GEOTECHNICAL REPORT

PSE Operational Training Center
325 Todd Road Northwest
Puyallup, Washington

Project No. T-8829

Terra Associates, Inc.

Prepared for:

Trammell Crow Company
Seattle, Washington

April 6, 2023
Revised August 28, 2023

TERRA ASSOCIATES, Inc.
Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

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Mr. Alex Garcia Mendoza
Trammell Crow Company
600 University Street, Suite 2912
Seattle, Washington 98101

Subject: Geotechnical Report
PSE Operational Training Center
325 Todd Road Northwest
Puyallup, Washington

Dear Mr. Mendoza:

As requested, we have conducted a geotechnical engineering study for the subject project. The attached report presents our findings and recommendations for the geotechnical aspects of project design.

Our field exploration indicates the site is generally underlain by native alluvial sediments composed of alternating and interbedded layers of soft to stiff stilt to clayey silt, and very loose to medium dense sand to silty sand. Below a depth of approximately 15 feet beneath existing surface grades, the relative density of the sand deposits becomes medium dense to very dense as indicated by some of the test borings and the deeper CPT data. Groundwater is shallow residing between five and ten feet below the current site grades at the time our field work was completed.

In our opinion, the native soils on the site will be suitable for support of the proposed development provided the recommendations presented in this report are incorporated into project design and construction.

We trust the information presented is sufficient for your current needs. If you have any questions or require additional information, please call.

Sincerely yours,
TERRA ASSOCIATES, INC.

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8-28-23

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1.0 PROJECT DESCRIPTION

The project consists of developing the approximately six-acre one parcel property with a PSE Operational Training Center (OTC) along with associated infrastructure improvements. Review of the site plan prepared by Zervas Architects, dated July 21, 2023, shows the OTC building centrally located on the property with a floor area of approximately 33,800 square feet. The area west of the building is designated for outdoor training and includes two smaller buildings, covered areas, burn pit, substation yard and other training features. Design elevations in this western outdoor training area will require raising site grades by placing five to six feet of fill material. Design elevations in the central building and paved eastern site areas are near existing with cuts and fills required to achieve design grades of less than two feet.

The main central building will be a timber framed structure with the western smaller training building steel framed. Both buildings will have their floors constructed at grade. We anticipate structural loading will be relatively light with columns carrying 50 to 75 kips and continuous bearing walls carrying 2 to 4 kips per lineal foot. Loading on the floor slab is not expected to exceed 200 pounds per square foot (psf).

Stormwater will be collected and conveyed to a below grade stormwater detention facility located in the eastern portion of the site. The vault floor will be constructed at approximately elevation 29 feet. When considering the thickness of the vault foundation, this design elevation will require an excavation approaching 20 feet below existing site grades.

The recommendations in the following sections of this report are based on our understanding of the design features outlined above. We should review design drawings as they become available to verify that our recommendations have been properly interpreted and to supplement them, if required.

2.0 SCOPE OF WORK

Our scope of work was completed in accordance with our authorized proposal, dated October 6, 2022. On November 16 and 17, 2022, we observed soil and groundwater conditions at the site by drilling 13 test borings advanced with a hollow-stem auger to depths ranging from approximately 10 to 30 feet below existing site grades. On November 18, 2022, two cone penetration tests (CPTs) were advanced at the site by In Situ Engineering, under subcontract with our office to maximum depths of approximately 60 to 70 feet below existing surface grades. In addition, seismic shear wave testing was completed at one of the CPT locations. Using this data, we performed analyses to develop geotechnical engineering recommendations for project design and construction. Specifically, this report addresses the following:

- Soil and groundwater conditions.
- Geologic hazards per the City of Puyallup Municipal Code (KCC).
- Site preparation and grading.
- Building preload/surcharge program.
- Excavations.
- Foundations.
- Floor slabs at grade.
- Lateral earth pressures for wall design.
- Stormwater facilities.
- Subsurface drainage.
- Utilities.
- Pavements.

It should be noted that recommendations outlined in this report regarding drainage are associated with soil strength, design earth pressures, erosion, and stability. Design and performance issues with respect to moisture as it relates to the structure environment is beyond Terra Associates' purview. A building envelope specialist or contactor should be consulted to address these issues, as needed.

3.0 SITE CONDITIONS

3.1 Surface

The site is located north and east of the intersection of Todd Road Northwest and 4th Street Northwest in Puyallup, Washington. The site is bounded by a railroad along the northeast. The site location is shown on the attached Vicinity Map, Figure 1.

The eastern parcel is currently partially developed and used as a storage yard. The western parcel is not developed and is largely an open grass-covered field. Site topography is relatively flat with no obvious signs of sloping.

3.2 Subsurface

The soil conditions observed at the exploration locations generally consisted of native alluvial sediments composed of alternating and interbedded layers of soft to stiff stilt to clayey silt, and very loose to medium dense sand to silty sand. Trace, small organic fragments were observed in several samples obtained from the test borings.

Below a depth of approximately 15 feet beneath existing surface grades, the relative density of the sand deposits becomes medium dense to very dense as indicated by some of the test borings and the deeper CPT data. The CPT data also indicate that the alluvial sediments become predominately fine-grained below a depth of approximately 45 feet beneath existing surface grades, composed of soft to stiff silt to clayey silt deposits. CPT-2 indicates the presence of medium dense to very dense sand deposits underlying the predominant silt deposits at a depth of approximately 67 feet below existing surface grades.

The exceptions to this general condition were observed at Test Borings B-7, B-8, B-9, B-12, and B-13. In Test Boring B-7, we observed numerous organic peat inclusions at a depth of approximately 10 feet. The sample obtained at approximately 20 feet in Test Boring B-9 consisted of a partially decomposed tree trunk. We observed up to approximately four feet of fill material in Test Borings B-8, B-12, and B-13 composed of loose to medium dense gravel with silt and sand to silty gravel with sand.

The *Geologic Map of the Tacoma 1:100,000-Scale Quadrangle, Washington*, by J.E. Schuster, A.A Cabibbo, J.F. Schilter, and I.J. Hubert (2015) maps the site as Alluvium (Qa). This map unit is consistent with the native soils observed in our field explorations.

The United States Department of Agriculture Natural Resources Conservation Service (NRCS) classifies the onsite soils as Pilchuck fine sand, Puyallup fine sandy loam, and Sultan silt loam materials. A soil horizon, consisting of these materials, is typically deposited by alluvial processes in the form of flood plains and is derived from alluvium deposited by the Puyallup River which is consistent with our exploratory findings and knowledge of the area's geologic setting.

The preceding discussion is intended to be a brief review of the soil conditions observed at the site. More detailed descriptions are presented on the Test Boring Logs and CPT Logs attached in Appendix A. The approximate locations of the Test Boring and CPTs are shown in attached Figure 2.

3.3 Groundwater

The site is underlain by a regional groundwater table residing in the alluvial sediments. Based on observations during drilling and measurements obtained from installed groundwater monitoring wells, groundwater was located at a depth of approximately 4.5 feet below existing grades in the western portion of the site to approximately 10 feet below existing grades in the eastern portion of the site at the time of our November exploration. Given the time of year our field work was completed, and our experience with groundwater conditions in the area, the groundwater levels observed during drilling likely represent near seasonal low levels.

To evaluate the seasonal weather influence, Test Borings B-11 and B-13 were converted to groundwater monitoring wells. The monitoring wells were instrumented with automatic level loggers. Based on data collected from December 2022 through March 29, 2023, this seasons high groundwater was recorded at a depth of 7.2 feet at Test Boring B-11 and 8 feet at Test Boring B-13. The fluctuation of the groundwater levels over the course of the study is shown in hydrographs presented in Appendix B of this report.

When referenced to existing surface elevations, the groundwater table is at approximately elevation 39 feet at Test Boring B-13 and 38.8 feet at Test Boring B-11. This indicates a slight approximately .1 percent groundwater flow gradient to the west. Projecting this gradient to western area of the site indicates the groundwater table would be around elevation 38.4 feet or about two to three feet below grade in this lower elevated portion of the site.

3.4 Geologically Hazardous Areas

Section 21.06.1210(1) of the City of Puyallup Municipal Code (PMC) defines geologic hazards as "…areas susceptible to erosion, landsliding, earthquake, volcanic activity or other potentially hazardous geological processes. Areas susceptible to these types of hazards are hereby designated as geologically hazardous areas and subject to the provisions of this chapter." We have evaluated the site for these hazards in the following sections below.

3.4.1 Erosion Hazard Areas

Section 21.06.1210(3)(a) of the PMC defines erosion hazard areas as "…areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service or identified by a special study as having a "moderate to severe," "severe," or "very severe" erosion potential."

The soils observed on the site are classified as Pilchuck fine sand, Puyallup fine sandy loam, and Sultan silt loam by the United States Department of Agriculture Natural Resources Conservation Service (NRCS). Over the site with existing gradients, these soils will have a slight susceptibility to erosion when exposed. Therefore, the site does not present an erosion hazard per the PMC. Regardless, the site soils would be susceptible to some erosion when exposed during construction. In our opinion, proper implementation, and maintenance of Best Management Practices (BMPs) for erosion prevention and sediment control would adequately mitigate the erosion potential in the planned development area. Erosion protection measures as required by the City of Puyallup will need to be in place prior to and during grading activities at the site.

3.4.2 Landslide Hazard Areas

> Section 21.06.1210(3)(b) of the PMC defines landslide hazard areas as "…areas subject to landslides based on a combination of geologic, topographic, and hydrologic factors. They include any areas susceptible to landslide because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other factors, and include, at a minimum, the following:
>
> (i) Areas of historic failures, such as:
>
> (A) Those areas delineated by the United States Department of Agriculture Natural Resources Conservation Service as having a significant limitation for building site development;
>
> (B) Those coastal areas mapped as class u (unstable), uos (unstable old slides), and urs (unstable recent slides) in the Department of Ecology Washington coastal atlas; or

(C) Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the United States Geological Survey or Washington Department of Natural Resources.

(ii) Areas with all three of the following characteristics:

(A) Slopes steeper than 15 percent;

(B) Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and

(C) Springs or groundwater seepage.

(iii) Areas that have shown movement during the holocene epoch (from 10,000 years ago to the present) or which are underlain or covered by mass wastage debris of this epoch;

(iv) Slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials;

(v) Slopes having gradients steeper than eighty percent subject to rockfall during seismic shaking;

(vi) Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action, including stream channel migration zones;

(vii) Areas that show evidence of, or are at risk from snow avalanches;

(viii) Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding; and

(ix) Any area with a slope of 40 percent or steeper and with a vertical relief of 10 or more feet except areas composed of bedrock. A slope is delineated by establishing its toe and top and measured by averaging the inclination over at least 10 feet of vertical relief."

As stated above, the site's topography is relatively flat with no obvious signs of sloping. There are no landslide hazard areas on or near the site.

3.4.3 Volcanic Hazard Areas

Section 21.06.1210(3)(d) of the PMC defines volcanic hazard areas as "…areas subject to pyroclastic flows, lava flows, debris avalanche, inundation by debris flows, lahars, mudflows, or related flooding resulting from volcanic activity. Volcanic hazard areas shall be classified as Case I or Case II lahars per the definitions in PMC 21.06.210. Pyroclastic-flow hazard zones and inundation zones for Case I and II lahars are identified in the report Sedimentology, Behavior, and Hazards of Debris Flows at Mount Rainier, Washington, U.S. Geological Survey Professional Paper 1547, 1995. All volcanic hazard areas regulated under this code are located within lahar time travel zone 3."

The site is located within the Mount Rainier lahar hazard zone as shown on the USGS Mt. Rainier Lahar Hazard Map, dated November 9, 2016. Given the distance from Mt. Rainier and the general absence of pervasive lahar deposits observed in the CPTs and test borings, it is our opinion that the site meets the definition of a Case I volcanic hazard area per the PMC.

3.4.4 Seismic Hazard Areas

Section 21.06.1210(3)(c) of the PMC defines seismic hazard areas as "… areas subject to severe risk of damage as a result of earthquake-induced ground shaking, slope failure, settlement or subsidence, soil liquefaction, or tsunamis. Settlement and soil liquefaction conditions occur in areas underlain by cohesionless, loose, or soft-saturated soils of low density, typically in association with a shallow ground water table."

Liquefaction is a phenomenon where there is a reduction or complete loss of soil strength due to an increase in water pressure induced by vibrations. Liquefaction mainly affects geologically recent deposits of fine-grained sands underlying the groundwater table. Soils of this nature derive their strength from intergranular friction. The generated water pressure or pore pressure essentially separates the soil grains and eliminates this intergranular friction; thus, eliminating the soil's strength.

The site is mapped as having a high susceptibility to soil liquefaction on the Washington Department of Natural Resources *Natural Hazards Single-Topic Map*.

Based on the soil and groundwater conditions observed at the site, we expected that the site soils would have the potential to liquefy. Therefore, we completed an analysis of soil liquefaction potential incorporating field soil strength values and soil types determined from the CPT's. An assumed depth to groundwater of five feet was used in the analysis based on depths to groundwater measured in the monitoring wells prior to the wet season. The analysis is based on a Magnitude 7 earthquake inducing ground motions having a peak ground acceleration (PGA) value of 0.5g. This acceleration represents an earthquake with a 2 percent probability of exceedance in 50 years.

