City of Tumwater Operations & Maintenance Facility

Draft Geotechnical Engineering Report

Prepared for:

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Tacoma, WA 98403

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October 4, 2023

TCF Architecture
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Attn: Mark Hurley – Principal Architect
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Re: Draft Geotechnical Engineering Report
City of Tumwater Operations & Maintenance Facility
7842 Trails End Dr SE
Tumwater, Thurston County, WA
Terracon Project No. 81225124

Dear Mr. Hurley:

We have completed the scope of services for the above referenced project in general accordance with Terracon Proposal No. P81225124 dated July 29, 2022, and our subconsultant agreement dated August 7, 2023. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements 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

DRAFT **DRAFT** **DRAFT**

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Exploration and Testing Procedures
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Site Location and Exploration Plans
Exploration and Laboratory Results
Supporting Information

Note: This report was originally delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon logo will bring you back to this page. For more interactive features, please view your project online at **client.terracon.com**.

Refer to each individual Attachment for a listing of contents.

Report Summary

Topic [1]	Overview Statement [2]
Project Description	8,000 square foot single-story office building structure Total of 34,800 square feet enclosed shops Total of 21,200 square feet canopy structures Structural loads and grading plans were not provided to Terracon by the time of this report. Assumed site grading to be less than 5 feet of cut and/or fill to level the site and facilitate stormwater drainage. Minor excavation other than foundation construction and utility installation Expected traffic for pavement areas: ■ Light-duty Pavements: < 100,000 ESALs ■ Heavy-duty Flexible Pavements: 1,500,000 ESALs ■ Heavy-duty Rigid Pavements: 1,900,000 ESALs
Geotechnical Characterization	Some areas of existing fill up to ~8 inches deep in some explorations with cobbles existing in the near-surface soils Organic-rich topsoil present to ~2½ to 5½ feet Loose to medium dense sand with variable silt and gravel content to ~11½ to 16 feet Medium dense to very dense sand and gravel with variable sand, silt, gravel, and cobble content present to termination depths Groundwater not observed during our exploration
Earthwork	Remove topsoil and existing fill where observed at structure locations Due to topsoil thickness, recommendations for partial removal are provided A minimum 2-foot layer of structural fill should be placed below foundations, slabs, and pavements Existing recessional outwash sand and gravel soils can be used for engineered fill Near-surface soils have appreciable organic content and may be moisture sensitive and become unstable when expose to excessive moisture

Shallow Foundations	Shallow foundations are recommended for building support Allowable bearing pressure dependent on foundation size Expected settlements: < 1-inch total, < 3/4-inch differential Detect and remove zones of fill and topsoil as noted in **Earthwork**.
Stormwater Management	Based on grain size evaluations, subsurface soils do not meet hydrologic criteria for Group A – infiltration testing is recommended Infiltration rate for Soil Layer 1 is 2 inches per hour Infiltration rate for Soil Layer 2 is 8 inches per hour
Pavements	With subgrade prepared as noted in **Earthwork**. Asphalt: Light Duty: 4” HMA over 4” granular base Heavy Duty: 6” HMA over 6” granular base Concrete: Light Duty: 5” PCC over 4” granular base Heavy Duty: 8.5” PCC over 4” granular base
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.

Introduction

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed Public Works Facility to be located at 7842 Trails End Dr SE in Tumwater, Thurston County, WA. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and groundwater conditions
- Seismic considerations and liquefaction
- Site preparation and earthwork
- Foundation design and construction
- Floor slab design and construction
- Stormwater management considerations
- Pavement design and construction

The geotechnical engineering Scope of Services for this project included the advancement of six soil borings and seven test pits to depths ranging from approximately 21½ to 51½ and 12 to 15 feet below existing site grades, respectively, and laboratory testing, engineering analysis, and preparation of this report.

Drawings showing the site and exploration locations are shown on the **Site Location** and **Exploration Plan**, respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the exploration logs and as separate graphs in the **Exploration Results** section.

Project Description

Our initial understanding of the project was provided in our proposal and was discussed during project planning. Our final understanding of the project conditions are provided in the following table.

Item	Description
Information Provided	▪ Email request for proposal prepared by TCF dated June 10, 2022 ▪ Architectural site plans dated May 18, 2022 ▪ Critical Areas Survey Report prepared by Krippner Consulting, LLC, dated July 8, 2016. ▪ Phase I Environmental Site Assessment prepared by Associated Environmental Group, LLC, dated June 20, 2014
Project Description	The project consists of developing a 6.7-acre site with multiple enclosed and covered storage structures for the maintenance and storage of City of Tumwater Public Works fleet and equipment. The site is relatively flat, and existing improvements will be demolished. A 20-stall parking lot will be constructed near the office building on the west side of Trails End Drive, with an additional 50-stall parking lot on the east side of Trails End Drive.
Proposed Structures	The project includes a single-story administrative/crew building with a footprint of about 8,000 square feet and additional enclosed shops having footprints of about 13,000, 9,600, 10,400, and 1,800 square feet. The buildings are anticipated to be slab-on-grade (non-basement). Additionally, there will be canopy covered storage structures having footprints of about 4,000, 3,300, 9,100, and 4,800 square feet.
Building Construction	The structures are assumed to be wood or steel framed, with slab-on-grade floors and shallow spread footings.
Finished Floor Elevation	Finished floor elevation is expected to be near existing site grade. Grading plans have not been provided to Terracon.
Maximum Loads	Structural loads not provided to Terracon. Maximum column loads are anticipated to be less than 40 kips.
Grading/Slopes	Less than 5 feet of cut and/or fill to level the site is anticipated to develop final grade but clearing and grubbing of the entire site will be required. Final slope angles and grading will need to address stormwater management of the site. Grading plans have not been provided to Terracon.

Item	Description
Pavements	Paved driveway and parking will be constructed on approximately 5 acres of the site west of Trails End Drive. Additional paved parking will be constructed on approximately 0.2 acre on the east side of Trails End Drive. Both rigid (concrete) and flexible (asphalt) pavement sections were considered. Based on the vehicle types indicated in the City of Tumwater Public Works (CTPW) Vehicle Parking List and the anticipated 4 to 8 trips per day provided by CTPW, we evaluated the ESALs to be approximately 1.9 million for rigid pavement and 1.5 million for flexible pavement (due to differing load factors) for Heavy Duty Pavements. Light Duty pavement recommendations for parking lots are also provided based on an estimated ESAL less than 100,000. The pavement design period is 20 years.
Building Code	In 2022, the State of Washington amended the 2018 International Building Code (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. Terracon has assumed 2018 IBC and ASCE 7-22 for seismic considerations.

Terracon should be notified if any of the above information is inconsistent with the planned construction, as modifications to our recommendations may be necessary.

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 on two adjoining parcels with addresses 7842 Trails End Dr SE and 1500 79th Avenue SE in Tumwater, Thurston County, WA. The 1500 79th Avenue SE parcel is split by Trails End Drive SE. Combined Lot Size west of Trails End Drive SE: 6.7 acres Lot Size east of Trails End Drive SE: 17 acres Latitude (approximate): 46.9727° North Longitude (approximate): 122.8834° West See **Site Location**
Existing Improvements	Two existing buildings (approximately 16,000 square feet each), on opposite sides of Trails End Drive. There is fencing around the lot perimeters, and a fenced-in area with a wooden observation tower on the west lot. The Trails End Drive right of way is improved with trees, and a sidewalk on the west side. Three existing buildings existed on the west lot until they were demolished between 2019 and 2020 according to historical aerial imagery.
Current Ground Cover	Earthen, lightly vegetated grassland with areas of trees and brush. Existing buildings to be demolished. Asphalt paved parking lot covering about 1¼ acres at the southwest corner of the lot east of Trails End Drive.
Existing Topography	Existing topography is nearly flat across the site at an elevation of approximately 204 to 205 feet MSL. Appears that the site gently grades from higher in the west and north to lower in the south and east (**Google Earth Pro**).

We also collected photographs at the time of our field exploration program. Representative photos are provided in our **Photography Log**.

Geotechnical Characterization

Geology

The surficial geology of the site is mapped as Q_{gos} – Pleistocene Continental Glacial Outwash Sand when viewed using the Washington State Department of Natural Resources online application. The soil units observed in the subsurface explorations were consistent with the geologic mapped unit and were predominantly glacial outwash overlain by topsoil and recent fill.

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting, and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of the site. Conditions observed at each exploration point are indicated on the individual logs. The individual logs and the GeoModel can be found in the **Exploration Results** section of this report.

Soil Conditions

Our review of geologic maps and existing subsurface information indicated subsurface conditions likely consist of recessional glacial outwash comprised primarily of loose to medium dense sand and silt deposits with variable gravel content. This is consistent with our observations during the geotechnical explorations.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring or test pit location, refer to the GeoModel.

Soil Layer[1]	Layer Name	USCS	General Description
1	**Surface Materials**	-	Surface materials comprised of topsoil, fill, and/or asphalt with base course: ▪ The topsoil is observed to a depth between ~2½ and 5½ feet below ground surface (bgs). The topsoil is comprised of very loose to medium dense, brown to dark brown, fine grained, silty sand with ~6.5% to 7% organics. In some places topsoil was observed underlying fill. ▪ ~8 inches of fill material observed at B-06, TP-04, and TP-05. Comprised of well graded gravel with silt, and sand with cobbles and organics. This unit is yellowish brown in color with rounded gravels.

Soil Layer[1]	Layer Name	USCS	General Description
			~1½ inches of asphalt followed by ~3 inches of base course in existing paved areas.
2	**Upper Recessional Outwash**	SM, SP-SM, SP	This unit is observed below the surface materials and extends to a depth of ~11½ to 16 feet bgs. It is comprised of sand with variable silt and gravel content. This unit is yellowish brown to grayish brown, loose to medium dense, and contains occasional trace organics and iron oxidation.
3	**Lower Recessional Outwash**	SM, SP-SM, SP, GW-GM, GW	This unit is observed below the Upper Recessional Outwash and extends to termination depth of the explorations. It is comprised of sand and gravel with variable sand, silt, gravel, and cobble content. This unit is brownish gray to brown and medium dense to very dense.

1. This summary is for convenience only. It should be used in conjunction with the entire report for preliminary design purposes.

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not observed at any of the exploration locations.

Monitoring wells were constructed following the advancement of soil borings B-01, B-05, and B-06. The soil borings were advanced in a manner consistent with the **Exploration and Testing Procedures** section. The well construction consisted of a screen interval and sand pack from the bottom of the borehole to about 10 feet below the existing ground surface (bgs). On August 16, 2023, data logging piezometers were installed in all three monitoring wells to record and monitor groundwater levels. Groundwater level monitoring at these wells will continue through the fall and winter to observe potential fluctuations due to seasonal variations.

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 structures 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

The site appears suitable for the proposed construction based upon geotechnical conditions encountered in the test pits and borings, provided that the recommendations provided in this report are implemented in the design and construction phases of this project.

The near-surface soils in the top 2.5 to 5.5 feet were observed to contain an appreciable organic content ranging from 6.5% to 7%. In general, soils with an organic content over about 3% are susceptible to loss of bearing support and additional settlement as the organic material decays. This leads to undesirable, post-construction settlement. Soils with an appreciable organic content that occur within the building footprint should be removed.

Existing fill soils were observed at boring location B-06 and test pits TP-04 and TP-05. Where encountered during excavation for foundation or under the building pad, these fill soils and topsoil should be excavated and replaced with compacted structural fill. Exposed subgrades should be reviewed by the geotechnical engineer to aid the contractor in identifying existing fill and topsoil. Existing fill soils and topsoil within the building footprint should be removed. Additional site preparation recommendations are provided in the **Earthwork** section.

Based on the conditions encountered and estimated load-settlement relationships, the proposed structures can be supported on conventional continuous or spread footings. Due to the settlement potential of near surface soils, the foundations should be supported on at least 2 feet of structural fill. Grading for the proposed foundations should incorporate the limits of the foundations plus a lateral distance beyond the outside edge of footings, where space is available. On-site Soil Layer 2 soils are considered suitable to be used as engineered fill materials. The **Shallow Foundations** section addresses support of the building directly bearing on engineered fill over Soil Layer 2.

The **Floor Slabs** section addresses slab-on-grade support of the building on structural fill following overexcavation and replacement of existing fill and topsoil.

Our opinion of pavement section thickness design has been developed based on our understanding of the intended use, assumed traffic, and subgrade preparation recommended herein using methodology contained in ACI 330 "Guide to Design and Construction of Concrete Parking Lots" / NAPA IS-109 "Design of Hot Mix Asphalt Pavements" and adjusted with consideration to the WSDOT Pavement Policy. The **Pavements** section includes minimum pavement component thickness.

Support of pavements on or above fill and topsoil materials is discussed in this report. However, even with the recommended construction procedures, an inherent risk remains for the owner. This risk of unforeseen conditions cannot be eliminated without completely removing Soil Layer 1 but can be reduced by following the recommendations contained in this report. To take advantage of the cost benefit of not removing the entire amount of unsuitable material, the owner must be willing to accept the risk of increased differential performance which can result in increased cracking and differential settlement. Should this risk be acceptable, pavements can be supported above the fill and topsoil.

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, (M41-10)*.

The recommendations contained in this report are based upon the results of field and laboratory testing (presented in the **Exploration Results**), engineering analyses, and our current understanding of the proposed project. The **General Comments** section provides an understanding of the report limitations.

Seismic Considerations

Ground Motion

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 [1]
ASCE 7-22 Site Classification	CD
Site Latitude	46.9727° North
Site Longitude	122.8834° West
S_S – Short Period Spectral Acceleration [3]	1.50 g
S_1 – 1-Second Period Spectral Acceleration [3]	0.48 g
S_{MS} – Short Period Spectral Acceleration Adjusted for Site Class	1.74 g

Description	Value [1]
S_{M1} – 1-Second Spectral Acceleration Adjusted for Site Class	0.82 g
S_{DS} – Design Short Period Spectral Acceleration	1.16 g
S_{D1} – Design 1-Second Spectral Acceleration	0.55 g
PGA_M - ASCE 7, Peak Ground Acceleration	0.72 g
Seismic Design Category	D

1. Two multi-channel analyses of surface waves (MASW) were performed to obtain shear wave velocity for the upper 100 feet of the soil profile. The approximate weighted average shear wave velocity was 1,110 ft/sec.

Surface-Fault Rupture

The risk 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 September 14, 2023. The closest mapped fault is the Olympia structure fault zone, which lies approximately 4 miles to the northeast, and is anticipated to be inactive as it has an unspecified slip rate.

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. Based on the site geology and subsurface groundwater conditions, the risk of liquefaction of the site soils is low for this site during a design level earthquake.

Geologic Hazards

Geologic Hazardous Areas as specified in the City of Tumwater's code Chapter 16.20 were not observed within the areas of proposed development investigated by Terracon.

Earthwork

Earthwork is anticipated to include demolition, clearing and grubbing, excavations, and engineered fill placement. 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

We understand that proposed development includes demolition of existing buildings on the site, as well as portions of the exterior sidewalks, pavements, and utilities. We recommend existing foundations, slabs, and utilities be removed from within the proposed building footprints and at least 5 feet beyond the outer edge of foundations.

For areas outside the proposed building footprints and foundation bearing zones, existing foundations, floor slabs, and utilities should be removed where they conflict with proposed utilities and pavements. In such cases, existing foundations and utilities should be removed to a depth of at least 2 feet below the affected utility or design pavement subgrade elevation.

Site Preparation

Prior to placing fill, existing vegetation, topsoil, and root mats should be removed. Complete stripping of the topsoil should be performed in the proposed building and parking/driveway areas.

Although no evidence of deep fill or underground facilities (such as septic tanks, cesspools, basements, and utilities) was observed during the exploration and site reconnaissance, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed, and all debris and loose soil be removed from the excavation prior to backfill placement and/or construction.

Subgrade Preparation

We recommend that the soils within the footprint of the proposed structures be removed to a minimum depth of 2 feet below the bottom of footings and floor slabs, or down to the extent of Soil Layer 1, whichever is deeper. Structural fill placed beneath the entire footprint of the foundations should extend horizontally a minimum distance of 2 feet beyond the outside edge of footings. Portions of the near-surface materials anticipated to be developed as excavation spoils are not considered suitable for use as structural fill due to the observed organic content.

Subgrade soils beneath proposed exterior slabs and pavements should be removed to a minimum depth of 2 feet beneath proposed slab or pavement section, or existing grade, whichever is greater.

The subgrade should be proofrolled with an adequately loaded vehicle such as a fully loaded tandem-axle dump truck. The proofrolling should be performed under the observation of the Geotechnical Engineer or representative. Areas excessively deflecting under the proofroll should be delineated and subsequently addressed by the Geotechnical Engineer. Such areas should be removed and recompacted. Excessively wet or dry material should either be removed and replaced with structural fill, or moisture conditioned and recompacted.

All exposed areas which will receive fill, once properly cleared, should be scarified to a minimum depth of 12 inches, moisture conditioned as necessary, and compacted per the compaction requirements in this report. Compacted structural fill soils should then be placed to the proposed design grade and the moisture content and compaction of subgrade soils should be maintained until foundation or pavement construction.

