21905 64th Avenue W, Ste 100 Mountlake Terrace, WA 98043
PH. (425) 771-3304 FAX. (425) 771-3549

SHORING EARTH PRESSURE DIAGRAM

Olive Way Apartments
1661 E Olive Way
Seattle, Washington

FIGURE 1

LATERAL EARTH PRESSURE FROM POINT LOAD, Q_P (SPREAD FOOTING)



FOR $m \leq 0.4$

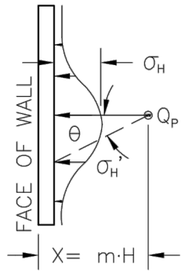
$$\sigma_H = \frac{0.28 Q_P n^2 K}{H^2 (0.16+n^2)^3}$$

FOR $m > 0.4$

$$\sigma_H = \frac{1.77 Q_P m^2 n^2 K}{H^2 (m^2+n^2)^3}$$

m	$P_H\left(\frac{H}{Q_P}\right)$	R
0.2	0.78	0.59H
0.4	0.78	0.59H
0.6	0.45	0.48H

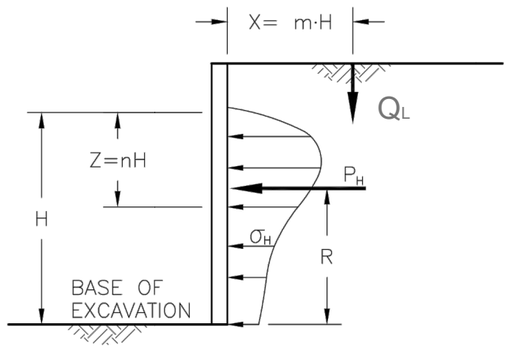
$$\sigma_H' = \sigma_H \cos^2(1.1\theta)$$



SECTION A–A' (Plan View)

Pressures from Point Load Q_P

LATERAL EARTH PRESSURE FROM LINE LOAD, Q_L (CONTINUOUS WALL FOOTING)



FOR $m \leq 0.4$

$$\sigma_H = \frac{0.2n \cdot Q_L K}{H(0.16+n^2)^2}$$

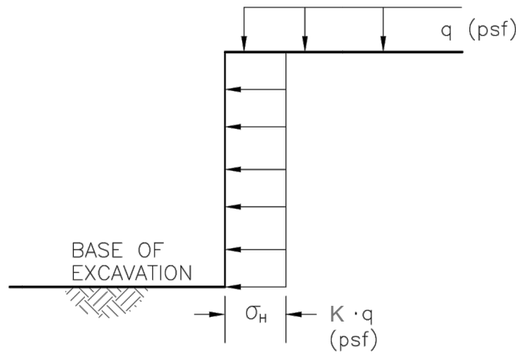
FOR $m > 0.4$

$$\sigma_H = \frac{1.28 m^2 n \cdot Q_L K}{H(m^2+n^2)^2}$$

RESULTANT $P_H = \frac{0.64 Q_L K}{(m^2+1)}$

m	R
0.1	0.60H
0.3	0.60H
0.5	0.56H
0.7	0.48H

UNIFORM SURCHARGES, q (FLOOR LOADS, LARGE FOUNDATION ELEMENTS OR TRAFFIC LOADS)



σ_H = LATERAL SURCHARGE PRESSURE FROM UNIFORM SURCHARGE

K = ASSUME LEVEL BACKSLOPE SEE GEOTECHNICAL REPORT FOR K VALUES.

Definitions:
Q_P = Point load in pounds
Q_L = Line load in pounds/ foot
q = Surcharge Pressure in PSF
H = Excavation height below footing, feet
σ_H = Lateral earth pressure from surcharge in PSF
θ = Radians
σ_H' = Distribution of σ_H in plan view
P_H = Resultant lateral force acting on wall, pounds
R = Distance from base of excavation to resultant lateral force, feet
K = Earth pressure coefficient

Notes:
1. Procedures for estimating surcharge pressures shown above are based on Design Manual 7.02 Naval Facilities Engineering Command (NAVFAC DM 7.02).
2. Lateral earth pressures from surcharge should be added to earth pressures presented in report.
3. See report text for where surcharge pressures are appropriate. Contact Terracon for complex surcharge configurations, if necessary.
4. Uniform surcharge extends to the base of the excavation or to a depth of 15 feet, which ever is less.

Project Mngr:	RDL
Drawn By:	AMP
Checked By:	RDL
Approved By:	RDL
Project No.	81235014
Scale:	NOT TO SCALE
File No.	Figure 2.dwg
Date:	July, 2023

Terracon
Consulting Engineers and Scientists
21905 64th Avenue W, Ste 100 Mountlake Terrace, WA 98043
PH. (425) 771-3304 FAX. (425) 771-3549

LATERAL PRESSURES FROM SURCHARGES

Olive Way Apartments
1661 E Olive Way
Seattle, Washington

FIGURE 2

ATTACHMENTS

SITE LOCATION AND EXPLORATION PLANS

Contents:

SITE LOCATION PLAN

Olive Way Apartments ■ Seattle, King County, Washington
July 14, 2023 ■ Terracon Project No. 81235014

