GEOTECH
CONSULTANTS, INC.

2401 10th Ave E
Seattle, Washington 98102
(425) 747-5618

March 21, 2022

JN 22007

Dorothy Strand
6950 Southeast Maker Street
Mercer Island, Washington 98040
via email: kcra2005@yahoo.com

Subject: **Transmittal Letter – Geotechnical Engineering Study and Critical Area Study**
Proposed New Residence
6950 Southeast Maker Street
Mercer Island, Washington

Dear Ms. Strand:

Attached to this transmittal letter is our geotechnical engineering report and Critical Area Study related to geologic hazards for the proposed new residence to be constructed on your property in Mercer Island. The scope of our services consisted of exploring site surface and subsurface conditions, and then developing this report to provide recommendations for general earthwork, stormwater infiltration considerations, critical area (geologically hazardous area) considerations, and design considerations for foundations, retaining walls, subsurface drainage, and temporary excavations/shoring. This work was authorized by your acceptance of our proposal, P-11052, dated December 16, 2021.

The attached report contains a discussion of the study and our recommendations. Please contact us if there are any questions regarding this report, or for further assistance during the design and construction phases of this project.

Respectfully submitted,

GEOTECH CONSULTANTS, INC.

Adam S. Moyer
Geotechnical Engineer

cc: **Jeffrey Almeter**
via email: jeffrey.almeter@gmail.com

ASM/MRM:kg

GEOTECHNICAL ENGINEERING STUDY AND CRITICAL AREA STUDY
Proposed New Residence
6950 Southeast Maker Street
Mercer Island, Washington

This report presents the findings and recommendations of our geotechnical engineering study and Critical Area Study for the proposed new residence to be constructed in Mercer Island. The scope of the Critical Area Study is intended to satisfy the requirements of the recently-adopted section 19.07.110 of the Mercer Island City Code (MICC), which applies to Critical Area Studies.

Development of the property is in the planning stage, and detailed plans were not available at the time of this study. We were provided with a preliminary site plan of the proposed new residence and a topographic map of the subject site. Based on these plans and conversations with Jeffrey Almeter, Architect, we understand that the existing house will be demolished, and a new residence will be constructed near the center of the property in generally the same location as the existing structure. We understand the new residence will have two floors over a basement; the proposed basement will have a finished floor near the existing house's basement slab elevation of 228 feet, or several feet below the existing western yard grade. We anticipate a bottom-of-excavation on the order of 11 feet beneath the ground surface along the eastern side of the existing house. Building setbacks of at least 25, 7.5, 20, and 37 feet are proposed from the and northern, eastern, southern, and western property lines, respectively.

If the scope of the project changes from what we have described above, we should be provided with revised plans in order to determine if modifications to the recommendations and conclusions of this report are warranted.

SITE CONDITIONS

SURFACE

The Vicinity Map, Plate 1, illustrates the general location of the site in Mercer Island. The rectangular-shaped subject site has 87.5 feet of frontage along the northern side of Southeast Maker Street, and has a depth of 100 feet in the north-south direction. A one-story house covers the central and northeastern portions of the property. The western half of the house has a finished floor elevation of 231.3 feet, near the surrounding ground surface, while the northeastern wing overlies a shallow basement with a finished floor elevation of 228.7 feet. An attached one-car garage extends south from the eastern wing, and has a floor slab elevation of 236.8 feet. A relatively flat yard and patio area are located west and north of the house, with an elevation of 228 to 231 feet. This flat yard area appears to have been created by placing loose fill soils over the original ground surface during the original site development, which was confirmed by test borings conducted for our study (this is discussed further is subsequent sections of this report).

The western edge of the flat yard is bordered by a short 2- to 3-foot rockery that sits above a 9- to 10-foot-tall rockery, where the grade drops to the west. Based on the provided topographic survey of the site, the toe of is stepped rockery system is generally located along the western property line. The rockery "wraps around" the subject site's southwestern corner, and straddles the western three-quarters of the southern property line. As Southeast Maker Street rises to the east along the property, the rockery decreases in height until its termination where the subject site's concrete driveway connects to the right-of-way in the southeast corner of the property. The rockery is its tallest in the southwest corner of the property, with a maximum height of 15.5 feet.

The ground surface rises to the east around the perimeter of the existing house, to an elevation of 236 to 237 feet between the house and the eastern property line. The yard of the eastern adjacent property is elevated above the subject site. A 4- to 5-foot-tall modular block wall borders the eastern property line (on the neighbor's property) alongside length of the existing house, where the grade rises to the yard on the eastern adjacent property; south of the existing house, the block wall transitions into a 5- to 7-foot-tall rockery, which extends the southeast corner of the subject site. Furthermore, offset approximately 5 feet east and upslope of the northern half of the block wall along the eastern property line, is a 5- to 7-foot-tall rockery that rises to the neighbor's level yard to the east. The rockery and block wall located on the eastern property likely were also constructed to retain fill placed to level that neighboring lot.

The City of Mercer Island's GIS tool maps the subject site within several geologic hazard areas. The majority of the site is mapped to lie within a seismic hazard area, and the entire property is mapped within both a potential landslide hazard area and an erosion hazard area. We did not observe any indications of recent slope instability on or around the site during our recent visit to the property. The mapped geologic hazard areas and their relation to the project are discussed in more detail in subsequent sections of this report.

SUBSURFACE

The subsurface conditions were explored by drilling three test borings and excavating two test holes at the approximate locations shown on the Site Exploration Plan, Plate 2. Our exploration program was based on the proposed construction, anticipated subsurface conditions and those encountered during exploration, and the scope of work outlined in our proposal.

The test borings were drilled on February 4, 2022 using a track-mounted, hollow-stem auger drill. Samples were taken at approximate 2.5- to 5-foot intervals with a standard penetration sampler. This split-spoon sampler, which has a 2-inch outside diameter, is driven into the soil with a 140-pound hammer falling 30 inches. The number of blows required to advance the sampler a given distance is an indication of the soil density or consistency. A geotechnical engineer from our staff observed the drilling process, logged the test borings, and obtained representative samples of the soil encountered. The Test Boring Logs are attached as Plates 3 through 5.

A geotechnical engineer from our firm excavated the test holes on February 4, 2022 with hand auger equipment. The Test Hole Logs are attached to the end of this report as Plate 6.

Soil Conditions

The subsurface explorations conducted for the project encountered native soils consisting of slightly gravelly, silty sand that became dense to very dense. The dense to very dense soil is glacially-compressed, and is termed glacial till. However, the borings found 5.5 to 11 feet of loose, silty sand fill beneath the relatively flat yard covering the western side of the property.

Test Boring 1 was conducted in the northern end of the western yard and encountered 5.5 feet of loose silty sand fill soils overlying the remnant topsoil layer. Beneath the buried topsoil layer, native loose to medium-dense silty clayey sand with gravel was revealed; the silty clayey sand became dense to very dense (glacial till) below a depth of 10 feet. The test boring was terminated at a depth of 19.4 feet due to refusal in the very dense glacial till. A thin sand layer was encountered within the glacial till from 15 to 17 feet.

Test Boring 2 was conducted in the southwest corner of the property, relatively close to the top of the approximately 12- to 13-foot-tall, tiered rockeries that border the property's western property line. Approximately 11 feet of loose silty sand fill soils were encountered over the remnant topsoil and overlying medium-dense silty clayey sand. The native soils became very dense (glacial till) below 15 feet and extended to the maximum-explored depth of 21.5 feet.

Test Boring 3, located in the southeast corner of the property, encountered a thin layer of loose fill beneath the existing driveway. Native, medium-dense silty clayey sand was encountered beneath the fill, and became dense to very dense (glacial till) 5 feet beneath the ground surface.

The hand-excavated test holes were conducted at the base of the adjacent eastern modular wall and rockery. Test Hole 1 was conducted near the toe of the neighbor's rockery. Medium-dense, native, silty clayey sand was encountered 2.8 feet beneath the ground surface, or near the base of the adjacent rockery. Test Hole 2 was conducted near the northern end of the subject site's eastern property line and along the toe of the 4- to 5-foot-tall modular block wall that rises to the east on the neighbor's property. Loose silty sand fill soils extended 12 inches beneath the ground surface, overlying loose native silty sand. Loose to medium-dense gravelly sand was revealed below 3.2 feet. The test hole was terminated at 4 feet due to refusal in the gravelly soils. Based on the observed conditions, we expect that both the modular wall and rockery were originally constructed to retain fill placed to level the adjacent eastern property.

No obstructions were revealed by our explorations. However, debris, buried utilities, and old foundation and slab elements are commonly encountered on sites that have had previous development. Although our explorations did not encounter cobbles or boulders, they are often found in soils that have been deposited by glaciers or fast-moving water.

Groundwater Conditions

No groundwater seepage was observed in our subsurface explorations. The test borings and test holes were left open for only a short time period. It should be noted that groundwater levels vary seasonally with rainfall and other factors. It is common to encounter at least localized groundwater perched on top of the impervious glacial till following extended wet weather.

The stratification lines on the logs represent the approximate boundaries between soil types at the exploration locations. The actual transition between soil types may be gradual, and subsurface conditions can vary between exploration locations. The logs provide specific subsurface information only at the locations tested. If a transition in soil type occurred between samples in the borings, the depth of the transition was interpreted. The relative densities and moisture descriptions indicated on the test boring and test hole logs are interpretive descriptions based on the conditions observed during drilling and excavation.

CRITICAL AREA STUDY (MICC 19.07)

Seismic Hazard and Potential Landslide Hazard Areas: The western three-quarters of the subject site is located within a mapped Seismic Hazard Area and the entire subject site is located within a Potential Landslide Hazard area. Both geologic hazard areas cover much of the general vicinity to the north, south, and west to Lake Washington. As previously discussed, the core of the subject site consists of dense, glacially compressed, silty sand (glacial till) that has a low potential for deep-seated landslides. No recent large-scale movement has been documented in this area. The proposed new residence will be supported on foundations bearing directly on the dense glacial till soils which are not liquefiable due to their dense nature and the absence of near-surface groundwater. This mitigates the Seismic Hazard.

Mitigation measures for the Potential Landslide Hazard are discussed in the following section.

Steep Slope Hazard Areas: Based on the provided topographic map of the subject site, the tiered rockery along the western edge of the site has an inclination of at least 40 percent over a horizontal distance of 30 feet (which the City of Mercer Island code defines as a Steep Slope). This steep slope area was created by filling, likely when the lot was originally developed. This was a common practice at the time, as evidenced by the modular wall and rockery that also retain fill place for the eastern lot. A Steep Slope is a qualification as a Landslide Hazard Area under the Mercer Island Code. The grade drops approximately 14.5 feet over 30 horizontal feet (for an inclination of 49 percent), rising from the toe of the western rockery. Both the existing development, and the proposed new residence will be located approximately 19 to 20 feet from the top of the western manmade steep slope (rockery), or within the prescriptive minimum 25-foot buffer for Shallow-Seated Landslide Hazard Areas that extends from the top of a steep slope.

The test borings conducted for this project found dense glacial till not susceptible to deep-seated movement underlies the subject site. However, as discussed above, the western end of the site and the western steep slope appears to consist of loose fill soils. We understand the proposed project will not disturb the approximate 20-foot setback between the existing house (and new residence) and the top of the western adjacent steep slope.

We conducted a slope stability analysis of the western steep slope using the modeling program Slope/W developed by GeoStudio. Based on this analysis (attached to the end of this report for reference), a potential deep-seated slope failure that reaches the western edge of the proposed residence has static and seismic safety factors greater than 1.5 and 1.2, respectively. The modelled failures occur in the loose upper soils above the competent glacial till.

