GEOTECHNICAL REPORT
PROPOSED RESIDENCE
825X West Mercer Way
Mercer Island, Washington

PROJECT NO. 17-405

February 2018

Prepared for:

Mr. Hu Wen

PanGEO INCORPORATED

Geotechnical & Earthquake

Engineering Consultants

PanGEO
INCORPORATED
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Engineering Consultants

February 8, 2018
PanGEO Project No. 17-405

Mr. Hu Wen
125 - 152nd Place Northeast
Bellevue, Washington 98007

Subject: **Geotechnical Report**
Proposed Residence
825X West Mercer Way, Mercer Island, Washington

Dear Mr. Wen:

As requested, PanGEO has completed a geotechnical engineering study for the proposed single-family residence at 825X West Mercer Way, Mercer Island, Washington. In preparing this report, we performed a reconnaissance of the site, drilled three test borings, and conducted our engineering analyses. The results of our study and our design recommendations are presented in the attached report.

In summary, the planned house footprint is underlain by medium stiff to hard silt and clay and medium dense to very dense silty sand and sandy gravel. In our opinion, the residence may be supported using spread footing foundations. It is also our opinion that the excavation on the upslope side of the proposed house and garage should be supported using soldier piles with timber lagging.

We appreciate the opportunity to be of service. Should you have any questions, please do not hesitate to call.

Sincerely,

Scott D. Dinkelman, LEG
Senior Engineering Geologist

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ATTACHMENTS:

GEOTECHNICAL REPORT
PROPOSED RESIDENCE
825X WEST MERCER WAY
MERCER ISLAND, WASHINGTON

1.0 GENERAL

PanGEO, Inc. is pleased to present the following geotechnical report to assist the project team with the design and permitting of the proposed residence at 825X West Mercer Way in Mercer Island, Washington. This study was prepared in general accordance with our mutually agreed scope of services outlined in our proposal dated October 30, 2017, which was approved on November 22, 2017. Our scope of services included reviewing readily available geologic and geotechnical data, conducting a site reconnaissance, advancing test borings at the site, conducting our engineering analyses, and preparing this report.

2.0 SITE AND PROJECT DESCRIPTION

The subject site is located at 825X West Mercer Way in Mercer Island, Washington, as shown on Figure 1, Vicinity Map.

The site is aligned oblique to the cardinal points. In order to simplify the descriptions in this report, we have assumed the long axis of the site trends north-south.

The site consists of a flagged-shaped parcel comprising about 18,600 square feet. The main portion of the site is roughly rectangular in-shape and extends about 100 feet in the east-west direction by 150 feet in the north-south direction. Along the west side of the site is a concrete paved driveway that extends up to West Mercer Way.

The site is currently vacant. Single-family homes are located on the north, south, east and west sides of the property. The site is forested with deciduous trees with an understory of ferns and ivy. Plate 1 on the following page shows the general site conditions in the proposed building area.

The site topography slopes down from north to south, with about 70 feet of elevation change between West Mercer Way on the north and the south property line. The driveway contains slopes in the range of 20 to 30 percent. Slopes in the area of the proposed residence range from 25 to 60 percent.

We understand it is planned to develop the site with a three-story single-family residence. The proposed residence will step down the naturally sloping grade, with the lower level comprised of a basement that daylights to the south. A bunker garage is planned for the northwest portion of the house.

Plate 1: *View of site from south looking north.*

Plate 2 below and the attached Figure 2 depicts the approximate location of the proposed house in relation to the property boundaries and existing site features.

Plate 2: *Rendering of the proposed residence.*

The main level of the house will have an elevation of about 93.5 feet and there will be a partial daylight basement level below the main floor. We anticipate the excavation to achieve construction subgrade elevations will be comprised of series of level benches that range from 10 to 15 feet deep, but the excavation for the garage may be as deep as 18 to 20 feet deep. The excavation will extend to within 10 to 25 feet of the north property line, 20 feet of the west property line, 10 feet of the east property line and will daylight to the south.

The conclusions and recommendations in this report are based on our understanding of the proposed development, 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 EXPLORATIONS

Our field exploration was performed on January 15, 2018. The subsurface exploration program included drilling three test borings identified as PG-1, PG-2 and PG-3. The approximate test boring locations were measured from existing site features and are shown on the attached Site and Exploration Plan (Figure 2). The borings were drilled to depths of about 9 to 16½ feet below grade using a portable Acker Soil Mechanic drill rig owned and operated by CN Drilling, of Seattle, Washington under subcontract to PanGEO. The drill rig was equipped with a 4-inch outside diameter hollow stem auger, and soil samples were obtained from the borings at 2½ and 5-foot 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 a distance of 18 inches using a 140-pound hammer falling a distance of 30 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.

A geologist from PanGEO was present during the field exploration to observe the test borings, obtain representative samples, and to describe and document the soils encountered in the explorations. The completed borings were backfilled with bentonite chips.

The soil samples retrieved from the borings were described using the system outlined on Figure A-1 of Appendix A and the summary boring logs are included as Figures A-2 through A-4.

4.0 SUBSURFACE CONDITIONS

4.1 Site Geology

Generalized subsurface information for the site was obtained from review of *The Geologic Map of Mercer Island* (Troost and Wisher, 2006). Based on our review, the surficial geologic units in the vicinity of the site include Lawton Clay (Geologic Map Unit Qvlc) and Pre-Olympia non-glacial deposits (Qpon).

Lawton clay typically consists of very stiff to hard laminated to massive silty clay and clayey silt. Pre-Olympia non-glacial deposits consist of sand, gravel, silt and clay deposited during an interglacial period. This deposit is characterized by the presence of organics and clasts comprised of rock types that originated from local sources.

4.2 Soil Conditions

The subsurface explorations at the site generally encountered topsoil overlying Pre-Olympia non-glacial deposits. For a detailed description of the subsurface conditions encountered at each exploration location, please refer to our boring logs provided in Appendix A. The stratigraphic contacts indicated on the boring logs represent the approximate depth to boundaries between soil units. Actual transitions between soil units may be more gradual or occur at different elevations. The descriptions of groundwater conditions and depths are likewise approximate. The following is a generalized description of the soils encountered in the borings.

> ***Topsoil:*** A surficial layer of organic rich topsoil and leaf litter was encountered at all of our boring locations. This layer was interpreted to be topsoil and forest duff, and was found to be very loose, consist primarily of silty fine sand and sandy silt, and varied in thickness from 6 inches to 12 inches.

