GEOTECHNICAL REPORT

Poulsbo Division 8
Jensen Way NE and NE Sunset Street
Poulsbo, Washington

Project No. T-8308

Terra Associates, Inc.

Prepared for:

Poulsbo Place Phase II, LLC
Bremerton, Washington

March 24, 2020

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

March 24, 2020
Project No. T-8308

Mr. Mike Brown
Poulsbo Place Phase II, LLC
423 Pacific Avenue, Suite 402
Bremerton, Washington 98337

Subject: Geotechnical Report
Poulsbo Division 8
Jensen Way NE and NE Sunset Street
Poulsbo, Washington

Dear Mr. Brown:

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

Our field exploration indicates the site soils generally consist of scattered fills and loose to dense native silt, silty sand, and silty sand with gravel overlying stiff to hard, moist, massive, clayey silt to silty clay. We observed localized wet soil zones indicative of perched groundwater in four of the test borings.

Based on our study, there are no geotechnical conditions that would preclude the planned development. In our opinion, structures can be supported on conventional spread footings bearing on competent native soils or on structural fill placed on a competent native soil subgrade. Floor slabs and pavements can be similarly supported.

Detailed recommendations addressing these issues and other geotechnical design considerations are presented in the attached report. 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.

John C Sadler

John C. Sadler, E.I.G., L.H.G.
Project Manager/Senior Engineering Geologist

Theodore J. Schepper
26742

3-24-2020

Theodore J. Schepper, P.E.
Principal

cc: Mr. Charlie Wenzlau, Wenzlau Architects

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1.0 PROJECT DESCRIPTION

The planned project is a mixed-use residential development. A conceptual development plan and site section plan by Wenzlau Architects, dated December 4, 2018 shows the proposed development consisting of 5 multi-unit townhome buildings in the eastern portion of the site and two mixed-use retail/residential buildings in the western portion of the site along with associated infrastructure and access improvements.

The plans indicate that the five townhome units will be two-story structures with a below-grade parking garage that spans all five units. The two mixed-use buildings have two levels of multi-family residential units over one level of structured below-grade parking that spans beneath both buildings. Building elevations are not indicated on the plan; however, the conceptual site section plan shows the main floor level of the five townhouse units constructed at the elevation of 3rd Avenue NE. The lower level of the two mixed-use buildings is shown at the elevation of Jensen Way NE. Foundation loads for the structures should be relatively light, in the range of 2 to 3 kips per foot for bearing walls and 25 to 50 kips for isolated columns.

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

2.0 SCOPE OF WORK

We explored subsurface conditions at the site by drilling eight 26.5-foot deep test borings with a limited-access track-mounted drill rig using hollow-stem auger drilling methods. Using the information obtained from the subsurface exploration and laboratory testing, analyses were undertaken to develop geotechnical recommendations for project design and construction. Specifically, this report addresses the following:

- Soil and groundwater conditions.
- Geologic Hazards per the City of Poulsbo Municipal Code.
- Seismic design parameters per the current International Building Code (IBC).
- Site preparation and grading.
- Excavation and shoring.
- Foundations

- Slab-on-grade floors.
- Lateral earth pressures for retaining wall design.
- Infiltration feasibility.
- 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 a vacant 2.2-acre assemblage of two parcels located southeast of and adjacent to the intersection of Jensen Way NE and NE Sunset Street in Poulsbo, Washington. The approximate site location is shown on Figure 1.

Site topography generally slopes down to the west over a slight relief of about 25 feet. A topographic site plan by MAP, Ltd dated March 19, 2014 shows existing surface gradients in the eastern portion of the site of about 10 to 35 percent with localized slope areas inclined at 40 to 60 percent over heights of about 6 to 8 feet. Surface gradients in the western portion of the site are generally flatter than 20 percent with localized 40 percent slope areas less than 6 feet in height.

A rockery with an estimated height of about 5 to 8 feet faces a vertical grade transition adjacent to the southern approximately 250 feet of the western property boundary. We were unable to closely view conditions above the rockery due to dense brush, or the face of the rockery, which lies on the Poulsbo Post Office property.

We observed evidence of past grading including a flat bench cut in the northeastern portion of the site, a fill lobe pushed out over the west-facing slope immediately south of the bench, and a stormwater detention pond located in the north-central portion of the site west of the bench cut. We observed standing water in the pond about five to six feet below adjacent grade to the west. We were unable to determine if there is an active inlet to the pond due to the presence of dense brush within and around the pond.

Review of historical aerial photographs using Google Earth shows site grading activities occurring between 2006 and 2007. The grading appears related to development of residential areas immediately north and northeast of the site. An aerial photograph from 1994 shows the western portion of the site occupied by seven residential-size structures. The structures had all been removed from the site in the next available photograph dated March 2004.

We observed areas of surface water accumulation in a relatively flat area in the southwestern portion of the site that is currently used as a parking lot. Based on our observations, it appears that precipitation is the primary source of the water at this location. We did not observe indications of persistent seepage or wet soil conditions on the site slopes; however, most slope areas, including areas upgradient from the parking lot, are obscured from view by dense brush.

Site vegetation consists primarily of dense blackberry vines. Younger trees are scattered along the eastern site margin and within the perimeter of the existing pond.

3.2 Soils

The native soils underlying the site generally consist of very stiff to hard, moist, massive, clayey silt to silty clay. We observed loose to medium dense sandy silt to silty sand and medium dense to dense, iron-oxide stained silty sand with gravel interpreted to be older glacial outwash deposits overlying the silt and clay in several of the borings.

We observed fill or possible fill/disturbed soils overlying the native soils in five of the eight test borings. The fill was typically observed in the upper approximately 5 to 6.5 feet of the borings and included loose to medium dense silty sand with gravel, very loose to medium dense sandy silt to silty sand, and soft clayey silt. Most of the fill materials contained trace to scattered amounts of organics.

The *Geologic Map of the Seabeck and Poulsbo 7.5-minute Quadrangles, Kitsap and Jefferson Counties, Washington* by M. Polenz, et al. (2013) shows surficial geology of the site consisting of pre-Vashon silt (Qpf) that is described as glaciolacustrine but may also include non-glacial deposits. The very stiff to hard silt and clay observed in the test borings is generally consistent with this geologic map unit.

Detailed descriptions of the subsurface conditions we observed in our site explorations are presented on the Boring Logs in Appendix A. The approximate boring locations are shown on Figure 2.

3.3 Groundwater

Groundwater was encountered in four of the eight test borings. In Borings B-1, B-2, and B-5, groundwater is perched above very stiff clayey silt to silty clay at depths of 15 feet, 10 feet, and between 11.5 and 15 feet, respectively. In Boring B-8, wet soils were encountered in the upper approximately five feet of the boring.

The occurrence of shallow perched groundwater is typical for sites underlain by relatively-impermeable materials such as glacially consolidated silt and clay or till. We expect that perched groundwater levels and flow rates will fluctuate seasonally and will typically reach their highest levels during and shortly following the wet winter months (October through May).