As further discussed in this report, the proposed new residence will be supported on foundations bearing directly on the dense underlying glacial till, which are not susceptible to deep-seated movement. The western perimeter of the foundation wall of the residence should be designed as a retaining wall to retain the slab subgrade soils beneath the residence. Furthermore, we recommend that no filling above the existing grade occurs west of the new residence, in order to avoid decreasing the stability of the filled area further. No new structures (including patios or decks) should be constructed west of the new residence, and no staging of materials for the construction of the residence should occur west of the residence footprint. Therefore, it is our opinion that no additional buffers or setbacks are required from the steep slope, provided the recommendations presented in this report are followed. The recommendations presented in the report are intended to prevent adverse impacts to the stability of the slope on the site and the neighboring properties, and to protect the planned development from damage in the event of potential shallow soil movement on the steep slope.

Based on our analyses, and observations, the rockeries placed in front of the fill on the west side of the lot are not engineered to properly retain the loose soils. As a result, there currently exists a risk that the fill and rockeries could shift or fail in the future. This would most likely occur during wet conditions or a large earthquake. Providing stability for these non-engineered rockeries would require the installation of a properly-designed stabilization wall embedded into the underlying glacial till. If the western yard area remains undisturbed, the planned development will not increase the risk of future slope movement. Further recommendations to prevent adverse impacts to stability of both the western rockeries and the adjacent eastern walls/rockery are discussed below in the ***General*** section.

Erosion Hazard Areas: The site also meets the City of Mercer Island's criteria for an Erosion Hazard Area. The temporary erosion control measures needed during the site development will depend heavily on the weather conditions that are encountered during the site work. One of the most important considerations, particularly during wet weather, is to immediately cover any bare soil areas to prevent accumulated water or runoff from the work area from becoming silty in the first place. A wire-backed silt fence bedded in compost, not native soil or sand, should be erected as close as possible to the planned work area, and the existing vegetation between the silt fence and the top of the steep slope be left in place. Rocked construction access and staging areas should be established wherever trucks will have to drive off of pavement, in order reduce the amount of soil or mud carried off the property by trucks and equipment. Covering the base of the excavation with a layer of clean gravel or rock is also prudent to reduce the amount of mud and silty water generated. Cut slopes and soil stockpiles should be covered with plastic during wet weather. Soil stockpiles should be minimized. Following rough grading, it may be necessary to mulch or hydroseed bare areas that will not be immediately covered with landscaping or an impervious surface.

Buffers and Mitigation: Under MICC 19.07.160(C), a prescriptive buffer of 25 feet is indicated from all sides of a shallow landslide-hazard area. The recommendations presented in this report are intended to protect the planned construction, which will be located within the footprint of the existing house, which is set back approximately 20 feet from the top of the rockery that defines the top of the steep slope along the western perimeter of the property.

As noted above, the entire subject site lies within a mapped Potential Landslide Hazard Area and the prescriptive buffer would encompass the entire residence footprint and the planned development area.

No buffer is required by the MICC for an Erosion Hazard Area.

> **<u>Recommended Buffer:</u>** In order to prevent adverse impacts to the stability or erosion potential on, and near, the steep slope, we recommend that no filling or substantial disturbance (such as clearing, utility installation, or construction staging) occur within 20 feet of the existing western rockery without the review of the project geotechnical engineer.

We recognize that the planned development will occur within the prescriptive critical area buffers. The recommendations presented in this geotechnical report are intended to allow the project to be constructed in the proposed configuration without adverse impacts to critical areas on the site or the neighboring properties. The geotechnical recommendations associated with foundations and erosion control will mitigate any potential hazards to critical areas on the site.

Statement of Risk: In order to satisfy the City of Mercer Island's requirements, a statement of risk is needed. As such, we make the following statement:

Provided the recommendations in this report are followed, it is our professional opinion that the recommendations presented in this report for the planned alterations will render the development as safe as if it were not located in a geologically hazardous area, and will not adversely impact critical areas on adjacent properties.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

THIS SECTION CONTAINS A SUMMARY OF OUR STUDY AND FINDINGS FOR THE PURPOSES OF A GENERAL OVERVIEW ONLY. MORE SPECIFIC RECOMMENDATIONS AND CONCLUSIONS ARE CONTAINED IN THE REMAINDER OF THIS REPORT. ANY PARTY RELYING ON THIS REPORT SHOULD READ THE ENTIRE DOCUMENT.

The subsurface explorations conducted for this study encountered dense glacial till beneath the subject site. On the eastern, upslope side of the property, the dense glacial till was revealed approximately 5 feet beneath the ground surface; however, the two test borings conducted west of the existing house footprint encountered 5.5 to 11 feet of loose fill soils overlying the native silty sands below. The dense glacial till was encountered 10 to 15 feet below the flat western yard, increasing in depth to the west. It appears fill soils were placed over the original sloping ground surface when the site was first developed, to create the flat western yard and the rockery along the property's western perimeter was constructed to "retain" these fill loose soils. This is discussed further below.

Based on the provided plans, the proposed new residence will be constructed within the existing development's footprint, and will not extend any farther west than the existing house. Based on our subsurface explorations, the dense glacial till rises to the east and is located within several feet of the ground surface beneath both the existing house and proposed residence footprints. We understand the new residence will overlie a basement with a finished floor elevation near 228 feet, or several feet beneath the existing ground surface. Therefore, we believe the new residence can be constructed on conventional footings bearing directly on the dense glacial till, which is not susceptible to slope instability. However, several feet of overexcavation may still be necessary beneath the western perimeter of the new residence's foundation to reach the competent glacial till soils below. No structural fill should be placed between the glacial till and the new footings. This western foundation wall will also need to be designed to retain the loose soils located upslope of the foundation wall and beneath the new residence.

We observed no signs of slope instability of the western perimeter rockery (steep slope) during our site visits. However, due to the loose nature of the upper fill soils behind the rockery, it would only be considered moderately stable, and likely has a current factor of safety of 1.0 or slightly higher with regards to slope stability. As previously discussed, based on our slope stability analysis, a potential deep-seated slope failure that reaches the western edge of the proposed residence has static and seismic safety factors greater than 1.5 and 1.2, respectively. The recommendations presented in this report to support the residence directly on the underlying glacial till soils, and for the foundations to retain the soils beneath the residence, are intended to prevent the proposed development from being impacted by the potential future movement of the loose upper soils on the western half of the site (which are outside of the proposed development area). Furthermore, the new building loads applied directly to the dense glacial till soils will not impact the stability of the loose upper soils that comprise the western steep slope. However, due to the moderately-stable condition of the existing western rockery, that area could be affected by future soil movement. It is impossible to accurately assess the extent of such future movement, which could range in size from simple shifting of the rockeries to more extensive movement or failure of the fill and rockeries. As discussed above, the planned construction of the new house can be undertaken without increasing this risk, but an extensive slope stabilization system would be necessary to prevent future movement of the fill and western rockeries. We recommend that the area west of the existing residence not be disturbed as part of the proposed development. This means no fill should be placed west of the existing/new residence and the area should also not be used for construction staging. Disturbance of this western area should be limited to the minimum necessary for landscaping. A sprinkler system should not be installed for the western yard, due to the potential for leakage in the underground piping, which could trigger a failure. All collected stormwater should be directed away from the western slope and to the stormwater collection system.

The excavation for the upslope eastern half of the proposed residence will be an important geotechnical consideration for the project where the grade rises to the east onto the neighboring property. A 4- to 5-foot-tall block wall is located on the eastern adjacent property along the shared property line with the subject site. Furthermore, offset approximately 5 feet east and upslope of the northern half of the block wall, is a 5- to 7-foot-tall rockery that rises to the upper level of the neighbor's yard to the east. The test hole we conducted along the toe of the block wall indicates the wall is constructed on loose fill and native soils. We understand the new residence will be constructed inside (west) of the existing house's eastern foundation wall and the new finished floor will generally match that of the existing basement near slab near elevation 228 feet. However, to prevent the excavation for the proposed residence from undermining the neighboring retaining wall and rockery, no un-shoring excavation should extend below the existing grade along the east side of the site. It may be feasible to use the existing eastern basement foundation wall for temporary shoring; however, we anticipate the existing wall will require structural bracing. This will need to be evaluated and designed by the project structural engineer. Alternatively, temporary shoring in the form of cantilevered soldier piles will be required along the eastern perimeter of the proposed excavation.

Additionally, the long-term stability of the eastern tiered block retaining wall and rockery is questionable. The tiered block wall and rockery along the eastern property line are likely at least partially retaining loose fill soils placed to create the eastern neighbor's flat yard. Therefore, we also recommend the space between the eastern perimeter foundation wall of new residence and the face of the existing block wall along the property line be filled with structural fill to provide stability to the toe of the tiered walls along the eastern property line.

The glacial till soils underlying the site are essentially impervious. Any water that percolates through the upper sand soils will become perched above the impervious underlying glacial till and migrate downslope in the direction of the steep slope on the western end of the property. This could reduce the stability of that slope. Therefore, it is our opinion that onsite dispersion or concentrated infiltration of collected stormwater is not appropriate for the subject site. All collected stormwater should be tightlined to an approved off-site stormwater discharge system.

All, or the vast majority, of the excavated soil will be unsuitable for reuse on the site. The native soils and upper un-engineered fill soils are silty in nature and thus are very difficult to adequately recompact due to their moisture sensitivity. As a result, we expect that excavated soils will be hauled off the site, and imported granular fill will be needed for the project. No fill soils should be stockpiled in the western yard area.

The above section entitled **Erosion Hazard Areas** covers typical temporary erosion control measures that would be prudent. In preventing erosion control problems on any site, it is most important that any disturbed soil areas be immediately protected. This requires diligence and frequent communication on the part of the general contractor and earthwork subcontractor. As with all construction projects undertaken during potentially wet conditions, it is important that the contractor's on-site personnel are familiar with erosion control measures and that they monitor their performance on a regular basis. It is also appropriate for them to take immediate action to correct any erosion control problems that may develop, without waiting for input from the geotechnical engineer or representatives of the City.

The drainage and/or waterproofing recommendations presented in this report are intended only to prevent active seepage from flowing through concrete walls or slabs. Even in the absence of active seepage into and beneath structures, water vapor can migrate through walls, slabs, and floors from the surrounding soil, and can even be transmitted from slabs and foundation walls due to the concrete curing process. Water vapor also results from occupant uses, such as cooking, cleaning, and bathing. Excessive water vapor trapped within structures can result in a variety of undesirable conditions, including, but not limited to, moisture problems with flooring systems, excessively moist air within occupied areas, and the growth of molds, fungi, and other biological organisms that may be harmful to the health of the occupants. The designer or architect must consider the potential vapor sources and likely occupant uses, and provide sufficient ventilation, either passive or mechanical, to prevent a build up of excessive water vapor within the planned structure.

As with any project that involves demolition of existing site buildings and/or extensive excavation and shoring, there is a potential risk of movement on surrounding properties. This can potentially translate into noticeable damage of surrounding on-grade elements, such as foundations and slabs. However, the demolition, shoring, and/or excavation work could just translate into *perceived* damage on adjacent properties. Unfortunately, it is becoming more and more common for adjacent property owners to make unsubstantiated damage claims on new projects that occur close to their developed lots. Therefore, we recommend making an extensive photographic and visual survey of the project vicinity, prior to demolition activities, installing shoring, and/or commencing with the excavation. This documents the condition of buildings, pavements, and utilities in the immediate vicinity of the site in order to avoid, and protect the owner from, unsubstantiated damage claims by surrounding property owners. Additionally, any adjacent structures should be monitored during demolition and construction to detect soil movements. To monitor their performance, we recommend establishing a series of survey reference points to measure any horizontal deflections of the shoring system. Control points should be established at a distance well away from the walls and slopes, and deflections from the reference points should be measured throughout construction by survey methods.