> ***Pre-Olympia Non-Glacial:*** Below the topsoil layer we encountered an interlayered deposit of sandy silt, clay, silty sand, and sandy gravel. The silt and clay were typically soft to medium stiff, grading to stiff and hard at about eight feet below grade. The silty sand and sandy gravel were medium dense, grading to dense at 7 feet below grade in Boring PG-2 and very dense in PG-1 and PG-2 at about 12 feet below grade.

Our descriptions of subsurface conditions 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 CONDITIONS

At the time of our subsurface investigation in January 2018, groundwater was not encountered. As such, we do not anticipate that groundwater seepage will result in significant construction related issues. However, with interlayered deposits, such as the soils underlying the site there is a potential to encounter perched groundwater seepage within more the more permeable soil layers.

Additionally, the design team and contractor should be aware that groundwater levels will fluctuate depending on the season and precipitation. In general, groundwater levels are higher during winter and spring.

5.0 GEOLOGIC HAZARDS ASSESSMENT

5.1 POTENTIAL LANDSLIDE HAZARDS

Based on review of the City of Mercer Island's Geologic Hazards Map, the subject site is mapped within a potential landslide hazard area. Review of the topographic survey indicates that slopes between 20 and 60 percent in gradient are present at the site. The map does not indicate that landslide or mass wasting deposits exist at the site, nor does the map indicate the presence of a landslide scarp.

A site reconnaissance of the subject property was conducted on January 15, 2018. During our site reconnaissance, we did not observe any apparent evidence of slope instability or ground movement at the site. Based on our field observations, the general topography of the site and vicinity, and the results of our subsurface explorations, in our opinion the subject site is globally stable in its current configuration.

Furthermore, it is our opinion that the proposed development as currently planned with the construction of permanent retaining walls and improvements to surface water control should improve the overall stability of the site soils.

5.2 Seismic Hazards

Based on our review of the City of Mercer Island's Geologic Hazards Maps, the 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. Based on the medium stiff to hard silt and clay and medium dense to very dense silty sand and sandy gravel underlying the site and the absence of a groundwater table, in our opinion, the potential for soil liquefaction during an IBC-code level earthquake is low.

It is also our opinion that the potential for seismic-induced slope failures are low at the site due to the medium stiff to hard silt and clay and medium dense to very dense underlying soils, and the generally gradual slope gradients.

5.3 Erosion Hazards

The subject site is mapped within a potential erosion hazard area according to the City of Mercer Island's Geologic Hazards Map. Based on soil conditions encountered in the borings, the near-surface site soils are likely to exhibit moderate 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 7.6 of this report.

6.0 GEOTECHNICAL RECOMMENDATIONS

6.1 SEISMIC DESIGN PARAMETERS

The 2015 International Building Code (IBC) seismic design section provides a basis for seismic design of structures. Table 1 below provides seismic design parameters for the site that are in conformance with the 2015 IBC, which specifies a design earthquake having a 2% probability of occurrence in 50 years (return interval of 2,475 years), and the 2008 USGS seismic hazard maps.

Table 1 – Seismic Design Parameters

Site Class	Spectral Acceleration at 0.2 sec. [g] S_S	Spectral Acceleration at 1.0 sec. [g] S_1	Site Coefficients		Design Spectral Response Parameters		Control Periods [sec.]	
			F_a	F_v	S_{DS}	S_{D1}	T_O	T_S
D	1.466	0.557	1.000	1.500	0.977	0.571	0.117	0.584

The spectral response accelerations were obtained from the USGS Earthquake Hazards Program website (2008 data) for the project latitude and longitude.

Liquefaction Potential: Liquefaction is a process that can occur when soils lose shear strength for short periods of time during a seismic event. Ground shaking of sufficient strength and duration results in the loss of grain-to-grain contact and an increase in pore water pressure, causing the soil to behave as a fluid. Soils with a potential for liquefaction are typically cohesionless, predominately silt and sand sized, loose to medium dense, and must be saturated. Based on the conditions encountered at our boring locations, the site is underlain by medium stiff to hard silt, clay, and sandy silt and medium dense to very dense silty sand, and sandy gravel without a defined water table. In our opinion, the liquefaction potential below the proposed structure is low, and design considerations related to soil liquefaction are not necessary for this project.

6.2 Foundations

Based on our understanding of the subsurface conditions at the site, in our opinion the proposed residence may be supported by conventional spread and strip footings. Footings should be founded on the medium stiff to stiff silt and clay and medium dense to very dense silty sand and sandy gravel anticipated to be present at the planned foundation subgrade elevation.

On the south side of the site, where the planned cuts to achieve foundation subgrade elevations will be relatively shallow, it should be anticipated there will be soft or loose soils encountered at the foundation subgrade elevation. In this area, the foundation may need to be extended down to stiff or dense soils or the loose or soft soils overexcavated and replaced with structural fill.

6.2.1 Allowable Bearing Pressure

We recommend a maximum allowable soil bearing pressure of 3,000 pounds per square foot (psf) be used to size the footings. The recommended allowable soil bearing pressure is for dead plus live loads. For allowable stress design, the recommended bearing pressure may be increased by one-third for transient loading, such as wind or seismic forces. Continuous and individual spread footings should have minimum widths of 18 and 24 inches, respectively.

Total and differential settlements are anticipated to be within tolerable limits for footings designed and constructed as discussed above. Footing settlement under static loading conditions is estimated to be less than about ¾-inch. We anticipate differential settlement across the footprint of the house should be less than about ½-inch. Most settlement will occur during construction as loads are applied.

6.2.2 Lateral Resistance

Lateral loads on the structure may be resisted by passive earth pressure developed against the embedded portion of the foundation system and by frictional resistance between the bottom of the foundation and the supporting subgrade soils. Footings bearing on the medium stiff to stiff or medium dense to very dense native soils, may be designed using a frictional coefficient of 0.30 to evaluate sliding resistance developed between the concrete and the subgrade soil. Passive soil resistance may be calculated using an equivalent fluid weight of 300 pcf, assuming foundations are backfilled with structural fill. The above values include a factor of safety of 1.5. Unless covered by pavements or slabs, the passive resistance in the upper 12 inches of soil should be neglected.