Based upon the subsurface conditions determined from the geotechnical exploration, subgrade soils exposed during construction are anticipated to be relatively workable; however, the workability of the subgrade may be affected by precipitation, repetitive construction traffic or other factors. If unworkable conditions develop, workability may be improved by scarifying and drying during periods of extended dry weather.

The moisture content and stability of subgrade soils should be maintained until slab or foundation construction. Concrete should be placed soon after excavating to reduce bearing soil disturbance. If allowed to collect, water can soften bearing subgrade and make disturbance by foot or construction traffic more likely. If concrete cannot be placed immediately after subgrade preparation, overcutting and placing a minimum 3-inch thickness of crushed rock or a “mud mat” consisting of lean or structural concrete may be necessary to protect the bearing soil surface during construction of forms and placing of reinforcement.

Existing Fill and Topsoil

As noted in **Geotechnical Characterization**, boring B-06 and test pits TP-04 and TP-05 encountered previously placed fill that was less than 1 foot thick. Additionally, fills may be present underneath and adjacent to the existing or historic structures. We have no records to indicate the degree of control during fill placement, and consequently, the fill is considered unreliable for support of foundation loads. Topsoil and topsoil overlain by fill was observed to be 2.5 to 5 feet thick. Areas of deeper undocumented fill, topsoil, or both may be present onsite that were not disclosed in our explorations. Recommendations related to the potential presence of existing fill and the depth of topsoil onsite are as follows:

- Within the footprint of the proposed structure and appurtenances, remove and replace all existing fill and topsoil. The Geotechnical Engineer can aid the contractor in identifying these soils.
- For pavement areas, it may be desirable to reduce earthwork costs by only partially removing these unsuitable soils. In doing so, the associated risks of unpredictable

settlements must be accepted by the owner. Provided the owner is willing to accept this risk, limited removal of the unsuitable soils is feasible. If the unsuitable soils are to be partially removed, we recommend overexcavating a minimum of 2-foot of these unsuitable soils and replacing them with Structural Fill may be acceptable.

Excavation

We anticipate that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. The bottom of excavations should be thoroughly cleaned of loose soils and disturbed materials prior to backfill placement and/or construction.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below, or within 10 feet of structures, pavements or constructed slopes. General fill is material used to achieve grade outside of these areas.

Import and On-Site Soil: Excavated on-site soil may be selectively reused as either structural or general fill, with general fill being used below landscaping areas and more than two feet below pavement. Portions of the on-site soil have an elevated fines and/or organic content and will be sensitive to moisture conditions (particularly during seasonally wet periods) and may not be suitable for reuse when above optimum moisture content.

Imported fill materials should meet the following material property requirements. Regardless of its source, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade.

Material property requirements for on-site soil for use as general fill and structural fill are noted in the table below:

Fill Type	Recommended Materials	Acceptable Location for Placement
Structural Fill	9-03.9(3) *Crushed Surfacing Base Course* [1] 9-03.14(1) *Gravel Borrow* [1] 9-03.14(2) *Select Borrow* [1] 9-03.14(3) Common *Borrow, Option 1* [1] On-site Soils (i.e., Soil Layer 2,3) [2, 3]	Beneath and adjacent to structural slabs, foundations, building appurtenances, and pavement subgrades

Fill Type	Recommended Materials	Acceptable Location for Placement
General Fill	Section 9-03.14(3) *Common Borrow* [1] On-site Soils (i.e., Soil Layer 1,2,3) [2, 3]	Grade filling, utility trench backfill outside the building foundation and appurtenances
Free-Draining Granular Fill	Structural Fill [4] 9-03.12(2) *Gravel Backfill for Walls* [1] 9-03.12(4) *Gravel Backfill for Drains* [1]	Backfilling in wet weather, drainage layers for walls, sump drains, footing drains [5]

1. WSDOT Standard Specifications
2. Structural and general fill should consist of approved materials free of organic matter, deleterious materials, and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site.
3. May contain local areas of higher fines content that could make this material moisture sensitive. Particles with a nominal diameter greater than about 3 in. should be removed.
4. Material provided must be specified to be less than 5-percent passing the #200 sieve for the portion of material passing the #4 sieve.
5. 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 the Geotechnical Engineer prior to use.

Fill Placement and Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill	General Fill
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	Same as structural fill

Item	**Structural Fill**	**General Fill**
Minimum Compaction Requirements[1,2]	95% of max. below foundations, below floor slabs, and within 2 foot of finished pavement subgrade 92% of max. above foundations and more than 2 feet below finished pavement subgrade	92% of maximum dry density
Water Content Range[1]	Granular Soils: -2% to +2% of optimum	As required to achieve min. compaction requirements

1. Maximum density and optimum water content as determined by the Modified Proctor test (ASTM D 1557).
2. If the granular material is a coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254). Materials not amenable to density testing should be placed and compacted to a stable condition observed by the Geotechnical Engineer or representative.

Utility Trench Backfill

Any soft or unsuitable materials encountered at the bottom of utility trench excavations should be removed and replaced with structural fill or bedding material in accordance with public works specifications for the utility to be supported. This recommendation is particularly applicable to utility work requiring grade control and/or in areas where subsequent grade raising could cause settlement in the subgrade supporting the utility. Trench excavation should not be conducted below a downward 1:1 projection from existing foundations without engineering review of shoring requirements and geotechnical observation during construction.

On-site Soil Layer 2 and 3 materials are considered suitable for backfill of utility and pipe trenches from 1 foot above the top of the pipe to the final ground surface, provided the material is free of organic matter and deleterious substances.

All trenches should be wide enough to allow for compaction around the haunches of the pipe. If water is encountered in the excavations, it should be removed prior to fill placement. The presence of cobbles and boulders may present challenges with respect to trench stability. Nested cobbles and boulders in trench side walls may become loosened during trench that could influence trench stability. While not observed in our explorations, nested cobbles and boulders are sometimes present in uncontrolled fills and can be found in recessional outwash soil. The utility contractor should be prepared to contend with the possible presence of cobbles and boulders in utility trench alignments.

Trench backfill should be mechanically placed and compacted as discussed earlier in this report. Compaction of initial lifts should be accomplished with hand-operated tampers or other lightweight compactors to avoid damaging piping or conduit. Where trenches are placed beneath slabs or footings, the backfill should satisfy the gradation requirements of engineered fill discussed in this report.

Grading and Drainage

All grades must provide effective drainage away from the building during and after construction and should be maintained throughout the life of the structure. Effective drainage will be essential during construction to limit the extent of soil disturbance during the wet season.

Water retained next to the building can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks. Gutters and downspouts should be routed into tightline pipes that discharge either directly into a municipal storm drain or to an alternative drainage facility. Splash-blocks should also be considered below hose bibs and water spigots.

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.

The roof should have gutters/drains with downspouts that discharge onto splash blocks at a distance of at least 10 feet from the building or be routed into tightline pipes that discharge either directly into a municipal storm drain or to an alternative drainage facility. Splash-blocks should also be considered below hose bibs and water spigots.

Earthwork Construction Considerations

Shallow excavations for the proposed structure are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of grade-supported improvements such as floor slabs and pavements. Construction traffic over the completed subgrades should be avoided. 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. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to floor slab construction.

As a minimum, excavations should be performed in accordance with WAC Chapter 296-155 Part N “Excavation, Trenching, and Shoring”, OSHA 29 CFR, Part 1926, Subpart P, “Excavations” and its appendices, and in accordance with any applicable local regulations. Terracon’s opinion is that the on-site soils should be considered Type C soil for temporary excavations.

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 observed by the Geotechnical Engineer (or others under their direction). Observation should include documentation of adequate removal of surficial materials (vegetation, topsoil, and pavements), evaluation and remediation of existing fill materials, as well as proofrolling and mitigation of unsuitable areas delineated by the proofroll.

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, as recommended by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 2,500 square feet of compacted fill in the building areas and 10,000 square feet in pavement areas. Where not specified by local ordinance, one density and water content test should be performed for every 250 linear feet of compacted utility trench backfill and a minimum of one test performed for every 12 vertical inches of compacted backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated by the Geotechnical Engineer. If unanticipated conditions are observed, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer’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 about 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.

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing Pressure [1, 2]	2,000 psf [3]
Minimum Foundation Dimensions	24 inches for Spread Footing 18 inches for Wall Footing
Sliding Resistance [4]	0.3 allowable coefficient of friction - granular material
Minimum Embedment below Finished Grade [5]	24 inches

Item	Description
Estimated Total Settlement from Structural Loads [2]	1 inch
Estimated Differential Settlement [2, 6]	About ¾ of total settlement

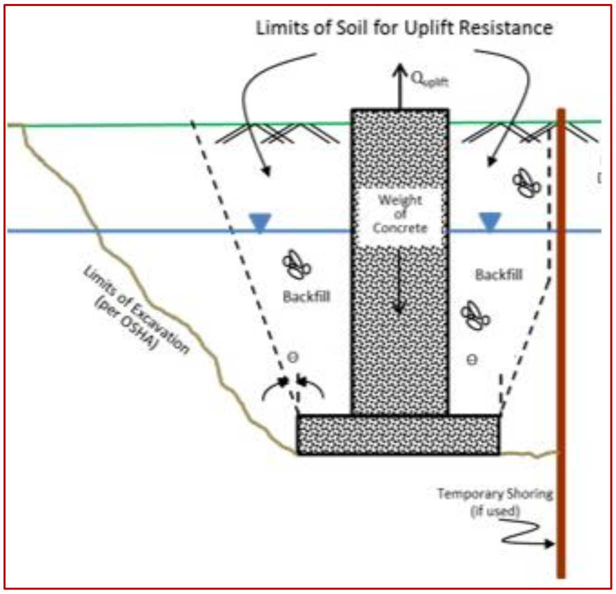
1. The maximum net allowable bearing pressure will be dependent on the foundation size as foundation loads have not been provided.
2. Values provided assume 1 inch total settlement for a rectangular footing with a width-to-length ratio of 10 embedded 24 inches. Assumes foundations remain 20 feet above groundwater table year-round.
3. Unsuitable or soft soils should be overexcavated and replaced per the recommendations presented in **Earthwork**.
4. 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.
5. 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.
6. 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

Design Parameters – Overturning and Uplift Loads

Shallow foundations subjected to overturning loads should be proportioned such that the resultant eccentricity is maintained in the center-third of the foundation (e.g., $e < b/6$, where b is the foundation width). This requirement is intended to keep the entire foundation area in compression during the extreme lateral/overturning load event. Foundation oversizing may be required to satisfy this condition.

Uplift resistance of spread footings can be developed from the effective weight of the footing and the overlying soils with consideration to the IBC basic load combinations. As illustrated on the subsequent figure, the effective weight of the soil prism, defined by diagonal planes extending up from the top of the perimeter of the foundation to the ground surface at an angle with vertical, can be included in uplift resistance. The maximum allowable uplift capacity should be taken as a sum of the effective weight of soil plus the dead weight of the foundation, divided by an appropriate factor of safety. The maximum unit weight and the angle of the diagonal plane for Structural Fill are provided in the following table:

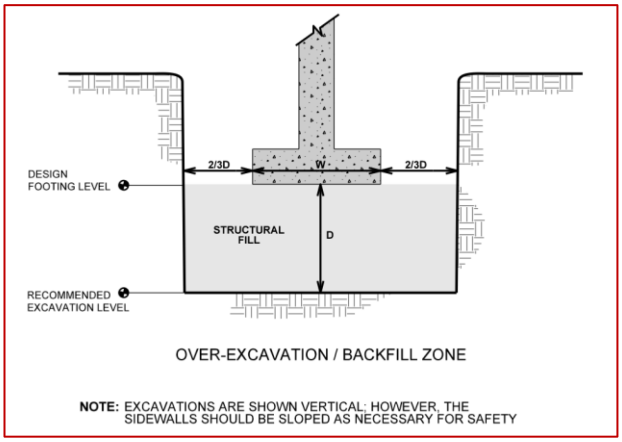
Item	Description
Soil Moist Unit Weight	120 pcf
Soil weight included in uplift resistance	Soil included within the prism extending up from the top perimeter of the footing at an angle of **20 degrees** from vertical to ground surface



Foundation Construction Considerations

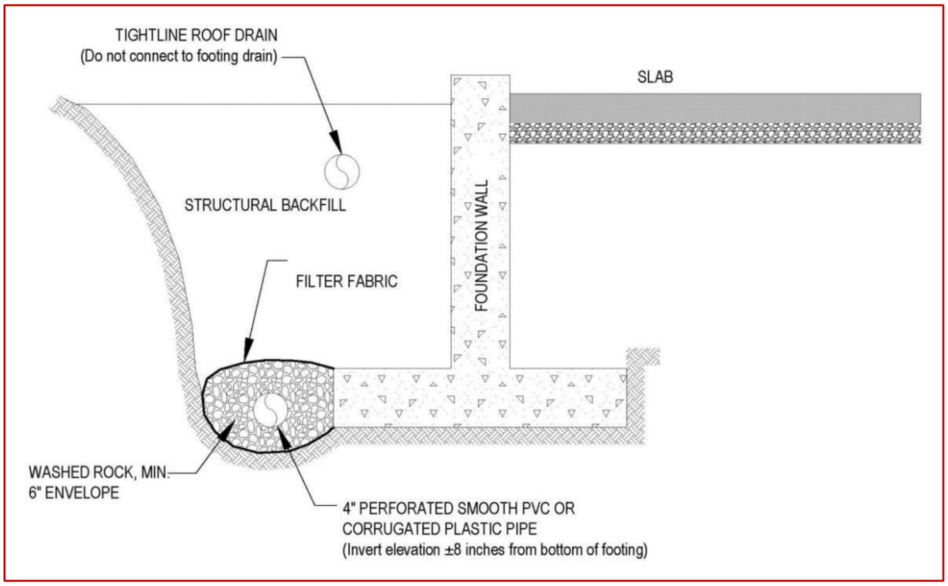
As noted in **Earthwork**, the footing excavations should be evaluated under the observation of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. 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.

Overexcavation for structural fill placement below footings should be conducted as shown below. The overexcavation should be backfilled up to the footing base elevation, with Structural Fill placed, as recommended in the **Earthwork** section.



Foundation Drains

We recommend the building be **encircled with a perimeter foundation** drain to collect exterior seepage water. This drain should consist of a 4-inch minimum 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 WSDOT Section 9-03.12(4), Gravel Backfill for Drains or 9-03.12(5), Gravel Backfill for Drywells. The washed rock envelope should be wrapped with filter fabric meeting the material requirements for Low Survivability Nonwoven with maximum AOS of No. 40 Geotextile for Underground Drainage found in WSDOT Section 9-33.2(1) (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. 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. These recommendations are summarized in the figure below.



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.

The floor slab should be supported on at least 2 feet of compacted suitable natural soils or structural fill.

Existing fill materials and materials described as topsoil were observed at the site to depths of 2.5 to 5 feet below existing grade. As previously described, any existing fill and/or topsoil present beneath floor slabs should be completely removed.

Floor Slab Design Parameters

Item	Description
Floor Slab Support [1]	Minimum 6 inches of free-draining of either of the following: ▪ Washed drain rock ▪ 9-03.12(1)A *Gravel Backfill for Foundations Class A* (compacted to at least 95% of ASTM D 1557) [2, 3]
Estimated Modulus of Subgrade Reaction [4]	350 pounds per square inch per inch (psi/in) for point loads 200 psi/in for distributed 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. WSDOT Standard Specification.
3. The floor slab design should include a capillary break, comprised of compacted material with less than 12% passing the No. 40 sieve and less than 5% fines (material passing the No. 200 sieve).
4. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads.

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, when the project includes humidity-controlled areas, 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 contraction 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 waterproof, 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.

Settlement of floor slabs supported on existing fill and/or topsoil materials cannot be accurately predicted but could be larger than normal and result in some cracking. Mitigation measures, as noted in **Existing Fill** within **Earthwork**, are critical to the performance of floor slabs. In addition to the mitigation measures, the floor slab can be stiffened by adding steel reinforcement, grade beams, and/or post-tensioned elements.

Floor Slab Construction Considerations

Finished subgrade, within and for at least 10 feet beyond the floor slab, 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 observe 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.

Stormwater Management

The Stormwater Management Manual for Western Washington (SWMMWW) presents various procedures and requirements for demonstrating the suitability of onsite stormwater management. The subsurface soil compositions appear favorable for a simplified design approach using grain size correlations.

Correlation With Grain Size

According to the SWMMWW, a saturated infiltration rate may also be determined using a grain-size correlation. The methodology recommended by the manual is the Massmann equation (2009).

It should be noted that grain-size correlations neglect considerations for soil density and therefore are less appropriate for design than values derived using PIT methodology.

Infiltration Rate Analysis

The analysis performed for estimating the design infiltration rate was consistent with the SWMMWW (2019) manual. The infiltration rates determined using the grain size analysis are to be reduced by several correction factors as follows:

$$K_{sat\ design} = K_{sat\ (estimated/measured)} \times CF_t \times CF_v \times CF_m;$$

Where,

- $K_{sat\ design}$ is the design infiltration rate
- $K_{sat\ (estimated/measured)}$ is measured infiltration rate from PIT testing or grain size analysis.
- CF_t is a test factor and is taken as 0.4 for grain-size based estimate of $K_{sat\ design}$.
- CF_m is a factor arising from the long-term plugging potential of the infiltrating soil. For the range of soils encountered during exploration, a value of 0.9 should be used for CF_m.
- CF_v is a factor between 0.33 and 1.0 accounting for the site variability and the number of locations tested, and this value is assumed to be 1.0.