3.4 Geologic Hazards

Per the Poulsbo Municipal Code (PMC), we evaluated site conditions for the presence of geologically hazardous areas as defined or identified in WAC 365-190-030, WAC 365-190-120, and as categorized in PMC Section 16.20.410. Geologically hazardous areas include areas susceptible to erosion, sliding, earthquake, or other geological events and are categorized by the PMC as follows:

1. Geologically Hazardous Areas

a. Areas with slopes greater than 30 percent and mapped by the Coastal Zone Atlas or Quaternary Geology and Stratigraphy of Kitsap County as unstable (U), unstable old landslides (UOS) or unstable recent slides (URS).

b. Areas with slopes greater than thirty percent in grade and deemed by a qualified geologist or geotechnical engineer to meet the criteria of U, UOS, or URS.

2. Areas of Geologic Concern

a. Areas designated U, UOS, or URS in the Coastal Zone Atlas or Quaternary Geology and Stratigraphy of Kitsap County, with slopes less than thirty percent; or areas found by a qualified geologist to meet the criteria for U, URS, or UOS with slopes less than 30 percent.

b. Slopes identified as intermediate (I) in the Coastal Zone Atlas or Quaternary Geology and Stratigraphy of Kitsap County, or areas found by a qualified geologist to meet the criteria of I.

c. Slopes 15 percent or greater, not classified as I, U, UOS, or URS, with soils classified by the U.S. Department of Agriculture Natural Resources Conservation Service as “highly erodible” or “potentially highly erodible.”

d. Slopes of 15 percent or greater with springs or groundwater seepage not identified in subsections (A)(2)(a) through (c) of this section.

e. Seismic areas subject to liquefaction from earthquakes (seismic hazard areas) such as hydric soils as identified by the Natural Resources Conservation Service, and areas that have been filled to make a site more suitable. Seismic areas may include former wetlands which have been covered with fill.

f. Areas mapped as “severe” in all development limitations based on mapped soil units of the USDA Soil Conservation Service. These designations are listed in Table 10 of Soil Survey of Kitsap County Area, Washington.

In our opinion, conditions falling into the category of Geologically Hazardous Areas do not exist at the site. Slope areas at the site that are 15 percent and steeper meet the defining criteria of the Areas of Geologic Concern category given in above item b (per the *Quaternary Geology and Stratigraphy of Kitsap County, Washington* map unit criteria) and item f. Discussion of potential hazards as they relate to the subject site is presented below.

3.4.1 Erosion Hazard Areas

Per WAC 365-190-030 those areas containing soils which, according to the United States Department of Agriculture Natural Resources Conservation Service Soil Survey Program, may experience significant erosion. Erosion hazard areas also include coastal erosion-prone areas and channel migration zones.

The Natural Resources Conservation Service (NRCS) has mapped the site soils as *Kitsap silt loam, 2 to 8 percent slopes* and *Kitsap silt loam, 15 to 30 percent slopes* in the western and eastern portions of the site, respectively. The NRCS describes the erosion hazard of the *Kitsap silt loam, 2 to 8 percent slopes* soil and the *Kitsap silt loam, 15 to 30 percent slopes* soil as slight and severe, respectively. In our opinion, the erosion hazard described as severe meets the definition of an erosion hazard area given above. The approximate location of the erosion hazard area at the site is shown on Figure 3.

We did not observe any indications of significant active erosion at the site; however, the site soils will be susceptible to erosion when exposed during development. In our opinion, the erosion potential of the site soils would be adequately mitigated with proper implementation and maintenance of Best Management Practices (BMPs) for erosion prevention and sedimentation control in the planned development area. BMPs for erosion prevention and sedimentation control will need to be in place prior to and during site development and should be maintained until permanent site stabilization measures are in place. All BMPs for erosion prevention and sedimentation control should conform to City of Poulsbo requirements.

3.4.2 Landslide Hazard Areas

Chapter 16.20.155 of the PMC defines landslide hazard areas as "…areas potentially subject to risk of mass movement due to a combination of geologic, topographic and hydrologic factors." Per WAC 365-190-120(6), geologically hazardous areas include the following:

(a) Areas of historic failures, such as:

> (i) Those areas delineated by the United States Department of Agriculture Natural Resources Conservation Service as having a significant limitation for building site development.
>
> (ii) 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.
>
> (iii) 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.

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

> (i) Slopes steeper than 15 percent.
>
> (ii) Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bed-rock.
>
> (iii) Springs or groundwater seepage.

(c) Areas that have shown movement during the holocene epoch (from ten thousand years ago to the present) or which are underlain or covered by mass wastage debris of this epoch;.

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

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

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

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

(h) Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or cata-strophic flooding.

(i) Any area with a slope of forty percent or steeper and with a vertical relief of ten 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 ten feet of vertical relief.

We did not observe conditions meeting the above criteria at the site. Based on our observations of existing surface and soil conditions and the apparent absence of groundwater seepage on the slope, it is our opinion that the site slopes are currently stable with respect to deep seated ground movement. Additionally, based on our review of the proposed development plan, we expect that any potential stability hazard associated with existing site slopes would be eliminated by grading.

Our opinion of existing slope stability is supported by the results of stability analyses discussed below.

Stability Analysis

We performed stability analyses of the steep slope using the computer program Slide 2018. Soil parameters used for our analyses are based on field data and our experience with similar soils. These parameters are shown on the attached Slide 2018 output. Our analyses were performed for both static and pseudostatic (seismic) conditions on a slope section identified on Figure 3 as Section A-A’.

The pseudostatic analysis used a horizontal earthquake coefficient value of 0.2g to model ground motions expected from a severe earthquake. The seismic acceleration used is one-half of the value determined for the site using the United States Geological Survey (USGS) Earthquake Hazards Program Universal Hazard Tool website (https://earthquake.usgs.gov/hazards/interactive/) for a seismic event having a 10 percent probability of exceedance in a 50-year period (475-year return period). The lowest safety factors determined by our analyses are presented in the following table:

	Minimum Safety Factors	
Section Analyzed	**Static**	**Pseudostatic k_h=0.2g**
A-A'	2.94	1.77

The results of the stability analyses indicate that the modeled slope area is stable with respect to deep-seated failure under static and pseudostatic conditions. The safety factors listed above are all higher than the minimum safety factors considered acceptable for stable slopes by local geotechnical engineering practice. The results of the stability analyses are attached in Appendix B.

3.4.3 Seismic Hazard Areas

Per WAC 365-190-030(18), seismic hazard areas are areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement, soil liquefaction, debris flows, lahars, or tsunamis.

Based on the soil and groundwater conditions we observed in our subsurface explorations, it is our opinion that there is no risk for damage resulting from seismically induced slope failure, settlement, soil liquefaction, debris flows, lahars, or tsunamis. In our opinion, unusual seismic hazard areas do not exist at the site and design in accordance with local building codes for determining seismic forces would adequately mitigate impacts associated with ground shaking.