6.2.3 Perimeter Footing Drains

Footing drains should be installed around the perimeter of the residence, at or just below the invert of the footings. Under no circumstances should roof downspout drain lines be connected to the footing drain systems. Roof downspouts must be separately tightlined to appropriate discharge locations. Cleanouts should be installed at strategic locations to allow for periodic maintenance of the footing drain and downspout tightline systems.

6.2.4 Footing Subgrade Preparation

Footing subgrades should be in a dense and stable condition prior to setting forms and placing reinforcing steel. Any loose or softened soil should be removed from the footing excavations. The adequacy of the footing subgrade soils should be verified by a representative of PanGEO, prior to placing forms or rebar.

If loose or disturbed soil is encountered at the footing elevation, the footing may be lowered to bear on the undisturbed soils, or the unsuitable soils should be removed and replaced with structural fill.

6.3 FLOORS SLABS

We anticipate that competent, native soil will be encountered at the slab-on-grade floor level. Structural fill placed below the slab should be properly compacted in accordance with the structural fill recommendations presented in this report. The exposed subgrade should be compacted to a firm and unyielding condition prior to placing the backfill or capillary break layer.

Interior concrete slab-on-grade floors should be underlain by a capillary break consisting of at least of 4 inches of pea gravel or compacted 5/8-inch, clean crushed rock (less than 3 percent fines). The capillary break material should meet the gradational requirements provided in Table 2, below.

Table 2 – Capillary Break Gradation

Sieve Size	Percent Passing
¾-inch	100
No. 4	0 – 10
No. 100	0 – 5
No. 200	0 – 3

The capillary break should be placed on the subgrade that has been compacted to a dense and unyielding condition.

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

6.4 Retaining Wall Design Parameters

Cast-in-place concrete retaining and basement walls should be designed to resist the lateral earth pressures exerted by the soils behind the wall. Proper drainage provisions should also be provided to intercept and remove groundwater that may be present behind the walls.

Cantilever walls should be designed for an equivalent fluid pressure of 35 pcf for a level backfill condition and assuming the walls are free to rotate.

If the walls are restrained at the top from free movement, such as basement walls with a floor diaphragm, an equivalent fluid pressure of 55 pcf should be used for a level backfill condition behind the walls. Permanent walls should be designed for an additional uniform lateral pressure of 7H psf for seismic loading, where H corresponds to the height of the buried depth of the wall.

The recommended lateral pressures assume the backfill behind the walls consists of free draining structural fill with adequate drainage provisions.

6.4.1 Surcharge

Surcharge loads, where present, should also be included in the design of retaining walls. We recommend 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 of one-half the wall height.

6.4.2 Lateral Resistance

Lateral forces from seismic loading and unbalanced lateral earth pressures may be resisted by a combination of passive earth pressures acting against the embedded portions of the foundations and by friction acting on the base of the wall foundation. Passive resistance values may be determined using an equivalent fluid weight of 300 pcf. This value includes a factor of safety of 1.5. A friction coefficient of 0.30 may be used to determine the frictional resistance at the base of the footings. The coefficient includes a factor of safety of 1.5.

6.4.3 Wall Drainage

Provisions for wall drainage should consist of a 4-inch diameter perforated drainpipe placed behind and at the base of the wall footings, embedded in 12 to 18 inches of clean crushed rock or 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.

6.4.4 Wall Backfill

Retaining wall backfill should consist of free draining granular material. The site soils consist of relatively fine sand with varying amounts of silt. We recommend importing a free draining granular material, such as Gravel Borrow as defined in Section 9-03.14(1) of the WSDOT *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT, 2018). In areas where space is limited between the wall and the face of excavation, pea gravel may be used as backfill without compaction.

Wall backfill should be moisture conditioned to near optimum moisture content, placed in loose, horizontal lifts less than 8 inches in thickness, and systematically compacted to a dense and relatively unyielding condition and to at least 95 percent of the maximum dry density, as determined using test method ASTM D-1557 (Modified Proctor). Within 5 feet of the wall, the backfill should be compacted with hand-operated equipment to at least 90 percent of the maximum dry density.

6.5 On-Site Infiltration Considerations

Based on our review of the City of Mercer Island Low Impact Development (LID) infiltration feasibility map, the project site is located in an area were infiltrating LID is not permitted.

6.6 Permanent Slope Inclinations

Permanent cut and fill slopes should be inclined no steeper than 2H:1V. Cut slopes should be observed by PanGEO during excavation to verify that conditions are as anticipated. Permanently exposed slopes should be seeded with an appropriate species of vegetation to reduce erosion and improve stability of the surficial layer of soil.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 Temporary Excavations

The following information is provided solely as a service to our client. Under no circumstances should this information be interpreted to mean that PanGEO is assuming responsibility for construction site safety or the Contractor's activities; such responsibility is not being implied and should not be inferred.

Temporary excavations should be constructed in accordance with Part N of the Washington Administrative Code (WAC) 296-155 as well as City and Federal safety regulations. The contractor is responsible for maintaining safe excavation slopes and/or shoring.

Based on the information obtained from our subsurface exploration, the soils encountered at our boring locations would be classified as Type C under WAC 296-155-66401 Appendix A-Soil Classification. For preliminary planning purposes, we recommend temporary excavations be inclined no steeper than 1½H:1V. If slopes of this inclination, or flatter, cannot be constructed, temporary shoring may be necessary. Recommendations for temporary shoring are provided in Section 7.2 of this report.

Temporary excavations should be evaluated in the field during construction based on actual observed soil conditions. If seepage is encountered, excavation slope inclinations may need to be reduced. During wet weather, the cut slopes may need to be flattened to reduce potential erosion and should be covered with plastic sheeting.

Consideration will also need to be given to keeping surface loads such as construction equipment, soil stockpiles and storage loads an adequate distance away from the top of the cut so the stability of the excavation is not affected.

7.2 Temporary and Permanent Excavation Shoring

The excavation for the garage will extend to a depth of 18 to 20 feet below existing grade. If the planned excavation cannot be accomplished using temporary open cuts, then temporary shoring may be needed. In our opinion, the most appropriate method of temporary shoring for the encountered soils is a cantilevered soldier pile wall with timber lagging. The shoring can be designed as a temporary system, with permanent support provided by the basement walls.

Along the north side of the garage, we recommend using permanent shoring. Due to the proximity of the shoring to the property lines, a U-shaped wall should be used with corner bracing instead of tiebacks.

