GEOTECHNICAL REPORT AND GEOLOGIC HAZARD AREAS REVIEW

Proposed ADU
4751 Fernridge
Mercer Island, Washington

PROJECT NO. 24-459
February 2025

PanGEO INCORPORATED

Geotechnical & Earthquake Engineering Consultants

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INCORPORATED
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Engineering Consultants

February 27, 2025
File No. 24-459

Keith Pleas
4751 Fernridge Lane
Mercer Island, WA 98040

Subject: Geotechnical Report and Geologic Hazard Areas Review
Proposed ADU
4751 Fernridge Lane, Mercer Island, WA

Dear Keith:

Attached please find our geotechnical report for the proposed ADU that will be constructed in the crawlspace of the existing residence. In preparing this report, we performed a site reconnaissance, drilled two test borings, and conducted our engineering analyses. The results of our study and our design recommendations are presented in the attached report.

At our test boring locations, we encountered 4 to 5 feet of very loose to loose fill overlying medium dense to very dense sand with gravel which we interpreted as native Advance outwash deposits. Groundwater was not encountered in our test borings at the time of drilling. Based on the soil conditions encountered, we recommend that 2-inch diameter driven pin piles be used to support the proposed ADU.

Based on our understanding of subsurface conditions and the project, in our opinion the proposed addition will not adversely impact the stability of the site and adjacent properties.

We appreciate the opportunity to work on this project. Please call if there are any questions.

Sincerely,

Siew L. Tan, P.E.
Principal Geotechnical Engineer

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4751 FERNRIDGE LN, MERCER ISLAND, WASHINGTON

1.0 INTRODUCTION

This report presents the results of our geotechnical study that was undertaken to support the design and construction of the proposed in Mercer Island, Washington. This study was performed in general accordance with our mutually agreed scope of service outlined in our proposal dated October 15th, 2024, which was subsequently signed on November 11th, 2024. Our scope of services included reviewing readily available geologic and geotechnical data in the project vicinity, drilling two test borings at the site, conducting a site reconnaissance, performing engineering analysis, and developing the conclusions and recommendations presented in this report.

2.0 SITE AND PROJECT DESCRIPTION

The project site is an approximately 16,440 square foot lot located at 4751 – Fernridge Ln in Mercer Island, Washington. The site location is approximately as shown on *Figure 1, Vicinity Map*. The site is irregular in shape, and borders Fernridge Ln to the south, east, and north, along with existing single-family residences around the property. The site is currently occupied by a two-story single-family house in the southern portion of the site. Based on review of the City of Mercer Island GIS maps and topographic survey, the existing site grade generally descends from north to south and southeast, and portions of the site grade are steeper than 40%, with a total vertical relief of about 50 feet within the property limits. The site layout and topographic features including areas that are steeper than 40% are shown in Figure 2.

The general conditions of the site at the time of our field exploration are shown on Plate 1 and 2, following page.

Based on review of the City of Mercer Island map, the site contains several geologic hazards, including potential landslide hazard, steep slope hazard, seismic hazard, and erosion hazard. The objective of this geotechnical study is to explore the site soil and groundwater conditions, evaluate the potential geologic hazards, and provide geotechnical design recommendations for the proposed construction.

Plate 1: *View of the existing residence. Looking northwest from southeast of the property.*

Plate 2: *View of the existing residence underneath the roofline. Looking south from east side of the property.*

We understand that you plan to convert the crawlspace into a 480-square-foot living space. The proposed ADU will be located entirely within the footprint of the existing building. Excavation will be needed in the crawlspace to increase the headroom in parts of the proposed ADU, and the excavation will extend below some of the existing foundation, which may need to be underpinned. New retaining walls will be constructed on the upslope side of the proposed ADU. Plate 3, below, is a schematic of the proposed improvements.

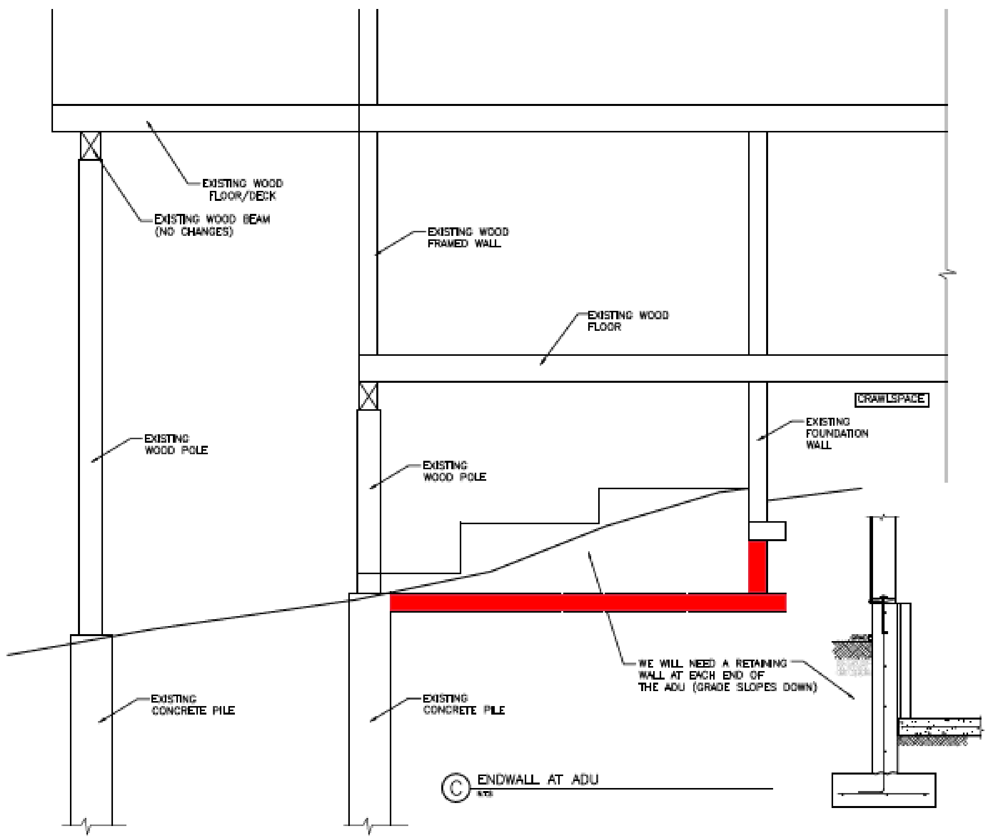


Plate 3. Building section showing the new wall and slab (in red) – Source: Keith Ryan, P.E.

The conclusions and recommendations in this report are based on our understanding of the proposed addition, which is in turn based on the project information provided. If the above project description is incorrect, or the project information changes, we should be consulted to review the recommendations contained in this study and make modifications, if needed. In any case PanGEO should be retained to provide a review of the final design to confirm that our geotechnical recommendations have been correctly interpreted and adequately implemented in the construction documents.

3.0 SUBSURFACE EXPLORATION

Two test borings, designated as PG-1 and PG-2, were completed at the approximate locations shown on Figure 2 on December 9th, 2024. The borings were drilled to depths of about 31½ and 26½ feet, using an Acker drill rig owned and operated by CN Drilling of Seattle, Washington.

The drill rig was equipped with 5-inch outside diameter hollow stem augers. Soil samples were obtained from the borings at 2½- and 5-foot depth intervals in general accordance with Standard Penetration Test (SPT) sampling methods (ASTM test method D-1586), in which the samples are obtained using a 2-inch outside diameter split-spoon sampler. The sampler was driven into the soil using a 140-pound weight falling 30 inches per stroke until reaching a total penetration of 18 inches. The number of blows required for each 6-inch increment of sampler penetration was recorded. The number of blows required to achieve the last 12 inches of sample penetration is defined as the SPT N-value. The N-value provides an empirical measure of the relative density of cohesionless soil, or the relative consistency of fine-grained soils. The completed borings were backfilled with drill cuttings and bentonite chips.

A geologist from PanGEO was present during the field exploration to observe the drilling, to assist in sampling, and to describe and document the soil samples obtained from the borings. The soils were logged in general accordance with the system summarized on Figure A-1, Terms and Symbols for Boring and Test Pit Logs, and summary test boring logs are included as Figures A-2 and A-3 in Appendix A.

4.0 SUBSURFACE CONDITIONS

4.1 SITE GEOLOGY

Based on review of *The Geologic Map of Mercer Island* (Troost and Wisher, 2006), and as shown on *Plate 3* on Page 7 of this report, the surficial geologic unit at the site consists of Vashon advance outwash (Geologic Map Unit Qva). Vashon advance outwash generally consists of sand with variable amounts of silt and gravel that were deposited by meltwater streams in front of the advancing glacier during the Vashon Stade of the Fraser glaciation. This soil was subsequently overridden by several thousand feet of glacial ice and is dense to very dense in its undisturbed state.