Using the equation presented in SWMMWW developed by Massmann (2003) for saturated hydraulic conductivity, a design infiltration rate ($K_{sat\ design}$) ranging from 2 to 11 inches per hour is estimated for samples taken at the test pit locations. The design infiltration rate ranged from 2 to 3 inches per hour and 6 to 11 inches per hour for Soil Layer 1 and Soil Layer 2, respectively.

Recommendations for stormwater infiltration

Infiltration testing at the location(s) of the rain gardens is understood by Terracon to be required by the City of Tumwater Drainage Design and Erosion Control Manual unless the rain garden site(s) is underlain by Group A soils. Based on our subsurface exploration and the results of soil sample gradation testing, the soils do not meet the Type A criteria specified by NCRS, as Type A materials are composed of at least 90% sand and/or gravel. Infiltration testing will likely be required within the footprint of the infiltration facilities.

Based on the results from the analysis methodology presented in the SWMMWW, and observations of subsurface conditions during the excavation of the test pits, we recommend the following:

- Design infiltration rate ($K_{sat\ design}$) of **2 inches per hour** for surficial material in the upper 3 to 5 feet (Soil Layer 1), and **8 inches per hour** for soils deeper than 3 feet (Soil Layer 2)
- If soil units of lower permeability are observed, perform overexcavation as needed to hydraulically connect the base of the infiltration system with the infiltrating soil unit
- If overexcavation is necessary, backfilling should use granular fill with a fines content less than 5% (i.e., percent passing the #200 sieve)
- The surface elevation of the stormwater facilities should be located deeper than the perimeter footing drains of any adjacent buildings
- Retain Terracon to observe the base of the stormwater facilities, once excavated, to aid the contractor in identifying the infiltrating unit.
- The above-mentioned design infiltration rates are valid under the assumptions of the use of tracked (i.e., low to moderate ground pressure) excavation equipment for leveling and grading soils beneath the base of the infiltration facility. Over-compacting within the infiltration area may reduce the infiltration rate

In general, and based on the subsurface information collected to date, management of surface water through stormwater infiltration appears feasible in the general vicinity of where test pits were performed.

Pavements

General Pavement Comments

Pavement designs are provided for the traffic conditions and pavement life conditions as noted in **Project Description** and in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs noted in this section must be applied to the site which has been prepared as recommended in the **Earthwork** section.

The standard equivalent single-axle load (ESAL) was estimated using 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO-1993). The traffic loading for flexible and rigid pavement areas were estimated based on the vehicle types and anticipated trip counts provided by the City of Tumwater.

Based on the provided traffic count, our assumptions of axle configuration, and our assumption of traffic loading, we have estimated the following Equivalent Single Axle Loads (ESALs):

- Light Duty Areas: < 100,000 ESALs
- Heavy Duty Areas: 1,500,000 ESALs (flexible pavement)
- Heavy Duty Areas: 1,900,000 ESALs (rigid pavement)

Pavement Design Parameters

A 20-year design life is assumed. A California Bearing Ratio (CBR) of 10 was used for the subgrade for the asphaltic concrete (AC) pavement designs. Any imported or borrow source fill placed below the proposed pavements should have a CBR value of at least 10.

Other design parameters assumed as follows:

- Pavement design life = 20 years
- Initial serviceability = 4.0
- Terminal serviceability = 2.5
- Reliability = 85%
- Drainage coefficient = 1.0
- Layer coefficients of 0.50 and 0.13 for AC and aggregate base layers, respectively
- Load transfer coefficient, J = 3.2 (dowelled joints)
- Standard deviation 0.50 for flexible pavements and 0.40 for rigid pavements
- For design purposes, we have assumed a CBR value of at least 10. Any imported or borrow source fill placed below the proposed pavements should have a CBR value of at least 10 when compacted to 95 percent of the modified Proctor maximum dry density.
- A modulus of subgrade reaction of 150 lbs per cubic inch (pci) was assumed for compacted subgrade for concrete pavement design.
- A modulus of rupture of 580 psi was used in design for the concrete (based on correlations with a minimum 28-day compressive strength of 4,000 psi).

Pavement Section Thicknesses

Design of Asphaltic Concrete (AC) pavements are based on the 1993 AASHTO guidelines and the WSDOT Pavement Policy (2018). Minimum recommended pavement section thicknesses are presented below:

Asphaltic Concrete (AC) Design

Layer	Light Duty Layer Thickness (inches)	Heavy Duty Layer Thickness (inches)
Compacted Subgrade [1]	24	24
Crushed Aggregate Base [2]	4	6
Asphalt Thickness [3, 4]	4	6

Asphaltic Concrete (AC) Design

Layer	Light Duty Layer Thickness (inches)	Heavy Duty Layer Thickness (inches)

1. May vary based on observations following proof-rolling.
2. Aggregate base meeting WSDOT:9-03.9(3) Base Course specifications, and the requirements specified in the **Earthwork** section.
3. Aggregates for asphalt surface meeting WSDOT: 9-03.8(2) ½-inch HMA and ¾-inch HMA requirements for Light Duty and Heavy Duty AC, respectively.
4. PG58H-22 asphalt binder (WSDOT Pavement Policy, 2018).

Portland Cement Concrete (PCC) Design

Layer	Light Duty Layer Thickness (inches)	Heavy Duty Layer Thickness (inches)
Compacted Subgrade [1]	24	24
Crushed Aggregate Base [2]	4	4
Portland Cement Concrete Thickness	5	8.5

1. May vary based on observations following proof-rolling.
2. Aggregate base meeting WSDOT:9-03.9(3) Base Course specifications, and the requirements specified in the **Earthwork** section.

We recommend that Portland cement concrete (PCC, rigid) pavement be used where rigid pavements are appropriate. These areas include but are not limited to entrance and exit sections, dumpster pads, or any areas where extensive wheel maneuvering or repeated loading are expected. The rigid pavement pads should be large enough to support the wheels of the truck or equipment which will bearing the haul load. The minimum thickness of PCC pavement should be 8.5 inches and underlain by a minimum of 4 inches of crushed aggregate base course (use WSDOT 9.03.9(3)). Adequate reinforcement and number of longitudinal and transverse control joints should be placed in the rigid pavement in accordance with ACI requirements. Dowelled joints are assumed for PCC. Although not required for structural support, the base course layer is recommended to help reduce potential for slab curl, shrinkage cracking, subgrade "pumping" through joints, and provide a workable surface. These thicknesses assume the subgrade is properly prepared and compacted as noted above. Proper joint spacing will also be required to prevent excessive slab curling and shrinkage cracking. All joints should be sealed to prevent entry of foreign material and dowelled where necessary for load transfer.

The minimum pavement sections outlined above were determined based on post-construction traffic loading conditions. These pavement sections do not account for heavy construction traffic during development. A partially constructed structural section that is subjected to heavy construction traffic can result in pavement deterioration and premature distress or failure. Our experience indicates that this pavement construction practice can result in pavements that will not perform as intended. Considering this information, several alternatives are available to mitigate the impact of heavy construction traffic prior to pavement construction. These include using thicker sections to account for the construction traffic after paving; using some method of soil stabilization to improve the support characteristics of the pavement subgrade; routing heavy construction traffic around paved areas; or delaying paving operations until as near the end of construction as is feasible.

Areas for parking of heavy vehicles, concentrated turn areas, and start/stop maneuvers could require thicker pavement sections. Edge restraints (i.e., concrete curbs or aggregate shoulders) should be planned along curves and areas of maneuvering vehicles.

Although not required for structural support, a minimum 4-inch-thick base course layer is recommended to help reduce potential for slab curl, shrinkage cracking, and subgrade pumping through joints. Proper joint spacing will also be required to prevent excessive slab curling and shrinkage cracking. Joints should be sealed to prevent entry of foreign material and doweled where necessary for load transfer. PCC pavement details for joint spacing, joint reinforcement, and joint sealing should be prepared in accordance with ACI 330 and ACI 325.

Where practical, we recommend early-entry cutting of crack-control joints in PCC pavements. Cutting of the concrete in its "green" state typically reduces the potential for micro-cracking of the pavements prior to the crack control joints being formed, compared to cutting the joints after the concrete has fully set. Micro-cracking of pavements may lead to crack formation in locations other than the sawed joints, and/or reduction of fatigue life of the pavement.

Openings in pavements, such as decorative landscaped areas, are sources for water infiltration into surrounding pavement systems. Water can collect in the islands and migrate into the surrounding subgrade soils thereby degrading support of the pavement. Islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils are particular areas of concern. The civil design for the pavements with these conditions should include features to restrict or collect and discharge excess water from the islands. Examples of features are edge drains connected to the stormwater collection system, longitudinal subdrains, or other suitable outlets and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the granular subbase.

We recommend drainage be included at the bottom of Aggregate Base (when used) at the storm structures to aid in removing water that may enter this layer. Drainage could consist of small diameter weep holes excavated around the perimeter of the storm structures. The weep holes should be excavated at the elevation of the Aggregate Base and soil interface. The excavation should be covered with Aggregate Base encompassed in Mirafi 140NL, or an approved equivalent, which will aid in reducing the amount of fines that enter the storm system.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic upkeep should be anticipated. Preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Pavement care consists of both localized (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Additional engineering consultation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur, and repairs may be required.

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to paved areas should slope down from the edges at a minimum 2%.
- Subgrade and pavement surfaces should have a minimum 2% slope to promote proper surface drainage.
- Install pavement drainage systems surrounding areas anticipated for frequent wetting.
- Install joint sealant and seal cracks immediately.
- Seal all landscaped areas in or adjacent to pavements to reduce moisture migration to subgrade soils.

- Place compacted, low permeability backfill against the exterior side of curb and gutter.

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 our site exploration. 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 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 affect 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. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. 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.

Attachments

Exploration and Testing Procedures

Field Exploration

Number of Explorations	Type of Explorations	Approximate Exploration Depth (feet) [1]	Location[2]
3	Soil Borings with Monitoring Wells	26½	Planned building areas
3	Soil Borings	26½ to 51½	Planned building areas
7	Test Pits	12 to 15	Planned building areas and parking/driveway areas
1[3]	Geophysical Survey	100 Feet	South side of the lot

1. Below ground surface.
2. The approximate locations of the proposed explorations are shown on the attached Exploration Site Plan.
3. Performed shear wave velocity testing in two 300-foot intersecting transects.

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ±5 feet) and referencing existing site features. Approximate ground surface elevations were obtained by interpolation from a Trimble GPS. If elevations and a more precise boring layout are desired, we recommend borings be surveyed.

Soil Boring Procedures: We advanced the borings with a track-mounted drill rig using hollow-stem augers. Four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. For safety purposes, all borings, except where monitoring wells were installed, were backfilled with bentonite chip after their completion in accordance with Washington Department of Ecology requirements related to completion of borings.

We also observed the boreholes while drilling and at the completion of drilling for the presence of groundwater. Groundwater was not observed at these times in the boreholes.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials observed during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Test Pit Procedure: Test pit excavations were advanced via an excavator outfitted with a toothed bucket. The excavation sidewalls and excavated soil were observed by a Terracon field engineer and characterized accordingly in the test pit logs. Groundwater seepage depths as well as fill, debris, and other deleterious materials observed are described in the logs. Excavated soils were stockpiled in the vicinity of the pit for further observation and for convenient backfilling. The density/consistency of the soil was inferred through frequent probing of the base of the excavations for the upper 4 feet. Thereafter, soil density presented on the logs are inferred from probing observations and excavator level of effort during test pit advancement. Bulk samples were collected for index testing and to evaluate potential reuse of onsite soils. Test pits were backfilled with excavated material. Pavement disturbed at TP-07 was not repaired given the proposed development at the site and concurrence with the city representative on site.

Shear Wave Velocity Testing: A geophysical survey, using multi-channel analysis of surface waves (MASW), was performed to characterize the shear wave velocity profile for the upper 100 feet and infer soil types, stratigraphy and soil conditions. Two 300-foot long, perpendicular alignments, Lines NS and EW, were tested as indicated in the **Exploration Plan**. The profile data is generated by measuring surface waves generated by a vertical impact seismic source, i.e., a sledgehammer striking a plate on the ground surface. The depth of subsurface penetration of a surface-wave is directly proportional to its wavelength. In a non-homogeneous medium, surface-waves are dispersive, i.e., each wavelength has a characteristic velocity stemming from subsurface heterogeneities. The relationship between surface-wave velocity and wavelength is used to calculate the shear-wave velocity of the medium with increasing depth. The resulting seismic energy from the impact is recorded using Geometrics SeisModule Controller software and the processed using the computer program SurfSeis, published by the Kansas Geological Survey. The results are presented in a 1D shear-wave velocity versus depth profile in the **Exploration Results**. Two profiles are generated for each line tested, one from each end of the alignment indicated by geophone numbers 1 and 24.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following types of tests:

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils (Gradation)
- ASTM D1140 Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing
- ASTM D2974 Standard Test Methods for Determining the Water (Moisture) Content, Ash Content, and Organic Material of Peat and Other Organic Soils
- ASTM D7928 Standard Test Method for Particle-Size Distribution of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis

The laboratory testing program often included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we described and classified the soil samples in accordance with the Unified Soil Classification System.

Photography Log

Photo 1: Sidewall of TP-04 showing 4-foot-thick surficial layer of fill over topsoil layer.

Photo 2: Sidewall of TP-05 showing fill layer over topsoil.

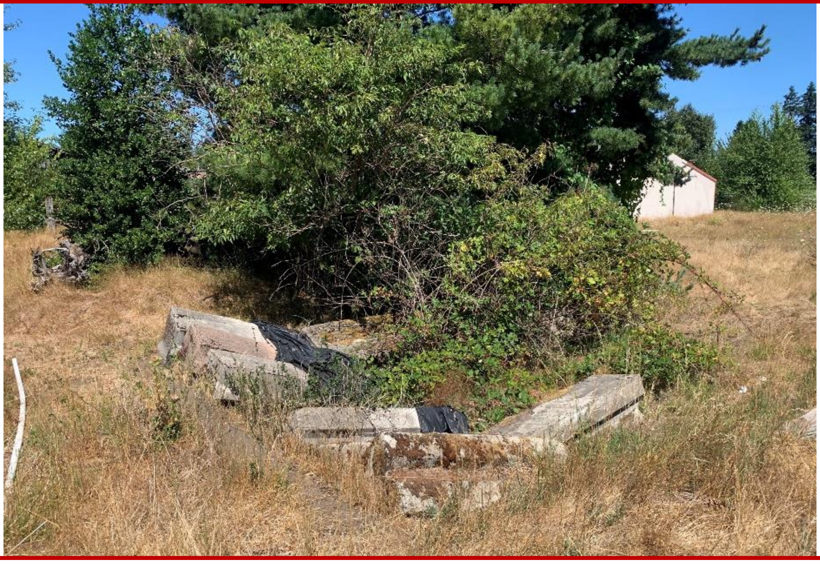


Photo 3: Discarded concrete blocks, plastic debris, logs, and a metal tank observed in a depression near B-04.

Photo 4: Photo of pavement area taken from the drive entrance on the east side of Trails End Rd SE looking southeast.

Photo 5: Surficial 3-foot boulder observed near TP-07. Full size and source unknown.

Photo 6: Photo of the project area looking north from the drive entrance on the west side of Trails End Rd SE.

Photo 7: Photo of the project area looking west from the drive entrance on the west side of Trails End Rd SE.

