NELSON GEOTECHNICAL ASSOCIATES, INC.

17311-135th Ave. N.E. Suite A-500
Woodinville, WA 98072
(425) 486-1669
www.nelsongeotech.com

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Edward and Catherine Moran
4882 Forest Avenue SE
Mercer Island, WA 98040
VIA Email: edmoran82@gmail.com
catherine.b.moran@gmail.com

Geotechnical Engineering Evaluation – ***REVISION 2***
Moran Residence Development
5000 West Mercer Way
Mercer Island, Washington
NGA File No. 1211520

Dear Edward and Catherine:

We are pleased to submit the attached report titled **"Geotechnical Engineering Evaluation – *REV2* – Moran Residence Development – 5000 West Mercer Way – Mercer Island, Washington."** The tax parcel for this property is 1924059244. Our services were completed in general accordance with the proposal signed by you on October 22, 2020.

The property is roughly rectangular in shape and covers 0.42 acres in area. It is currently vacant and forested. The property is bordered by West Mercer Way to the west, by a shared access driveway to the north, and adjacent residential properties to the east and south. Topographically, the site forms a generally level terrace situated between two, west-facing steep slopes occupying the western and eastern portions of the site, respectively. We understand the planned development will consist of constructing a new single-family residence within the central portion of the site. Final grading and stormwater plans were not developed at the time this report was prepared; therefore, we recommend we are retained to review the finalized plans to ensure they are compatible with the existing site conditions.

We explored the soil and groundwater conditions throughout the site with five trackhoe excavated test pits and two hand augers within the steeply sloping portions of the site. Our explorations indicated that the site underlain by surficial undocumented fill with competent glacial soils at relatively shallow depths. The site slopes appear to be generally stable with respect to deep-seated landsliding, and it is our opinion that the planned development is feasible from a geotechnical standpoint, provided that our recommendations are incorporated into the design and construction of this project.

We have recommended that the new structures be founded on the medium dense or better native soils for bearing capacity and settlement considerations. These soils should generally be encountered approximately three to five feet below the existing ground surface, based on our explorations. However, deeper areas of loose soil and/or undocumented fill could also exist within unexplored areas of the site.

Additionally, due to the proximity of the steep site slopes, we recommend the downhill foundation lines be additionally embedded a minimum of 2 feet into competent glacial material. Similarly, we anticipate retaining structures may be necessary to support the steep slopes above the planned residence and/or protect the residence from potential shallow slide debris; these systems could ultimately be incorporated into the planned residence foundations. General recommendations for retaining walls, as well as recommendations for site grading, subgrade preparation, drainage, and erosion control are further discussed in the attached report.

We recommend that we be retained to provide a review of the building placement and site drainage plans after they have been developed to verify that our recommendations have been incorporated into project plans. We also recommend that NGA be retained to provide monitoring and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications.

We appreciate the opportunity to provide service to you on this project. Please contact us if you have any questions regarding this report or require further information.

Sincerely,

NELSON GEOTECHNICAL ASSOCIATES, INC.

Khaled M. Shawish, PE
Principal

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INTRODUCTION

This report presents the results of our preliminary geotechnical engineering investigation and evaluation of the Moran residence development on Mercer Island, Washington. The project site is located at 5000 West Mercer Way, as shown on the Vicinity Map in Figure 1. The Tax Parcel number for the property is listed as 1924059244. For our use in preparing this report, we have been provided with an undated and untitled preliminary site plan showing the proposed conditions.

The site is currently undeveloped and moderately forested with young to mature trees and underbrush. Topography within the site consists of a relatively level bench area bisecting the central portion of the site from north to south, dividing west-facing steep slopes along the eastern and western portions of the site, respectively. The preliminary development plans indicate the construction of a new single-family residence within the central portion of the site along with a possible attached garage and driveway area within the north-central portion of the site. The existing site conditions are shown on the Site Plan in Figure 2.

SCOPE

The purpose of this study is to explore and characterize the site surface and subsurface conditions and provide general recommendations for site development.

Specifically, our scope of services included the following:

1. Review available soil and geologic maps of the area.
2. Explore the subsurface soil and groundwater conditions within the proposed residential development areas with trackhoe-excavated test pit explorations. Excavation services were subcontracted by NGA.
3. Map the conditions on the site slopes using shallow, hand-tool explorations where necessary to construct geological cross sections and qualitatively evaluate slope stability.
4. Perform laboratory grain-size sieve analysis on soil samples, if necessary.
5. Provide recommendations for structure setbacks from geologic hazards, as necessary.
6. Provide recommendations for earthwork and foundation support.

7. Provide recommendations for temporary and permanent slopes, if needed.

8. Provide our opinion on stormwater infiltration feasibility.

9. Provide general recommendations for site drainage and erosion control.

10. Document the results of our findings, conclusions, and recommendations in a written geotechnical report.

SITE CONDITIONS

Surface Conditions

The subject site consists of a roughly rectangular-shaped parcel covering approximately 0.42 acres. The site is currently undeveloped and moderately forested with young to mature trees and underbrush. The site is bound by West Mercer Way to the west, developed residential properties to the east and south, and a private access driveway to the north. The ground surface within the site generally descends from a relatively level area adjacent to the eastern property line down to a gently sloping bench area at gradients in the range of 18 to 33 degrees (32.5 to 64.9 percent). Below and to the west of the gently sloping bench area, steep west-facing slopes descend to the western property line adjacent to West Mercer Way at approximate gradients of 20 to 45 degrees (36.4 to 100 percent). The above ground surface geometry is presented on Cross Sections A-A' and B-B' in Figures 3 and 4 attached to this report. During our site visit on October 20, 2020 we did not observe any signs of recent erosional sloughing events or indications of deep-seated landslide activity. We also did not observe surface water within the site.

Subsurface Conditions

Geology: The geologic units for this area are shown on the <u>Geologic Map of Mercer Island, Washington</u>, by Kathy G. Troost and Aaron P. Wisher (City of Mercer Island, ESS, University of Washington, 2006). The site is mapped advance outwash (Qva) with Lawton clay (Qvlc) along the lower western portion of the site. Glacial till (Qvt) is also mapped in the near vicinity to the east. Advance outwash is generally described as well-sorted sand and gravel deposited by streams issuing from advancing ice sheet, while Lawton Clay is described as massive silt, clayey silt, and silty clay deposited in lakes dammed by the continental glacier during the Vashon Stade. Till is described as a compact diamicton of sand, silt, gravel, and clay glacially consolidated by overlying ice sheet. The soils encountered in our explorations varied from silty sand to sand with silt and variable gravel content underlain by silt/clay with fine sand at depth within the lower western portion of the site, generally consistent with the description of advance outwash and Lawton clay.

Explorations: The subsurface conditions within the site were explored on October 20, 2020 by excavating five test pits to depths in the range of 7.5 to 10.5 feet below the existing ground surface along with two hand augers extending to depths in the range of 4.5 to 7.5 feet below the existing ground surface. The approximate locations of our explorations are shown on the Site Plan in Figure 2. A geologist from NGA was present during the explorations, examined the soils and geologic conditions encountered, obtained samples of the different soil types, and maintained logs of the explorations.