3.5 Seismic Design Parameters

Based on soil conditions observed in the test pits and our knowledge of the area geology, per Chapter 16 of the current International Building Code (IBC), site class "D" should be used in structural design. Based on this site class, in accordance with the IBC, the following parameters should be used in computing seismic forces:

Spectral response acceleration (Short Period), S_{Ms}	1.311 g
Spectral response acceleration (1 – Second Period), S_{M1}	0.788 g
Five percent damped .2 second period, S_{Ds}	0.874 g
Five percent damped 1.0 second period, S_{D1}	0.525 g

The above values were determined for Latitude 47.737795°N and Longitude -122.645915°W using the web site https://seismicmaps.org, accessed March 23, 2020.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 General

Based on our study, it is our opinion that the site is suitable for the proposed development from a geotechnical standpoint. The fine-grained native soils are extremely moisture sensitive and are generally unsuitable for use as fill and backfill. The contractor should be prepared to import clean granular material for use as structural fill and backfill. Existing fill materials observed at the site are typically fine grained and poorly consolidated and will likely require removal and replacement with structural fill.

Undisturbed bearing surfaces composed of the fine-grained native soils would provide suitable support for conventional spread footing foundations and floor slabs; however, the soils will be easily disturbed by normal construction activity, particularly when wet. If disturbed, the soil will not be suitable for support, and the affected material would need to be removed with the foundations lowered to obtain support on an undisturbed soil subgrade. Alternatively, the soils can be removed, and grade restored with granular structural fill. To reduce the potential for subgrade disturbance, particularly during wet weather, consideration should be given to placing four inches of one- to two-inch sized crushed rock or a four-inch layer of lean concrete on completed subgrades to serve as a working surface.

The following sections provide detailed recommendations regarding these issues and other geotechnical design considerations. These recommendations should be incorporated into the final design drawings and construction specifications.

4.2 Site Preparation and Excavation

To prepare the site for construction, all vegetation, organic surface soils, and other deleterious materials should be removed from areas of planned construction. Soils containing organic material will not be suitable for use as structural fill but may be used for limited depths in nonstructural areas. Demolition of previous site improvements should include removal of existing buried utilities that will be abandoned, or they should be sealed to prevent water accumulation. Existing utilities beneath new foundations should be removed.

A representative of Terra Associates, Inc. should examine all bearing surfaces to verify that conditions encountered are as anticipated and are suitable for placement of structural fill or direct support of building and pavement elements. Our representative may request proofrolling exposed surfaces with a heavy rubber-tired vehicle to determine if any isolated soft and yielding areas are present. If unstable yielding areas are observed, they should be cut to firm bearing soil and filled to grade with structural fill. In pavement areas, if the depth of excavation to remove unstable soils is excessive, use of geotextile fabric such as Mirafi 500X or equivalent in conjunction with clean granular structural fill can be considered in order to limit the depth of removal.

All excavations at the site associated with confined spaces, such as utility trenches, must be completed in accordance with local, state, or federal requirements. Based on current Washington Industrial Safety and Health Act (WISHA) regulations, existing fill materials, loose to medium dense native silt, silty sand, sand, and medium dense to dense silty sand with gravel observed in the borings would be classified as a Type C soil. The underlying stiff to hard silty clay to clayey silt would generally be classified as a Type A soil. All exposed temporary slope faces should be covered with a durable reinforced plastic membrane during construction to prevent slope raveling and rutting during periods of precipitation.

Accordingly, for temporary excavations of less than 20 feet in depth, the side slopes in Type A and C soils should be laid back no steeper than the inclinations described below:

Soil Type	Temporary Slope Inclination (Horizontal:Vertical)
C	1.5:1
A	0.75:1

As discussed, site grading plans and building elevations are currently not available. For the purpose of this study, we have assumed that the basement excavation beneath the five multi-unit townhome buildings in the eastern portion of the site will be approximately ten feet below the elevation of 3rd Avenue NE and the lower level of the two mixed-use buildings in the western portion of the site at the approximate elevation of Jensen Way NE. Based on these elevations and the footprint of the proposed basement areas, it appears that sufficient room may exist to complete the excavations using open cuts that are sloped as discussed above. We should reevaluate potential excavation impacts once site development and building elevations are finalized. If it is determined that insufficient lateral space exists to slope excavations as described above, temporary shoring or a combination of shoring with an appropriately inclined backslope must be used.

We expect that some degree of perched groundwater seepage will be encountered in site excavations, particularly during the wet winter months. Based on our experience, the volume of water and rate of flow into excavations should be relatively minor, and typically would not be expected to impact the stability of excavations when completed, as described above. Typically, a system of collection trenches and conventional sump pumping procedures and/or the use of interceptor drains located upgradient of the excavation would be suitable for maintaining a relatively dry excavation for construction purposes.

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.

4.3 Structural Fill and Backfill

We expect that the site soils will not be suitable for use as structural fill. Structural fill and backfill should consist of an imported granular soil that meets the following minimum grading requirements:

U.S. Sieve Size	Percent Passing
6 inches	100
No. 4	75 maximum
No. 200	30 maximum* (dry weather) 5 maximum* (wet weather)

* Based on the 3/4-inch fraction.

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

Structural fill should be placed in horizontal layers not exceeding 12 inches and compacted to a density equal to or greater than 95 percent of its maximum dry density, as determined by ASTM Test Designation D-698 (Standard Proctor). The moisture content of the soil at the time of compaction should be within two percent of its optimum, as determined by this same ASTM standard.

4.4 Foundations

The building can be supported on conventional spread footing foundations bearing on a competent native soil subgrade or on structural fill placed on a competent native soil subgrade. Perimeter foundations exposed to the weather should be at a minimum depth of 18 inches below final exterior grades. Interior foundations can be constructed at any convenient depth below the floor slab.

We recommend designing foundations for a net allowable bearing capacity of 3,000 pounds per square foot (psf). For short-term loads, such as wind and seismic, a one-third increase in this allowable capacity can be used in design. With the anticipated loads and this bearing stress applied, building settlements should be less than one-inch total and one-half inch differential.

For designing foundations to resist lateral loads, a base friction coefficient of 0.3 can be used. Passive earth pressure acting on the sides of the footings may also be considered. We recommend calculating this lateral resistance using an equivalent fluid weight of 300 pounds per cubic foot (pcf). We recommend not including the upper 12 inches of soil in this computation because they can be affected by weather or disturbed by future grading activity. This value assumes the foundations will be constructed neat against competent native soil or the excavations are backfilled with structural fill as described in Section 4.3 of this report. The recommended passive and friction values include a safety factor of 1.5.

4.5 Slab-on-Grade Floors

Slab-on-grade floors can be supported on subgrades prepared as recommended in Section 4.2 of this report. 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 to 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 not be effective in assisting uniform curing of the slab and can actually serve as a water supply for moisture bleeding through the slab, potentially affecting 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 American Concrete Institute (ACI) Manual of Concrete Practice for further information regarding vapor barrier installation below slab-on-grade floors.

4.6 Lateral Earth Pressures for Retaining Wall Design

The magnitude of earth pressure development on retaining walls will partly depend on the quality and compaction of the wall backfill. We recommend placing and compacting wall backfill as structural fill, as described in Section 4.2 of this report. To prevent overstressing the walls during backfilling, heavy construction machinery should not be operated within five feet of the wall. Wall backfill in this zone should be compacted with hand-operated equipment. To prevent hydrostatic pressure development, wall drainage must also be installed. A typical wall drainage detail is shown on Figure 4. All drains should be routed to the storm sewer system or other approved point of controlled discharge.

