associated earth sciences incorporated

Subsurface Exploration, Geologic Hazard, and Geotechnical Engineering Report

MERCER ISLAND SFR
Mercer Island, Washington

Prepared for:
ELITE HOMES NW, LLC

Project No. 20220159E001
October 3, 2022

Associated Earth Sciences, Inc.

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associated earth sciences incorporated

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Project No. 20220159E001

Elite Homes NW, LLC
P.O. Box 50573
Bellevue, Washington 98015

Attention: Mr. Vadim Scherbinin

Subject: Subsurface Exploration, Geologic Hazard, and Geotechnical Engineering Report
Mercer Island SFR
9419 SE 54th Street
Mercer Island, Washington

Dear Mr. Scherbinin:

We are pleased to present this copy of the above-referenced report. This report summarizes the results of our subsurface exploration, geologic hazard, and geotechnical engineering studies, and offers recommendations for the design and development of the proposed project. This report is based on our conversations with you, review of project plans, review of *Geotechnical Feasibility Evaluation* for the property by Innovative Geo-Services, LLC dated March 21, 2022, and a site visit on April 22, 2022.

We have enjoyed working with you on this study and are confident the recommendations presented in this report will aid in the successful completion of your project. If you should have any questions or if we can be of additional help to you, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

Stephen A. Siebert, P.E.
Associate Geotechnical Engineer

SAS/jh -20220159E001-002

SUBSURFACE EXPLORATION, GEOLOGIC HAZARD, AND GEOTECHNICAL ENGINEERING REPORT

MERCER ISLAND SFR

Mercer Island, Washington

Prepared for:
Elite Homes NW, LLC
P.O. Box 50573
Bellevue, Washington 98015

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I. PROJECT AND SITE CONDITIONS

1.0 INTRODUCTION

This report, prepared by Associated Earth Sciences, Inc. (AESI), presents the results of our subsurface exploration, geologic hazard, and geotechnical engineering study for the subject project. The location of the subject site is shown on the "Vicinity Map," Figure 1. The approximate locations of the explorations accomplished by AESI for this study are presented on the "Existing Site and Exploration Plan," Figure 2 and the "Site and Exploration Plan," Figure 3. The logs of the subsurface explorations are included in the Appendix A. The conclusions and recommendations contained in this report should be reviewed and modified, or verified, as necessary once project plans have been finalized.

1.1 Purpose and Scope

The purpose of this study was to provide subsurface data to be used in the design and development of the subject project. Our study included a review of available geologic literature and drilling four exploration borings to assess the type, thickness, distribution, and physical properties of the subsurface sediments and shallow groundwater conditions. Geotechnical engineering studies were also conducted to assess the type of suitable foundations, allowable foundation capacities, retaining wall lateral pressures, floor support recommendations, and drainage considerations. This report summarizes our current fieldwork and offers preliminary development recommendations based on our present understanding of the project.

1.2 Authorization

Authorization to proceed was provided by Mr. Nick Scherbinin via a signed proposal. Our study was accomplished in general accordance with our scope of work letter, dated April 28, 2022. This report has been prepared for the exclusive use of Elite Homes NW, LLC and their agents, for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering and engineering geology practices in effect in this area at the time our report was prepared. No other warranty, express or implied, is made.

2.0 PROJECT AND SITE DESCRIPTION

The subject site consists of a single-family residence located at 9419 SE 54th Street on Mercer Island, Washington. The existing house consists of a single-story structure with a daylight basement level and detached carport. According to King County records the house was constructed in 1963. The site is comprised of a single tax parcel (King County No. 143870-0150) with a total area of approximately 19,800 square feet. The site is bounded to the north by SE 54th Street, to the south by undeveloped City of Mercer Island property, and to the west and east by single-family residential properties. Site grades are relatively level in the vicinity of the existing house and descend steeply towards the south City property and property to the east. Overall vertical relief across the site is about 50 feet.

We understand that the project will involve demolition of the existing house and construction of a new two-level single-family residence with a daylight basement level and attached garage. The location of the new residence will be in the central portion of the property near the location of the existing house and carport.

3.0 SUBSURFACE EXPLORATION

Our field study included drilling four exploration borings to obtain subsurface information about the site. The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix A. The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. The borings were approximately located in the field relative to known site features. The approximate locations of the borings are shown on Figure 2.

The conclusions and recommendations presented in this report are based, in part, on the subsurface conditions encountered in the borings. The location, depth, and number of borings were completed within site and budgetary constraints. It should be noted that subsurface conditions differing from those depicted on the log in Appendix A may be present at the site due to the random nature of deposition and the alteration of topography by past grading and/or filling. The nature and extent of any variations beyond the field exploration may not become fully evident until construction. If variations are observed at that time, it may be necessary to re-evaluate specific recommendations in this report and make appropriate changes.

3.1 Exploration Borings

Four exploration borings were completed using a limited-access, rubber-track mounted, drill rig advancing hollow-stem tooling under subcontract to AESI. During the drilling process, samples were generally obtained at 2.5- to 5-foot-depth intervals.

Disturbed but representative samples were obtained using the Standard Penetration Test (SPT) procedure in accordance with *ASTM International* (ASTM) D-1586. This test and sampling method consists of driving a standard, 2-inch, outside-diameter, split-barrel sampler a distance of 18 inches into the soil with a 140-pound hammer free-falling a distance of 30 inches. The number of blows for each 6-inch interval is recorded and the number of blows required to drive the sampler the final 12 inches is known as the Standard Penetration Resistance (“N”) or blow count. If a total of 50 is recorded within one 6-inch interval, the blow count is recorded as the number of blows for the corresponding inches of penetration. The resistance, or N-value, provides a measure of the relative density of granular soils or the relative consistency of cohesive soils; these values are plotted on the attached boring logs.

The borings were continuously observed and logged by a geologist from our firm. The samples obtained from the split-barrel sampler were classified in the field and representative portions placed in watertight containers. The samples were then transported to our laboratory for further visual classification. The exploration logs presented in Appendix A are based on the N-values, field observations, and drilling action.

4.0 SUBSURFACE CONDITIONS

Subsurface conditions at the project site were inferred from the field explorations accomplished for this study, visual reconnaissance of the site, and review of selected applicable geologic literature. As shown on the exploration logs, the overall stratigraphic sequence observed in our explorations included loose fill soils underlain by older glacial and nonglacial sediments. The following section presents more detailed subsurface information organized from the youngest (shallowest) to the oldest (deepest) sediment types. A copy of our exploration logs is included in Appendix A.

Grass/Topsoil/Asphalt

A surficial grass sod layer over an organic rich topsoil horizon was encountered at the location of exploration borings EB-1 and EB-2. Only topsoil was encountered at the location of EB-3 as it was likely the location of a geotechnical exploration pit previously excavated at the site. The topsoil horizon ranged in thickness from 6 to 12 inches. Exploration boring EB-4 encountered 3 inches of asphalt driveway surfacing. Grass sod, topsoil, and asphalt are not considered suitable for foundation support or for use as structural fill.

Fill

Below the surficial topsoil horizon, we generally encountered very loose to loose, moist, orangish brown to dark brown, silty, fine sand with variable gravel content and organics interpreted as existing fill soils (those not naturally placed). Fill soils were observed to depths of 4 feet in EB-1, 5.5 feet in EB-2, and 3 feet in EB-4. The 10 feet of fill encountered in EB-3 is interpreted as backfill for a geotechnical exploration pit previously excavated at the site and is not representative of fill thickness in the vicinity of EB-3. Due to its variable composition and density, existing fill is not suitable for foundation support.

Pre-Olympia Glacial Till

Underlying the fill, all borings encountered medium dense to very dense, gray to light brown with oxidation mottling, unsorted, silty, fine sand with some gravel. We interpret these sediments to be representative of pre-Olympia age glacial till. This glacial till was deposited directly from basal, debris-laden glacial ice during a glaciation before the Olympia nonglacial interval which began 60,000 years ago. The high relative density characteristic of pre-Olympia glacial till is due to its consolidation by the massive weight of the glacial ice from which it was deposited and by subsequent glaciations. Pre-Olympia glacial till is suitable for support of structural loads when prepared as recommended in this report. Pre-Olympia glacial till contains a significant fine-grained fraction and is sensitive to excess moisture during placement in structural fill applications.

Pre-Olympia Nonglacial Deposits

Underlying the Pre-Olympia glacial till, all borings encountered dense to very dense, light brown, fine sand with trace to some silt and trace gravel with mica flakes. A 6-inch thick, hard, silt bed was encountered at the top of this unit within EB-3. We interpret these sediments to be representative of Pre-Olympia nonglacial deposits. These sediments were deposited during an interglacial period prior to the Olympia nonglacial interval which began 60,000 years ago. The high relative density of these sediments is due to its consolidation by the massive weight of multiple subsequent glacial advances. Pre-Olympia nonglacial deposits are suitable for support of structural loads when prepared as recommended in this report. Pre-Olympia nonglacial deposits contain a significant fine-grained fraction and are sensitive to excess moisture during placement in structural fill applications.

4.1 Geologic Map Review

Review of the regional geologic map, *Geologic Map of Mercer Island, Washington,* GeoMapNW, Department of Earth and Space Sciences, University of Washington, 2006, indicates that the subject site vicinity is underlain by pre-Olympia age nonglacial deposits with pre-Olympia glacial diamict mapped upslope. Our interpretations are consistent with the regional geologic mapping.

4.2 Regional Soils Mapping

Review of the US Department of Agriculture Natural Resources Conservation Service *Web Soil Survey* indicates that the soil present at the subject site is *Kitsap silt loam, 15 to 30 percent slopes* (KpD). Kitsap soils have a parent material of "lacustrine deposits". Mapped 50 feet upslope from the subject site is *Alderwood gravelly sandy loam, 8 to 15 percent slopes* (AgC) which has a parent material of "glacial drift". Our interpretations are in general agreement with the regional soils mapping.

4.3 Hydrology

Groundwater seepage was not encountered within our explorations. In areas underlain by glacial till, it is common for shallow perched groundwater to accumulate seasonally at the top of the unweathered till surface. This perched seepage, known as "interflow," occurs when surface water infiltrates down through relatively permeable soils, such as topsoil, loose fill, or weathered till sediments and becomes perched atop a comparatively very low-permeability barrier such as the underlying unweathered glacial till. This water may travel laterally and typically will follow the ground surface topography.

No areas of saturated soils or groundwater seepage were observed on the steep slopes at the time of our reconnaissance. South of the subject site, in the City of Mercer Island property, we observed a very small, slow moving stream near the base of the slope. We estimated the flow within this stream at approximately 1 to 2 gallons per minute. Our exploration boring EB-1 was advanced to an elevation below the base of this stream and did not encounter any groundwater seepage. Therefore, we interpret this stream to be perched near the surface with a source upslope from the project area.

Groundwater conditions will largely depend on the soil grain-size distribution, topography, seasonal precipitation, on- and off-site land usage, and other factors. Our explorations were conducted in late-June when groundwater levels are typically declining toward a seasonal low.

II. GEOLOGIC HAZARDS AND MITIGATIONS

The following discussion of potential geologic hazards is based on the geologic, slope, and groundwater conditions, as observed and discussed herein.

5.0 LANDSLIDE HAZARDS AND MITIGATION

The *Mercer Island City Code* (MICC 19.16.010) defines Landslide Hazard Areas as the following:

> *Those areas subject to landslides based on a combination of geologic, topographic, and hydrologic factors, including:*
>
> 1. *Areas of historic failures;*
> 2. *Areas with all three of the following characteristics:*
>   a. *Slopes steeper than 15 percent; and*
>   b. *Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and*
>   c. *Springs or ground water seepage;*
> 3. *Areas that have shown evidence of past movement or that are underlain or covered by mass wastage debris from past movements;*
> 4. *Areas potentially unstable because of rapid stream incision and stream bank erosion;*
> 5. *Steep Slope. Any slope of 40 percent or greater calculated by measuring the vertical rise over any 30-foot horizontal run.*

Review of the LiDAR-based topographic contours presented in Figure 2 and the steep slope shading presented in Figure 3 indicate that the slope along the southern portion of the property is approximately 46 feet tall and is inclined at 40 to 60 percent. Therefore, this portion of the site is classified as a Landslide Hazard area.