The soils were visually classified in general accordance with the Unified Soil Classification System, presented in Figure 5. The logs of our explorations are attached to this report and are presented as Figures 6 and 7. We present a brief summary of the subsurface conditions in the following paragraph. For a detailed description of the subsurface conditions, the logs should be reviewed.

At the surface of Test Pits One through Five we generally encountered approximately 1.0 to 3.0 feet of dark brown to brown, silty sand with varying amounts of gravel, roots, and organics, which we interpreted as topsoil and/or undocumented fill soils. Underlying the undocumented fill, we generally encountered light brown to gray-brown, fine to medium sand with varying amounts of silt, gravel, and iron-oxide staining, which we interpreted as native glacial advance outwash deposits. Underlying the granular outwash soils in Test Pit Three we encountered gray to gray-blue silt/clay with fine sand, which we interpreted as Lawton clay deposits. We also noted that particularly loose soil conditions were encountered in Test Pit Five within the upper approximately 6- to 7-feet, which we interpreted as disturbed native deposits. Test Pits One through Five terminated at respective depths of 10.5, 7.5, 10.5, 10.0, and 10.0 feet below the existing ground surface.

At the surface of Hand Augers One and Two, we generally encountered approximately 1.0 to 5.0 feet of dark brown to brown, silty sand with varying amounts of roots, gravel, and organics in a loose to medium dense conditions, which we interpreted as topsoil and/or undocumented fill soils. Underlying the topsoil and undocumented fill we encountered orange-brown to gray-brown, granular silty sand with varying amounts of silt, gravel, and iron-oxide staining, which we interpreted as native outwash deposits. Hand Augers One and Two terminated at approximate depths of 7.0 and 4.5 feet below the existing ground surface, respectively.

Hydrogeologic Conditions

Groundwater seepage was encountered in Test Pits Three, Four, and Five at depths in the range of 8.5 to 10.0 feet below the existing ground surface. We anticipate the groundwater observed is perched groundwater mantling the underlying mostly impermeable Lawton clay deposits. Perched water occurs when surface water infiltrates through less dense, more permeable soils and accumulates on top of relatively low permeability materials. The more permeable soils consist of the topsoil/weathered soils. The low permeability soil consists of relatively silty glacial soils. Perched water does not represent a regional groundwater "table" within the upper soil horizons. Perched water tends to vary spatially and is dependent upon the amount of rainfall. We would expect the amount of perched groundwater to decrease during drier times of the year and increase during wetter periods.

SENSITIVE AREA EVALUATION

Seismic Hazard

The 2018 International Building Code (IBC) seismic design section provides a basis for seismic design of structures. Table 1 below provides seismic design parameters for the site that are in conformance with the 2018 IBC, which specifies a design earthquake having a 2% probability of occurrence in 50 years (return interval of 2,475 years), and the 2008 USGS seismic hazard maps.

Table 1 – 2018 IBC Seismic Design Parameters

Site Class	Spectral Acceleration at 0.2 sec. (g) S_s	Spectral Acceleration at 1.0 sec. (g) S_1	Site Coefficients		Design Spectral Response Parameters	
			F_a	F_v	S_{DS}	S_{D1}
D	1.439	0.552	1.000	1.500	0.959	0.552

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

Hazards associated with seismic activity include liquefaction potential and amplification of ground motion by soft deposits. Liquefaction is caused by a rise in pore pressures in a loose, fine sand deposit beneath the groundwater table. The glacial soils interpreted to underlie the site have a low potential for liquefaction or amplification of ground motion.

Although ancient landslide scarps are mapped in the vicinity of the site, the glacial soils interpreted to form the core of the site slopes are considered stable with respect to deep-seated slope failures within the site. However, the overlying loose surficial materials on the slopes have the potential for shallow sloughing failures during seismic events. Such events should not affect the planned residence structures provided the foundations are designed with the recommended setback and embedment values as described in this report.

Erosion Hazard

The criteria used for determination of erosion hazard areas include soil type, slope gradient, vegetation cover, and groundwater conditions. The erosion sensitivity is related to vegetative cover and the specific surface soil types, which are related to the underlying geologic soil units. The Soil Survey of King County Area, Washington, by the Soil Conservation Service (SCS) lists the soils within the site as Alderwood gravelly sandy loam, 8 to 15 percent slopes and Alderwood and Kitsap soils, very steep for the central to western and upper eastern steeply sloping portions of the site, respectively. Soils on this site to have a slight to moderate erosion hazard where the vegetative cover is removed. The on-site soils should have a low to moderate hazard for erosion where the vegetation is not disturbed.

Landslide Hazard/Slope Stability

The criteria used for evaluation of landslide hazards include soil type, slope gradient, and groundwater conditions. We understand the proposed single-family residence will be situated within the central portion of the site on a gently sloping bench area bound by moderate to steep west-facing slopes to the east and west. The upper steep slopes generally descend from the eastern property line at gradients in the range of 18 to 33 degrees (32.5 to 64.9 percent) down to the upper portion of the gently sloping bench area, while the lower western steep slopes descend from the planned building area at gradients in the range of 20 to 45 degrees (36.4 to100 percent). The ground surface gradients throughout the site are depicted on Cross-Sections A-A’ and B-B’ in Figures 3 and 4 attached to this report. The overall vertical relief of the upper eastern steep slopes is approximately 30 to 35 feet while the lower western frontage steep slopes provide approximately 10 to 16 feet of relief. The gently sloping bench and planned development area spans approximately 45 to 65 feet in width from east to west and provides approximately 5 to 10 feet of relief.

We did not observe evidence of significant slope instability within the property during our investigation, such as deep-seated landsliding, although an ancient slide scarp has been identified above and to the east of the property which appears to be diffused when viewed under LiDAR imagery, suggesting landslide activity is relatively old, although no specific age-dating information has been completed for this identified feature. We also did not observe significant groundwater seepage along the steep slopes or signs of erosion or sloughing on the slopes at the time of our visit.

The core of the site slopes is inferred to consist primarily of medium dense or better native glacial soils. Inclinations of up to 33 to 45 degrees (64.9 to 100 percent) on the slopes within the property indicate high internal strength within the underlying soils. Relatively shallow sloughing failures as well as surficial erosion are natural processes and should be expected on these slopes during extreme weather conditions. It is our opinion that while there is potential for erosion, soil creep, and shallow failures within the loose surficial soils on the steep slopes, there is not a significant potential for deep-seated slope failure under current site conditions. Proper site grading and drainage as well as adequate foundation placement as recommended in this report should help maintain current stability conditions.

CONCLUSIONS AND RECOMMENDATIONS

General

It is our opinion that the planned development is feasible from a geotechnical standpoint. It is also our opinion that the soils that underlie the site and form the core of the site slopes should be stable with respect to deep-seated earth movements, due to their inherent strength and slope geometry. There is, however, a potential for shallow sloughing and erosion events to occur on the steeper portions of the slopes, especially in the upper loose surficial soils. Proper erosion and drainage control measures should reduce this potential. We recommend that we be retained to review the plans after they have been developed.

