GEOTECH
CONSULTANTS, INC.

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

March 23, 2021

JN 21061

Daniel and Susan Steinborn
2011 – 19th Avenue
Seattle, Washington 98112
via email: disteinborn@gmail.com

Subject: **Transmittal Letter – Geotechnical Engineering Study and Critical Area Study**
Proposed Steinborn Residence
Vacant Lot East of 8431 S.E. 47th Place
Parcel #3317500040
Mercer Island, Washington

Greetings,

Attached to this transmittal letter is our geotechnical engineering report for the proposed new residence to be constructed on the subject lot 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 and design considerations for foundations, retaining walls, subsurface drainage, slope stability, and temporary excavations. This work was authorized by your acceptance of our proposal, P-10808.

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.

Marc R. McGinnis, P.E.
Principal

cc: **Mercer Builders** – Thom Schultz
via email: thom.schultz@mercerbuilders.com

MRM:kg

GEOTECHNICAL ENGINEERING STUDY
Proposed Steinborn Residence
Vacant Lot East of 8431 S.E. 47th Place
Parcel #3317500040
Mercer Island, Washington

This report presents the findings and recommendations of our geotechnical engineering study for the site of the proposed new Steinborn residence in Mercer Island.

We were provided with a Topographic Survey prepared by Terrance, as well as conceptual plans for the proposed development prepared by Studio Ectypos. Based on this information, we expect that a relatively modest home would be constructed in the central portion of the lot. The lower floor of the house would be cut into the sloping ground. The garage is to be accessed from a driveway following the alignment of the existing access road that extends along the angled western property line.

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 on Mercer Island. The irregular-shaped property is located on the north side of Southeast 47th Place. The lot itself is vacant, but is surrounded on all sides by developed single-family properties. The majority of the site is covered with ivy, blackberry vines, and other low brush.

It is apparent that the site was graded in the past, likely for potential development with a residence, that never occurred. An access road following the proposed driveway alignment extends up the angled western side of the lot from Southeast 47th Place. There are short, oversteepened cuts along the upslope side of this road. The access road terminates in the center of the property, where a relatively level bench was created by excavation into the sloping ground on the northeastern portion of the lot. Along the southern and southeastern sides of the lot are short, oversteepened slopes that have resulted from filling to create the central bench area, and from excavation for Southeast 47th Place and the shallow ditch located alongside this street. Off the southeastern corner of the property are short oversteepened areas that are the result of excavation for landscape elements on the adjoining lot (#8450).

We saw no indications of slope instability on the site or the adjacent lots.

The Mercer Island GIS indicates that the site is mapped as a Potential Landslide Hazard, Seismic Hazard, and Erosion Hazard. Also, a Steep Slope is mapped in the southeastern portion of the lot. Based on our observations, the steeper-than-40-percent slopes on, or close to, the site are: 1) generally less than 10 feet in height, and/or 2) manmade from previous grading associated with development of the neighboring lot or the street.

The *Mercer Island Landslide Hazard Assessment* shows mapped potential landslide scarps on, and near, the site. These were obviously based solely on aerial topography, and were not field verified. The mapped potential scarps are simply the oversteepened cut slope areas discussed above, and are not the result of slope movement.

SUBSURFACE

The subsurface conditions on the subject lot were explored by drilling three test borings 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 borings were drilled on March 4, 2021 using a track-mounted, hollow-stem auger drill. Samples were taken at approximate 2.5 and 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.

Soil Conditions

Test Borings 1 and 2 were drilled along the upslope side of the central bench that has resulted from the previous site grading. Both of these borings encountered a thin layer of loose, weathered, gravelly, silty sand immediately below the ground surface. This soil was underlain at a depth of less than 5 feet by dense to very dense, gravelly, silty sand. The dense to very dense soil has been glacially compressed, and is referred to as glacial till. The glacial till is cemented, and it was not possible to auger more than 15 to 20 feet into it. As is typical, there are thin lenses of cleaner sand within the glacial till.

Boring 3 was conducted along the downslope side of the central bench and found approximately 5 feet of fill overlying the original topsoil and a layer of loose, weathered, gravelly, silty sand. Glacial till was also encountered in this boring.

There were no indications of disturbed native soils or landslide deposits encountered in the borings.

Groundwater Conditions

Our explorations were conducted following several months of rainy weather. Perched groundwater seepage on top of the impervious glacial till was encountered in the borings. Additionally, potential trapped seepage was observed in the cleaner sand lenses within the glacial till.

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 logs are interpretive descriptions based on the conditions observed during drilling.

CRITICAL AREA STUDY (MICC 19.07)

Seismic Hazard and Potential Landslide Hazard Areas: The entire site is located within a mapped Seismic Hazard Area and a Potential Landslide Hazard area. This is noted on the attached Site Exploration Plan.

Both geologic hazard areas also cover much of the general vicinity. The core of the subject site consists of dense, glacially compressed, native soil that has a low potential for deep-seated landslides. However, this competent soil is overlain by looser fill and medium-dense native soils that could experience shallow slope movement, particularly during a large earthquake. All structures will be supported on the glacially-compressed soils, protecting them in the event of any future shallow soil movement. The recommendations presented in our report are intended to stabilize the new development in the event of foreseeable slope movement, thereby mitigating the Potential Landslide Hazard risk. These recommendations will also prevent the planned development from adversely impacting the stability of the neighboring properties. No buffers are necessary to mitigate the mapped Potential Landslide Hazard.

The foundations for the new addition will be supported on dense, non-liquefiable soils, which will mitigate the Seismic Hazard.

Steep Slope Hazard Areas: Based on the provided site plan of the subject site, and our site observations, the steeper-than-40-percent slopes on, and near, the site are less than 10 feet in height and/or have been created by previous grading.

It is our opinion that no buffers or setbacks are needed from the Steep Slope areas on, or adjoining, the site, 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 Steep Slopes, and to protect the planned development from foreseeable future soil movement on the slopes. The oversteepened slopes along the west, north, and east sides of the development areas will be regraded or retained to create permanent slopes that are stabilized and inclined at 40 percent, or less.

Erosion Hazard Area: The site also meets the City of Mercer Island's criteria for an Erosion Hazard Area. This has also been indicated on the attached Site Exploration Plan.