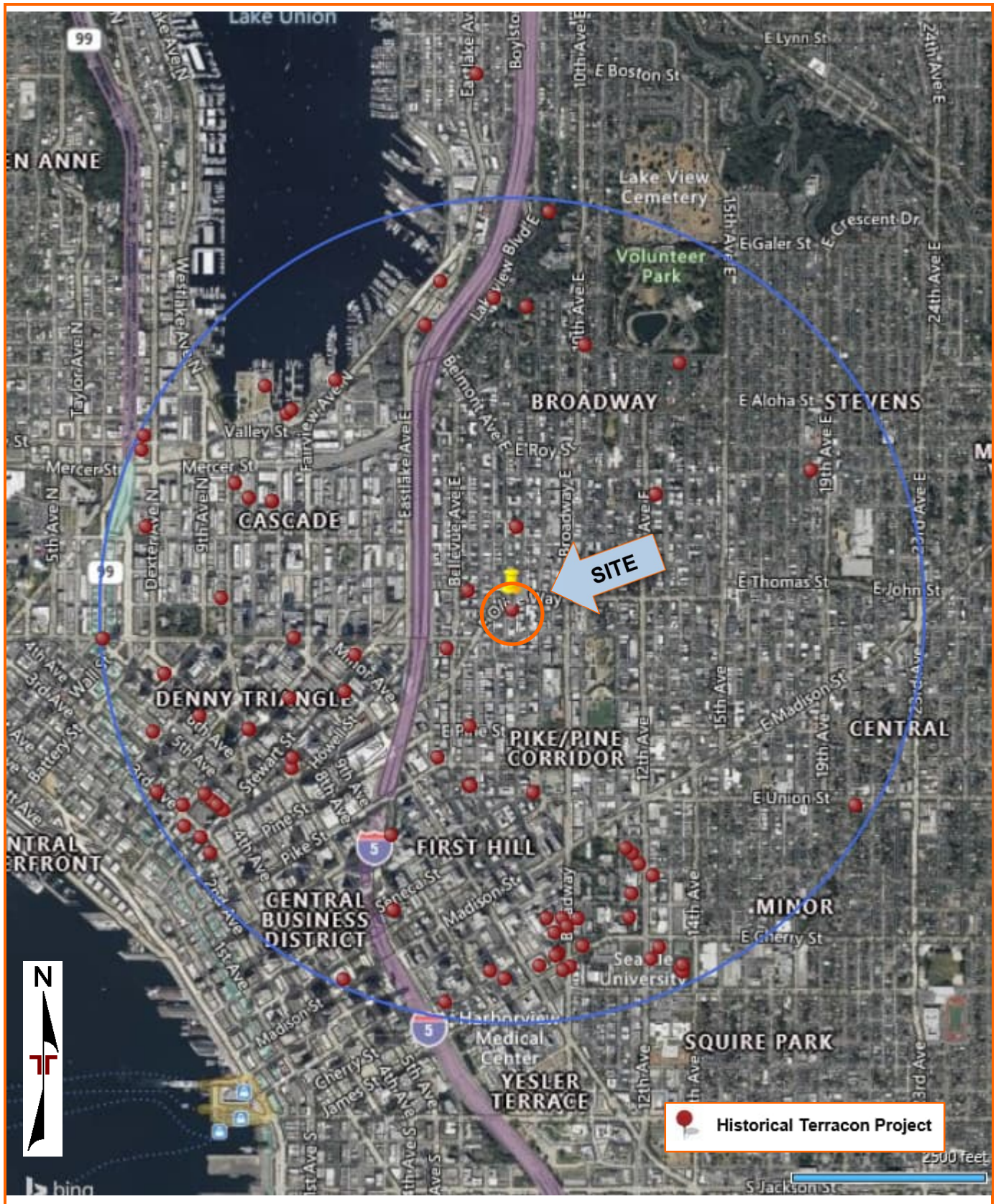


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Olive Way Apartments ■ Seattle, King County, Washington
July 14, 2023 ■ Terracon Project No. 81235014

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

FIELD EXPLORATION

Historical Field Exploration

The field exploration for this project included the following borings conducted by others as follows:

- Three (3) onsite Terracon environmental borings ranging between 20½ and 46 feet bgs and four (4) environmental borings associated with monitoring wells ranging between 35 and 46½ feet bgs
- Three (3) offsite PanGeo geotechnical borings to the north ranging between 25 and 35 feet bgs
- Two (2) offsite Hart Crower geotechnical borings to the east and northeast ranging between 18 and 23 feet bgs
- Two (2) offsite Geotech Consultants geotechnical borings to the east and southeast ranging between 25 and 35 feet bgs

The approximate exploration locations are shown on the Exploration Plan. Exploration locations were determined based on the site plan provided by others and should be considered accurate to +/- 50 feet. Approximate elevations of Terracon environmental borings are based on an arbitrary elevation of 100 feet and do not match the actual site topographic survey elevations.

HISTORICAL EXPLORATION RESULTS

Contents:

Boring Logs and Lab Testing Results

- Terracon Environmental, 2018
- Pan Geo, 2009
- Hart Crowser, 1992
- Geotech Consultants, 1998

BORING LOG NO. B1

PROJECT: Olive Way

CLIENT: Continental Properties LLC
Bellevue, WA

SITE: 1651 and 1661 E Olive Way and 123 and 127 Boylston Ave E, Seattle, WA 98102

GRAPHIC LOG	DEPTH	MATERIAL DESCRIPTION	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	SPT N-VALUE	OVA/PID (ppm)	Sample Number
LOCATION See Exhibit 2								
	0.2	**FILL - TOPSOIL**						
		SILTY SAND WITH GRAVEL (SM), brown, no odor						
		tan	5			7-12-15	0.2	
		tan gray	10			37-50/5"	0.7	
	15.0	**SANDY SILT WITH GRAVEL (ML)**, gray, no odor	15			35-50/6"	0.5	
	20.0	**SILTY SAND WITH GRAVEL (SM)**, gray, no odor	20		X	32-50/5"	0.8	B1-21
			25					

The stratification lines represent the approximate transition between differing soil types and/or rock types; in-situ these transitions may be gradual or may occur at different depths than shown.

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with bentonite chips upon completion.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Boring Started: 12-04-2018	Boring Completed: 12-04-2018
Drill Rig: CME-75	Driller: Holt
Project No.: 81187378	Exhibit: B-1

BORING LOG NO. B1

PROJECT: Olive Way

CLIENT: Continental Properties LLC
Bellevue, WA

SITE: 1651 and 1661 E Olive Way and 123 and 127 Boylston Ave E, Seattle, WA 98102

GRAPHIC LOG	DEPTH	MATERIAL DESCRIPTION	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	SPT N-VALUE	OVA/PID (ppm)	Sample Number
		LOCATION See Exhibit 2						
		SILTY SAND WITH GRAVEL (SM), gray, no odor *(continued)*				50/5"	0.6	
			30			50/6"	0.5	
	35.0							
		SILTY SAND (SM), gray, no odor	35			50/6"	0.7	
		No recovery. Rock in shoe.	40			50/5"		
	46.0		45			36-50/5"	1.3	B1-46
		Boring Terminated at 46 Feet						

The stratification lines represent the approximate transition between differing soil types and/or rock types; in-situ these transitions may be gradual or may occur at different depths than shown.

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with bentonite chips upon completion.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Boring Started: 12-04-2018	Boring Completed: 12-04-2018
Drill Rig: CME-75	Driller: Holt
Project No.: 81187378	Exhibit: B-1

BORING LOG NO. B2

PROJECT: Olive Way

CLIENT: Continental Properties LLC
Bellevue, WA

SITE: 1651 and 1661 E Olive Way and 123 and 127 Boylston Ave E, Seattle, WA 98102

LOCATION See Exhibit 2

DEPTH	MATERIAL DESCRIPTION	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	SPT N-VALUE	OVA/PID (ppm)	Sample Number
0.2	**TOPSOIL**						
	SANDY SILT (ML), brown, no odor						
	tan, increasing gravel component	5			20-43-40	0.9	
	gray	10		X	29-50/6"	2.2	B2-11
	denser soil						
15.0	**SANDY SILT WITH GRAVEL (ML)**, gray, no odor	15		X	22-40-50 N=90	1.9	B2-16.5
20.0							
20.5	**SILT WITH SAND (ML)**, trace gravel, gray, no odor	20		X	50/6"	1.2	B2-20.5
	Boring Terminated at 20.5 Feet						

The stratification lines represent the approximate transition between differing soil types and/or rock types; in-situ these transitions may be gradual or may occur at different depths than shown.

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with bentonite chips upon completion.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Boring Started: 12-05-2018 | Boring Completed: 12-05-2018

Drill Rig: CME-75 | Driller: Holt

Project No.: 81187378 | Exhibit: B-2

BORING LOG NO. B3

PROJECT: Olive Way

CLIENT: Continental Properties LLC
Bellevue, WA

SITE: 1651 and 1661 E Olive Way and 123 and 127 Boylston Ave E, Seattle, WA 98102

LOCATION See Exhibit 2

DEPTH	MATERIAL DESCRIPTION	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	SPT N-VALUE	OVA/PID (ppm)	Sample Number
0.2	**TOPSOIL**						
	SANDY SILT (ML), tan, no odor						
	gray	5					
10.0							
	SILTY SAND WITH GRAVEL (SM), gray, no odor	10		X	35-50/5"	0.2	B3-11
		15		X	22-50/2"	0	B3-15.5
20.5		20		X	50/5"	0.1	B3-20.5
	Boring Terminated at 20.5 Feet						

The stratification lines represent the approximate transition between differing soil types and/or rock types; in-situ these transitions may be gradual or may occur at different depths than shown.

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with bentonite chips upon completion.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Boring Started: 12-06-2018	Boring Completed: 12-06-2018
Drill Rig: CME-75	Driller: Holt
Project No.: 81187378	Exhibit: B-3

WELL LOG NO. MW1

PROJECT: Olive Way

CLIENT: Continental Properties LLC
Bellevue, WA

SITE: 1651 and 1661 E Olive Way and 123 and 127 Boylston Ave E, Seattle, WA 98102

GRAPHIC LOG	DEPTH	MATERIAL DESCRIPTION	INSTALLATION DETAILS	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	SPT N-VALUE	OVA/PID (ppm)	Sample Number
LOCATION See Exhibit 2			Well Completion: Monument						
	0.2	**TOPSOIL**	Well monument						
		SANDY SILT WITH GRAVEL (ML), tan gray, no odor	Blank 2" PVC pipe with cement seal						
			Blank 2" PVC pipe with soil cuttings	5					
		denser soil							
		gray		10			10-22-45 N=67	12.0	MW1-11.5
			Blank 2" PVC pipe with bentonite seal	15					
	20.0	**SILTY SAND (SM)**, gray, no odor		20			34-50/5"	2.7	MW1-21
				25					

The stratification lines represent the approximate transition between differing soil types and/or rock types; in-situ these transitions may be gradual or may occur at different depths than shown.