Our explorations indicated that the site is underlain by competent native glacial soils at depth. These glacial soils should provide adequate support for foundation, slab, and pavement loads. We recommend that the structures be designed utilizing shallow conventional foundations. Footings should extend through any loose surficial soil and undocumented fill and be keyed into the underlying competent native soils. These soils should be encountered roughly three to five feet below the existing ground surface. We recommend that the downhill and at least 10 feet of the northern and southern residence foundation lines in proximity to the slopes be additionally embedded a minimum of 12 inches into the competent native soils to provide protection from any potential shallow slope failures. We should be retained to evaluate the residence foundation subgrade soils prior to placing foundation forms.

Due to site constraints and relatively close proximity of the planned residence to the toe of the steep west-facing eastern slopes, we also recommend the upslope side of the proposed structure be designed to retain the slope and extends a minimum of three feet above finished ground surface, to protect the structure against potential failures on this slope. This is intended to provide a catchment measure should any sloughing debris travel towards the proposed structures during extreme weather or as a result of an earthquake. Alternatively, a separate debris protection structure or fence could be utilized.

All grading operations and drainage improvements planned as part of this development should be planned and completed in a matter which enhances the stability of the steep slopes, not reduces it. Excavation spoils should not be stockpiled near the slopes or be allowed to encroach on the slopes. Also, runoff generated within the site should be collected and routed into a permanent discharge system and not be allowed to flow over the slopes. Future vegetation management on the slope should be the subject of a specific evaluation and a plan approved by the City of Mercer Island. The slopes should be monitored on an on-going basis, especially during the wet season, for any signs of instability, and corrective actions promptly taken should any signs of instability be observed. Lawn clipping and any other household trash or debris should never be allowed to reach the slopes.

The surficial soils encountered on this site are considered moisture-sensitive and will disturb easily when wet. To lessen the potential impacts of construction on the slopes and to reduce cost overruns and delays, we recommend that construction take place during the drier summer months. If construction takes place during the rainy months, additional expenses and delays should be expected. Additional expenses could include the need for placing erosion control and temporary drainage measures to protect the slopes, the need for placing a blanket of rock spalls on exposed subgrades, and construction traffic areas prior to placing structural fill, and the need for importing all-weather material for structural fill.

Under no circumstances, should water be allowed to flow over or concentrate on the site slopes, both during construction, and after construction has been completed. We recommend that stormwater runoff from the roof and yard drains be collected and tightlined to a suitable discharge point. The slopes should be protected from erosion. We recommend that all disturbed areas be replanted with vegetation to re-establish vegetation cover as soon as possible. Specific recommendations for erosion control are presented in the **Erosion Control and Slope Protection Measures** subsection of this report.

Erosion Control and Slope Protection Measures

The erosion hazard for the on-site soils is considered to be moderate, but the actual hazard will be dependent on how the site is graded and how water is allowed to concentrate. Best Management Practices (BMPs) should be used to control erosion. Areas disturbed during construction should be protected from erosion. Erosion control measures may include diverting surface water away from the stripped or disturbed areas. Silt fences and/or straw bales should be erected to prevent muddy water from leaving the site or flowing over the slopes. Stockpiles should be covered with plastic sheeting during wet weather and stockpiled material should be no closer than 25 feet from the top of the slopes. Disturbed areas should be planted as soon as practical, and the vegetation should be maintained until it is established. The erosion potential for areas not stripped of vegetation should be low.

Protection of the steep slope areas should be performed as required by the City of Mercer Island. Specifically, we recommend that the sloping areas outside the proposed development area not be disturbed or modified through placement of any fill or removal of the existing vegetation. No additional material of any kind should be placed on either slope or be allowed to reach the slopes, such as excavation spoils, lawn clippings, and other yard waste, trash, and soil stockpiles. Trees should not be cut down or removed from the slopes unless a mitigation plan is developed, such as the replacement of vegetation for erosion protection. Vegetation should not be removed from the slopes. Replacement of vegetation should be performed in accordance with the City of Mercer Island code. Any proposed development within the steep slope areas outside the proposed residence should be the subject of a specific geotechnical evaluation. Under no circumstances should water be allowed to concentrate on the slopes.

Site Preparation and Grading

After erosion control measures are implemented, site preparation should consist of stripping any loose soils to expose medium dense or better native soil in foundation, slab-on-grade, and pavement areas. The stripped materials should be removed from the site. Stockpiles should be kept a minimum of 25 feet away from the top of the steep slopes and should be covered with plastic. The recommended 4-foot over excavations along the downhill and portions of the northern and southern foundation lines could then be performed.

If the ground surface, after site stripping, should appear to be loose, it should be compacted to a non-yielding condition. Areas observed to pump or weave during compaction should be over-excavated and replaced with properly compacted structural fill or rock spalls. If loose soils are encountered in any slab areas, the loose soils should be removed and replaced with rock spalls or granular structural fill. If significant surface water flow is encountered during construction, this flow should be diverted around areas to be developed, and the exposed subgrades should be maintained in a semi-dry condition.

This site is underlain by moisture sensitive soils. Due to these conditions, special site stripping and grading techniques might be necessary. These could include using large excavators equipped with wide tracks and a smooth bucket to complete site grading and promptly covering exposed subgrades with a layer of crushed rock for protection. If wet conditions are encountered or construction is attempted in wet weather, the subgrade should not be compacted as this could cause further subgrade disturbance. In wet conditions, it may be necessary to cover the exposed subgrade with a layer of crushed rock as soon as it is exposed to protect the moisture sensitive soils from disturbance by machine or foot traffic during construction. The prepared subgrade should be protected from construction traffic and surface water should be diverted around prepared subgrade. Shallow groundwater, if encountered, should be intercepted with cut-off drains and routed around the planned grading area, or the groundwater should be controlled with sump-pumps or dewatering systems. Failure to follow these recommendations could cause erosion and failures on the slopes, as well as result in inadequate subgrades.

Temporary and Permanent Slopes

Temporary cut slope stability is a function of many factors, including the type and consistency of soils, depth of the cut, surcharge loads adjacent to the excavation, length of time a cut remains open, and the presence of surface water or groundwater. It is exceedingly difficult under these variable conditions to estimate a stable, temporary, cut slope angle. Therefore, it should be the responsibility of the contractor to maintain safe slope configurations since they are continuously at the job site, able to observe the soil and groundwater conditions encountered, and able to monitor the nature and condition of the cut slopes.

The following information is provided solely for the benefit of the owner and other design consultants and should not be construed to imply that Nelson Geotechnical Associates, Inc. assumes responsibility for job site safety. Job site safety is the sole responsibility of the project contractor.