Review of the LiDAR-based topographic contours presented in Figure 2 and the steep slope shading presented in Figure 3 indicate that the slope along the eastern portion of the property is approximately 14 feet tall and is inclined at 40 to 45 percent. Therefore, this portion of the site is also classified as a Landslide Hazard area.

Our subsurface exploration, slope reconnaissance, and review of geologic mapping indicates that the only code defined Landslide Hazard Area characteristic met on this site is MICC 19.16.010.5, “Any slope of 40 percent or greater calculated by measuring the vertical rise over any 30-foot horizontal run”.

As these site slopes are classified as Landslide Hazard Areas, project design will have to conform with the development standards of MICC 19.07.160.C. Buffers required from the south and east site slopes are specified in MICC 19.07.160.C.2:

> 2. *Buffers shall be applied as follows. When more than one condition applies to a site, the largest buffer shall be applied:*
>   a. *Steep slopes. Buffer widths shall be equal to the height of a steep slope, but not more than 75 feet, and applied to the top and toe of slopes;*
>   b. *Shallow landslide hazard areas shall have minimum 25-foot buffers applied in all directions; and*
>   c. *Deep-seated landslide hazard areas shall have 75-foot buffers applied in all directions.*

Our subsurface exploration, slope reconnaissance, and review of geologic mapping did not observe any evidence of shallow or deep landsliding on the south or east slopes, so only the "Steep Slope" buffer equal to the height of the slope applies. The height of the south slope is approximately 46 feet, while the height of the east slope is approximately 14 feet. Therefore, the required buffers from the top of the south and east slopes are 46 and 14 feet, respectively.

The City of Mercer Island does allow alteration and development within Landslide Hazard Area buffers as specified by MICC 19.07.160.B.2:

> 2. *Alteration of landslide hazard areas and seismic hazard areas and associated buffers may occur if the critical area study documents find that the proposed alteration:*
>   a. *Will not adversely impact other critical areas;*
>   b. *Will not adversely impact the subject property or adjacent properties;*
>   c. *Will mitigate impacts to the geologically hazardous area consistent with best available science to the maximum extent reasonably possible such that the site is determined to be safe; and*
>   d. *Includes the landscaping of all disturbed areas outside of building footprints and installation of hardscape prior to final inspection.*

5.1 Slope Stability Analysis

A numerical slope stability analysis of the each of the steep slopes present at the site was completed using the computer program SLOPE/W, Version 8.16 by GeoSlope International. The program used the Morgenstern-Price method for evaluating a rotational failure. Input parameters for the analysis included slope geometry, geology, and soil strength parameters. The profiles used for our analysis were located along section lines A-A' and B-B' as depicted on Figure 2. The LiDAR-based topography presented on Figure 2 was used for the existing slope conditions. The geology of the slopes was based on the subsurface conditions encountered in our explorations. Soil strength parameters used for our analysis were assumed based on published values for similar materials and our prior experience. The values used for our analysis were selected to be conservatively low and are shown on the SLOPE/W profiles included in Appendix B. For evaluation of slope stability under seismic conditions, a horizontal ground acceleration of 0.33g was used for our analysis. This value is equivalent to ½ of the peak horizontal ground acceleration based on a seismic event with a 2-percent probability of exceedance in 50 years in accordance with the 2018 *International Building Code* (IBC). For the existing and proposed residence surcharge, a surcharge load of 500 PSF was used. Groundwater seepage was not encountered in our explorations or observed during our slope reconnaissance. To maintain a conservative slope stability model, we added a weathered horizon with perched groundwater to the top of the pre-Olympia glacial till.

The factor of safety of a slope is the ratio between the forces that resist sliding to the forces that drive sliding. For example, a factor of safety of 1.0 would indicate a slope where the driving forces and the resisting forces are exactly equal. Increasing factor of safety values greater than 1.0 indicate increased stability.

An acceptable factor of safety would depend on the level of risk deemed acceptable by the owner and the City of Mercer Island. A static factor of safety of 1.5 would be considered suitable with respect to generally accepted geotechnical engineering practices. During short-term seismic loading, considering a potential ground acceleration of 0.33g, a dynamic factor of safety of 1.1 is generally considered suitable.

South Slope (A-A')

Minimum factors of safety calculated for the existing south facing slope were equal to 2.2 for static conditions and 1.1 for seismic conditions.

We also conducted an analysis of the proposed post-construction slope conditions with a new residence with daylight basement in the central portion of the property. Minimum factors of safety calculated for the proposed improvements at the south slope were equal to 2.2 for static conditions and 1.1 for seismic conditions.

The factors of safety calculated for the proposed development under static and seismic conditions are generally equal to or greater than the factors of safety calculated for the existing south slope and exceed generally accepted standards. Copies of the results of the slope stability analyses are included in Appendix B.

East Slope (B-B')

Minimum factors of safety calculated for the existing east facing slope conditions were equal to 3.1 for static conditions and 1.6 for seismic conditions.

We also conducted an analysis of the proposed post-construction slope conditions with a new residence with daylight basement in the central portion of the property. Minimum factors of safety at the east slope calculated for the post-construction conditions were equal to of 3.1 for static conditions and 1.5 for seismic conditions.

The factors of safety calculated for the proposed development under static and seismic conditions are generally equal to the factors of safety calculated for the existing east slope and exceed generally accepted standards of 1.5 for static conditions and 1.1 for seismic conditions for a permanent slope. Copies of the results of the slope stability analyses are included in Appendix B.

5.2 Buffer Analysis and Recommendations

MICC 19.07.160.C.2 specifies that the required buffers from the top of the south and east slopes are 46 and 14 feet, respectively. Based on project plans, the proposed residence is located approximately 12 feet away from the top of the south slope and approximately 13 feet away from the top of the east slope.

As described in MICC 19.07.160.B.2, the City of Mercer Island allows development within Landslide Hazard Area buffers provided that critical area study documents find that the alteration will not adversely impact other critical areas, impact the subject property or adjacent properties, and will mitigate impacts to the geologically hazardous area consistency with best available science to the maximum extent reasonably possible such that the site is determined to be safe.

Our explorations encountered very dense, glacially overridden, pre-Olympia glacial till and nonglacial deposits at shallow depths, extending beyond the full depth explored, and did not encounter adverse groundwater conditions. Our slope stability analysis for the south and east slopes, for the existing and proposed post-construction conditions, show favorable factors of safety under static and seismic conditions.

Provided that the recommendations presented in this report are properly followed, and the location and scope of the proposed residential development does not substantially change, it is our opinion that alterations within the Landslide Hazard Area buffers for the proposed residential development will not result in adverse impacts to the stability of the slope on the subject site or on the adjacent properties and the risk of the damage to the proposed improvements by landsliding is low.

6.0 SEISMIC HAZARDS AND MITIGATION

The following discussion is a general assessment of seismic hazards that is intended to be useful to the project design team in terms of understanding seismic issues, and to the structural engineer for design.

All of Western Washington is at risk of strong seismic events resulting from movement of the tectonic plates associated with the Cascadia Subduction Zone (CSZ), where the offshore Juan de Fuca plate subducts beneath the continental North American plate. The site lies within a zone of strong potential shaking from subduction zone earthquakes associated with the CSZ. The CSZ can produce earthquakes up to magnitude 9.0, and the recurrence interval is estimated to be on the order of 500 years. Geologists infer the most recent subduction zone earthquake occurred in 1700 (Goldfinger et al., 2012[1]). Three main types of earthquakes are typically associated with subduction zone environments: crustal, intraplate, and interplate earthquakes. Seismic records in the Puget Sound region document a distinct zone of shallow crustal seismicity (e.g., the Seattle Fault Zone[SFZ]). These shallow fault zones may include surficial expressions of previous seismic events, such as fault scarps, displaced shorelines, and shallow bedrock exposures. The shallow fault zones typically extend from the surface to depths ranging from 16 to 19 miles. A deeper zone of seismicity is associated with the subducting Juan de Fuca plate. Subduction zone seismic events produce intraplate earthquakes at depths ranging from 25 to 45 miles beneath the Puget Lowland including the 1949, 7.2-magnitude event; the 1965, 6.5-magnitude event; and the 2001, 6.8-magnitude event, and interplate earthquakes at shallow depths near the Washington coast including the 1700 earthquake, which had a magnitude of approximately 9.0. The 1949 earthquake appears to have been the largest in this region during recorded history and was centered in the Olympia area. Evaluation of earthquake return rates indicates that an earthquake of the magnitude between 5.5 and 6.0 is likely within a given 20-year period.

The *Mercer Island City Code* (MICC 19.16.010) defines Seismic Hazards as the following:

> *Seismic hazard areas are areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement, soil liquefaction or surface faulting.*

Generally, there are four types of potential geologic hazards associated with large seismic events: 1) surficial ground rupture, 2) seismically induced landslides, 3) liquefaction, and 4) ground motion. The potential for each of these hazards to adversely impact the proposed project is discussed below.

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[1] Goldfinger, C., Nelson, C.H., Morey, A.E., Johnson, J.E., Patton, J.R., Karabanov, E., Gutierrez-Pastor, J., Eriksson, A.T., Gracia, E., Dunhill, G., Enkin, R.J, Dallimore, A., and Vallier, T.,2012, *Turbidite Event History—Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone*: U.S. Geological Survey Professional Paper 1661–F, 170.

6.1 Surficial Ground Rupture

Seattle Fault

The site is located within the mapped limits of the Seattle Fault Zone (SFZ). The SFZ is a broad east – west oriented zone that extends from approximately Issaquah to Alki beach and is approximately 2.5 to 4 miles in width from north to south. The SFZ is speculated to contain multiple distinct fault "strands", some of which are well understood and some of which may be poorly understood or unknown. Mapping of individual fault strands is imprecise, as a result of pervasive modification of the land surface by development, which has obscured possible surficial expression of past seismic events. Studies by the U.S. Geological Survey and others have provided evidence of surficial ground rupture along strands of the Seattle Fault (USGS, 2010[2]; Pratt et. al, 2015[3]; Haugerud, 2005[4]; Liberty et. al, 2008[5]). According to USGS studies the latest movement of this fault was about 1,100 years ago when about 20 feet of surficial displacement took place. This displacement can presently be seen in the form of raised, wave-cut beach terraces along Alki Point in West Seattle and Restoration Point at the south end of Bainbridge Island.

Review of the USGS U.S. Quaternary Faults Interactive Fault Map indicates that an inferred trace of the SFZ is mapped in the southern portion of the subject property.

As part of this study, we reviewed the source of this inferred fault: Blakely et. al., 2002, *Location, structure, and seismicity of the Seattle fault, Washington—Evidence from aeromagnetic anomalies, geologic mapping, and seismic-reflection data*: Geological Society of America Bulletin, v. 114, no. 2, p. 169-177.

The inferred fault trace at the site was mapped by measuring aerial gravity anomalies and seismic reflection surveys throughout the central Puget Sound region. As such, the map resolution is not accurate enough for site-specific studies and no additional data, such as trenching, is available to confirm the presence of this specific inferred trace on the subject site. Due to the mapped scale of the gravity anomaly and seismic reflection data, the inferred trace on the subject site could vary in location on the order of hundreds of feet. Therefore, it is not practical to use the location of inferred fault trace as mapped by the USGS Interactive Fault Map for site specific seismic hazard analysis.

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[2] U.S. Geological Survey, 2010, Quaternary fault and fold database for the United States, accessed November 10, 2010, from USGS web site: http://earthquake.usgs.gov/hazards/qfaults/.

[3] Pratt, et al., 2015, Kinematics of shallow backthrusts in the Seattle fault zone, Washington State: Geosphere, v. 11, no. 6, p. 1-27).