Advancement Method:
Hollow Stem Auger

Abandonment Method:

Notes:
Well ID BLI 151

WATER LEVEL OBSERVATIONS

Measured depth to water during drilling

Measured depth to water following well development

Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Well Started: 12-05-2018	Well Completed: 12-06-2018
Drill Rig: CME-75	Driller: Holt
Project No.: 81187378	Exhibit: MW-1

WELL LOG NO. MW1

PROJECT: Olive Way

CLIENT: Continental Properties LLC
Bellevue, WA

SITE: 1651 and 1661 E Olive Way and 123 and 127 Boylston Ave E, Seattle, WA 98102

LOCATION See Exhibit 2

DEPTH	MATERIAL DESCRIPTION	DEPTH (ft)	SPT N-VALUE	OVA/PID (ppm)	Sample Number
	SILTY SAND (SM), gray, no odor *(continued)* increasing gravel component, from auger cuttings				
30.0		30			
31.0	**SAND (SP)**, gray, no odor, wet		16-41-50/4"	2.4	
	SANDY SILT (ML), gray, no odor			0.8	MW1-31.5
	trace gravel, from auger cuttings	35			
	minor gravel	40	22-50/5"	1.0	MW1-41
41.0	***Boring Terminated at 41 Feet***				

Slotted 2" PVC pipe with sand filter pack

Slough

The stratification lines represent the approximate transition between differing soil types and/or rock types; in-situ these transitions may be gradual or may occur at different depths than shown.

Advancement Method:
Hollow Stem Auger

Abandonment Method:

Notes:
Well ID BLI 151

WATER LEVEL OBSERVATIONS

Measured depth to water during drilling

Measured depth to water following well development

Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Well Started: 12-05-2018 | Well Completed: 12-06-2018

Drill Rig: CME-75 | Driller: Holt

Project No.: 81187378 | Exhibit: MW-1

WELL LOG NO. MW2

PROJECT: Olive Way

CLIENT: Continental Properties LLC
Bellevue, WA

SITE: 1651 and 1661 E Olive Way and 123 and 127 Boylston Ave E, Seattle, WA 98102

GRAPHIC LOG	DEPTH	MATERIAL DESCRIPTION	INSTALLATION DETAILS	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	SPT N-VALUE	OVA/PID (ppm)	Sample Number
LOCATION See Exhibit 2			Well Completion: Monument						
	0.3	**ASPHALT CONCRETE**, brick	Well monument						
		SILTY SAND WITH GRAVEL (SM), olive tan, no odor	Blank 2" PVC pipe with cement seal						
			Blank 2" PVC pipe with sand	5					
		dense gravel lens, possible boulder							
	10.0			10			14-25-43 N=68	0.0	MW2-10
		SILT WITH SAND (ML), gray, no odor, trace gravel	Blank 2" PVC pipe with bentonite seal						
				15			50/5"	0.0	MW2-15
				20	▽		31-20-34 N=54	0.1	MW2-20
				25					

The stratification lines represent the approximate transition between differing soil types and/or rock types; in-situ these transitions may be gradual or may occur at different depths than shown.

Advancement Method:
Hollow Stem Auger

Abandonment Method:

Notes:
Well ID BLI 152

WATER LEVEL OBSERVATIONS

▽ *Measured depth to water during drilling*

▽ *Measured depth to water following well development*

Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Well Started: 12-07-2018	Well Completed: 12-07-2018
Drill Rig: CME-75	Driller: Holt
Project No.: 81187378	Exhibit: MW-3

WELL LOG NO. MW2

PROJECT: Olive Way

CLIENT: Continental Properties LLC
Bellevue, WA

SITE: 1651 and 1661 E Olive Way and 123 and 127 Boylston Ave E, Seattle, WA 98102

LOCATION See Exhibit 2

DEPTH	MATERIAL DESCRIPTION		DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	SPT N-VALUE	OVA/PID (ppm)	Sample Number
	SILT WITH SAND (ML), gray, no odor, trace gravel *(continued)*					50/6"	0.0	MW2-25
	wet	Slotted 2" PVC pipe with sand filter pack	30	▽				
35.0	***Boring Terminated at 35 Feet***		35					

The stratification lines represent the approximate transition between differing soil types and/or rock types; in-situ these transitions may be gradual or may occur at different depths than shown.

Advancement Method:
Hollow Stem Auger

Abandonment Method:

Notes:
Well ID BLI 152

WATER LEVEL OBSERVATIONS

▽ *Measured depth to water during drilling*

▽ *Measured depth to water following well development*

Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Well Started: 12-07-2018	Well Completed: 12-07-2018
Drill Rig: CME-75	Driller: Holt
Project No.: 81187378	Exhibit: MW-3

WELL LOG NO. MW3

PROJECT: Olive Way

CLIENT: Continental Properties LLC
Bellevue, WA

SITE: 1651 and 1661 E Olive Way and 123 and 127 Boylston Ave E, Seattle, WA 98102

DEPTH	MATERIAL DESCRIPTION	INSTALLATION DETAILS	SPT N-VALUE	OVA/PID (ppm)	Sample Number
0.5	**CONCRETE**	Well monument; Well Completion: Monument			
	SILTY SAND WITH GRAVEL (SM), brown, no odor	Blank 2" PVC pipe with cement seal			
		Blank 2" PVC pipe with sand			
	gray				
10.0					
	SANDY SILT (ML), brown, no odor		9-9-24 N=33	1.4	MW3-10
11.0					
	SAND (SP), gray, no odor, trace silt				
		Blank 2" PVC pipe with bentonite seal			
15.0					
	SANDY SILT (ML), brown, no odor, trace gravel and organics, slight sheen rock in shoe		50/4"	13.2	MW3-15
			50/5"	2.5	MW3-20

DEPTH (ft): 5, 10, 15, 20, 25

WATER LEVEL OBSERVATIONS

SAMPLE TYPE

The stratification lines represent the approximate transition between differing soil types and/or rock types; in-situ these transitions may be gradual or may occur at different depths than shown.

Advancement Method:
Hollow Stem Auger

Abandonment Method:

Notes:
Well ID BLI 153

WATER LEVEL OBSERVATIONS

▽ *Measured depth to water following well development*

Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Well Started: 12-10-2018	Well Completed: 12-10-2018
Drill Rig: CME-75	Driller: Holt
Project No.: 81187378	Exhibit: MW-3

WELL LOG NO. MW3

PROJECT: Olive Way

CLIENT: Continental Properties LLC
Bellevue, WA

SITE: 1651 and 1661 E Olive Way and 123 and 127 Boylston Ave E, Seattle, WA 98102

LOCATION See Exhibit 2

DEPTH	MATERIAL DESCRIPTION	DEPTH (ft)	SAMPLE TYPE	SPT N-VALUE	OVA/PID (ppm)	Sample Number
	SANDY SILT (ML), brown, no odor, trace gravel and organics, slight sheen *(continued)* gray, no sheen			50/4"	0.4	
	increasing gravel component	30		50/5"	0.0	MW3-30
35.0						
	SILT WITH SAND (ML), gray, no odor, trace gravel	35		38-50/2"	0.2	
40.0						
	SANDY SILT (ML), gray, no odor, trace gravel	40		39-50/3"	0.2	
45.0						
45.5	**SILT (ML)**, gray, no odor, trace sand and gravel	45		50/6"	3.3	MW3-45
	Boring Terminated at 46.5 Feet					

Slotted 2" PVC pipe with sand filter pack

Slough

The stratification lines represent the approximate transition between differing soil types and/or rock types; in-situ these transitions may be gradual or may occur at different depths than shown.