The results of our analysis indicate soil liquefaction could occur during the design earthquake event, resulting in total settlements approaching approximately three-and-one-half to five inches, with one-half of that settlement likely being differential in nature. Results of the analysis are attached in Appendix C.

In our opinion, the potential settlement is borderline regarding structural impairment and should be reviewed by the project structural engineer. If the owner is not willing to accept the risk of building damage, requiring repair, should liquefaction-induced settlements occur, or if the structural engineer cannot design the structure to meet all governing life safety codes, including the life safety provisions of the current International Building Code, foundations should be supported on ground improved using vibrated stone columns designed to mitigate soil liquefaction settlements.

3.5 Seismic Site Class

As discussed, soil conditions at the site will be subject to the soil liquefaction phenomenon. Because of this condition, per the current International Building Code (IBC), subsurface conditions would be assigned Site Class "F", which would require performing a site-specific seismic analysis to determine seismic forces for structural design. However, the IBC allows for using code derived seismic values for the soil conditions indicated if the buildings fundamental period is equal to or less than .5 seconds. We expect that this building will fall into this category. In this case, based on soil conditions encountered, Site Class "E" can be used to determine seismic design forces.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 General

Based on our study, development of the site as proposed is feasible from a geotechnical engineering standpoint. The primary geotechnical concern at the site is the presence of soil strata susceptible to consolidation under the planned building loads. The compressible soils consist of layers of very soft to stiff silt, in addition to collections and inclusions of organic peat, that vary in thickness across the site. These soils are compressible and, if not mitigated, will likely cause unacceptable levels of differential building settlement under expected static building loads.

Given the depth to the compressible silt layers, in our opinion, the potential post-construction building settlements can be mitigated by implementing a surcharge program. This would entail raising site grades to finish floor elevation and then placing an additional depth of surcharge fill for a period of time to induce settlements prior to application of building loads. Building construction can begin after completion of the surcharge program.

The building can be supported on conventional spread footings bearing on a minimum of two feet of structural fill. Depending upon final building grades, the existing granular fill observed at Test Borings B-8 and B-12, located in the eastern developed storage yard area, could serve as this structural fill layer provided it is re-compacted to achieve structural fill compaction requirements. The building floor and exterior pavements can be similarly supported.

If building schedules do not allow for a surcharge program to take place, or if the owner is unwilling to or cannot accept the risk of seismically induced building settlement, the building can be supported on ground improved by installing vibrated stone columns. If completed over the entire building footprint, this would preclude the need for a fill surcharge program. If stone columns are only used to improve ground conditions below building footings, surcharging to mitigate potential floor slab settlement is recommended.

The majority of the native and existing fill soils observed at the site contain a significant amount of fines and will be difficult to compact as structural fill when too wet. The ability to use native soil soils from site excavations as structural fill will depend upon its moisture content and the prevailing weather conditions at the time of construction.

If grading activities will take place during winter, the owner should be prepared to import clean granular material for use as structural fill and backfill. Alternatively, stabilizing the moisture in the native and existing fill soils with cement or lime can be considered.

Detailed recommendations regarding these issues and other geotechnical design considerations are provided in the following sections. These recommendations should be incorporated into the final design drawings and construction specifications.

4.2 Site Preparation and Grading

To prepare the site for construction, all vegetation and organic surface soils should be stripped and removed from the site. We expect surface stripping depths of about three to six inches will be required to remove the organic surficial soils. Organic soils will not be suitable for use as structural fill but may be used for limited depths in nonstructural areas or for landscaping purposes.

Demolition of existing structures should include removal of existing foundations and other buried utilities. Abandoned utility pipes that fall outside of new building areas can be left in place provided they are sealed to prevent intrusion of groundwater seepage and soil.

Prior to fill placement or construction of building foundations or site pavements, we recommend all exposed subgrade surfaces be observed by a representative of Terra Associates, Inc. to verify soil conditions are as expected and suitable for support. The contractor should be prepared to proofroll subgrade areas with heavy construction equipment to assist in evaluating the suitability of the bearing subgrade. If excessively yielding areas are observed and cannot be stabilized in place by compaction, the affected soils should be excavated and removed to firm bearing and grade restored with new structural fill. If the depth of excavation to remove unstable soils is excessive, use of a geotextile reinforcing/separation fabric, such as Mirafi 600X or equivalent, can be considered in conjunction with structural fill. Our experience has shown that, in general, a minimum of 18 to 24 inches of a clean, granular structural fill over the geotextile fabric should establish a stable bearing surface.

All building footings should obtain support on a minimum of two feet of granular structural fill, extending at least one foot laterally from the edge of footing. As discussed earlier, the existing granular fill observed at Test Borings B-8 and B-12 located in the eastern developed storage yard area, could serve as this structural fill layer provided it is re-compacted to achieve structural fill compaction requirements.

The majority of the native and existing fill soils observed at the site contain a sufficient percentage of fines (silt and clay size particles), which will make them difficult to re-compact as structural fill if they are too wet or too dry. Accordingly, the ability to use the soils from site excavations as structural fill will depend upon their moisture content and the prevailing weather conditions when site grading activities take place. Soils that are too wet to properly compact can be dried by aeration during dry weather conditions. Alternatively, treatment with cement or lime can be considered. If additives are used, additional Best Management Practices (BMPs) will need to be implemented to mitigate potential impacts to construction stormwater runoff.

If grading activities are planned during the wet winter months, or if they are initiated during the summer and extend into fall and winter, the contractor should be prepared to import wet weather structural fill. For this purpose, we recommend importing a granular soil that meets the following grading requirements:

U.S. Sieve Size	Percent Passing
6 inches	100
No. 4	75 maximum
No. 200	5 maximum*

*Based on the 3/4-inch fraction.

Prior to use, Terra Associates, Inc. should examine and test all materials imported to the site for use as structural fill.

Structural fill should be placed in uniform loose layers not exceeding 12 inches and compacted to a minimum of 95 percent of the soil's maximum dry density, as determined by American Society for Testing and Materials (ASTM) Test Designation D-1557 (Modified Proctor). The moisture content of the soil at the time of compaction should be within two percent of its optimum, as determined by this ASTM standard. In nonstructural areas, the degree of compaction can be reduced to 90 percent.

4.3 Surcharge Program

We recommend surcharging the building area to limit building foundation and floor slab settlements to tolerable levels. For this procedure, we recommend placing structural fill in the building areas to the design floor elevation and then placing an additional four-foot depth of surcharge fill. The surcharge fill should extend a minimum of two feet beyond the building perimeter footing edge. This surcharge fill does not need to meet any special requirements other than having a minimum in-place unit weight of 120 pounds per cubic foot (pcf). However, it may be advisable to use a good quality fill to raise grades in other portions of the site, such as parking and driveway areas, if necessary.

In the western pavement areas where five to six feet of fill is required to establish design grades, the recommended full surcharge depth is not required. Here we recommend placing fill to the design final pavement elevation and allowing settlement under this fill loading to occur prior to pavement or utility construction.

Total settlement under the surcharge fill is estimated in the range of four to six inches. These settlements are expected to occur in about four to six weeks following full application of the building fill.

To verify the amount of settlement and the time rate of movement, the surcharge program should be monitored by installing settlement markers. The settlement markers should be installed on the existing grade prior to placing any building or preload fills. Once installed, elevations of both the fill height and marker should be taken twice weekly until the full height of the surcharge is in place. Once fully surcharged, readings should continue weekly until the anticipated settlements have occurred. A typical settlement marker detail is provided as Figure 3.

It is critical that the grading contractor recognize the importance of the settlement marker installations. All efforts must be made to protect the markers from damage during fill placement. It is difficult, if not impossible, to evaluate the progress of the surcharge program if the markers are damaged or destroyed by construction equipment. As a result, it may be necessary to install new markers and extend the surcharging time period in order to ensure that settlements have ceased and building construction can begin.

Potential long-term settlements due to secondary compression of the peat layers, which cannot be fully mitigated by surcharging, will also occur. The magnitude of this settlement will be greater in the early years diminishing with time. The approximate total settlement due to secondary compression is estimated to be 1.5 to 2 inches in 20 years. Approximately 50 percent of the total secondary settlement may be differential in nature due to the varying thickness of the peat layers. For floor slab design purposes, we estimate these differential settlements will occur over a distance of 100 feet.

4.4 Excavations

All excavations at the site associated with confined spaces, such as utility trenches, must be completed in accordance with local, state, and federal requirements. Based on regulations outlined in the Washington Industrial Safety and Health Act (WISHA), the fill soils would be classified as Type C soil.

Accordingly, temporary excavations in Type C soils should have their slopes laid back at an inclination of 1.5:1 (Horizontal:Vertical) or flatter, from the toe to the crest of the slope. All exposed temporary slope faces that will remain open for more than two days should be covered with a durable reinforced plastic membrane during construction to prevent slope raveling and rutting during periods of precipitation. If there is insufficient room to slope, the temporary excavation sides shoring will be required. Properly designed and installed shoring trench boxes can be used to support utility trench excavations where required.

Based on our study, groundwater should be anticipated within excavations extending below depths of about three to seven feet below existing site grades during the wet winter months. Excavations extending below these depths will likely encounter groundwater with volumes and flow rates sufficient to require some level of dewatering. Shallow excavations that do not extend more than two feet below the groundwater table can likely be dewatered by conventional sump-pumping procedures along with a system of collection trenches. Deeper excavation as is expected for construction of the stormwater detention facility will require dewatering by well points or isolated deep-pump wells. The dewatering system should be designed and installed by an experienced dewatering contractor.

This information is provided solely for the benefit of the owner and other design consultants and should not be construed to imply that Terra Associates, Inc. assumes responsibility for job site safety. It is understood that job site safety is the sole responsibility of the project contractor.

4.5 Foundations

In our opinion, following the successful implementation of the surcharge program, the buildings can be supported on conventional spread footing foundations bearing on structural fill as recommended in the Site Grading and Preparation section of this report. However, if the owner is not willing to accept the risk for building damage due to the potential for liquefaction induced settlements during an earthquake or it is determined that the estimated liquefaction settlements would preclude design of the structure the building shell to meet all governing life safety codes, including the life safety provisions of the current International Building Code, the building foundations should be supported on ground improved using vibrated stone columns designed to mitigate soil liquefaction settlements.

Spread Footings

In our opinion, following the completion of a successful surcharge program as outlined in Section 4.3, the building may be supported on conventional spread footing foundations. As noted, all foundations must be supported on a minimum of two feet of structural fill that extends laterally beyond the edge of the footing a minimum distance of one foot. Structural fill used for support of footings should consist of a granular import material meeting the grading recommendations for a wet weather structural fill.

Foundations exposed to the weather should bear at a minimum depth of one and one-half feet below adjacent exterior grades for frost protection. Interior foundations should be supported at a minimum depth of one foot below the finished floor elevation.

We recommend designing foundations for a net allowable bearing capacity of 2,500 psf. For short-term loads, such as wind and seismic, a one-third increase in this allowable capacity can be used. With the expected building loads and this bearing stress applied, in general, total, and differential settlements should not exceed one inch and one-half inch, respectively. The differential settlement is expected to occur between perimeter wall and interior column locations.

For designing foundations to resist lateral loads, a base friction coefficient of 0.35 can be used. Passive earth pressures acting on the sides of the footings should be considered. We recommend calculating this lateral resistance using an equivalent fluid weight of 300 pounds per cubic foot (pcf). We do not recommend including the upper 12 inches of soil in this computation because it can be affected by weather or disturbed by future grading activity. This value assumes the foundation will be backfilled with structural fill, as described in Section 4.2 of this report. The values recommended include a safety factor of 1.5.

Ground Improvement

As noted earlier if the owner is unwilling to accept the risk of building damage due to liquefaction settlement, the building can be supported on ground improved using vibrated stone columns specifically designed to mitigate liquefaction settlement to tolerable levels. This method creates highly densified columns of graded aggregate that would extend through the upper loose and soft to medium stiff soils into the underlying medium dense to dense sand deposits. Due to the methods used to construct the columns, some improvement of the adjacent soils is also realized.

Moreover, these methods can provide liquefaction mitigation by providing drainage paths and reduced pore pressures during ground shaking, and by constructing stiff, non-liquefiable inclusions in the soils. Once constructed, conventional spread footing foundations can be designed to bear immediately above the stone columns.

These ground improvement techniques are typically completed on a design/build approach with both design and construction completed by a geotechnical specialty contractor. We can assist in contacting and selecting the specialty contractor, if desired.

4.6 Slab on Grade Floors

Suitable support for slab on grade floors will be provided by subgrade prepared as recommended in Section 4.2 of this report following implementation of the surcharge program. Immediately below the floor slab, we recommend placing a four-inch-thick capillary break layer composed of clean, coarse sand or fine gravel that has less than three percent passing the No. 200 sieve. This material will reduce the potential for upward capillary movement of water through the underlying soil and subsequent wetting of the floor slab.