Excavation and construction of the planned residence can be accomplished without adverse erosion impacts to the site and surrounding properties by exercising care and being proactive with the maintenance and potential upgrading of the erosion control system through the entire construction process. Proper erosion control implementation will be important to prevent adverse impacts to the site and neighboring properties, particularly if grading and construction occurs during the wet season. 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. Silty water cannot be discharged off the site, so a temporary holding tank should be planned for wet weather earthwork. 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 north of the silt fence be 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. Silty water accumulating in the excavation must not be allowed to flow off the site. In wet conditions, this can require the use of temporary holding tanks (aka Baker tanks). 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: The attached Site Exploration Plan (Plate 2) denotes the extents of the critical areas that cover the site. Under MICC 19.07.160(C), the code-prescriptive buffer of 25 feet is indicated from all sides of a shallow landslide-hazard area. As noted above, the entire site lies within a mapped Potential Landslide Hazard Area, and the prescriptive buffer would extend far beyond the boundaries of the property and the planned development area.

We recognize that the planned development will occur within the designated critical areas and their applicable prescriptive buffers. The recommendations presented in this geotechnical report are intended to allow the project to be constructed in the proposed configuration without the need for a buffer from the top of the steep slope. Following the recommendations of this report, the planned development will not adversely impact the stability of the neighboring properties, or result in a need for increased critical area buffers on those adjacent properties. The geotechnical recommendations associated with foundations, shoring, and erosion control will mitigate any potential hazards to geologic critical areas on the site.

Summary of Slope Stability Analysis: We utilized the Slope/W computer program to assess the stability of the dense glacial till for the slope beneath the proposed house. The results of the slope stability analyses for both static and seismic conditions are attached to the end of this report as Appendix A. According to the International Building Code (IBC) and ASCE 7, the Design Earthquake for seismic analyses is equal to two-thirds of the Maximum Considered Earthquake (MCE). As noted later in the report, the peak ground acceleration for the MCE is 0.680g. For the seismic slope analyses, we utilized a peak ground acceleration of two-thirds of this value, or 0.453g for the Design Earthquake. The seismic coefficient used in the analyses was one-half of this value, or 0.226.

The slope stability analyses confirm that the safety factor against a failure within the glacial till beneath the planned house is in excess of 1.2 and 1.5 for seismic and static conditions, respectively.

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:

> *The design and construction practices recommended in this report for the alteration will render the development as safe as if it were not located in a geologically hazardous area and will not cause adverse geotechnical impacts to the 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 test borings conducted for this study encountered fill and loose native soil overlying dense to very dense glacial till. The glacial till is suitable to support new foundations for the planned residence. All footings will have to be excavated to bear on these competent soils. The glacial till soils will be susceptible to disturbance and softening from foot traffic during the placement of forms and rebar. For this reason, all excavated bearing surfaces should be protected with several inches of clean crushed rock.

Temporary sloped excavations are possible. However, shoring in the form of soldier piles may be needed for at least the excavation of the house into the sloping ground on the east side of the property. Proper retention of the oversteepened slopes along the west, north, and east sides of the site will need to be provided by engineered walls. Permanent soldier pile walls could be used for this purpose. The use of soldier pile shoring for either temporary or permanent retention will decrease the volume of excavation needed for the project.

The excavated soil will generally be unusable as fill for the project and should be hauled off the site. In dry conditions, a small amount of soil could be used for the upper few feet of backfill of the retaining walls. However, in general, imported free-draining soil should be used to backfill foundation and retaining walls.

Due to the silty, fine-grained nature of the upper fill and native soils onsite, the impervious nature of the glacial till, the likely presence of basement living space in the proposed house, and the presence of sloped ground downgradient of the planned development, it is our professional opinion that onsite infiltration or dispersion of stormwater are infeasible for this project. All collected stormwater, even from paved surfaces, should be discharged to an approved stormwater system. Pervious pavements should not be used for this project.

The drainage and 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 buildup of excessive water vapor within the planned structure.

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 1.44g and 0.50g, 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 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 near-surface groundwater.

CONVENTIONAL FOUNDATIONS

The proposed structure can be supported on conventional continuous and spread footings bearing on undisturbed, glacial till soils or on structural fill (quarry spalls or railroad ballast rock) placed above these competent soils. All fill, topsoil, and loose, weathered soil must be removed beneath footings. As discussed above, due to the moisture sensitivity of the glacial till, the excavated bearing surfaces should be protected with a thin layer of clean crushed rock to prevent disturbance and softening during the placement of foundation forms and rebar.

We recommend that continuous and individual spread footings have minimum widths of 16 and 24 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.

An allowable bearing pressure of 4,000 pounds per square foot (psf) is appropriate for footings supported on competent native soil. 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-half-inch, with differential settlements on the order of one-quarter-inch in a distance of 25 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	0.45
Passive Earth Pressure	350 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 *	40 pcf (Level Backfill) 55 pcf (2.5H:1V Backfill)
Passive Earth Pressure	300 pcf
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 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. The site soils are fine-grained and have a high silt content. As a result, they are not free draining. We recommend that the native soils not be reused as retaining wall backfill.

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.

BUILDING FLOORS

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 discussed in the ***General*** section, a layer of gravel with perforated pipes should be installed below the basement to provide underslab drainage for any subsurface water that bypasses the perimeter footing drains. A typical detail for underslab drainage is attached as Plate 6.

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.

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. Based upon Washington Administrative Code (WAC) 296, Part N, the fill and loose soil at the subject site would generally be classified as Type B. Temporary cut slopes in these soils should be excavated at an inclination no steeper than 1:1 (Horizontal:Vertical), extending continuously between the top and the bottom of a cut. Temporary cuts extending into the glacial till soils (Type A soil) can be cut at a 0.75:1 (H:V) inclination. If zones of seepage are encountered, and result in soil sloughing, it may be necessary to place a layer of clean crushed rock against the cut face.

The above-recommended temporary slope inclination is 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 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 onsite soil should be inclined no steeper than 2.5:1 (H:V). 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 SHORING

Soldier pile systems have proven to be an efficient and economical method for providing excavation shoring. 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. ((We anticipate that the holes could be drilled without casing, but the 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.

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.

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.

Footing drains placed inside 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).

Soldier Pile Wall Design

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). Traffic surcharges can typically be accounted for by increasing the effective height of the shoring wall by 2 feet. Slopes above the shoring walls will exert additional surcharge pressures. These surcharge pressures will vary, depending on the configuration of the cut slope and shoring wall. We can provide recommendations regarding slope surcharge pressures when the preliminary shoring design is completed.