Geotech Consultants, Inc. should be allowed to review the final development plans to verify that the recommendations presented in this report are adequately addressed in the design. Such a plan review would be additional work beyond the current scope of work for this study, and it may include revisions to our recommendations to accommodate site, development, and geotechnical constraints that become more evident during the review process.

We recommend including this report, in its entirety, in the project contract documents. This report should also be provided to any future property owners so they will be aware of our findings and recommendations.

SEISMIC CONSIDERATIONS

In accordance with the International Building Code (IBC), the site class within 100 feet of the ground surface is best represented by Site Class Type D (Stiff Soil). As noted in the USGS website, the mapped spectral acceleration value for a 0.2 second (S_s) and 1.0 second period (S_1) equals 1.41g and 0.49g, respectively.

The IBC and ASCE 7 require that the potential for liquefaction (soil strength loss) during an earthquake be evaluated for the peak ground acceleration of the Maximum Considered Earthquake (MCE), which has a probability of occurring once in 2,475 years (2 percent probability of occurring in a 50-year period). The MCE peak ground acceleration adjusted for site class effects (F_{PGA}) equals 0.67g. The soils beneath the site are not susceptible to seismic liquefaction under the ground motions of the MCE because of their dense nature and the absence of a defined near-surface water table.

Sections 1803.5 of the IBC and 11.8 of ASCE 7 require that other seismic-related geotechnical design parameters (seismic surcharge for retaining wall design and slope stability) include the potential effects of the Design Earthquake. The peak ground acceleration for the Design Earthquake is defined in Section 11.2 of ASCE 7 as two-thirds (2/3) of the MCE peak ground acceleration, or 0.44g.

CONVENTIONAL FOUNDATIONS

The proposed residence can be supported on conventional continuous and spread footings bearing on undisturbed, dense to very dense glacial till. We recommend that continuous and individual spread footings have minimum widths of 12 and 16 inches, respectively. Exterior footings should also be bottomed at least 18 inches below the lowest adjacent finish ground surface for protection against frost and erosion. The local building codes should be reviewed to determine if different footing widths or embedment depths are required. Footing subgrades must be cleaned of loose or disturbed soil prior to pouring concrete. Depending upon site and equipment constraints, this may require removing the disturbed soil by hand.

Thickened slabs are sometimes included in the design to support interior walls. It is important to remember that thickened slab areas support building loads, just like conventional footings do. For this reason, the subgrade below thickened slabs must be prepared in the same way as for conventional footings. All unsuitable soils have to be removed and any structural fill compacted in accordance with the recommendations of this report. We recommend against the use of thickened slabs for most projects, particularly single-family residential, as it is difficult to ensure that the subgrades have been appropriately prepared. Also, the compacted slab fill has to be protected from disturbance by the earthwork, foundation, and utility contractors.

An allowable bearing pressure of 3,000 pounds per square foot (psf) is appropriate for footings supported on dense to very dense glacial till. A one-third increase in this design bearing pressure may be used when considering short-term wind or seismic loads. For the above design criteria, it is anticipated that the total post-construction settlement of footings founded on competent native soil, will be about one inch, with differential settlements on the order of one half-inch in a distance of 50 feet along a continuous footing with a uniform load.

Lateral loads due to wind or seismic forces may be resisted by friction between the foundation and the bearing soil, or by passive earth pressure acting on the vertical, embedded portions of the foundation. For the latter condition, the foundation must be either poured directly against relatively level, undisturbed soil or be surrounded by level, well-compacted fill. We recommend using the following ultimate values for the foundation's resistance to lateral loading:

PARAMETER	ULTIMATE VALUE
Coefficient of Friction	0.50
Passive Earth Pressure	300 pcf

Where: pcf is Pounds per Cubic Foot, and Passive Earth Pressure is computed using the Equivalent Fluid Density.

If the ground in front of a foundation is loose or sloping, the passive earth pressure given above will not be appropriate. The above ultimate values for passive earth pressure and coefficient of friction do not include a safety factor.

FOUNDATION AND RETAINING WALLS

Retaining walls backfilled on only one side should be designed to resist the lateral earth pressures imposed by the soil they retain. The following recommended parameters are for walls that restrain level backfill:

PARAMETER	VALUE
Active Earth Pressure * - Level Backfill - Eastern Foundation Wall With Adjacent Upslope Walls	 35 pcf 55 pcf
Passive Earth Pressure	300 pcf
Coefficient of Friction	0.50
Soil Unit Weight	130 pcf

Where: pcf is Pounds per Cubic Foot, and Active and Passive Earth Pressures are computed using the Equivalent Fluid Pressures.

*** For a restrained wall that cannot deflect at least 0.002 times its height, a uniform lateral pressure equal to 10 psf times the height of the wall should be added to the above active equivalent fluid pressure. This applies only to walls with level backfill.**

The design values given above do not include the effects of any hydrostatic pressures behind the walls and assume that no surcharges, such as those caused by slopes, vehicles, or adjacent foundations will be exerted on the walls. If these conditions exist, those pressures should be added to the above lateral soil pressures. Where sloping backfill is desired behind the walls, we will need to be given the wall dimensions and the slope of the backfill in order to provide the appropriate design earth pressures. The surcharge due to traffic loads behind a wall can typically be accounted for by adding a uniform pressure equal to 2 feet multiplied by the above active fluid density. Heavy construction equipment should not be operated behind retaining and foundation walls within a distance equal to the height of a wall, unless the walls are designed for the additional lateral pressures resulting from the equipment.

The values given above are to be used to design only permanent foundation and retaining walls that are to be backfilled, such as conventional walls constructed of reinforced concrete or masonry. It is not appropriate to use the above earth pressures and soil unit weight to back-calculate soil strength parameters for design of other types of retaining walls, such as soldier pile, reinforced earth, modular or soil nail walls. We can assist with design of these types of walls, if desired.

The passive pressure given is appropriate only for a shear key poured directly against undisturbed native soil, or for the depth of level, well-compacted fill placed in front of a retaining or foundation wall. The values for friction and passive resistance are ultimate values and do not include a safety factor. Restrained wall soil parameters should be utilized the wall and reinforcing design for a distance of 1.5 times the wall height from corners or bends in the walls, or from other points of restraint. This is intended to reduce the amount of cracking that can occur where a wall is restrained by a corner.

Wall Pressures Due to Seismic Forces

Per IBC Section 1803.5.12, a seismic surcharge load need only be considered in the design of walls over 6 feet in height. A seismic surcharge load would be imposed by adding a uniform lateral pressure to the above-recommended active pressure. The recommended seismic surcharge pressure for this project is 9**H** pounds per square foot (psf), where **H** is the design retention height of the wall. Using this increased pressure, the safety factor against sliding and overturning can be reduced to 1.2 for the seismic analysis.

Retaining Wall Backfill and Waterproofing

Backfill placed behind retaining or foundation walls should be coarse, free-draining structural fill containing no organics. This backfill should contain no more than 5 percent silt or clay particles and have no gravel greater than 4 inches in diameter. The percentage of particles passing the No. 4 sieve should be between 25 and 70 percent. Drainage composite similar to Miradrain 6000 should be placed against the backfilled retaining walls. The drainage composites should be hydraulically connected to the foundation drain system. Free-draining backfill should be used for the entire width of the backfill where seepage is encountered. For increased protection, drainage composites should be placed along cut slope faces, and the walls should be backfilled entirely with free-draining soil. The later section entitled ***Drainage Considerations*** should also be reviewed for recommendations related to subsurface drainage behind foundation and retaining walls.

The purpose of these backfill requirements is to ensure that the design criteria for a retaining wall are not exceeded because of a build-up of hydrostatic pressure behind the wall. Also, subsurface drainage systems are not intended to handle large volumes of water from surface runoff. The top 12 to 18 inches of the backfill should consist of a compacted, relatively impermeable soil or topsoil, or the surface should be paved. The ground surface must also slope away from backfilled walls at one to 2 percent to reduce the potential for surface water to percolate into the backfill.

Water percolating through pervious surfaces (pavers, gravel, permeable pavement, etc.) must also be prevented from flowing toward walls or into the backfill zone. Foundation drainage and waterproofing systems are not intended to handle large volumes of infiltrated water. The compacted subgrade below pervious surfaces and any associated drainage layer should therefore be sloped away. Alternatively, a membrane and subsurface collection system could be provided below a pervious surface.

It is critical that the wall backfill be placed in lifts and be properly compacted, in order for the above-recommended design earth pressures to be appropriate. The recommended wall design criteria assume that the backfill will be well-compacted in lifts no thicker than 12 inches. The compaction of backfill near the walls should be accomplished with hand-operated equipment to prevent the walls from being overloaded by the higher soil forces that occur during compaction. The section entitled ***General Earthwork and Structural Fill*** contains additional recommendations regarding the placement and compaction of structural fill behind retaining and foundation walls.

The above recommendations are not intended to waterproof below-grade walls, or to prevent the formation of mold, mildew or fungi in interior spaces. Over time, the performance of subsurface drainage systems can degrade, subsurface groundwater flow patterns can change, and utilities can break or develop leaks. Therefore, waterproofing should be provided where future seepage through the walls is not acceptable. This typically includes limiting cold-joints and wall penetrations, and using bentonite panels or membranes on the outside of the walls. There are a variety of different waterproofing materials and systems, which should be installed by an experienced contractor familiar with the anticipated construction and subsurface conditions. Applying a thin coat of asphalt emulsion to the outside face of a wall is not considered waterproofing, and will only help to reduce moisture generated from water vapor or capillary action from seeping through the concrete. As with any project, adequate ventilation of basement and crawl space areas is important to prevent a buildup of water vapor that is commonly transmitted through concrete walls from the surrounding soil, even when seepage is not present. This is appropriate even when waterproofing is applied to the outside of foundation and retaining walls. We recommend that you contact an experienced envelope consultant if detailed recommendations or specifications related to waterproofing design, or minimizing the potential for infestations of mold and mildew are desired.

The ***General***, ***Slabs-On-Grade***, and ***Drainage Considerations*** sections should be reviewed for additional recommendations related to the control of groundwater and excess water vapor for the anticipated construction.

SLABS-ON-GRADE

The building floors can be constructed as slabs-on-grade atop non-organic native soil, or on structural fill. The subgrade soil must be in a firm, non-yielding condition at the time of slab construction or underslab fill placement. Any soft areas encountered should be excavated and replaced with select, imported structural fill.

Even where the exposed soils appear dry, water vapor will tend to naturally migrate upward through the soil to the new constructed space above it. This can affect moisture-sensitive flooring, cause imperfections or damage to the slab, or simply allow excessive water vapor into the space above the slab. All interior slabs-on-grade should be underlain by a capillary break drainage layer consisting of a minimum 4-inch thickness of clean gravel or crushed rock that has a fines content (percent passing the No. 200 sieve) of less than 3 percent and a sand content (percent passing the No. 4 sieve) of no more than 10 percent. Pea gravel or crushed rock are typically used for this layer.

As noted by the American Concrete Institute (ACI) in the *Guides for Concrete Floor and Slab Structures*, proper moisture protection is desirable immediately below any on-grade slab that will be covered by tile, wood, carpet, impermeable floor coverings, or any moisture-sensitive equipment or products. ACI recommends a minimum 10-mil thickness vapor retarder for better durability and long term performance than is provided by 6-mil plastic sheeting that has historically been used. A vapor retarder is defined as a material with a permeance of less than 0.3 perms, as determined by ASTM E 96. It is possible that concrete admixtures may meet this specification, although the manufacturers of the admixtures should be consulted. Where vapor retarders are used under slabs, their edges should overlap by at least 6 inches and be sealed with adhesive tape. The sheeting should extend to the foundation walls for maximum vapor protection.

If no potential for vapor passage through the slab is desired, a vapor *barrier* should be used. A vapor barrier, as defined by ACI, is a product with a water transmission rate of 0.01 perms when tested in accordance with ASTM E 96. Reinforced membranes having sealed overlaps can meet this requirement.