Site Location and Exploration Plans

Contents:

Site Location Plan
Exploration Plan

Site Location

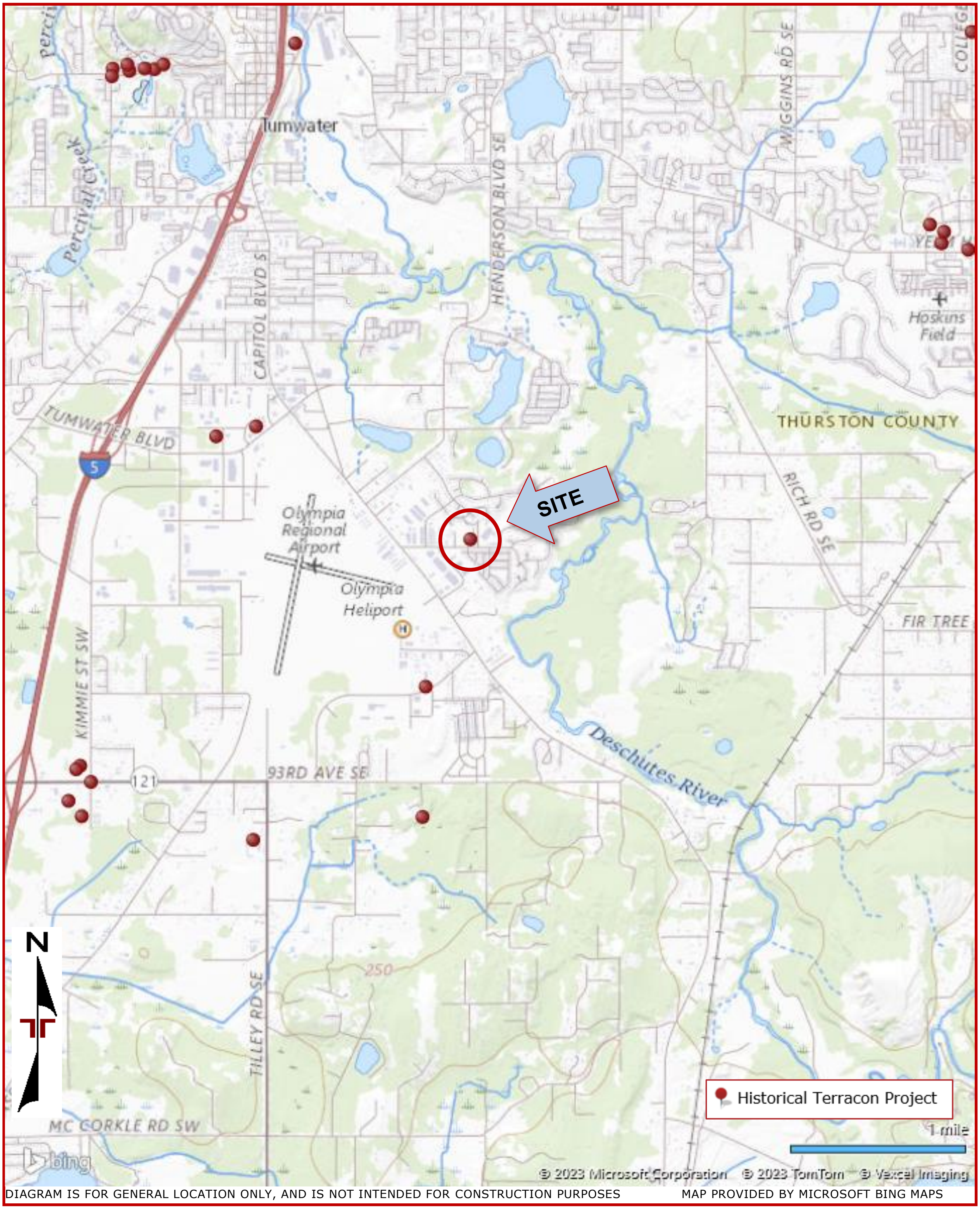


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

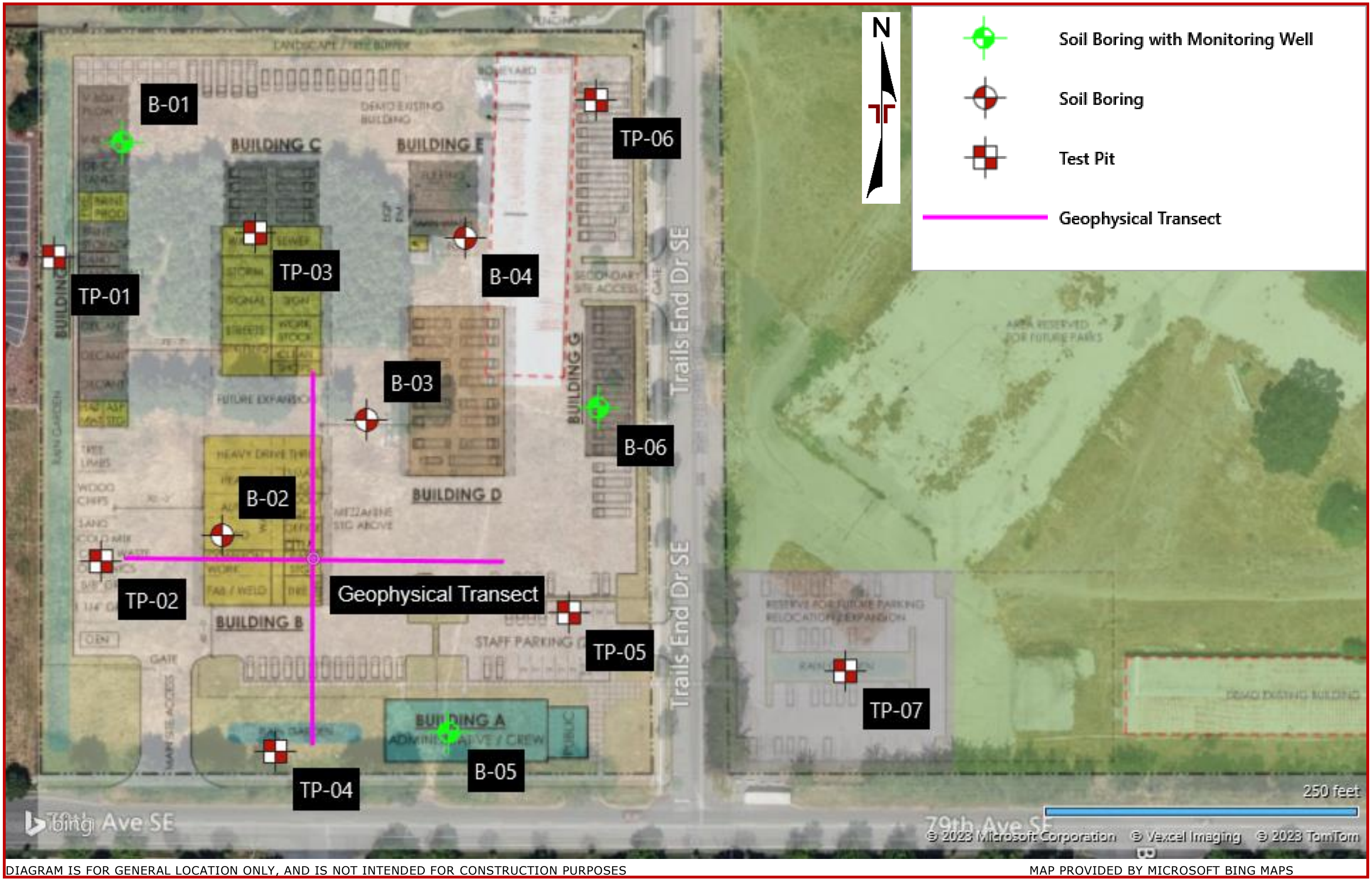


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

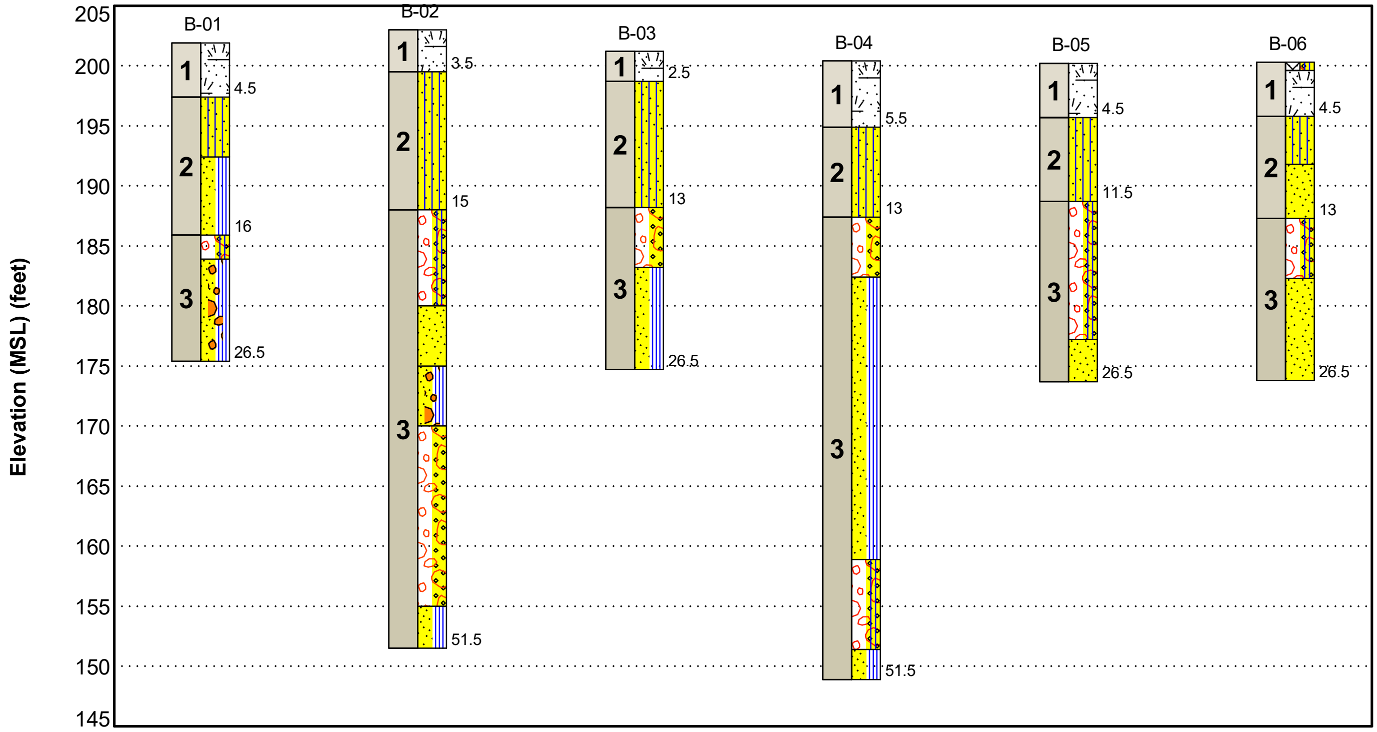
Borings GeoModel
Test Pits GeoModel
Boring Logs (B-01 through B-06)
Test Pit Logs (TP-01 through TP-07)
Atterberg Limits
Grain Size Distribution (4 pages)
Shear-Wave Velocity (4 pages)

Note: All attachments are one page unless noted above.

City of Tumwater Operations & Maintenance Facility
7842 Trails End Dr SE | Tumwater, WA
Terracon Project No. 81225124

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

GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	**Surface Materials**	Topsoil comprised of brown to dark brown silty sand with organics / fill material comprised of brown gravel with silt and sand with cobbles and organics / asphalt and base course
2	**Upper Recessional Outwash**	SAND with variable silt and gravel content, yellowish brown to grayish brown, loose to medium dense, occasional trace organics and iron oxidation
3	**Lower Recessional Outwash**	GRAVEL and SAND with variable silt, sand, gravel, and cobble content, brownish gray to brown, medium dense to very dense

LEGEND

- ▨ Topsoil
- ▨ Silty Sand
- ▨ Poorly-graded Sand with Silt
- ▨ Well-graded Gravel with silt and sand
- ▨ Poorly-graded Sand with Silt and Gravel
- ▨ Poorly-graded Sand
- ▨ Well-graded Gravel w/sand

NOTES:

Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

City of Tumwater Operations & Maintenance Facility
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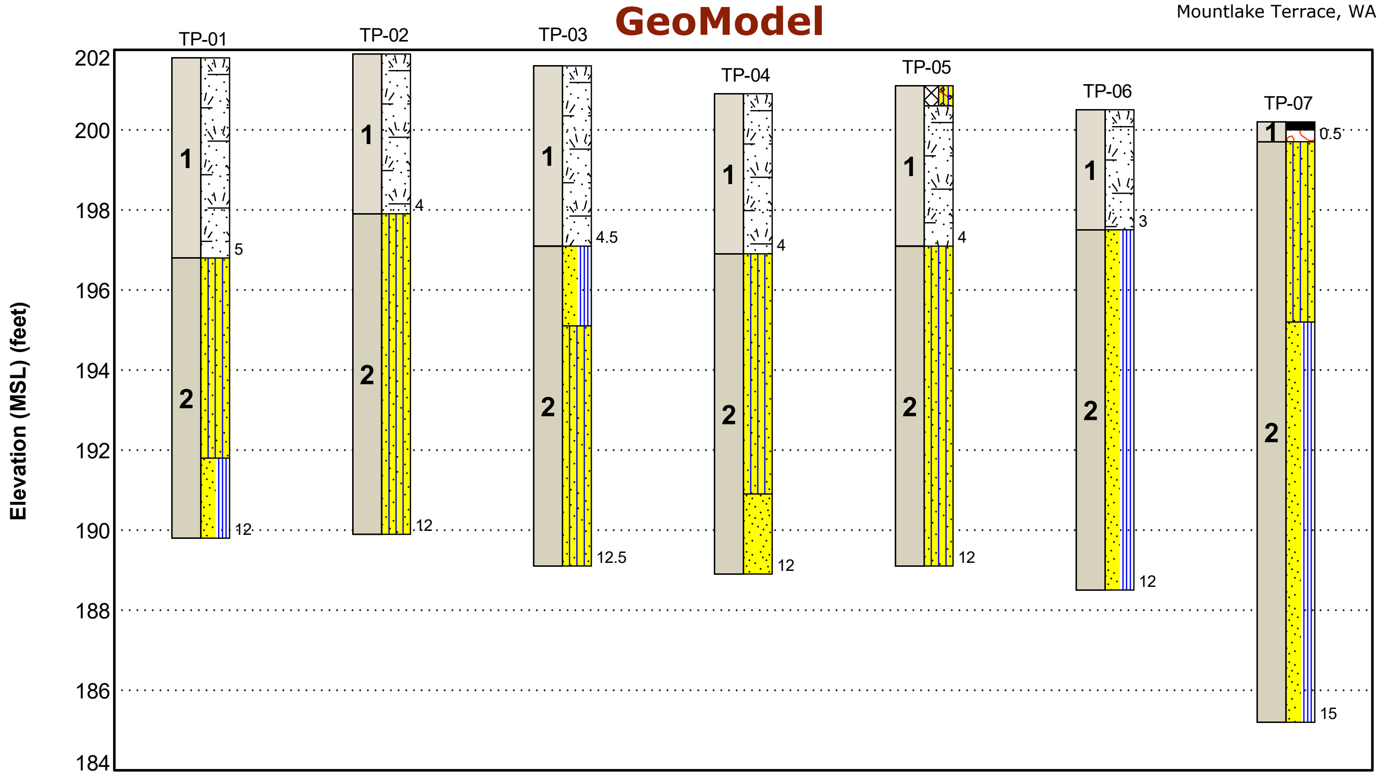
Terracon Project No. 81225124

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

GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Surface Materials	Topsoil comprised of brown to dark brown silty sand with organics / fill material comprised of brown gravel with silt and sand with cobbles and organics / asphalt and base course
2	Upper Recessional Outwash	SAND with variable silt and gravel content, yellowish brown to grayish brown, loose to medium dense, occasional trace organics and iron oxidation
3	Lower Recessional Outwash	GRAVEL and SAND with variable silt, sand, gravel, and cobble content, brownish gray to brown, medium dense to very dense

LEGEND

- Topsoil
- Silty Sand
- Poorly-graded Sand with Silt
- Poorly-graded Sand
- Well-graded Gravel with silt and sand
- ■ Asphalt
- Aggregate Base Course

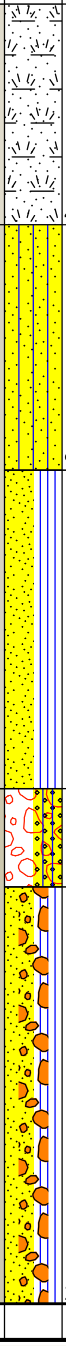
NOTES:

Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

Boring Log No. B-01

Location: See Exploration Plan

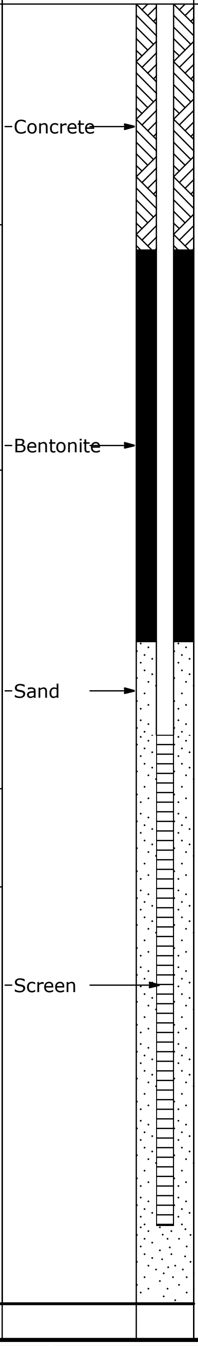
Latitude: 46.973533° Longitude: -122.884361°



Model Layer	Depth (Ft.)	Material Description	Elevation: 201.9 (Ft.) +/-
1	4.5	**SILTY SAND (SM)**, with organics (fine roots), fine grained, dark brown, moist, loose	197.4
2	9.5	**SILTY SAND (SM)**, fine grained, yellowish brown, moist, loose S-2: trace iron oxidation present at ~8.5 feet: increase in silt content, grades to sandy SILT (ML), nonplastic	192.4
2	16.0	**POORLY GRADED SAND WITH SILT (SP-SM)**, medium to fine grained, grayish brown, moist, medium dense	185.9
3	18.0	**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, fine to coarse grained, subrounded to rounded, grayish brown, moist, dense	183.9
3	26.5	**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)**, fine to coarse grained, grayish brown, moist, medium dense decreasing gravel content and grain size with depth, grades to poorly graded SAND with silt (SP-SM), trace gravel, fine to medium grained	175.4

Boring Terminated at 26.5 Feet

Installation Details



Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Sample ID	Water Content (%)	Percent Fines
	☒	11	0-2-4 N=6	S-1		
	☒	9	2-2-2 N=4	S-2		
	☒	12	4-5-4 N=9	S-3		
	☒	15	3-6-8 N=14	S-4	8.7	10
	☒	14	4-14-25 N=39	S-5		
	☒	6	11-8-5 N=13	S-6		
	☒	11	7-11-6 N=17	S-7		

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with dry grasses

Rock fragments present in S-5 and lodged in the sampler shoe at S-6. Blow counts may be overstated at these sample locations.