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 ultimate passive soil pressure equal to that pressure exerted by a fluid with a density of 400 pcf. 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. The minimum embedment below the floor of the excavation for cantilever soldier piles should be equal to the height of the "stick-up."

If permanent soldier pile walls are used, the active and seismic surcharge design pressures given above in ***Foundation and Retaining Walls*** are appropriate.

DRAINAGE CONSIDERATIONS

Footing drains 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. Drains should also be placed at the base of all earth-retaining walls. These drains should be surrounded by at least 6 inches of 1-inch-minus, washed rock that is encircled with 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 bottom of a slab floor or the level of a crawl space. The discharge pipe for subsurface drains should be sloped for flow to the outlet point. Roof and surface water drains must not discharge into the foundation drain system. A typical footing drain detail is attached to this report as Plate 7. For the best long-term performance, perforated PVC pipe is recommended for all subsurface drains. Clean-outs should be provided for potential future flushing or cleaning of footing drains.

Recommendations for underslab drainage under the basement slab are given above.

As a minimum, a vapor retarder, as defined in the ***Building Floors*** 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.

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 the residence 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 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).

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 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. 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.

This report has been prepared for the exclusive use of Daniel and Susan Steinborn, and their 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	Typical Underslab Drainage
Plate 7	Typical Footing Drain Detail
Appendix A	Slope Stability Analyses

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.

03/23/2021

Marc R. McGinnis, P.E.
Principal

MRM;kg

NORTH

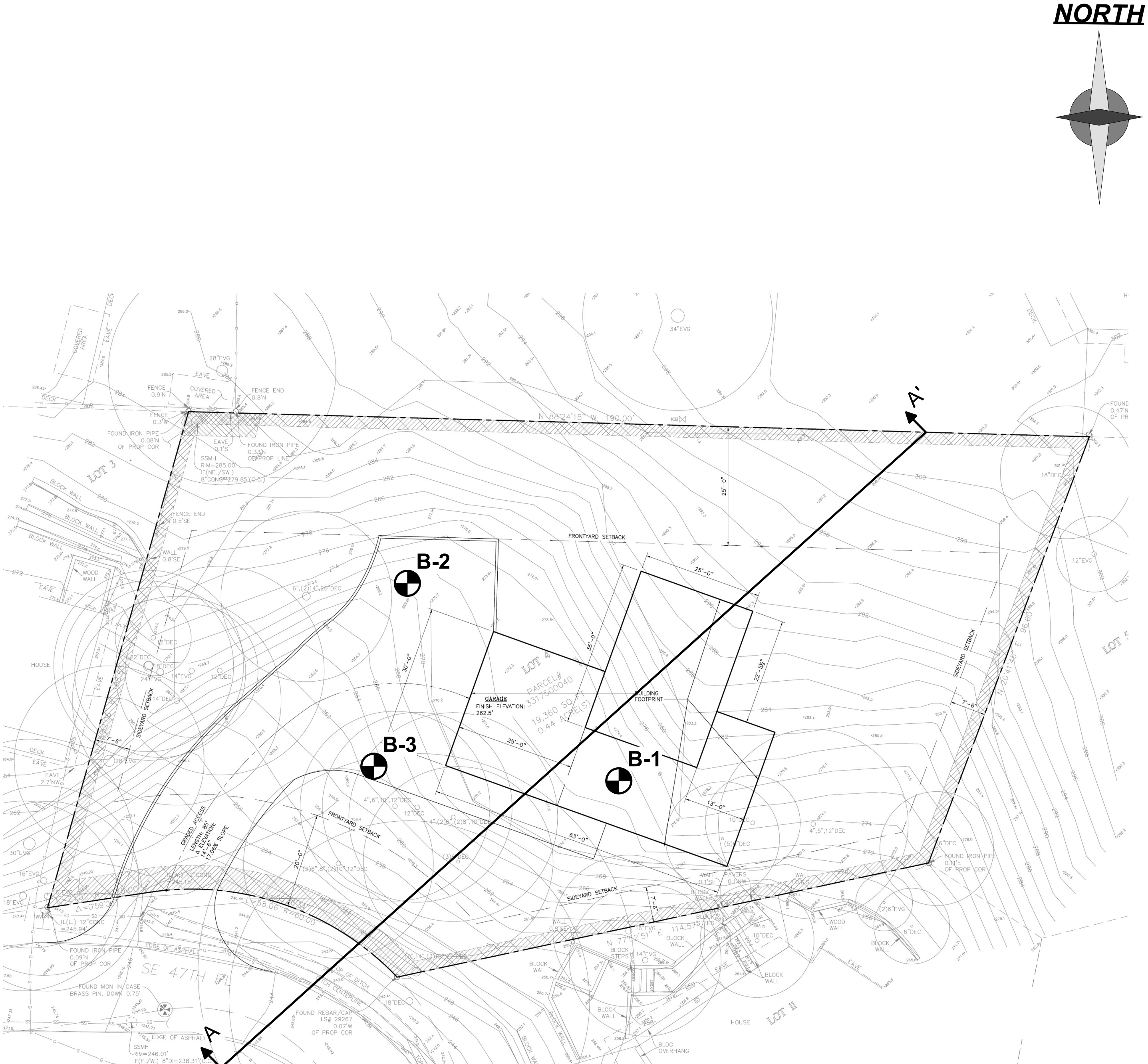
(Source: Microsoft MapPoint, 2013)

GEOTECH
CONSULTANTS, INC.

VICINITY MAP

84XX Southeast 47th Street
Mercer Island, Washington

Job No:	Date:		Plate:
21061	Mar. 2021		1



* The City of Mercer Island GIS tool maps the subject site as a Seismic Hazard Area, Potential Landslide Hazard Area, and an Erosion Hazard Area in its entirety. The prescriptive buffers for shallow Potential Landslide Hazard Areas under MICC 19.07 extend beyond the property boundaries.

Legend:

- Test Boring Location
- Cross Section A-A'

GEOTECH
CONSULTANTS, INC.