Advancement Method:
Hollow Stem Auger

Abandonment Method:

Notes:
Well ID BLI 153

WATER LEVEL OBSERVATIONS

▽ *Measured depth to water following well development*

Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Well Started: 12-10-2018 | Well Completed: 12-10-2018

Drill Rig: CME-75 | Driller: Holt

Project No.: 81187378 | Exhibit: MW-3

WELL LOG NO. MW4

PROJECT: Olive Way

CLIENT: Continental Properties LLC
Bellevue, WA

SITE: 1651 and 1661 E Olive Way and 123 and 127 Boylston Ave E, Seattle, WA 98102

GRAPHIC LOG	DEPTH	MATERIAL DESCRIPTION	INSTALLATION DETAILS	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	SPT N-VALUE	OVA/PID (ppm)	Sample Number
	0.2	**ASPHALT**	Well monument; Blank 2" PVC pipe with cement seal						
		SILT WITH SAND (ML), brown, no odor	Blank 2" PVC pipe with sand						
		tan, increasing sand component		5					
	10.0	**SANDY SILT (ML)**, tan, no odor, some gravel gray		10			16-45-50/6"	0.4	MW4-11.5
				15			34-50/4"	0.0	MW4-16
			Blank 2" PVC pipe with bentonite seal		▽				
				20			50/6"	0.2	
				25					

LOCATION See Exhibit 2

The stratification lines represent the approximate transition between differing soil types and/or rock types; in-situ these transitions may be gradual or may occur at different depths than shown.

Advancement Method:
Hollow Stem Auger

Abandonment Method:

Notes:
Well ID BLI 154

WATER LEVEL OBSERVATIONS

▽ *Measured depth to water following well development*

Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Well Started: 12-11-2018	Well Completed: 12-11-2018
Drill Rig: CME-75	Driller: Holt
Project No.: 81187378	Exhibit: MW-4

WELL LOG NO. MW4

PROJECT: Olive Way

CLIENT: Continental Properties LLC
Bellevue, WA

SITE: 1651 and 1661 E Olive Way and 123 and 127 Boylston Ave E, Seattle, WA 98102

LOCATION See Exhibit 2

DEPTH	MATERIAL DESCRIPTION	DEPTH (ft)	SAMPLE TYPE	SPT N-VALUE	OVA/PID (ppm)	Sample Number
	SANDY SILT (ML), tan, no odor, some gravel *(continued)*					
	gray, silty sand lens			25-50/5"	0.4	MW4-26
	no gravel	30		40-50/4"	0.6	
		35		50/6"	0.4	MW4-35.5
	minor gravel	40		18-41-50/4"	0.6	
	no gravel	45		24-50/4"	0.7	
46.0	gray, silt lens					
	Boring Terminated at 46 Feet					

Slotted 2" PVC pipe with sand filter pack

The stratification lines represent the approximate transition between differing soil types and/or rock types; in-situ these transitions may be gradual or may occur at different depths than shown.

Advancement Method:
Hollow Stem Auger

Abandonment Method:

Notes:
Well ID BLI 154

WATER LEVEL OBSERVATIONS

▽ *Measured depth to water following well development*

Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Well Started: 12-11-2018 | Well Completed: 12-11-2018

Drill Rig: CME-75 | Driller: Holt

Project No.: 81187378 | Exhibit: MW-4

Project:	Olive Way Mixed Use	Surface Elevation:	+/- 295.5
Job Number:	09-094	Top of Casing Elev.:	N/A
Location:	1650 E Olive Way, Seattle	Drilling Method:	Hollow Stem Auger
Coordinates:	Northing: , Easting:	Sampling Method:	Std Pen Test

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						4.5-inch concrete.
						Medium dense, brown, silty sandy GRAVEL to dark brown, silty SAND with some gravel, moist **(Fill)**.
	S1		3 5 13			Medium dense to dense, tan - brown, silty SAND, some gravel, very moist **(Weathered Till)**
5	S2		18 50/6			Very dense, gray, silty SAND, some gravel, moist; a rock was stuck in the sampler shoe **(Glacial Till)**
	S3		30 50/5	GS		
10	S4		23 32 33			Hard, dark gray, SILT to sandy SILT, trace sand, moist.
15	S5		50/5			Very dense, gray, silty SAND, some gravel, moist.
20	S6		50/4			
25	S7		50/5			-becomes gray, slightly silty SAND with some gravel, very dense.
						Boring terminated at about 25.4 feet below surface. No groundwater encountered during drilling.
30						
35						
40						

N-Value ▲

PL — Moisture — LL

RQD — Recovery

0 — 50 — 100

Completion Depth:	25.4ft
Date Borehole Started:	8/4/09
Date Borehole Completed:	8/4/09
Logged By:	HMX
Drilling Company:	BoreTec Drilling

Remarks: Boring drilled using a track-mounted drill rig. Standard Penetration Test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with a rope and cathead mechanism. Borehole elevation based on topographic data on a preliminary site plan.

PanGEO INCORPORATED
Phone: 206.262.0370

LOG OF TEST BORING BH-1

Figure A-2

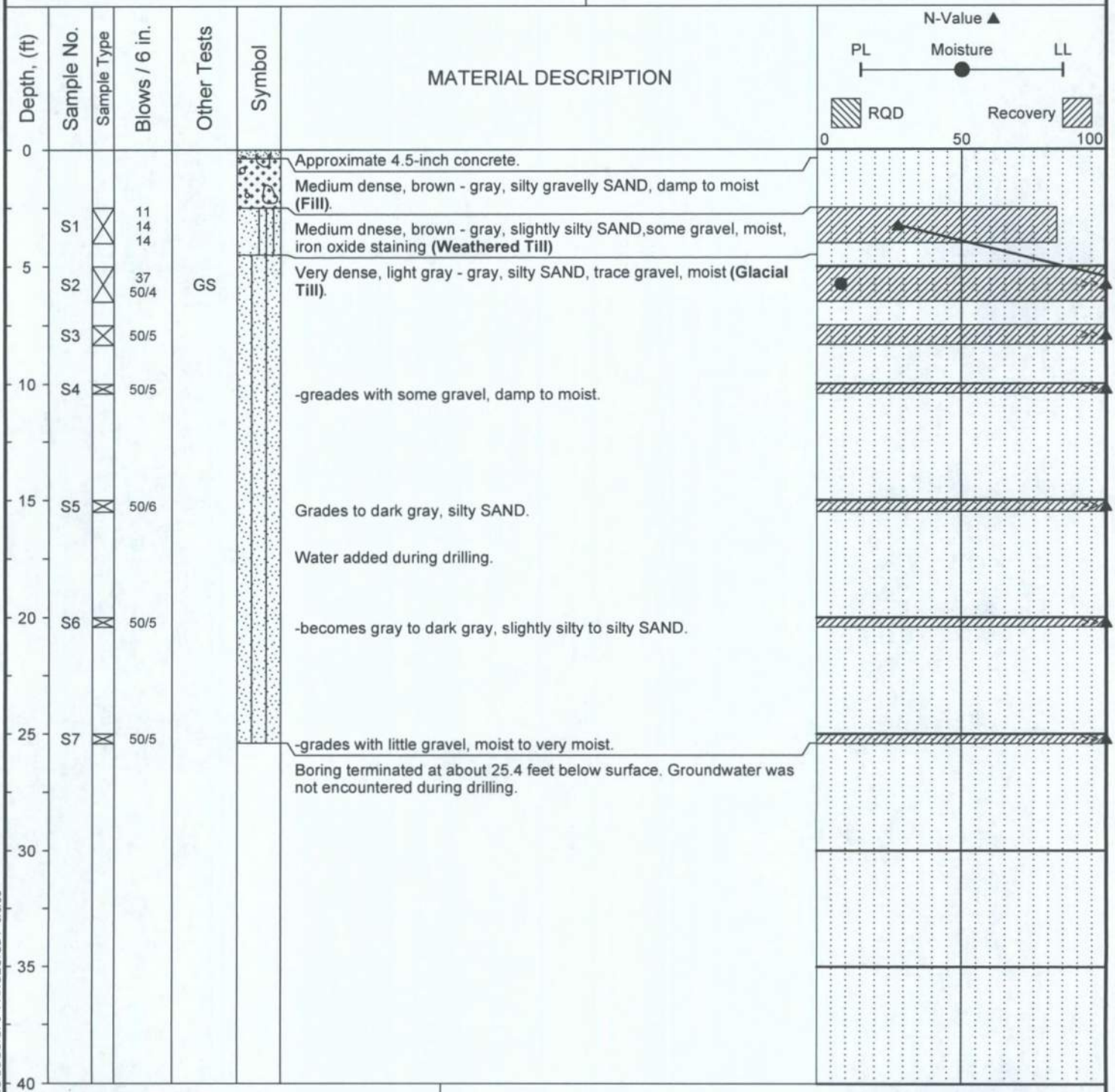
The stratification lines represent approximate boundaries. The transition may be gradual.