For planning purposes, we recommend that temporary cuts in the on-site soils be no steeper than 1.5H:1V. If significant groundwater seepage or surface water flow were encountered, we would expect that flatter inclinations would be necessary. We recommend that cut slopes be protected from erosion. The slope protection measures may include covering cut slopes with plastic sheeting and diverting surface runoff away from the top of cut slopes. We do not recommend vertical slopes for cuts deeper than four feet, if worker access is necessary. We recommend that cut slope heights and inclinations conform to appropriate OSHA/WISHA regulations. If the above inclinations cannot be met due to property line constraints and/or worker access issues, we recommend that shoring be considered for the planned cuts. We are available to provide specific recommendations for temporary shoring once grading plans have been finalized.

Permanent cut and fill slopes should be no steeper than 2H:1V, unless specifically approved by NGA. Also, flatter inclinations may be required in areas where loose soils are encountered. Permanent slopes should be vegetated, and the vegetative cover maintained until established. We should specifically review all plans for grading on steep slopes for this project.

Foundation Support

Conventional shallow spread foundations should be placed on undisturbed medium dense or better native soils. Medium dense soils should be encountered roughly three to five feet below the ground surface based on our explorations; however, deeper loose soil may be encountered in unexplored areas of the site. Where undocumented fill or less dense soils are encountered at footing bearing elevation, the subgrade should be over-excavated to expose suitable bearing soil. In addition, we recommend that the downhill western and at least ten feet of the northern and southern residence foundation lines are additionally embedded a minimum of four feet into competent native material.

Footings should extend at least 18 inches below the lowest adjacent finished ground surface for frost protection and bearing capacity considerations. Foundations should be designed in accordance with the 2018 IBC. Footing widths should be based on the anticipated loads and allowable soil bearing pressure. Water should not be allowed to accumulate in footing trenches. All loose or disturbed soil should be removed from the foundation excavation prior to placing concrete.

For foundations constructed as outlined above, we recommend an allowable design bearing pressure of not more than 1,500 pounds per square foot (psf) be used for the footing design for footings founded on the medium dense or better native soils or structural fill extending to the native competent material. The foundation bearing soil should be evaluated by a representative of NGA. We should be consulted if higher bearing pressures are needed. Current IBC guidelines should be used when considering increased allowable bearing pressure for short-term transitory wind or seismic loads. Potential foundation settlement using the recommended allowable bearing pressure is estimated to be less than 1-inch total and ½-inch differential between adjacent footings or across a distance of about 20 feet, based on our experience with similar projects.

Lateral loads may be resisted by friction on the base of the footing and passive resistance against the subsurface portions of the foundation. A coefficient of friction of 0.35 may be used to calculate the base friction and should be applied to the vertical dead load only. Passive resistance may be calculated as a triangular equivalent fluid pressure distribution. An equivalent fluid density of 200 pounds per cubic foot (pcf) should be used for passive resistance design for a level ground surface adjacent to the footing. This level surface should extend a distance equal to at least three times the footing depth. These recommended values incorporate safety factors of 1.5 and 2.0 applied to the estimated ultimate values for frictional and passive resistance, respectively. To achieve this value of passive resistance, the foundations should be poured “neat” against the native medium dense soils or compacted fill should be used as backfill against the front of the footing. We recommend that the upper 1-foot of soil be neglected when calculating the passive resistance.

Retaining Walls

Final grading and development plans were not available at the time this report was prepared but retaining walls will likely be needed along the uphill side of the residence due to close proximity to the toe of the upper eastern steep slope area. We recommend that the uphill foundation wall be extended a minimum of four feet above the finished ground surface to protect the structure against potential failures from the slope above. This is intended to provide a catchment measure should any sloughing debris travel towards the residence during extreme weather or as a result of an earthquake. Alternatively, the uphill-facing foundations may be extended a minimum of 4.0 feet above grade to provide debris catchment. With this approach, we recommend limiting at-grade fenestration on the uphill facing portion of the house where possible. A structural engineer licensed in the State of Washington should design the foundations, but prescriptive debris protection elements of the foundations should be a minimum of 12 inches in width below grade, and 8 inches in width for the extended, 4-foot minimum above grade portion.

The lateral pressure acting on subsurface retaining walls is dependent on the nature and density of the soil behind the wall, the amount of lateral wall movement which can occur as backfill is placed, wall drainage conditions, the inclination of the backfill, and other possible surcharge loads. For walls that are free to yield at the top at least one thousandth of the height of the wall (active condition), soil pressures will be less than if movement is limited by such factors as wall stiffness or bracing (at-rest condition). We recommend that walls supporting horizontal backfill and not subjected to hydrostatic forces be designed using a triangular earth pressure distribution equivalent to that exerted by a fluid with a density of 40 pcf for yielding (active condition) walls, and 60 pcf for non-yielding (at-rest condition) walls. A seismic design loading of 8H in psf should also be included in the wall design where "H" is the total height of the wall. We recommend an 18-inch above-retained-grade section of the wall be employed as debris protection for the underlying areas beneath the wall. The portion of the wall acting as debris protection should be designed for an active pressure of 90 pcf. We should note that the 18-inch stickup will catch small debris and potential slope failures but will not completely mitigate the risk for debris to reach the walkway underlying the retaining wall. Regular slope maintenance and vegetation management should reduce this risk, as outlined in the **Erosion Control and Slope Protection Measures** subsection of this report.

If the uphill side of the residence is instead intended to perform as a debris wall, we recommend the residence wall be designed for an active pressure of 90 pcf.

These recommended lateral earth pressures are for a drained granular backfill and are based on the assumption of a maximum 2H:1V backfill inclinations and do not account for additional surcharge loads. Additional lateral earth pressures should be considered for surcharge loads acting adjacent to subsurface walls and within a distance equal to the subsurface height of the wall. This would include the effects of surcharges such as traffic loads, floor slab and foundation loads, or other surface loads. We are available to provide consultation regarding additional loads on retaining walls during final design, if needed.

The lateral pressures on walls may be resisted by friction between the foundation and subgrade soil, and by passive resistance acting on the below-grade portion of the foundation. Recommendations for frictional and passive resistance to lateral loads are presented in the **Foundations** subsection of this report.

All wall backfill should be well compacted as outlined in the **Structural Fill** subsection of this report. Care should be taken to prevent the buildup of excess lateral soil pressures, due to over-compaction of the wall backfill. This can be accomplished by placing wall backfill in thin loose lifts and compacting it with small, hand-operated compactors within a distance behind the wall equal to at least one-half the height of the wall. The thickness of the loose lifts should be reduced to accommodate the lower compactive energy of the hand-operated equipment. The recommended level of compaction should still be maintained.

Permanent drainage systems should be installed for retaining walls. Recommendations for these systems are found in the **Subsurface Drainage** subsection of this report. We recommend that we be retained to evaluate the proposed wall drain backfill material and drainage systems.

Structural Fill

General: Fill placed beneath foundations, slabs, pavements, or other settlement-sensitive structures should be placed as structural fill. Structural fill, by definition, is placed in accordance with prescribed methods and standards, and is monitored by an experienced geotechnical professional or soils technician. Field monitoring procedures would include the performance of a representative number of in-place density tests to document the attainment of the desired degree of relative compaction. The area to receive the fill should be suitably prepared as described in the **Site Preparation and Grading** subsection prior to beginning fill placement. Sloping areas to receive fill should be benched to key the fill into the sloping grade. The benches should be level and a minimum of six feet wide.