The steep slope southwest of the site is also identified as being underlain by landslide deposits and Vashon Lawton Clay (Qvlc). Landslide deposits are described as very loose to very dense and soft to hard, diamict of broken to internally coherent surficial deposits transported down slope *en masse* by gravity. Lawton Clay typically consists of very stiff to hard, laminated to massive silt and clay deposited in proglacial lakes early in the Vashon glaciation.

In addition, a landslide scarp is mapped at the top of the steep slope on the southwest side of the site.

4.2 Soil Conditions

In general, the soil conditions encountered in both test borings were quite consistent and generally consisted of fill overlying native soils that we interpreted as Advance outwash deposit, which is generally consistent with the mapped geology. Our test borings did not encounter the Lawton Clay and landslide deposits mapped in the vicinity of the site.

The following is a generalized description of the soils encountered in the borings. For a more detailed description of the subsurface conditions encountered at each exploration location for this study, please refer to our boring logs provided in Appendix A.

> **Fill** – Below the ground surface, both borings encountered very loose to loose silty sand with variable amounts of gravel. This soil unit extended to about 4 to 5 feet below existing grade in both borings. We interpret this soil unit as fill.
>
> **Advance Outwash (Qva)** – Below the fill, both borings encountered medium dense to very dense, interlayered poorly graded silty sand and sandy silt. This soil unit appeared consistent with the Vashon advance outwash mapped at the site by Troost (2006). This unit is characterized by its dense/hard condition and poorly to uniformly graded soil texture. Both test borings were terminated in this soil unit.

Our subsurface descriptions are based on the conditions encountered at the time of our exploration. Soil conditions between our exploration locations may vary from those encountered. The nature and extent of variations between our exploratory locations may not become evident until construction. If variations do appear, PanGEO should be requested to reevaluate the recommendations in this report and to modify or verify them in writing prior to proceeding with earthwork and construction.

4.3 Groundwater

Groundwater was not observed within the maximum depths of our test borings at the time of drilling. Additionally, during our field exploration we did not note the presence of hydrophytic or water-loving plants like horsetails at the site.

The designers and contractor should be aware there will be fluctuations in groundwater conditions depending on the season, amount of rainfall, surface water runoff, and other factors. Generally, the water level is higher, and seepage rates are greater in the wetter, winter months (typically October through May).

5.0 GEOLOGICALLY HAZARDOUS AREAS CONSIDERATIONS

Based on review of the City of Mercer Island map, the site contains several geologic hazards, including potential landslide hazard, steep slope hazard, seismic hazard, and erosion hazard. Geologically Hazardous Areas are identified in the City of Mercer Island Municipal Code (MIMC) Chapter 19.07.160 as lands that are susceptible to erosion, landslides, seismic events, or other factors as identified by Washington Administrative Code (WAC) 365-190-120. The City's criteria for these hazard areas and our assessment of the hazard areas with respect to the subject site are provided in the following sections of this report.

5.1 Landslide Hazards

Based on our review of the City of Mercer Island's Geologic Hazards Maps, the project site is mapped as a landslide hazard area. The City of Mercer Island defines landslide hazard area as 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; or*
5. *Steep slope. Any slope of 40 percent or greater calculated by measuring the vertical rise over any 30-foot horizontal run.*

In order to evaluate the presence of historical failures and geologic conditions that may identify the presence of landslide features at the site, we reviewed geologic maps, LiDAR imagery, Mercer Island mapping information, and conducted a reconnaissance of the site slopes.

5.1.1 Map Review

According to the *Geologic Map of Mercer Island, Washington* (Troost, et al, 2006), the site is located in a prehistoric landslide. The approximate extent of the landslide relative to the site is shown in *Plate 3*.

Plate 4, on the following page, shows the approximate extent of landslide hazard areas mapped by the City of Mercer Island. Based on review of the City's mapping, the entire site is located in a landslide hazard area and potential landslide hazard area. Additionally, the slope on the southwest side of the property and beyond the property line is also mapped as a 40 percent and steeper slope area. The approximate extent of the 40 percent slopes mapped by Mercer Island are shown on *Plate 5*, on the following page.

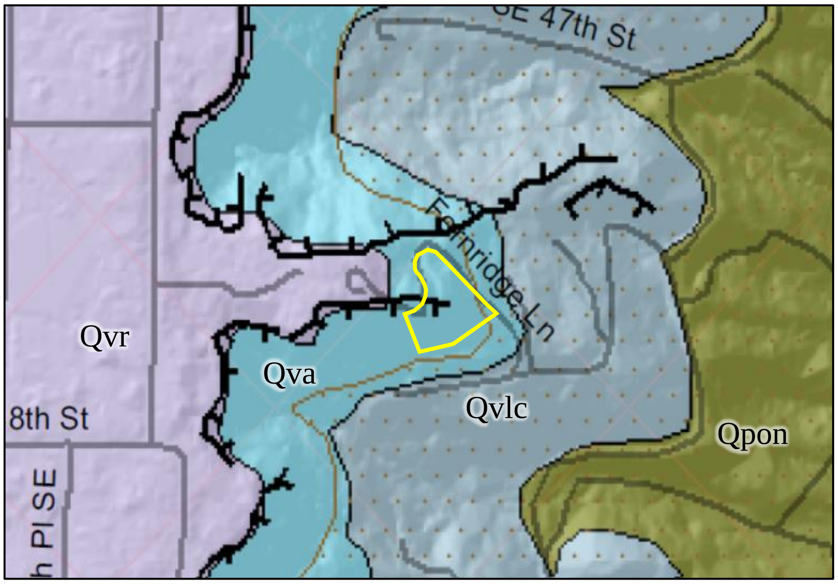


Plate 3: *Geologic map of the site vicinity showing the prehistoric (ancient) landslide scarp on west side of site.*

The approximate site location is outlined in yellow.

-- Image source Geologic Map of Mercer Island, Washington (Troost 2006).

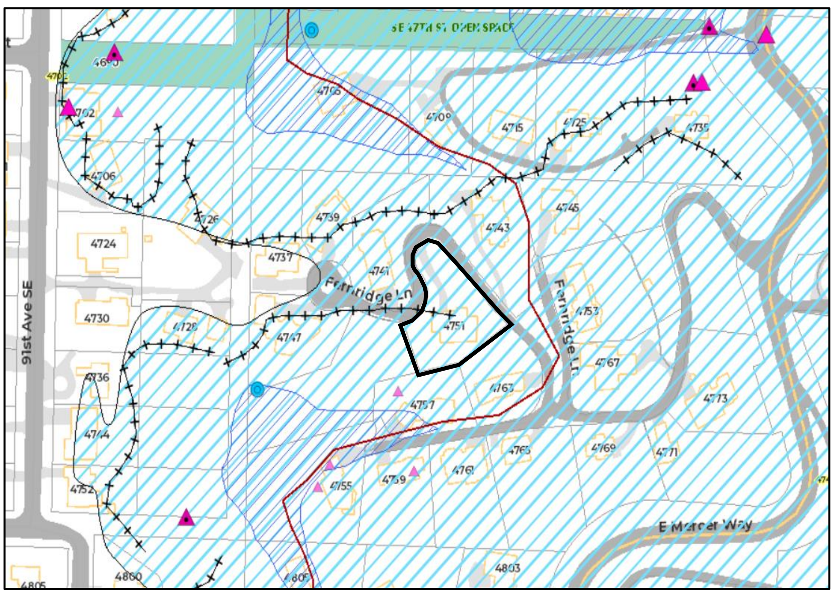


Plate 4: *The blue hatched area is the approximate extent of the Landslide and Potential Landslide Area identified by Mercer Island.*

The site is outlined in black. Approximately south three quarters of the site is located within the potential landslide area mapped by the City of Mercer Island.