With drainage properly installed, we recommend designing unrestrained walls for an active earth pressure equivalent to a fluid weighing 35 pounds per cubic foot (pcf). For restrained walls, an additional uniform load of 100 psf should be included in the wall design. To account for typical traffic surcharge loading, the walls can be designed for an additional imaginary height of two feet (two-foot soil surcharge).

For evaluation of wall performance under seismic loading, a uniform pressure equivalent to 8H psf, where H is the height of the below-grade portion of the wall should be applied in addition to the static lateral earth pressure. These values assume a horizontal backfill condition and that no other surcharge loading, sloping embankments, or adjacent buildings will act on the wall. If such conditions exist, then the imposed loading must be included in the wall design. Friction at the base of foundations and passive earth pressure will provide resistance to these lateral loads. Values for these parameters are provided in Section 4.4 of this report.

4.7 Infiltration Feasibility

In our opinion, the fine-grained silt and clay soils underlying the site are not suitable for stormwater infiltration or the use of low impact development (LID) natural drainage practices (NDPs).

4.8 Drainage

Surface

Final exterior grades should promote free and positive drainage away from the buildings at all times. Water must not be allowed to pond or collect adjacent to foundations or within the immediate building areas. We recommend providing a positive drainage gradient away from the building perimeters. If this gradient cannot be provided, surface water should be collected adjacent to the structures and disposed to appropriate storm facilities.

Subsurface

In addition to the drainage for the walls, we recommend installing perimeter foundation drains adjacent to shallow foundations. The drains can be laid to grade at an invert elevation equivalent to the bottom of footing grade. The drains can consist of four-inch diameter perforated PVC pipe that is enveloped in washed pea gravel-sized drainage aggregate. The aggregate should extend six inches above and to the sides of the pipe. Roof and foundation drains should be tightlined separately to the storm drains. All drains should be provided with cleanouts at easily accessible locations.

4.9 Utilities

Utility pipes should be bedded and backfilled in accordance with American Public Works Association (APWA) or local jurisdictional requirements. At minimum, trench backfill should be placed and compacted as structural fill, as described in Section 4.3 of this report. As noted, we anticipate that soils excavated from the site will generally not be suitable for use as backfill material. We recommend importing suitable wet weather fill for utility trench backfilling.

4.10 Pavements

Pavements should be constructed on subgrades prepared as recommended 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. Proofrolling the subgrade with heavy construction equipment should be completed 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. For traffic consisting mainly of light passenger vehicles with only occasional heavy traffic, and with a stable subgrade prepared as recommended, we recommend the following pavement sections:

- Two inches of hot mix asphalt (HMA) over four inches of crushed rock base (CRB)
- 3 ½ inches full depth HMA over prepared subgrade

The paving materials used should conform to the Washington State Department of Transportation (WSDOT) specifications for ½-inch class HMA and CRB.

Long-term pavement performance will depend on surface drainage. A poorly-drained pavement section will be subject to premature failure as a result of surface water infiltrating into the subgrade soils and reducing their supporting capability. For optimum pavement 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 when they occur.

5.0 ADDITIONAL SERVICES

Terra Associates, Inc. should review the final designs 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 in order 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. This report is the copyrighted property of Terra Associates, Inc. and is intended for specific application to the Poulsbo Division 8 project in Poulsbo, Washington. This report is for the exclusive use of Poulsbo Place Phase II, LLC and their authorized representatives. No other warranty, expressed or implied, is made.

The analyses and recommendations presented in this report are based on data obtained from our on-site borings. 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: WSDOT GEOPORTAL

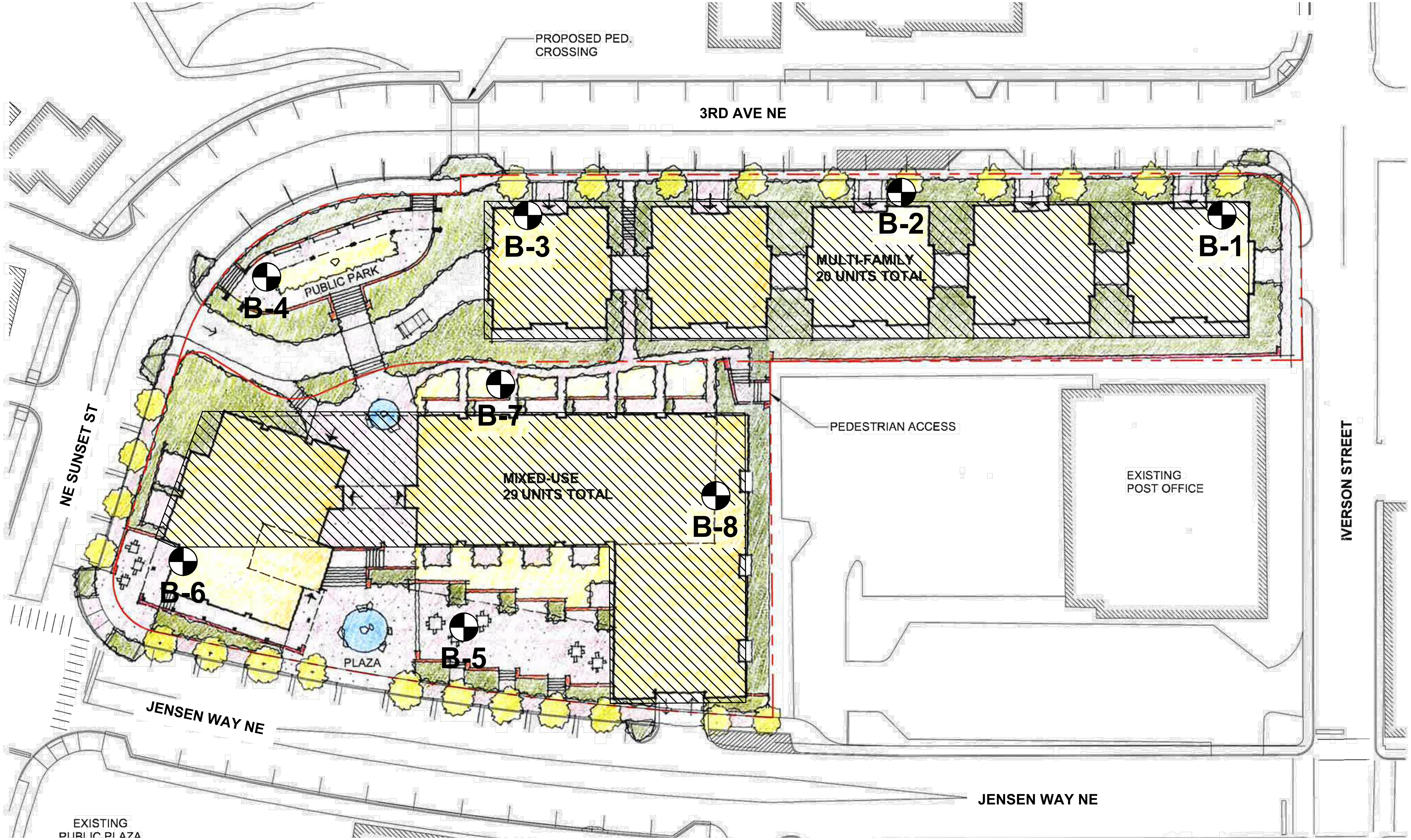
NOT TO SCALE

Terra Associates, Inc.

Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

VICINITY MAP
POULSBO DIVISION 8
POULSBO, WASHINGTON

Proj. No.T-8308	Date MAR 2020	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:

WENZLAU ARCHITECTS

LEGEND:

●	APPROXIMATE BORING LOCATION
▨	LOWER LEVEL PARKING

0 50 100

APPROXIMATE SCALE IN FEET

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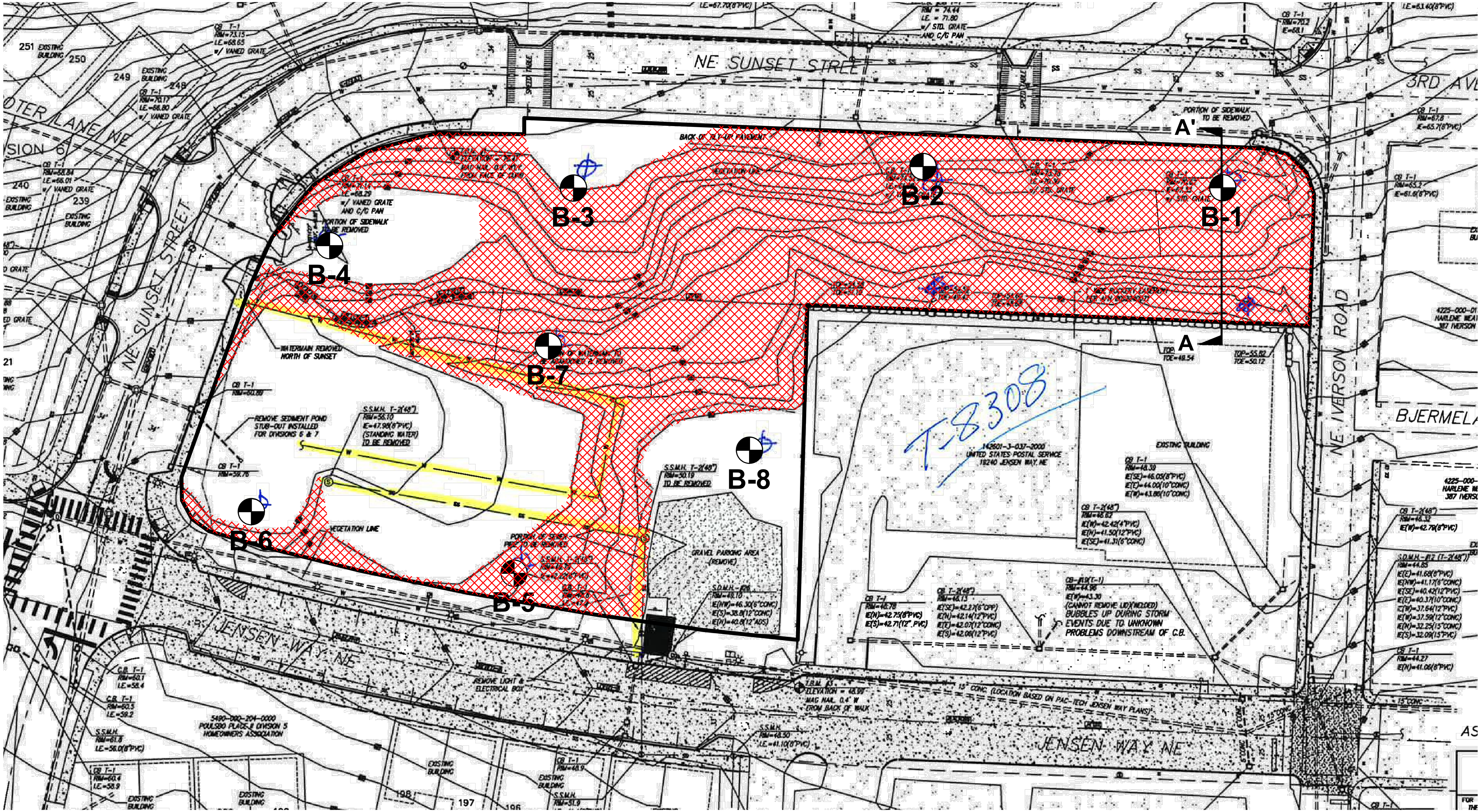
Environmental Earth Sciences

EXPLORATION LOCATION PLAN
POULSBO DIVISION 8
POULSBO, WASHINGTON

Proj. No.T-8308	Date MAR 2020	Figure 2



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:

MAP, LTD

LEGEND:

◐ APPROXIMATE BORING LOCATION

🟥 APPROXIMATE EROSION HAZARD AREA PER PMC

A A' GEOLOGIC SECTION A-A'

0 50 100

APPROXIMATE SCALE IN FEET

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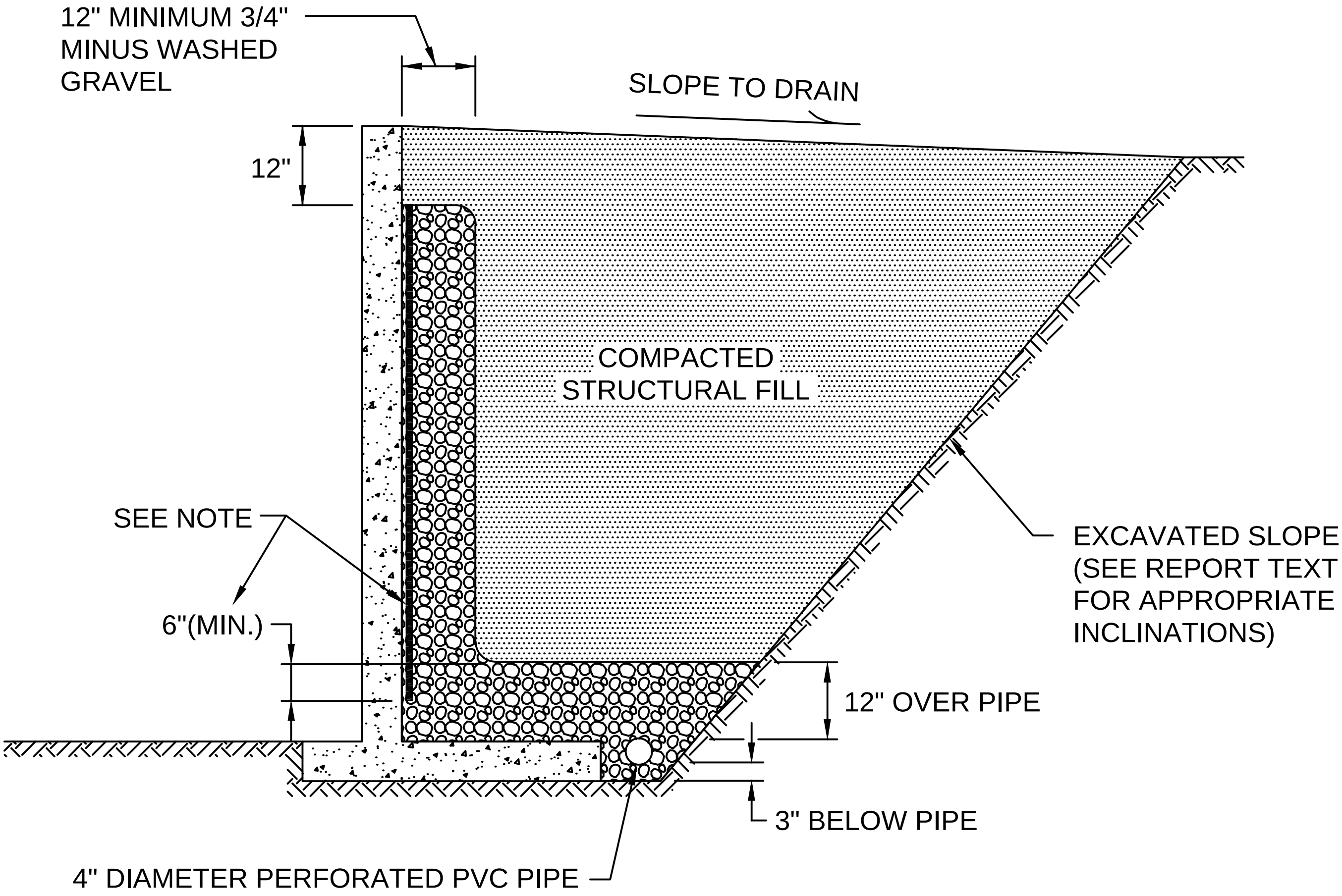
GEOLOGIC HAZARD AREAS MAP
POULSBO DIVISION 8
POULSBO, WASHINGTON