We recommend that the contractor, the project materials engineer, and the owner discuss these issues and review recent ACI literature and ASTM E-1643 for installation guidelines and guidance on the use of the protection/blotter material.

The ***General***, ***Permanent Foundation and Retaining Walls***, and ***Drainage Considerations*** sections should be reviewed for additional recommendations related to the control of groundwater and excess water vapor for the anticipated construction.

EXCAVATIONS AND SLOPES

Temporary excavation slopes should not exceed the limits specified in local, state, and national government safety regulations. Also, temporary cuts should be planned to provide a minimum 2 to 3 feet of space for construction of foundations, walls, and drainage. Temporary cuts to a maximum overall depth of about 4 feet may be attempted vertically in unsaturated soil, if there are no indications of slope instability. However, vertical cuts should not be made near property boundaries, or existing utilities and structures. Unless approved by the geotechnical engineer of record, it is important that vertical cuts not be made at the base of sloped cuts. Based upon Washington Administrative Code (WAC) 296, Part N, the loose near-surface soils beneath the subject site would generally be classified as Type C. Therefore, temporary cut slopes greater than 4 feet in height should not be excavated at an inclination steeper than 1.5:1 (Horizontal:Vertical), extending continuously between the top and the bottom of a cut. However, as noted above, no temporary cut slopes should be made in front of the eastern wall and rockery without the use of temporary shoring.

The above-recommended temporary slope inclinations are based on the conditions exposed in our explorations, and on what has been successful at other sites with similar soil conditions. It is possible that variations in soil and groundwater conditions will require modifications to the inclination at which temporary slopes can stand. Temporary cuts are those that will remain unsupported for a relatively short duration to allow for the construction of foundations, retaining walls, or utilities. Temporary cut slopes should be protected with plastic sheeting during wet weather. It is also important that surface runoff be directed away from the top of temporary slope cuts. Cut slopes should also be backfilled or retained as soon as possible to reduce the potential for instability. Please note that sand or loose soil can cave suddenly and without warning. Excavation, foundation, and utility contractors should be made especially aware of this potential danger. These recommendations may need to be modified if the area near the potential cuts has been disturbed in the past by utility installation, or if settlement-sensitive utilities are located nearby.

All permanent cuts into existing soil should be inclined no steeper than 2.5:1 (H:V), provided these cuts are not made below existing settlement-sensitive elements, such as the eastern wall and rockery.

Water should not be allowed to flow uncontrolled over the top of any temporary or permanent slope. All permanently exposed slopes should be seeded with an appropriate species of vegetation to reduce erosion and improve the stability of the surficial layer of soil.

Any disturbance to the existing slope outside of the building limits may reduce the stability of the slope. Damage to the existing vegetation and ground should be minimized, and any disturbed areas should be revegetated as soon as possible. Soil from the excavation should not be placed on the slope, and this may require the off-site disposal of any surplus soil.

TEMPORARY CANTILEVERED SOLDIER PILE SHORING

Cantilevered soldier pile systems have proven to be an efficient and economical method for providing excavation shoring where the depth of excavation is less than approximately 15 feet. A safety factor of 1.2 should be included in the design of the temporary shoring.

Soldier Pile Installation

Soldier pile walls would be constructed after making planned cut slopes, and prior to commencing the mass excavation, by setting steel H-beams in a drilled hole and grouting the space between the beam and the soil with concrete for the entire height of the drilled hole. The shoring contractor should be prepared to case the holes or use the slurry method if caving soil is encountered. Excessive ground loss in the drilled holes must be avoided to reduce the potential for settlement on adjacent properties. If water is present in a hole at the time the soldier pile is poured, concrete must be tremied to the bottom of the hole.

If shoring is installed close to the face of the existing eastern wall/rockery, the maximum center-to-center spacing of the soldier piles should be limited to 6 feet. This reduces the potential for soil caving during the excavation and placement of lagging between the piles.

As excavation proceeds downward, the space between the piles should be lagged with timber, and any voids behind the timbers should be filled with pea gravel, or a slurry comprised of sand and fly ash. Treated lagging is usually required for permanent walls, while untreated lagging can often be utilized for temporary shoring walls. Temporary vertical cuts will be necessary between the soldier piles for the lagging placement. The prompt and careful installation of lagging is important, particularly in loose or caving soil, to maintain the integrity of the excavation and provide safer working conditions. Additionally, care must be taken by the excavator to remove no more soil between the soldier piles than is necessary to install the lagging. Caving or overexcavation during lagging placement could result in loss of ground on neighboring properties. Timber lagging should be designed for an applied lateral pressure of 30 percent of the design wall pressure, if the pile spacing is less than three pile diameters. For larger pile spacings, the lagging should be designed for 50 percent of the design load.

<u>Soldier Pile Wall Design</u>

Temporary soldier pile shoring that is cantilevered and that has a level backslope should be designed for an active soil pressure equal to that pressure exerted by an equivalent fluid with a unit weight of 40 pounds per cubic foot (pcf).
Shoring walls along the eastern perimeter of the development along the toe of the neighboring tiered walls/rockeries should be designed to include a surcharge for these elements. This surcharge will depend on the proximity of the shoring to the eastern property line.

Additional cut slopes above the shoring walls will exert surcharge pressures. Traffic surcharges can typically be accounted for by increasing the effective height of the shoring wall by 2 feet. We can review the initial shoring design to verify our preliminary surcharge considerations are still appropriate for the design layout.

It is important that the shoring design provides sufficient working room to drill and install the soldier piles, without needing to make unsafe, excessively steep temporary cuts. Cut slopes should be planned to intersect the backside of the drilled holes, not the back of the lagging.

Lateral movement of the soldier piles below the excavation level will be resisted by an <u>ultimate</u> passive soil pressure equal to that pressure exerted by a fluid with a density of 450 pcf. A reduction factor is included in this passive pressure to account for strain compatibility in regards to pile deflection. For permanent walls, we recommend a minimum factor of safety of 1.5 be applied to overturning and sliding calculations when using this ultimate value (temporary installations may use a factor of safety of 1.2). This soil pressure is valid only for a level excavation in front of the soldier pile; it acts on two times the grouted pile diameter. Cut slopes made in front of shoring walls significantly decrease the passive resistance. This includes temporary cuts necessary to install internal braces or rakers. The minimum embedment below the floor of the excavation for cantilever soldier piles should be equal to the height of the "stick-up." A typical cantilevered soldier pile shoring detail was attached to this report as Plate 7.

EXCAVATION AND SHORING MONITORING

As with any shoring system, there is a potential risk of greater-than-anticipated movement of the shoring and the ground outside of the excavation. This can translate into noticeable damage of surrounding on-grade elements, such as foundations and slabs. Therefore, we recommend making an extensive photographic and visual survey of the project vicinity, prior to demolition activities, installing shoring or commencing excavation. This documents the condition of buildings, pavements, and utilities in the immediate vicinity of the site in order to avoid, and protect the owner from, unsubstantiated damage claims by surrounding property owners.

Additionally, the shoring walls and any adjacent foundations should be monitored during construction to detect soil movements. To monitor their performance, we recommend establishing a series of survey reference points to measure any horizontal deflections of the shoring system. Control points should be established at a distance well away from the walls and slopes, and deflections from the reference points should be measured throughout construction by survey methods. At least every other soldier pile should be monitored by taking readings at the top of the pile. Additionally, benchmarks installed on the surrounding buildings should be monitored for at least vertical movement. We suggest taking the readings at least once a week, until it is established that no deflections are occurring. The initial readings for this monitoring should be taken before starting any demolition or excavation on the site.

DRAINAGE CONSIDERATIONS

We anticipate that permanent foundation walls may be constructed against the shoring walls. Where this occurs, a plastic-backed drainage composite, such as Miradrain, Battledrain, or similar, should be placed against the entire surface of the shoring prior to pouring the foundation wall. Weep pipes located no more than 6 feet on-center should be connected to the drainage composite and poured into the foundation walls or the perimeter footing. A footing drain installed along the inside of the perimeter footing will be used to collect and carry the water discharged by the weep pipes to the storm system. Isolated zones of moisture or seepage can still reach the permanent wall where groundwater finds leaks or joints in the drainage composite. This is often an acceptable risk in unoccupied below-grade spaces, such as parking garages. However, formal waterproofing is typically necessary in areas where wet conditions at the face of the permanent wall will not be tolerable. If this is a concern, the permanent drainage and waterproofing system should be designed by a specialty consultant familiar with the expected subsurface conditions and proposed construction. Plate 8 presents typical considerations for foundation drains at shoring walls.

Footing drains placed inside the building, outside of the building, or behind backfilled walls should consist of 4-inch, perforated PVC pipe surrounded by at least 6 inches of 1-inch-minus, washed rock wrapped in a non-woven, geotextile filter fabric (Mirafi 140N, Supac 4NP, or similar material). At its highest point, a perforated pipe invert should be at least 6 inches below the level of a crawl space or the bottom of a floor slab, and it should be sloped slightly for drainage. All roof and surface water drains must be kept separate from the foundation drain system.

Footing drains outside of the building should be used where: (1) crawl spaces or basements will be below a structure; (2) a slab is below the outside grade; or, (3) the outside grade does not slope downward from a building. A typical footing drain detail is attached to this report as Plate 9. Clean-outs should be provided for potential future flushing or cleaning of footing drains.

As a minimum, a vapor retarder, as defined in the ***Slabs-On-Grade*** section, should be provided in any crawl space area to limit the transmission of water vapor from the underlying soils. Crawl space grades are sometimes left near the elevation of the bottom of the footings. As a result, an outlet drain is recommended for all crawl spaces to prevent an accumulation of any water that may bypass the footing drains. Providing a few inches of free draining gravel underneath the vapor retarder is also prudent to limit the potential for seepage to build up on top of the vapor retarder.

No groundwater was observed during our field work. If seepage is encountered in an excavation, it should be drained from the site by directing it through drainage ditches, perforated pipe, or French drains, or by pumping it from sumps interconnected by shallow connector trenches at the bottom of the excavation.

The excavation and site should be graded so that surface water is directed off the site and away from the tops of slopes. Water should not be allowed to stand in any area where foundations, slabs, or pavements are to be constructed. Final site grading in areas adjacent to a building should slope away at least one to 2 percent, except where the area is paved. Surface drains should be provided where necessary to prevent ponding of water behind foundation or retaining walls. A discussion of grading and drainage related to pervious surfaces near walls and structures is contained in the ***Foundation and Retaining Walls*** section.

GENERAL EARTHWORK AND STRUCTURAL FILL

All building and pavement areas should be stripped of surface vegetation, topsoil, organic soil, and other deleterious material. It is important that existing foundations be removed before site development. The stripped or removed materials should not be mixed with any materials to be used as structural fill, but they could be used in non-structural areas, such as landscape beds.

Structural fill is defined as any fill, including utility backfill, placed under, or close to, a building, or in other areas where the underlying soil needs to support loads. All structural fill should be placed in horizontal lifts with a moisture content at, or near, the optimum moisture content. The optimum moisture content is that moisture content that results in the greatest compacted dry density. The moisture content of fill is very important and must be closely controlled during the filling and compaction process.

The allowable thickness of the fill lift will depend on the material type selected, the compaction equipment used, and the number of passes made to compact the lift. The loose lift thickness should not exceed 12 inches, but should be thinner if small, hand-operated compactors are used. We recommend testing structural fill as it is placed. If the fill is not sufficiently compacted, it should be recompacted before another lift is placed. This eliminates the need to remove the fill to achieve the required compaction. The following table presents recommended levels of relative compaction for compacted fill:

LOCATION OF FILL PLACEMENT	MINIMUM RELATIVE COMPACTION
Beneath slabs or walkways	95%
Filled slopes and behind retaining walls	90%
Beneath pavements	95% for upper 12 inches of subgrade; 90% below that level

Where: Minimum Relative Compaction is the ratio, expressed in percentages, of the compacted dry density to the maximum dry density, as determined in accordance with ASTM Test Designation D 1557-91 (Modified Proctor).