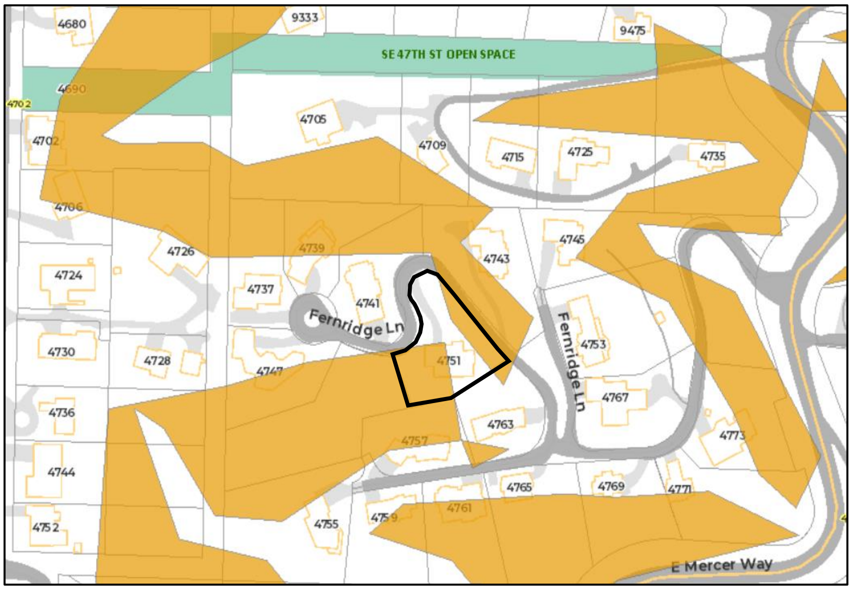


Plate 5: *The orange shaded area is the approximate extent of 40 percent and steeper slope identified by Mercer Island.*

Also see Figure 2 for the extent of steep slope areas.

The site is outlined in black.

5.1.2 LiDAR Review

The presence of landslide features for the site area was further evaluated by reviewing LiDAR (Light Detection and Radar) imaging for the site obtained from the Washington State Department of Natural Resources LiDAR Portal. LiDAR is a remote sensing technique that is used to produce high-resolution elevation data for use in mapping applications. LiDAR allows for digitally removing surface vegetation and manmade features, providing a bare earth image of the ground surface. We reviewed LiDAR mapping for the site from using the 2021 King County West data set which is the most recent imagery available. The LiDAR imagery for the site and vicinity is included in *Plate 6* below.

In the LiDAR imagery, the ridge line outlining the top of the prehistoric slope failure is visible as a well-defined series of arcuate-shaped scarps or scallops. The ground surface in the slopes below the scarps has a distinctive stippled pattern indicating uneven or hummocky topography, which is a characteristic of a landslide deposit. The shadowed arcuate shape on the slope below the subject site is likely a more recent slope failure. However, we did not see evidence of recent landslides within the property limits.

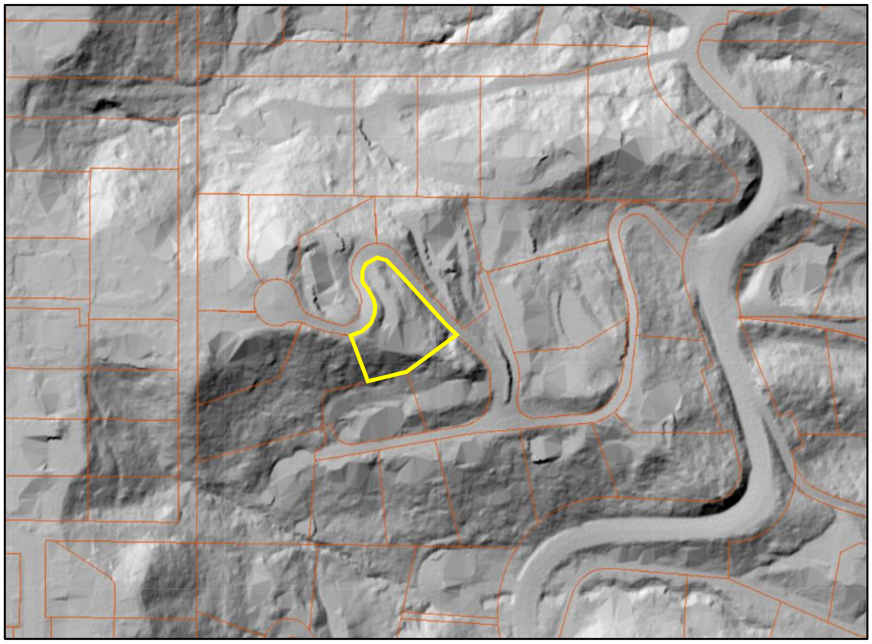


Plate 6: *LiDAR imagery for the site and vicinity.*

The site is outlined in yellow.

--Imagery modified from King County iMap Portal

5.1.3 Site Reconnaissance

We conducted a reconnaissance of the site and site slopes on December 9th, 2024. The purpose of our reconnaissance was to review the condition of the site slopes and identify indications of landslide features such as scarps, bowl-shaped depressions, hummocky topography, distressed vegetation and leaning or pistol butted trees. The following is a summary of our observations:

- During our site reconnaissance we did not observe evidence of recent or ongoing instability in the project area, such as tensions cracks or breaks in vegetation at the top of the steep south slope.
- The south slope was densely vegetated with mature Douglas fir, bigleaf maple trees and a dense understory of ferns, vine maple, and brush. At the time of our reconnaissance, the visibility of the ground surface was limited due to surface vegetation.
- The majority of the mature trees appeared to be generally straight, indicating that the slope is relatively stable.
- We did not observe groundwater seepage or hydrophytic or water loving plants at the site.
- The existing building foundation was observed to be in fair condition.

5.1.4 Landslide Hazard Summary

Based on our review and the conditions observed during our reconnaissance, the site meets the City's criteria for a landslide hazard area.

Although we did not observe indications of recent slope movement affecting the subject site, the site is located in a mapped prehistoric landslide. It would not be economically feasible or practical to stabilize the entire mapped landslide. Building in a mapped landslide such as this requires accepting a certain level of risk, including the risk of re-activation of the known prehistoric slide, especially during a strong seismic event.

Because the proposed ADU is located within the footprint of the existing building, it is our opinion that the proposed improvement will have no impact on the stability of the site or adjacent properties, provided that the project is designed in accordance with the recommendations outlined in this report.

The following mitigation recommendations and the subsequent recommendations presented in this report should be implemented during design and construction to reduce potential risks at the site:

- Earthwork should be limited to the area of the proposed additions.
- Clearing should be limited to the building footprint.
- Cuts deeper than four feet should be sloped at a 1H:1V (Horizontal:Vertical) during excavation or supported using temporary shoring. If needed, PanGEO can provide recommendations for temporary shoring.
- All disturbed areas outside of the building footprints should be covered in hardscaping or planted with an appropriate species of vegetation to reduce erosion and improve stability of the surficial layer of soil.

5.2 SEISMIC HAZARD AREAS

Based on our review of the City of Mercer Island's Geologic Hazards Maps, the entire project site is mapped as a seismic hazard area. The City of Mercer Island Code defines seismic hazard areas as those areas subject to risk of damage as a result of earthquake-induced ground shaking, slope failure, soil liquefaction or surface faulting. The approximate extent of the mapped seismic hazard area is shown on *Plate 7*.

Seismic hazard areas are identified in the MIMC as the following:

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

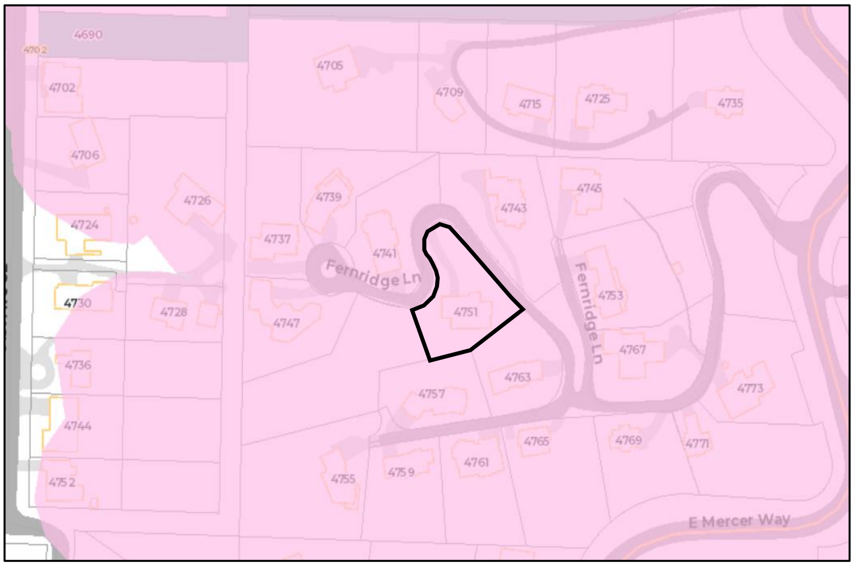


Plate 7: *Approximate extent of the seismic hazard areas identified by the City of Mercer Island.*

The site is outlined in black

Based on the soil observed in our test borings and the absence of a groundwater table, in our opinion, the potential for soil liquefaction is negligible and design considerations associated with soil liquefaction are not needed.