7.2.1 Soldier Pile Wall

A soldier pile wall consists of vertical steel beams, typically spaced from 6 to 8 feet apart along the proposed excavation wall, spanned by timber lagging. Prior to the start of excavation, the steel beams are installed into holes drilled to a design depth and then backfilled with lean mix or structural concrete. As the excavation proceeds downward and the steel piles are subsequently exposed, timber lagging is installed between the piles to support the soils between piles.

7.2.2 Wall Design Parameters

We recommend the earth pressures depicted on Figure 3, *Design Lateral Pressures, Soldier Pile Wall, Cantilevered* be used for design of soldier pile walls for this project. Our shoring design parameters assume the excavation is fully dewatered and do not include hydrostatic pressures from groundwater.

The vertical capacity of the soldier piles should be determined using an allowable skin friction value of 0.5 ksf for the portion of the pile below the bottom of the excavation, and an allowable end soil bearing pressure value of 10 ksf.

7.2.3 Permanent Wall Considerations

Permanent walls can be designed using the soil parameters shown on Figure 3. However, a surcharge pressure of 7H to account for seismic loading must be included in the design. In addition, the piles should include corrosion protection, or be over-sized to account for corrosion. Lagging for permanent walls may consist of pressure-treated timber, cast-in-place or pre-cast concrete beams, or steel sheets.

7.2.4 Lagging

Lagging design recommendations for general conditions are presented on Figure 6. Lagging located within 10 feet of the top of the shoring which may be subjected to surcharge loads from construction equipment or material storage should be designed for an additional uniform lateral surcharge pressure of 200 psf. This pressure approximately corresponds to a vertical uniform surcharge load of 500 psf at the top of the wall for general construction surcharge. Point loads located close to the top of the wall, such as outriggers of heavy cranes, may apply additional loads to the lagging. These loads may need to be individually analyzed. However, lagging designed for a uniform load of 600 psf in the top 10 feet of the wall should be able to accommodate most crane outrigger loads.

We recommend voids behind the lagging be backfilled with CDF.

7.2.5 Baseline Survey and Monitoring

Ground movements will occur as a result of excavation activities. As such, ground surface elevations of the adjacent properties and city streets should be documented prior to commencing earthwork to provide baseline data. As a minimum, optical survey points should be established at the following locations:

- The top of every other soldier pile. These monitoring points should be monitored twice a week. The monitoring frequency may be reduced based on the monitoring results.

- Adjacent structures located within 25 feet of the shoring walls.

The monitoring program should include monitoring for changes in both the horizontal (x and y directions) and vertical deformations. The monitoring should be performed by the contractor or the project surveyor, and the results should be promptly submitted to PanGEO for review. The results of the monitoring will allow the design team to confirm design parameters, and for the contractor to make adjustments if necessary.

We also recommend the existing conditions along the adjacent private properties be photo-documented prior to commencing earthwork at the site.

7.3 MATERIAL REUSE

The native soils underlying the site are moisture sensitive will become disturbed and soft when exposed to inclement weather conditions and construction traffic. For planning purposes, we do not recommend reusing the native soils as structural fill. If it is planned to use the native soil in non-structural areas, the excavated soil should be stockpiled and protected with plastic sheeting to prevent it from becoming saturated by precipitation or runoff.

7.4 STRUCTURAL FILL AND COMPACTION

Structural fill should consist of a well-graded granular material having a maximum grain size of six inches and no more than 5 percent fines passing the US No. 200 sieve based on the minus 3/4-inch fraction.

Structural fill should be placed in 8- to 12-inch thick loose lifts and compacted to at least 95 percent maximum dry density, per ASTM D-1557 (Modified Proctor). In non-structural areas, the recommended compaction level may be reduced to 90 percent. Heavy compaction equipment should not operate directly over utilities until a minimum of 2 feet of backfill has been placed.

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

7.5 Wet Weather Construction

General recommendations relative 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.

7.6 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 maintain on a regular basis to verify they are functioning as intended.

8.0 ADDITIONAL SERVICES

To confirm that our recommendations are properly incorporated into the design and construction of the proposed structure, PanGEO should be retained to conduct a review of the final project plans and specifications, and to monitor the construction of geotechnical elements. The City of Mercer Island, as part of the permitting process, may also require geotechnical construction monitoring services. PanGEO can provide you a cost estimate for construction monitoring services at a later date.

9.0 CLOSURE

We have prepared this report for Mr. Hu Wen and the project design team. 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 services.

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 services specifically excludes the assessment of environmental characteristics, particularly those involving hazardous substances. We are not mold consultants nor are our recommendations to be interpreted as being preventative of mold development. A mold specialist should be consulted for all mold-related issues.

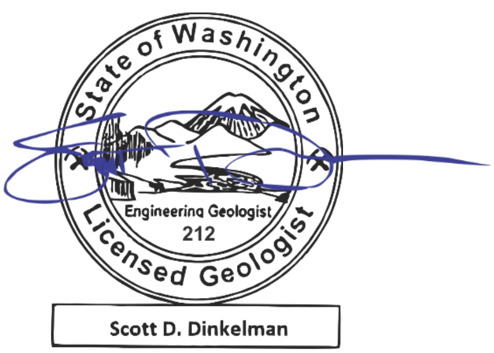
This report has been prepared for planning and design purposes for specific application to the proposed project in accordance with the generally accepted standards of local practice at the time this report was written. No warranty, express or implied, is made.

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 this report.

Sincerely,

PanGEO, Inc.