Structural fill that will be placed in wet weather should consist of a coarse, granular soil with a silt or clay content of no more than 5 percent. The percentage of particles passing the No. 200 sieve should be measured from that portion of soil passing the three-quarter-inch sieve.

LIMITATIONS

The conclusions and recommendations contained in this report are based on site conditions as they existed at the time of our exploration and assume that the soil and groundwater conditions encountered in the test borings and test holes are representative of subsurface conditions on the site. If the subsurface conditions encountered during construction are significantly different from those observed in our explorations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. Unanticipated conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking samples in test borings and test holes. Subsurface conditions can also vary between exploration locations. Such unexpected conditions frequently require making additional expenditures to attain a properly constructed project. It is recommended that the owner consider providing a contingency fund to accommodate such potential extra costs and risks. This is a standard recommendation for all projects.

The recommendations presented in this report are directed toward the protection of only the proposed residence from damage due to slope movement. Predicting the future behavior of steep slopes and the potential effects of development on their stability is an inexact and imperfect science that is currently based mostly on the past behavior of slopes with similar characteristics. This is especially true for un-engineered structures that retain fill soils, which exist to the west and east of the planned development area. Landslides and soil movement can occur on steep slopes before, during, or after the development of property. The owner of any property containing, or located close to steep slopes must ultimately accept the possibility that some slope movement could occur, resulting in possible loss of ground or damage to the facilities around the proposed building residence.

This report has been prepared for the exclusive use of Dorothy Strand and her representatives, for specific application to this project and site. Our conclusions and recommendations are professional opinions derived in accordance with our understanding of current local standards of practice, and within the scope of our services. No warranty is expressed or implied. The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design. Our services also do not include assessing or minimizing the potential for biological hazards, such as mold, bacteria, mildew and fungi in either the existing or proposed site development.

ADDITIONAL SERVICES

In addition to reviewing the final plans, Geotech Consultants, Inc. should be retained to provide geotechnical consultation, testing, and observation services during construction. This is to confirm that subsurface conditions are consistent with those indicated by our exploration, to evaluate whether earthwork and foundation construction activities comply with the general intent of the recommendations presented in this report, and to provide suggestions for design changes in the event subsurface conditions differ from those anticipated prior to the start of construction. However, our work would not include the supervision or direction of the actual work of the contractor and its employees or agents. Also, job and site safety, and dimensional measurements, will be the responsibility of the contractor.

During the construction phase, we will provide geotechnical observation and testing services when requested by you or your representatives. Please be aware that we can only document site work we actually observe. It is still the responsibility of your contractor or on-site construction team to verify that our recommendations are being followed, whether we are present at the site or not.

The following plates are attached to complete this report:

Plate 1	Vicinity Map
Plate 2	Site Exploration Plan
Plates 3 - 5	Test Boring Logs
Plate 6	Test Hole Logs
Plate 7	Cantilevered Soldier Pile Shoring
Plate 8	Typical Shoring Drain Detail
Plate 9	Typical Footing Drain Detail
Attachment	Slope Stability Analysis

We appreciate the opportunity to be of service on this project. Please contact us if you have any questions, or if we can be of further assistance.

Respectfully submitted,

GEOTECH CONSULTANTS, INC.

Adam S. Moyer
Geotechnical Engineer

3/21/2022

Marc R. McGinnis, P.E.
Principal

ASM/MRM:kg

NORTH

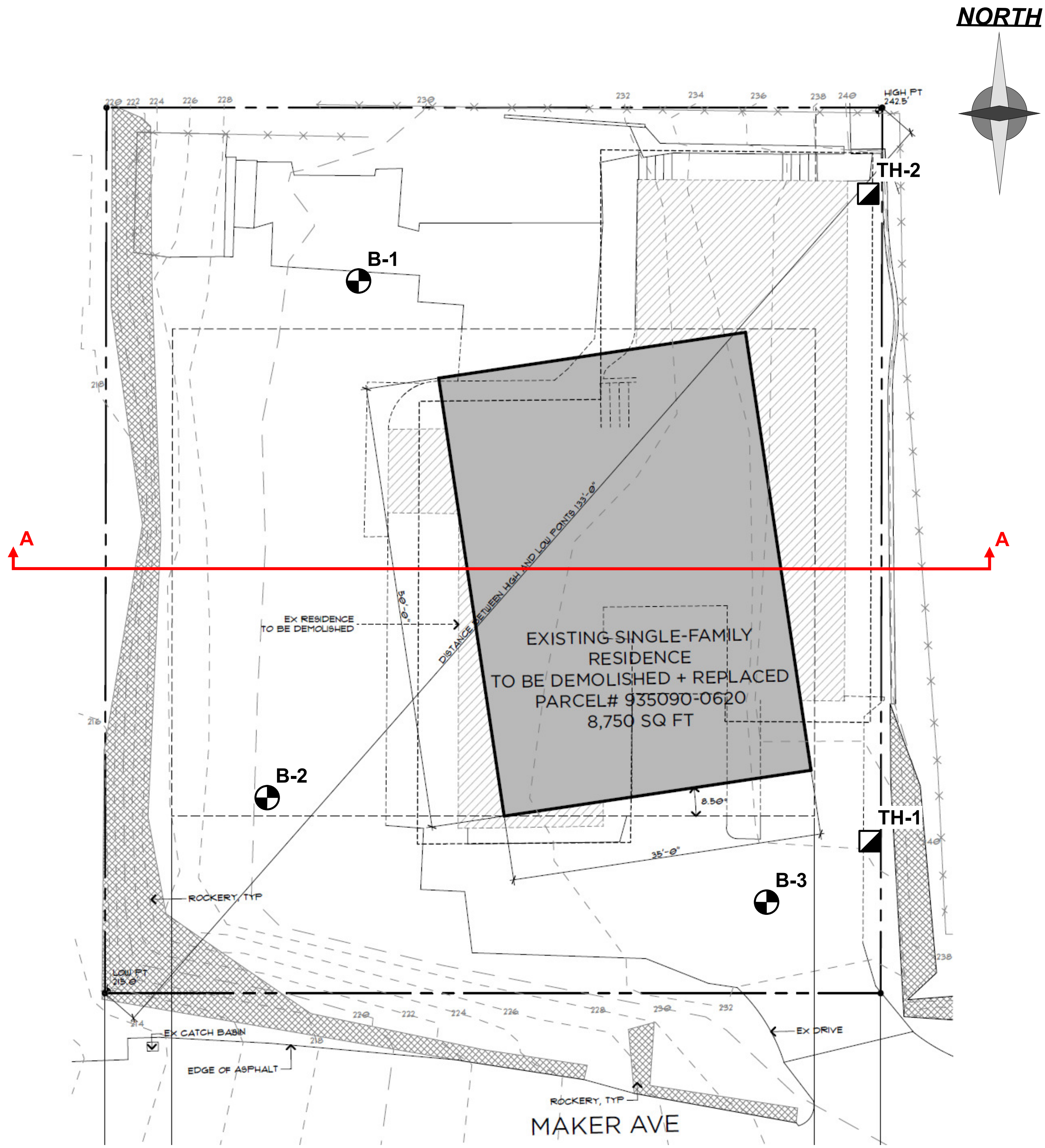
(Source: Microsoft MapPoint, 2013)

GEOTECH
CONSULTANTS, INC.

VICINITY MAP

6950 Southeast Maker Street
Mercer Island, Washington

Job No:	Date:		Plate:
22007	Mar. 2022		1



Legend:

Test Boring Location

Test Hole Location

Slope Stability Analysis Cross Section

GEOTECH
CONSULTANTS, INC.

SITE EXPLORATION PLAN

6950 Southeast Maker Street
Mercer Island, Washington

Job No:	Date:		Plate:
22007	Mar. 2022	No Scale	2

BORING 1

Depth (ft.)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description (Elevation ±231 feet)
						Gray-brown silty SAND with gravel, fine- to medium-grained, moist, loose **(FILL)**
			6	1	FILL	
5						
			4	2		
						Remnant Topsoil
						Brown silty SAND with gravel, fine- to medium-grained, moist, loose
						-becomes fine- to coarse-grained, with occasional sandy lenses
			12	3		
10					SM	-becomes gray-brown, clayey, gravelly, dense **(Glacial Till)**
			45	4		
15						Gray-brown SAND with silt and gravel, fine- to medium-grained, moist, medium-dense
			16	5	SP	
					SM	Brownish-gray silty clayey SAND with gravel, fine- to medium-grained, moist, very dense
			50/4"	6		
20						

*** Test boring was terminated at 19.4 feet due to refusal on February 4, 2022.**
*** No groundwater was encountered during drilling.**

GEOTECH
CONSULTANTS, INC.

TEST BORING LOG

6950 Southeast Maker Street
Mercer Island, Washington

Job No:	Date:	Logged by:	Plate:
22007	Mar. 2022	ASM	3

BORING 2

Depth (ft.)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description — Elevation ±230 feet
					FILL	Dark-brown silty SAND with gravel and organics, fine- to medium-grained, moist, loose
			3	1		
5			5	2		-with trace burnt wood and concrete debris
			9	3		-becomes gray-brown, no wood or concrete debris
10			5	4		-becomes dark-brown, with abundant organics and decomposed wood
						Remnant Topsoil
			24	5	SM	Gray-brown silty clayey SAND with gravel and occasional sandy seams, fine- to medium-grained, moist, medium-dense
15			60	6		-becomes very dense
20			64	7		

*** Test boring was terminated at 21.5 feet due to refusal on February 4, 2022.**
*** No groundwater was encountered during drilling.**

GEOTECH
CONSULTANTS, INC.

TEST BORING LOG

6950 Southeast Maker Street
Mercer Island, Washington

Job No:	Date:	Logged by:	Plate:
22007	Mar. 2022	ASM	4

BORING 3

Elevation ±233 feet

Depth (ft.)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
0					FILL	Gray-brown gravelly silty SAND, fine- to medium-grained, dry, loose **(FILL)**
					SM	Gray-brown with rust mottling, silty clayey SAND with gravel and occasional sand seams, fine- to medium-grained, moist, medium-dense
			20	1		
5						-becomes gray-brown, dense **(Glacial Till)**
			39	2		
						-becomes very dense
			78/11"	3		
10						-becomes fine-grained, no sand seams
			50/6"	4		
			50/5"	5		
15						
20						

*** Test boring was terminated at 10.9 feet due to refusal on February 4, 2022.**
*** No groundwater was encountered during drilling.**

GEOTECH
CONSULTANTS, INC.

TEST BORING LOG

6950 Southeast Maker Street
Mercer Island, Washington

Job No:	*Date:*	*Logged by:*	*Plate:*
22007	Mar. 2022	ASM	5

TEST HOLE 1

Depth (feet)	Soil Description
0.0 – 1.5	Topsoil
1.5 – 2.8	Gray-brown silty clayey SAND with gravel, fine- to medium-grained, moist, loose **(FILL)**
2.8 – 3.0	Gray-brown silty clayey SAND with gravel, fine- to medium-grained, moist, medium-dense **[SM]**

Test Hole was terminated at 3.0 feet on February 4, 2022.
No groundwater seepage was encountered in the test hole.