The capillary break layer will not prevent moisture intrusion through the slab caused by water vapor transmission. Where moisture by vapor transmission is undesirable, such as covered floor areas, a common practice is to place a durable plastic membrane on the capillary break layer and then cover the membrane with a layer of clean sand or fine gravel to protect it from damage during construction, and aid in uniform curing of the concrete slab. It should be noted that if the sand or gravel layer overlying the membrane is saturated prior to pouring the slab, it will be ineffective in assisting uniform curing of the slab and can actually serve as a water supply for moisture transmission through the slab that affects floor coverings. Therefore, in our opinion, covering the membrane with a layer of sand or gravel should be avoided if floor slab construction occurs during the wet winter months and the layer cannot be effectively drained. We recommend floor designers and contractors refer to the updated American Concrete Institute (ACI) Manual of Concrete Practice for further information regarding vapor barrier installation below slab-on-grade floors.

With the floor subgrade prepared as recommended, a subgrade modulus (k_s) value of 100 pounds per square inch per inch of deflection (pci) can be used in design of the building floor slabs subject to heavy lift truck traffic.

4.7 Lateral Earth Pressures for Wall Design

The magnitude of earth pressure development on retaining walls partly depend upon the quality of wall backfill. Where fill is placed behind retaining walls, we recommend placing and compacting it as structural fill. The fill should be compacted to a minimum of 90 percent of its maximum dry unit weight as determined by ASTM Test Designation D-1557 (Modified Proctor). To guard against the build-up of hydrostatic pressure, wall drainage must also be installed. We recommend that wall drainage consist of a minimum 12-inch-thick layer of washed gravel placed adjacent to the wall. Alternatively, a composite drainage panel such as Mirafi G100N or equal can be used. A four-inch diameter perforated pipe should be placed on a bed of gravel along the base of the wall footing and directed to a suitable outlet. A typical wall drainage detail is attached as Figure 4.

With granular backfill placed and compacted as recommended and drainage properly installed, we recommend designing restrained (not free to deflect) retaining walls for an at-rest earth pressure equivalent to a fluid weighing 50 pcf. A value of 35 pcf may be used for the case where the wall is unrestrained. These values do not include other surcharge loading such as from fill backslopes or adjacent footings that may act on the wall. If such conditions exist, then the imposed loading must be included in wall design. Values of friction at the base of wall foundations and passive earth pressure that are used in design to resist lateral loads are provided in Section 4.5 of this report.

4.8 Stormwater Detention Vault

With the eastern detention vault foundation bearing at a depth of 15 to 20 feet below existing site grades, soils that will likely be exposed will consist of medium dense fine to medium sand. These sands will be suitable for support of the detention vault and no over excavation and replacement with crushed rock would be required for bearing purposes. For constructability however, it would be advisable to construct a working mat to avoid excessive disturbance of the native sand subgrade. For this purpose, we recommend over-excavating the by 6-inches and restoring grade with clean 1 ¼-inch to 2-inch crushed rock. Additionally, any organic peat or organic inclusions exposed should be removed to expose competent native soils. Vault foundations supported in this manner can be designed for an allowable bearing capacity of 2,500 psf. For short-term loads, such as seismic, a one-third increase in this allowable capacity can be used.

Vault walls should be designed as below-grade retaining walls following the parameters outline in Section 4.7 of this report. Any portion of the wall for which drainage cannot be provided should be designed for an earth pressure equivalent to a fluid weighing 85 pcf. Where applicable, a uniform horizontal traffic value of 75 psf should be included in the design of vault walls.

The detention vault will be subject to uplift pressures if drainage is not provided for the detention vault walls. For design, uplift forces should be based on a groundwater elevation equal to elevation 40 feet. The weight of the structure and the weight of the soil above its foundation will provide resistance to uplift. A soil unit weight of 125 pcf can be used in designing the structure to resist uplift forces.

4.9 Drainage

Infiltration Feasibility

In general, based on the shallow seasonal water table and the fine-grained nature of the soils observed across the site, it is our opinion that infiltration should not be relied on to manage development stormwater runoff on a whole scale basis. Conventional stormwater detention with controlled release should be used to manage a majority of the stormwater runoff.

It may be feasible to use low impact development (LID) features such as shallow bioretention cells or permeable pavements for managing a minor component of the runoff. Bioretention cells could be considered along the northern margin of the site where shallow soil conditions generally consist of silty sand and sand with silt with a few silt seams. Designing these elements with an infiltration component equivalent to .2 inches per hour would be feasible in our opinion. Permeable concrete pavement could also be considered across the site with design based on an infiltration rate of .05 inches per hour.

Surface

Final exterior grades should promote free and positive drainage away from the building areas. We recommend providing a gradient of at least three percent for a minimum distance of ten feet from the building perimeter, except in paved locations. In paved locations, a minimum gradient of two percent should be provided, unless provisions are included for collection and disposal of surface water adjacent to the structures.

Subsurface

Foundation drains should be installed where floor slab wetness or interior moisture due to water vapor is not desired. Where foundation drainage is installed, we recommend it consist of four-inch diameter perforated PVC pipe that is enveloped in washed ½- to ¾-inch gravel-sized drainage aggregate. The aggregate should extend six inches above and to the sides of the pipe. The foundation drains and roof downspouts should be tightlined separately to an approved point of controlled discharge.

4.10 Utilities

Utility pipes should be bedded and backfilled in accordance with American Public Works Association (APWA), or City of Puyallup specifications. As a minimum, trench backfill should be placed and compacted as structural fill, as described in Section 4.2 of this report. As noted, the existing fill and native soils are moisture sensitive and close moisture control will be required to facilitate proper compaction. If utility construction takes place during the wet winter months, it will likely be necessary to import suitable wet weather fill for utility trench backfilling.

The utility contractor should also be prepared for encountering unstable loose native soils below the pipe invert elevations. If not removed from below the pipe and replaced with crushed rock or additional bedding material, pipe deflections may occur as a result of the soil yielding and compressing in response to loading imposed during trench backfilling. The need to over-excavate and stabilize the pipe foundation before backfilling should be evaluated by observation and testing during construction.

4.11 Pavements

Pavement subgrades should be prepared as described in Section 4.2 of this report. Regardless of the degree of relative compaction achieved, the subgrade must be firm and relatively unyielding before paving. The subgrade should be proof rolled with heavy rubber-tired construction equipment such as a loaded 10-yard dump truck to verify this condition.

The pavement design section is dependent upon the supporting capability of the subgrade soils and the traffic conditions to which it will be subjected. New pavements for the project will consist of drive aisles accessing parking spaces and storage areas. Accordingly, we expect traffic will consist of cars and light trucks, along with heavy traffic in the form of tractor-trailer rigs. For design considerations, we have assumed traffic in parking and in car/light truck access pavement areas can be represented by an 18-kip Equivalent Single Axle Loading (ESAL) of 50,000 over a 20-year design life. For heavy traffic pavement areas, we have assumed an ESAL of 300,000 would be representative of the expected loading. These ESALs represent loading approximately equivalent to 3 and 18, loaded (80,000-pound GVW) tractor-trailer rigs traversing the pavement daily in each area, respectively. If higher truck traffic volumes are expected, we should be notified and asked to review and revise the following pavement recommendations, as needed.

With a stable subgrade prepared as recommended, we recommend the following options for pavement sections:

Light traffic and parking:

- Two inches of hot mix asphalt (HMA) over four inches of crushed rock base (CRB).
- Full depth HMA – four inches.

Heavy traffic:

- Three inches of HMA over eight inches of CRB.
- Full depth HMA – six inches.

For exterior Portland cement concrete (PCC) pavement, we recommend the following:

- Six inches of PCC over two inches of CRB.
    - 28-day compressive strength – 4,000 psi.
    - Control joints spaced at a maximum of 15 feet.

Soil cement stabilization or constructing a soil cement base for support of the pavement section can also be considered as an alternative to the above conventional pavement sections. Assuming a properly constructed soil cement base having a minimum thickness of 12 inches and a minimum seven-day compressive strength of 100 pounds per square inch (psi), a minimum HMA pavement thickness of three inches would be required for the heavy traffic areas. The design of the soil cement base should be completed using samples of the subgrade exposed at the time of construction.

The paving materials used should conform to the Washington State Department of Transportation (WSDOT) specifications for half-inch class HMA, PCC, and CRB.

Long-term pavement performance will depend upon surface drainage. A poorly drained pavement section will be subject to premature failure resulting from surface water infiltrating the subgrade soils and reducing their supporting capability. For optimum performance, we recommend surface drainage gradients of at least two percent. Some degree of longitudinal and transverse cracking of the pavement surface should be expected over time. Regular maintenance should be planned to seal cracks as they occur. In addition, because of long-term secondary compression of the peat material, some subsidence of the pavement surface resulting in depressed bird bath areas should be expected. Above normal maintenance of the pavement requiring repair of failed pavement in these areas should be planned for.

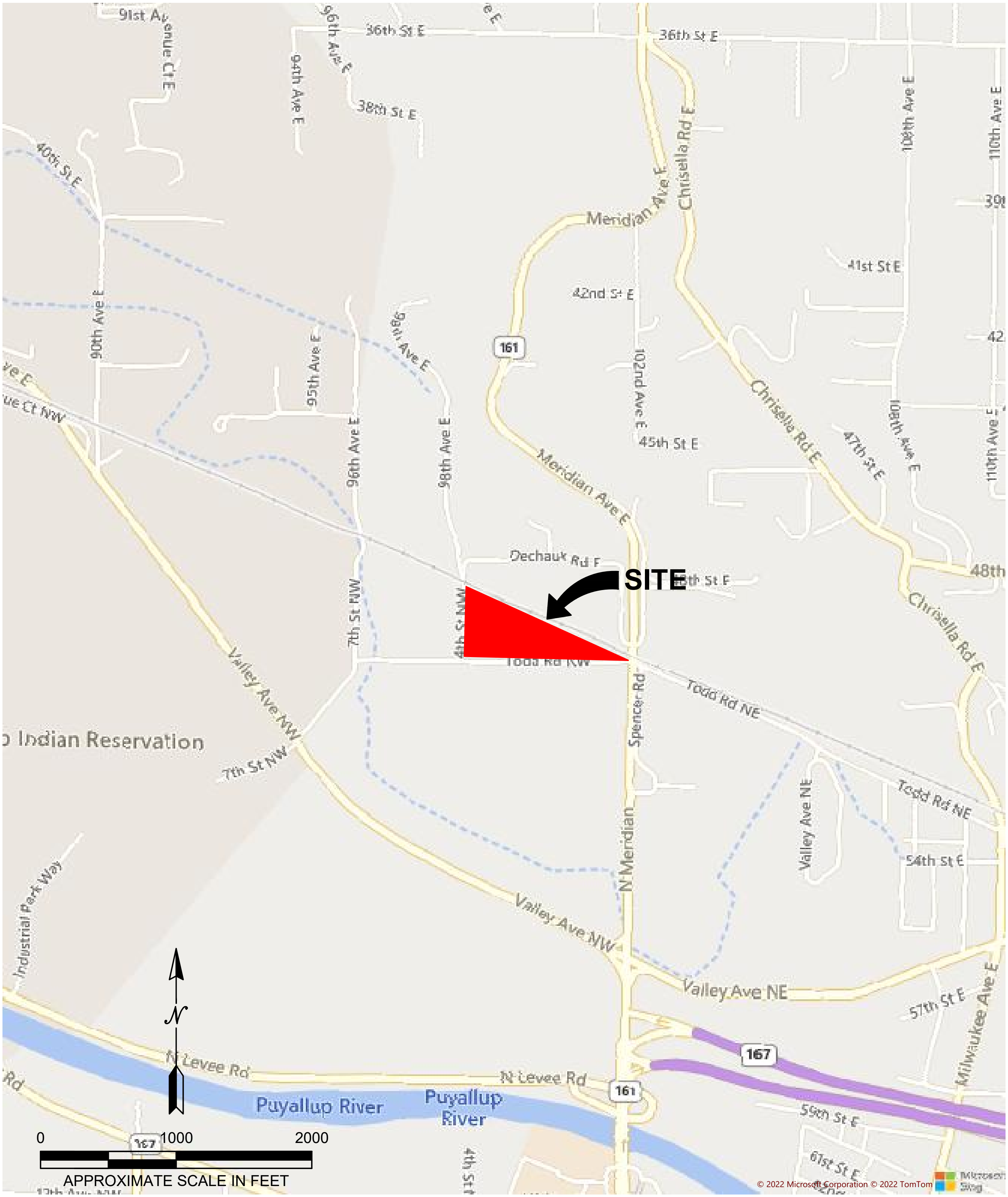
5.0 ADDITIONAL SERVICES

Terra Associates, Inc. should review the final design drawings and specifications in order to verify that earthwork and foundation recommendations have been properly interpreted and implemented in project design. We should also provide geotechnical services during construction to observe compliance with our design concepts, specifications, and recommendations. This will allow for design changes if subsurface conditions differ from those anticipated prior to the start of construction.