[4] Haugerud, R.A., 2005, Preliminary geologic map of Bainbridge Island, Washington: U.S. Geological Survey Open-File Report 2005-1387, version 1.0, 1 sheet, scale 1:24,000.

[5] Liberty, Lee M.; Pratt, Thomas L., 2008, Structure of the eastern Seattle fault zone, Washington State -New insights from seismic reflection data: Bulletin of the Seismological Society of America, v. 98, no. 4, p. 1681-1695.

Due to the suspected long recurrence interval, the potential for surficial ground rupture along the SFZ is considered to be low during the expected life of the proposed improvements.

6.2 Seismically Induced Landslides

The results of our seismic slope stability analysis are presented in Section 5.1. Based upon our explorations, the site topography, and our slope stability analysis, it is our opinion that the risk of damage to the proposed improvements by seismically induced landsliding is low, provided the recommendations in this report are properly followed.

6.3 Liquefaction

Liquefaction is a process through which unconsolidated soil loses strength as a result of vibrations, such as those which occur during a seismic event. During normal conditions, the weight of the soil is supported by both grain-to-grain contact and by the fluid pressure within the pore spaces of the soil below the water table. Extreme vibratory shaking can disrupt the grain-to-grain contact, increase the pore pressure, and result in a temporary decrease in soil shear strength. The soil is said to be liquefied when nearly all of the weight of the soil is supported by pore pressure alone. Liquefaction can result in deformation of the sediment and settlement of overlying structures. Areas most susceptible to liquefaction include those areas underlain by non-cohesive silt and sand with low relative densities, accompanied by a shallow water table.

Review of the *City of Mercer Island Seismic Hazard Assessment* (GeoMapNW 2009) indicates that the site is not mapped within a seismic hazard area.

In our opinion, the potential risk of damage to the proposed improvements by liquefaction is low due to the high relative density of the underlying sediments and the absence of a shallow groundwater table. No detailed quantitative liquefaction assessment was completed as part of this study, and none is warranted, in our opinion.

6.4 Ground Motion

It is our opinion that earthquake damage to the proposed structures, when founded on suitable bearing strata in accordance with the recommendations contained herein, will likely be caused by the intensity and acceleration associated with the event. Structural design should follow 2018 IBC standards using Site Class “D” as defined in Table 20.3-1 of *American Society of Civil Engineers (ASCE) 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures*.

7.0 EROSION HAZARDS AND MITIGATION

The *Mercer Island City Code* (MICC 19.16.010) defines Erosion Hazard Areas as the following:

> *Those areas greater than 15 percent slope and subject to a severe risk of erosion due to wind, rain, water, slope and other natural agents including those soil types and/or areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a "severe" or "very severe" rill and inter-rill erosion hazard.*

Review of the US Department of Agriculture Natural Resources Conservation Service *Web Soil Survey* indicates that the soil present at the subject site is *Kitsap silt loam, 15 to 30 percent slopes* (KpD) with an erosion hazard rating of “severe”. As such, the site meets the code requirement to be classified as an Erosion Hazard Area and development must follow the requirements of MICC 19.07.160.E.

The fill and natural soils underlying the site contain substantial quantities of silt and fine sand and will be sensitive to disturbance when wet. In order to mitigate erosion hazards and the potential for off-site sediment transport, we recommend the following best management practices (BMPs):

1. Construction activity should be scheduled or phased as much as possible to avoid earthwork activity during the wet season.

2. The winter performance of a site is dependent on a well-conceived plan for control of site erosion and stormwater runoff. The site plan should include ground-cover measures and staging areas. The contractor should be prepared to implement and maintain the required measures to reduce the amount of exposed ground.

3. Temporary erosion and sedimentation control (TESC) elements and perimeter flow control should be established prior to the start of grading.

4. During the wetter months of the year, or when significant storm events are predicted during the summer months, the work area should be stabilized so that if showers occur, it can receive the rainfall without excessive erosion or sediment transport. The required measures for an area to be “buttoned-up” will depend on the time of year and the duration that the area will be left unworked. During the winter months, areas that are to be left unworked for more than 2 days should be mulched or covered with plastic. During the summer months, stabilization will usually consist of seal-rolling the subgrade. Such measures will aid in the contractor’s ability to get back into a work area after a storm event. The stabilization process also includes establishing temporary stormwater conveyance channels through work areas to route runoff to the approved treatment/discharge facilities.

5. All disturbed areas should be revegetated as soon as possible. If it is outside of the growing season, the disturbed areas should be covered with mulch. Straw mulch provides a cost-effective cover measure and can be made wind-resistant with the application of a tackifier after it is placed.

6. Surface runoff and discharge should be controlled during and following development. Uncontrolled discharge may promote erosion and sediment transport.

7. Soils that are to be reused around the site should be stored in such a manner as to reduce erosion from the stockpile. Protective measures may include, but are not limited to, covering stockpiles with plastic sheeting, or the use of silt fences around pile perimeters.

It is our opinion that with the proper implementation of the TESC plans and by field-adjusting appropriate erosion mitigation (BMPs) throughout construction, the potential adverse impacts from erosion hazards on the project will be mitigated.

III. DESIGN RECOMMENDATIONS

8.0 INTRODUCTION

Our subsurface explorations indicate that, from a geotechnical standpoint, the proposed development is feasible, provided the recommendations in this report are followed.

The project area is underlain by varying thicknesses of loose, uncontrolled fill that may be subject to consolidation and settlement under foundation loads. We anticipate that this loose fill will likely be removed during excavation of the daylight basement level for the proposed residence.

Temporary cuts for the daylight basement will likely be on the order of 10 to 12 feet deep. Depending on the final location of the proposed residence, temporary shoring may be necessary where temporary excavations would otherwise extend onto neighboring properties. We are available to provide temporary shoring recommendations should the final location of the proposed residence require it.

9.0 SITE PREPARATION

Erosion control measures should be established around the perimeter of the project to satisfy City of Mercer Island requirements. Site preparation of the building area should include removal of all existing pavement, grass, trees, brush, debris, and any other deleterious materials. Any existing foundation elements, utilities or other structures that underlie the building area should also be removed. Any depressions below planned final grades caused by demolition activities should be backfilled with structural fill, as discussed under the “Structural Fill” section of this report.

Existing topsoil and fill soils should be stripped from structural areas. After stripping, any remaining roots and stumps should be removed from structural areas. All soils disturbed by stripping and grubbing operations should be recompacted as described subsequently for structural fill.

9.1 Temporary and Permanent Cut Slopes

In our opinion, stable construction slopes should be the responsibility of the contractor and should be determined during construction based on the local conditions encountered at that time. For planning purposes, we anticipate that temporary, unsupported cut slopes within the existing fill soils can be made at a maximum slope of 1.5H:1V (Horizontal:Vertical). Temporary, unsupported cut slopes within the dense pre-Olympia glacial till and nonglacial deposits can be made at a maximum slope of 1H:1V. Flatter inclinations are recommended in areas of seepage.

As is typical with earthwork operations, some sloughing and raveling may occur, and cut slopes may have to be adjusted in the field. In addition, WISHA/OSHA regulations should be followed at all times. Permanent cut slopes should not exceed an inclination of 2H:1V.

10.0 STRUCTURAL FILL

Placement of structural fill may be necessary to establish desired grades in some areas or to backfill foundation walls. All references to structural fill in this report refer to subgrade preparation, fill type, and placement and compaction of materials as discussed in this section. If a percentage of compaction is specified under another section of this report, the value given in that section should be used.

10.1 Subgrade Compaction

After overexcavation/stripping has been performed to the satisfaction of the geotechnical engineer/engineering geologist, the exposed ground should be recompacted to a firm and unyielding condition. If the subgrade contains too much moisture, suitable recompaction may be difficult or impossible to attain and should probably not be attempted. In lieu of recompaction, the area to receive fill should be blanketed with washed rock or quarry spalls to act as a capillary break between the new fill and the wet subgrade. Where the exposed ground remains soft and further overexcavation is impractical, placement of an engineering stabilization fabric (such as Mirafi® 500X or approved equivalent) may be necessary to prevent contamination of the free-draining layer by silt migration from below.

After recompaction of the exposed ground is approved, or a free-draining rock course is laid, structural fill may be placed to attain desired grades.

10.2 Structural Fill Compaction

Structural fill is defined as non-organic soil, acceptable to the geotechnical engineer, placed in maximum 8-inch loose lifts, with each lift being compacted to at least 95 percent of the modified Proctor maximum dry density using ASTM D-1557 as the standard. Utility trench backfill should be placed and compacted in accordance with applicable municipal codes and standards. Fill slopes should either be overbuilt and trimmed back to final grade or surface-compacted to the specified density.

10.3 Moisture-Sensitive Fill

Soils in which the amount of fine-grained material (smaller than No. 200 sieve) is greater than approximately 5 percent (measured on the minus No. 4 sieve size) should be considered moisture-sensitive. The use of moisture-sensitive soil in structural fills should be limited to favorable dry weather conditions.

The on-site pre-Olympia glacial till and pre-Olympia nonglacial sediments underlying the site are suitable for use as structural fill provided, they are free of roots or other deleterious materials and have a moisture content suitable for achieving the specified compaction. The sediments encountered in our explorations contain substantially more than 5 percent fine-grained material and are considered highly moisture-sensitive.

If fill is placed during wet weather or if proper compaction cannot be attained, a select import material consisting of a clean, free-draining gravel and/or sand should be used. Free-draining fill consists of non-organic soil with the amount of fine-grained material limited to 5 percent by weight when measured on the minus No. 4 sieve fraction.

10.4 Structural Fill Testing

The contractor should note that any proposed fill soils must be evaluated by AESI prior to their use in fills. This would require that we have a sample of the material at least 3 business days in advance to perform a modified Proctor test and determine its field compaction standard.

A representative from our firm should observe the stripped subgrade and be present during placement of structural fill to observe the work and perform a representative number of in-place density tests. In this way, the adequacy of the earthwork may be evaluated as filling progresses and any problem areas may be corrected at that time. It is important to understand that taking random compaction tests on a part-time basis will not assure uniformity or acceptable performance of a fill. As such, we are available to aid the owner in developing a suitable monitoring and testing frequency.

11.0 FOUNDATIONS

Conventional spread footings may be used for foundation support when founded directly on the dense pre-Olympia glacial till, dense pre-Olympia nonglacial deposits, or on structural fill placed over these dense native sediments. We recommend that foundations be designed using an allowable foundation soil bearing pressure of 2,500 pounds per square foot (psf). An increase of one-third may be used for short-term wind or seismic loading.

Perimeter footings should be buried at least 18 inches into the surrounding soil for frost protection. However, all footings must penetrate to the prescribed bearing stratum, and no footing should be founded in or above organic or loose soils. All footings should have a minimum width of 18 inches.

It should be noted that the area bound by lines extending downward at 1H:1V from any footing must not intersect another footing or intersect a filled area that has not been compacted to at least 95 percent of ASTM D-1557. In addition, a 1.5H:1V line extending down from any footing must not daylight because sloughing or raveling may eventually undermine the footing. Thus, footings should not be placed near the edge of steps or cuts in the bearing soils.

Anticipated settlement of footings founded as described above should be on the order of 1 inch or less. Disturbed soil not removed from footing excavations prior to footing placement could result in increased settlements. All footing areas should be observed by AESI prior to placing concrete to verify that the design bearing capacity of the soils has been attained and that construction conforms to the recommendations contained in this report. Such observations may be required by the governing municipality.

12.0 DRAINAGE CONSIDERATIONS

Traffic across the on-site soils when they are damp or wet will result in disturbance of the otherwise firm stratum. Therefore, during site work and construction, the contractor should provide surface drainage and subgrade protection, as necessary.