Sampling performed using 2 inch outside diameter, 1-1/2 inch inside diameter split-spoon

Water Level Observations
Groundwater not encountered

Advancement Method
Hollow Stem Auger

Abandonment Method
Monitoring well was installed (2-inch diameter)
Well ID: BPQ 608

Drill Rig
D-50 track rig #107

Hammer Type
Auto. (ETR=96%)

Driller
Holocene Drilling

Logged by
BAS

Boring Started
08-15-2023

Boring Completed
08-15-2023

Boring Log No. B-02

Location: See Exploration Plan

Latitude: 46.972674° Longitude: -122.884046°

Depth (Ft.) Elevation: 203.0 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Sample ID	Water Content (%)	Percent Fines
1		**SILTY SAND (SM)**, with organics (fine roots), fine grained, brown, moist, loose								
		3.5 199.5			☒	11	3-2-3 N=5	S-1		
2		**SILTY SAND (SM)**, fine grained, yellowish brown, moist, loose to medium dense	5		☒	9	3-3-3 N=6	S-2		
		at S-3: trace iron oxidation present			☒	10	4-6-6 N=12	S-3		
		grades to grayish brown	10		☒	16	4-6-8 N=14	S-4		
		15.0 188	15							
3		**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, with cobbles, fine to coarse grained, subrounded to rounded, grayish brown to brown, moist, very dense			☒	15	21-38-40 N=78	S-5		
		cobbles up to ~3 inches in diameter observed in soil cuttings								
		decrease in density, grades to medium dense increase in moisture content, decrease in grain size	20		☒	9	10-6-8 N=14	S-6		
		23.0 180								
		POORLY GRADED SAND (SP), trace silt, fine grained, grayish brown, moist, loose	25		☒	14	4-5-4 N=9	S-7	8.1	5

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Drill Rig
D-50 track rig #107

Hammer Type
Auto. (ETR=96%)

Driller
Holocene Drilling

Logged by
BAS

Boring Started
08-16-2023

Boring Completed
08-16-2023

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with dry grasses

Rock fragments present in S-5 and S-8. Blow counts may be overstated at these sample locations

Sampling performed using 2 inch outside diameter, 1-1/2 inch inside diameter split-spoon

Advancement Method
Hollow Stem Auger

Abandonment Method
Boring backfilled with bentonite upon completion.

City of Tumwater Operations & Maintenance Facility
7842 Trails End Dr SE | Tumwater, WA
Terracon Project No. 81225124

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

Boring Log No. B-02

Location: See Exploration Plan

Latitude: 46.972674° Longitude: -122.884046°

Depth (Ft.) Elevation: 203.0 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.)	Description	Elevation	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Sample ID	Water Content (%)	Percent Fines
3		28.0	**POORLY GRADED SAND (SP)**, trace silt, fine grained, grayish brown, moist, loose *(continued)*	175								
			increasing silt and gravel content with depth **POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)**, fine to medium grained, grayish brown, moist, dense		30		☒	7	15-22-19 N=41	S-8		
		33.0		170								
			WELL GRADED GRAVEL WITH SAND (GW), fine grained, brown, moist, medium dense		35		☒	8	3-6-7 N=13	S-9		
					40		☒	10	6-8-10 N=18	S-10		
					45		☒	9	7-8-7 N=15	S-11	3.0	2
		48.0		155								
			POORLY GRADED SAND WITH SILT (SP-SM), trace gravel, fine to medium grained, brown, moist, dense		50		☒	10	7-13-20 N=33	S-12		
		51.5		151.5								
			Boring Terminated at 51.5 Feet									

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with dry grasses

Rock fragments present in S-5 and S-8. Blow counts may be overstated at these sample locations

Sampling performed using 2 inch outside diameter, 1-1/2 inch inside diameter split-spoon

Water Level Observations
Groundwater not encountered

Advancement Method
Hollow Stem Auger

Abandonment Method
Boring backfilled with bentonite upon completion.

Drill Rig
D-50 track Rig #107

Hammer Type
Auto. (ETR=96%)

Driller
Holocene Drilling

Logged by
BAS

Boring Started
08-16-2023

Boring Completed
08-16-2023

City of Tumwater Operations & Maintenance Facility
7842 Trails End Dr SE | Tumwater, WA
Terracon Project No. 81225124

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

Boring Log No. B-03

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 46.972926° Longitude: -122.883583° Depth (Ft.) Elevation: 201.2 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Sample ID	Water Content (%)	Percent Fines
1		**SILTY SAND (SM)**, with organics (fine roots), fine grained, brown, moist, medium dense 2.5 198.7								
2		**SILTY SAND (SM)**, fine grained, yellowish brown, moist, medium dense to loose			☒	15	4-6-6 N=12	S-1		
			5		☒	9	4-5-4 N=9	S-2		
		grades to grayish brown			☒	16	4-4-4 N=8	S-3	22.9	22
			10		☒	10	3-2-2 N=4	S-4		
		at S-4: trace iron oxidation present 13.0 188.2								
3		**WELL GRADED GRAVEL WITH SAND (GW)**, trace silt, fine to coarse grained, subrounded to rounded, brown, moist, very dense	15		☒	8	20-30-50/6" N=80/12"	S-5		
		18.0 183.2								
		POORLY GRADED SAND WITH SILT (SP-SM), trace gravel, fine to medium grained, grayish brown, moist, medium dense	20		☒	10	5-10-11 N=21	S-6		
		decrease in gravel content 26.5 174.7	25		☒	14	4-5-11 N=16	S-7		
		Boring Terminated at 26.5 Feet								

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Drill Rig
D-50 track Rig #107

Hammer Type
Auto. (ETR=96%)

Driller
Holocene Drilling

Logged by
BAS

Boring Started
08-16-2023

Boring Completed
08-16-2023

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with dry grasses and scattered trees

Rock fragments present in S-5. Blow counts may be overstated at this sample location

Sampling performed using 2 inch outside diameter, 1-1/2 inch inside diameter split-spoon

Advancement Method
Hollow Stem Auger

Abandonment Method
Boring backfilled with bentonite upon completion.

City of Tumwater Operations & Maintenance Facility
7842 Trails End Dr SE | Tumwater, WA
Terracon Project No. 81225124

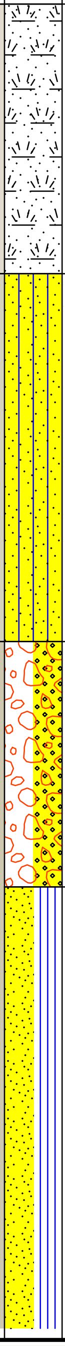
Terracon
21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Boring Log No. B-04

Location: See Exploration Plan

Latitude: 46.973324° Longitude: -122.883267°

Depth (Ft.) Elevation: 200.4 (Ft.) +/-



Model Layer	Depth (Ft.)	Description	Elevation (Ft.)
1	5.5	**SILTY SAND (SM)**, with organics (fine roots), trace gravel, fine grained, brown, moist, medium dense	194.9
2	13.0	**SILTY SAND (SM)**, fine grained, yellowish brown, moist, loose to medium dense between ~7 and 9.5 feet: interbedded layer of sandy SILT (ML), nonplastic, brown, moist stiff grades to grayish brown	187.4
3	18.0	**WELL GRADED GRAVEL WITH SAND (GW)**, trace silt, with cobbles, fine to coarse grained, subrounded to rounded, grayish brown, moist, dense	182.4
3		**POORLY GRADED SAND WITH SILT (SP-SM)**, trace gravel, fine to medium grained, grayish brown, moist, medium dense cobbles up to ~5 inches in diameter observed in soil cuttings decrease in gravel content	

Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Sample ID	Water Content (%)	Percent Fines
		☒	8	15-11-7 N=18	S-1		
5		☒	11	10-5-4 N=9	S-2		
		☒	10	4-4-5 N=9	S-3		
10		☒	16	4-5-6 N=11	S-4		
15		☒	9	7-10-30 N=40	S-5		
20		☒	12	7-5-9 N=14	S-6		
25		☒	13	5-7-9 N=16	S-7	7.3	9

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Drill Rig
D-50 track Rig #107

Hammer Type
Auto. (ETR=96%)

Driller
Holocene Drilling

Logged by
BAS

Boring Started
08-16-2023

Boring Completed
08-16-2023

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with dry grasses and shrubs

Rock fragments present at S-8 and lodged in sampler shoe at S-5, S-10, and S-11. Blow counts may be overstated at these sample locations

Sampling performed using 2 inch outside diameter, 1-1/2 inch inside diameter split-spoon

Advancement Method
Hollow Stem Auger

Abandonment Method
Boring backfilled with bentonite upon completion.

Boring Log No. B-04

Location: See Exploration Plan

Latitude: 46.973324° Longitude: -122.883267°

Depth (Ft.) Elevation: 200.4 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Sample ID	Water Content (%)	Percent Fines
3		**POORLY GRADED SAND WITH SILT (SP-SM)**, trace gravel, fine to medium grained, grayish brown, moist, medium dense *(continued)*								
		between ~27 and 33 feet: interbedded layer of well-graded SAND with silt and gravel (SW-SM), fine to coarse grained, brown, moist	30		☒	8	12-13-9 N=22	S-8		
			35		☒	13	15-23-23 N=46	S-9		
		41.5 158.9	40		☒	15	15-17-13 N=30	S-10	6.8	7
		WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM), fine to coarse grained, subrounded to rounded, brown, moist, dense	45		☒	2	20-30-15 N=45	S-11		
		49.0 151.4								
		POORLY GRADED SAND WITH SILT (SP-SM), fine grained, grayish brown, moist, medium dense	50		☒	15	7-11-12 N=23	S-12		
		51.5 148.9								
		Boring Terminated at 51.5 Feet								

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with dry grasses and shrubs

Rock fragments present at S-8 and lodged in sampler shoe at S-5, S-10, and S-11. Blow counts may be overstated at these sample locations

Sampling performed using 2 inch outside diameter, 1-1/2 inch inside diameter split-spoon

Advancement Method
Hollow Stem Auger

Abandonment Method
Boring backfilled with bentonite upon completion.

Drill Rig
D-50 track Rig #107

Hammer Type
Auto. (ETR=96%)

Driller
Holocene Drilling

Logged by
BAS

Boring Started
08-16-2023

Boring Completed
08-16-2023

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

Boring Log No. B-05

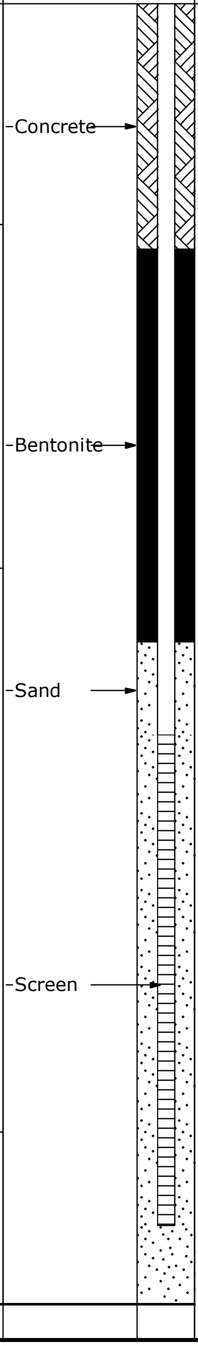
Location: See Exploration Plan

Latitude: 46.972243° Longitude: -122.883315°

Model Layer	Description	Depth (Ft.)	Elevation: 200.2 (Ft.) +/-
1	**SILTY SAND (SM)**, with organics (fine roots), fine grained, brown, moist, loose	4.5	195.7
2	**SILTY SAND (SM)**, trace organics, fine grained, yellowish brown to grayish brown, moist, loose to medium dense at S-3: ~1 inch lens of sandy SILT (ML), trace iron oxidation present at S-4: ~1-inch laminations of sandy SILT (ML)	11.5	188.7
3	**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, with cobbles, fine to coarse grained, subrounded to rounded, brownish gray, moist, very dense to dense cobbles observed in soil cuttings up to ~3.5 inches in diameter	23.0	177.2
3	**POORLY GRADED SAND (SP)**, trace silt, trace gravel, fine to medium grained, grayish brown, moist, medium dense	26.5	173.7

Boring Terminated at 26.5 Feet

Installation Details



Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Sample ID	Water Content (%)	Percent Fines
2.5		☒	2-2-2 N=4	S-1		
5		☒	2-2-3 N=5	S-2		
7.5		☒	2-4-6 N=10	S-3		
10		☒	4-4-5 N=9	S-4		
15		☒	15-24-31 N=55	S-5	2.7	6
20		☒	9-16-16 N=32	S-6		
25		☒	4-6-8 N=14	S-7		

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with dry grasses

Rock fragments present in S-5 and S-6. Blow counts may be overstated at these sample locations

Sampling performed using 2 inch outside diameter, 1-1/2 inch inside diameter split-spoon

Advancement Method
Hollow Stem Auger

Abandonment Method
Monitoring well was installed (2-inch diameter) Well ID: BPQ 607

Drill Rig
D-50 track Rig #107

Hammer Type
Auto. (ETR=96%)

Driller
Holocene Drilling

Logged by
BAS

Boring Started
08-15-2023

Boring Completed
08-15-2023

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

Boring Log No. B-06

Location: See Exploration Plan

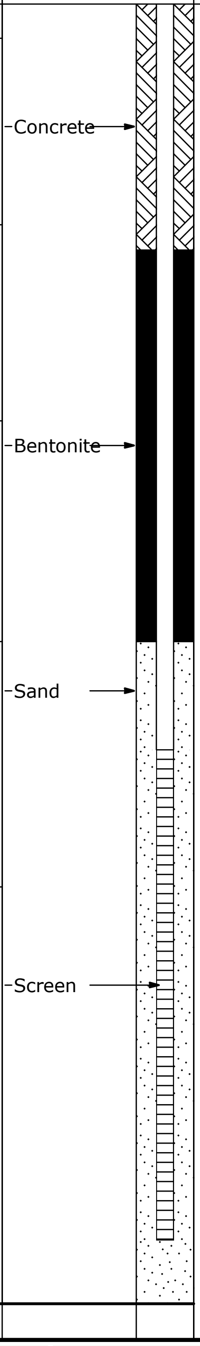
Latitude: 46.972953° Longitude: -122.882836°

Elevation: 200.3 (Ft.) +/-

Model Layer	Depth (Ft.)	Description	Elevation
1	0.7	**FILL - WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, with organics and cobbles, fine to coarse grained, rounded, yellowish brown, moist, fill with abundant fine roots observed in upper ~8 inches	199.6
1	4.5	**SILTY SAND (SM)**, with organics (fine roots), fine grained, brown, moist, loose sand and moisture content increasing with depth	195.8
2	8.5	**SILTY SAND (SM)**, fine grained, yellowish brown, moist, loose to medium dense	191.8
2	13.0	**POORLY GRADED SAND (SP)**, trace gravel, trace silt, fine to medium grained, grayish brown, moist, medium dense to loose	187.3
3	18.0	**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, fine to coarse grained, subrounded to rounded, grayish brown, moist, medium dense	182.3
3	26.5	**POORLY GRADED SAND (SP)**, trace silt, fine to medium grained, grayish brown, moist, medium dense increase in gravel content, trace gravel	173.8

Boring Terminated at 26.5 Feet

Installation Details



Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Sample ID	Water Content (%)	Percent Fines
	☒	6	3-3-3 N=6	S-1		
	☒	14	2-3-2 N=5	S-2		
	☒	13	3-4-7 N=11	S-3		
	☒	13	3-4-5 N=9	S-4	5.8	4
	☒	8	13-14-11 N=25	S-5		
	☒	13	5-9-6 N=15	S-6		
	☒	12	4-7-11 N=18	S-7		

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with dry grasses and shrubs

Rock fragments present in S-5. Blow counts may be overstated at this sample location

Fill depth and soil description inferred from test pit observations

Sampling performed using 2 inch outside diameter, 1-1/2 inch inside diameter split-spoon

Advancement Method
Hollow Stem Auger

Abandonment Method
Monitoring well was installed (2-inch diameter)
Well ID: BPQ 606

Drill Rig
D-50 track Rig #107

Hammer Type
Auto. (ETR=96%)

Driller
Holocene Drilling

Logged by
BAS

Boring Started
08-15-2023

Boring Completed
08-15-2023

City of Tumwater Operations & Maintenance Facility
7842 Trails End Dr SE | Tumwater, WA
Terracon Project No. 81225124

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

Test Pit Log No. TP-01

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 46.973282° Longitude: -122.884584° Depth (Ft.) Elevation: 201.8 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Sample ID	Organic Content (%)	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
1		**SILTY SAND (SM)**, with organics (fine to large size roots), fine grained, dark brown, moist, (very loose to loose)								
					✋	S-1	7.1	8.3		17
		grades to brown, organic content decreasing with depth								
					✋	S-2				
		5.0 196.8								
2		**SILTY SAND (SM)**, trace organics, fine grained, yellowish brown, moist, (loose)	5		✋	S-3		8.1		13
		sand and moisture content increasing with depth								
					✋	S-4				
		trace fine roots present to ~10 feet bgs								
					✋	S-5				
		10.0 191.8	10							
		POORLY GRADED SAND WITH SILT (SP-SM), fine to medium grained, grayish brown, moist, (loose to medium dense), iron oxidation present								
					✋	S-6				
		12.0 189.8								
		Test Pit Terminated at 12 Feet								

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Excavator
Bobcat E85

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with grass and shrubs

Density after ~4 feet inferred from excavation conditions

fine roots: <1/4-inch, medium roots: >1/4-inch and <3/4-inch, large roots: >3/4-inch

Advancement Method
Excavate with 2-foot toothed bucket

Abandonment Method
Test pit backfilled with spoils upon completion.