6.0 LIMITATIONS

We prepared this report in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made. This report is the copyrighted property of Terra Associates, Inc. and is intended for specific application to the PSE Operational Training Center project in Puyallup, Washington. This report is for the exclusive use of Trammell Crow Company and their authorized representatives.

The analyses and recommendations presented in this report are preliminary in nature and are based on data obtained from the test borings and CPTs completed on the site. Variations in soil conditions can occur, the nature and extent of which may not become evident until construction. If variations appear evident, Terra Associates, Inc. should be requested to reevaluate the recommendations in this report prior to proceeding with construction.



REFERENCE: https://www.bing.com/maps

ACCESSED 2023

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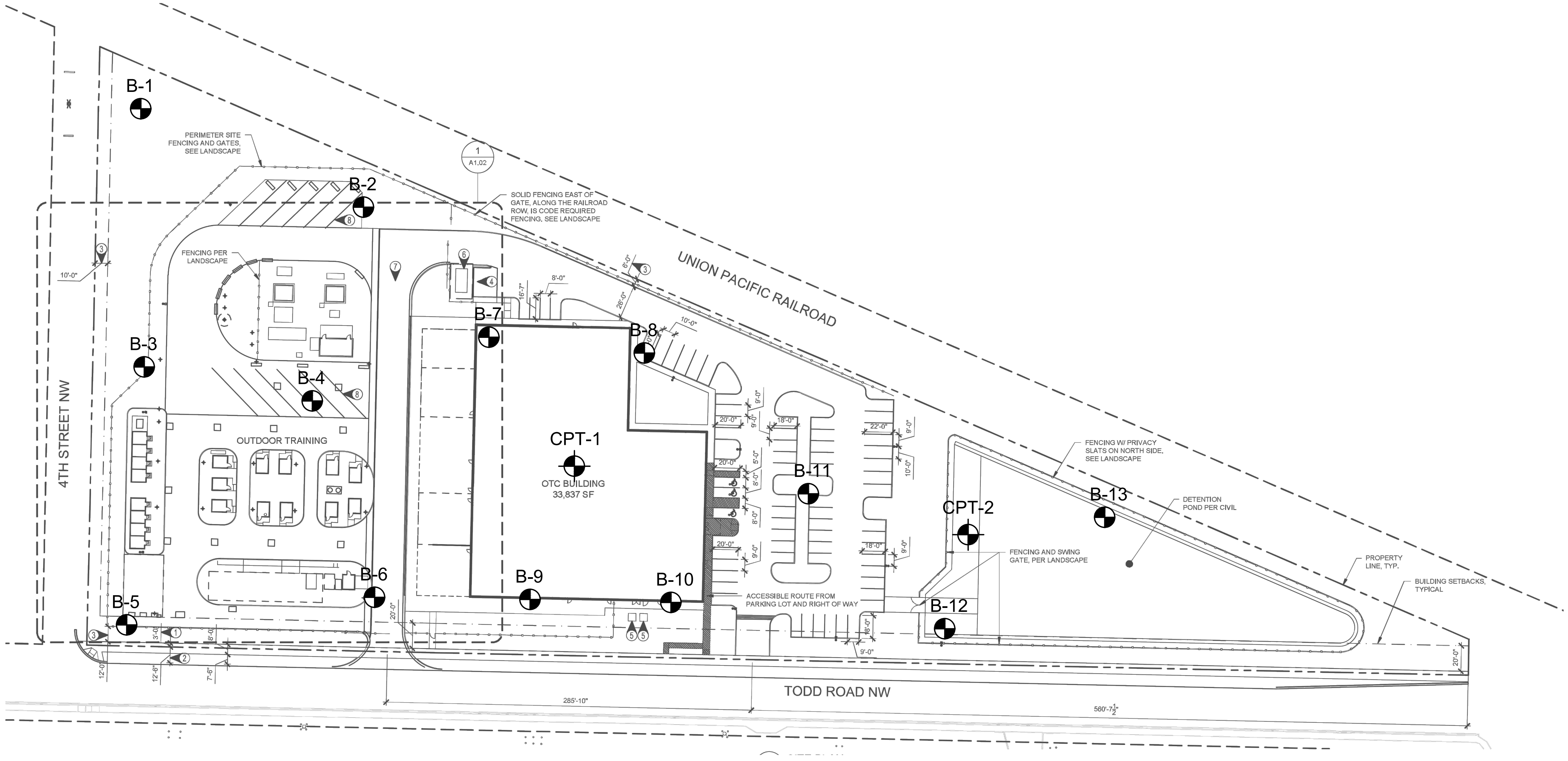
Geology and
Environmental Earth Sciences

VICINITY MAP
PSE OPERATION TRAINING CENTER
PUYALLUP, WASHINGTON

Proj.No. T-8829	Date: AUG 2023	Figure 1



NOTE:

THIS SITE PLAN IS SCHEMATIC. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE. IT IS INTENDED FOR REFERENCE ONLY AND SHOULD NOT BE USED FOR DESIGN OR CONSTRUCTION PURPOSES.

REFERENCE: SITE PLAN PROVIDED BY CLIENT.

LEGEND:

- ◐ APPROXIMATE BORING LOCATION
- ⊕ APPROXIMATE CONE PENETRATION TEST

0 100 200

APPROXIMATE SCALE IN FEET

N

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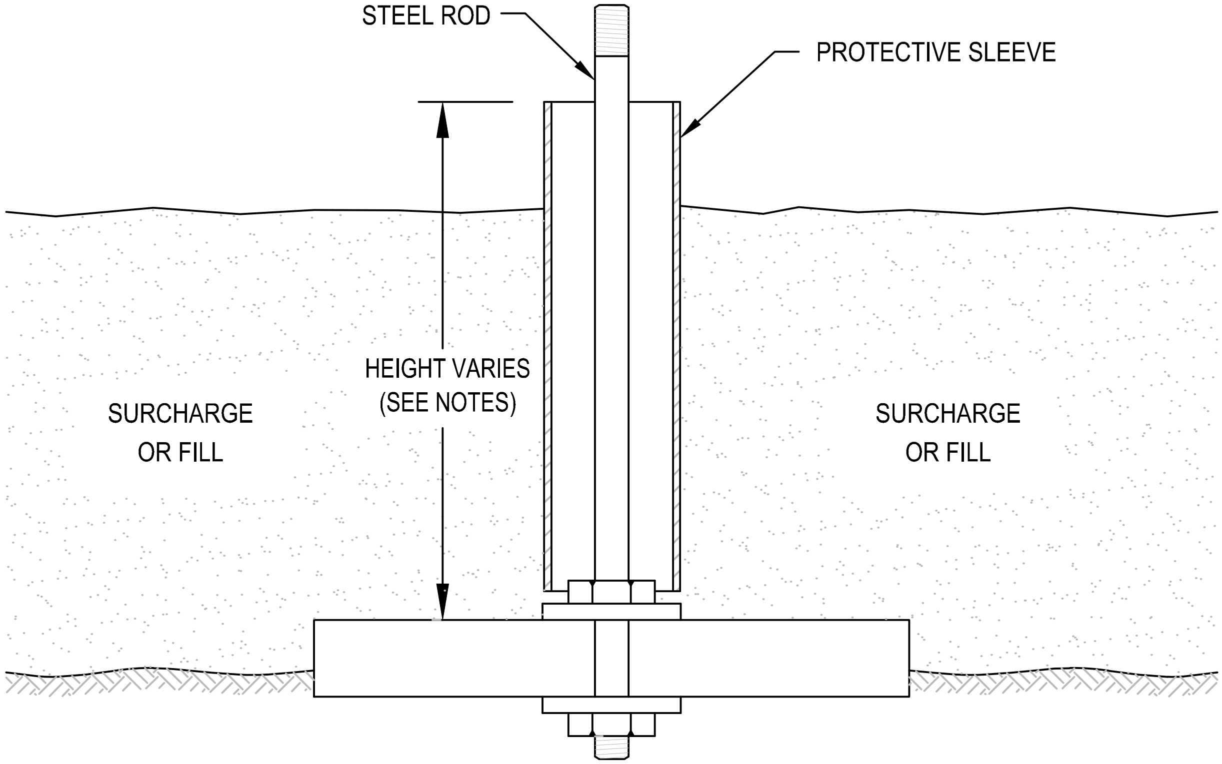
EXPLORATION LOCATION PLAN
PSE OPERATION TRAINING CENTER
PUYALLUP, WASHINGTON

Proj.No. T-8829	Date: AUG 2023	Figure 2



NOT TO SCALE

NOTES:

1. BASE CONSISTS OF 3/4" THICK, 2'x2' PLYWOOD WITH CENTER DRILLED 5/8" DIAMETER HOLE.
2. BEDDING MATERIAL, IF REQUIRED, SHOULD CONSIST OF CLEAN COARSE SAND.
3. MARKER ROD IS 1/2" DIAMETER STEEL ROD THREADED AT BOTH ENDS.
4. MARKER ROD IS ATTACHED TO BASE BY NUT AND WASHER ON EACH SIDE OF BASE.
5. PROTECTIVE SLEEVE SURROUNDING MARKER ROD SHOULD CONSIST OF 2" DIAMETER PLASTIC TUBING. SLEEVE IS NOT ATTACHED TO ROD OR BASE.
6. ADDITIONAL SECTIONS OF STEEL ROD CAN BE CONNECTED WITH THREADED COUPLINGS.
7. ADDITIONAL SECTIONS OF PLASTIC PROTECTIVE SLEEVE CAN BE CONNECTED WITH PRESS-FIT PLASTIC COUPLINGS.
8. STEEL MARKER ROD SHOULD EXTEND AT LEAST 6" ABOVE TOP OF PLASTIC PROTECTIVE SLEEVE.
9. PLASTIC PROTECTIVE SLEEVE SHOULD EXTEND AT LEAST 1" ABOVE TOP OF FILL SURFACE.

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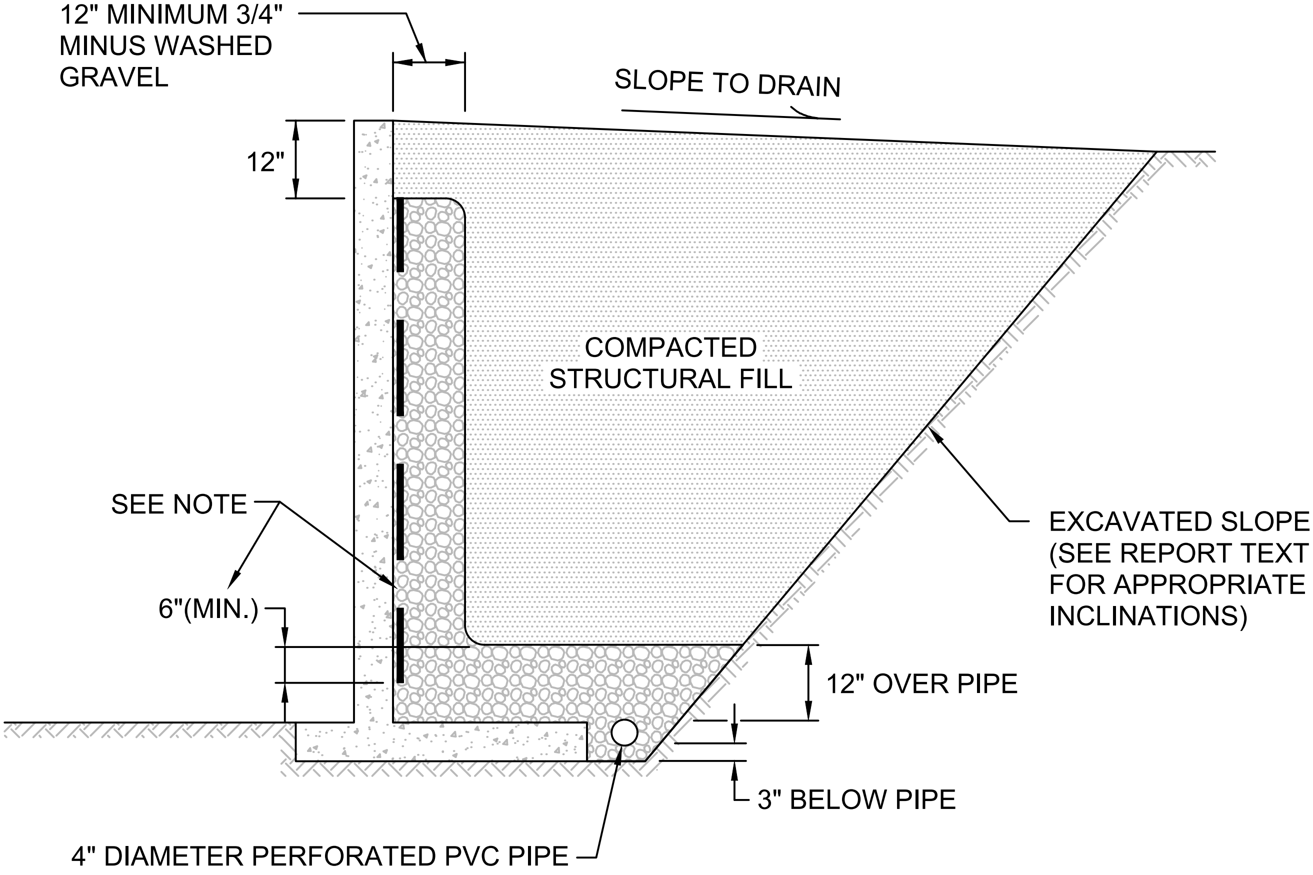
SETTLEMENT MARKER DETAIL
PSE OPERATION TRAINING CENTER
PUYALLUP, WASHINGTON

Proj.No. T-8829	Date: AUG 2023	Figure 3



NOT TO SCALE

NOTE:

MIRADRAIN G100N PREFABRICATED DRAINAGE PANELS OR SIMILAR PRODUCT CAN BE SUBSTITUTED FOR THE 12-INCH WIDE GRAVEL DRAIN BEHIND WALL. DRAINAGE PANELS SHOULD EXTEND A MINIMUM OF SIX INCHES INTO 12-INCH THICK DRAINAGE GRAVEL LAYER OVER PERFORATED DRAIN PIPE.