Any retaining walls and all perimeter foundation walls should be provided with a drain at the footing elevation. Drains should consist of rigid, perforated, polyvinyl chloride (PVC) pipe surrounded by washed gravel. The level of the perforations in the pipe should be set at the bottom of the footing, and the drains should be constructed with sufficient gradient to allow gravity discharge away from the building. The perforations should be located on the lower portion of the pipe. In addition, any retaining or subgrade walls should be lined with a minimum, 12-inch-thick, washed gravel blanket, over the full height of the wall (excluding the first 1 foot below the surface) or backfilled completely with free-draining material. The drainage aggregate should tie into and freely communicate with the footing drains. Roof and surface runoff should not discharge into the footing drain system, but should be handled by a separate, rigid, tightline drain.

To mitigate erosion, stormwater discharge or concentrated runoff should not be allowed to flow down any steep slopes. In planning, exterior grades adjacent to walls should be sloped downward away from the structures at an inclination of at least 3 percent to achieve surface drainage. Runoff water from impervious surfaces should be collected by a storm drain system that discharges into the City-approved site stormwater system.

13.0 FLOOR SUPPORT

Floor slabs can be supported directly by the dense to very dense pre-Olympia glacial till sediments, dense pre-Olympia nonglacial sediments, or by new structural fill placed above these dense natural sediments. New structural fill placed beneath the slab must be compacted to at least 95 percent of ASTM D-1557. The floors should be cast atop a minimum of 4 inches of washed pea gravel or washed crushed rock to act as a capillary break where moisture migration through the slabs is to be controlled. The capillary break material should be overlain by a 10-mil-thick vapor barrier material prior to concrete placement.

14.0 FOUNDATION WALLS

All backfill behind foundation walls or around foundation units should be placed as per our recommendations for structural fill and as described in this section of the report.

14.1 Lateral Earth Pressures

Horizontally backfilled walls, which are free to yield laterally at least 0.1 percent of their height, may be designed to resist lateral earth pressure represented by an equivalent fluid equal to 35 pounds per cubic foot (pcf). Fully restrained, horizontally backfilled, rigid walls that cannot yield should be designed for an equivalent fluid of 50 pcf. Walls with sloping backfill up to a maximum gradient of 2H:1V should be designed using an equivalent fluid of 55 pcf for yielding conditions or 75 pcf for fully restrained conditions. If parking areas are adjacent to walls, a surcharge equivalent to 2 feet of soil should be added to the wall height in determining lateral design forces.

The lateral pressures presented above are based on the conditions of a uniform backfill consisting of excavated on-site soils, or imported structural fill compacted to 90 percent of ASTM D-1557 within about 3 feet of the wall. A higher degree of compaction is not recommended, as this will increase the pressure acting on the walls. A lower compaction may result in settlement of the slab-on-grade or other structures supported above the walls. Thus, the compaction level is critical and must be tested by our firm during placement. Surcharges from adjacent footings or heavy construction equipment must be added to the above values. Perimeter footing drains should be provided for all retaining walls, as discussed under the “Drainage Considerations” section of this report. It is imperative that proper drainage be provided so that hydrostatic pressures do not develop against the walls. Wall drainage recommendations are presented in Section 12.0 of this report.

14.2 Seismic Surcharge

As required by the 2018 IBC, retaining wall design should include a seismic surcharge pressure in addition to the equivalent fluid pressures presented above. Considering the site soils and the recommended wall backfill materials, we recommend a seismic surcharge pressure of 10H and 12H psf, where H is the wall height in feet for the "active" and "at-rest" loading conditions, respectively. The seismic surcharge should be modeled as a rectangular distribution with the resultant applied at the midpoint of the walls.

14.3 Passive Resistance and Friction Factors

Lateral loads can be resisted by friction between the foundation and the natural soils or supporting structural fill soils, and by passive earth pressure acting on the buried portions of the foundations. The foundations must be backfilled with structural fill and compacted to at least 95 percent of the maximum dry density to achieve the passive resistance provided below. We recommend the following allowable design parameters:

- Passive equivalent fluid = 250 pcf
- Coefficient of friction = 0.35

15.0 STATEMENT OF RISK

For Section 19.07.160.B.3 of the *Mercer Island City Code*, the City of Mercer Island requires a statement of risk by the geotechnical engineer. It is the opinion of Associated Earth Sciences, Inc. (AESI) that the development has been designed so that the risk to the site and adjacent property is eliminated or mitigated such that the site is determined to be safe, provided the recommendations in this report are followed.

16.0 PROJECT DESIGN AND CONSTRUCTION MONITORING

We are available to provide additional geotechnical consultation as the project design develops and possibly changes from that upon which this report is based. We recommend that AESI perform a geotechnical review of the plans prior to final design completion. In this way, our earthwork and foundation recommendations may be properly interpreted and implemented in the design.

We are also available to provide geotechnical engineering and monitoring services during construction. The integrity of the foundations depends on proper site preparation and construction procedures. In addition, engineering decisions may have to be made in the field in the event that variations in subsurface conditions become apparent. Construction monitoring services are not part of this current scope of work. If these services are desired, please let us know, and we will prepare a proposal.

We have enjoyed working with you on this study and are confident these recommendations will aid in the successful completion of your project. If you should have any questions or require further assistance, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

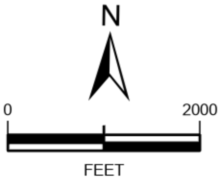
STEPHEN A. SIEBERT
30329
10/3/22

Joshua S. P. Greer, L.G.
Project Geologist

Bruce L. Blyton, P.E.
Senior Principal Geotechnical Engineer

Stephen A. Siebert, P.E.
Associate Geotechnical Engineer

Attachments:	Figure 1:	Vicinity Map
	Figure 2:	Existing Site and Exploration Plan
	Figure 3:	Site and Exploration Plan
	Appendix A:	Exploration Logs
	Appendix B:	Slope Stability Analysis



DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NGS 2013
KING CO: STREETS, CITY LIMITS, PARCELS, PARKS 9/21
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

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VICINITY MAP

MERCER ISLAND SFR
MERCER ISLAND, WASHINGTON

PROJ NO.	DATE:	FIGURE:
20220159E001	9/22	1

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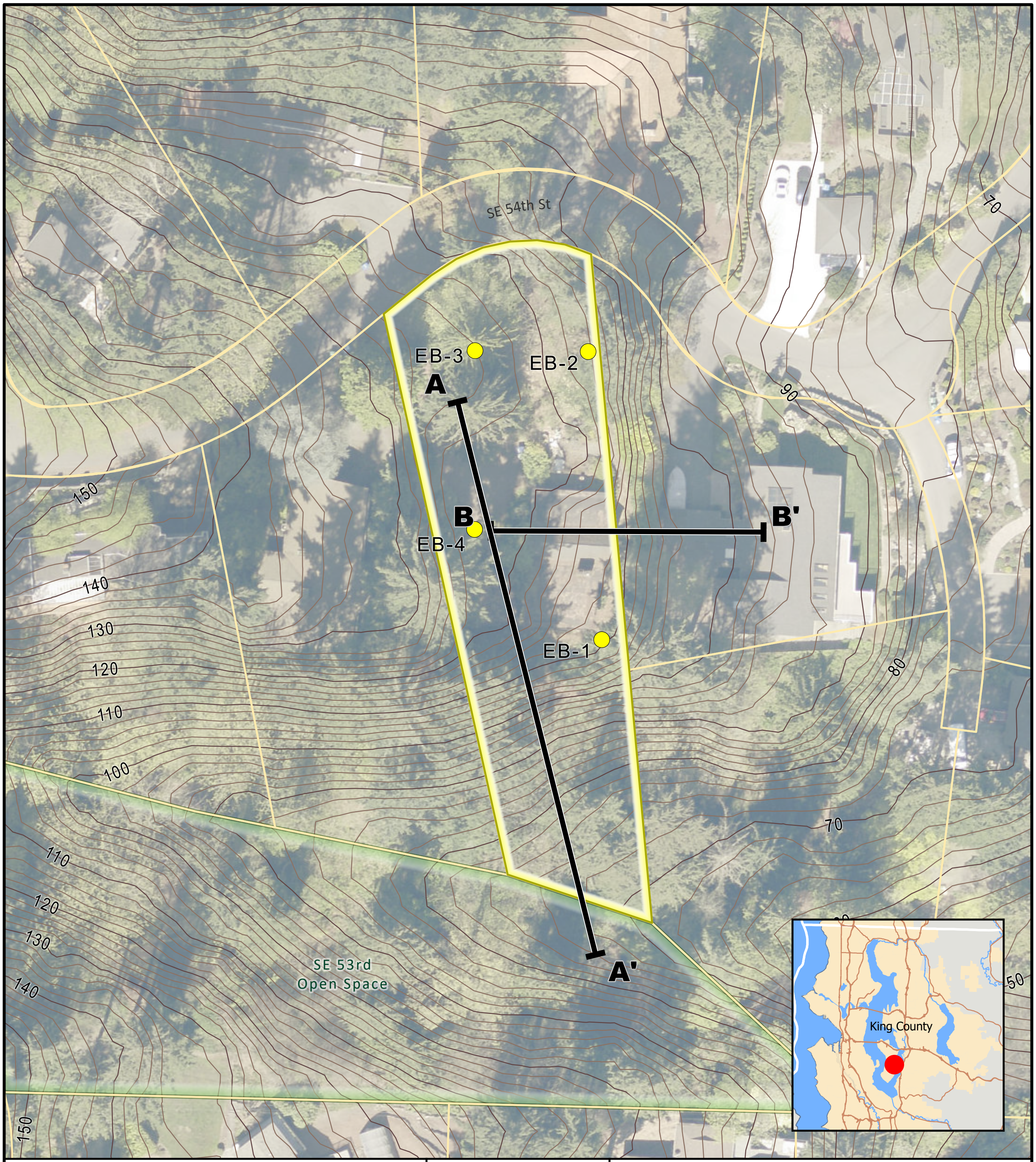

LEGEND

- SITE
- ● EXPLORATION BORING
- CROSS-SECTION
- PARCEL
- 🟩 PARK
- CONTOUR 10 FT
- CONTOUR 2 FT

DATA SOURCES / REFERENCES:
PSLC: KING COUNTY 2016, GRID CELL SIZE IS 3'.
DELIVERY 1 FLOWN 2/24/16 - 3/28/16, CONTOURS FROM LIDAR
KING CO: STREETS, PARCELS, 9/21
AERIAL: PICTOMETRY INT. 2021
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

N

0 60
FEET

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

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EXISTING SITE AND EXPLORATION PLAN