Operator
Terracon

Logged by
BAS, MM

Test Pit Started
08-07-2023

Test Pit Completed
08-07-2023

City of Tumwater Operations & Maintenance Facility
7842 Trails End Dr SE | Tumwater, WA
Terracon Project No. 81225124

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

Test Pit Log No. TP-02

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 46.972617° Longitude: -122.884433° Depth (Ft.) Elevation: 201.9 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Sample ID	Organic Content (%)	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
1		**SILTY SAND (SM)**, with organics (fine roots), fine grained, dark brown, moist, (medium dense to very loose)								
					✋	S-1		8.0		38
		soil partially desiccated in the upper ~2 feet sand and moisture content increasing with depth								
					✋	S-2				
		4.0 197.9								
2		**SILTY SAND (SM)**, fine to medium grained, yellowish brown, moist, (loose to medium dense)								
		at ~5 feet: iron oxidation present to termination depth	5		✋	S-3				
		at ~7 feet: grades to grayish brown			✋	S-4		9.5		13
			10		✋	S-5				
					✋	S-6				
		12.0 189.9								
		Test Pit Terminated at 12 Feet								

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with dry grasses

Density after ~4 feet inferred from excavation conditions

fine roots: <1/4-inch, medium roots: >1/4-inch and <3/4-inch, large roots: >3/4-inch

Water Level Observations
Groundwater not encountered

Advancement Method
Excavate with 2-foot toothed bucket

Abandonment Method
Test pit backfilled with spoils upon completion.

Excavator
Bobcat E85

Operator
Terracon

Logged by
BAS, MM

Test Pit Started
08-07-2023

Test Pit Completed
08-07-2023

Test Pit Log No. TP-03

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 46.973335° Longitude: -122.883939° Depth (Ft.) Elevation: 201.6 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Sample ID	Organic Content (%)	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
1		**SILTY SAND (SM)**, with organics (fine to medium size roots), fine grained, grayish brown, moist, (medium dense to very loose)								
		soil desiccated in the upper ~1.5 feet			✋	S-1				
		silt and organic content decreasing with depth, trace fine roots			✋	S-2		9.6	NP	12
		4.5 197.1								
2		**POORLY GRADED SAND WITH SILT (SP-SM)**, trace organics, fine grained, yellowish brown, moist, (loose)	5		✋	S-3		7.7		10
		medium to large size roots present to ~6 feet bgs								
		6.5 195.1								
		SILTY SAND (SM), fine grained, yellowish brown, (loose to medium dense)			✋	S-4		8.4		21
			10		✋	S-5				
		at ~11 feet: decrease in silt content, grades to poorly graded SAND with silt (SP-SM)			✋	S-6				
		at ~12 feet: ~3-inch layer of desiccated silty SAND (SM), with fine roots								
		12.5 189.1								
		Test Pit Terminated at 12.5 Feet								

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: densely wooded with young trees and shrubs

Density after ~4 feet inferred from excavation conditions

fine roots: <1/4-inch, medium roots: >1/4-inch and <3/4-inch, large roots: >3/4-inch

Water Level Observations
Groundwater not encountered

Advancement Method
Excavate with 2-foot toothed bucket

Abandonment Method
Test pit backfilled with spoils upon completion.

Excavator
Bobcat E85

Operator
Terracon

Logged by
BAS, MM

Test Pit Started
08-07-2023

Test Pit Completed
08-07-2023

City of Tumwater Operations & Maintenance Facility
7842 Trails End Dr SE | Tumwater, WA
Terracon Project No. 81225124

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

Test Pit Log No. TP-04

Location: See Exploration Plan

Latitude: 46.972202° Longitude: -122.883875°

Model Layer	Depth (Ft.)	Description	Elevation: 200.9 (Ft.) +/-
1		**SILTY SAND (SM)**, with organics (fine roots), fine grained, dark grayish brown, moist, (loose) medium to large size roots from ~3 to 4 feet bgs	
	4.0		196.9
2		**SILTY SAND (SM)**, trace organics, fine grained, yellowish brown, moist, (loose), iron oxidation present trace fine roots present to ~6 feet bgs at ~7 feet: grades to grayish brown	
	10.0		190.9
2		**POORLY GRADED SAND (SP)**, fine to medium grained, brownish gray, moist, (loose to medium dense), iron oxidation present	
	12.0		188.9

Test Pit Terminated at 12 Feet

Water Level Observations	Sample Type	Sample ID	Organic Content (%)	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
	✋	S-1		11.1		30
	✋	S-2				
	✋	S-3		11.0		15
	✋	S-4				
	✋	S-5				
	✋	S-6				

Depth (Ft.) scale: 5, 10

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with dry grasses and shrubs

Density after ~4 feet inferred from excavation conditions

fine roots: <1/4-inch, medium roots: >1/4-inch and <3/4-inch, large roots: >3/4-inch

Advancement Method
Excavate with 2-foot toothed bucket

Abandonment Method
Test pit backfilled with spoils upon completion.

Excavator
Bobcat E85

Operator
Terracon

Logged by
BAS, MM

Test Pit Started
08-07-2023

Test Pit Completed
08-07-2023

City of Tumwater Operations & Maintenance Facility
7842 Trails End Dr SE | Tumwater, WA
Terracon Project No. 81225124

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

Test Pit Log No. TP-05

Location: See Exploration Plan

Latitude: 46.972505° Longitude: -122.882935°

Depth (Ft.) Elevation: 201.1 (Ft.) +/-

Model Layer	Depth (Ft.)	Material Description	Elevation (Ft.)
1	0.5	**FILL - WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)**, with organics, with cobbles, fine to coarse grained, rounded, yellowish brown, moist, (dense to medium dense), fill with abundant fine roots observed in upper ~8 inches	200.6
1	4.0	**SILTY SAND (SM)**, with organics (fine roots), fine grained, brown to dark brown, moist, (medium dense to loose) soil desiccated in upper ~1.5 feet increase in silt content	197.1
2	12.0	**SILTY SAND (SM)**, fine grained, yellowish brown, moist, (loose to medium dense) at ~8 feet: grades to grayish brown at ~11 feet: increase in moisture and silt content	189.1

Test Pit Terminated at 12 Feet

Sample Type	Sample ID	Organic Content (%)	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
✋	S-1				
✋	S-2	6.8	12.2	NP	
✋	S-3				
✋	S-4				
✋	S-5		30.1		

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with grass and shrubs

Density after ~4 feet inferred from excavation conditions

fine roots: <1/4-inch, medium roots: >1/4-inch and <3/4-inch, large roots: >3/4-inch

Water Level Observations
Groundwater not encountered

Advancement Method
Excavate with 2-foot toothed bucket

Abandonment Method
Test pit backfilled with spoils upon completion.

Excavator
Bobcat E85

Operator
Terracon

Logged by
BAS, MM

Test Pit Started
08-07-2023

Test Pit Completed
08-07-2023

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

Test Pit Log No. TP-06

Location: See Exploration Plan

Latitude: 46.973625° Longitude: -122.882848°

Depth (Ft.) Elevation: 200.5 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Sample ID	Organic Content (%)	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
1		**SILTY SAND (SM)**, with organics (fine roots), fine grained, dark brown, moist, (very loose to loose)			✋	S-1	6.7	8.3		
		3.0 — 197.5								
2		**POORLY GRADED SAND WITH SILT (SP-SM)**, fine to medium grained, yellowish brown, moist, (loose to medium dense)			✋	S-2				
		trace fine roots present to ~4 feet bgs								
		at ~5 feet: iron oxidation present to termination depth	5		✋	S-3				
					✋	S-4				
		at ~9 feet: grades to brownish gray			✋	S-5				
			10							
					✋	S-6				
		12.0 — 188.5								
		Test Pit Terminated at 12 Feet								

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Excavator
Bobcat E85

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately vegetated with dry grasses and shrubs

Density after ~4 feet inferred from excavation conditions

fine roots: <1/4-inch, medium roots: >1/4-inch and <3/4-inch, large roots: >3/4-inch

Advancement Method
Excavate with 2-foot toothed bucket

Abandonment Method
Test pit backfilled with spoils upon completion.

Operator
Terracon

Logged by
BAS, MM

Test Pit Started
08-07-2023

Test Pit Completed
08-07-2023

City of Tumwater Operations & Maintenance Facility
7842 Trails End Dr SE | Tumwater, WA
Terracon Project No. 81225124

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

Test Pit Log No. TP-07

Location: See Exploration Plan

Latitude: 46.972378° Longitude: -122.882049°

Model Layer	Depth (Ft.)	Description	Elevation: 200.2 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Sample ID	Organic Content (%)	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
1	0.2	**ASPHALT**, ~2.5 inches of asphalt	200								
	0.5	**AGGREGATE BASE COURSE**, ~3 inches of base course	199.7								
2		**SILTY SAND (SM)**, fine grained, dark brown, moist, (very loose to loose)									
						✋	S-1				
						✋	S-2				
		at ~3 feet: grades to yellowish brown, decrease in silt content									
						✋	S-3		10.9		19
	5.0		195.2	5							
		POORLY GRADED SAND WITH SILT (SP-SM), fine grained, yellowish brown, moist, (loose to medium dense)				✋	S-4				
		at ~7 feet: grades to grayish brown									
						✋	S-5		9.7		11
						✋	S-6				
				10							
		at ~12 feet: grades to fine to medium grained, brownish gray									
						✋	S-7				
	15.0		185.2	15							
		Test Pit Terminated at 15 Feet									

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered

Notes

Elevation Reference: Elevations measured in the field using handheld GPS

Surface conditions: moderately weathered and fractured asphalt pavement

Density after ~4 feet inferred from excavation conditions

fine roots: <1/4-inch, medium roots: >1/4-inch and <3/4-inch, large roots: >3/4-inch

Advancement Method
Excavate with 2-foot toothed bucket

Abandonment Method
Test pit backfilled with spoils upon completion.

Excavator
Bobcat E85

Operator
Terracon

Logged by
BAS, MM

Test Pit Started
08-07-2023

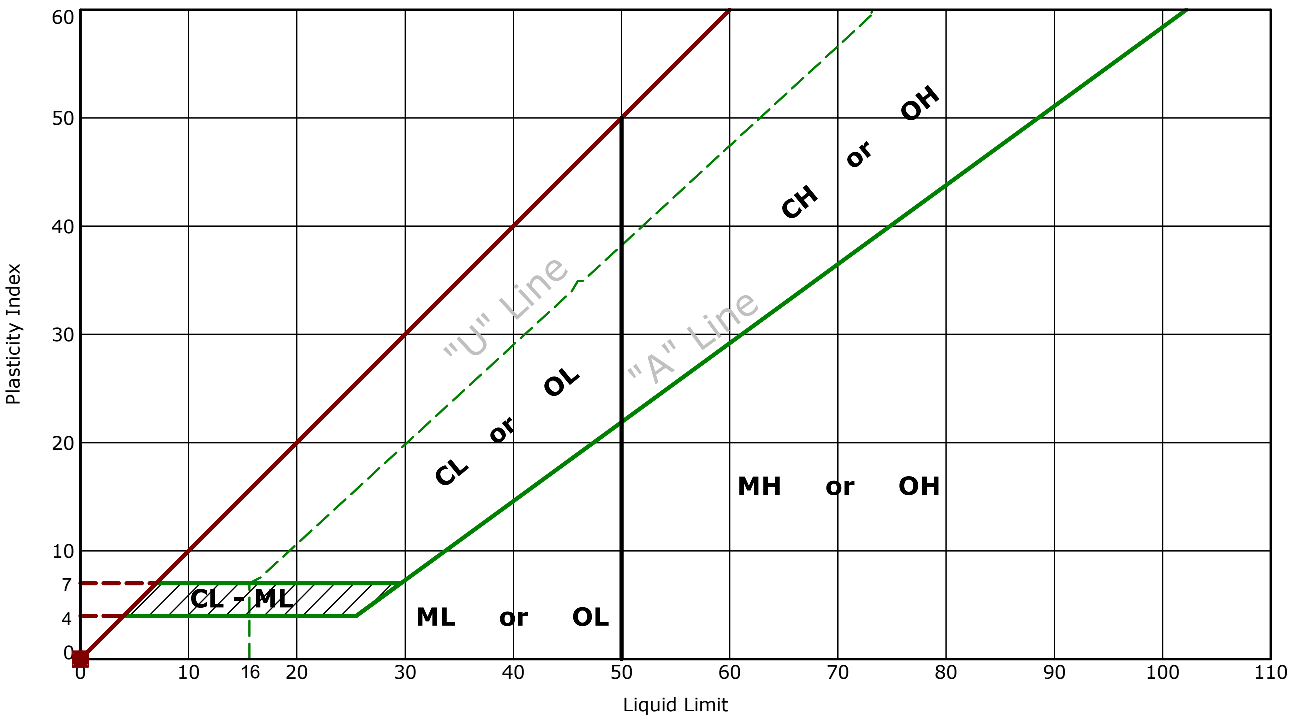
Test Pit Completed
08-07-2023

City of Tumwater Operations & Maintenance Facility
7842 Trails End Dr SE | Tumwater, WA
Terracon Project No. 81225124

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

Atterberg Limit Results

ASTM D4318

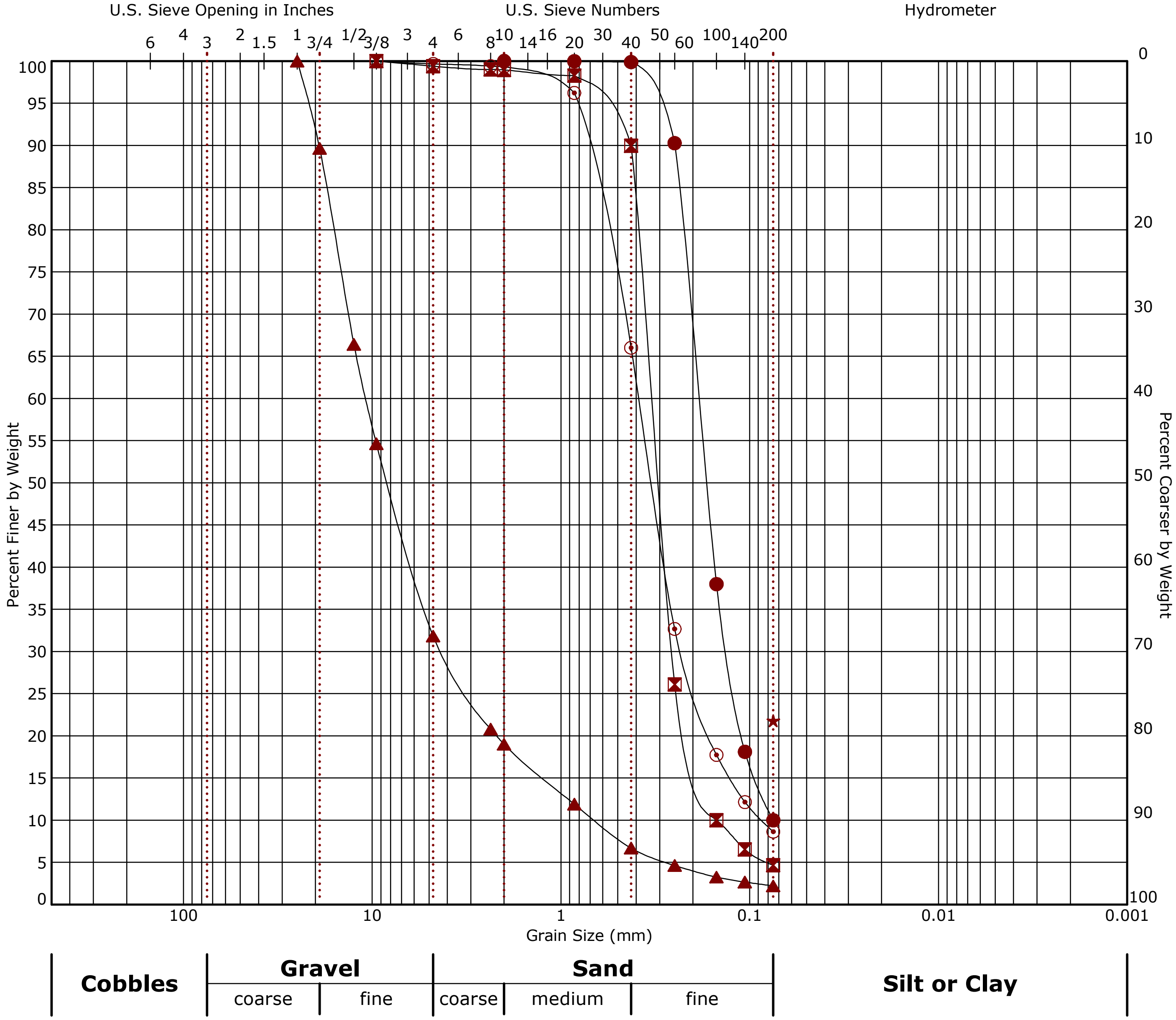


	Boring ID	Depth (Ft)	LL	PL	PI	Fines	USCS	Description
●	TP-03	3 - 4	NP	NP	NP	12.4	SM	Silty SAND
☒	TP-05	2 - 3	NP	NP	NP		SM	Silty SAND