Scott D. Dinkelman, LEG
Senior Engineering Geologist

Siew L Tan, P.E.
Principal Geotechnical Engineer

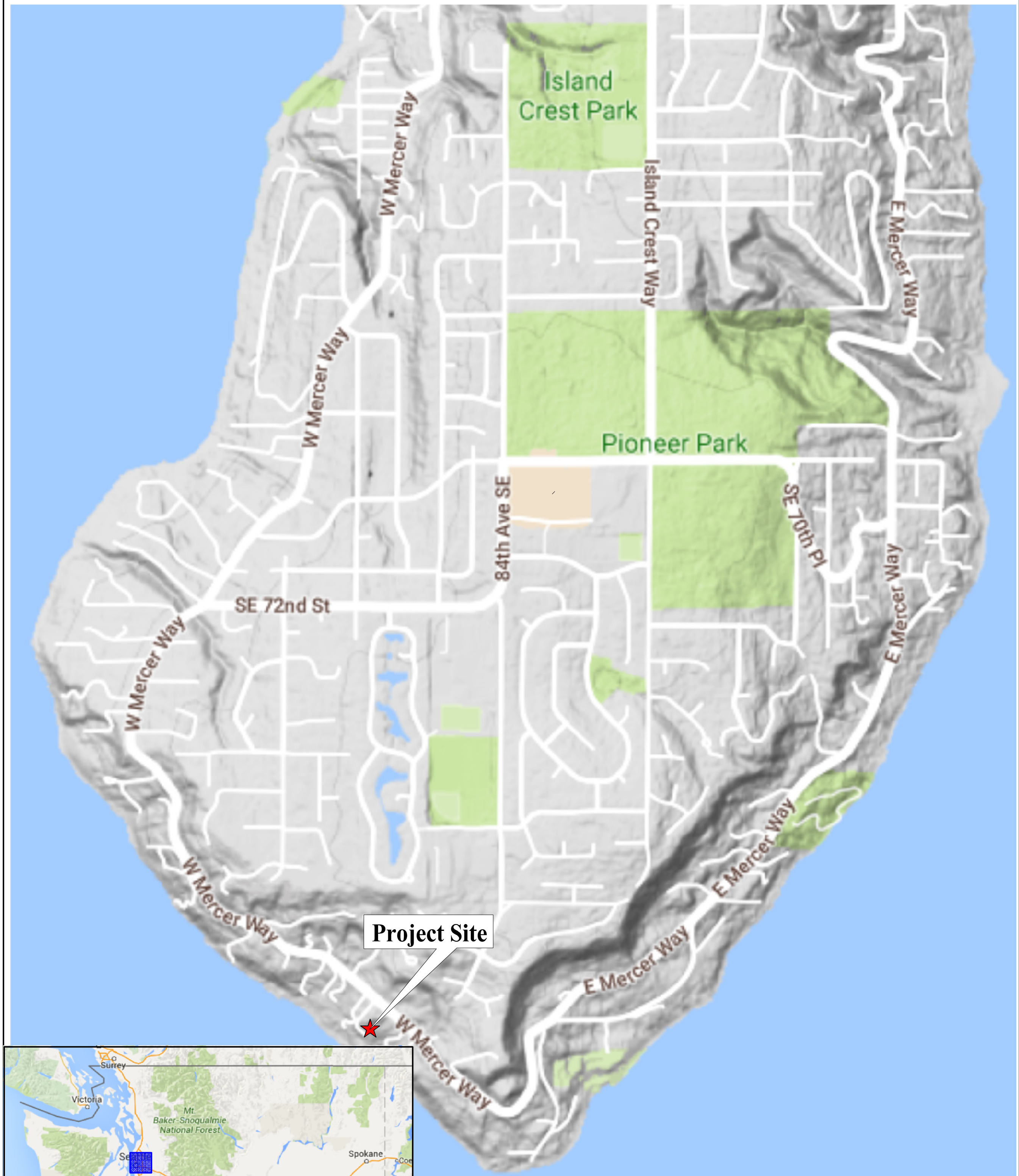
10.0 REFERENCES

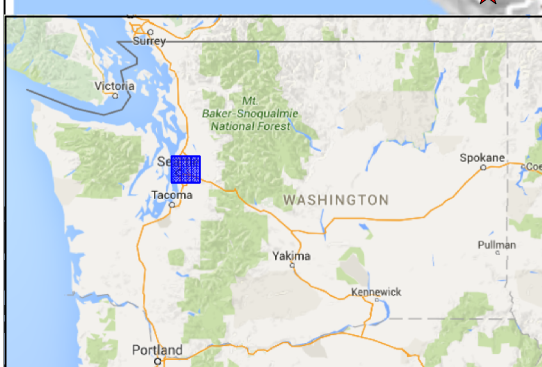
International Code Council, 2015, *International Building Code (IBC), 2015*.

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

United States Geological Survey, *Earthquake Hazards Program, 2008 Data*, accessed via: http://earthquake.usgs.gov/designmaps/us/application.php

WSDOT, 2018, *Standard Specifications for Road, Bridge and Municipal Construction, M 41-10.*





Base Map: Google Maps

NORTH

Approx. Scale: Not to Scale

PanGEO INCORPORATED

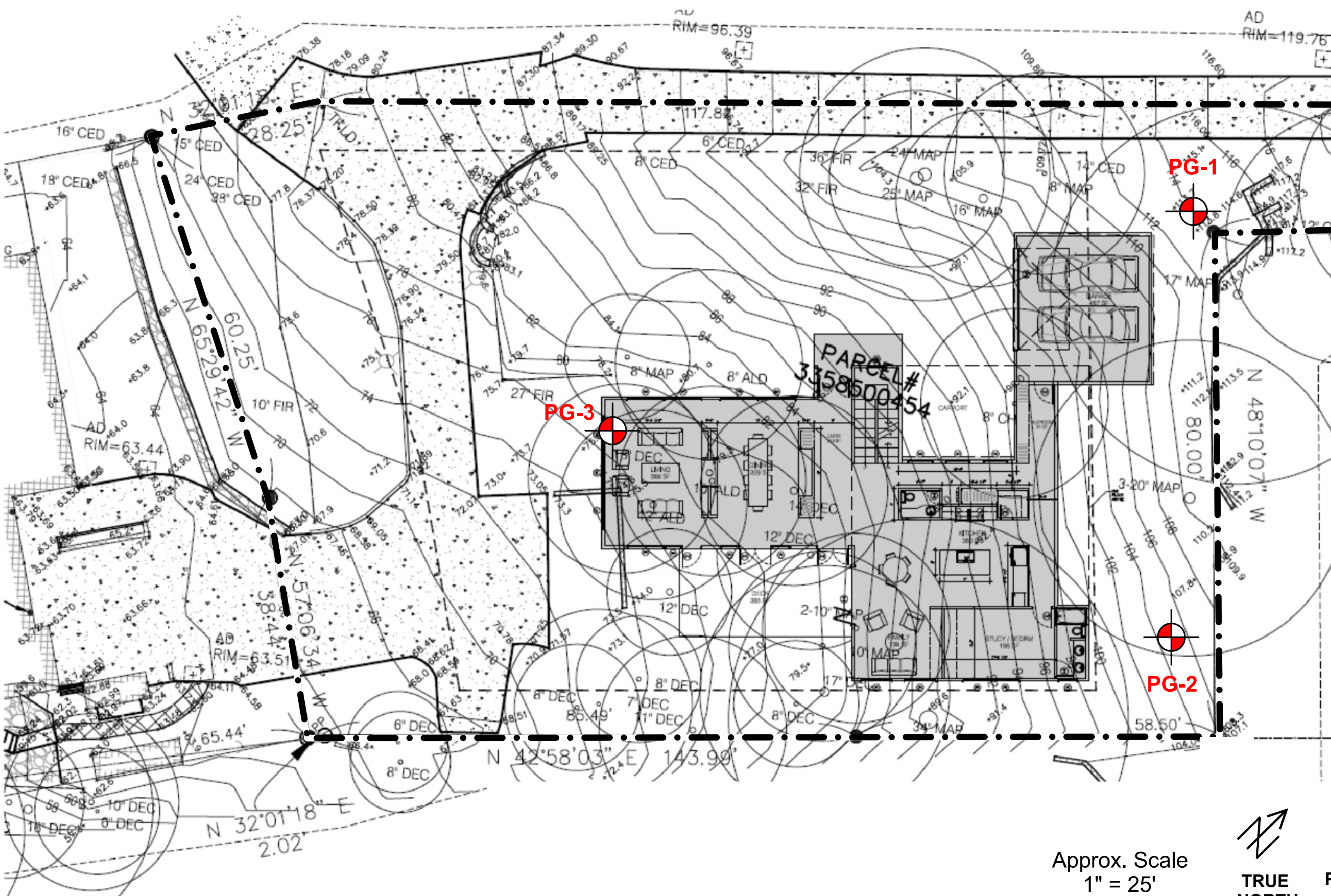
Proposed Residence
825X West Mercer Way
Mercer Island, Washington