TEST HOLE 2

Depth (feet)	Soil Description
0.0 – 1.0	Gray-brown silty SAND with gravel, fine- to medium-grained, moist, loose **(FILL)**
1.0 – 3.2	Rust-brown silty SAND with gravel, fine- to medium-grained, moist, loose **[SM]** - at 3 feet; becomes gray-brown
3.2 – 4.0	Gray-brown gravelly SAND with silt, fine- to coarse-grained, moist, loose to medium-dense **[SW]**

Test Hole was terminated at 4.0 feet due to refusal on gravels on February 4, 2022.
No groundwater seepage was encountered in the test hole.

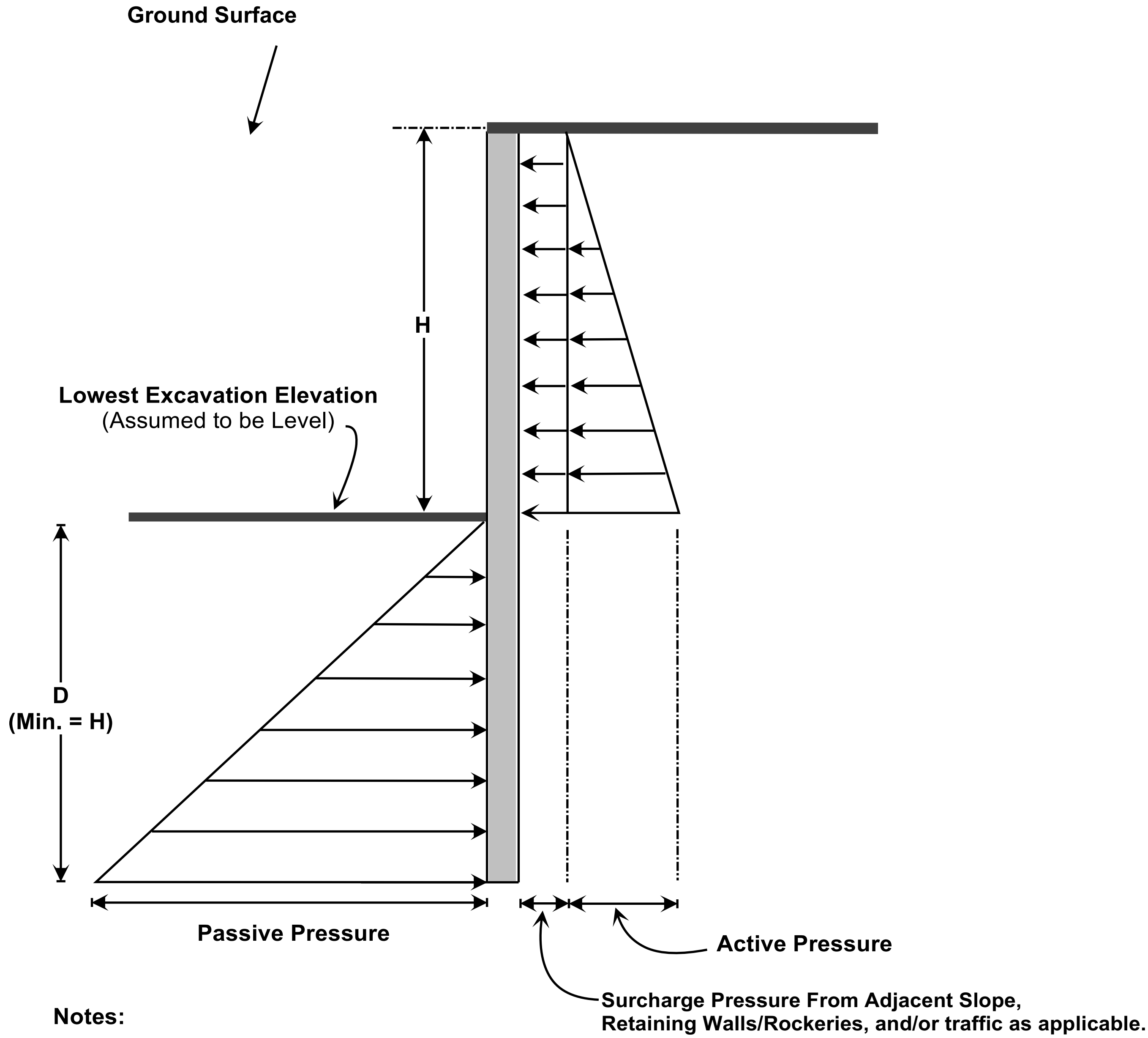
*__NOTE__ – Letters in brackets **[ ]** denote the USCS soil classification.

GEOTECH
CONSULTANTS, INC.

HAND BORING LOGS

6950 Southeast Maker Street
Mercer Island, Washington

Job No:	Date:		Plate:
22007	Mar. 2022		6



Notes:

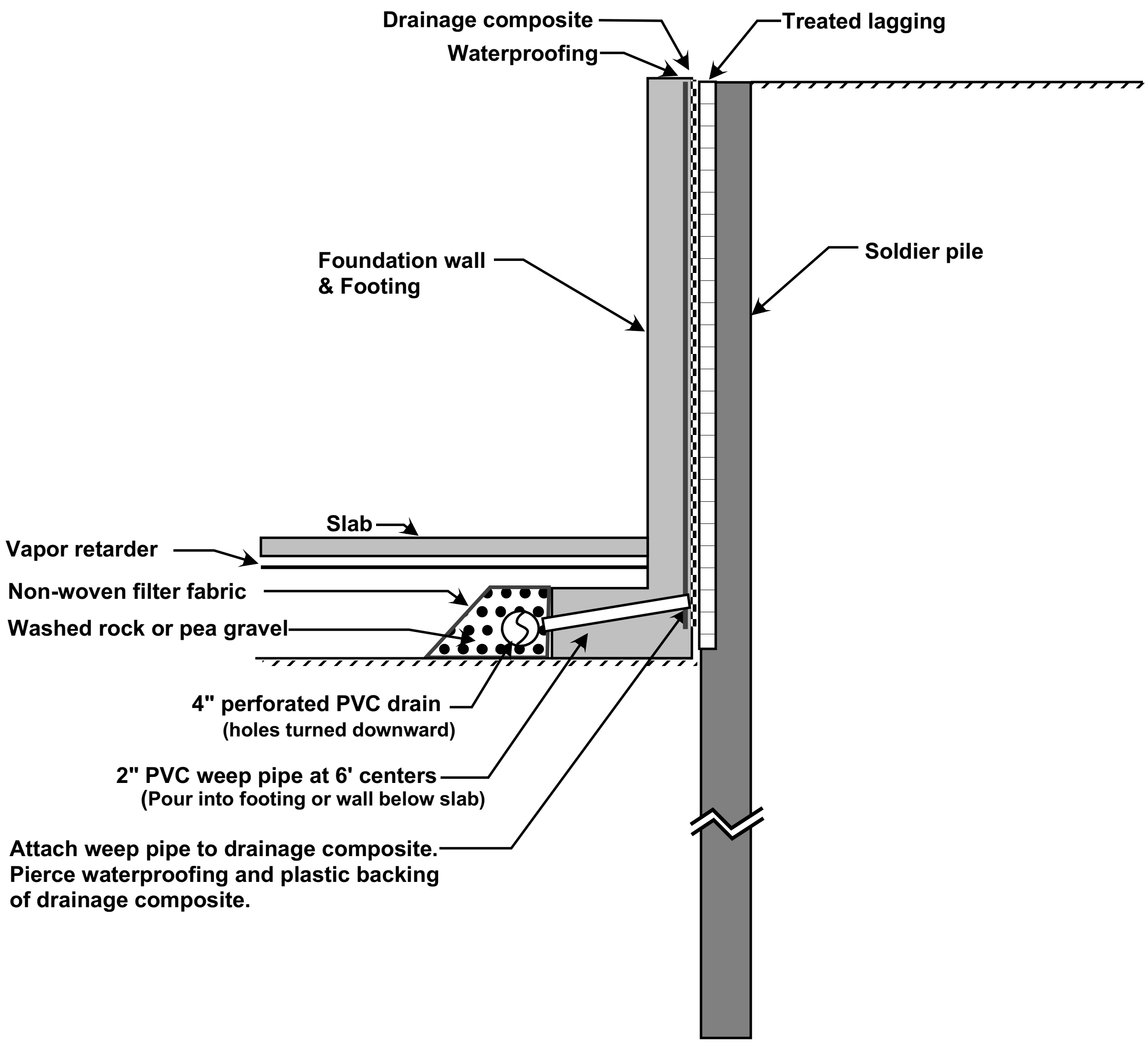
(1) The report should be referenced for specifics regarding design and installation.
(2) Active pressures act over the pile spacing.
(3) Passive pressures act over twice the grouted soldier pile diameter or the pile spacing, whichever is smaller.
(4) It is assumed that no hydrostatic pressures act on the back of the shoring walls.
(5) Cut slopes or adjacent structures positioned above or behind shoring will exert additional pressures on the shoring wall.

GEOTECH
CONSULTANTS, INC.

CANTILEVERED SOLDIER PILE SHORING

6950 Southeast Maker Street
Mercer Island, Washington

Job No:	Date:		Plate:
22007	Mar. 2022		7



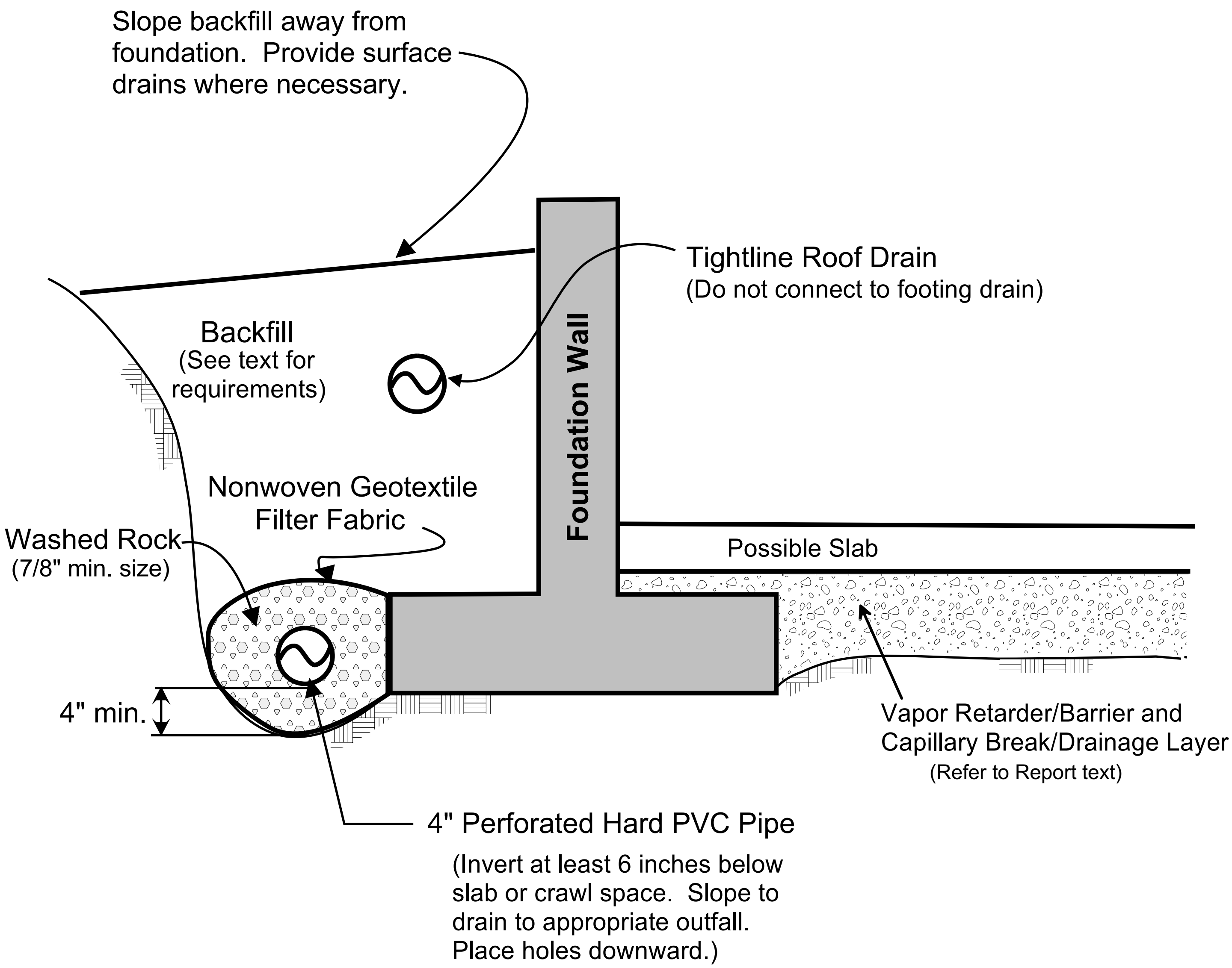
Note - Refer to the report for additional considerations related to drainage and waterproofing.