SITE EXPLORATION PLAN

84XX Southeast 47th Street
Mercer Island, Washington

Job No:	Date:		Plate:
21061	Mar. 2021	No Scale	2

BORING 1

Depth (ft.) | Moisture | Water Table | Blows per Foot | Sample | USCS | Description — Elevation ±273 feet

Depth (ft.)	Water Table	Blows per Foot	Sample	USCS	Description
					Rust-brown gravelly silty SAND, fine- to medium-grained, moist, loose
					-becomes gray, cemented, very dense **(Glacial Till)**
		87	1	SM	
5		50/5"	2		
					Gray gravelly SAND with silt / slightly silty gravelly SAND, fine- to medium-grained, very moist, very dense
		59	3	SP/SM	
10	▽				-becomes very moist to wet
		83/11"	4		Gray gravelly silty SAND, fine-grained, cemented, moist, very dense **(Glacial Till)**
				SM	
15					-becomes blue-gray
		55	5		
20					

*** Test boring was terminated at 16.0 feet on March 4, 2021.**
*** Very slight perched was encountered from 10 to 10.5 feet during drilling.**

GEOTECH
CONSULTANTS, INC.

TEST BORING LOG

84XX Southeast 47th Street
Mercer Island, Washington

Job No:	Date:	Logged by:	Plate:
21061	Mar. 2021	ASM	3

BORING 2

Elevation ±271 feet

Depth (ft.)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
					SM	Brown silty SAND with gravel, fine-grained, very moist, loose
			16	1		-becomes medium-dense
5						-becomes gray-brown, cemented, moist, very dense **(Glacial Till)**
			90/11"	2		
			71	3		-becomes blue-gray
10			50/5"	4		
			50/6"	5		
15						
20						

*** Test boring was terminated at 14.0 feet on March 4, 2021.**
*** No groundwater was encountered during drilling.**

GEOTECH
CONSULTANTS, INC.

TEST BORING LOG

84XX Southeast 47th Street
Mercer Island, Washington

Job No:	Date:	Logged by:	Plate:
21061	Mar. 2021	ASM	4

BORING 3

Elevation ±264 feet

Depth (ft.)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
0–4.5			4	1	FILL	Dark-brown silty SAND with abundant organics, fine- to medium-grained, moist, loose **(FILL)**
4.5					SM	Brown silty SAND with gravel, fine-grained, wet, loose
5			5	2		-becomes gray-brown with rust mottling
7.5			23	3		-becomes moist, medium-dense
10			65	4		-becomes very moist, very dense, with occasional sand seams
15			67	5		-becomes blue-gray, moist
20			48	6		-with occasional thin silt seams

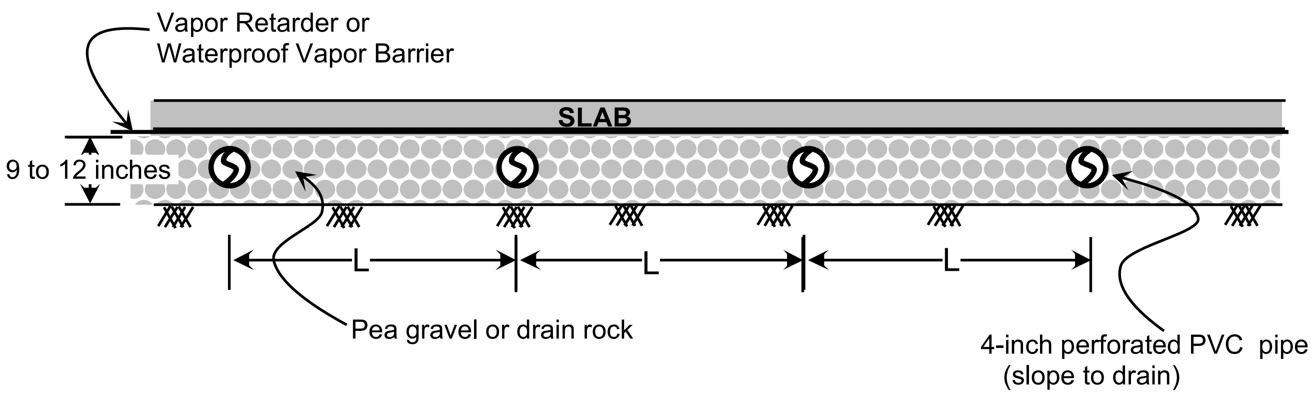
*** Test boring was terminated at 21.5 feet on March 4, 2021.**
*** Perched groundwater was encountered from 5 to 8 feet during drilling.**

GEOTECH
CONSULTANTS, INC.

TEST BORING LOG

84XX Southeast 47th Street
Mercer Island, Washington

Job No:	*Date:*	*Logged by:*	*Plate:*
21061	Mar. 2021	ASM	5



NOTES:

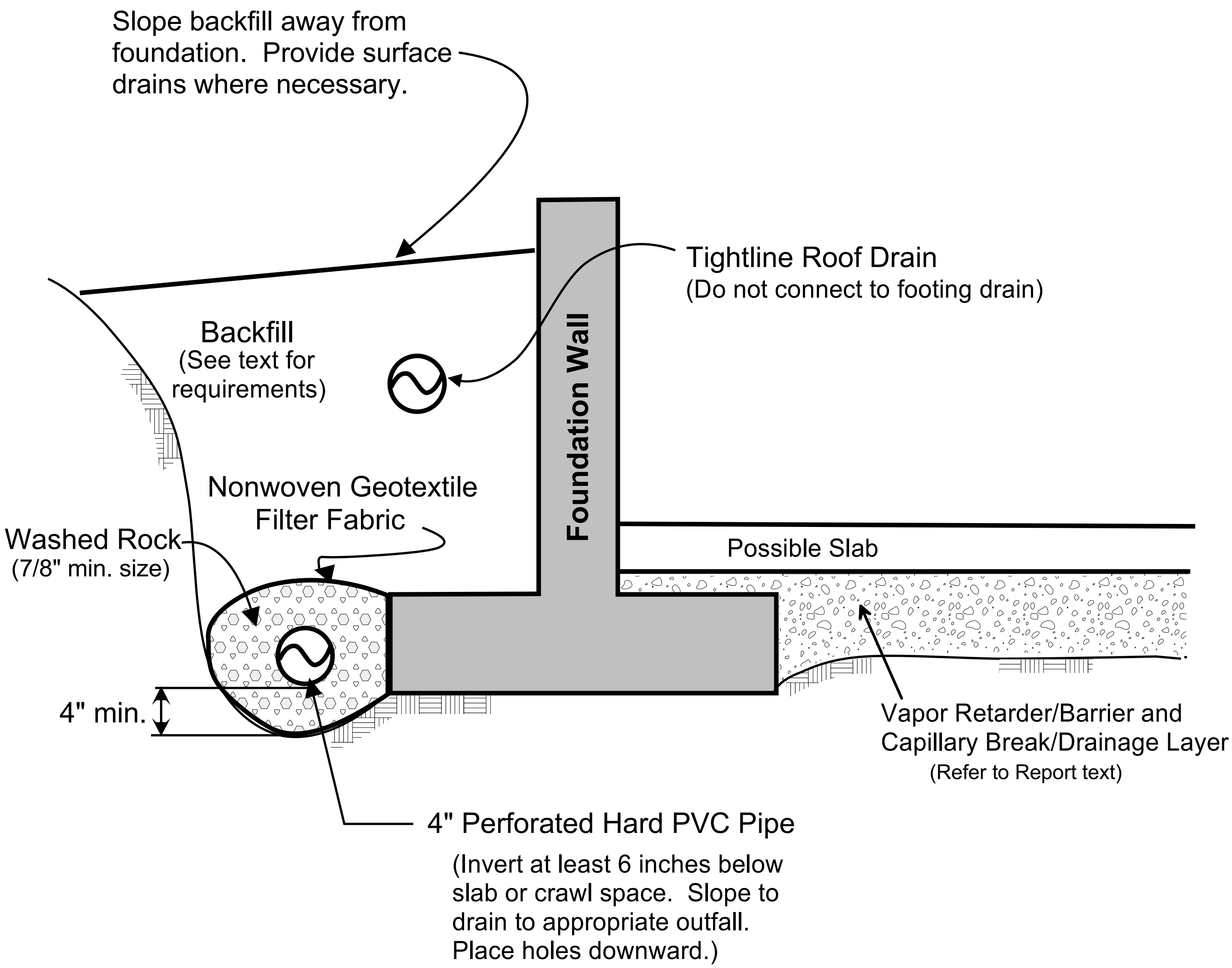
(1) Refer to the report text for additional drainage and waterproofing considerations.
(2) The typical maximum underslab drain separation (L) is 15 to 20 feet.
(3) No filter fabric is necessary beneath the pipes as long as a minimum thickness of 4 inches of rock is maintained beneath the pipes.
(4) The underslab drains and foundation drains should discharge to a suitable outfall.

GEOTECH CONSULTANTS, INC.

TYPICAL UNDERSLAB DRAINAGE

84XX Southeast 47th Street
Mercer Island, Washington

Job No:	Date:		Plate:
21061	Mar. 2021		6



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.

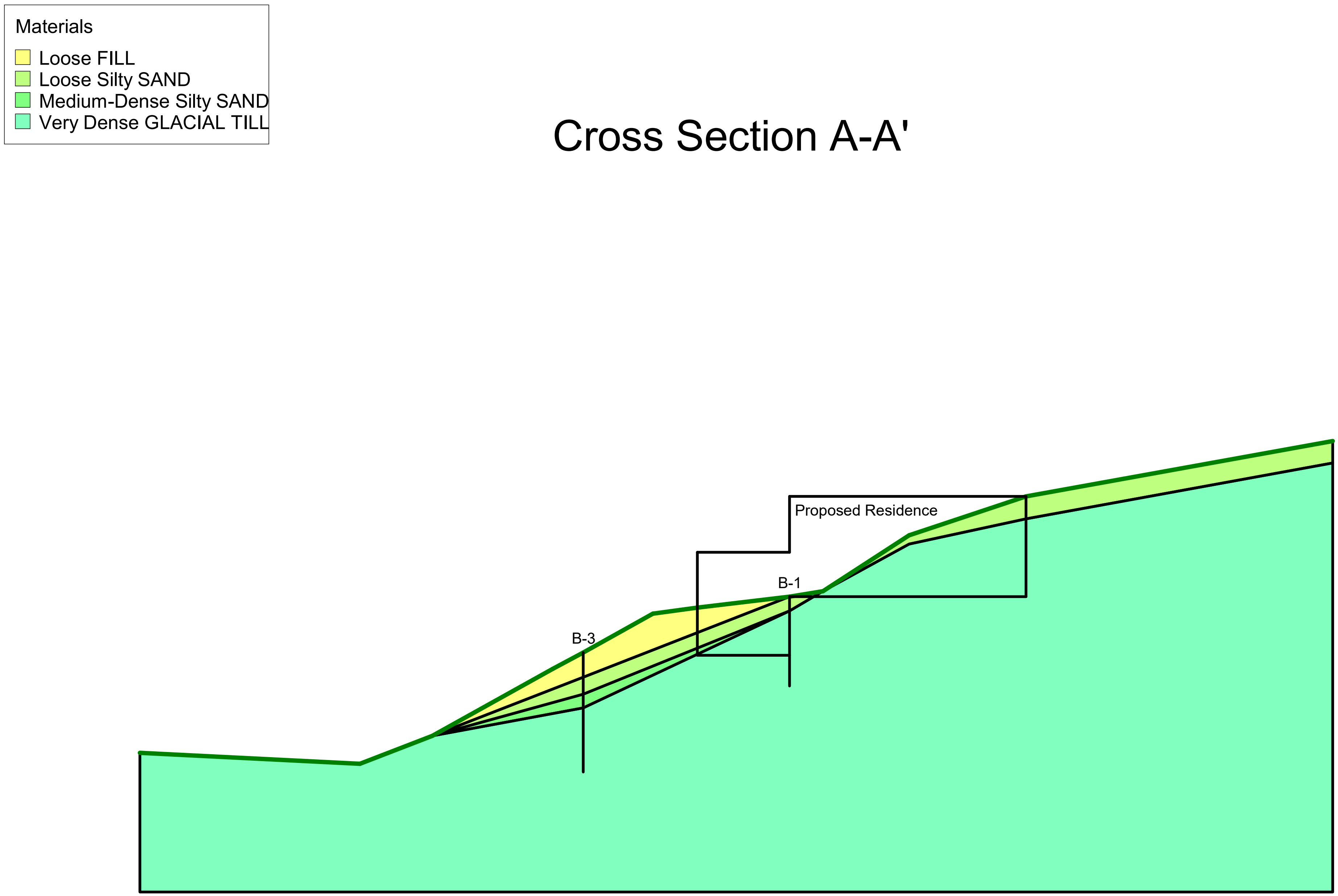
GEOTECH
CONSULTANTS, INC.