VICINITY MAP

Project No. **17-405**

Figure No. **1**

file.grf w/ file.dat 2/8/18 (13:28) SDD



Approx. Scale
1" = 25'

TRUE NORTH

PROJECT NORTH

LEGEND:

Proposed Residence

Approximate Test Boring Locations, PanGEO, Inc., January 2018

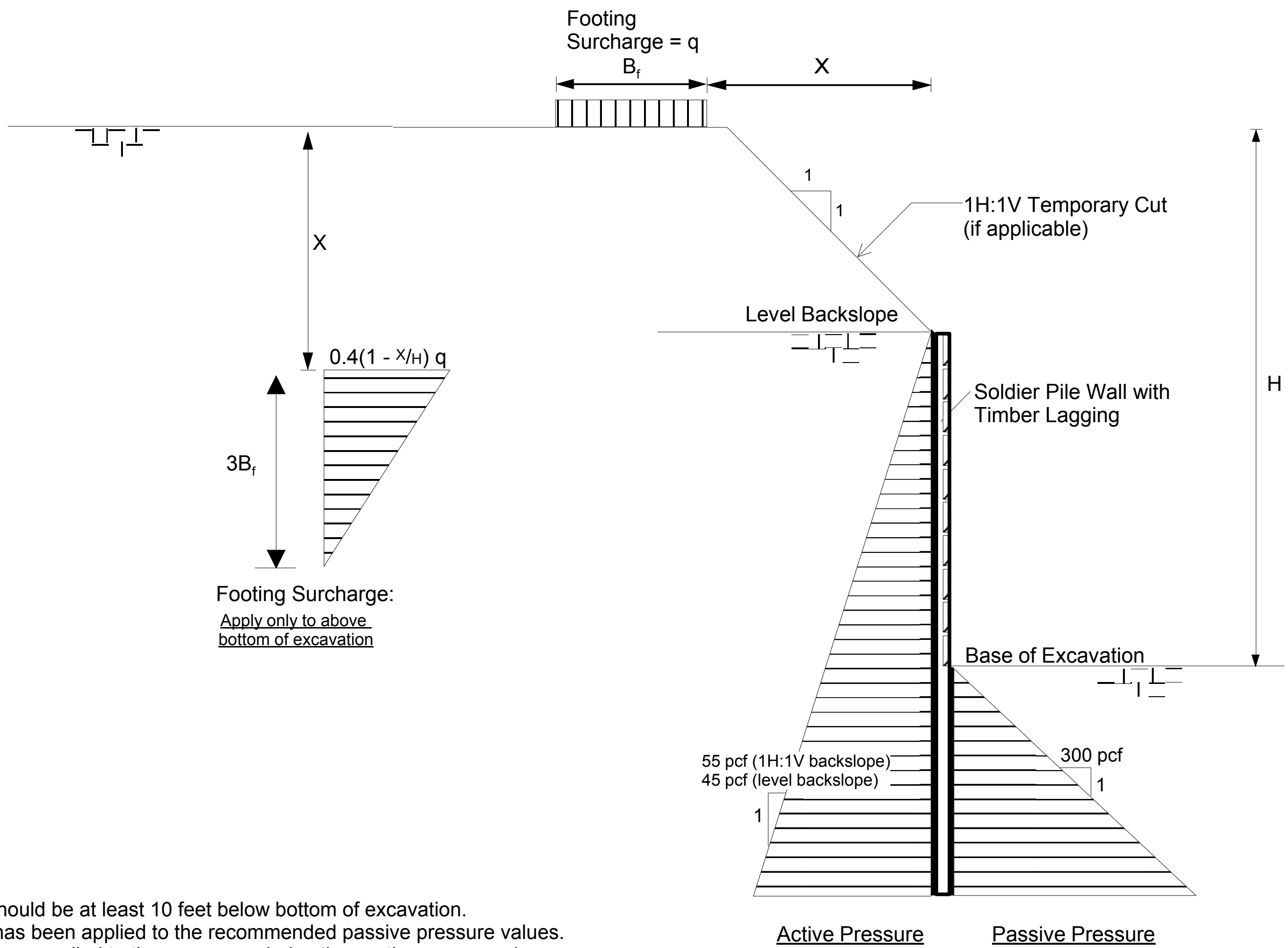
Note: Base map modified from Topographc & Boundary survey by Terrane dated June 1, 2017

PanGEO INCORPORATED

Proposed Residence
825X West Mercer Way
Mercer Island, Washington

SITE AND EXPLORATION PLAN

Project No.	17-405	Figure No.	2



Notes:
1. Minumum embedment should be at least 10 feet below bottom of excavation.
2. A factor of safety of 1.5 has been applied to the recommended passive pressure values. No factor of safety has been applied to the recommended active earth pressure values.
3. Active pressures should be applied over the full width of the pile spacing above the base of the excavation, and over one pile diameter below the base of the excavation.
4. Surcharge pressures should be applied over the entire length of the loaded area.
5. Passive pressure should be applied to two times the diameter of the soldier piles.
6. Use 50% of the active and surcharge pressures for lagging design with soldier piles spaced at 8' or less.
7. Refer to report text for additional discussions.