As discussed above, the site is located within a prehistoric landslide zone. A strong seismic event consistent with the IBC design earthquake has the potential to re-activate the prehistoric landslide, which could impact the existing and proposed improvements. However, considering the scale of the pre-historic landslide and the height of the slope, it is not practical to mitigate the risk of such an event.

5.3 Erosion Hazards

The entire site is mapped within a potential erosion hazard area according to the City of Mercer Island's Geologic Hazards Map, see *Plate 8*. Based on soil conditions encountered in the borings, the near-surface site soils are likely to exhibit moderate to high erosion potential. In our opinion, the erosion hazards at the site can be effectively mitigated with the best management practice during construction and with properly designed and implemented landscaping for permanent erosion control. Recommendations for controlling erosion are provided in Section 7.5 of this report.

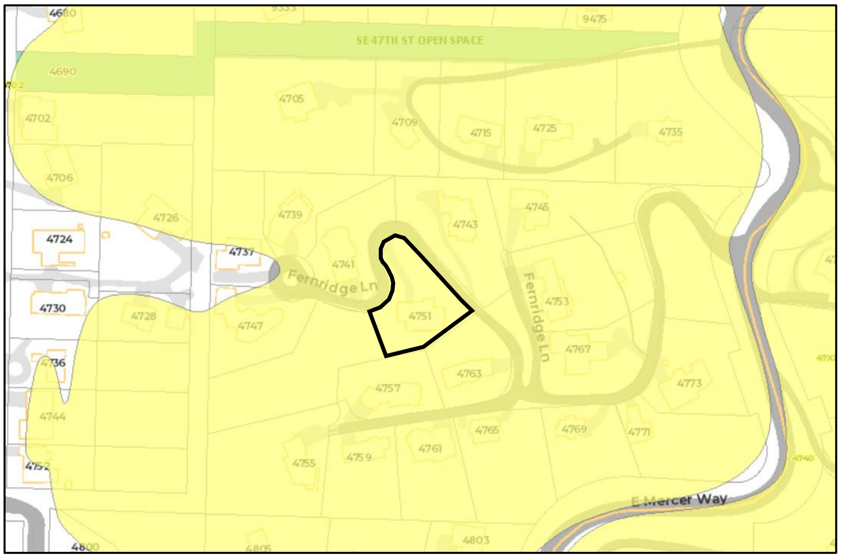


Plate 8: *Approximate extent of erosion hazard areas identified by the City of Mercer Island.*

The site is outlined in black.

6.0 GEOTECHNICAL RECOMMENDATIONS

6.1 Seismic Site Class

We assume the seismic design of the proposed structure will be accomplished in accordance with the 2021 International Building Code (IBC), which specifies a design earthquake having a 2% probability of occurrence in 50 years (return interval of 2,475 years). Based on the results of our test borings and the geology at the site, it is our opinion that Site Class D (Stiff Soils) is considered appropriate for determining the site coefficients for the seismic design of the proposed additions.

6.2 Building Foundations – Pin Piles

As previously mentioned, 4 to 5 feet of fill unsuitable for foundation bearing was encountered in our test borings. To avoid the needs for over-excavation, driven small diameter steel pipe piles (i.e., pin piles) may be used to support the foundations. Where equipment access is limited, the use of 2-inch pin piles may be more appropriate since it can be installed with hand-held equipment.

The principal advantages of driven pipe piles are that the pile lengths can be easily adjusted in the field, the speed of installation, and no spoils to be disposed of. The following sections present our recommendation for pin piles.

6.2.1 Pile Capacity and Driving Criteria

In our opinion, given the limited headroom, 2-inch diameter piles are likely the most appropriate pile size because it can be installed with hand-held equipment with limited head rooms. Two-inch piles shall be driven to refusal with a minimum 90-lb jackhammer or a 140-lb Rhino hammer. Refusal is defined as no more than 1 inch of penetration for 1 minute of continuous driving. Piles driven to refusal are adequate for supporting an allowable axial compression load of 3 tons with a factor of safety of at least 2.0.

The tensile capacity of pin piles should be ignored in design calculations.

It is our experience that the driven pipe pile foundations should provide adequate support with total settlements on the order of ½-inch or less.

6.2.2 Lateral Resistance

Lateral capacity of vertical pin piles should be ignored in design calculations. Some resistance to lateral loads may be accomplished by battering the piles to a slope of 1(H):4(V), or steeper. Passive soil resistance values for embedded pile caps and grade beams may be determined using an equivalent fluid weight of 300 pounds per cubic foot (pcf). This value includes a factor of safety of at least 1.5 assuming level ground surface and properly compacted structural fill will be placed adjacent to the sides of the pile caps and grade beams.

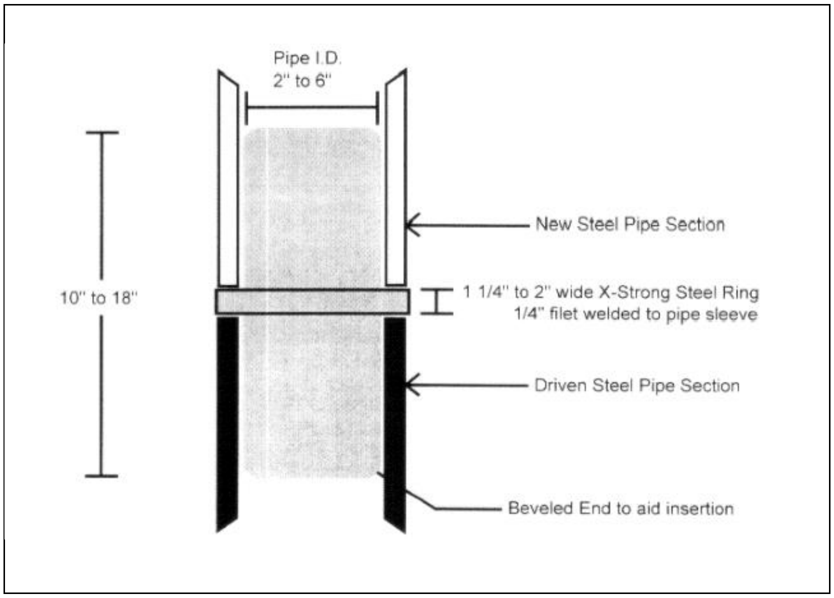
Friction resistance at the bottom of pile-supported footings should be ignored in design calculations.

6.2.3 Pile Specifications

We recommend that the following specifications be included on the foundation plan:

1. 2-inch diameter piles should consist of Schedule-80, ASTM A-53 Grade "A" pipe.
2. 2-inch piles shall be driven to refusal with a minimum 90-lb jackhammer or a 140-lb Rhino hammer. Refusal is defined as no more than 1 inch of penetration for 1 minute of continuous driving. Please note that the City requires load testing if a differential driving criteria is used for a different hammer size.
3. Piles shall be driven in nominal sections and connected with compression fitted sleeve couplers (see detail on following page – Courtesy of McDowell Pile King, Kent, WA).

We discourage welding of pipe joints, particularly when galvanized pipe is used, as we have frequently observed welds broken during driving.



The quality of a pin pile foundation is dependent, in part, on the experience and professionalism of the installation company. We recommend that a company with experienced personnel be selected to install the piles.

6.2.4 Estimated Pile Length

The required pile length in order to develop the recommended pile capacity is expected to vary across the footprint of the structure, depending on the actual driving conditions encountered. For planning and cost estimating purposes, we estimate that the pile lengths, on average, may range from 10 to 15 feet.

6.2.5 Obstruction

Obstructions may be encountered within the fill. Where possible, the obstructions should be removed to facilitate the pile driving. If obstructions cannot be removed, the structural engineer of record should be notified to revise the pile layout to accommodate moving the piles.

6.2.5 Construction Monitoring

The geotechnical engineer of record or his/her representative shall provide full time observation of driven pin piles to verify that the piles/piers have been driven to adequate refusal within the anticipated bearing stratum.

6.3 UNDERPINNING

The proposed excavation is expected to extend below the existing foundation. We understand that the existing house maybe supported on augercast piles. However, there are no design plans or inspection reports to confirm that the existing house is pile supported. As a result, for planning purposes, where the proposed excavation will extend below the existing footings, the footings should be underpinned.

It is our opinion that, where needed, 2-inch diameter pin piles may be used to underpin the existing footings. Recommendations outlined in Section 6.2 of this report are also applicable for underpinning.