Materials: Structural fill should consist of a good quality, granular soil, free of organics and other deleterious material, and be well graded to a maximum size of about three inches. All-weather structural fill should contain no more than five-percent fines (soil finer than U.S. No. 200 sieve, based on that fraction passing the U.S. 3/4-inch sieve). The on-site soils should not be used as structural fill. We should be retained to evaluate proposed structural fill material prior to placement.

Fill Placement: Following subgrade preparation, placement of structural fill may proceed. All filling should be accomplished in uniform lifts up to eight inches thick. Each lift should be spread evenly and be thoroughly compacted prior to placement of subsequent lifts. All structural fill should be compacted to a minimum of 95 percent of its maximum dry density. Maximum dry density, in this report, refers to that density as determined by the ASTM D-1557 Compaction Test procedure. The moisture content of the soils to be compacted should be within about two percent of optimum so that a readily compactable condition exists. It may be necessary to over-excavate and remove wet soils in cases where drying to a compactable condition is not feasible. All compaction should be accomplished by equipment of a type and size sufficient to attain the desired degree of compaction.

Slab-on-Grade

Slabs-on-grade should be supported on subgrade soils prepared as described in the **Site Preparation and Grading** subsection of this report. We recommend that all floor slabs be underlain by at least six inches of free-draining gravel with less than three percent by weight of the material passing Sieve #200 for use as a capillary break. We recommend that the capillary break be hydraulically connected to the footing drain system to allow free drainage from under the slab. A suitable vapor barrier, such as heavy plastic sheeting (6-mil minimum), should be placed over the capillary break material. An additional 2-inch thick moist sand layer may be used to cover the vapor barrier. This sand layer is optional and is intended to protect the vapor barrier membrane during construction.

Site Drainage

Surface Drainage: Final site grades should allow for drainage away from the top of the slopes and away from the planned residence structures. We suggest that the finished ground be sloped at a minimum gradient of three percent for a distance of at least 10 feet away from the buildings and top of the slopes. Runoff generated on this site should be collected and routed into a permanent discharge system at the bottom of the slope. This should include all downspouts and runoff generated on all hard surfaces and yards areas. Due to the steep slopes and impermeable soils interpreted to underly the site at relatively shallow depths, onsite stormwater infiltration should be considered infeasible. Under no circumstances should water be allowed to flow uncontrolled over the slopes. Water should not be allowed to collect in any area where footings or slabs are to be constructed. Under no circumstances should any water generated on this site be allowed to flow uncontrollably over the site slopes either during construction or on a permanent basis after the improvements are complete.

Subsurface Drainage: If groundwater is encountered during construction, we recommend that the contractor slope the bottom of the excavation and collect the water into ditches and small sump pits where the water can be pumped out of the excavation and routed into a suitable outlet. We recommend that the residence down spouts and footing drains be tightlined to an appropriate discharge location at the bottom of the steep slopes or into the drainage system on the road.

We recommend the use of footing drains around structures. Footing drains should be installed at least one foot below planned finished floor elevation. The drains should consist of a minimum four-inch-diameter, rigid, slotted or perforated, PVC pipe surrounded by free-draining material wrapped in a filter fabric. We recommend that the free-draining material consist of an 18-inch-wide zone of clean (less than three-percent fines), granular material placed along the back of walls.

Washed rock is an acceptable drain material, or a drainage composite may be used instead. The free-draining material should extend up the wall to one foot below the finished surface. The top foot of soil should consist of low permeability soil placed over plastic sheeting or building paper to minimize the migration of surface water or silt into the footing drain. Footing drains should discharge into tightlines leading to an appropriate collection and discharge point with convenient cleanouts to prolong the useful life of the drains. Roof drains should not be connected to wall or footing drains.

USE OF THIS REPORT

NGA has prepared this report for **Mr. and Mrs. Moran** and their agents, for use in the planning and design of the development planned on this site only. The scope of our work does not include services related to construction safety precautions and our recommendations are not intended to direct the contractors' methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design. There are possible variations in subsurface conditions between the explorations and also with time. Our report, conclusions, and interpretations should not be construed as a warranty of subsurface conditions. A contingency for unanticipated conditions should be included in the budget and schedule. This report is preliminary, and therefore, we recommend that we be retained to review the project plans after they have been developed to determine that recommendations in the report were incorporated into project plans.

All people who own or occupy homes with hills should realize that landslide movements are always a possibility. The landowner should periodically inspect the site slopes, especially after a winter storm. If distress is evident, a geotechnical engineer should be contacted for advice on remedial/preventative measures. The probability that landsliding will occur is substantially reduced by the proper maintenance of drainage control measures at the site (the runoff from the roofs should be led to an approved discharge point). Therefore, the homeowner should take responsibility for performing such maintenance. Consequently, we recommend that a copy of our report be provided to any future homeowners of the property if the home is sold.

We recommend that NGA be retained to provide monitoring and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications. We should be contacted a minimum of one week prior to construction activities and could attend pre-construction meetings if requested.

Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering practices in effect in this area at the time this report was prepared. No other warranty, expressed or implied, is made. Our observations, findings, and opinions are a means to identify and reduce the inherent risks to the owner.

o-o-o

It has been a pleasure to provide service to you on this project. If you have any questions or require further information, please call.

Sincerely,

NELSON GEOTECHNICAL ASSOCIATES, INC.