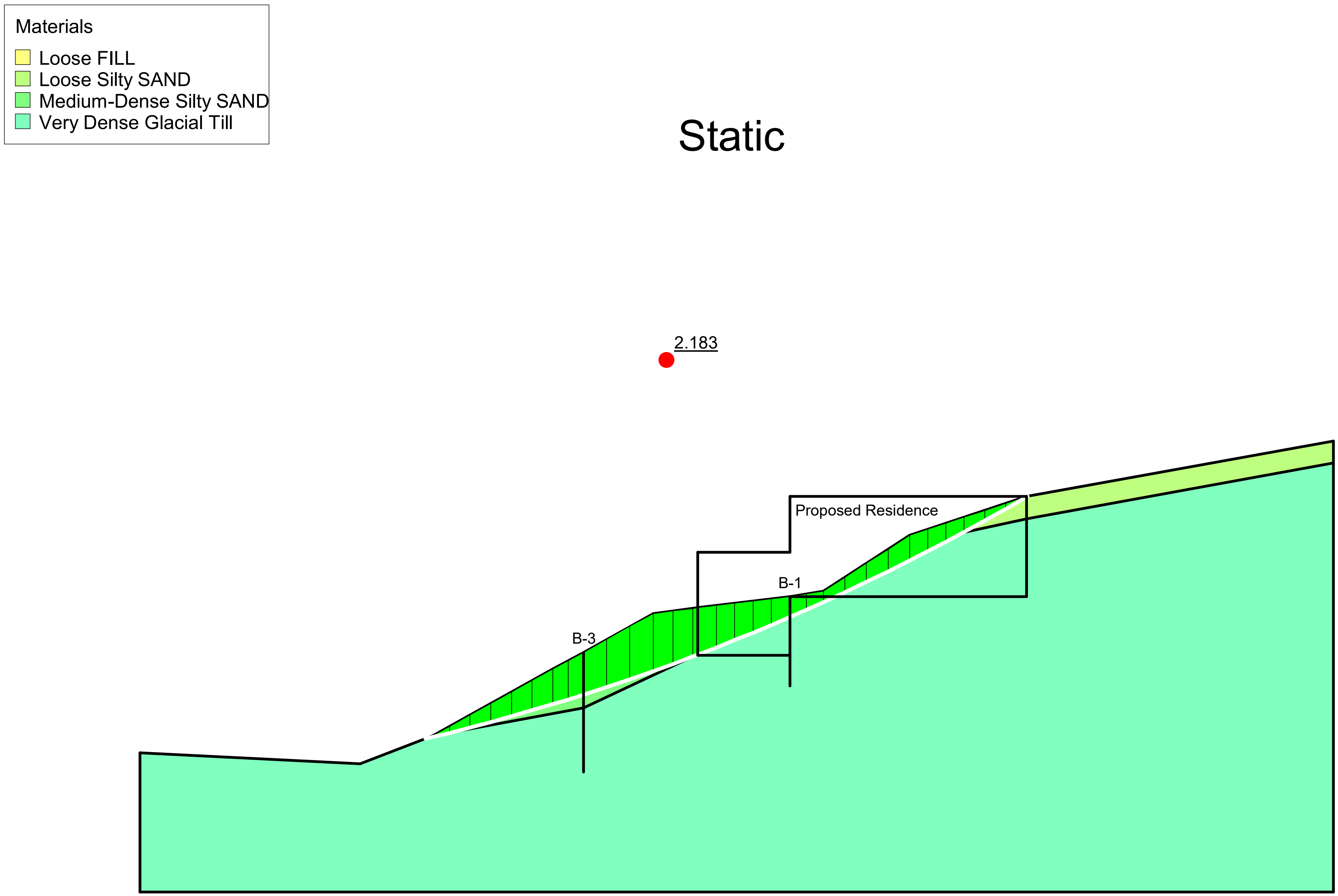
FOOTING DRAIN DETAIL

84XX Southeast 47th Street
Mercer Island, Washington

Job No:	Date:		Plate:
21061	Mar. 2021		7

Cross Section A-A'




Materials
Loose FILL
Loose Silty SAND
Medium-Dense Silty SAND
Very Dense Glacial Till
Static
2.183
Proposed Residence
B-1
B-3

Slope Stability - Static

File Information

- File Version: 8.15
- Title: 21061 Slope Stability Analysis
- Created By: Adam Moyer
- Last Edited By: Adam Moyer
- Revision Number: 7
- Date: 3/22/2021
- Time: 11:48:00 AM
- Tool Version: 8.15.6.13446
- File Name: 21061 Slope Stability Analysis - Steinborn.gsz
- Directory: C:\Users\AdamM\Geotech Consultants\Shared Documents - Documents\2021 Jobs\21061 Steinborn (MRM)\
- Last Solved Date: 3/22/2021
- Last Solved Time: 11:48:02 AM

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

Slope Stability - 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: 125 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

Loose Silty SAND

Model: Mohr-Coulomb
Unit Weight: 125 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 °

Very Dense Glacial Till

Model: Mohr-Coulomb
Unit Weight: 135 pcf
Cohesion': 100 psf
Phi': 40 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range

Left-Zone Left Coordinate: (39.5, 243) ft
Left-Zone Right Coordinate: (52.5, 248) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (159.11821, 291.02149) ft
Right-Zone Right Coordinate: (186, 295.90909) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (0, 245) ft
Right Coordinate: (214, 301) ft

Points

	X (ft)	Y (ft)
Point 1	0	245
Point 2	39.5	243
Point 3	52.5	248
Point 4	74	260
Point 5	79.5	263
Point 6	92	270
Point 7	100	271
Point 8	100	262.5
Point 9	113.5	272
Point 10	116.5	273
Point 11	120	273
Point 12	122.5	274
Point 13	138	284
Point 14	159	291
Point 15	214	301
Point 16	0	220
Point 17	214	220
Point 18	116.5	270.5
Point 19	116.5	257
Point 20	79.5	258.5
Point 21	79.5	255.5
Point 22	79.5	253
Point 23	79.5	241.5
Point 24	214	297
Point 25	159	287
Point 26	138	282.5

Regions

	Material	Points	Area (ft^2)

Region 1	Very Dense Glacial Till	24,17,16,1,2,3,22,18,12,26,25	10,184
Region 2	Medium-Dense Silty SAND	3,21,18,22	80
Region 3	Loose Silty SAND	3,20,10,12,18,21	149.75
Region 4	Loose FILL	10,7,6,5,4,3,20	212
Region 5	Loose Silty SAND	12,13,14,15,24,25,26	289.38