6.4 CONCRETE SLAB-ON-GRADE

Floor slabs may be constructed using conventional concrete slab-on-grade floor construction. The floor slabs should be constructed on at least 4 inches of capillary break. If loose soils are encountered at the proposed design slab subgrade elevations, we recommend that the loose soils be removed and replaced with at least one foot of properly compacted structural fill below the capillary break.

The capillary break material should also have no more than 10 percent passing the No. 4 sieve and less than 5 percent by weight of the material passing the U.S. Standard No. 100 sieve. The capillary break should be placed on the subgrade that has been compacted to a dense and unyielding condition.

A 10-mil polyethylene vapor barrier should also be placed directly below the slab. We also recommend that construction joints be incorporated into the floor slab to control cracking.

6.5 RETAINING WALL DESIGN PARAMETERS

Concrete retaining walls should be properly designed to resist the lateral earth pressures exerted by the soils behind the wall. Proper drainage provisions should also be provided behind the walls to intercept and remove groundwater and seepage that may be present behind the wall. Our geotechnical recommendations for the design and construction of the retaining and basement walls are presented below.

Lateral Earth Pressures – Concrete walls that are free to rotate should be designed for an equivalent fluid pressure of 35 pcf for level backfills behind the walls assuming the walls are free to rotate. If walls are to be restrained at the top from free movement, such as below-grade and basement walls, equivalent fluid pressures of 50 pcf should be used for level backfills behind the walls. Retaining walls with a maximum 2H:1V backslope should be designed for an active and at rest earth pressure of 55 and 65 pcf, respectively.

For the seismic condition, we recommend a uniform lateral earth pressure of 10H psf (where H is the wall height) be added to the static pressure for sizing the retaining and basement walls. The recommended lateral pressure assumes that adequate wall drainage will be incorporated into the design and construction of the walls to prevent the development of hydrostatic pressure.

Wall Surcharge – The retaining and basement walls should be designed to accommodate surcharge loads from nearby footings. We recommend that a lateral load coefficient of 0.4 be used to compute the lateral pressure on the wall face resulting from surcharge loads located within a horizontal distance equal to the wall height.

Wall Drainage – Provisions for wall drainage should consist of a 4-inch diameter perforated drainpipe behind and at the base of the wall footings, embedded in 12 to 18 inches of clean crushed rock and pea gravel wrapped with a layer of filter fabric. A minimum 18-inch-wide zone of free draining granular soils (i.e., pea gravel or washed rock) is recommended to be placed adjacent to the wall for the full height of the wall. Alternatively, a composite drainage material, such as Miradrain 6000, may be used in lieu of the clean crushed rock or pea gravel. The drainpipe at the base of the wall should be graded to direct water to a suitable outlet.

Wall Backfill – Where wall backfill will be needed, the backfill should consist of free draining granular soils such as WSDOT Gravel Borrow Section 9-03.9(3) (WSDOT, 2024) or an approved equivalent. On-site soils that are sandy or gravelly in nature may be re-used, provided they can be adequately compacted. The use of the on-site soils should be evaluated during construction by PanGEO. For cost estimating purposes, it may be more appropriate to assume that wall backfill, where needed, should entirely consist of imported soils.

Wall backfill should be moisture conditioned to near optimum moisture content, placed in loose, horizontal lifts less than 12 inches in thickness, and systematically compacted to a dense and relatively unyielding condition. If density tests will be performed, the test results should indicate at least 95 percent of the maximum dry density, as determined using test method ASTM D 1557. Within five feet of the wall, the backfill should be compacted to 90 percent of the maximum dry density.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 TEMPORARY EXCAVATIONS

Based on our understating of the site soil conditions and the current building setbacks, we anticipate that unsupported slope cuts may be incorporated into the excavation design. All temporary excavations should be performed in accordance with Part N of WAC (Washington Administrative Code) 296-155. The contractor is responsible for maintaining safe excavation slopes and/or shoring.

In general, temporary excavations deeper than a total of 4 feet should be sloped or shored. However, excavations less than 4 feet deep, if located along or near property lines, will also need to be sloped or supported if sufficient space is not available to lay back the excavations without encroaching into neighboring properties.

Based on the soil conditions at the site, for planning purposes, it is our opinion that temporary excavations for the proposed construction may be sloped as steep as 1H:1V (Horizontal: Vertical). Based on the current design plans, unsupported open cuts appear to be feasible for foundation construction for the buildings. In the event that sufficient space is not available for unsupported open cuts, PanGEO can provide temporary shoring recommendation if requested. Where space may be limited, the use of L-shaped footings may be required to conserve space for the temporary cuts.

For planning purposes, the temporary unsupported excavation may be sloped as steep as 1H:1V (Horizontal: Vertical). The cut slopes may also need to be flattened in the wet reasons and should be covered with plastic sheets. We also recommend that heavy construction equipment, building materials, excavated soil, and vehicular traffic should not be allowed within a distance equal to 1/3 the slope height from the top of any excavation.

7.2 Material Reuse

In the context of this report, structural fill is defined as compacted fill placed under footings, concrete stairs and landings, and slabs, or other load-bearing areas. The contractor should be aware that the site soils are poorly graded and may be difficult to compact to the requirements of structural fill. As a result, the excavated site materials may not be suitable for use as structural backfill, particularly during periods of wet weather. For planning and budgeting purposes, we recommend granular import fill such as Gravel Borrow (Section 9.03.14 (1) of the 2024 WSDOT Standard Specifications) or approved equivalent.

Well-graded recycled crushed concrete may also be considered as a source of structural fill. Use of recycled concrete as structural fill should be approved by the geotechnical engineer. The on-site soil can be used as a general fill in the non-structural and landscaping areas. If use of the on-site soil is planned, the excavated soil should be stockpiled and protected with plastic sheeting to prevent softening from rainfall in the wet season.

7.3 Structural Fill and Compaction

Structural fill should be moisture conditioned to near its optimum moisture content, placed in loose, horizontal lifts less than 8 to 12 inches in thickness, and systematically compacted to a dense and relatively unyielding condition.

The procedure to achieve proper density of a compacted fill depends on the size and type of compaction equipment, the number of passes, thickness of the lifts being compacted, and certain soil properties. If the excavation to be backfilled is constricted and limits the use of heavy equipment, smaller equipment can be used, but the lift thickness will need to be reduced to achieve the required relative compaction.

Generally, loosely compacted soils are a result of poor construction technique or improper moisture content. Soils with high fines contents are particularly susceptible to becoming too wet and coarse-grained materials easily become too dry, for proper compaction. Silty or clayey soils with a moisture content too high for adequate compaction should be dried as necessary, or moisture conditioned by mixing with drier materials, or other methods.

The surficial fill layer is not suitable for use as structural fill, nor should it be mixed with materials to be used as structural fill.

7.4 Wet Weather Construction

General recommendations related to earthwork performed in wet weather or in wet conditions are presented below. The following procedures are best management practices recommended for use in wet weather construction:

- Earthwork should be performed in small areas to minimize subgrade exposure to wet weather. Excavation or the removal of unsuitable soil should be followed promptly by the placement and compaction of clean structural fill. The size and type of construction equipment used may have to be limited to prevent soil disturbance.
- During wet weather, the allowable fines content of the structural fill should be reduced to no more than 5 percent by weight based on the portion passing the 3/4-inch sieve. The fines should be non-plastic.
- The ground surface within the construction area should be graded to promote run-off of surface water and to prevent the ponding of water.
- Geotextile silt fences should be installed at strategic locations around the site to control erosion and the movement of soil.
- Excavation slopes and soils stockpiled on site should be covered with plastic sheeting.

7.5 Erosion Considerations

Surface runoff can be controlled during construction by careful grading practices. The erosion control plan should include measures for reducing concentrated surface runoff and protecting disturbed or exposed surfaces by mulching and revegetation. The temporary erosion and sediment control (TESC) plan should include the following:

- Construction activity should be scheduled or phased as much as possible to reduce the amount of earthwork that is performed during the wet season – October through May.
- The TESC plan should include adequate ground cover measures, access roads, and staging areas. The contractor should be prepared to implement and maintain the TESC measures to maximize the effectiveness of the TESC elements.
- Where practical, a buffer of vegetation should be maintained around cleared areas.
- The TESC measures should be installed in conjunction with the initial ground clearing. The recommended sequence of construction within a given area after clearing would

be to install silt fences and straw waddles around the site perimeter prior to starting mass grading.