Proj. No.T-8308	Date MAR 2020	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
POUSLBO DIVISION 8
POULSBO, WASHINGTON

Proj. No.T-8308	Date MAR 2020	Figure 4

APPENDIX A

FIELD EXPLORATION AND LABORATORY TESTING

Poulsbo Division 8
Poulsbo, Washington

We explored subsurface conditions at the site in eight 26.5-foot deep test borings drilled with a track-mounted drill rig using hollow-stem auger drilling methods. The test boring locations are shown on Figure 2. The test boring locations were approximately determined in the field by pacing and sighting from existing surface features. The Boring Logs are presented on Figures A-2 through A-9.

An engineering geologist from our office conducted the field exploration. Our representative classified the soil conditions encountered, maintained a log of each boring, obtained representative soil samples, and recorded groundwater levels observed during drilling. Soil samples were obtained during drilling 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 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 Boring Logs. 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 Boring Logs. Grain size analyses were performed on two soil samples. The results are shown on Figure A-10.

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

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

	Consistancy	Standard Penetration Resistance in Blows/Foot
COHESIVE	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
Ⅱ	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
POULSBO DIVISION 8
POULSBO, WASHINGTON

Proj. No.T-8308	Date MAR 2020	Figure A-1

LOG OF BORING NO. 1

Figure No. A-2

Project: Poulsbo Division 8 **Project No:** T-8308 **Date Drilled:** February 26, 2020

Client: Poulsbo Place Ph II, LLC **Driller:** Boretec **Logged By:** JCS

Location: Poulsbo, Washington **Depth to Groundwater:** 15 ft **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot	Moisture Content (%)
0					
5		Brown sandy SILT to silty SAND, fine sand, trace of fine gravel, moist, scattered mottling. (ML/SM) (Possible fill)	Loose	8	20.8
10		- Trace of black organic specks below 10 feet.	Medium Dense	27	15.6
▼15		Gray-brown silty SAND with gravel, fine to medium sand, fine gravel, wet, numerous iron oxide stains. (SM) Gray-brown SAND with silt to silty SAND fine grained, wet. (SP-SM/SM)	Dense	38	24.5 22.4
20		Gray clayey SILT to silty CLAY, moist, trace of gray-brown fine sand seams below 21.3 feet. (ML/CL) Pp=4.5+ tons/sf LL=49, PI=20	Very Stiff	22	27.8
25				24	25.5
		Boring terminated at 26.5 feet. Wet soils encountered between 15 and 16.5 feet.			
30					

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. 2

Figure No. A-3

Project: Poulsbo Division 8
Project No: T-8308
Date Drilled: February 26, 2020

Client: Poulsbo Place Ph II, LLC
Driller: Boretec
Logged By: JCS

Location: Poulsbo, Washington
Depth to Groundwater: 5 ft, 10 ft
Approx. Elev: NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot 10 30 50	Moisture Content (%)
0		Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, wet. (SM) (Possible fill)	Loose		
▼ 5				6	23.9
		Gray-brown sandy SILT, fine sand, trace of fine gravel, moist, mottled. (ML)			
		Brown silty SAND with gravel, fine sand, fine to coarse gravel, wet, scattered iron oxide stains. (SM)	Medium Dense		
▼ 10				17	16.6
		Gray-brown to gray clayey SILT to silty CLAY, moist, massive. (ML/CL)	Very Stiff		30.7
15		Trace of dark brown organic speck between 15 and 16.5 feet. Pp=4.5+ tons/sf		20	27.7
20		Pp=4.5+ tons/sf		18	30.3
25				24	30.5
		Boring terminated at 26.5 feet. Wet soils encountered between 5 and 6 feet and between 10 and 10.5 feet.			
30					

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. 3

Figure No. A-4

Project: Poulsbo Division 8 **Project No:** T-8308 **Date Drilled:** February 26, 2020

Client: Poulsbo Place Ph II, LLC **Driller:** Boretec **Logged By:** JCS

Location: Poulsbo, Washington **Depth to Groundwater:** NA **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot	Moisture Content (%)
0					
5	I	Fill: Brown silty fine SAND and gray clayey SILT, moist. (SM/ML)	Very Loose / Soft	3	21.9
10	I	Gray-brown clayey SILT, moist. (ML) Pp=4.5 tons/sf	Very Stiff	25	27.0
15	I	Trace of dark brown organic specks and iron-oxide stained partings below 15 feet.		19	28.2
20	I	Gray silty CLAY to clayey SILT, moist, scattered light gray silt partings. (CL/ML)		27	24.9
25	I	Gray clayey SILT, moist. (ML) Pp=4.5+ tons/ sf		25	26.7
		Boring terminated at 26.5 feet. No groundwater encountered.			
30					

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. 4

Figure No. A-5

Project: Poulsbo Division 8 **Project No:** T-8308 **Date Drilled:** February 26, 2020

Client: Poulsbo Place Ph II, LLC **Driller:** Boretec **Logged By:** JCS

Location: Poulsbo, Washington **Depth to Groundwater:** NA **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot	Moisture Content (%)
0		Gray-brown SILT, moist, mottled. (ML)	Meidum Dense		
5	I			20	27.1
		Gray-brown clayey SILT, moist, scattered mottling. (ML) Pp=4.5+ tons/sf	Very Stiff		
10	I	Gray clayey SILT to silty CLAY, moist, trace of brown organic specks, trace of mottling. (ML/CL) Pp=4.5+ tons/sf		26	25.3
15	I		Hard	31	24.8
20	I		Very Stiff	28	25.2
25	I			28	24.8
		Boring terminated at 26.5 feet. No groundwater encountered.			
30					