MERCER ISLAND SFR
MERCER ISLAND, WASHINGTON

PROJ NO. 20220159E001
DATE: 9/22
FIGURE: 2

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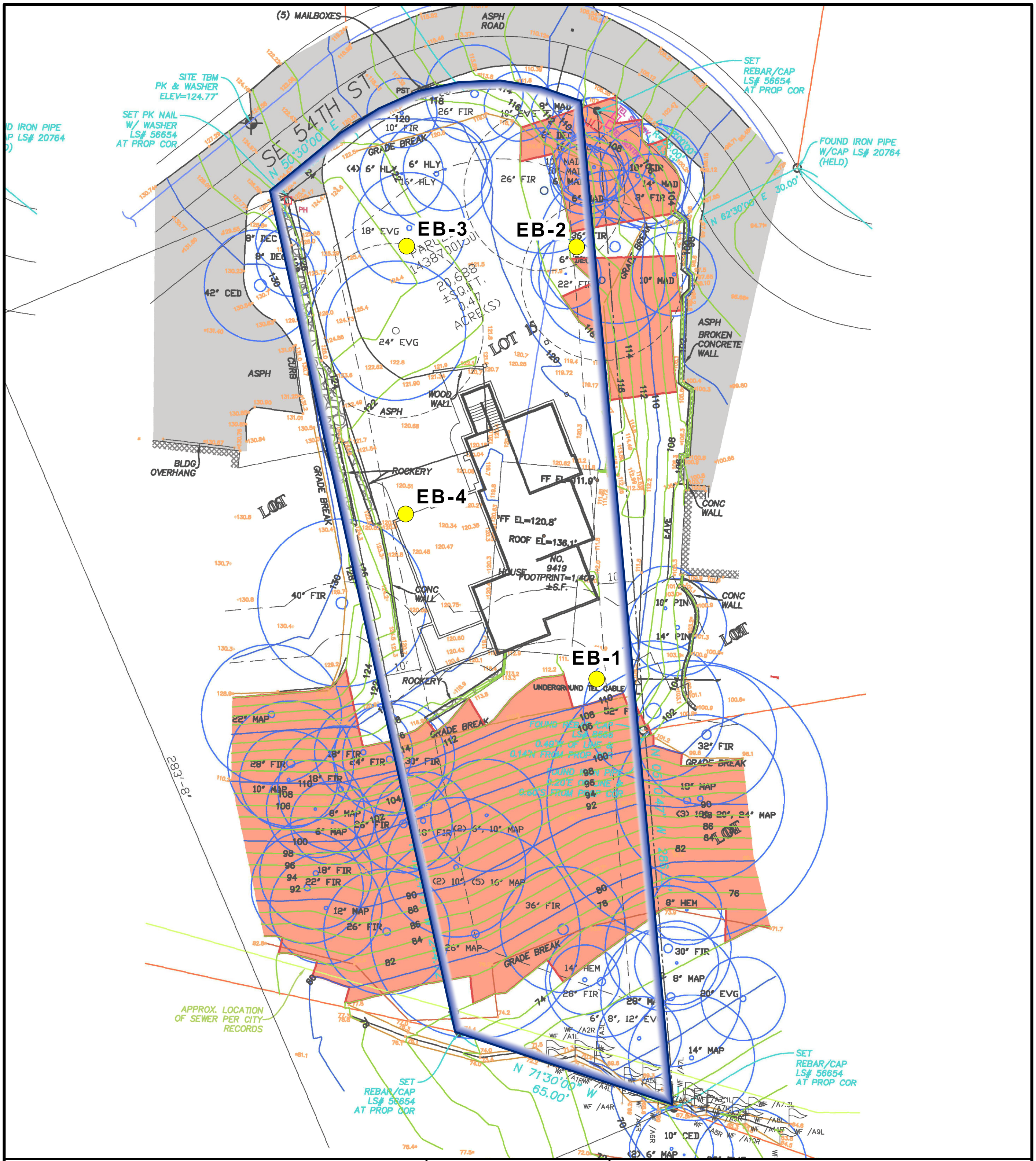

LEGEND

▭ SITE

● EXPLORATION BORING

🟥 STEEP SLOPE > 40%

DATA SOURCES / REFERENCES:
PROPOSED NEW SFR SITE PLAN, UNDATED
PROJECT BOUNDARY FROM KING CO PARCEL DATA 9/21
GEOREFERENCED USING AERIAL: PICTOMETRY INT. 2021
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

N

0 40
FEET

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

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SITE AND EXPLORATION PLAN

MERCER ISLAND SFR
MERCER ISLAND, WASHINGTON

PROJ NO.	DATE:	FIGURE:
20220159E001	9/22	3

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APPENDIX A

Exploration Logs

Coarse-Grained Soils - More than 50%(1) Retained on No. 200 Sieve	Gravels - More than 50%(1) of Coarse Fraction Retained on No. 4 Sieve	≤5% Fines (5)	▨	**GW**	Well-graded gravel and gravel with sand, little to no fines
			▨	**GP**	Poorly-graded gravel and gravel with sand, little to no fines
		≥12% Fines (5)	▨	**GM**	Silty gravel and silty gravel with sand
			▨	**GC**	Clayey gravel and clayey gravel with sand
	Sands - 50%(1) or More of Coarse Fraction Passes No. 4 Sieve	≤5% Fines (5)	▨	**SW**	Well-graded sand and sand with gravel, little to no fines
			▨	**SP**	Poorly-graded sand and sand with gravel, little to no fines
		≥12% Fines (5)	▨	**SM**	Silty sand and silty sand with gravel
			▨	**SC**	Clayey sand and clayey sand with gravel
Fine-Grained Soils - 50% (1) or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less than 50		▨	**ML**	Silt, sandy silt, gravelly silt, silt with sand or gravel
			▨	**CL**	Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay
			▨	**OL**	Organic clay or silt of low plasticity
	Silts and Clays Liquid Limit 50 or More		▨	**MH**	Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt
			▨	**CH**	Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel
			▨	**OH**	Organic clay or silt of medium to high plasticity
Highly Organic Soils			▨	**PT**	Peat, muck and other highly organic soils

Terms Describing Relative Density and Consistency

	Density	SPT(2) blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50
	Consistency	SPT(2) blows/foot
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Chemical
DD = Dry Density
K = Permeability

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

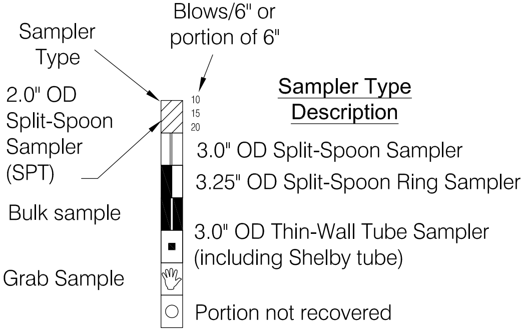
(3) Estimated Percentage

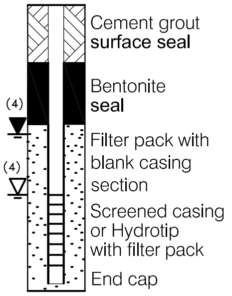
Component	Percentage by Weight
Trace	<5
Some	5 to <12
Modifier (silty, sandy, gravelly)	12 to <30
Very *modifier* (silty, sandy, gravelly)	30 to <50

Moisture Content

Dry - Absence of moisture, dusty, dry to the touch
Slightly Moist - Perceptible moisture
Moist - Damp but no visible water
Very Moist - Water visible but not free draining
Wet - Visible free water, usually from below water table

Symbols





(1) Percentage by dry weight
(2) (SPT) Standard Penetration Test (ASTM D-1586)
(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)
(4) Depth of ground water
▼ ATD = At time of drilling
∇ Static water level (date)
(5) Combined USCS symbols used for fines between 5% and 12%

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

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EXPLORATION LOG KEY

FIGURE A1

blocks \ dwg \ log_key.dwg LAYOUT: Layout 4 -2014 Qty Chng

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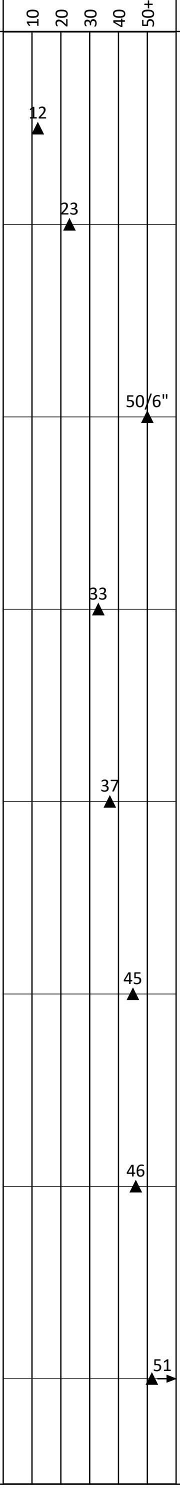
Exploration Boring **EB-1**

Mercer Island SFR | Sheet: 1 of 2
Mercer Island, WA | Start Date: 06-23-22 | Logged By: JG
20220159E001 | Ending Date: 06-23-22 | Approved By: CMM

Driller/Equipment: Geologic Drill/Mini-Bobcat HSA
Hammer Weight/Drop: 140#/30"
Hole Diameter (in): 6
▼ Groundwater Depth ATD (ft): N/A

Total Depth (ft): 51.5
Ground Surface Elevation (ft): 110
Datum: NAVD88
▽ Groundwater Depth Post Drilling (ft) (Date): N/A ()

Depth (ft)	Sample Type	Sample	% Recovery	Graphic Symbol	Description	Water Level	Blows/6"	Blows/Foot	Other Tests
0					**Grass / Topsoil - 6 inches**				
					Fill				
		1			Moist, grayish brown with occasional irregular oxidation mottling, silty, fine SAND, trace gravel, trace organics (SM).		3 4 8	12	
					Pre-Olympia Glacial Till				
5		2			Moist, gray to light brown with oxidation mottling, silty, fine SAND, some gravel; micaceous; massively bedded (SM). High drilling action at 5 to 10 feet. Slow drill progress.		6 12 11	23	
10		3			As above.		12 21 50/6"	50/6"	
					Pre-Olympia Nonglacial Deposits				
15		4			Moist, light brown, fine SAND, trace to some silt, trace mica flakes; massively bedded (SP/SP-SM)		13 15 18	33	
20		5			As above.		13 17 20	37	
25		6			As above.		15 20 25	45	
30		7			As above; with very faint planes (0.25 inches thick) of trace oxidation.		15 17 29	46	
35		8			As above.		21 24 27	51	



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Exploration Boring EB-1

Mercer Island SFR			Sheet: 2 of 2
Mercer Island, WA	Start Date: 06-23-22	Logged By: JG	
20220159E001	Ending Date: 06-23-22	Approved By: CMM	

Driller/Equipment: Geologic Drill/Mini-Bobcat HSA
Hammer Weight/Drop: 140#/30"
Hole Diameter (in): 6
▼ Groundwater Depth ATD (ft): N/A

Total Depth (ft): 51.5
Ground Surface Elevation (ft): 110
Datum: NAVD88
▽ Groundwater Depth Post Drilling (ft) (Date): N/A ()

Depth (ft)	Sample Type	Sample	% Recovery	Graphic Symbol	Description	Water Level	Blows/6"	Blows/Foot (10 20 30 40 50+)	Other Tests
40		9			As above.		19 23 30	53	
45		10			As above.		16 21 29	50	
50		11			As above.		21 26 27	53	
					No groundwater encountered.				
55									
60									
65									
70									
75									

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Exploration Boring EB-2

Mercer Island SFR

Sheet: 1 of 1

Mercer Island, WA	Start Date: 06-23-22	Logged By: JG
20220159E001	Ending Date: 06-23-22	Approved By: CMM

Driller/Equipment: Geologic Drill/Mini-Bobcat HSA
Hammer Weight/Drop: 140#/30"
Hole Diameter (in): 6
▼ Groundwater Depth ATD (ft): N/A

Total Depth (ft): 21
Ground Surface Elevation (ft): 116
Datum: NAVD88
▽ Groundwater Depth Post Drilling (ft) (Date): N/A ()

Depth (ft)	Sample Type	Sample	% Recovery	Graphic Symbol	Description	Water Level	Blows/6"	Blows/Foot (10 20 30 40 50+)	Other Tests
0					**Grass / Topsoil - 6 inches**				
					Fill				
		1			Upper 6 inches: Moist, dark brown, silty, fine SAND, some gravel; frequent organics (SM). Lower 6 inches: Moist, light brown, fine to medium SAND, some gravel, trace silt (SP).		5 3 3	6	
5		2			Upper 6 inches: Moist, light brown, fine to medium SAND, some gravel, trace silt (SP).		4 7 10	17	
					Pre-Olympia Glacial Till				
					Lower 6 inches: Moist, brownish gray with oxidation mottling, silty, fine SAND, some gravel; unsorted (SM).				
10		3			High drilling action 7 to 19 feet. Moist, brownish gray, silty, fine SAND, trace to some gravel; unsorted (SM).		14 19 21	40	
15		4			As above.		22 28 26	54	
					Pre-Olympia Nonglacial Deposits				
20		5			Moist, grayish brown, fine SAND, some silt; two thin beds of silt; stratified (SP-SM).		22 50/6"	50/6"	
					No groundwater encountered.				
25									
30									
35									

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Exploration Boring — EB-3

Mercer Island SFR — Sheet: 1 of 1

Mercer Island, WA	Start Date: 06-23-22	Logged By: JG
20220159E001	Ending Date: 06-23-22	Approved By: CMM

Driller/Equipment: Geologic Drill/Mini-Bobcat HSA
Hammer Weight/Drop: 140#/30"
Hole Diameter (in): 6
▼ Groundwater Depth ATD (ft): N/A