Current Slip Surface

Slip Surface: 1,090

F of S: 2.183

Volume: 517.82242 ft³

Weight: 65,490.075 lbs

Resisting Moment: 20,151,919 lbs-ft

Activating Moment: 9,232,871.1 lbs-ft

Resisting Force: 47,359.243 lbs

Activating Force: 21,698.591 lbs

F of S Rank (Analysis): 1 of 1,331 slip surfaces

F of S Rank (Query): 1 of 1,331 slip surfaces

Exit: (51.2, 247.5) ft

Entry: (159.11821, 291.02149) ft

Radius: 395.28869 ft

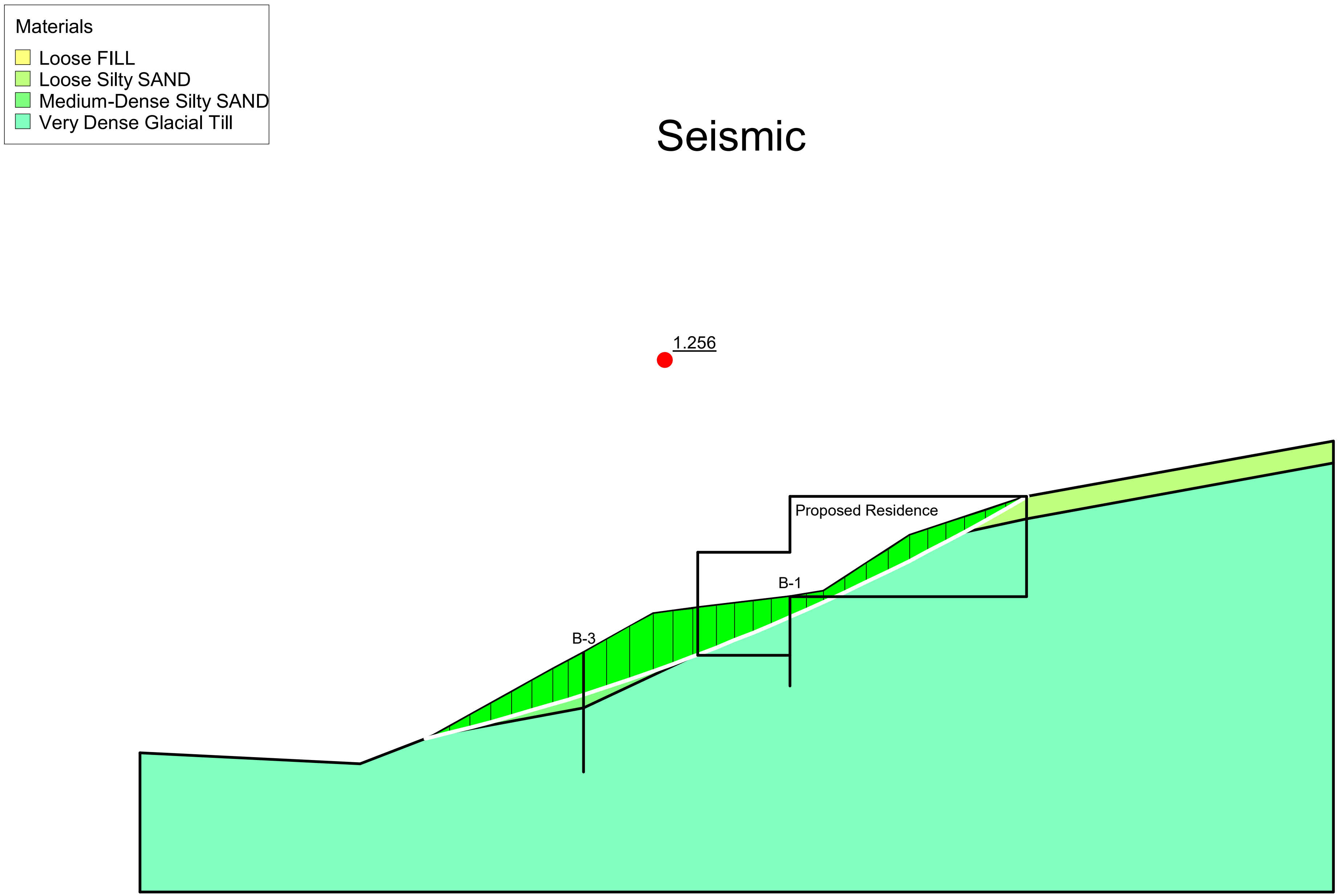
Center: (-41.073899, 631.86789) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	51.85	247.65721	0	2.5534862	2.1426293	100
Slice 2	53.98322	248.18188	0	70.256161	58.951919	100
Slice 3	57.319797	249.02567	0	199.03391	134.25007	0
Slice 4	61.026508	249.99753	0	327.29533	220.76349	0
Slice 5	64.73322	251.00794	0	450.02516	303.5458	0
Slice 6	68.439932	252.05722	0	566.40764	382.04678	0
Slice 7	72.146644	253.14568	0	675.79317	455.82825	0
Slice 8	75.375	254.12362	0	763.30275	514.85421	0
Slice 9	78.125	254.98238	0	830.78276	560.37004	0
Slice 10	81.583333	256.09728	0	912.6885	615.61617	0
Slice 11	85.75	257.48305	0	1,005.9577	678.52704	0
Slice 12	89.916667	258.92052	0	1,090.2192	735.36214	0
Slice 13	93.767697	260.29373	0	1,077.5268	726.80103	0
Slice 14	97.30309	261.59583	0	972.65422	656.06356	0
Slice 15	99.535393	262.43329	0	944.49689	792.52699	100
Slice 16	101.65	263.24897	0	879.94075	738.35796	100