GEOTECH
CONSULTANTS, INC.

SHORING DRAIN DETAIL

6950 Southeast Maker Street
Mercer Island, Washington

Job No:	Date:		Plate:
22007	Mar. 2022		8



NOTES:

(1) In crawl spaces, provide an outlet drain to prevent buildup of water that bypasses the perimeter footing drains.

(2) Refer to report text for additional drainage, waterproofing, and slab considerations.

GEOTECH
CONSULTANTS, INC.

FOOTING DRAIN DETAIL

6950 Southeast Maker Street
Mercer Island, Washington

Job No:	Date:		Plate:
22007	Mar. 2022		9

22007 - Strand

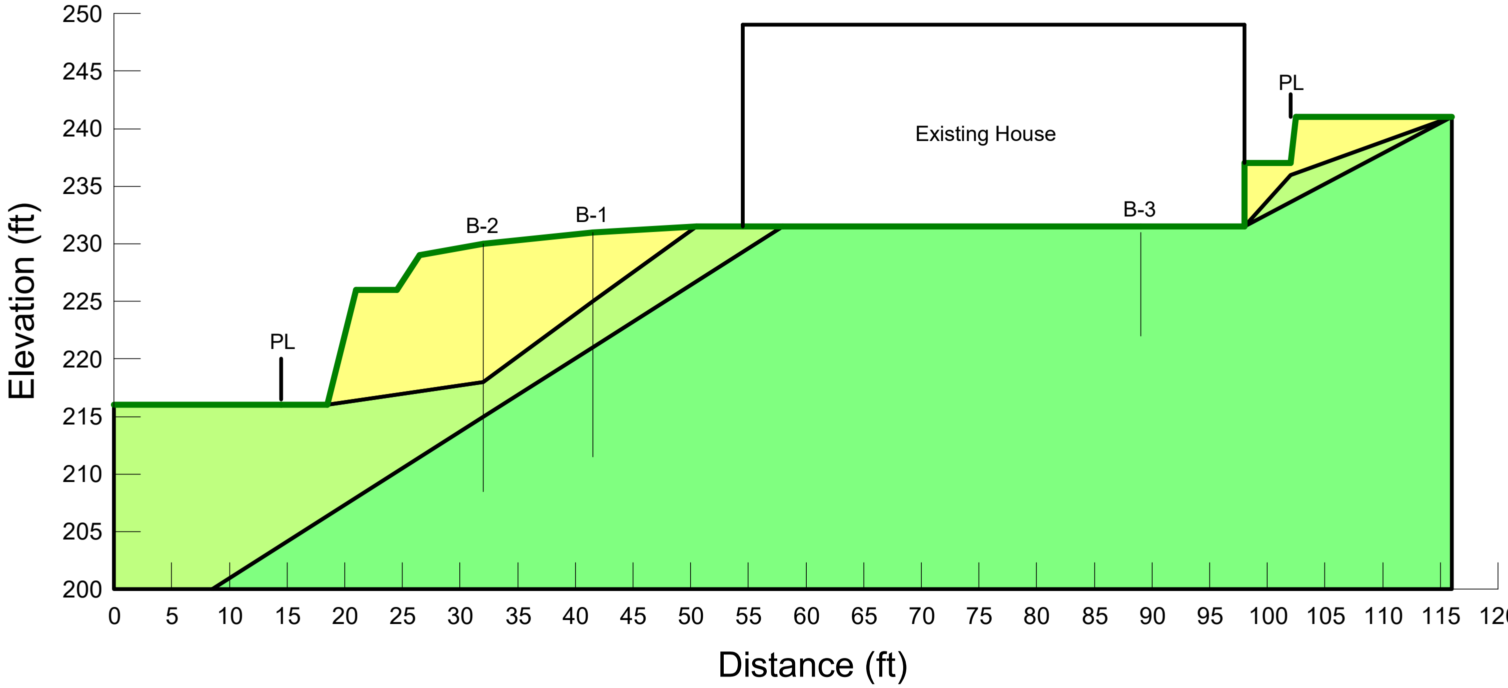
Cross Section A - A

Materials
- Loose FILL
- Medium-Dense Silty SAND
- Dense GLACIAL TILL

Name: Loose FILL
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Medium-Dense Silty SAND
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 34 °

Name: Dense GLACIAL TILL
Unit Weight: 140 pcf
Cohesion': 100 psf
Phi': 40 °



22007 - Strand

Static

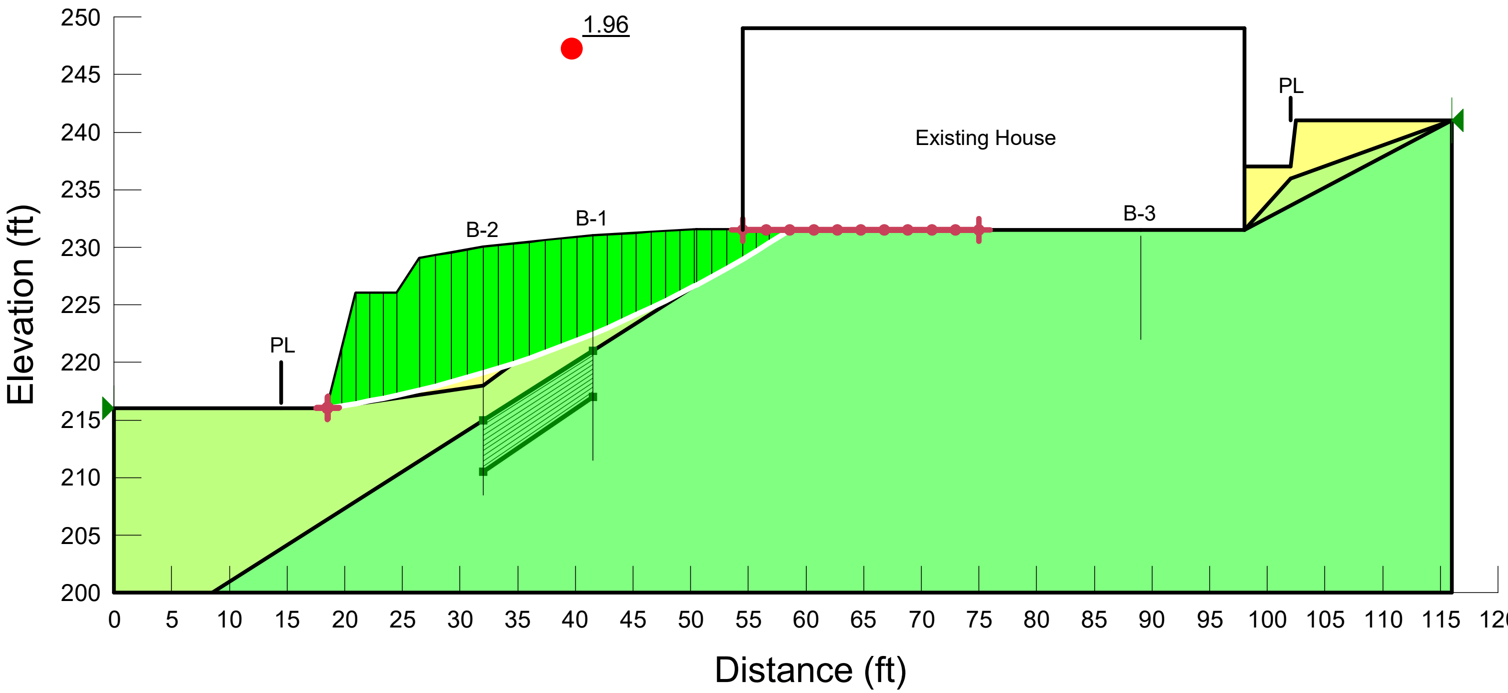
Materials

- Loose FILL
- Medium-Dense Silty SAND
- Dense GLACIAL TILL

Name: Loose FILL
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Medium-Dense Silty SAND
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 34 °

Name: Dense GLACIAL TILL
Unit Weight: 140 pcf
Cohesion': 100 psf
Phi': 40 °



Static

File Information

File Version: 8.15
Title: 22007 Slope Stability Analysis
Created By: Adam Moyer
Last Edited By: Adam Moyer
Revision Number: 19
Date: 2/21/2022
Time: 1:46:57 PM
Tool Version: 8.15.6.13446
File Name: 22007 Slope Stability Analysis - Strand.gsz
Directory: C:\Users\AdamM\Geotech Consultants\Shared Documents - Documents\2022 Jobs\22007 Strand (MRM)\
Last Solved Date: 2/21/2022
Last Solved Time: 1:47:00 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Static

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: (none)

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °

Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Loose FILL

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

Medium-Dense Silty SAND

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °

Dense GLACIAL TILL

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 100 psf
Phi': 40 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (18.5, 216) ft
Left-Zone Right Coordinate: (18.52409, 216.09635) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (54.5, 231.5) ft
Right-Zone Right Coordinate: (75, 231.5) ft
Right-Zone Increment: 10

Radius Increments: 10

Slip Surface Limits

Left Coordinate: (0, 216) ft

Right Coordinate: (116, 241) ft

Points

	X (ft)	Y (ft)
Point 1	0	216
Point 2	14.5	216
Point 3	18.5	216
Point 4	21	226
Point 5	24.5	226
Point 6	26.5	229
Point 7	32	230
Point 8	41.5	231
Point 9	54.5	231.5
Point 10	89	231.5
Point 11	98	231.5
Point 12	98	237
Point 13	102	237
Point 14	102.5	241
Point 15	116	241
Point 16	0	200
Point 17	116	200
Point 18	41.5	225
Point 19	41.5	221
Point 20	41.5	211.5
Point 21	32	218
Point 22	32	215
Point 23	32	208.5
Point 24	89	228
Point 25	89	222
Point 26	50.5	231.5
Point 27	8.5	200
Point 28	58	231.5
Point 29	102	236

Regions

	Material	Points	Area (ft²)
Region 1	Loose FILL	3,4,5,6,7,8,26,18,21	243.75
Region 2	Medium-Dense Silty SAND	1,16,27,22,19,28,9,26,18,21,3,2	439.88
Region 3	Dense GLACIAL TILL	27,22,19,28,10,11,15,17	2,692.9
Region 4	Loose FILL	11,12,13,14,15,29	47