Alex B. Rinaldi, GIT
Project Geologist

09.27.2021

Khaled M. Shawish, PE
Principal

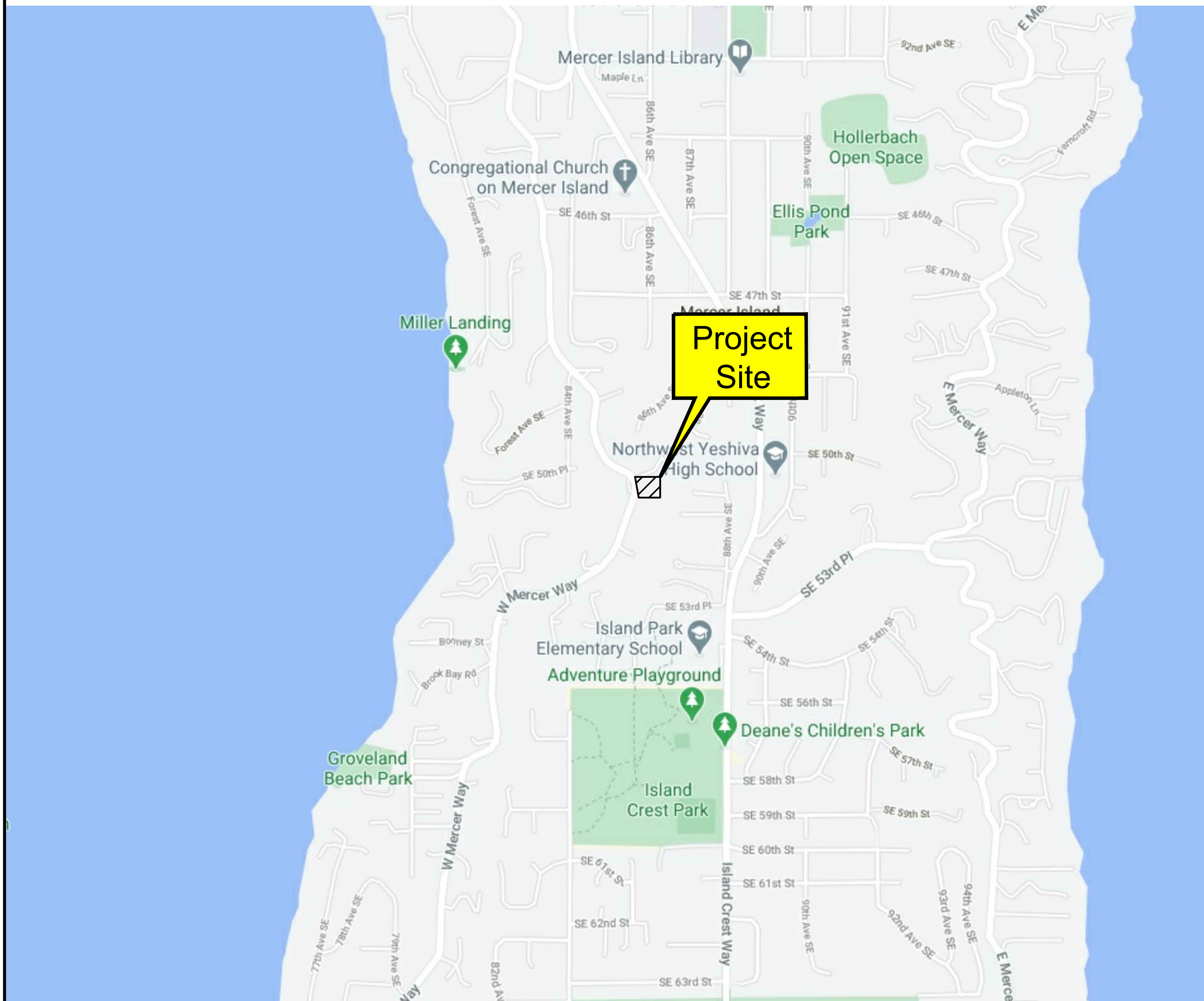
ABR:KMS:dy

Seven Figures Attached

VICINITY MAP

Not to Scale

N



Mercer Island, WA

Project Number 1211520	Moran Residence Development Vicinity Map	NELSON GEOTECHNICAL ASSOCIATES, INC. GEOTECHNICAL ENGINEERS & GEOLOGISTS	No.	Date	Revision	By	CK
Figure 1		Woodinville Office 17311-135th Ave. NE, A-500 Woodinville, WA 98072 (425) 486-1669 / Fax: 481-2510 www.nelsongeotech.com Wenatchee Office 105 Palouse St. Wenatchee, WA 98801 (509) 665-7696 / Fax: 665-7692	1	11/3/20	Original	DPN	DJO

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Schematic Site Plan

LEGEND

Property line

TP-1 Number and approximate location of test pit

A A' Approximate location of cross-section

HA-1 Number and approximate location of hand auger

0 40 80

Approximate Scale: 1 inch = 40 feet

Reference: Site plan based on field measurements, observations, and aerial parcel map review.

Project Number 1211520

Figure 2

Moran Residence Development

Schematic Site Plan

NGA
NELSON GEOTECHNICAL ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS & GEOLOGISTS
Woodinville Office
17311-135th Ave NE, A-500
Woodinville, WA 98072
(425) 486-1669 / Fax: 481-2510
Wenatchee Office
105 Palouse St.
Wenatchee, WA 98801
(509) 665-7696 / Fax: 665-7692
www.nelsongeotech.com

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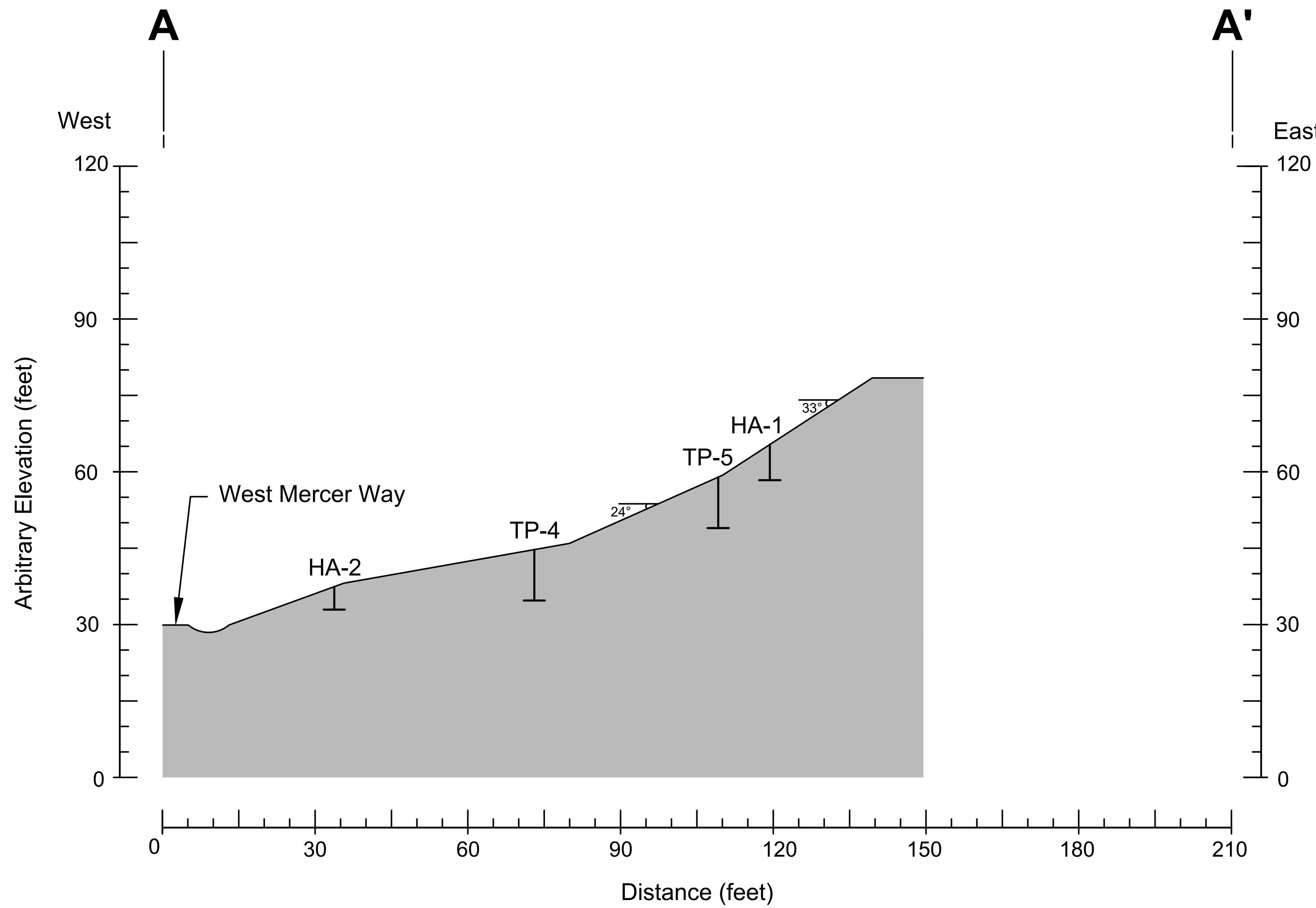

Exploration

Test Pit / Hand Auger Designation → TP-1 / HA-1

Groundwater Level During Exploration →

Geologic Contact (approximate) → ? — — ?