Sheet 1 of 1

LOG OF BOREHOLE 09-094 BORING LOGS.GPJ PANGEO.GDT 9/8/09

PanGEO INCORPORATED
Phone: 206.262.0370
Figure A-2
The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Olive Way Mixed Use	Surface Elevation:	+/- 297.0
Job Number:	09-094	Top of Casing Elev.:	N/A
Location:	1650 E Olive Way, Seattle	Drilling Method:	Hollow Stem Auger
Coordinates:	Northing: , Easting:	Sampling Method:	Std Pen Test



Completion Depth:	25.4ft
Date Borehole Started:	8/4/09
Date Borehole Completed:	8/4/09
Logged By:	HMX
Drilling Company:	BoreTec Drilling

Remarks: Boring drilled using a track-mounted drill rig. Standard Penetration Test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with a rope and cathead mechanism. Borehole elevation based on topographic data on a preliminary site plan.

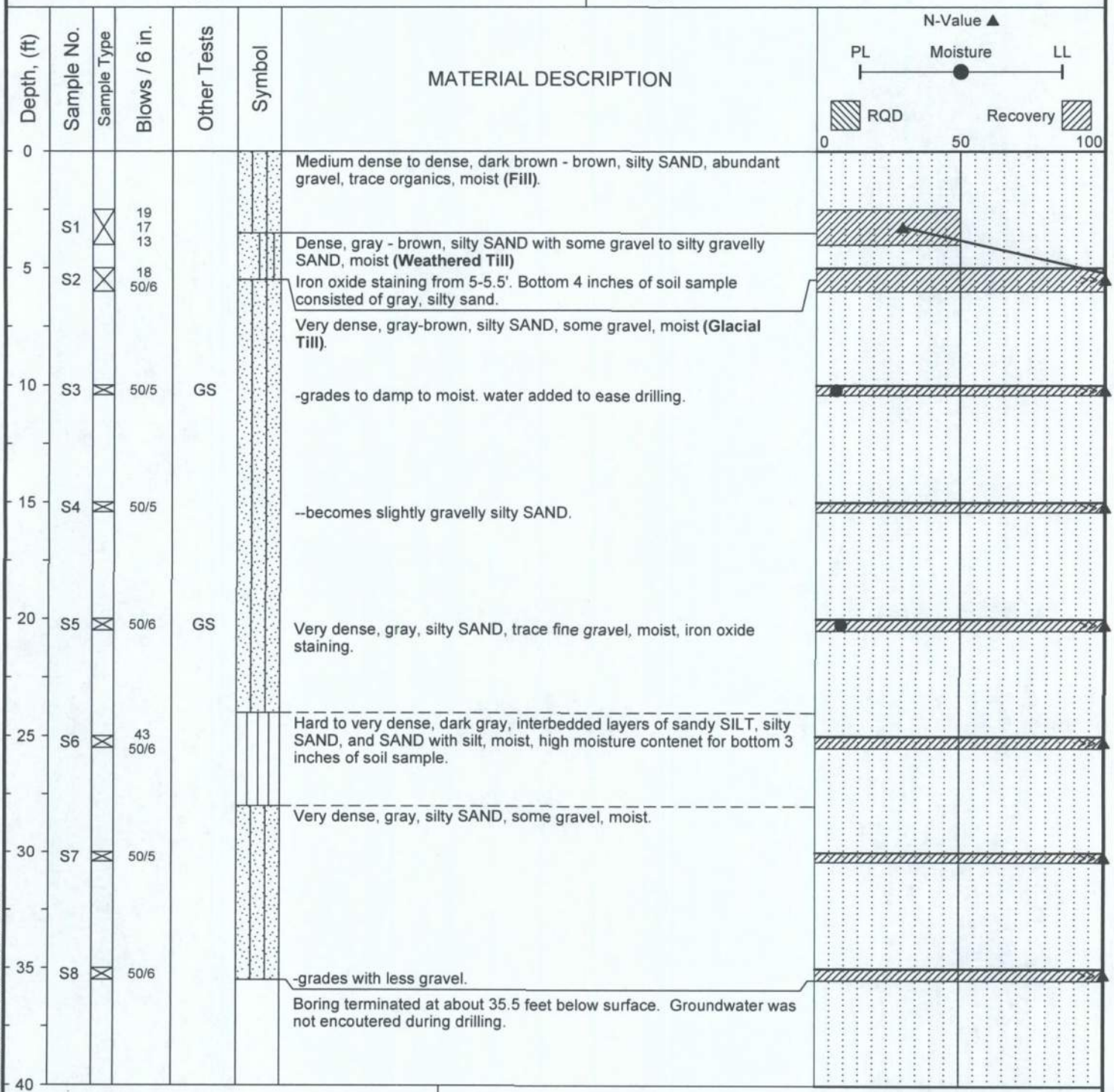
PanGEO INCORPORATED
Phone: 206.262.0370

LOG OF TEST BORING BH-2

Figure A-3

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Olive Way Mixed Use	Surface Elevation:	+/- 309
Job Number:	09-094	Top of Casing Elev.:	N/A
Location:	1650 E Olive Way, Seattle	Drilling Method:	Hollow Stem Auger
Coordinates:	Northing: , Easting:	Sampling Method:	Std Pen Test



Completion Depth:	35.5ft
Date Borehole Started:	8/4/09
Date Borehole Completed:	8/4/09
Logged By:	HMX
Drilling Company:	BoreTec Drilling

Remarks: Boring drilled using a track-mounted drill rig. Standard Penetration Test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with a rope and cathead mechanism. Borehole elevation based on topographic data on a preliminary site plan.

PanGEO INCORPORATED
Phone: 206.262.0370

LOG OF TEST BORING BH-3

Figure A-4

The stratification lines represent approximate boundaries. The transition may be gradual.