- In areas where grading is complete, hydroseed or straw mulch should be placed.
- During the wet season, or when large storm events are predicted during the summer months, work areas should be stabilized so that if showers occur, the work area can receive the rainfall without excessive erosion or sediment transport. Areas that are to be left un-worked for more than two days should be covered with straw mulch or plastic sheeting.
- Soils that are to be stockpiled on-site should be covered with plastic sheeting staked and sandbagged in place.

The erosion control measures should be reviewed, adjusted and maintained on a regular basis to verify they are functioning as intended.

8.0 STATEMENT OF RISK

The Mercer Island Municipal Code Section 19.07.160(B)(2) states:

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.

As previously discussed above, it is opinion that criteria *a*, *b*, and *c* are met for this project, provided that the project will be designed and constructed in accordance with our recommendations. PanGEO will review the final design plan when the design document is completed, to verify that criterion *d* is met.

Additionally, the Mercer Island Municipal Code Section 19.07.160(B)(3) states:

Alteration of landslide hazard areas, seismic hazard areas and associated buffers may occur if the conditions listed in subsection (B)(2) of this section are satisfied and the geotechnical professional provides a statement of risk matching one of the following:

> *a. An evaluation of site-specific subsurface conditions demonstrates that the proposed development is not located in a landslide hazard area or seismic hazard area;*
>
> *b. The landslide hazard area or seismic hazard area will be modified or 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;*
>
> *c. Construction practices are proposed for the alteration that would render the development as safe as if it were not located in a geologically hazardous area and do not adversely impact adjacent properties; or*
>
> *d. The development is so minor as not to pose a threat to the public health, safety and welfare.*

The proposed development as currently planned is very small and is located within the footprint of the existing house. As such, it is our opinion that criterion *d* is applicable to the project. In our opinion, the development is so minor as not to pose a threat to public health, safety and welfare, provided that the recommendations presented in this report are properly incorporated into the design and construction of the project.

9.0 ADDITIONAL SERVICES

To confirm that our recommendations are properly incorporated into the design and construction of the proposed development, PanGEO should be retained to conduct a review of the final project plans and specifications, and to monitor the construction of geotechnical elements.

10.0 LIMITATIONS

We have prepared this report for use by Keith Pleas and the project team, and their designers and consultants. The conclusions and recommendations contained in this report are based on a site reconnaissance, a subsurface exploration program, review of pertinent subsurface information, and our understanding of the project. The study was performed using a mutually agreed-upon scope of work.

Variations in soil conditions may exist between the locations of the explorations and the actual conditions underlying the site. The nature and extent of soil variations may not be evident until construction occurs. If any soil conditions are encountered at the site that are different from those described in this report, we should be notified immediately to review the applicability of our recommendations. Additionally, we should also be notified to review the applicability of our recommendations if there are any changes in the project scope.

The scope of our work does not include services related to construction safety precautions. Our recommendations are not intended to direct the contractors' methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design. Additionally, the scope of our work specifically excludes the assessment of environmental characteristics, particularly those involving hazardous substances.

This report has been prepared for planning and design purposes for specific application to the proposed project in accordance with the generally accepted standards of local practice at the time this report was written. No warranty, express or implied, is made.

This report may be used only by the client and for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both off and on-site), or other factors including advances in our understanding of applied science, may change over time and could materially affect our findings. Therefore, this report should not be relied upon after 24 months from its issuance. PanGEO should be notified if the project is delayed by more than 24 months from the date of this report so that we may review the applicability of our conclusions considering the time lapse.

It is the client's responsibility to see that all parties to this project, including the designer, contractor, subcontractors, etc., are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk. Any party other than the client who wishes to use this report shall notify PanGEO of such intended use and for permission to copy this report. Based on the intended use of the report, PanGEO may require that additional work be performed and that an updated report be reissued. Noncompliance with any of these requirements will release PanGEO from any liability resulting from the use of this report.

We appreciate the opportunity to be of service.

Sincerely,

February 27，2025

Siew L. Tan, P.E.
Principal Geotechnical Engineer
STan@pangeoinc.com

11.0 REFERENCES

ASTM D1557-12e1, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))*, ASTM International, West Conshohocken, PA, 2012, www.astm.org

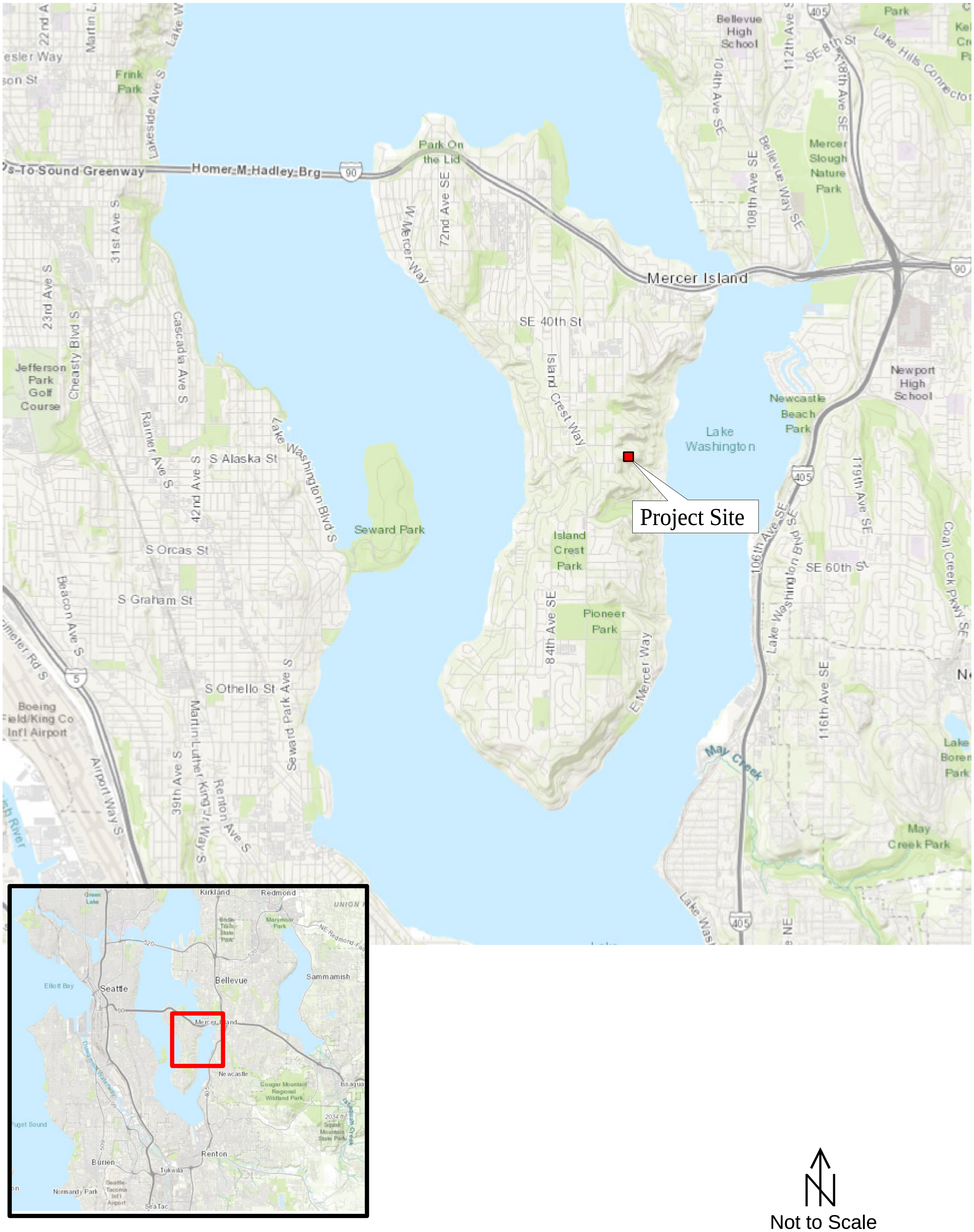
ASTM D1586-11, *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*, ASTM International, West Conshohocken, PA, 2011, www.astm.org.

International Building Code (IBC), 2021, *International Code Council.*

Troost, K.G., and Wisher, A. P, 2006. *Geologic Map of Mercer Island, Washington, scale 1:24,000.*

Washington Administrative Code (WAC), 2019, Chapter 296-155 - *Safety Standards for Construction Work, Part N - Excavation, Trenching, and Shoring*, Olympia, Washington.