Region 5	Medium-Dense Silty SAND	11,29,15	21.5

Current Slip Surface

Slip Surface: 24
F of S: 1.96
Volume: 299.85379 ft³
Weight: 36,328.752 lbs
Resisting Moment: 2,337,459.4 lbs-ft
Activating Moment: 1,193,750.5 lbs-ft
Resisting Force: 21,342.102 lbs
Activating Force: 10,899.49 lbs
F of S Rank (Analysis): 1 of 1,331 slip surfaces
F of S Rank (Query): 1 of 1,331 slip surfaces
Exit: (18.5, 216) ft
Entry: (58.6, 231.5) ft
Radius: 102.6123 ft
Center: (2.3753023, 317.33744) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	19.125	216.10341	0	275.4314	159.02039	0
Slice 2	20.375	216.31818	0	826.53313	477.19913	0
Slice 3	21.583333	216.54071	0	1,090.2522	629.45742	0
Slice 4	22.75	216.77005	0	1,065.331	615.06911	0
Slice 5	23.916667	217.01348	0	1,037.2777	598.87254	0
Slice 6	25.5	217.37006	0	1,164.5122	672.33146	0
Slice 7	27.1875	217.77271	0	1,296.1973	748.35986	0
Slice 8	28.5625	218.12551	0	1,276.3126	736.87941	0
Slice 9	29.9375	218.49869	0	1,252.3514	723.0454	0
Slice 10	31.3125	218.89249	0	1,224.7447	707.10667	0
Slice 11	32.6504	219.29542	0	1,189.4182	686.71092	0
Slice 12	33.951199	219.70661	0	1,147.1327	662.29737	0
Slice 13	35.291439	220.15061	0	1,103.87	744.56968	0
Slice 14	36.671119	220.62889	0	1,057.7084	713.43329	0
Slice 15	38.050799	221.12933	0	1,009.7027	681.0531	0
Slice 16	39.43048	221.65228	0	960.27525	647.71384	0
Slice 17	40.81016	222.19812	0	909.77919	613.65381	0
Slice 18	42.131406	222.74217	0	857.46396	578.36674	0
Slice						

19	43.394218	223.2829	0	803.57102	542.01549	0
Slice 20	44.65703	223.84381	0	749.33631	505.43373	0
Slice 21	45.919842	224.42528	0	694.75797	468.62017	0
Slice 22	47.182654	225.02768	0	639.76934	431.52987	0
Slice 23	48.445466	225.65144	0	584.24149	394.07586	0
Slice 24	49.708278	226.29698	0	527.98643	356.13134	0
Slice 25	50.419842	226.66773	0	473.00619	396.89932	100
Slice 26	51.166667	227.07055	0	431.44994	362.02949	100
Slice 27	52.5	227.80413	0	355.43915	298.24886	100
Slice 28	53.833333	228.5638	0	277.54412	232.88717	100
Slice 29	55.083333	229.29947	0	202.59002	169.99321	100
Slice 30	56.25	230.00858	0	130.48333	109.48851	100
Slice 31	57.416667	230.73921	0	56.091374	47.066251	100
Slice 32	58.3	231.30499	0	-3.909711	-3.2806371	100

22007 - Strand

Seismic

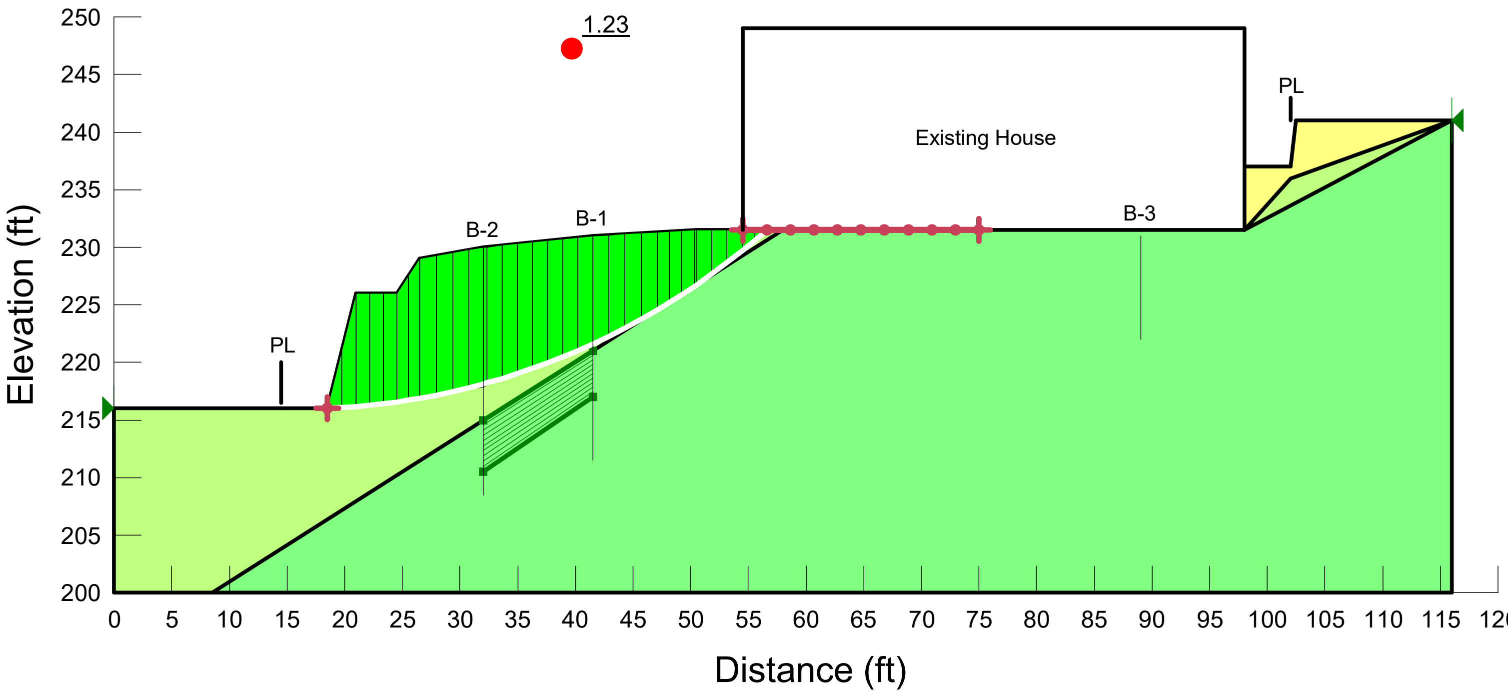
Materials

- Loose FILL
- Medium-Dense Silty SAND
- Dense GLACIAL TILL

Name: Loose FILL
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Medium-Dense Silty SAND
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 34 °

Name: Dense GLACIAL TILL
Unit Weight: 140 pcf
Cohesion': 100 psf
Phi': 40 °



Seismic

File Information

- File Version: 8.15
- Title: 22007 Slope Stability Analysis
- Created By: Adam Moyer
- Last Edited By: Adam Moyer
- Revision Number: 19
- Date: 2/21/2022
- Time: 1:46:57 PM
- Tool Version: 8.15.6.13446
- File Name: 22007 Slope Stability Analysis - Strand.gsz
- Directory: C:\Users\AdamM\Geotech Consultants\Shared Documents - Documents\2022 Jobs\22007 Strand (MRM)\
- Last Solved Date: 2/21/2022
- Last Solved Time: 1:47:00 PM

Project Settings

- Length(L) Units: Feet
- Time(t) Units: Seconds
- Force(F) Units: Pounds
- Pressure(p) Units: psf
- Strength Units: psf
- Unit Weight of Water: 62.4 pcf
- View: 2D
- Element Thickness: 1

Analysis Settings

Seismic

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: (none)
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °

Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Loose FILL

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

Medium-Dense Silty SAND

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °

Dense GLACIAL TILL

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 100 psf
Phi': 40 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Point
Left Coordinate: (18.5, 216) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (54.53757, 231.5) ft
Right-Zone Right Coordinate: (75, 231.5) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (0, 216) ft
Right Coordinate: (116, 241) ft

Seismic Coefficients

Horz Seismic Coef.: 0.222

Points

	X (ft)	Y (ft)
Point 1	0	216
Point 2	14.5	216
Point 3	18.5	216
Point 4	21	226
Point 5	24.5	226
Point 6	26.5	229
Point 7	32	230
Point 8	41.5	231
Point 9	54.5	231.5
Point 10	89	231.5
Point 11	98	231.5
Point 12	98	237
Point 13	102	237
Point 14	102.5	241
Point 15	116	241
Point 16	0	200
Point 17	116	200
Point 18	41.5	225
Point 19	41.5	221
Point 20	41.5	211.5
Point 21	32	218
Point 22	32	215
Point 23	32	208.5
Point 24	89	228
Point 25	89	222
Point 26	50.5	231.5
Point 27	8.5	200
Point 28	58	231.5
Point 29	102	236

Regions

	Material	Points	Area (ft^2)
Region 1	Loose FILL	3,4,5,6,7,8,26,18,21	243.75

Region 2	Medium-Dense Silty SAND	1,16,27,22,19,28,9,26,18,21,3,2	439.88
Region 3	Dense GLACIAL TILL	27,22,19,28,10,11,15,17	2,692.9
Region 4	Loose FILL	11,12,13,14,15,29	47
Region 5	Medium-Dense Silty SAND	11,29,15	21.5

Current Slip Surface

Slip Surface: 12
F of S: 1.23
Volume: 316.23566 ft³
Weight: 38,312.206 lbs
Resisting Moment: 1,460,811.4 lbs-ft
Activating Moment: 1,185,378.3 lbs-ft
Resisting Force: 22,434.365 lbs
Activating Force: 18,200.037 lbs
F of S Rank (Analysis): 1 of 121 slip surfaces
F of S Rank (Query): 1 of 121 slip surfaces
Exit: (18.5, 216) ft
Entry: (56.583813, 231.5) ft
Radius: 61.562432 ft
Center: (15.66695, 277.49721) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	19.125	216.03516	0	297.44707	200.63058	0
Slice 2	20.375	216.11827	0	920.0776	620.60018	0
Slice 3	21.583333	216.22253	0	1,265.6401	853.68504	0
Slice 4	22.75	216.34642	0	1,303.3711	879.13487	0
Slice 5	23.916667	216.49288	0	1,328.3884	896.00931	0
Slice 6	25	216.64845	0	1,431.1496	965.32257	0
Slice 7	26	216.81028	0	1,611.5313	1,086.9916	0
Slice 8	27.214275	217.03182	0	1,689.6469	1,139.6812	0
Slice 9	28.642826	217.32225	0	1,652.1352	1,114.3792	0
Slice 10	30.071376	217.64819	0	1,578.6195	1,064.7923	0
Slice 11	31.392826	217.98053	0	1,370.3014	791.14387	0
Slice 12	32.153589	218.18365	0	1,306.8878	754.53203	0
Slice 13	32.963808	218.41859	0	1,337.4386	902.11376	0
Slice 14	34.277069	218.81909	0	1,214.6832	819.31415	0
Slice 15	35.590329	219.25195	0	1,093.1573	737.34389	0
Slice 16	36.903589	219.7179	0	978.40141	659.94008	0
Slice	38.216849	220.21775	0	874.04223	589.54892	0

17						
Slice 18	39.53011	220.75238	0	781.91321	527.40712	0
Slice 19	40.84337	221.32281	0	702.39132	473.76893	0
Slice 20	42.201864	221.9524	0	629.99919	424.93982	0
Slice 21	43.605592	222.64518	0	564.58096	380.81466	0
Slice 22	45.00932	223.38325	0	509.06649	343.36968	0
Slice 23	46.413047	224.16847	0	460.90006	310.88102	0
Slice 24	47.644227	224.8949	0	443.96458	372.53052	100
Slice 25	48.70286	225.55332	0	391.57545	328.57082	100
Slice 26	49.761492	226.24205	0	339.84478	285.16363	100
Slice 27	50.395404	226.66561	0	315.01226	212.47846	0
Slice 28	51.166667	227.20768	0	285.59675	192.63744	0
Slice 29	52.5	228.17615	0	230.61702	155.55314	0
Slice 30	53.833333	229.20085	0	167.93785	113.27551	0
Slice 31	55.020953	230.16079	0	103.26115	69.650524	0
Slice 32	56.06286	231.04695	0	36.563357	24.662296	0