Total Depth (ft): 26.5
Ground Surface Elevation (ft): 124
Datum: NAVD88
▽ Groundwater Depth Post Drilling (ft) (Date): N/A ()

Depth (ft)	Sample Type	Sample	% Recovery	Graphic Symbol	Description	Water Level	Blows/6"	Blows/Foot	Other Tests
0					**Topsoil - 6 inches**				
					Fill				
		1			Moist, light brown, fine SAND, trace gravel, trace silt; massive (SP).		4 5 6	11	
5		2			As above; becomes some gravel; one silty clast near tip (SP).		7 6 7	13	
10		3			Upper 6 inches: Moist, light brown, fine to medium SAND, some gravel, trace silt (SP).		6 8 8	16	
					Pre-Olympia Glacial Till				
					Lower 12 inches: Moist, grayish brown with oxidation, silty, fine SAND, some gravel (SM).				
15		4			Moist, grayish brown, fine SAND, some silt to silty, some gravel; unsorted (SP-SM/SM).		15 17 19	36	
20		5			Upper 12 inches: Moist, grayish brown, fine SAND, some silt, trace gravel; unsorted (SP-SM).		15 17 21	38	
					Pre-Olympia Nonglacial Deposits				
					Lower 6 inches: Moist, light brown, SILT; massive (ML).				
25		6			Moist, light brown, fine SAND, some silt to silty, some gravel; stratified (SM/SP-SM).		10 15 20	35	
					No groundwater encountered.				
30									
35									

Blows/Foot scale: 10 20 30 40 50+

9/29/2022

20220159E001

associated earth sciences incorporated

Exploration Boring — EB-4

Mercer Island SFR — Sheet: 1 of 1

Mercer Island, WA	Start Date: 06-23-22	Logged By: JG
20220159E001	Ending Date: 06-23-22	Approved By: CMM

Driller/Equipment: Geologic Drill/Mini-Bobcat HSA
Hammer Weight/Drop: 140#/30"
Hole Diameter (in): 6
▼ Groundwater Depth ATD (ft): N/A

Total Depth (ft): 21.5
Ground Surface Elevation (ft): 122
Datum: NAVD88
▽ Groundwater Depth Post Drilling (ft) (Date): N/A ()

Depth (ft)	Sample Type	Sample	% Recovery	Graphic Symbol	Description	Water Level	Blows/6"	Blows/Foot	Other Tests
0					**Asphalt - 3 inches**				
					Fill				
		1			Upper 9 inches: Moist, brown, gravelly, fine to coarse SAND, trace silt (SP).		10 8 9	17	
					Pre-Olympia Glacial Till Lower 9 inches: Moist, grayish brown, silty, fine SAND, some gravel; unsorted (SM).				
5		2			Moist, grayish brown, silty, fine SAND, some gravel; unsorted (SM).		12 29 43	72	
10		3			Becomes some silt to silty (SP-SM/SM).		12 18 29	47	
					Pre-Olympia Nonglacial Deposits				
15		4			Moist, light brown, fine SAND, trace gravel, trace silt; micaceous (SP).		11 17 23	40	
20		5			As above.		12 16 23	39	
					No groundwater encountered.				
25									
30									
35									

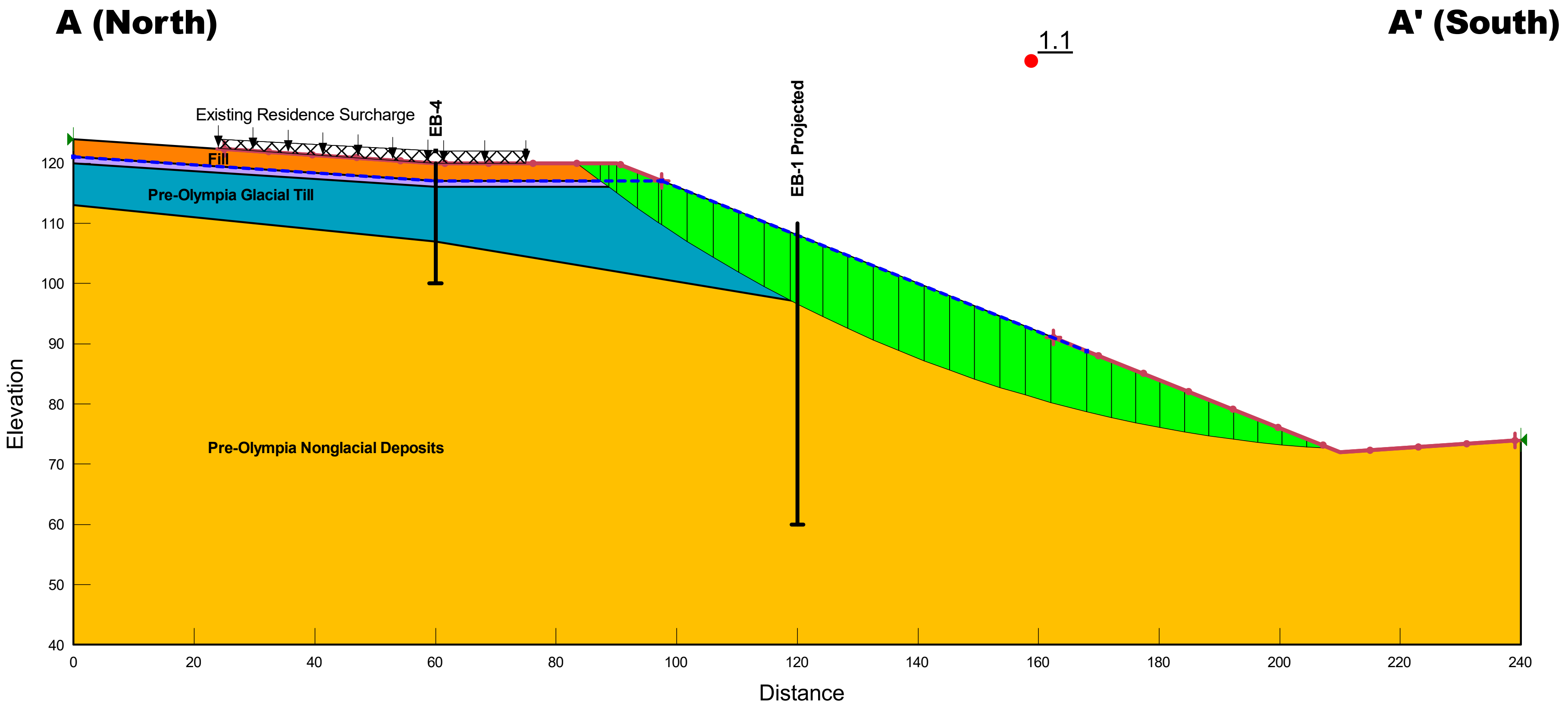
Blows/Foot scale: 10 20 30 40 50+

APPENDIX B

Slope Stability Analysis

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟧	Fill	125	0	30
🟦	Pre-Olympia Glacial Till	125	200	38
🟨	Pre-Olympia Nonglacial Deposits	125	0	38
🟪	Weathered Pre-Olympia Glacial Till	125	200	34