WSDOT, 2024, *Standard Specifications for Road, Bridge and Municipal Construction, M 41-10, Washington State Department of Transportation.*



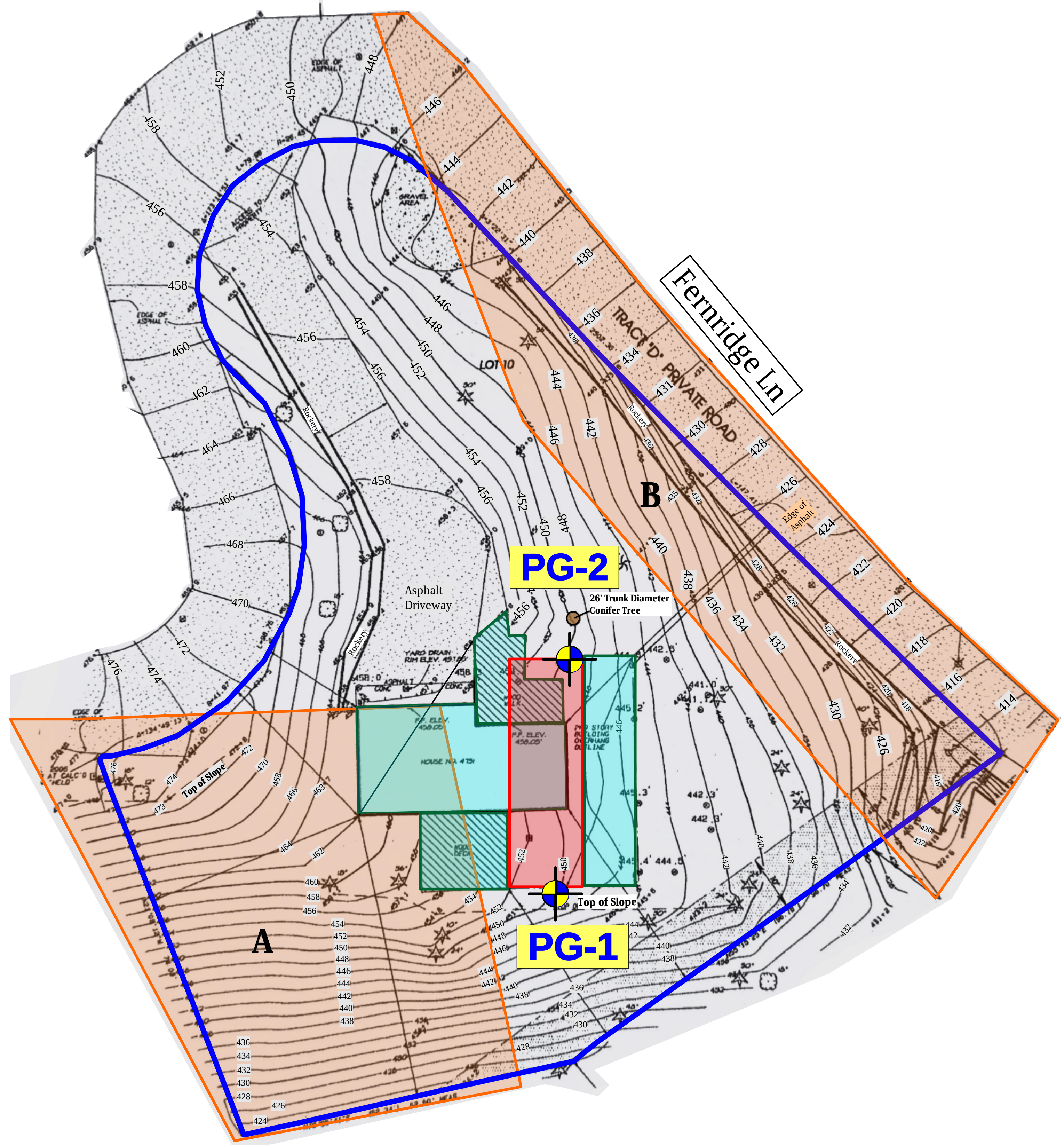
Base Map: King County iMap

PanGEO INCORPORATED

Proposed ADU
4751 Fernridge Ln
Mercer Island, WA

VICINITY MAP

Project No.	**24-459**	Figure No.	**1**



0' 15' 30'

Approx. Scale
1" = 30'

Legend:

- PanGEO Test Boring Location, dated December 2024
- Existing House and Roofline, including wood deck and walkway
- Property Line
- Approximate Location of Steep Slope Hazard Areas (i.e., >40% Gradient with Rise of 10' or Greater)
- Approximate Location of Proposed ADU, underneath crawlspace

Note: Basemap based on *Topographic and Boundary Survey prepared by GeoDimensions, dated June 20th, 2005.* Approximate Location of Steep Slope based on *City of Mercer Island GIS. Approximate Location* Proposed ADU layout based on a *4751 Fernridge ADU Expansion Keith and Georgina Pleas Residence*, *dated September 25th, 2024*.

PanGEO INCORPORATED

Proposed ADU
4751 Fernridge Ln
Mercer Island, Washington

SITE AND EXPLORATION PLAN

Project No.	Figure No.
24-459	2

APPENDIX A

SUMMARY BORING LOGS

RELATIVE DENSITY / CONSISTENCY

SAND / GRAVEL			SILT / CLAY		
Density	SPT N-values	Approx. Relative Density (%)	Consistency	SPT N-values	Approx. Undrained Shear Strength (psf)
Very Loose	<4	<15	Very Soft	<2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Med. Dense	10 to 30	35 - 65	Med. Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	>50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	>30	>4000

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS		GROUP DESCRIPTIONS	
Gravel 50% or more of the coarse fraction retained on the #4 sieve. Use dual symbols (eg. GP-GM) for 5% to 12% fines.	GRAVEL (<5% fines)	GW	Well-graded GRAVEL
		GP	Poorly-graded GRAVEL
	GRAVEL (>12% fines)	GM	Silty GRAVEL
		GC	Clayey GRAVEL
Sand 50% or more of the coarse fraction passing the #4 sieve. Use dual symbols (eg. SP-SM) for 5% to 12% fines.	SAND (<5% fines)	SW	Well-graded SAND
		SP	Poorly-graded SAND
	SAND (>12% fines)	SM	Silty SAND
		SC	Clayey SAND
Silt and Clay 50%or more passing #200 sieve	Liquid Limit < 50	ML	SILT
		CL	Lean CLAY
		OL	Organic SILT or CLAY
	Liquid Limit > 50	MH	Elastic SILT
		CH	Fat CLAY
		OH	Organic SILT or CLAY
Highly Organic Soils		PT	PEAT

Notes:

1. Soil exploration logs contain material descriptions based on visual observation and field tests using a system modified from the Uniform Soil Classification System (USCS). Where necessary laboratory tests have been conducted (as noted in the "Other Tests" column), unit descriptions may include a classification. Please refer to the discussions in the report text for a more complete description of the subsurface conditions.

2. The graphic symbols given above are not inclusive of all symbols that may appear on the borehole logs. Other symbols may be used where field observations indicated mixed soil constituents or dual constituent materials.

DESCRIPTIONS OF SOIL STRUCTURES

Layered: Units of material distinguished by color and/or composition from material units above and below

Laminated: Layers of soil typically 0.05 to 1mm thick, max. 1 cm

Lens: Layer of soil that pinches out laterally

Interlayered: Alternating layers of differing soil material

Pocket: Erratic, discontinuous deposit of limited extent

Homogeneous: Soil with uniform color and composition throughout

Fissured: Breaks along defined planes

Slickensided: Fracture planes that are polished or glossy

Blocky: Angular soil lumps that resist breakdown

Disrupted: Soil that is broken and mixed

Scattered: Less than one per foot

Numerous: More than one per foot

BCN: Angle between bedding plane and a plane normal to core axis

COMPONENT DEFINITIONS

COMPONENT	SIZE / SIEVE RANGE	COMPONENT	SIZE / SIEVE RANGE
Boulder:	> 12 inches	Sand	
Cobbles:	3 to 12 inches	Coarse Sand:	#4 to #10 sieve (4.5 to 2.0 mm)
Gravel		Medium Sand:	#10 to #40 sieve (2.0 to 0.42 mm)
Coarse Gravel:	3 to 3/4 inches	Fine Sand:	#40 to #200 sieve (0.42 to 0.074 mm)
Fine Gravel:	3/4 inches to #4 sieve	Silt	0.074 to 0.002 mm
		Clay	<0.002 mm

TEST SYMBOLS

for In Situ and Laboratory Tests listed in "Other Tests" column.