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. 5

Figure No. A-6

Project: Poulsbo Division 8 **Project No:** T-8308 **Date Drilled:** February 26, 2020

Client: Poulsbo Place Ph II, LLC **Driller:** Boretec **Logged By:** JCS

Location: Poulsbo, Washington **Depth to Groundwater:** 11.5-15 ft **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot	Moisture Content (%)
0			Medium Dense		
5	I	Fill: Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist to wet, scattered organics. (SM)		18	18.3
10	I	Gray-brown silty SAND to sandy SILT, fine sand, trace of fine gravel, moist, mottled. (SM/ML)		17	18.3
▼					
15	I	Sampler wet from soils between 11.5 and 15 feet. Gray clayey SILT, moist. (ML) Pp=4.5+ tons/sf	Very Stiff	20	30.7
20	I	Gray silty CLAY, moist. (CL)	Stiff	13	38.5
25	I	Gray clayey SILT to silty CLAY, moist. (ML/CL)		13	41.5
		Boring terminated at 26.5 feet. Wet soils encountered between 11.5 and 15 feet.			
30					

SPT scale: 10 30 50

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. 6

Figure No. A-7

Project: Poulsbo Division 8 **Project No:** T-8308 **Date Drilled:** February 26, 2020

Client: Poulsbo Place Ph II, LLC **Driller:** Boretec **Logged By:** JCS

Location: Poulsbo, Washington **Depth to Groundwater:** NA **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot 10 30 50	Moisture Content (%)
5		Fill: Brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered organics. (SM)	Loose	7	27.1
10		Gray-brown slightly clayey SILT, moist, mottled. (ML) Pp=4.5 tons/sf LL=46, PI=16	Very Stiff	19	28.1
15		Gray clayey SILT, moist, trace of fine gravel. (ML)		26	25.8
20				28	24.0
25			Hard	35	25.9
		Boring terminated at 26.5 feet. No groundwater encountered.			
30					

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. 7

Figure No. A-8

Project: Poulsbo Division 8 **Project No:** T-8308 **Date Drilled:** February 26, 2020

Client: Poulsbo Place Ph II, LLC **Driller:** Boretec **Logged By:** JCS

Location: Poulsbo, Washington **Depth to Groundwater:** NA **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot 10 30 50	Moisture Content (%)
0		Gray-brown SILT, moist, mottled, scattered silty fine sand seams. (ML)	Medium Dense		
5	I			19	25.9
10	I	Gray-brown clayey SILT, moist, trace of fine sand seams, trace of black organic fragments and partings. (ML)	Very Stiff	26	24.4
15	I	Gray clayey SILT, moist, trace of coarse sand. (ML)		23	26.4
20	I	Gray SILT to clayey SILT, moist. (ML)	Medium Dense / Very Stiff	22	27.6
25	I			25	26.1
30		Boring terminated at 26.5 feet. No groundwater encountered.			

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. 8

Figure No. A-9

Project: Poulsbo Division 8 **Project No:** T-8308 **Date Drilled:** February 26, 2020

Client: Poulsbo Place Ph II, LLC **Driller:** Boretec **Logged By:** JCS

Location: Poulsbo, Washington **Depth to Groundwater:** NA **Approx. Elev:** NA

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	SPT (N) Blows/foot 10 30 50		Moisture Content (%)
▼ 0		Surface: Brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, wet. (SM)	Medium Dense			
5	I	Fill: Gray-brown sandy SILT, fine sand, moist, trace of wet, gray fine sand layers. (ML)		●	25	19.4
10	I	Gray-brown sandy SILT to gravelly SILT, fine sand, fine to coarse gravel, moist, scattered iron oxide stains and fine organic fibers. (ML) (Possible fill/disturbed)		●	17	18.1
15	I	Gray silty CLAY to clayey SILT, moist. (CL/ML) Pp=4.5 tons/sf	Stiff	●	12	44.4
20	I			●	14	40.9
25	I	Pp=4.5 tons/sf	Very Stiff	●	25	35.4
		Boring terminated at 26.5 feet. Wet soils encountered above 5 feet.				
30						

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	0.6	10.5	47.9	41.0	
☐	0.0	14.0	4.2	0.9	4.9	8.6	67.4	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.3896	0.2495	0.1963					
☐			17.4324							

Material Description	USCS	AASHTO
○ silty SAND	SM	
☐ gravelly SILT	ML	

Project No. T-8308 **Client:** Poulsbo Place Phase II

Project: Poulsbo Division 8

○ **Location:** B-1 **Depth:** 16'

☐ **Location:** B-8 **Depth:** 10'

Remarks:

Terra Associates, Inc.