Horizontal Seismic Acceleration: 0.33

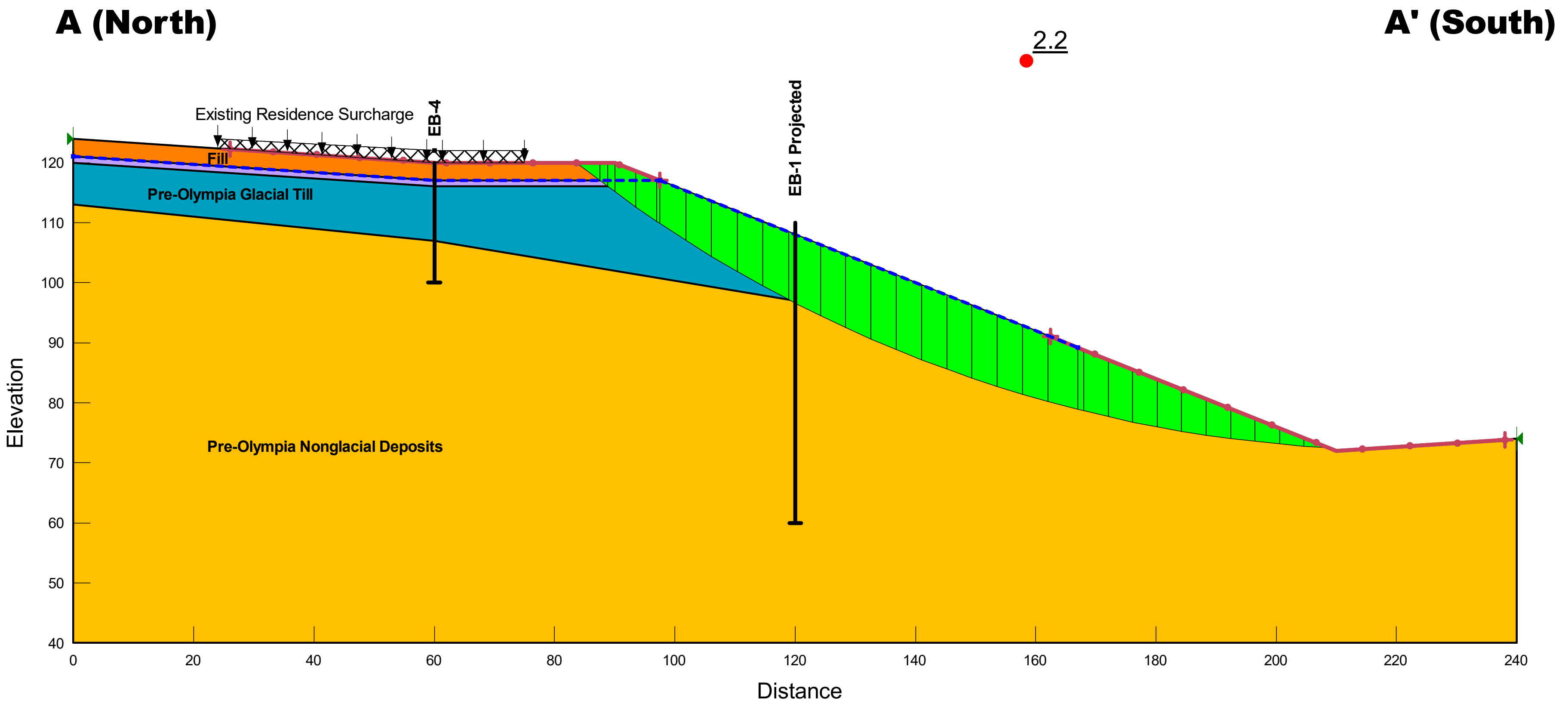


A-A': Existing Slope - Seismic

20220159_Mercer Island SFR_A-A' Existing.gsz

9/30/2022 1:330

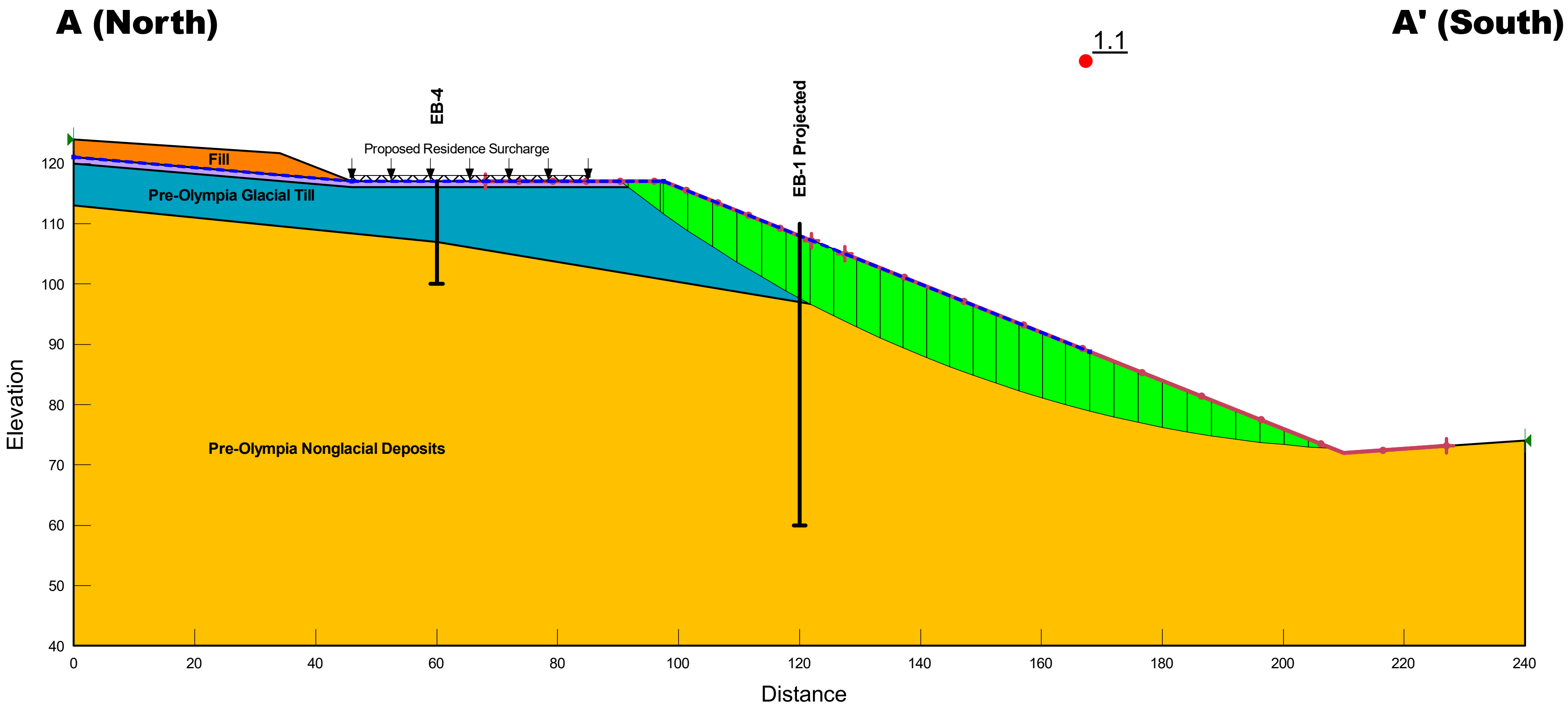
Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟧	Fill	125	0	30
🟦	Pre-Olympia Glacial Till	125	200	38
🟨	Pre-Olympia Nonglacial Deposits	125	0	38
🟪	Weathered Pre-Olympia Glacial Till	125	200	34



A-A': Existing Slope - Static	
20220159_Mercer Island SFR_A-A' Existing.gsz	
9/30/2022	1:330

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
🟧	Fill	125	0	30	1
🟦	Pre-Olympia Glacial Till	125	200	38	
🟨	Pre-Olympia Nonglacial Deposits	125	0	38	
🟪	Weathered Pre-Olympia Glacial Till	125	200	34	1

Horizontal Seismic Acceleration: 0.33

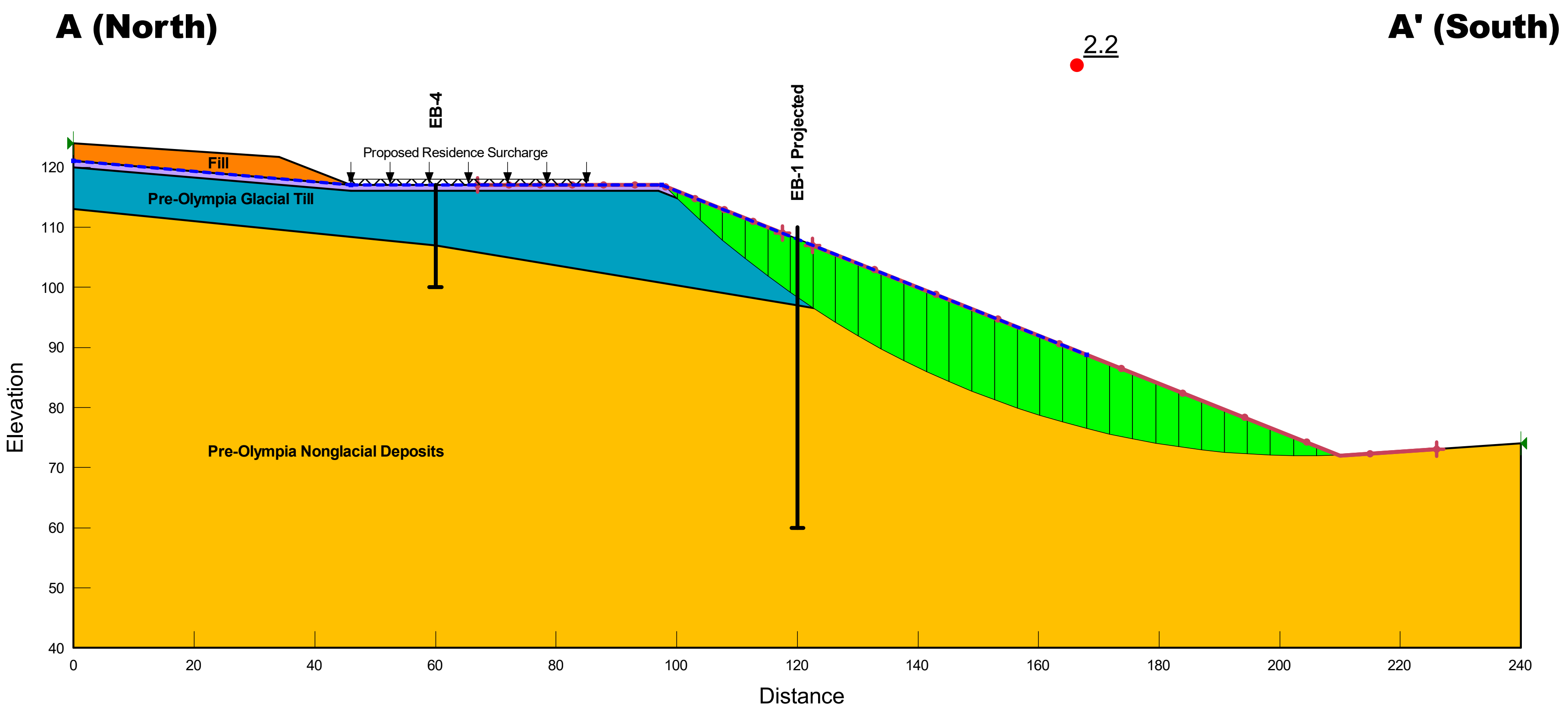


A-A': Proposed Slope - Seismic

20220159_Mercer Island SFR_A-A' Proposed.gsz

9/30/2022 1:330

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
🟧	Fill	125	0	30	1
🟦	Pre-Olympia Glacial Till	125	200	38	
🟨	Pre-Olympia Nonglacial Deposits	125	0	38	
🟪	Weathered Pre-Olympia Glacial Till	125	200	34	1



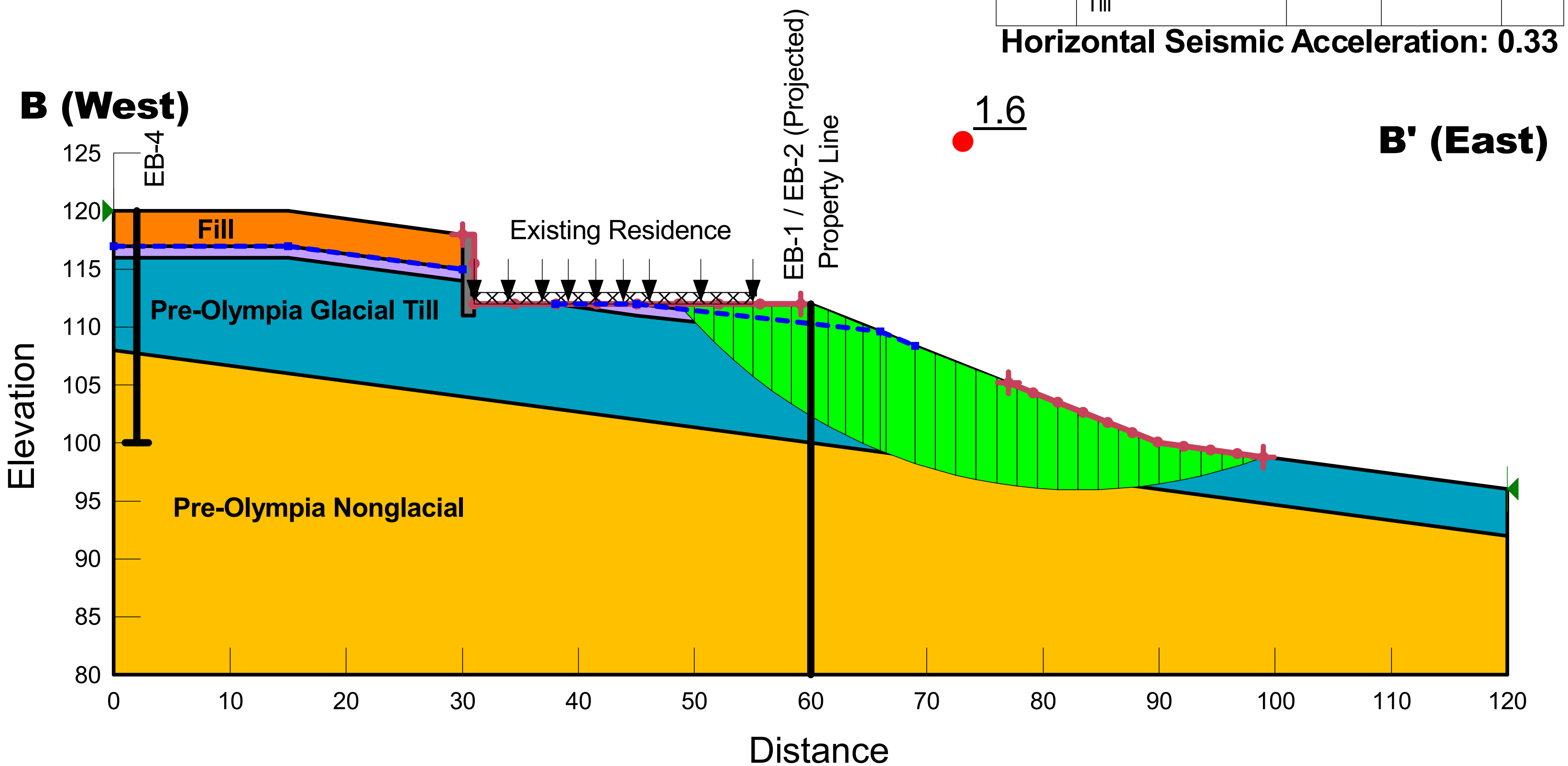
A-A': Proposed Slope - Static

20220159_Mercer Island SFR_A-A' Proposed.gsz

9/30/2022 1:330

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
⬛	Basement Wall	150		
🟧	Fill	125	0	30
🟦	Pre-Olympia Glacial Till	125	200	38
🟨	Pre-Olympia Nonglacial Deposits	125	0	38
🟪	Weathered Pre-Olympia Glacial Till	125	200	34