PanGEO INCORPORATED	**Proposed Residence** **825X W Mercer Way** **Mercer Island, WA**	**DESIGN LATERAL PRESSURES** **CANTILEVERED SOLDIER** **PILE SHORING**
		Project No. **17-405** — Figure No. **3**

APPENDIX A

TEST 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 09-118 LOG.GPJ PANGEO.GDT 11/12/13

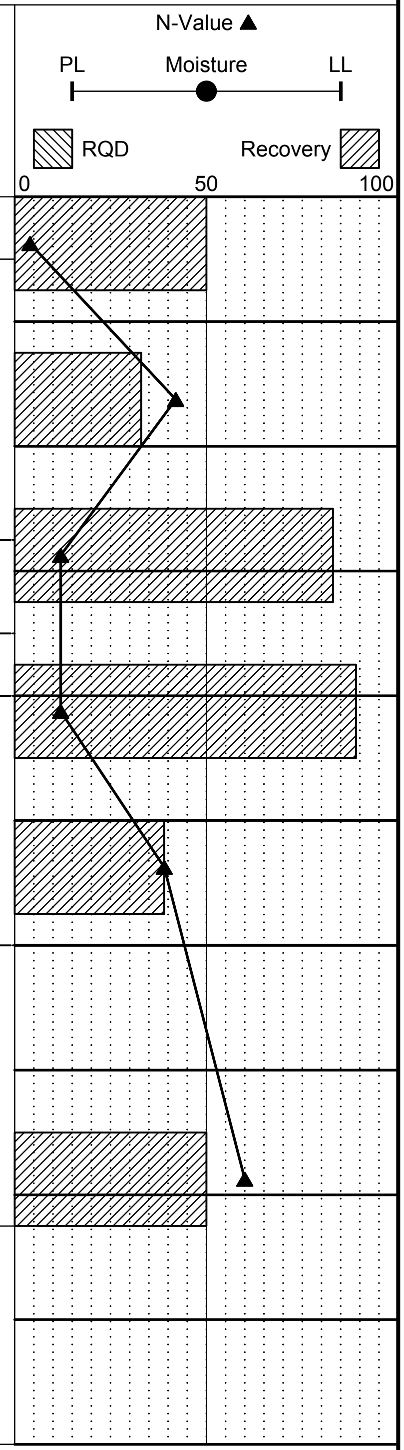
PanGEO INCORPORATED
Phone: 206.262.0370

Terms and Symbols for Boring and Test Pit Logs

Figure A-1

Project:	Proposed Residence	Surface Elevation:	114.0ft
Job Number:	17-405	Top of Casing Elev.:	N/A
Location:	8251 W Mercer Way, Mercer Island, WA	Drilling Method:	HSA
Coordinates:	Northing: 47.528, Easting: -122.23154	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0	S-1	X	1, 1, 3			Very loose, brown, slightly organic silty fine SAND (SM); moist; poorly graded, rootlets [Topsoil].
1						Stiff, grey-brown, fine sandy SILT with gravel (ML); moist; non-plastic, organics [Qpon - Nonglacial Deposits].
3	S-2	X	3, 30, 12			--blow count elevated due to gravel, stiff.
5.5	S-3	X	2, 5, 7			Stiff, light brown, CLAY with sand trace gravel (CL); moist; no-to-low plasticity [Qpon - Nonglacial Deposits].
7						Medium dense, grey-brown, silty, sandy GRAVEL (GM); moist; well-graded [Qpon - Nonglacial Deposits].
8	S-4	X	10, 7, 5			Stiff to hard, light brown, CLAY with sand trace gravel (CL); moist; no-to-low plasticity [Qpon - Nonglacial Deposits].
10	S-5	X	15, 19, 20			--becomes hard.
12						Very dense, grey-brown, silty, sandy GRAVEL (GM); moist; well-graded, non-plastic fines [Qpon - Nonglacial Deposits].
15.5	S-6	X	17, 24, 36			
16.5						Boring terminated at about 16.5 feet below ground surface. No groundwater encountered during drilling.



Completion Depth:	16.5ft
Date Borehole Started:	1/15/18
Date Borehole Completed:	1/15/18
Logged By:	Bart Weitering
Drilling Company:	CN Drilling

Remarks: Drilling was performed using an Acker Portable Drill with a hollow-stem auger. Standard Penetration Test (SPT) sampler driven with a 140-lb safety hammer using a rope and cat-head dropping 30 inches per stroke. Ground elevation from Topographic & Boundary by Terrane dated June 1, 2017.