NOTES:
1) Stratigraphic conditions are interpolated between the explorations. Actual conditions may vary.
2) Elevations are arbitrary.

Reference: Cross Section is based on field measurements using a hand-held clinometer and 100-ft tape measure.

Project Number 1211520

Figure 3

Moran Residence Development
Cross-Section A-A'

NELSON GEOTECHNICAL ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS & GEOLOGISTS
Woodinville Office
17311-135th Ave. NE, A-500
Woodinville, WA 98072
(425) 486-1669 / Fax: 481-2510
Wenatchee Office
105 Palouse St.
Wenatchee, WA 98801
(509) 665-7696 / Fax: 665-7692
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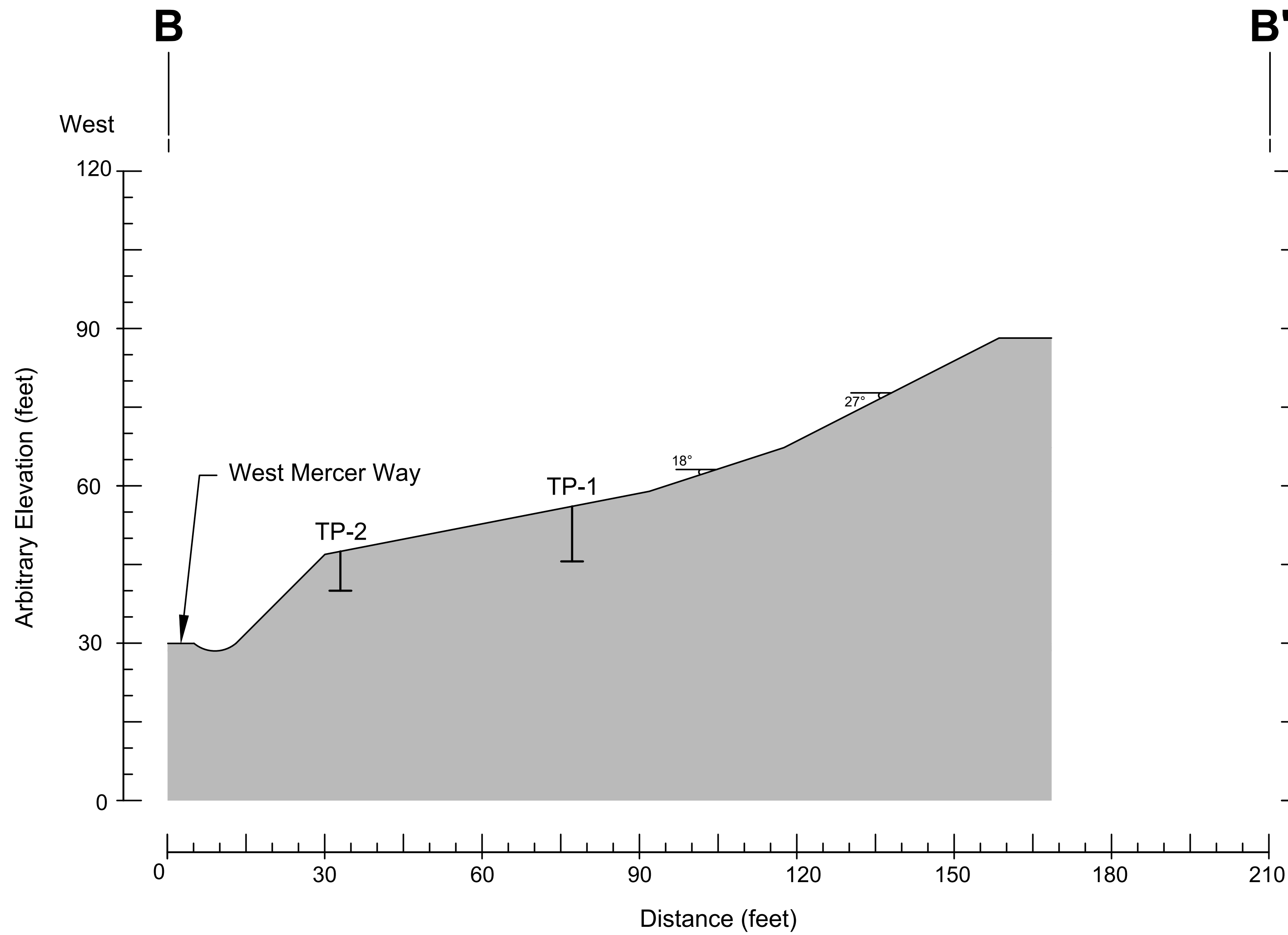

Exploration

Test Pit / Hand Auger Designation → TP-1 / HA-1

Groundwater Level During Exploration →

Geologic Contact (approximate) → ?— — —?

NOTES:
1) Stratigraphic conditions are interpolated between the explorations. Actual conditions may vary.
2) Elevations are arbitrary.

Reference: Cross Section is based on field measurements using a hand-held clinometer and 100-ft tape measure.

Project Number 1211520

Figure 4

Moran Residence Development
Cross-Section B-B'

NELSON GEOTECHNICAL ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS & GEOLOGISTS
Woodinville Office
17311-135th Ave. NE, A-500
Woodinville, WA 98072
(425) 486-1669 / Fax: 481-2510
www.nelsongeotech.com
Wenatchee Office
105 Palouse St.
Wenatchee, WA 98801
(509) 665-7696 / Fax: 665-7692

No.	Date	Revision	By	CK
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UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE - GRAINED SOILS MORE THAN 50 % RETAINED ON NO. 200 SIEVE	GRAVEL MORE THAN 50 % OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50 % OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE - GRAINED SOILS MORE THAN 50 % PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50 %	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50 % OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1) Field classification is based on visual examination of soil in general accordance with ASTM D 2488-93.

2) Soil classification using laboratory tests is based on ASTM D 2488-93.

3) Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry - Absence of moisture, dusty, dry to the touch

Moist - Damp, but no visible water.