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

Grain Size Distribution

ASTM D422 / ASTM C136



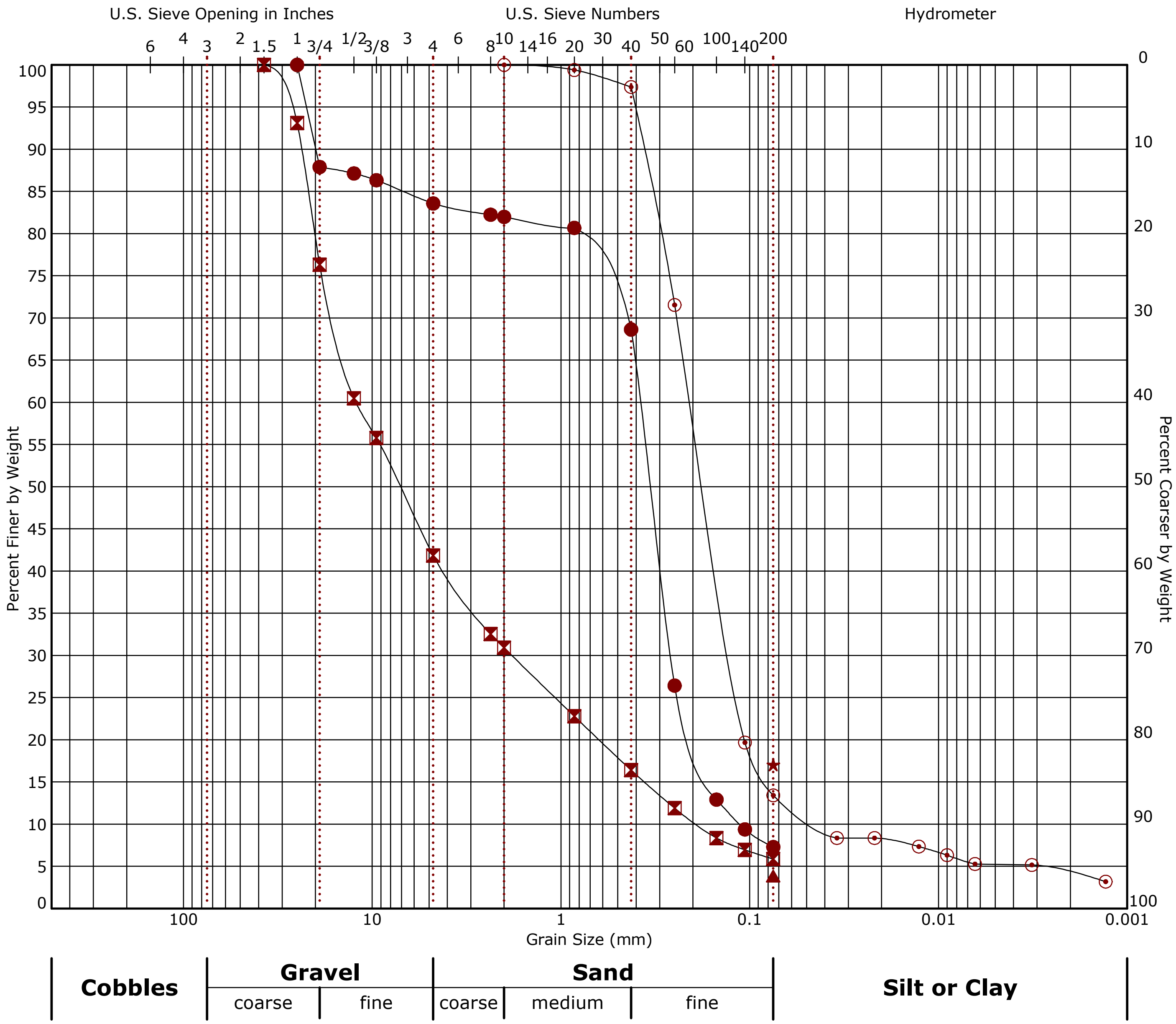
	Boring ID	Depth (Ft)	Description	USCS	LL	PL	PI	Cc	Cu
●	B-01	10 - 11.5	Poorly graded SAND with silt	SP-SM				1.22	2.48
☒	B-02	25 - 26.5	Poorly graded SAND	SP				1.34	2.21
▲	B-02	45 - 46.5	Well-graded GRAVEL with sand	GW				2.52	16.32
★	B-03	7.5 - 9	Silty SAND	SM					
⊙	B-04	25 - 26.5	Poorly graded SAND with silt	SP-SM				1.57	4.50

	Boring ID	Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	B-01	10 - 11.5	2	0.186	0.13	0.075	0.0	0.0	90.0	10.0		
☒	B-02	25 - 26.5	9.5	0.331	0.258	0.15	0.0	0.6	94.7	4.7		
▲	B-02	45 - 46.5	25	10.764	4.232	0.659	0.0	68.2	29.6	2.2		
★	B-03	7.5 - 9	0.075							21.8		
⊙	B-04	25 - 26.5	9.5	0.386	0.228	0.086	0.0	0.3	91.0	8.6		

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

Grain Size Distribution

ASTM D422 / ASTM C136

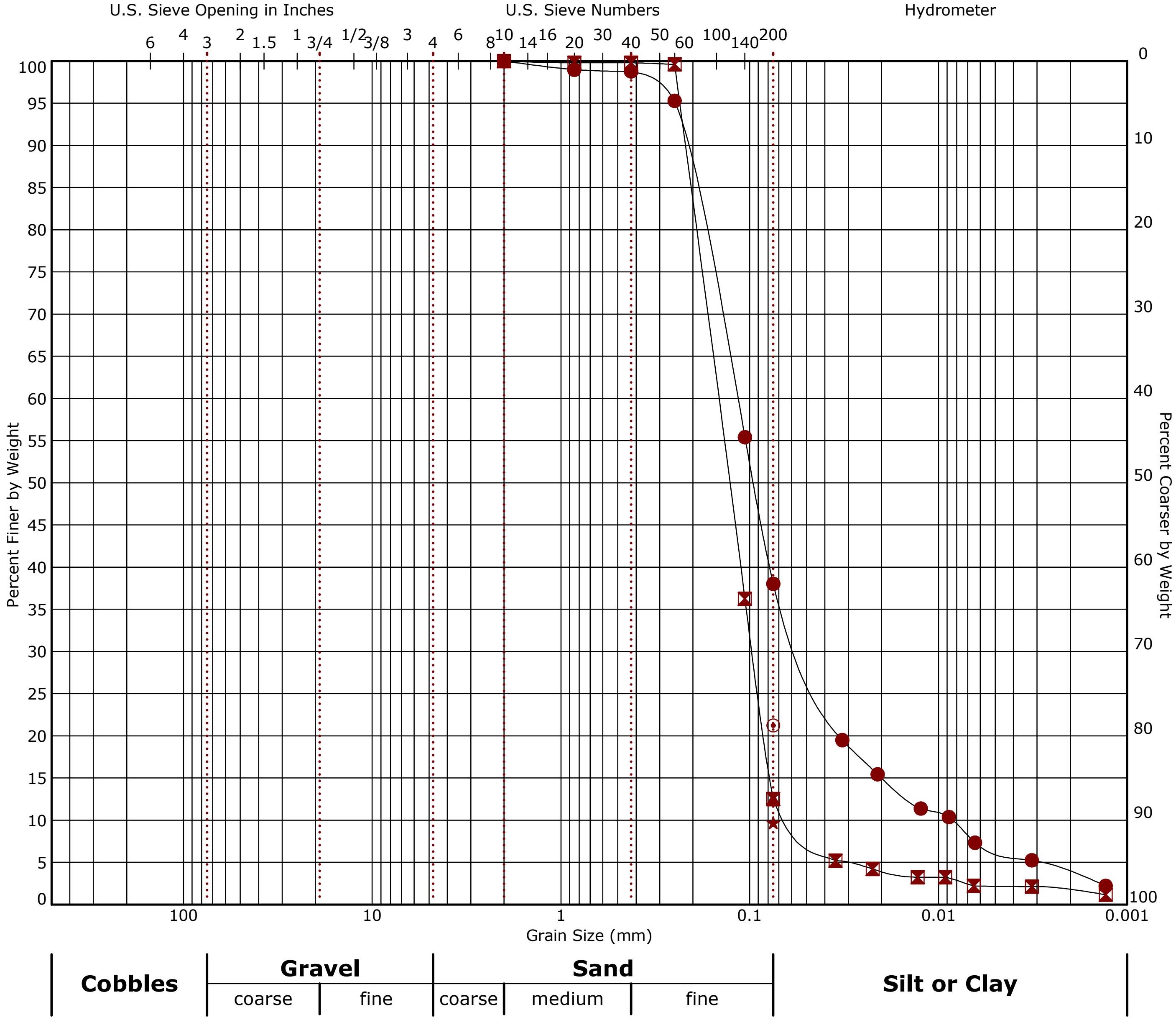


Boring ID		Depth (Ft)	Description	USCS	LL	PL	PI	Cc	Cu
●	B-04	40 - 41.5	Poorly graded SAND with silt and gravel	SP-SM				1.59	3.38
☒	B-05	15 - 16.5	Well-graded GRAVEL with silt and sand	GW-GM				1.43	64.05
▲	B-06	10 - 11.5	Poorly graded SAND	SP					
★	TP-01	1 - 2	Silty SAND	SM					
⊙	TP-01	5 - 6	Silty SAND	SM				1.72	4.65

Boring ID		Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	B-04	40 - 41.5	25	0.381	0.262	0.113	0.0	16.4	76.3	7.3		
☒	B-05	15 - 16.5	37.5	12.166	1.816	0.19	0.0	58.1	36.0	5.9		
▲	B-06	10 - 11.5	0.075							3.8		
★	TP-01	1 - 2	0.075							17.0		
⊙	TP-01	5 - 6	2	0.207	0.126	0.044	0.0	0.0	86.6		8.2	5.2

Grain Size Distribution

ASTM D422 / ASTM C136

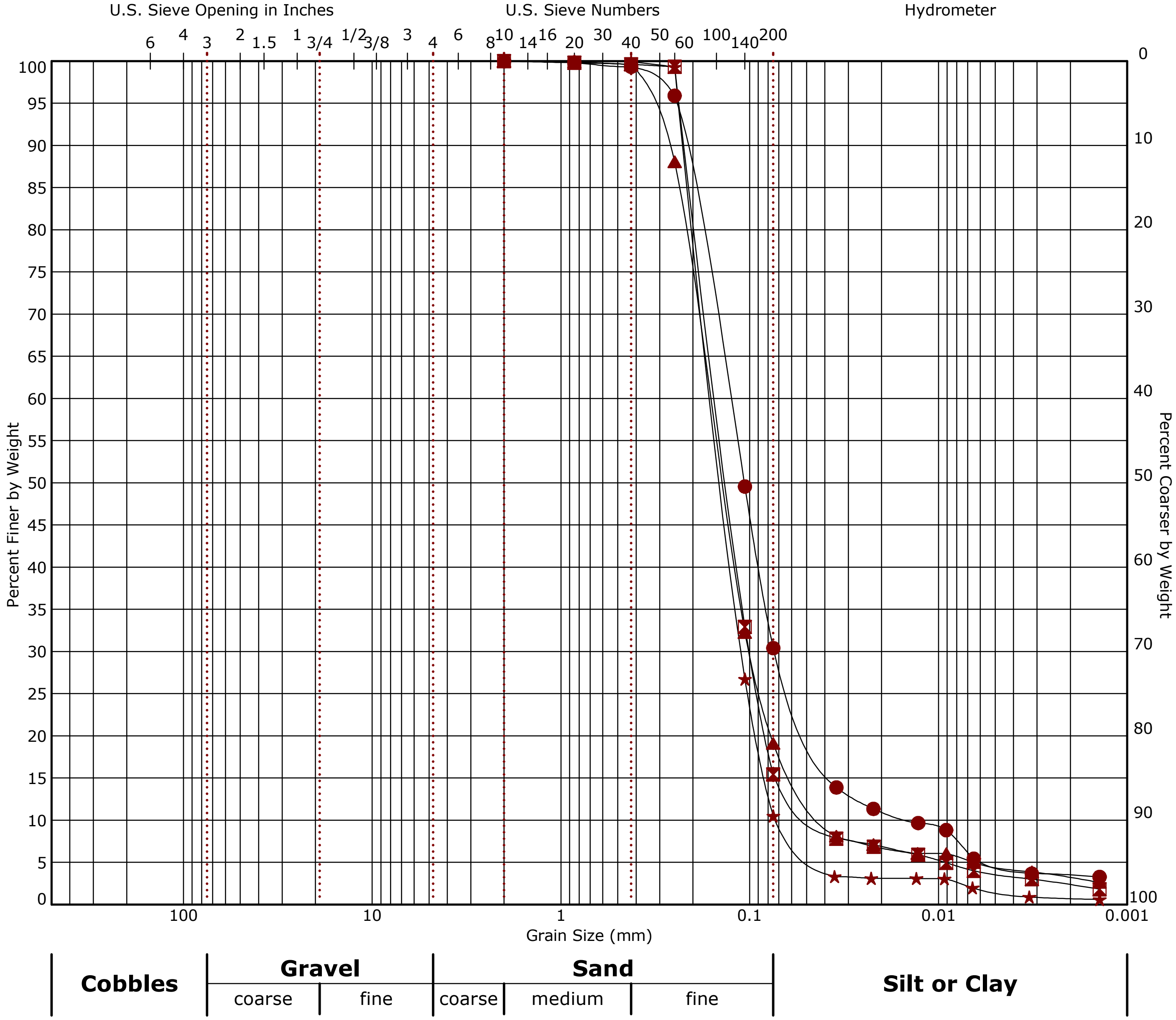


Boring ID		Depth (Ft)	Description	USCS	LL	PL	PI	Cc	Cu
●	TP-02	1 - 2	Silty SAND	SM				2.74	13.83
☒	TP-02	7 - 8	Silty SAND	SM				1.11	2.53
▲	TP-03	3 - 4	Silty SAND	SM	NP	NP	NP		
★	TP-03	5 - 6	Poorly graded SAND with silt	SP-SM					
⊙	TP-03	7 - 8	Silty SAND	SM					

Boring ID		Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	TP-02	1 - 2	2	0.117	0.052	0.008	0.0	0.0	62.0		31.4	6.6
☒	TP-02	7 - 8	2	0.146	0.097	0.058	0.0	0.0	87.5		10.3	2.2
▲	TP-03	3 - 4	0.075							12.4		
★	TP-03	5 - 6	0.075							9.7		
⊙	TP-03	7 - 8	0.075							21.2		