Horizontal Seismic Acceleration: 0.33

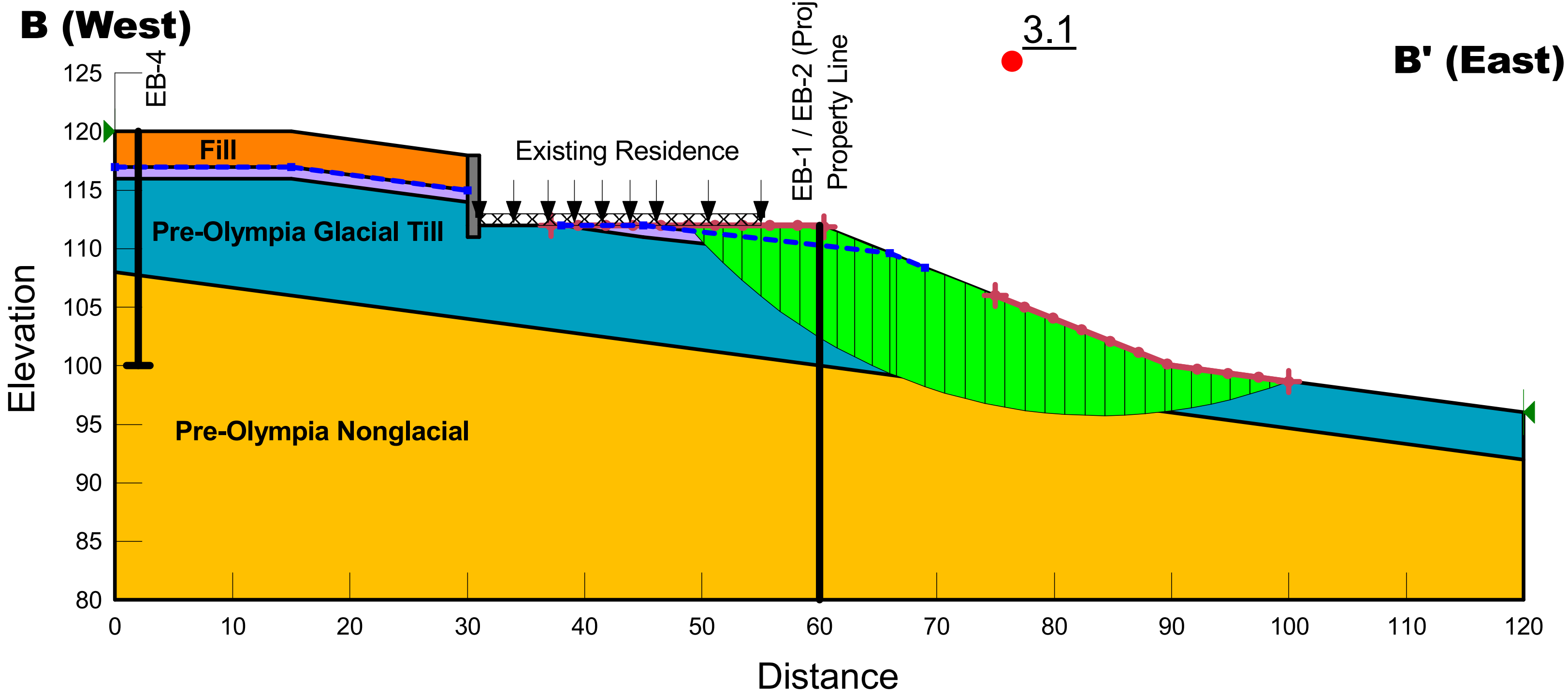


B-B': Existing Slope - Seismic

20220159_Mercer Island SFR_B-B' Existing.gsz

9/30/2022 1:190

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
⬛	Basement Wall	150		
🟧	Fill	125	0	30
🟦	Pre-Olympia Glacial Till	125	200	38
🟨	Pre-Olympia Nonglacial Deposits	125	0	38
🟪	Weathered Pre-Olympia Glacial Till	125	200	34



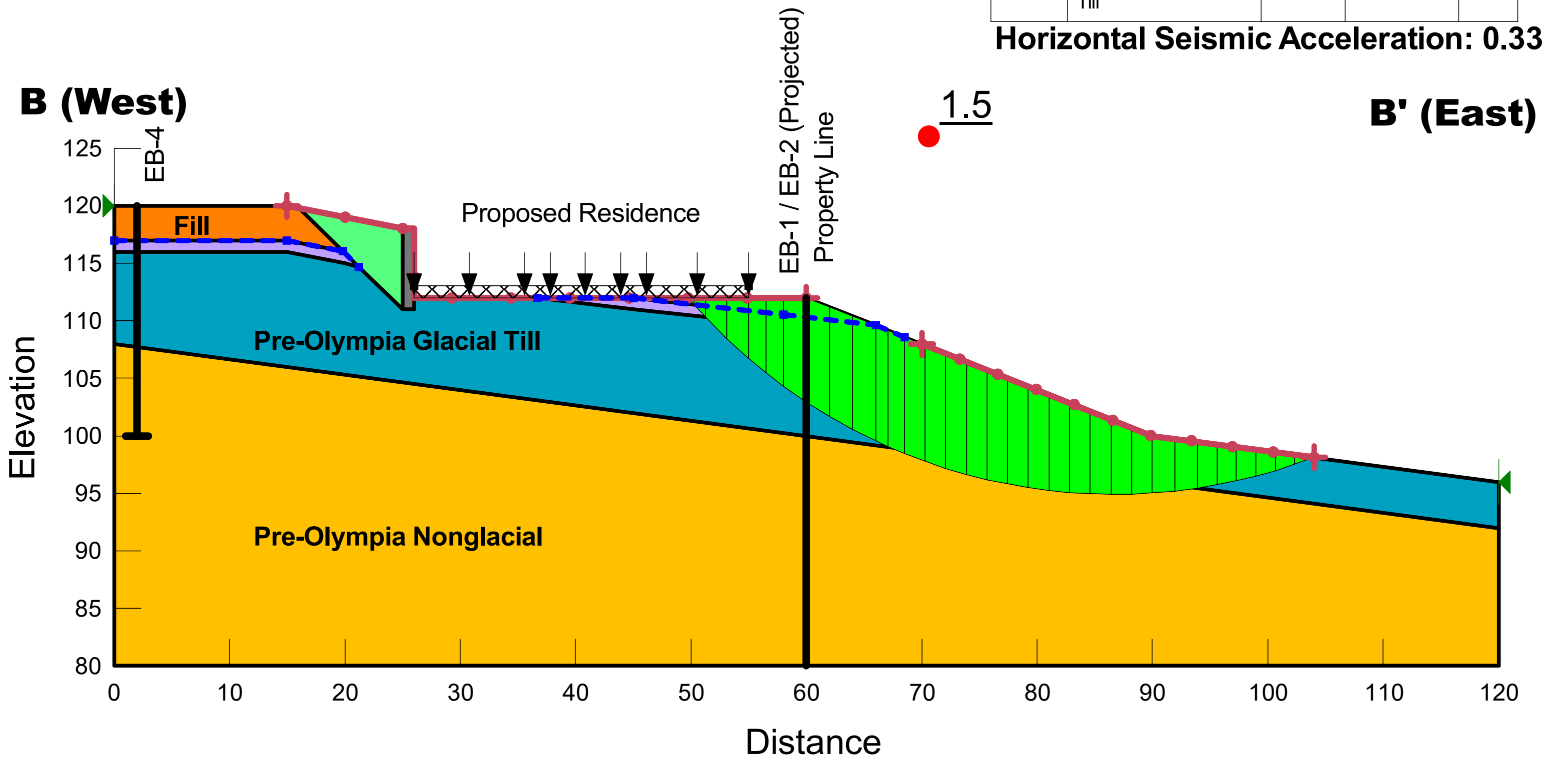
B-B': Existing Slope - Static

20220159_Mercer Island SFR_B-B' Existing.gsz

9/30/2022 1:190

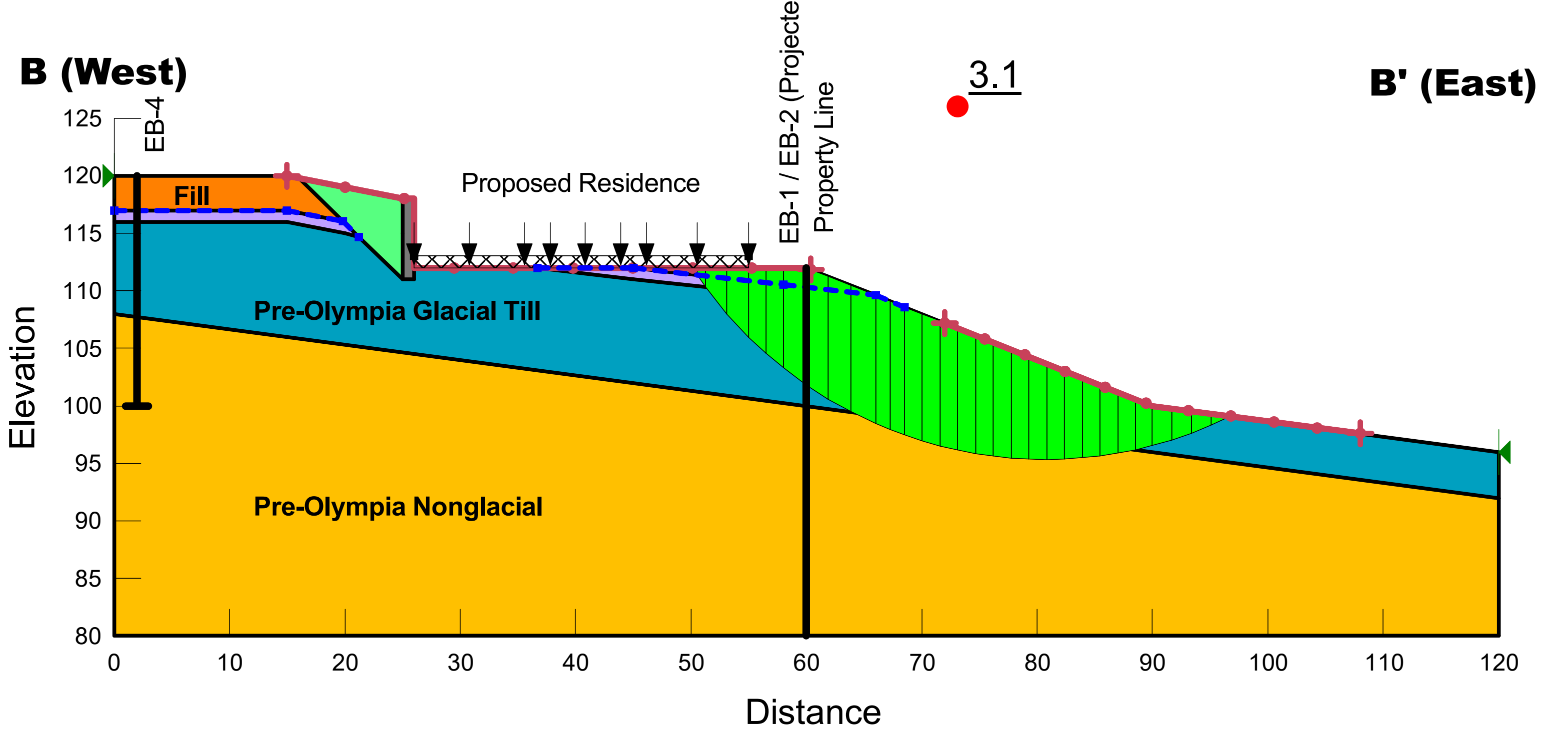
Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
⬛	Basement Wall	150		
🟧	Fill	125	0	30
🟦	Pre-Olympia Glacial Till	125	200	38
🟨	Pre-Olympia Nonglacial Deposits	125	0	38
🟩	Structural Fill	125	0	34
🟪	Weathered Pre-Olympia Glacial Till	125	200	34

Horizontal Seismic Acceleration: 0.33



B-B': Proposed Slope - Seismic
20220159_Mercer Island SFR_B-B' Proposed.gsz
9/30/2022 1:200

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
⬛	Basement Wall	150		
🟧	Fill	125	0	30
🟦	Pre-Olympia Glacial Till	125	200	38
🟨	Pre-Olympia Nonglacial Deposits	125	0	38
🟩	Structural Fill	125	0	34
🟪	Weathered Pre-Olympia Glacial Till	125	200	34



B-B': Proposed Slope - Static

20220159_Mercer Island SFR_B-B' Proposed.gsz

9/30/2022 1:200