ATT	Atterberg Limit Test
Comp	Compaction Tests
Con	Consolidation
DD	Dry Density
DS	Direct Shear
%F	Fines Content
GS	Grain Size
Perm	Permeability
PP	Pocket Penetrometer
R	R-value
SG	Specific Gravity
TV	Torvane
TXC	Triaxial Compression
UCC	Unconfined Compression

SYMBOLS

Sample/In Situ test types and intervals

- 2-inch OD Split Spoon, SPT (140-lb. hammer, 30" drop)
- 3.25-inch OD Spilt Spoon (300-lb hammer, 30" drop)
- Non-standard penetration test (see boring log for details)
- Thin wall (Shelby) tube
- Grab
- Rock core
- Vane Shear

MONITORING WELL

- Groundwater Level at time of drilling (ATD)
- Static Groundwater Level
- Cement / Concrete Seal
- Bentonite grout / seal
- Silica sand backfill
- Slotted tip
- Slough
- Bottom of Boring

MOISTURE CONTENT

Dry	Dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water

LOG KEY 16-056_LOGS.GPJ PANGEO.GDT 02/22/16

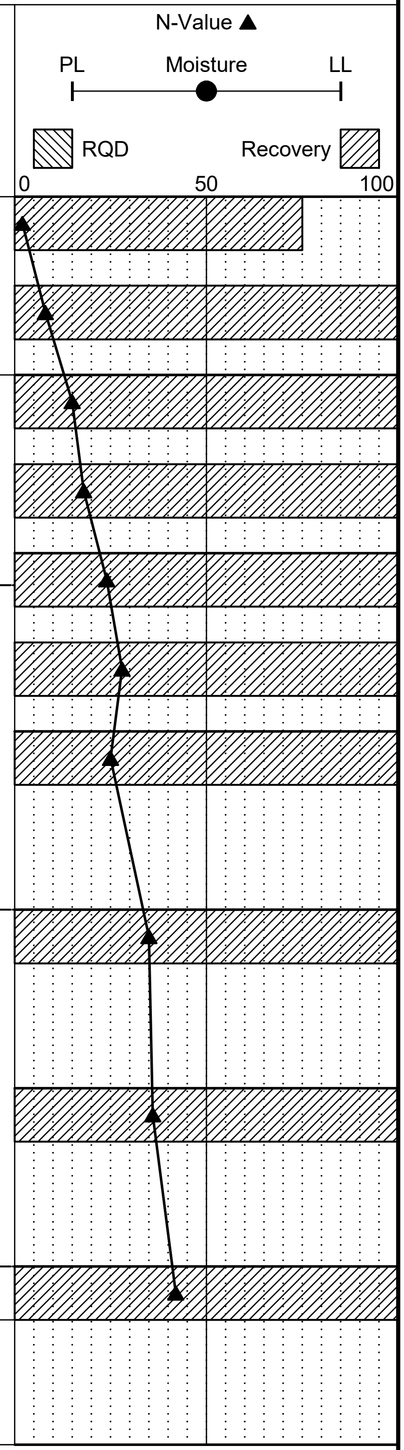
PanGEO INCORPORATED
Phone: 206.262.0370

Terms and Symbols for Boring and Test Pit Logs

Figure A-1

Project:	Proposed ADU	Surface Elevation:	~ 450
Job Number:	24-459	Top of Casing Elev.:	N/A
Location:	4751 Fernridge LN, Mercer Island	Drilling Method:	HSA
Coordinates:	Northing: 47.65119, Easting: -122.32179	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0.0	S-1		1, 1, 1			**FILL** Very loose to loose, brown silty SAND with trace rootlets and organics; moist, disturbed appearance.
	S-2		2, 4, 4			-- Increase in gravel content and driller added water.
5.0	S-3		5, 7, 8			**Advance Outwash Deposits (Pleistocene) - [Qva]** Medium dense, light brown fine silty SAND with trace gravel; moist, poorly-graded, iron-oxide staining.
	S-4		6, 8, 10			-- Becomes unoxidized and turns gray.
10.0	S-5		8, 7, 17			Very Stiff, brown, sandy SILT; moist, poorly-graded.
	S-6		7, 13, 15			-- Iron-oxide staining. -- 3 inches of medium dense, brown fine silty SAND; moist, poorly-graded.
15.0	S-7		3, 11, 14			-- Driller added water.
20.0	S-8		11, 15, 20			Dense, brown fine silty SAND with fine gravel; moist, poorly-graded.
25.0	S-9		10, 15, 21			
30.0	S-10		10, 17, 25			Hard, gray to brown, sandy SILT; moist, poorly-graded. Boring terminated at about 31.5 feet below grade. Groundwater or groundwater seepage was not observed during drilling.
35.0						



Completion Depth:	31.5ft
Date Borehole Started:	12/9/24
Date Borehole Completed:	12/9/24
Logged By:	S. Paquet
Drilling Company:	CN Drilling

Remarks: Boring drilled using an Acker portable drill rig. Standard penetration test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with a rope and cathead mechanism. Surface elevations estimated based on Topographic and Boundary Survey, dated June 20th, 2005.

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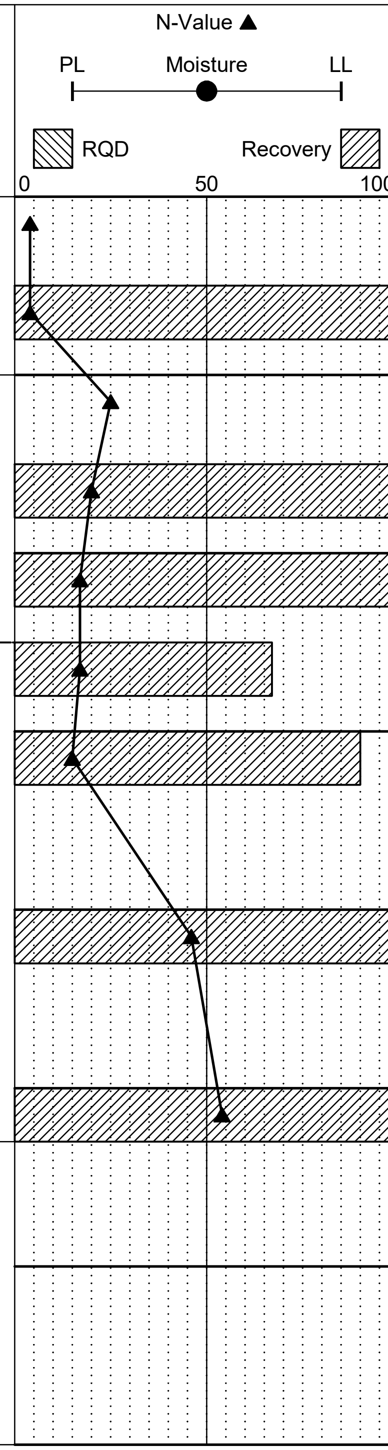
LOG OF TEST BORING PG-1

Figure A-2

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

Project:	Proposed ADU	Surface Elevation:	~ 450
Job Number:	24-459	Top of Casing Elev.:	N/A
Location:	4751 Fernridge LN, Mercer Island	Drilling Method:	HSA
Coordinates:	Northing: 47.56096, Easting: -122.21484	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0.0	S-1	X	1 1 3			**FILL** Very loose to loose, brown silty SAND with trace rootlets and organics; moist, disturbed appearance.
	S-2	X	1 1 3			-- Driller post-holed first 2.5 feet due to a tree in the vicinity of the hole.
5.0	S-3	X	5 11 14			**Advance Outwash Deposits (Pleistocene) - [Qva]** Medium dense to dense, light brown sandy SILT with trace gravel; moist, poorly-graded, iron-oxide staining.
	S-4	X	3 9 11			-- Driller added water.
10.0	S-5	X	5 7 10			
	S-6	X	6 7 10			Medium dense, brown fine silty SAND; moist, poorly-graded. --2 inches of gray to brown, fine sandy SILT with iron-oxide staining; moist.
15.0	S-7	X	5 7 8			Medium dense, brown fine silty SAND; moist, poorly-graded. 2 inches of gray to brown fine, sandy SILT with iron-oxide staining; moist. -- Driller added water.
20.0	S-8	X	12 21 25			Dense, gray to brown, fine silty SAND with iron-oxide staining; moist.
25.0	S-9	X	8 26 28			-- Becomes very dense. Boring terminated at about 26.5 feet below grade. Groundwater or groundwater seepage was not observed during drilling.
30.0						
35.0						



Completion Depth:	26.5ft
Date Borehole Started:	12/9/24
Date Borehole Completed:	12/9/24
Logged By:	S. Paquet
Drilling Company:	CN Drilling

Remarks: Boring drilled using an Acker portable drill rig. Standard penetration test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with a rope and cathead mechanism. Surface elevations estimated based on Topographic and Boundary Survey by GeoDimensions, dated June 20th, 2005.

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LOG OF TEST BORING PG-2

Figure A-3

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