Grain Size Distribution

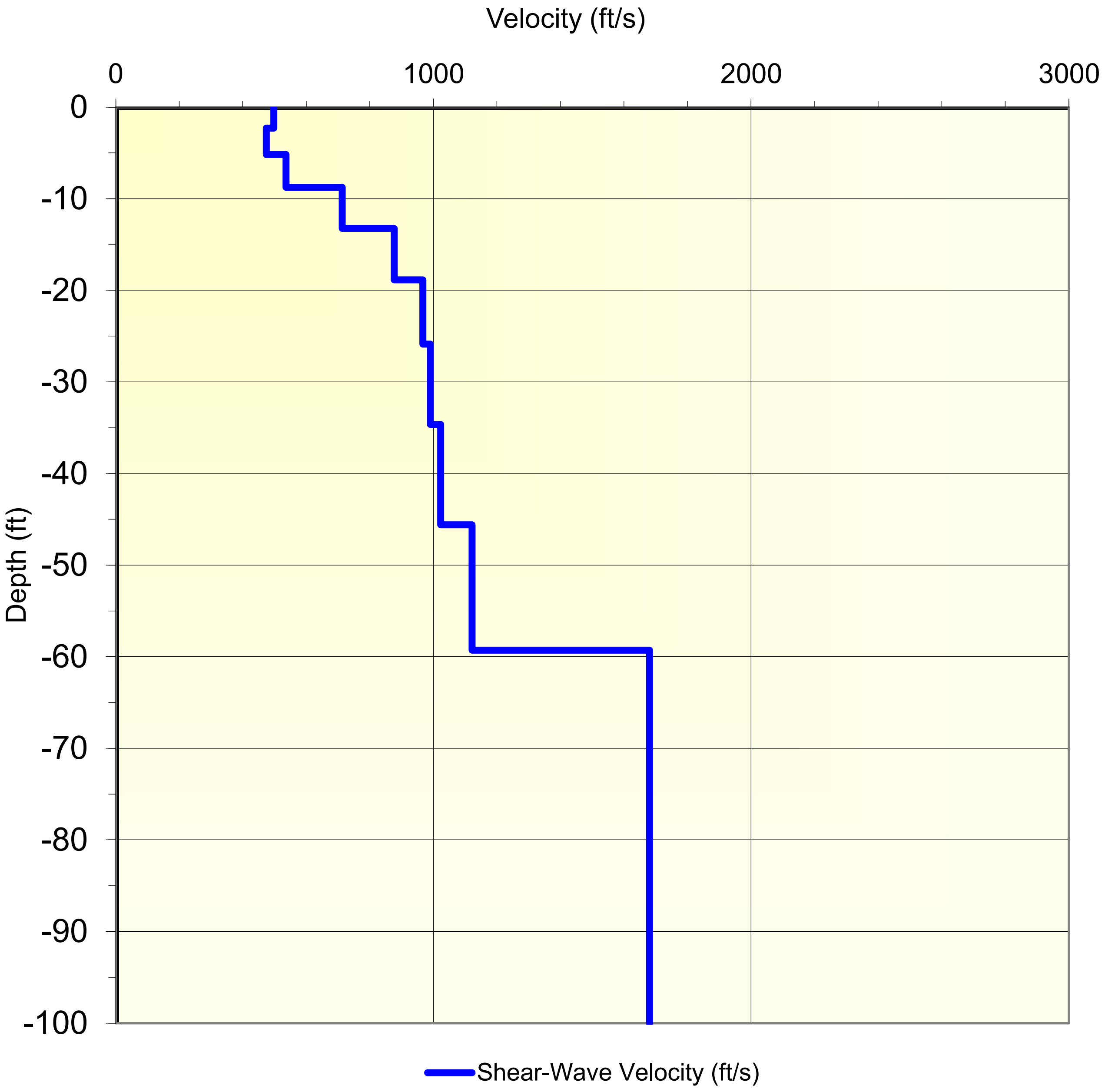
ASTM D422 / ASTM C136



Boring ID		Depth (Ft)	Description	USCS	LL	PL	PI	Cc	Cu
●	TP-04	1 - 2	Silty SAND	SM				2.95	9.01
⊠	TP-04	5 - 6	Silty SAND	SM				1.54	3.47
▲	TP-07	3 - 4	Silty SAND	SM				1.55	4.09
★	TP-07	7.5 - 8.5	Poorly graded SAND with silt	SP-SM				1.09	2.21

Boring ID		Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	TP-04	1 - 2	2	0.129	0.074	0.014	0.0	0.0	69.6		25.6	4.8
⊠	TP-04	5 - 6	2	0.15	0.1	0.043	0.0	0.0	84.6		11.8	3.6
▲	TP-07	3 - 4	2	0.162	0.1	0.04	0.0	0.0	80.9		14.5	4.6
★	TP-07	7.5 - 8.5	0.85	0.157	0.11	0.071	0.0	0.0	89.5		9.0	1.6

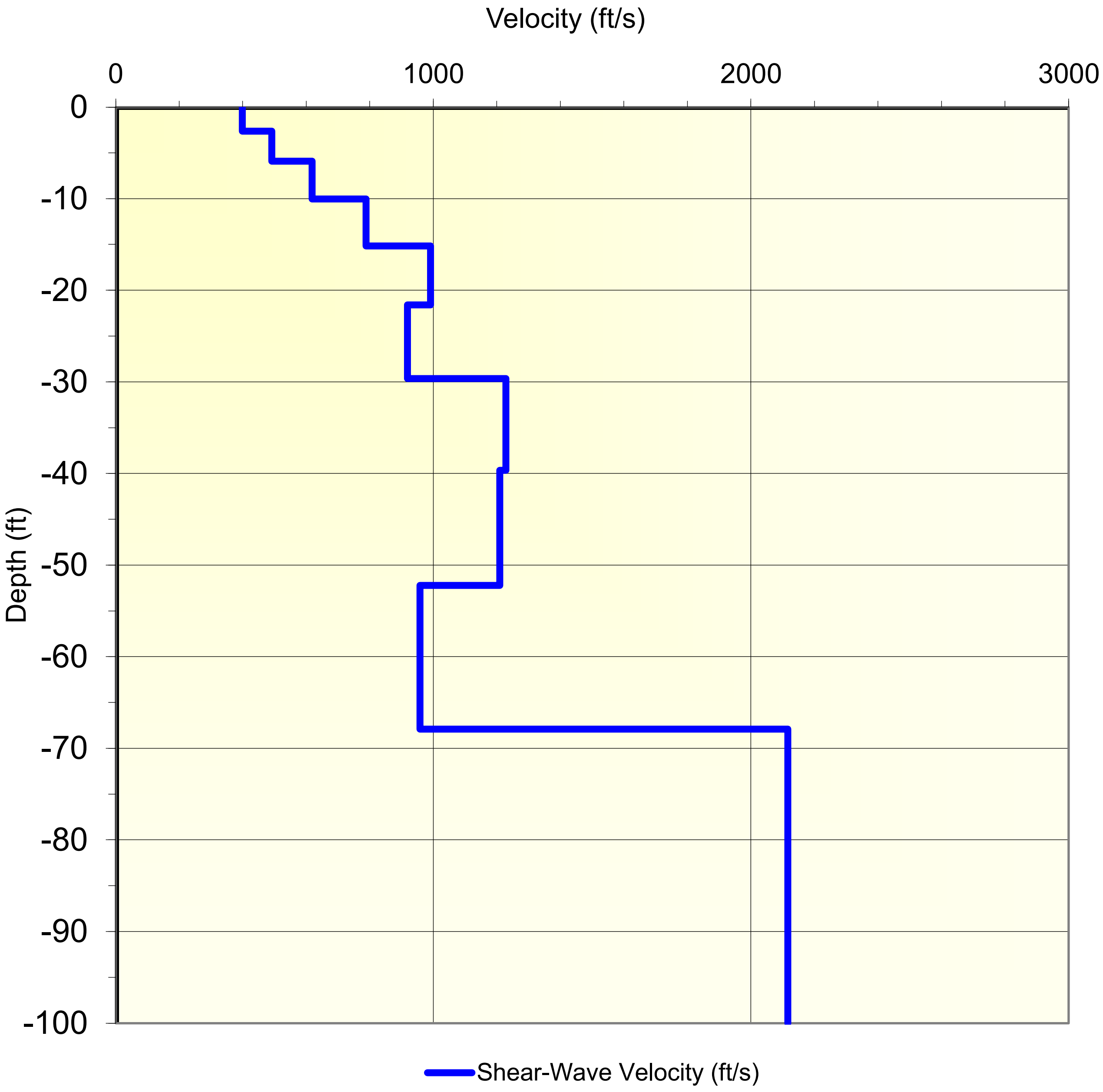
Seismic Velocity Profile – EW off 1



Average Shear-Wave Velocity for 100 ft: 1,125 ft/s

Exhibit 1

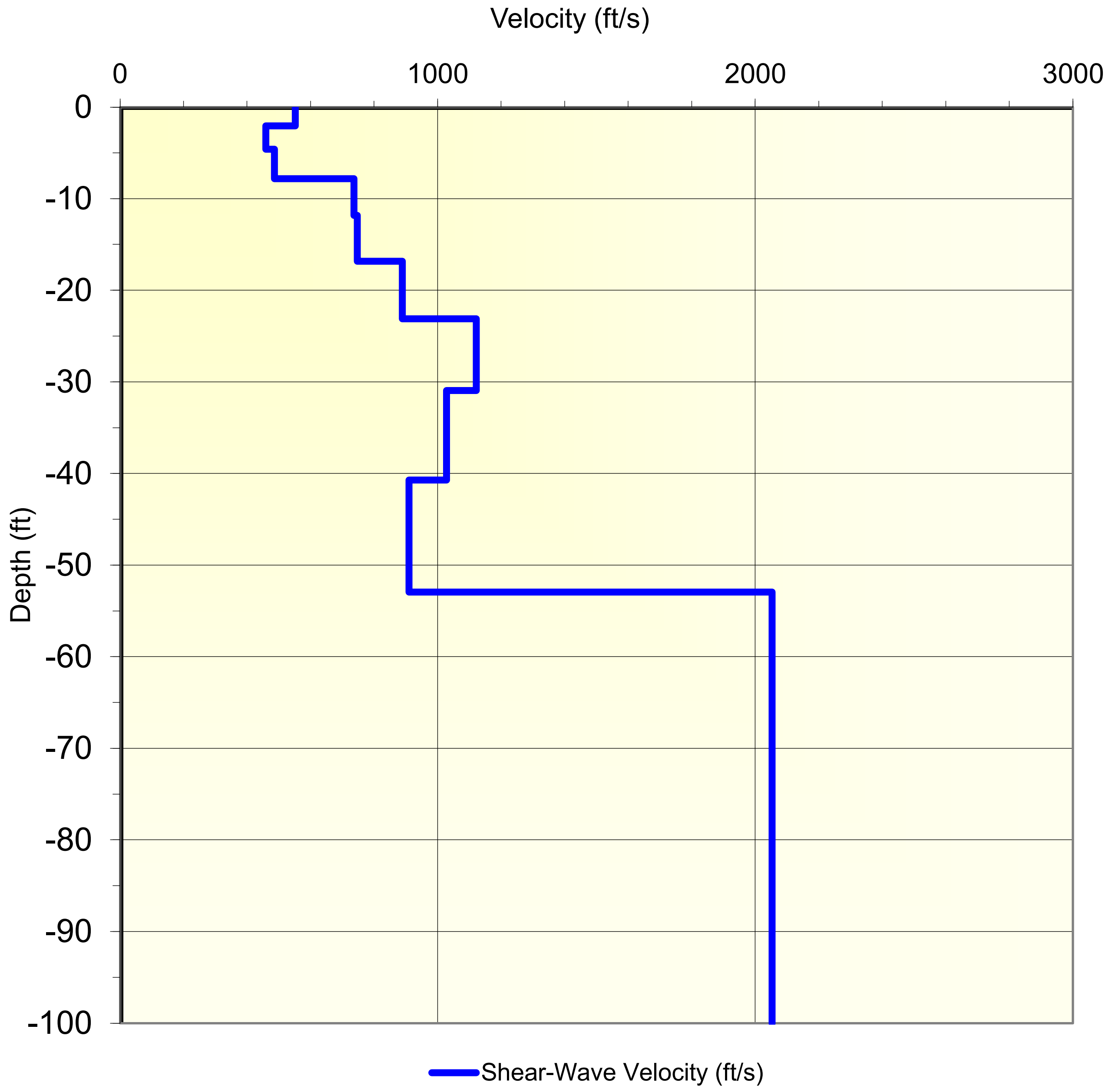
Seismic Velocity Profile – EW off 24



Average Shear-Wave Velocity for 100 ft: 1,100ft/s

Exhibit 2

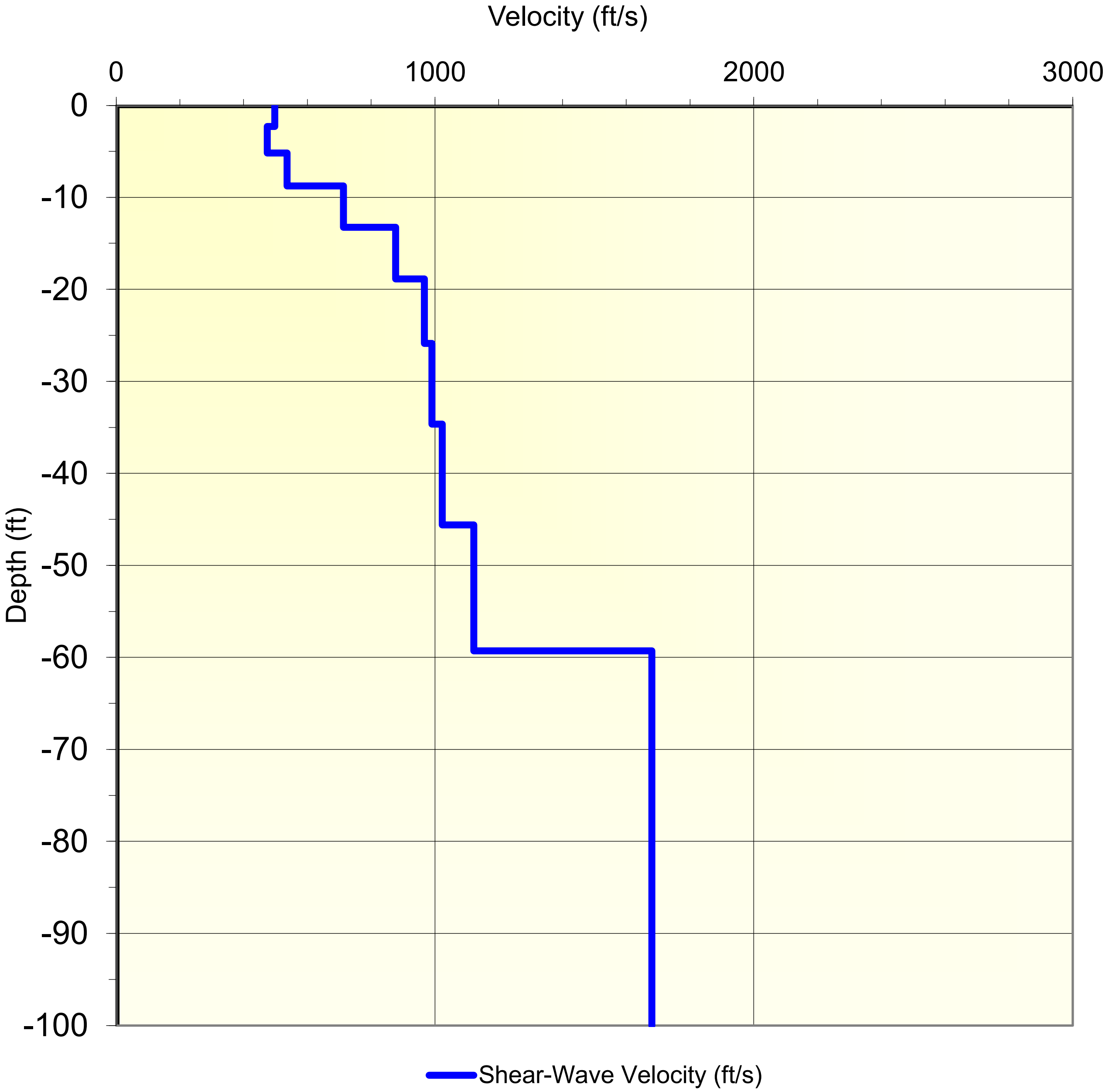
Seismic Velocity Profile – NS off 1



Average Shear-Wave Velocity for 100 ft: 1,150 ft/s

Exhibit 3

Seismic Velocity Profile – NS off 24



Average Shear-Wave Velocity for 100 ft: 1,075 ft/s

Exhibit 4

Supporting Information

Contents:

General Notes
Unified Soil Classification System

General Notes

Sampling

✋	Grab Sample
☒	Standard Penetration Test

Water Level

▽	Water Initially Encountered
▽	Water Level After a Specified Period of Time
▼	Water Level After a Specified Period of Time
▨	Cave In Encountered

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

Field Tests

N	Standard Penetration Test Resistance (Blows/Ft.)
(HP)	Hand Penetrometer
(T)	Torvane
(DCP)	Dynamic Cone Penetrometer
UC	Unconfined Compressive Strength
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

Descriptive Soil Classification

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

Location And Elevation Notes

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

Strength Terms

Relative Density of Coarse-Grained Soils

(More than 50% retained on No. 200 sieve.)
Density determined by Standard Penetration Resistance

Relative Density	Standard Penetration or N-Value (Blows/Ft.)
Very Loose	0 - 3
Loose	4 - 9
Medium Dense	10 - 29
Dense	30 - 50
Very Dense	> 50

Consistency of Fine-Grained Soils

(50% or more passing the No. 200 sieve.)
Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance

Consistency	Unconfined Compressive Strength Qu (tsf)	Standard Penetration or N-Value (Blows/Ft.)
Very Soft	less than 0.25	0 - 1
Soft	0.25 to 0.50	2 - 4
Medium Stiff	0.50 to 1.00	4 - 8
Stiff	1.00 to 2.00	8 - 15
Very Stiff	2.00 to 4.00	15 - 30
Hard	> 4.00	> 30

Relevance of Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	**Group Name** [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu≥4 and 1≤Cc≤3 [E]	GW	Well-graded gravel [F]
			Cu<4 and/or [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≥6 and 1≤Cc≤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 above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	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:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	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] $Cu = D_{60}/D_{10} \qquad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[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.