Slice 17	104.95	264.54376	0	777.28841	652.22241	100
Slice 18	108.25	265.87288	0	672.02961	563.8998	100
Slice 19	111.55	267.23672	0	564.41212	473.598	100
Slice 20	114.85	268.63565	0	454.54916	381.41204	100
Slice 21	118	270.00333	0	356.08417	298.79009	100
Slice 22	121	271.33704	0	268.83423	225.5787	100
Slice 23	124.4375	272.9047	0	259.64895	217.87134	100
Slice 24	128.3125	274.71695	0	325.87257	273.43955	100
Slice 25	132.1875	276.5807	0	386.1506	324.01883	100
Slice 26	136.0625	278.49677	0	441.1539	370.17208	100
Slice 27	139.62227	280.3018	0	432.68908	363.06925	100
Slice 28	142.86681	281.98848	0	361.40557	303.25528	100
Slice 29	146.11135	283.71356	0	286.10913	240.07407	100
Slice 30	149.61135	285.61988	0	227.11921	131.12734	0
Slice 31	153.36681	287.71486	0	145.40512	83.949684	0
Slice 32	157.12227	289.86392	0	54.019693	31.188285	0
Slice 33	159.0591	290.98679	0	2.5899478	1.4953071	0

Seismic



Materials
Loose FILL
Loose Silty SAND
Medium-Dense Silty SAND
Very Dense Glacial Till
1.256
Proposed Residence
B-1
B-3

Slope Stability - Seismic

File Information

File Version: 8.15
Title: 21061 Slope Stability Analysis
Created By: Adam Moyer
Last Edited By: Adam Moyer
Revision Number: 7
Date: 3/22/2021
Time: 11:48:00 AM
Tool Version: 8.15.6.13446
File Name: 21061 Slope Stability Analysis - Steinborn.gsz
Directory: C:\Users\AdamM\Geotech Consultants\Shared Documents - Documents\2021 Jobs\21061 Steinborn (MRM)\
Last Solved Date: 3/22/2021
Last Solved Time: 11:48:03 AM

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

Slope Stability - 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: 125 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

Loose Silty SAND

Model: Mohr-Coulomb
Unit Weight: 125 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 °

Very Dense Glacial Till

Model: Mohr-Coulomb
Unit Weight: 135 pcf
Cohesion': 100 psf
Phi': 40 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range

Left-Zone Left Coordinate: (39.5, 243) ft
Left-Zone Right Coordinate: (52.47326, 247.98972) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (159.19993, 291.03635) ft
Right-Zone Right Coordinate: (185, 295.72727) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (0, 245) ft
Right Coordinate: (214, 301) ft

Seismic Coefficients

Horz Seismic Coef.: 0.226

Points

	X (ft)	Y (ft)
Point 1	0	245
Point 2	39.5	243
Point 3	52.5	248
Point 4	74	260
Point 5	79.5	263
Point 6	92	270
Point 7	100	271
Point 8	100	262.5
Point 9	113.5	272
Point 10	116.5	273
Point 11	120	273
Point 12	122.5	274
Point 13	138	284
Point 14	159	291
Point 15	214	301
Point 16	0	220
Point 17	214	220
Point 18	116.5	270.5
Point 19	116.5	257
Point 20	79.5	258.5
Point 21	79.5	255.5
Point 22	79.5	253
Point 23	79.5	241.5
Point 24	214	297
Point 25	159	287
Point 26	138	282.5

Regions

	Material	Points	Area (ft²)
Region 1	Very Dense Glacial Till	24,17,16,1,2,3,22,18,12,26,25	10,184
Region 2	Medium-Dense Silty SAND	3,21,18,22	80
Region 3	Loose Silty SAND	3,20,10,12,18,21	149.75
Region 4	Loose FILL	10,7,6,5,4,3,20	212
Region 5	Loose Silty SAND	12,13,14,15,24,25,26	289.38

Current Slip Surface

Slip Surface: 1,090
F of S: 1.256
Volume: 518.09401 ft³
Weight: 65,525.729 lbs
Resisting Moment: 18,489,774 lbs-ft
Activating Moment: 14,716,408 lbs-ft
Resisting Force: 43,285.198 lbs
Activating Force: 34,469.898 lbs
F of S Rank (Analysis): 1 of 1,331 slip surfaces
F of S Rank (Query): 1 of 1,331 slip surfaces
Exit: (51.175935, 247.49074) ft
Entry: (159.19993, 291.03635) ft
Radius: 397.17213 ft
Center: (-41.700442, 633.65092) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	51.837968	247.65117	0	-6.3850614	-5.3577026	100
Slice 2	53.993596	248.18239	0	49.748957	41.744331	100
Slice 3	57.338473	249.02988	0	187.31617	126.34636	0
Slice 4	61.041034	250.00236	0	311.08525	209.82965	0
Slice 5	64.743596	251.01313	0	428.90651	289.30109	0
Slice 6	68.446158	252.06251	0	541.318	365.1236	0
Slice 7	72.148719	253.15081	0	648.81844	437.63356	0
Slice 8	75.375	254.12889	0	737.21447	497.25744	0
Slice 9	78.125	254.98816	0	807.73093	544.82139	0
Slice 10	81.583333	256.10356	0	896.34656	604.59339	0
Slice 11	85.75	257.48972	0	1,002.1618	675.9667	0
Slice 12	89.916667	258.92734	0	1,103.7662	744.4997	0
Slice 13	93.784507	260.30667	0	1,108.6329	747.78236	0
Slice 14	97.35352	261.62126	0	1,015.3074	684.83347	0

Slice 15	99.569013	262.45228	0	759.47022	637.27118	100
Slice 16	101.65	263.25488	0	704.90973	591.48949	100
Slice 17	104.95	264.54904	0	617.10268	517.81063	100
Slice 18	108.25	265.87736	0	526.97642	442.18572	100
Slice 19	111.55	267.24021	0	434.09152	364.24604	100
Slice 20	114.85	268.63799	0	338.09536	283.69569	100
Slice 21	118	270.00441	0	251.46621	211.00521	100
Slice 22	121	271.33674	0	174.49493	146.41863	100
Slice 23	124.4375	272.90262	0	174.12212	146.1058	100
Slice 24	128.3125	274.71262	0	249.73645	209.55376	100
Slice 25	132.1875	276.57384	0	320.28728	268.75294	100
Slice 26	136.0625	278.48709	0	384.6065	322.72317	100
Slice 27	139.63242	280.29454	0	383.48717	321.78395	100
Slice 28	142.89725	281.98916	0	319.1201	267.77356	100
Slice 29	146.16209	283.72244	0	251.75573	211.24814	100
Slice 30	149.66209	285.62572	0	256.92664	148.33666	0
Slice 31	153.39725	287.70585	0	154.23635	89.0484	0
Slice 32	157.13242	289.83914	0	55.282267	31.917232	0
Slice 33	159.09996	290.97777	0	3.9875832	2.3022323	0