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TYPICAL WALL DRAINAGE DETAIL
PSE OPERATION TRAINING CENTER
PUYALLUP, WASHINGTON

Proj.No. T-8829	Date: AUG 2023	Figure 4

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

PSE Operational Training Center
Puyallup, Washington

On November 16, 2022, and November 17, 2022, we observed soil conditions at 13 test borings drilled to depths of approximately 10 to 30 feet below existing surface grades. On November 18, 2022, In-Situ Engineering, under subcontract with Terra Associates, Inc., performed 2 cone penetration tests (CPTs). Test boring and CPT locations were determined in the field by measuring from existing site features. The approximate locations of the test borings and CPTs are shown on the attached Exploration Location Plan, Figure 2. Test Boring Logs are attached as Figures A-2 through A-14.

A geotechnical engineer from our office conducted the field exploration. Our representative classified the soil conditions encountered, maintained a log of each test boring, obtained representative soil samples, and recorded water levels observed during drilling. During drilling, soil samples were obtained in general accordance with ASTM Test Designation D-1586. Using this procedure, a 2-inch (outside diameter) split barrel sampler is driven into the ground 18 inches using a 140-pound hammer free falling from a height of 30 inches. The number of blows required to drive the sampler 12 inches after an initial 6-inch set is referred to as the Standard Penetration Resistance value or N value. This is an index related to the consistency of cohesive soils and relative density of cohesionless materials. N values obtained for each sampling interval are recorded on the Test Boring Logs, Figures A-2 through A-14. All soil samples were visually classified in accordance with the Unified Soil Classification System (USCS) described on Figure A-1.

Representative soil samples obtained from the test borings were placed in sealed plastic bags and taken to our laboratory for further examination and testing. The moisture content of each sample was measured and is reported on the Test Boring Logs. Grain size analyses were performed on select soil samples. The results are shown on Figures A-15 and A-16.

InSitu Engineering, under subcontract with Terra Associates, Inc., conducted two electric CPTs at locations selected by Terra Associates, Inc. which are shown in Figure 2. The CPTs were advanced to depths of 60 to 70 feet below the surface. The CPT was instrumented, and an approximately 1.5-inch diameter cone was pushed into the ground at a constant rate. During advancement, continuous measurements are made of the resistance to penetration of the cone and the friction of the outer surface of the sleeve. The cone is also equipped with a porous filter and a pressure transducer for measuring groundwater or pore water pressure generated. Measurements of tip and sleeve frictional resistance, pore pressure, and interpreted soil conditions are summarized in graphical form on the attached CPT Logs.

MAJOR DIVISIONS			LETTER SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS More than 50% material larger than No. 200 sieve size	**GRAVELS** More than 50% of coarse fraction is larger than No. 4 sieve	Clean Gravels (less than 5% fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines.
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines.
	SANDS More than 50% of coarse fraction is smaller than No. 4 sieve	Clean Sands (less than 5% fines)	SW	Well-graded sands, sands with gravel, little or no fines.
			SP	Poorly-graded sands, sands with gravel, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures, non-plastic fines.
			SC	Clayey sands, sand-clay mixtures, plastic fines.
FINE GRAINED SOILS More than 50% material smaller than No. 200 sieve size	**SILTS AND CLAYS** Liquid Limit is less than 50%		ML	Inorganic silts, rock flour, clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity. (Lean clay)
			OL	Organic silts and organic clays of low plasticity.
	SILTS AND CLAYS Liquid Limit is greater than 50%		MH	Inorganic silts, elastic.
			CH	Inorganic clays of high plasticity. (Fat clay)
			OH	Organic clays of high plasticity.
HIGHLY ORGANIC SOILS			PT	Peat.

DEFINITION OF TERMS AND SYMBOLS

COHESIONLESS

Density	Standard Penetration Resistance in Blows/Foot
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	>50

COHESIVE

Consistancy	Standard Penetration Resistance in Blows/Foot
Very Soft	0-2
Soft	2-4
Medium Stiff	4-8
Stiff	8-16
Very Stiff	16-32
Hard	>32

I	2" OUTSIDE DIAMETER SPILT SPOON SAMPLER
‖	2.4" INSIDE DIAMETER RING SAMPLER OR SHELBY TUBE SAMPLER
▼	WATER LEVEL (Date)
Tr	TORVANE READINGS, tsf
Pp	PENETROMETER READING, tsf
DD	DRY DENSITY, pounds per cubic foot
LL	LIQUID LIMIT, percent
PI	PLASTIC INDEX
N	STANDARD PENETRATION, blows per foot

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UNIFIED SOIL CLASSIFICATION SYSTEM
PSE OPERATION TRAINING CENTER
PUYALLUP, WASHINGTON

Proj.No. T-8829 | Date: AUG 2023 | Figure A-1

LOG OF BORING NO. B-1

Figure No. A-2

Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 17, 2022

Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 4.5 ft **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot 10 30 50	Moisture Content (%)
0		Blackish-gray silty SAND, fine to coarse sand, moist to wet, trace rootlets, occasional silt seam. (SM)	Loose		
				5	20.4
▼					
5				5	29.1
				4	29.0
		Blackish-gray SAND with silt, fine to coarse sand, wet, trace small organic fragments. (SP-SM)			
10				7	27.5
		Test Boring terminated at approximately 10 feet. Groundwater seepage observed at approximately 4.5 feet.			
15					

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-2

Figure No. A-3

Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 17, 2022

Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 4.5 ft **Approx. Elev:** NA

Depth (ft)	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot 10 30 50	Moisture Content (%)
0	Blackish-gray SAND, fine to medium sand, moist, trace rootlets, occasional sandy silt seam. (SP)	Loose	9	10.1
5	Gray sandy SILT, fine sand, wet, occasional clayey silt layer, occasional rootlet. (ML)		6	31.6
	Gray clayey SILT, wet, trace rootlets, interbedded sand seams. (ML)	Soft	2	52.3
10		Stiff	9	31.1
	Blackish-gray SAND, fine to coarse sand, wet, interbedded silt seams. (SP)	Loose		27.5
15	Test Boring terminated at approximately 10 feet. Groundwater seepage observed at approximately 4.5 feet.			

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-3

Figure No. A-4

Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 17, 2022

Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 4.5 ft **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot 10 30 50	Moisture Content (%)
0		Gray SILT, moist, mottled, occasional rootlet, occasional sand seam. (ML)	Medium Stiff	5	35.4
▼					
5		Gray clayey SILT, wet, occasional rootlet. (ML)	Soft	2	36.7
		Blackish-gray SAND with silt, fine to coarse sand, wet, occasional small organic fragment, occasional clayey silt seam. (SP-SM)	Loose	5	27.3
10				6	29.0
		Test Boring terminated at approximately 10 feet. Groundwater seepage observed at approximately 4.5 feet.			
15					

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-4

Figure No. A-5

Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 17, 2022

Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 4.5 ft **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot 10 30 50	Moisture Content (%)
0		Gray SILT, moist, generally mottled, localized oxidized laminations, occasional rootlet, occasional charcoal inclusion. (ML)	Soft		
	├┤			● 3	38.7
▼					
5	├┤	Blackish-gray to gray clayey SILT, wet, mottled, occasional rootlet, occasional sand with silt layer. (ML)		● 2	37.7
	├┤	*Interbedded sand seams observed*	Medium Stiff	● 8	31.9
		Blackish-gray SAND, fine to coarse sand, wet, trace gravel, occasional silt seam. (SP)	Loose		23.7
10	├┤			● 7	24.8
		Test Boring terminated at approximately 10 feet. Groundwater seepage observed at approximately 4.5 feet.			
15					

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-5

Figure No. A-6

Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 17, 2022

Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 4.5 ft **Approx. Elev:** NA

Depth (ft)	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot 10 30 50	Moisture Content (%)
0	Alternating layers of brownish-gray silty SAND and sandy SILT, fine to medium sand, moist, mottled, trace rootlets. (SM/ML)	Very Loose	3	27.7
5	Gray clayey SILT, wet, mottled, trace sand, occasional rootlet. (ML)	Soft	2	40.6
		Medium Stiff	6	36.8
	Blackish-gray SAND with silt, fine to medium sand, wet, occasional silt seam. (SP-SM)	Loose		25.2
10	Blackish-gray SAND, fine to coarse sand, wet, occasional silt layer. (SP)	Very Loose	3	26.1
	Test Boring terminated at approximately 10 feet. Groundwater seepage observed at approximately 4.5 feet.			
15				

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-6

Figure No. A-7

Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 17, 2022

Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 6 ft **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot 10 30 50	Moisture Content (%)
0		Brownish-gray silty SAND, fine sand, moist, occasional rootlet, occasional clayey silt layer. (SM)	Loose	6	19.2
5 ▼		Alternating layers of silty SAND and sandy SILT, fine sand, moist to wet, mottled, occasional sand seam. (SM/ML)	Very Loose	3	28.8
		Gray SILT, moist to wet, mottled, interbedded sandy silt layers, occasional sand seam. (ML)	Soft	4	33.7
10		Gray clayey SILT, moist to wet, oxidized laminations. (ML)		3	39.7
		Test Boring terminated at approximately 10 feet. Groundwater seepage observed at approximately 6 feet.			
15					

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-7

Figure No. A-8

Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 16, 2022

Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 6 ft **Approx. Elev:** NA

Depth (ft)	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot	Moisture Content (%)
0	Brownish-gray silty SAND, fine sand, moist to wet, slightly mottled, trace sandy silt seams, occasional rootlet. (SM)			
		Very Loose	3	18.9
5		Loose	5	38.0
	Brownish-gray SAND with silt, fine to medium sand, wet, trace silt layers. (SP-SM)		8	29.0
10	Gray clayey SILT, moist, trace small organic fragments, interbedded sand layers. (ML) *Numerous organic PEAT inclusions observed in upper 6 inches of sample*	Soft	3	42.2
	Blackish-gray SAND with silt, fine to medium sand, wet, occasional silt layer. (SP-SM)	Loose	9	29.3
15		Medium Dense	17	29.1
20	Gray SILT, moist, occasional small organic fragment, interbedded and inundated sand layers. (ML)	Very Stiff	19	27.9
	Test Boring terminated at approximately 20 feet, Groundwater seepage observed at approximately 6 feet.			
25				

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-8

Figure No. A-9

Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 16, 2022

Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 10 ft **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot 10 30 50	Moisture Content (%)
0		FILL: Gray silty GRAVEL with sand, fine to coarse sand, fine to coarse gravel, wet, trace rootlets. (GM)	Loose	5	5.6
5		Brownish-gray clayey SILT, moist, mottled, trace sand seams, occasional rootlet. (ML)	Medium Stiff	5	30.4 16.8
		Brownish-gray SAND with silt, fine to medium sand, moist, occasional silt layer. (SP-SM)	Loose	5	36.0
		Gray sandy SILT, fine to medium sand, moist, mottled, trace sand seams. (ML)			
10 ▼		Blackish-gray SAND with silt, fine to coarse sand, wet, occasional silt layer. (SP-SM)	Medium Dense	11	26.4
		Gray SILT, moist to wet, trace sand seams, trace fine gravel. (ML)	Medium Stiff	5	44.4
15		Blackish-gray SAND with silt, fine to medium sand, wet, occasional fine gravel. (SP-SM)	Medium Dense	13	28.6
20		Dark gray SAND with silt, fine to medium sand, wet, occasional fine gravel, interbedded silt layers. (SP-SM)		20	27.8
25		Blackish-gray SAND with silt, fine to medium sand, wet, interbedded silt layers. (SP-SM)		24	27.6
30			Dense	31	24.2
		Test Boring terminated at approximately 30 feet. Groundwater seepage observed at approximately 10 feet.			
35					