Wet - Visible free water or saturated, usually soil is obtained from below water table

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Project Number 1211520	Moran Residence Development Soil Classification Chart	NELSON GEOTECHNICAL ASSOCIATES, INC. NGA	No.	Date	Revision	By	CK
Figure 5		GEOTECHNICAL ENGINEERS & GEOLOGISTS	1	11/3/20	Original	DPN	DJO

Woodinville Office
17311-135th Ave. NE, A-500
Woodinville, WA 98072
(425) 486-1669 / Fax: 481-2510

www.nelsongeotech.com

Wenatchee Office
105 Palouse St.
Wenatchee, WA 98801
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LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
TEST PIT ONE		
0.0 – 3.0		DARK BROWN TO BROWN, SILTY SAND WITH ROOTS, ORGANICS, AND GRAVEL (LOOSE, MOIST) (**TOPSOIL/UNDOCUMENTED FILL**)
3.0 – 10.5	SM	GRAY TO GRAY-BROWN, SILTY FINE SAND WITH IRON-OXIDE STAINING AND TRACE ROOTS (MEDIUM DENSE TO DENSE, MOIST)
		SAMPLES WERE COLLECTED AT 2.7, 5.0, 8.0, 9.5, AND 10.5 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT WAS COMPLETED AT 10.5 FEET ON 10/20/20
TEST PIT TWO		
0.0 – 3.0		DARK BROWN TO BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, ROOTS, ORGANICS, AND TRACE IRON-OXIDE STAINING (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL/UNDOCUMENTED FILL**)
3.0 – 7.5	SM	BROWN TO GRAY-BROWN, SILTY FINE SAND WITH IRON-OXIDE STAINING (MEDIUM DENSE TO DENSE, MOIST)
		SAMPLES WERE COLLECTED AT 4.5 AND 6.0 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT WAS COMPLETED AT 7.5 FEET ON 10/20/20
TEST PIT THREE		
0.0 – 2.5		DARK BROWN TO ORANGE-BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, ROOTS, AND ORGANICS (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL/UNDCOUMENTED FILL**)
2.5 – 3.3	SP-SM	LIGHT BROWN TO BROWN, FINE TO MEDIUM SAND WITH SILT, COBBLES, GRAVEL, AND IRON-OXIDE STAINING (MEDIUM DENSE TO DENSE, MOIST)
3.3 – 4.3	SP-SM	LIGHT BROWN TO BROWN, FINE TO MEDIUM SAND WITH SILT (MEDIUM DENSE TO DENSE, MOIST)
4.3 – 8.5	SP-SM	GRAY TO GRAY-BROWN, FINE TO MEDIUM SAND WITH SILT (MEDIUM DENSE TO DENSE, MOIST)
8.5 – 10.5	ML	GRAY SILT WITH FINE SAND (MEDIUM STIFF TO STIFF, MOIST)
		SAMPLES WERE COLLECTED AT 4.0, 6.0, AND 8.5 FEET SLIGHT GROUNDWATER SEEPAGE WAS ENCOUNTERED AT 10.0 FEET TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT WAS COMPLETED AT 10.5 FEET ON 10/20/20
TEST PIT FOUR		
0.0 – 2.3		BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, ROOTS, TRACE CHARCOAL FRAGMENTS (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL/UNDCOUMENTED FILL**)
2.3 – 4.0	SP-SM	BROWN, FINE TO COARSE SAND WITH SILT, GRAVEL, IRON-OXIDE STAINING, TRACE COBBLES (MEDIUM DENSE TO DENSE, MOIST)
4.0 – 6.0	SP-SM	GRAY, FINE TO MEDIUM SAND WITH SILT, TRACE GRAVEL AND IRON-OXIDE STAINING (MEDIUM DENSE TO DENSE, MOIST)
6.0 – 10.0	SP-SM	GRAY, FINE TO COARSE SAND WITH SILT AND GRAVEL (MEDIUM DENSE TO DENSE, MOIST TO WET)
		SAMPLES WERE COLLECTED AT 4.0, 6.0, AND 8.5 FEET SLIGHT GROUNDWATER SEEPAGE WAS ENCUONTERED AT 9.0 FEET TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT WAS COMPLETED AT 10.5 FEET ON 10/20/20

LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
TEST PIT FIVE		
0.0 – 0.5		UNDERBRUSH UNDERLAIN BY DARK BROWN, SILTY SAND WITH ORGANICS, ROOTS, AND TRACE GRAVEL (LOOSE, MOIST) (**TOPSOIL**)
0.5 – 6.0	SM	LIGHT BROWN, SILTY FINE TO MEDIUM SAND WITH ROOTS, GRAVEL, AND ORGANICS (LOOSE TO MEDIUM DENSE, MOIST)
6.0 – 10.0	SP-SM	GRAY-BROWN TO ORANGE-BROWN, FINE TO MEDIUM SAND WITH SILT AND IRON-OXIDE STAINING (MEDIUM DENSE, MOIST TO WET)
		SAMPLES WERE COLLECTED AT 7.0 AND 8.5 FEET SLIGHT GROUNDWATER SEEPAGE WAS ENCUONTERED AT 8.5 FEET TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT WAS COMPLETED AT 10.0 FEET ON 10/20/20
HAND AUGER ONE		
0.0 – 0.5		DARK BROWN, ORGANIC-LADE SILTY SAND WITH GRAVEL (LOOSE, MOIST) (**TOPSOIL**)
0.5 – 2.0		BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, ROOTS, AND ORGANICS (LOOSE TO MEDIUM DENSE, MOIST) (**UNDOCUMENTED FILL**)
2.0 – 5.0		BROWN TO GRAY-BROWN, SILTY FINE TO MEDIUM SAND WITH ROOTS (LOOSE TO MEDIUM DENSE, MOIST) (**UNDOCUMENTED FILL**)
5.0 – 7.0	SP-SM	GRAY TO GRAY-BROWN, FINE SAND WITH SILT AND IRON-OXIDE STAINING (MEDIUM DENSE, MOIST)
		SAMPLES WERE NOT COLLECTED GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED HAND AUGER CAVING WAS NOT ENCOUNTERED HAND AUGER WAS COMPLETED AT 7.0 FEET ON 10/20/20
HAND AUGER TWO		
0.0 – 0.5		DARK BROWN, SILTY SAND WITH ORGANICS, ROOTS, AND GRAVEL (LOOSE, MOIST) (**TOPSOIL**)
0.5 – 2.5	SM	SILTY, FINE TO MEDIUM SAND WITH GRAVEL, TRACE ROOTS AND IRON-OXIDE STAINING (LOOSE TO MEDIUM DENSE, MOIST)
2.5 – 3.5	SM	ORANGE-BROWN, SILTY FINE TO COARSE SAND WITH GRAVEL, ROOTS, AND IRON-OXIDE STAINING (MEDIUM DENSE, MOIST)
3.5 – 4.5	SM	GRAY-BROWN TO GRAY, SILTY FINE TO MEDIUM SAND WITH GRAVEL, TRACE ROOTS, AND IRON-OXIDE STAINING (MEDIUM DENSE TO DENSE, MOIST)
		SAMPLES WERE NOT COLLECTED GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED HAND AUGER CAVING WAS NOT ENCOUNTERED HAND AUGER WAS COMPLETED AT 4.5 FEET ON 10/20/20