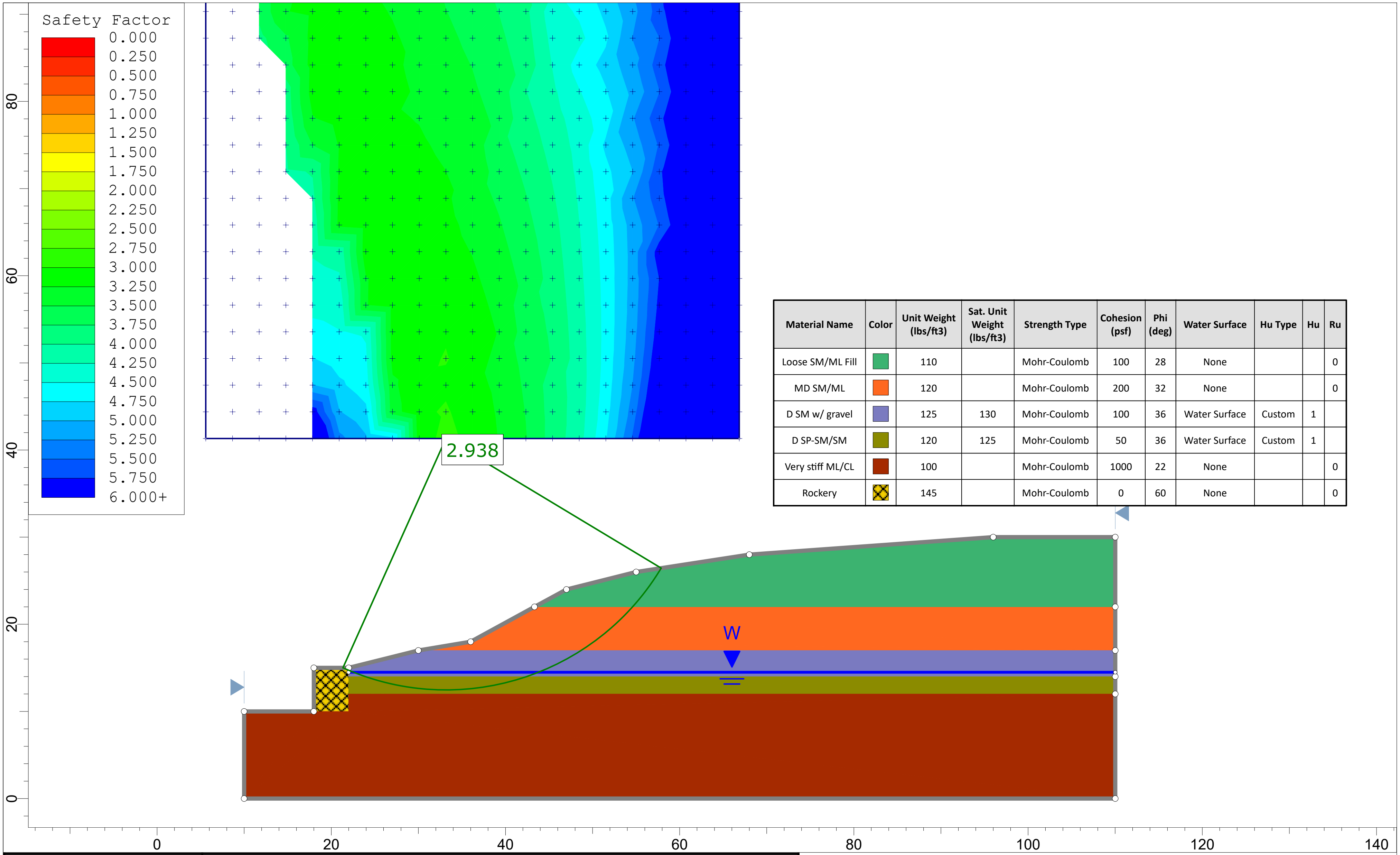
Kirkland, WA

Figure A-10

Tested By: FQ

APPENDIX B

STABILITY ANALYSES OUTPUT



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Loose SM/ML Fill	🟩	110		Mohr-Coulomb	100	28	None			0
MD SM/ML	🟧	120		Mohr-Coulomb	200	32	None			0
D SM w/ gravel	🟦	125	130	Mohr-Coulomb	100	36	Water Surface	Custom	1	
D SP-SM/SM	🟨	120	125	Mohr-Coulomb	50	36	Water Surface	Custom	1	
Very stiff ML/CL	🟫	100		Mohr-Coulomb	1000	22	None			0
Rockery	▨	145		Mohr-Coulomb	0	60	None			0

Project
Poulsbo Division 8

Analysis Description A-A' Static

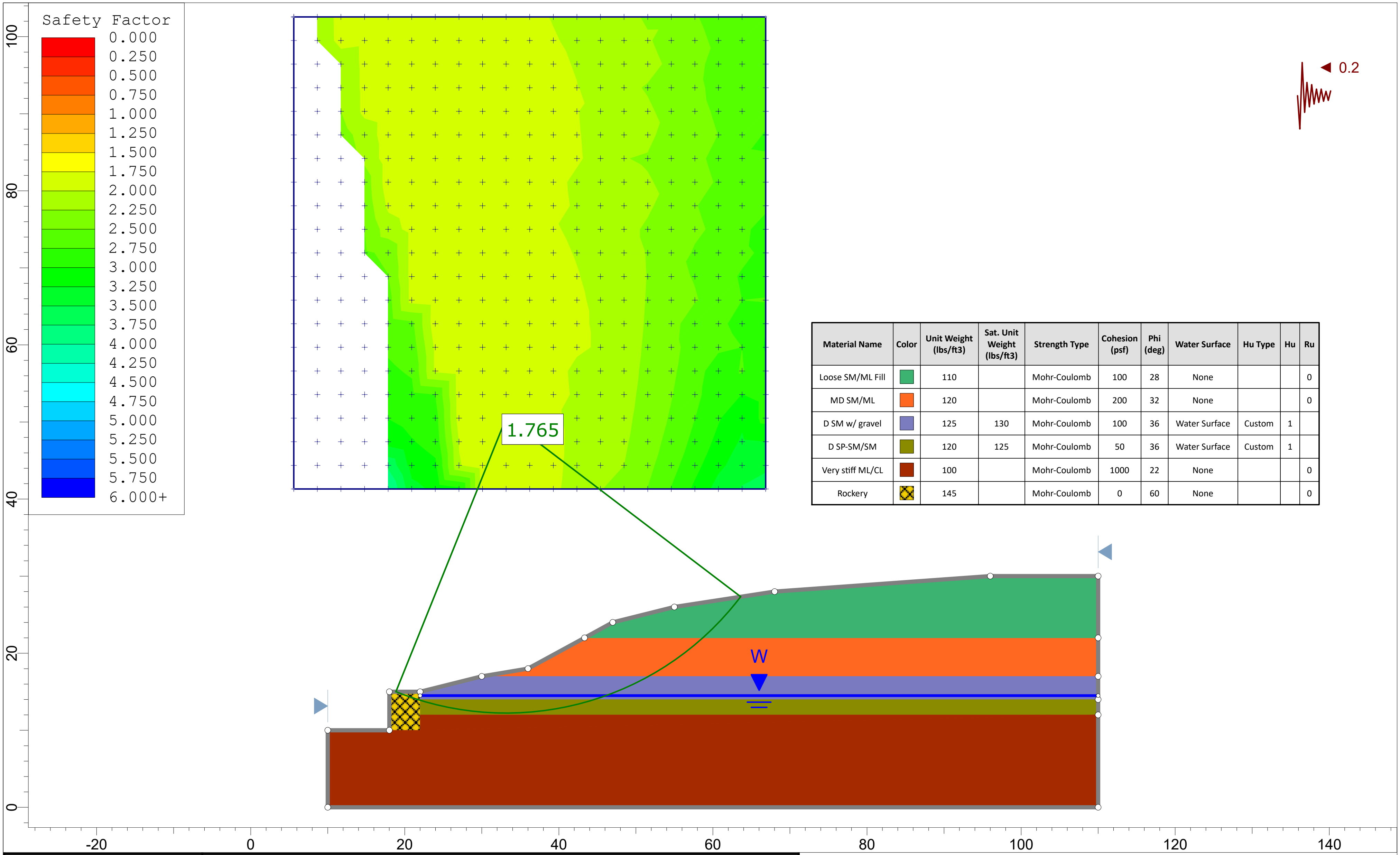
Drawn By JCS

Company Terra Associates, Inc.

Date 3/24/2020

File Name A-A'.slmd

SLIDEINTERPRET 8.024



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Loose SM/ML Fill	🟩	110		Mohr-Coulomb	100	28	None			0
MD SM/ML	🟧	120		Mohr-Coulomb	200	32	None			0
D SM w/ gravel	🟪	125	130	Mohr-Coulomb	100	36	Water Surface	Custom	1	
D SP-SM/SM	🟫	120	125	Mohr-Coulomb	50	36	Water Surface	Custom	1	
Very stiff ML/CL	🟥	100		Mohr-Coulomb	1000	22	None			0
Rockery	▨	145		Mohr-Coulomb	0	60	None			0

rocscience

SLIDEINTERPRET 8.024

Project	Poulsbo Division 8
Analysis Description	A-A' Pseudostatic
Drawn By	JCS
Company	Terra Associates, Inc.
Date	3/24/2020
File Name	A-A'.slmd