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-9

Figure No. A-10

Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 16, 2022

Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 7.5 ft **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot	Moisture Content (%)
0					
	⊢	Brownish-gray silty SAND, fine sand, moist, occasional gravel, occasional rootlet, interbedded sand seams, interbedded silt seams. (SM)	Loose	6	16.3
5	⊢			5	17.8
▼	⊢	Gray sandy SILT, fine sand, moist to wet, mottled, interbedded and inundated sand seams. (ML)		7	33.5
10	⊢	Gray clayey SILT, moist to wet, occasional localized mottling, occasional localized oxidized lamination. (ML)	Medium Stiff	6	42.8
	⊢	Gray SILT, wet, occasional small organic fragment. (ML)		4	40.4
15	⊢	Blackish-gray SAND with silt, fine to medium sand, wet, interbedded silt layers. (SP-SM)	Loose	9	30.7
20	⊢	Light brown organic PEAT, wet, fibrous, trace sand. (PT) (Partially decomposed tree trunk)	Very Loose	3	211.4
25	⊢	Gray sandy SILT, fine to medium sand, wet, interbedded silty sand layers. (ML)	Medium Dense	26	33.2
30	⊢	Gray SILT with sand, fine to medium sand, wet, interbedded silty sand layers. (ML)	Stiff	13	32.2
		Test Boring terminated at approximately 30 feet. Groundwater seepage observed at approximately 7.5 feet.			
35					

SPT scale: 10 30 50

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LOG OF BORING NO. B-10

Figure No. A-11

Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 16, 2022

Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 10 ft **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot 10 30 50	Moisture Content (%)
0		Grayish-brown sandy SILT, fine sand, moist, localized mottling, localized oxidized laminations, trace small organic fragments, interbedded fine sand layers. (ML)	Loose	7	12.9
5				5	23.3
		Brownish-gray SAND, fine to medium sand, moist, occasional silt seam. (SP)		6	11.3
▼10		Gray SILT, moist to wet, oxidized laminations, trace small organic fragments, interbedded and inundated sand layers. (ML)	Medium Stiff	4	36.8
			Stiff	10	35.2
15		Gray SAND with silt, fine to medium sand, wet, interbedded silt layers. (SP-SM)	Medium Dense	14	28.4
		Gray sandy SILT, fine sand, moist to wet, occasional silt seam, occasional wood waste inclusion. (ML)			
20				13	32.6
		Test Boring terminated at approximately 20 feet. Groundwater seepage observed at approximately 10 feet.			
25					

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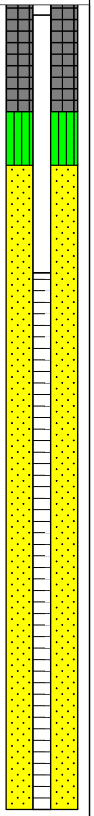
LOG OF BORING NO. B-11

Figure No. A-12

Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 16, 2022

Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 10 ft **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot 10 30 50	Moisture Content (%)	Observ. Well
0		Brownish-gray SILT with sand, fine sand, moist, mottled, trace rootlets. (ML)	Medium Stiff	4	36.6	
5		Brownish-gray silty SAND, fine sand, moist to wet, interbedded silt with sand layers. (SM)	Loose	4	24.3	
		Gray SAND with silt, fine to medium sand, moist to wet, interbedded and mottled silty sand and silt layers. (SP-SM)		5	28.2	
▼10				4	30.7	
		Gray SILT, moist to wet, interbedded and inundated sand with silt layers. (ML)	Stiff	8	46.2	
15		Gray SAND with silt, fine to medium sand, wet, occasional silt layer. (SP-SM)	Medium Dense	11	31.2	
20		Test Boring terminated at approximately 15 feet. Groundwater seepage observed at approximately 10 feet. Boring converted to groundwater monitoring well with monument no. BNV 571.				

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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LOG OF BORING NO. B-12

Figure No. A-13

Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 16, 2022

Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 9 ft **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot 10 30 50	Moisture Content (%)
0		FILL: Gray GRAVEL with silt and sand, fine to coarse sand, fine to coarse gravel, moist, scattered rootlets. (GP-GM)	Loose	8	9.1
5		Gray SILT, moist, mottled, trace sand seams. (ML)	Stiff	11	32.5
		Brown SAND, fine to coarse sand, moist, (SP)	Medium Dense		9.6
▼		Gray SAND with silt, fine to coarse sand, moist to wet, trace gravel, occasional silt seam. (SP-SM)		10	16.3
10		Blackish-gray SAND, fine to coarse sand, wet, trace fine gravel, trace silt. (SP)		11	24.7
				12	18.7
15			Loose	9	19.8
		Test Boring terminated at approximately 15 feet. Groundwater seepage observed at approximately 9 feet.			
20					

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LOG OF BORING NO. B-13

Figure No. A-14

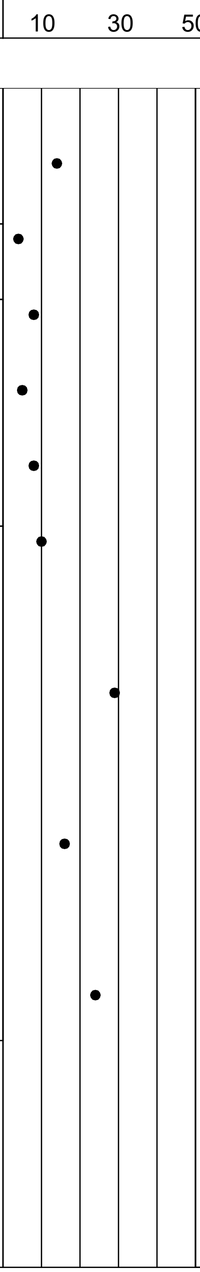
Project: PSE Operational Training Facility **Project No:** T-8829 **Date Drilled:** November 16, 2022

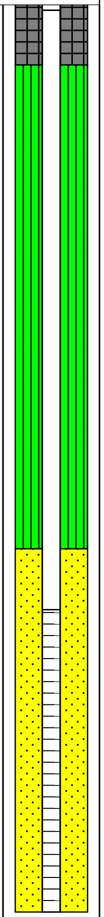
Client: Trammel Crow Company **Driller:** BoreTec **Logged By:** MJX

Location: Puyallup, Washington **Depth to Groundwater:** 10 ft **Approx. Elev:** NA

Soil Description	Consistency/ Relative Density
FILL: Gray GRAVEL with silt and sand, fine to coarse sand, fine to coarse gravel, moist. (GP-GM)	Medium Dense
Brownish-gray sandy SILT, fine sand, moist, mottled, occasional gravel, occasional rootlet. (ML)	Loose
Gray SILT, moist to wet, oxidized laminations, trace sand, occasional small organic fragment, interbedded sand with silt and silty sand layers. (ML)	Medium Stiff
Blackish-gray SAND with silt, fine to medium sand, wet, occasional fine gravel, interbedded silty sand and silt layers. (SP-SM)	Medium Dense
Test Boring terminated at approximately 30 feet. Groundwater seepage observed at approximately 10 feet. Boring converted to groundwater monitoring well with monument no. BNV 572.	

Depth (ft)	SPT (N) Blows / foot	Moisture Content (%)
	14	9.9
5	4	22.3
	8	20.1
10	5	36.5
	8	26.5
15	10	31.2
20	29	25.0
25	16	26.6
30	24	24.9





NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

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Particle Size Distribution Report

	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.1	0.4	49.7	49.8	
☐	0.0	0.0	0.2	0.3	6.9	82.8	9.8	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.2081	0.1612	0.0773					
☐			0.3720	0.2736	0.2455	0.1961	0.1585	0.0795	1.77	3.44

Material Description	USCS	AASHTO
○ Silty SAND	SM	
☐ SAND with silt	SP-SM	

Project No. T-8829 **Client:** Trammel Crow Company

Project: PSE Operational Training Facility

○ **Location:** Test Boring B-7 **Depth:** 2.5 ft **Sample Number:** 1

☐ **Location:** Test Boring B-8 **Depth:** 15 ft **Sample Number:** 7

Terra Associates, Inc.

Kirkland, WA

Remarks:

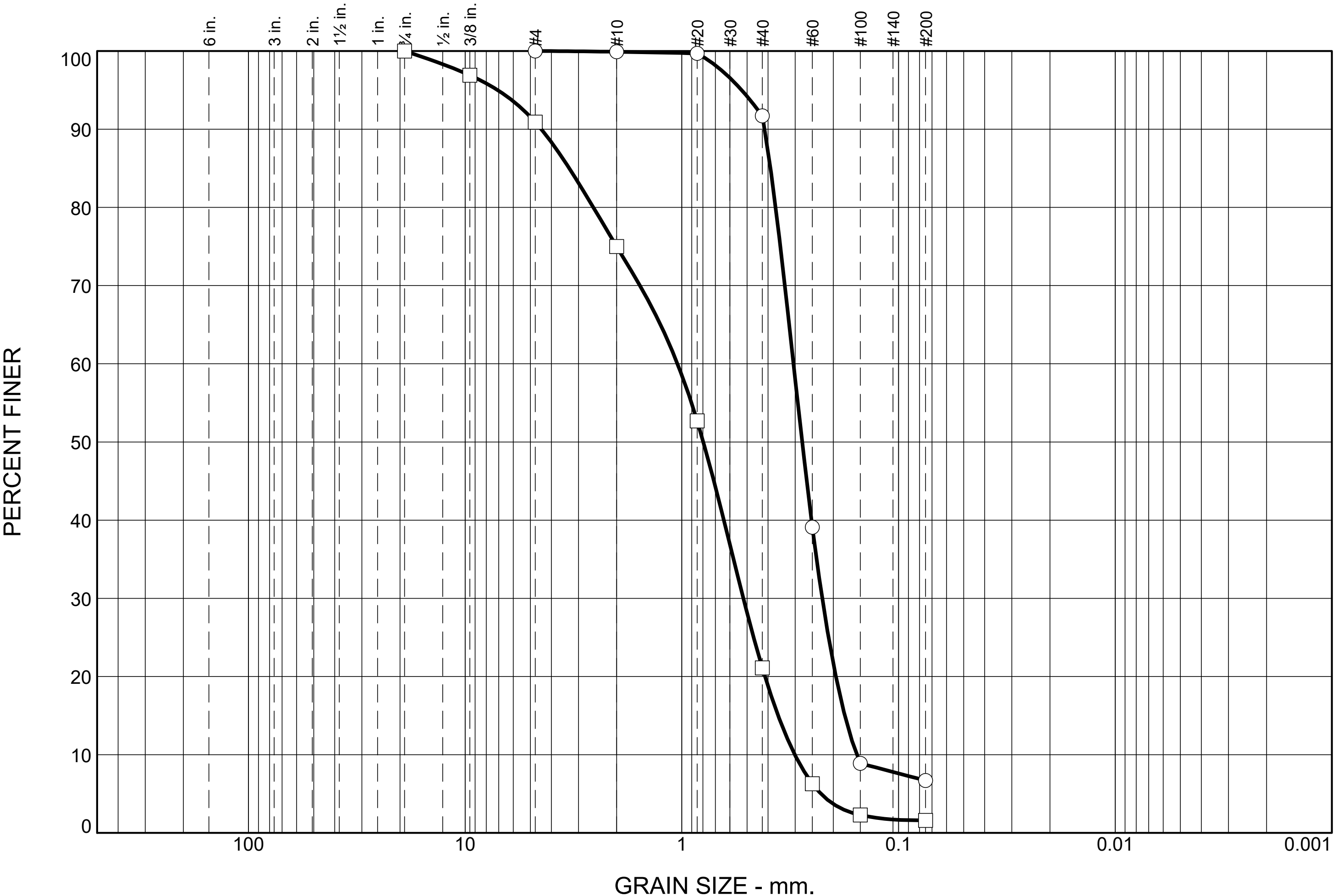
○ Tested on November 29, 2022

☐ Tested on November 29, 2022

Figure A-15

Tested By: KJ

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.1	8.2	85.0	6.7	
□	0.0	0.0	9.1	15.9	53.9	19.5	1.6	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.3897	0.3051	0.2784	0.2251	0.1769	0.1556	1.07	1.96
□			3.3088	1.0474	0.7961	0.5200	0.3592	0.3008	0.86	3.48

Material Description	USCS	AASHTO
○ SAND with silt	SP-SM	
□ SAND	SP	

Project No. T-8829 **Client:** Trammel Crow Company

Project: PSE Operational Training Facility

○ **Location:** Test Boring B-8 **Depth:** 25 ft **Sample Number:** 9

□ **Location:** Test Boring B-12 **Depth:** 15 ft **Sample Number:** 7

Terra Associates, Inc.