Boring Log B-1

Soil Descriptions

Ground Surface Elevation in Feet 302

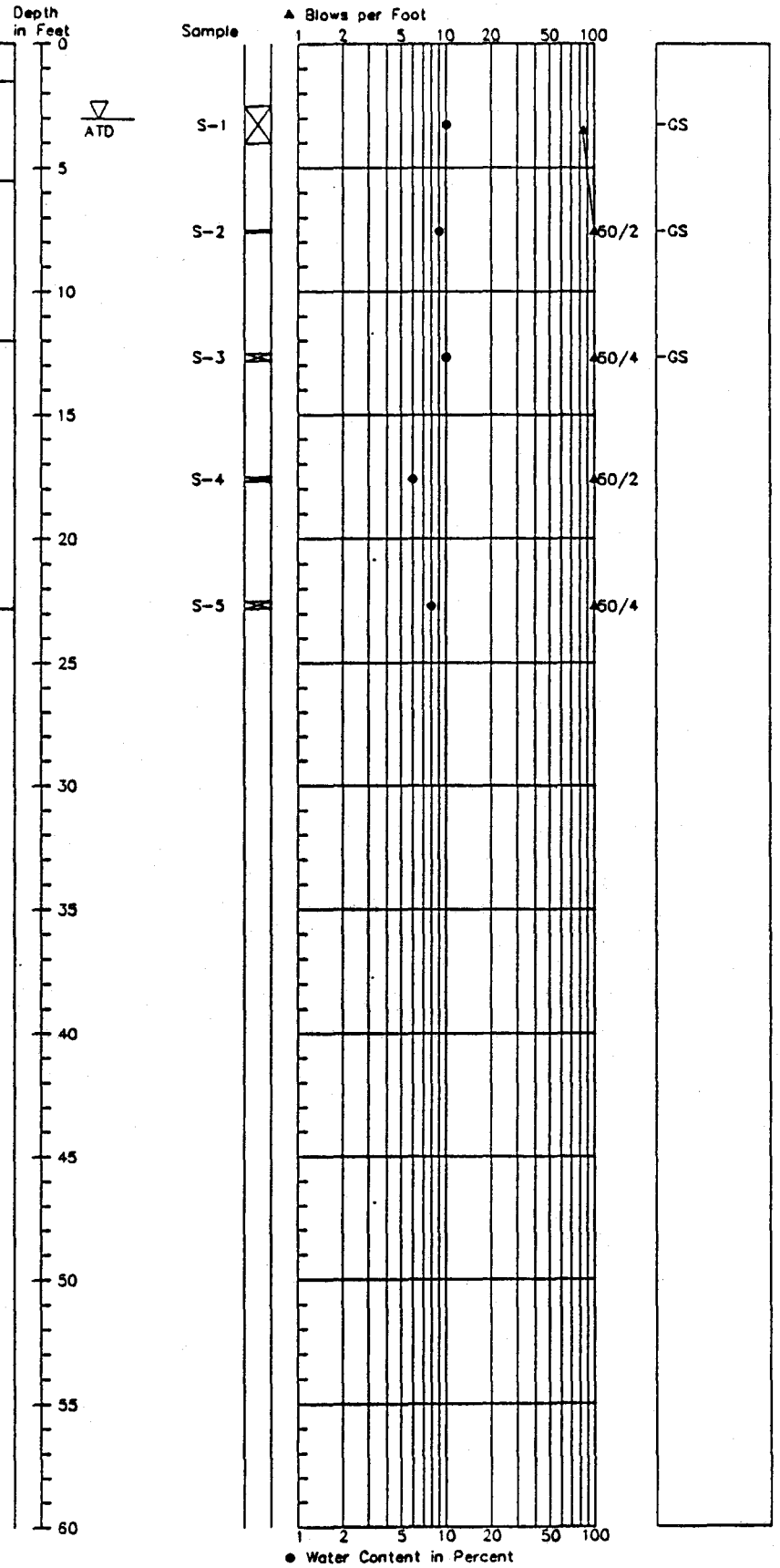
Asphalt over sandy GRAVEL. (FILL)

Very dense, moist to wet, brown–gray, slightly gravelly, silty SAND.

Very dense, moist, gray, gravelly, silty SAND.

Very dense, moist, gray, slightly gravelly, silty SAND.

Bottom of Boring at 22.8 Feet.
Completed 1/10/92.



1. Refer to Figure A–1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-3484 1/92

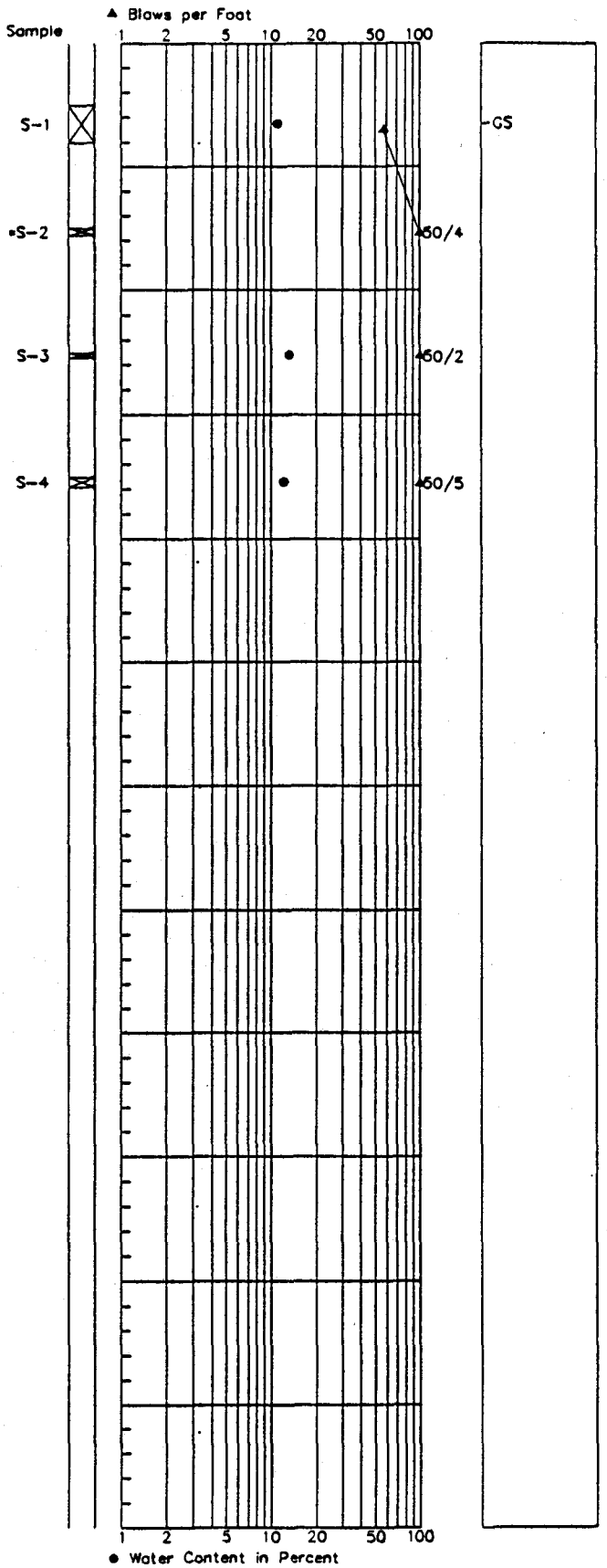
Figure A-2 1/1

Boring Log B-2

Soil Descriptions

Ground Surface Elevation in Feet 300

Depth in Feet	
0	Asphalt over sandy GRAVEL. (FILL)
5	Very dense, moist, gray, silty, gravelly SAND.
10	Very dense, moist to wet, gray, slightly gravelly, silty SAND.
15	
20	Bottom of Boring at 17.9 Feet. Completed 1/10/92.
25	
30	
35	
40	
45	
50	
55	
60	



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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Figure A-3 1/1

BORING 1

Well Design	Water Table	Blows per Foot	Sample	USCS	Description
				FILL	Crushed rock surface - Brown, silty, fine SAND with gravel, moist, medium-dense *(FILL)*
5		78	1		Brown, silty, fine SAND with some gravel, moist, medium-dense to dense
10		64	2		- becomes very dense *(Glacial Till)*
15		50/4"	3	SM	- becomes gray
20		50/4"	4		
25		100/3"	5		
30					
35					
40					

* Boring was drilled to 25.5 feet on September 24, 1997.
* No groundwater seepage was encountered during drilling.
* No caving was encountered during drilling.