PanGEO INCORPORATED

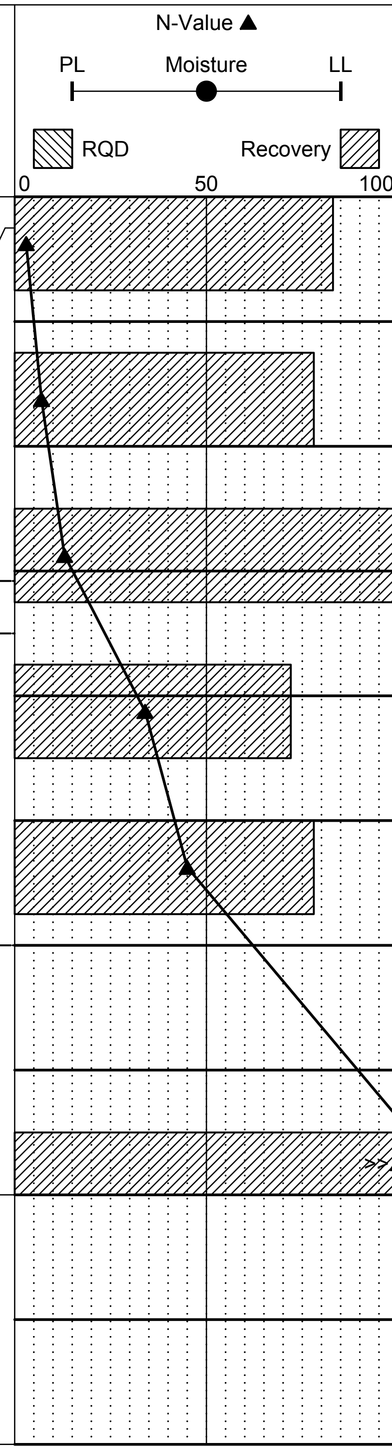
LOG OF TEST BORING PG-1

Figure A-2

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

Project:	Proposed Residence	Surface Elevation:	105.0ft
Job Number:	17-405	Top of Casing Elev.:	N/A
Location:	8251 W Mercer Way, Mercer Island, WA	Drilling Method:	HSA
Coordinates:	Northing: 47.52786, Easting: -122.23142	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0	S-1		1, 1, 2			Very soft, dark brown, slightly organic sandy SILT (ML); moist; non-plastic, rootlets [Topsoil].
						Soft to medium stiff, light brown, CLAY with sand trace gravel (CL); moist; no-to-low plasticity, trace organics [Qpon - Nonglacial Deposits].
2	S-2		1, 2, 5			--becomes medium stiff.
4						
	S-3		3, 5, 8			
6						Stiff, brown, sandy SILT trace fine gravel (ML); moist; non-plastic [Qpon - Nonglacial Deposits].
						Dense, grey-brown, SAND with silt and gravel (SP-SM); moist; poorly graded, trace iron oxide staining [Qpon - Nonglacial Deposits].
8	S-4		6, 14, 20			--sandy GRAVEL in tip.
10	S-5		12, 18, 27			--increasing % fines.
12						Very dense, grey-brown, sandy GRAVEL with silt (GP-GM); moist; poorly graded [Qpon - Nonglacial Deposits].
14						
	S-6		19, 50/6			
16						Boring terminated at about 16 feet below ground surface. No groundwater encountered during drilling.
18						
20						



Completion Depth:	16.0ft
Date Borehole Started:	1/15/18
Date Borehole Completed:	1/15/18
Logged By:	Bart Weitering
Drilling Company:	CN Drilling

Remarks: Drilling was performed using an Acker Portable Drill with a hollow-stem auger. Standard Penetration Test (SPT) sampler driven with a 140-lb safety hammer using a rope and cat-head dropping 30 inches per stroke. Ground elevation from Topographic & Boundary by Terrane dated June 1, 2017.

PanGEO INCORPORATED

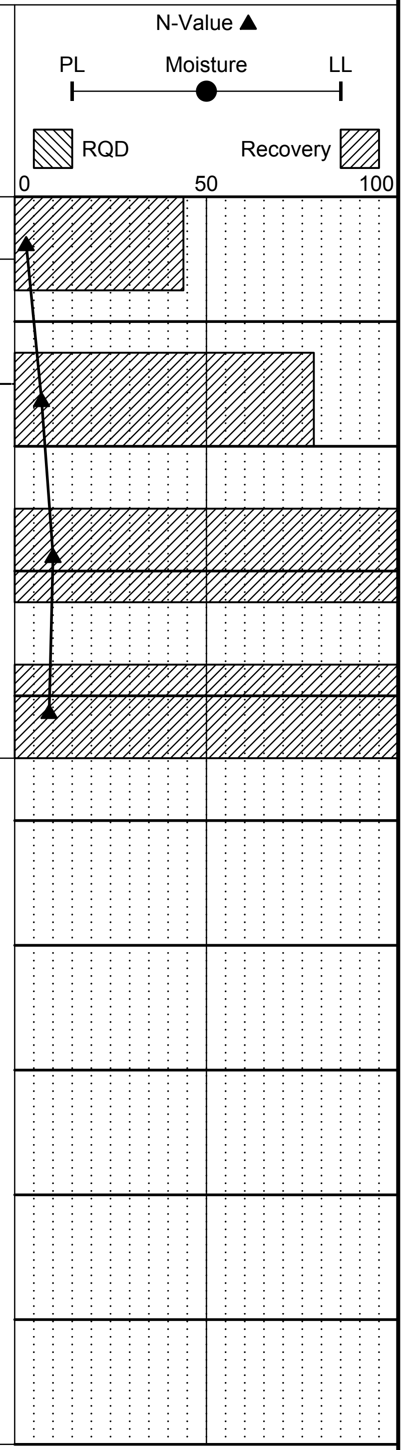
LOG OF TEST BORING PG-2

Figure A-3

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

Project:	Proposed Residence	Surface Elevation:	77.0ft
Job Number:	17-405	Top of Casing Elev.:	N/A
Location:	8251 W Mercer Way, Mercer Island, WA	Drilling Method:	HSA
Coordinates:	Northing: 47.52778, Easting: -122.23178	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0	S-1	SPT	1, 1, 2			Soft, dark brown, slightly organic sandy SILT (ML); moist; non-plastic, rootlets [Topsoil].
1						Soft, grey-brown, fine sandy SILT trace gravel (ML); moist; non-plastic, organics [Qpon - Nonglacial Deposits].
3	S-2	SPT	2, 2, 5			Medium stiff to stiff, light brown, CLAY with sand trace gravel (CL); moist; no-to-low plasticity, trace iron oxide staining [Qpon - Nonglacial Deposits].
5	S-3	SPT	1, 4, 6			--becomes stiff.
7.5	S-4	SPT	2, 4, 5			
9						Boring terminated at about 9 feet below ground surface. No groundwater encountered during drilling.



Completion Depth:	9.0ft
Date Borehole Started:	1/15/18
Date Borehole Completed:	1/15/18
Logged By:	Bart Weitering
Drilling Company:	CN Drilling

Remarks: Drilling was performed using an Acker Portable Drill with a hollow-stem auger. Standard Penetration Test (SPT) sampler driven with a 140-lb safety hammer using a rope and cat-head dropping 30 inches per stroke. Ground elevation from Topographic & Boundary by Terrane dated June 1, 2017.

PanGEO INCORPORATED

LOG OF TEST BORING PG-3

Figure A-4

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