Kirkland, WA

Remarks:

○ Tested on November 29, 2022

□ Tested on November 29, 2022

Figure A-16

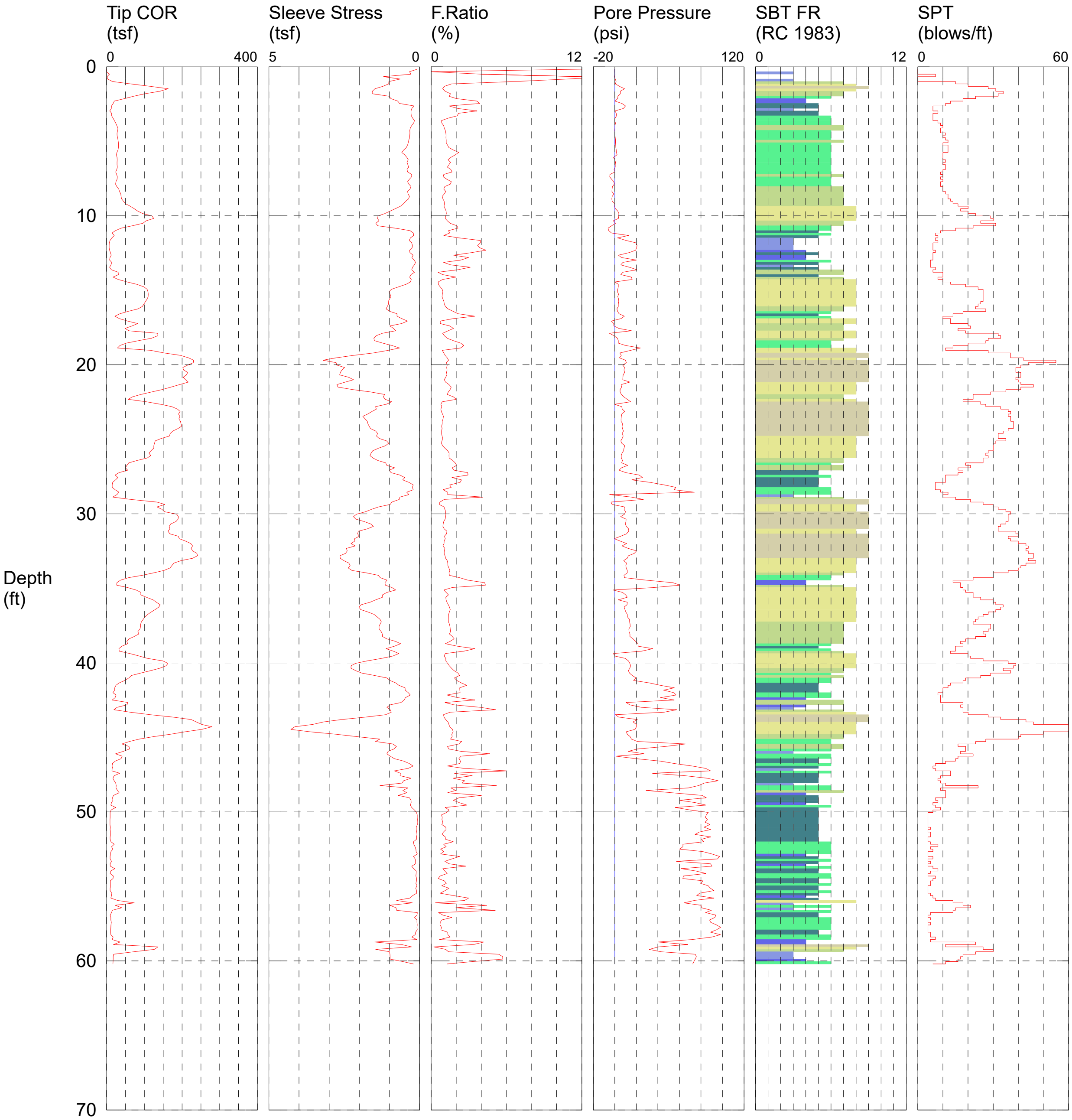
Tested By: KJ

CPT LOGS

CPT-01

CPT CONTRUCTOR: In Situ Engineering
CUSTOMER: Terra Associates
LOCATION: Puyallup
JOB NUMBER: T-8829
COMMENT: PSE Operational Training Center
COMMENT:

OPERATOR: Okbay
CONE ID: DDG1351
TEST DATE: 11/18/2022 11:40:03 AM
PREDRILL: 0 ft
BACK FILL: 20% Grout + Bentonite Chips
SURFACE PATCH: None



TOTAL DEPTH: 60.203 ft

DEPTH INTERVAL: 0.050 m

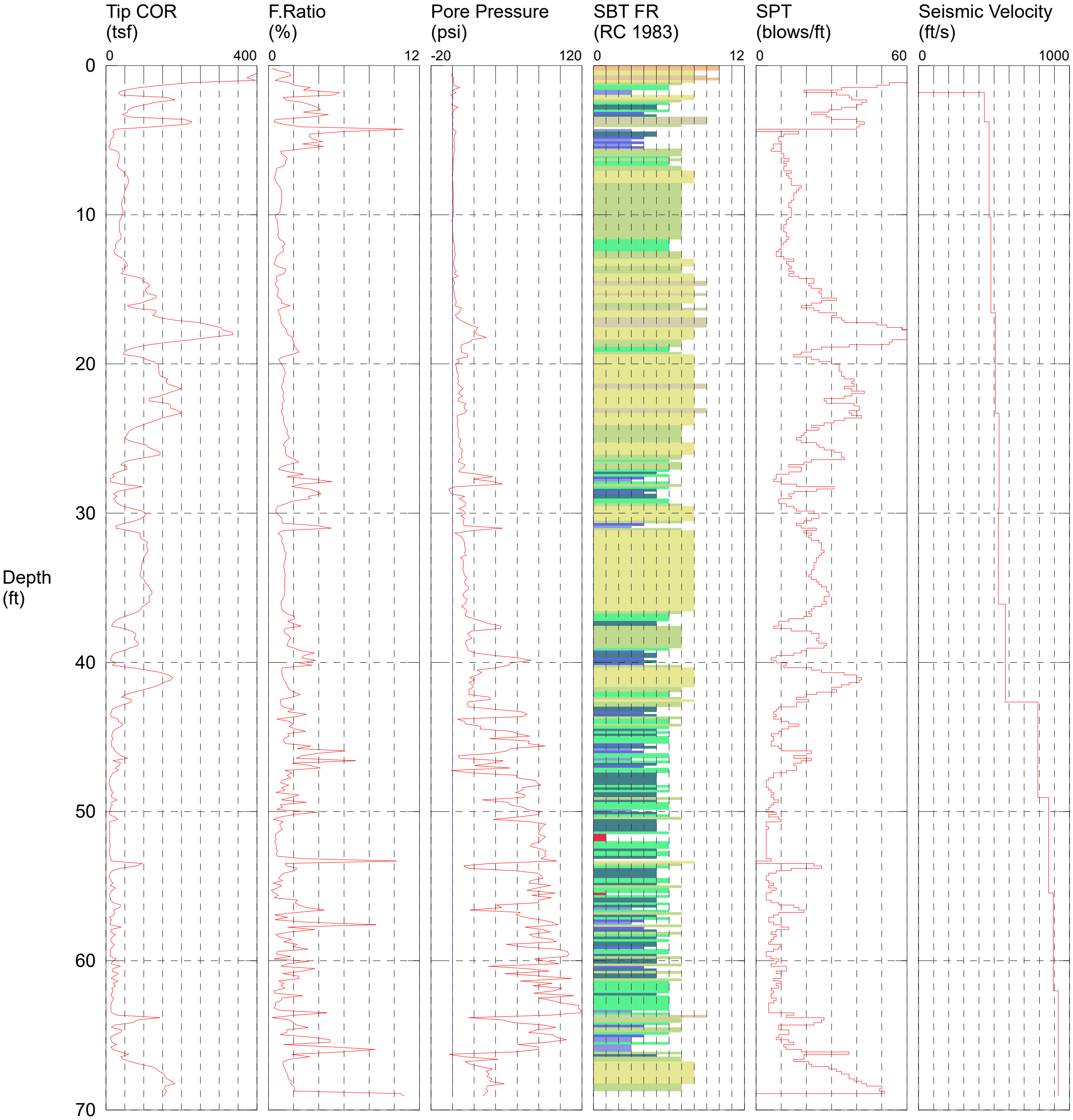
🟥 1 sensitive fine grained
🟥 2 organic material
🟦 3 clay
🟦 4 silty clay to clay
🟩 5 clayey silt to silty clay
🟩 6 sandy silt to clayey silt
🟩 7 silty sand to sandy silt
🟨 8 sand to silty sand
🟫 9 sand
🟧 10 gravelly sand to sand
⬜ 11 very stiff fine grained (*)
⬛ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

CPT-02

CPT CONTRUCTOR: In Situ Engineering
CUSTOMER: Terra Associates
LOCATION: Puyallup
JOB NUMBER: T-8829
COMMENT: PSE Operational Training Center
COMMENT:

OPERATOR: Okbay
CONE ID: DDG1351
TEST DATE: 11/18/2022 1:29:19 PM
PREDRILL: 0 ft
BACK FILL: 20% Grout + Bentonite Chips
SURFACE PATCH: None



TOTAL DEPTH: 69.062 ft

DEPTH INTERVAL: 0.050 m

■ 1 sensitive fine grained
■ 2 organic material
■ 3 clay
■ 4 silty clay to clay
■ 5 clayey silt to silty clay
■ 6 sandy silt to clayey silt
■ 7 silty sand to sandy silt
■ 8 sand to silty sand
■ 9 sand
■ 10 gravelly sand to sand
■ 11 very stiff fine grained (*)
■ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

HOLE NUMBER: CPT-02

OPERATOR: Okbay

CUSTOMER:

LOCATION: Puyallup

JOB NUMBER: T-8829

CPT CONTRUCTOR: In Situ Engineering

CONE ID: DDG1351

TEST DATE: 11/18/2022 1:29:19 PM

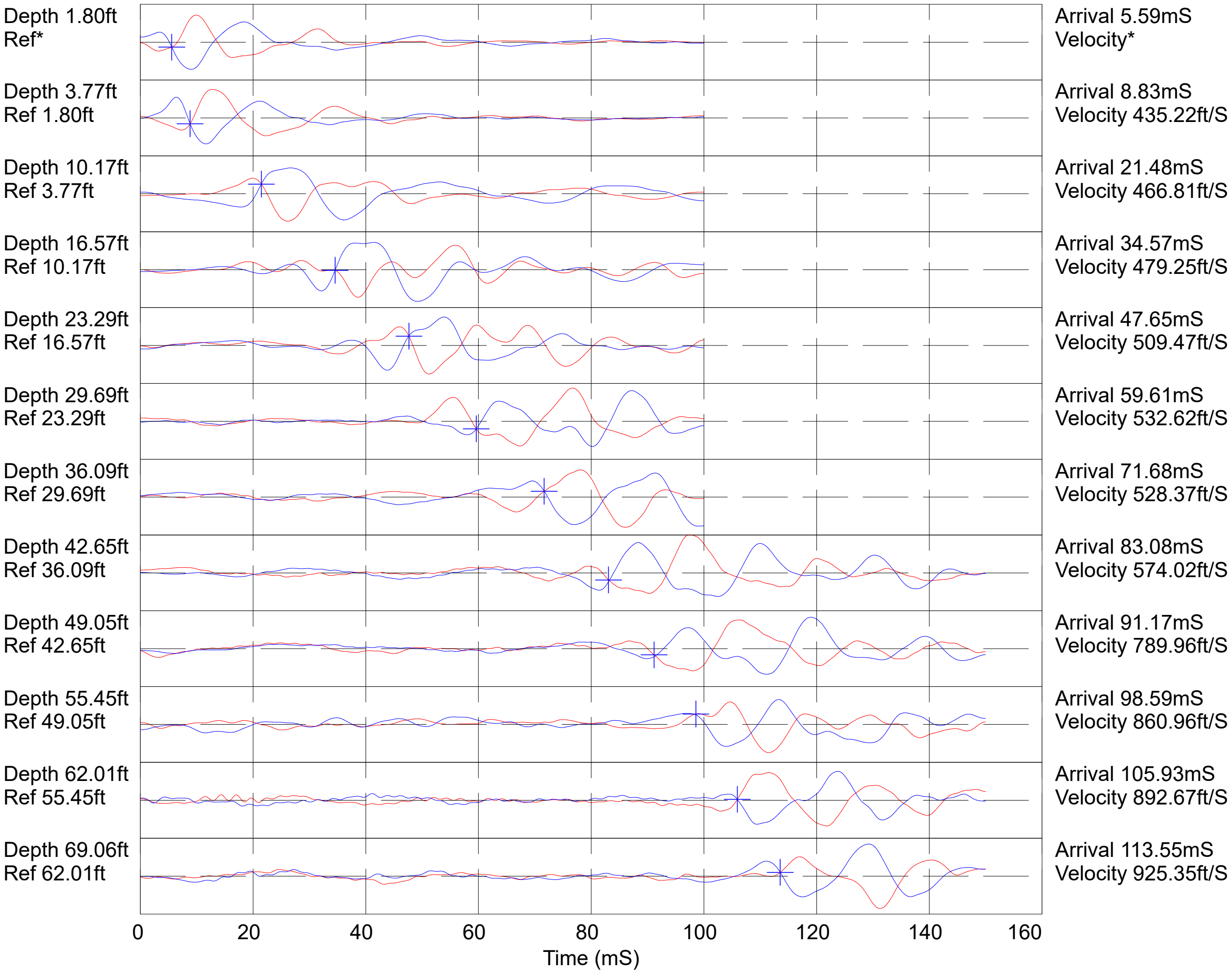
COMMENT: PSE Operational Training Center