GEOTECH
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BORING LOG

Proposed Maxwell Mixed-Use Building
702 East Denny Way
Seattle, Washington

Job No:	Date:	Logged by:	Plate:
97326	January 1998	DBG	3

BORING 2

Well Design	Water Table	Blows per Foot	Sample	USCS	Description
				FILL	Brown, silty, gravelly, fine SAND, moist, medium-dense *(FILL)*
		89	1		Gray, silty, gravelly SAND, moist, very dense *(Glacial Till)*
		50/1"	2		
	▼	50/5"	3		- becomes wet
		50/6"	4	SM	- becomes moist
		50/3"	5		- becomes dark gray, very moist
		50/2"	6		
		50/5"	7		

5 10 15 20 25 30 35 40

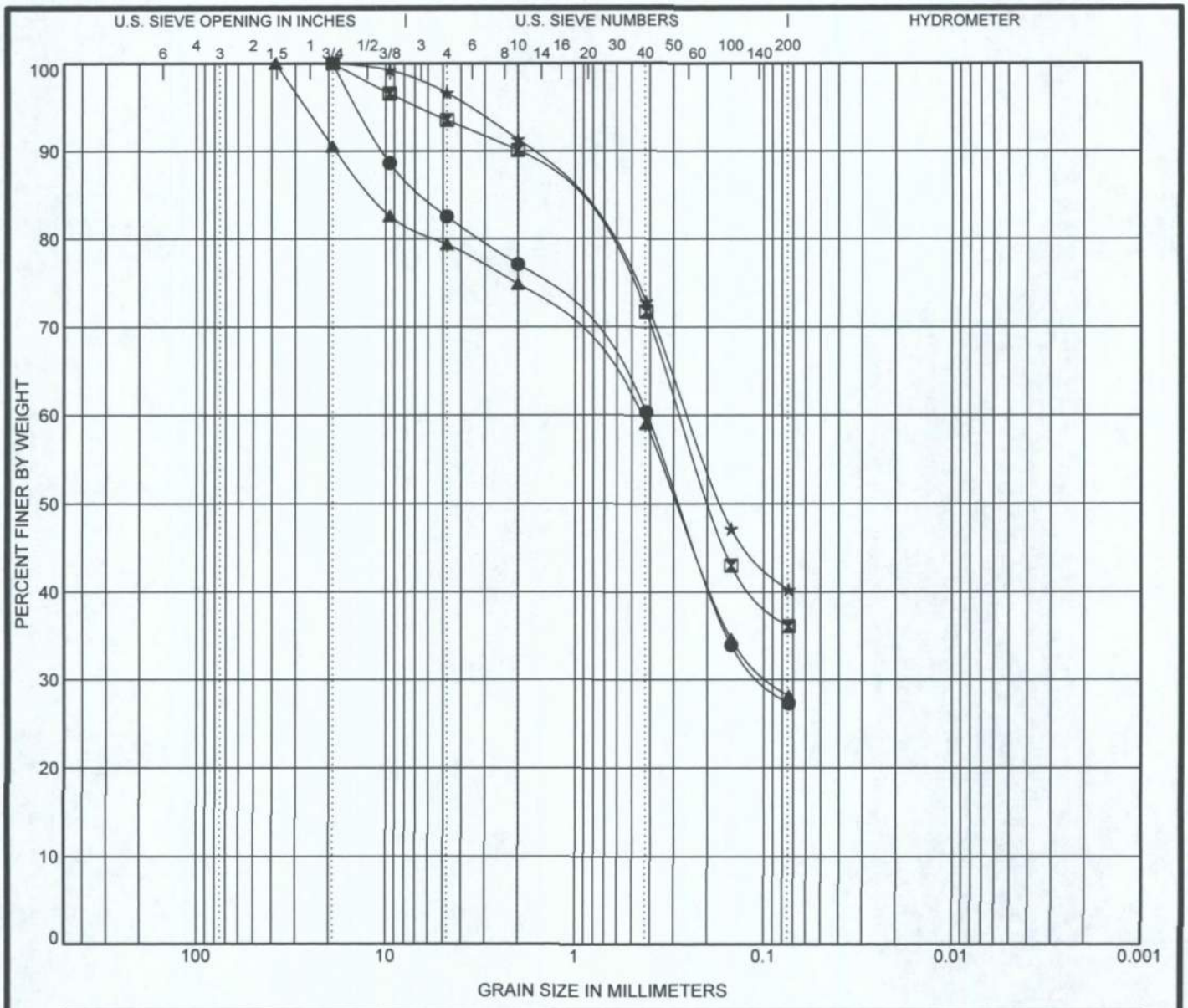
* Boring was drilled to 35.5 feet on September 29, 1997.
* Groundwater seepage was encountered at 16 feet during drilling.
* No caving was encountered during drilling.

GEOTECH
CONSULTANTS, INC.

BORING LOG

Proposed Maxwell Mixed-Use Building
702 East Denny Way
Seattle, Washington

Job No:	Date:	Logged by:	Plate:
97326	January 1998	DBG	4



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	BH-1	@ 7.5 ft.	Gray, silty SAND (SM) with some gravel					
⊠	BH-2	@ 5.0 ft.	Light gray-gray, silty SAND (SM) with trace gravel					
▲	BH-3	@ 10.0 ft.	Gray-brown, silty SAND (SM) with some gravel					
★	BH-3	@ 20.0 ft.	Gray, silty SAND (SM) with trace fine gravel					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	BH-1	7.5	19.05	0.414	0.099		17.5	55.1	27.4	
⊠	BH-2	5.0	19.05	0.275			6.5	57.3	36.2	
▲	BH-3	10.0	38.1	0.461	0.091		20.6	51.1	28.3	
★	BH-3	20.0	19.05	0.25			3.4	56.2	40.4	