PREDRILL 0 ft

BACK FILL: 20% Grout + Bentonite Chips

SURFACE PATCH: None

HOLE NUMBER: CPT-02

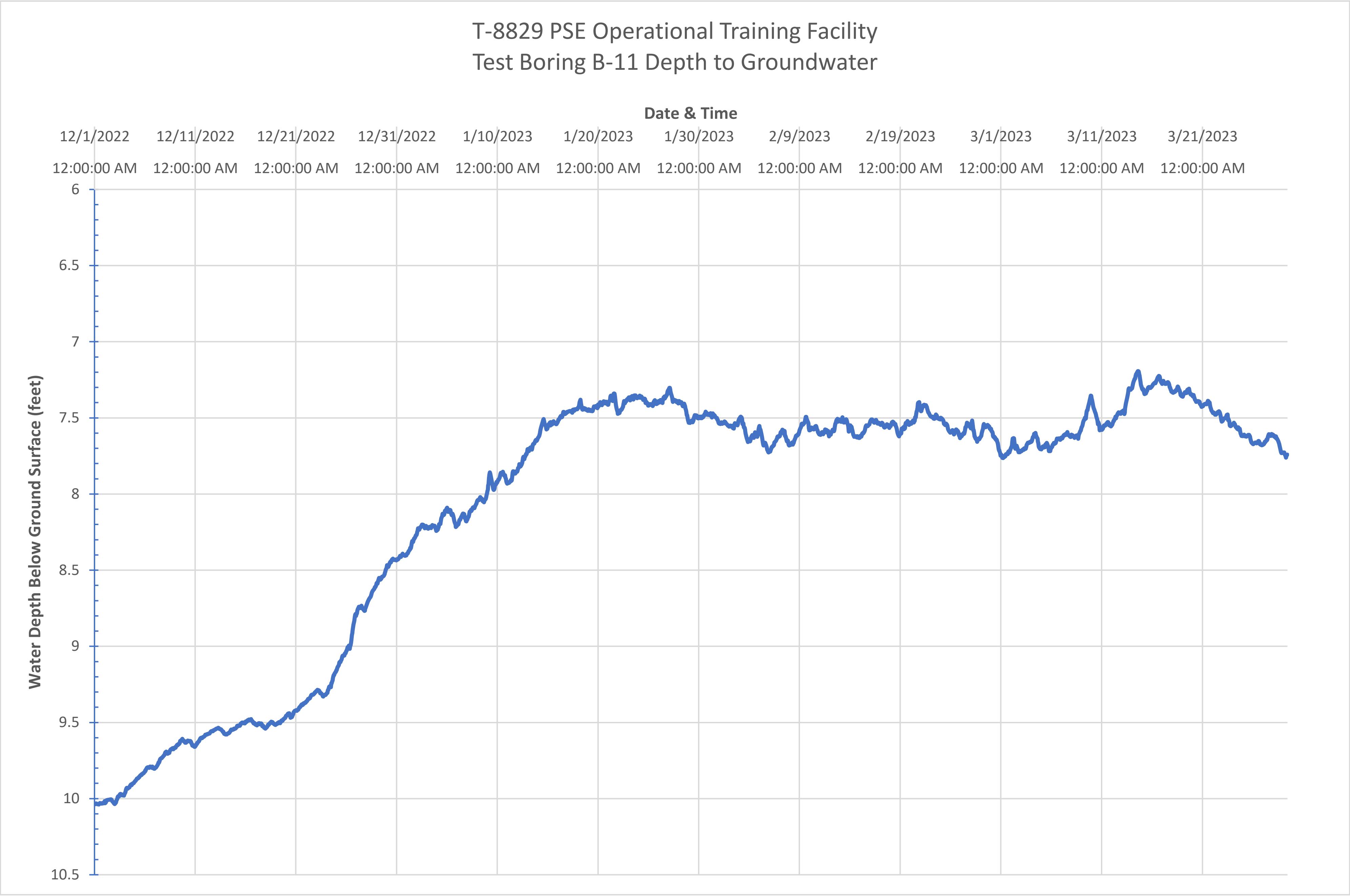


Hammer to Rod String Distance (ft): 2.62
* = Not Determined

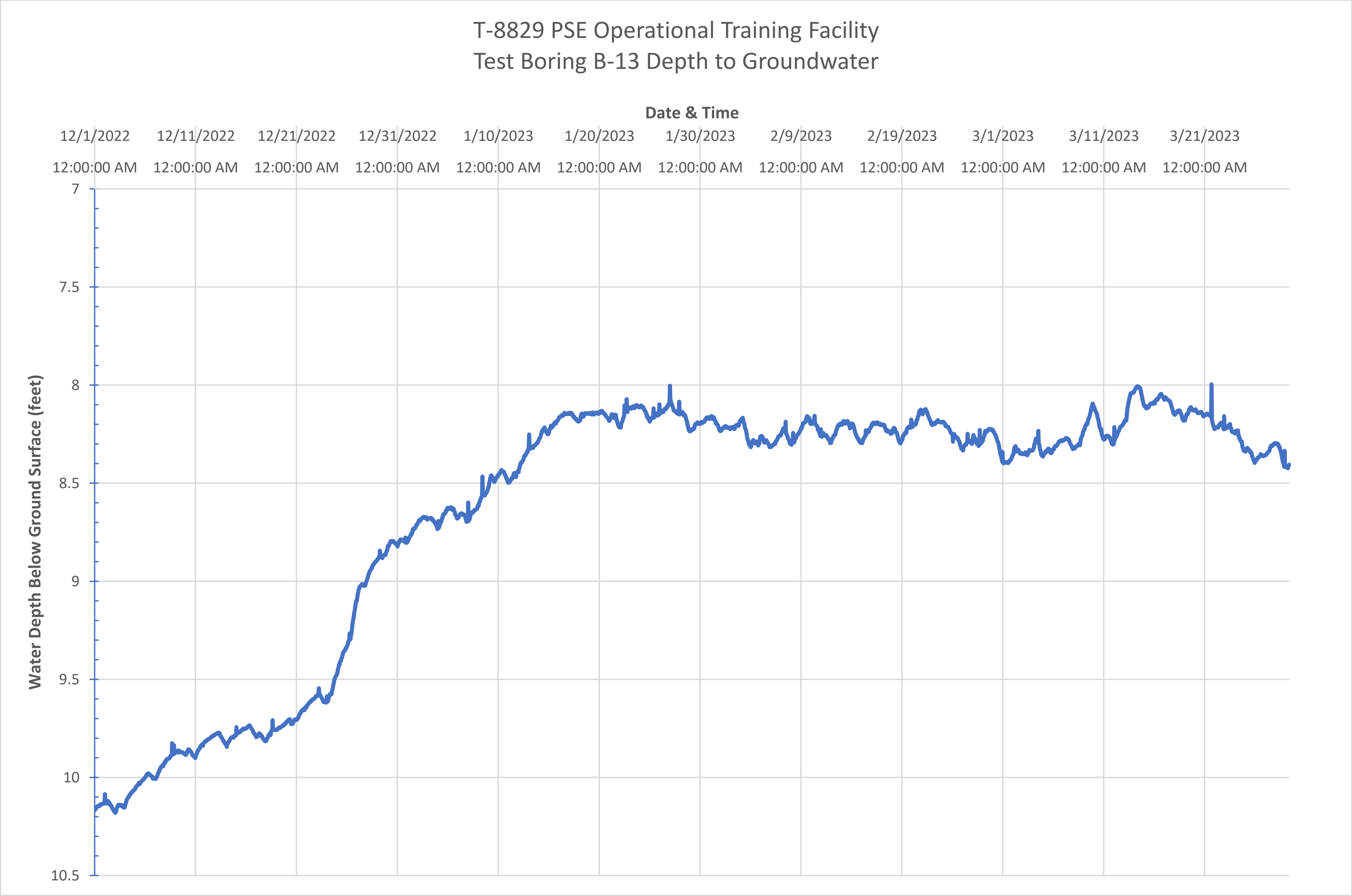
COMMENT: PSE Operational Training Center

APPENDIX B

GROUNDWATER MONITORING HYDROGRAPHS



T-8829 PSE Operational Training Facility
Test Boring B-11 Depth to Groundwater

T-8829 PSE Operational Training Facility
Test Boring B-13 Depth to Groundwater
Date & Time
12/1/2022 12:00:00 AM
12/11/2022 12:00:00 AM
12/21/2022 12:00:00 AM
12/31/2022 12:00:00 AM
1/10/2023 12:00:00 AM
1/20/2023 12:00:00 AM
1/30/2023 12:00:00 AM
2/9/2023 12:00:00 AM
2/19/2023 12:00:00 AM
3/1/2023 12:00:00 AM
3/11/2023 12:00:00 AM
3/21/2023 12:00:00 AM
Water Depth Below Ground Surface (feet)
7
7.5
8
8.5
9
9.5
10
10.5

APPENDIX C

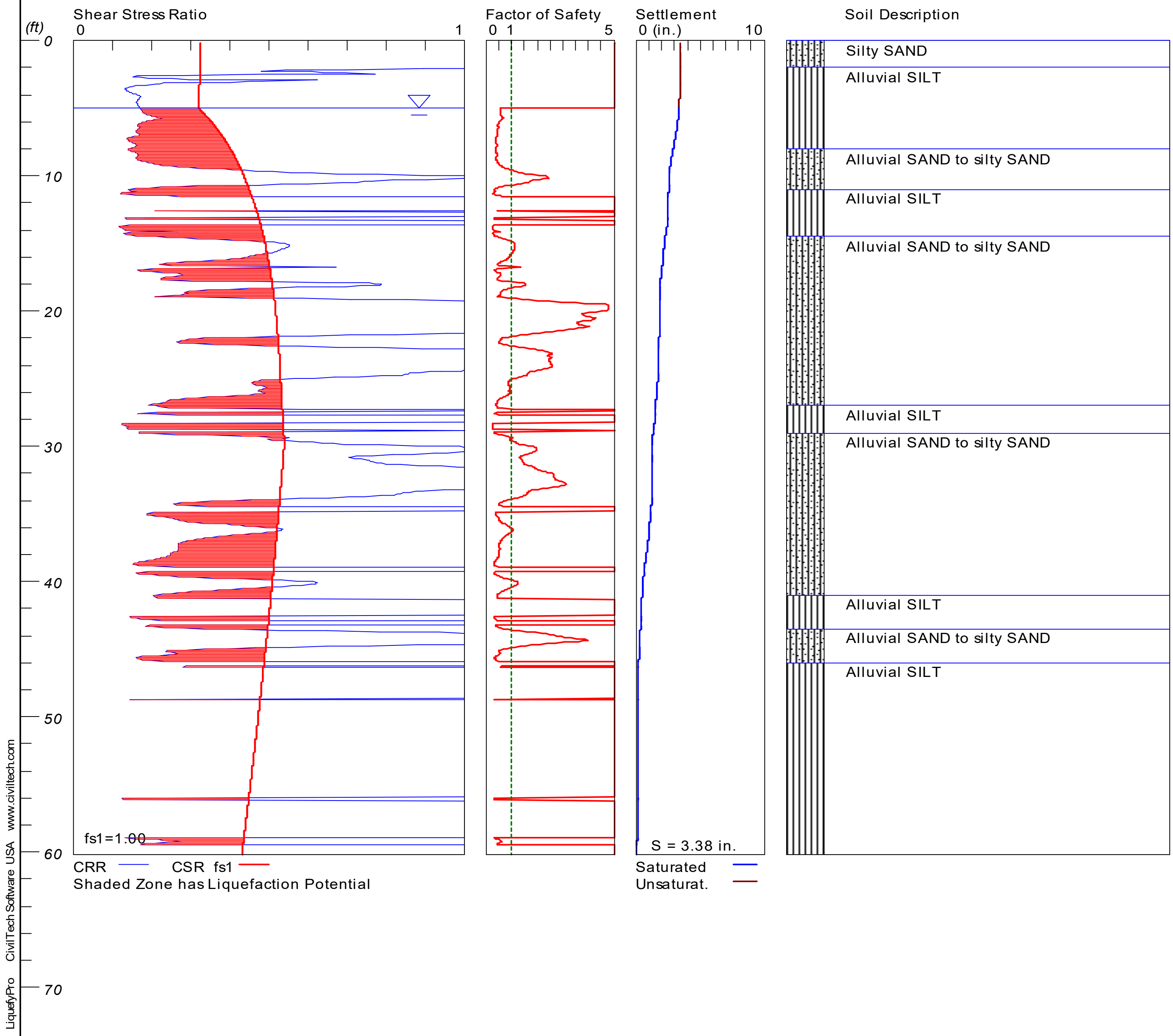
LIQUEFACTION ANALYSIS RESULTS

LIQUEFACTION ANALYSIS

T-8829 PSE Operational Training Facility

Hole No.=CPT-01   Water Depth=5 ft

Magnitude=7
Acceleration=0.5g



LIQUEFACTION ANALYSIS

T-8829 PSE Operational Training Facility

Hole No.=CPT-02 Water Depth=5 ft

Magnitude=7
Acceleration=0.5g