PanGEO INCORPORATED
Phone: 206.262.0370

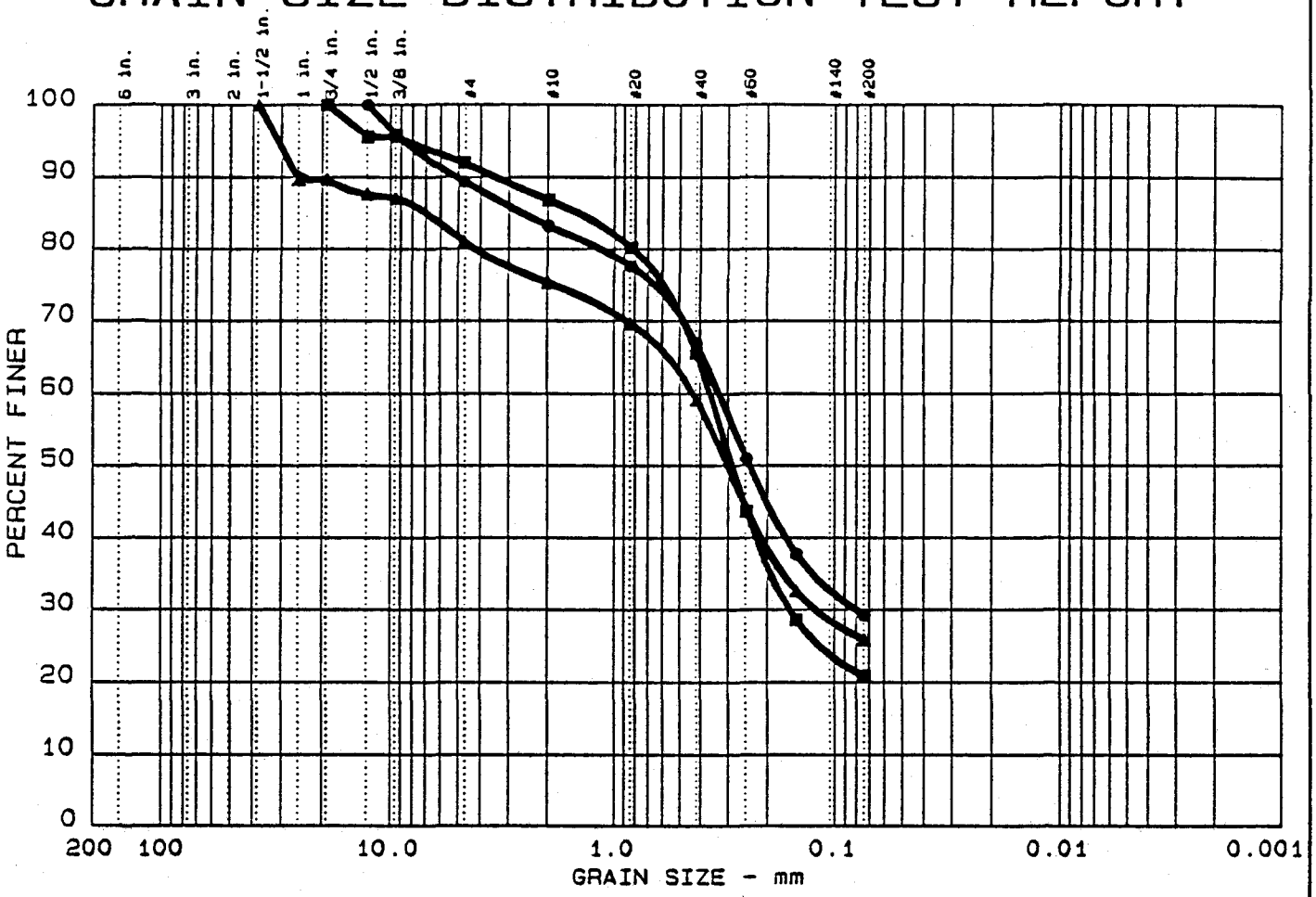
GRAIN SIZE DISTRIBUTION

Project: Olive Way Mixed Use
Job Number: 09-094
Location: 1650 E Olive Way, Seattle

Figure B-1

GRAIN SIZE 09-094 BORING LOGS.GPJ PANGEO.GDT 9/3/09

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	10.6	60.1	29.3	
▲	2	0.0	19.0	55.2	25.8	
■	4	0.0	8.0	71.2	20.8	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			2.63	0.33	0.24	0.080				
▲			7.00	0.43	0.30	0.122				
■			1.48	0.36	0.29	0.160				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Slightly gravelly, silty SAND	SM	10%
▲ Gravelly, silty, SAND	SM	9%
■ Slightly gravelly, silty, SAND	SM	10%

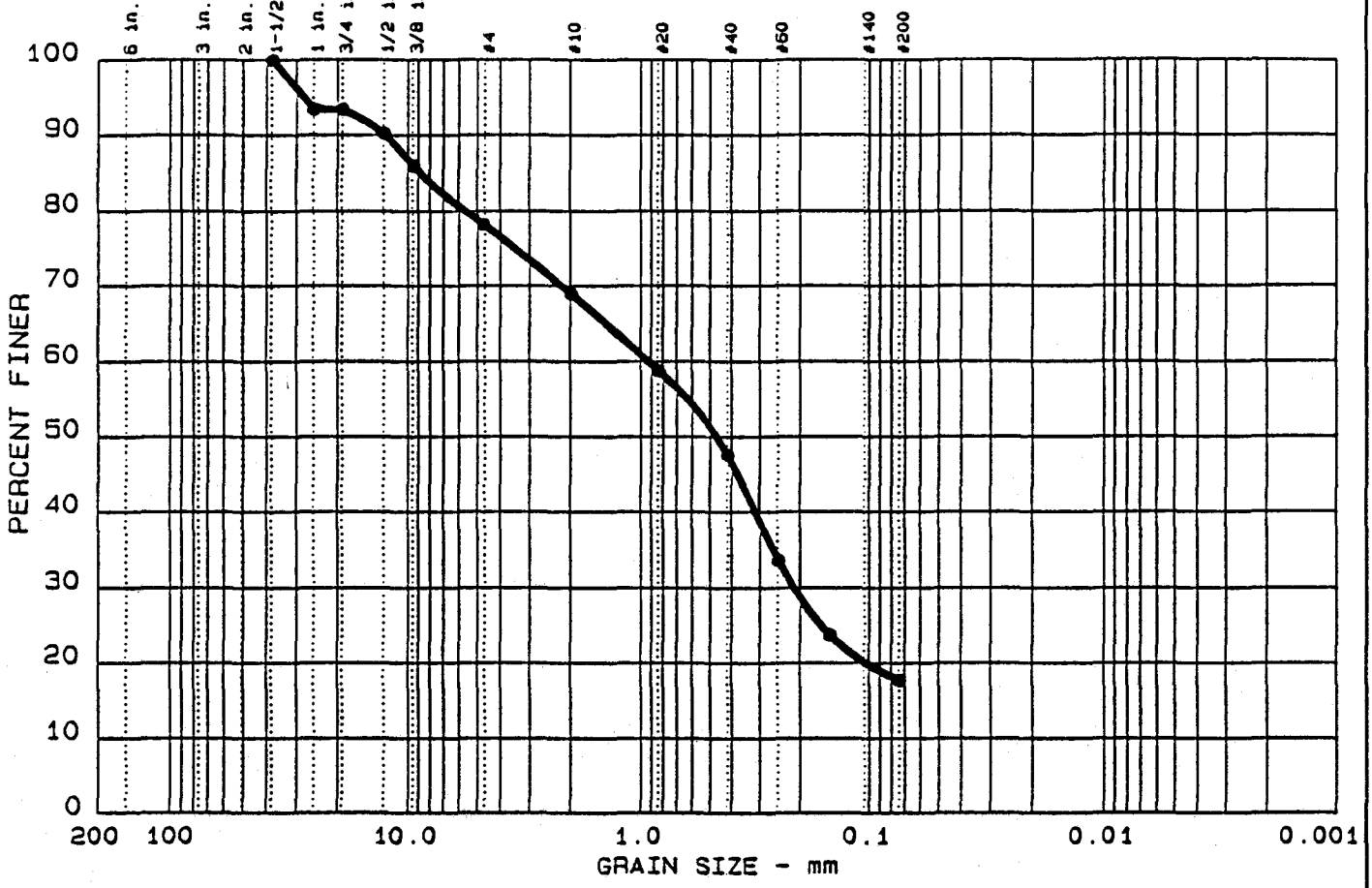
Remarks:

Project: Henry's Place
- ● Location: B-1, S-1 @ 2.5-4'
- ▲ Location: B-1, S-2 @ 7.5-7.7'
- ■ Location: B-1, S-3 @ 12.5-12.7'

HARTCROWSER J-3484 1/15/92

Figure B-2

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	21.8	60.5	17.7	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			8.81	0.92	0.47	0.214				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Silty, gravelly, SAND	SM	11%

Remarks:

Project: Henry's Place

● Location: B-2, S-1 @ 2.5-4'

HART CROWSER

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Figure B-3

SUPPORTING INFORMATION

Contents:

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or [$Cc<1$ or $Cc>3.0$] [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F, G, H]
			Fines classify as CL or CH		GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or [$Cc<1$ or $Cc>3.0$] [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G, H, I]
			Fines classify as CL or CH		SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A"		CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OL	Organic clay [K, L, M, N] / Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K, L, M]
			PI plots below "A" line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OH	Organic clay [K, L, M, P] / Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

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

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.