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December 2, 2016

Mr. and Mrs. David and Joan Loney
c/o Larry Throndsen - LOT Design Group
lthrondsen@msn.com

Geotechnical Engineering Evaluation - REVISED
Loney Residence Development
1603 Debrelon Lane
Mukilteo, Washington
NGA File No. 971416

Dear Mr. and Mrs. Loney:

We are pleased to submit the attached report titled "Geotechnical Engineering Evaluation – Loney Residence Development – 1603 Debrelon Lane – Mukilteo, Washington." Our services were completed in general accordance with the proposal signed by you on September 20, 2016.

The property is currently occupied by an existing single-family residence within an upper relatively level bench area within the western portion of the property. The ground surface below and to the east of the existing residence descends moderately to steeply down from the upper bench area to east to a lower gentle to moderately sloping area within the eastern portion of the property. We understand that the proposed development will subdivide the existing property into separate western and eastern lots, and constructing a new single-family residence within the lower eastern portion of the property. The existing residence will remain as a part of the overall development plans. Specific grading and stormwater plans were not available at the time this proposal was prepared.

We explored the site with seven track-hoe excavated test pits extending to depths in the range of 7.0 to 11.0 feet below the existing ground surface. We also performed one hand auger exploration within the steep slope above the proposed residence. Our explorations indicated that the proposed new residence area is generally underlain by loose to medium dense, undocumented fill soils with localized areas of the site underlain by medium dense or better, fine to medium sand with silt, which we interpreted as native advanced outwash soils.

It is our opinion from a geotechnical standpoint that the site is compatible with the planned development provided that our recommendations are incorporated into the design and construction of this project. In our opinion, the significant amount of undocumented fill soils that underlie a majority of the proposed residence are not suitable to provide adequate support for foundation and slab loads utilizing conventional shallow foundations, without experiencing significant settlement and distress to the structure. Based on our explorations, we recommend that the proposed residence be supported on a deep foundation system consisting of 4-inch driven pin piles in order to advance the structure loads through the loose upper soils, down to more competent native deposits interpreted to underlie the site at depth. Due to our explorations

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7. Perform grain-size sieve analysis on soil samples, as needed.
8. Provide recommendations for earthwork, foundation support, and slabs-on-grade.
9. Provide recommendations for retaining walls.
10. Provide recommendations for temporary and permanent slopes.
11. Provide recommendations for pavement subgrade.
12. Provide recommendations for site drainage and erosion control.
13. Document the results of our findings, conclusions, and recommendations in a written geotechnical report.

SITE CONDITIONS

Surface Conditions

The site consists of a rectangular-shaped parcel covering approximately 0.41 acres. The property is currently occupied by an existing single-family residence structure and attached garage located within the upper western portion of the site. There is an approximately twelve-foot-tall, block retaining wall located to the east of the existing residence. From the existing residence, driveway, and block retaining wall, the site slopes moderately to steeply down to the east to a gently sloping bench area and then continues to slope moderately down to the east to the eastern property line at gradients in the range of 7 to 28 degrees (12 to 53 percent) as shown on Cross Sections A-A' and B-B' in Figures 3 and 4, respectively. The site is generally vegetated with grass and landscaping vegetation with a few scattered young to mature deciduous trees. The property is bordered to the south and east by wooded areas and an access driveway, and to the north and west by existing single-family residences properties. We did not observe any surface water within the proposed development areas during our site visit on October 6, 2016.

Subsurface Conditions

Geology: The Distribution and Description of Geologic Units in the Mukilteo Quadrangle, Washington, by James P. Minard (USGS, 1982), was reviewed for this site. The site is mapped as Advance Outwash (Qva). The Advance Outwash deposits are described as mostly clean, gray, well stratified, unconsolidated sand with pebbles and some cobbles. Our explorations generally encountered medium dense to dense, brown, fine to medium sand with silt, on and directly adjacent to the steep slope area within the western portion of the property, which we interpreted as native advanced outwash deposits. Our explorations within the eastern portion of the property underlying the proposed building area encountered loose to medium dense, undocumented fill soils to the depths explored.

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 groundwater to decrease during drier times of the year and increase during wetter periods.

SENSITIVE AREA EVALUATION

Seismic Hazard

We reviewed the 2015 International Building Code (IBC) for seismic site classification for this project. Since medium dense or better native glacial soils were encountered at depth in most of our explorations, the site conditions best fit the description for Site Class D.

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 loose to medium dense native soils and undocumented fill interpreted to underlie the site have a low to moderate potential for liquefaction or amplification of ground motion. The deep foundation systems recommended for residence support should alleviate such issues.

The medium dense or better outwash soil interpreted to form the core of the site slopes is considered stable with respect to deep-seated slope failures. All steep slopes have the potential for shallow sloughing failures during seismic events. Such events should not affect the planned residence provided the foundations are designed with the recommended setback values and the slope and drainage systems are maintained as described in this letter.

Erosion Hazard

The criteria used for determining the erosion hazard for the site soils includes 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 Snohomish County Area, Washington, by the Soil Conservation Service (SCS), was reviewed to determine the erosion hazard of the on-site soils. The site surface soils were classified using the SCS classification system as Alderwood-Everett gravelly sandy loams, 25 to 70 percent slopes. The Alderwood-Everett gravelly sandy loam is listed as having a severe erosion hazard. It is our opinion that the site soils should have a slight to moderate hazard for erosion in areas that are not disturbed and where vegetation cover is not removed.

overall pile depths prior to finalizing the foundation plan. Depending on final grading plans, residence foundations within the western portion of the property may expose competent native glacial soils at the proposed subgrade. These foundations could possibly be supported on shallow conventional foundations, however, some minor settlement between the portion of the residence supported on the deep foundation system and the conventional foundations is possible. If desired, we can review grading and development plans as they are being finalized to better assess this potential.

We recommend that the slab-on-grade within the basement portion of the residence be designed as a structural slab and be supported on the deep foundation system. Other hard surfaces, such as paved areas, patios or walkways that are supported on the existing undocumented fill soil within the eastern portion of the property have some risk of future settlement, cracking, and the need for maintenance. To reduce this risk, we recommend over-excavating a minimum of two feet of the upper soil from these areas and replacing this material with compacted pit run or crushed rock structural fill. The subgrade should be compacted to a firm condition prior to placing the pit run. This recommendation is only for exterior hard surfaces to be supported on grade and does not apply for the interior slab.

It is also our opinion that the soils that underlie the site and form the core of the site slope should be stable with respect to deep-seated earth movements, due to their inherent strength and slope geometry. However, there is a potential for shallow sloughing and erosion events to occur on the moderate to steep slope along the western side of the site. Based on our site observations, it is our opinion that the proposed structure setback of 25 feet from the toe of the steep slopes should provide adequate protection for the proposed residence from shallow failures originating on the steep slopes above and help maintain the existing stability of the slopes. Proper setbacks, erosion and drainage control measures, along with long-term maintenance of the slope and drainage systems as recommended in this report, should reduce this potential. We recommend that we review the project plans after they have been developed.

Due to the moderately to steeply sloping nature of the overall site and the presence of a significant amount of unsuitable undocumented fill soils within the lower portion of the site, it is our opinion that onsite stormwater infiltration is not feasible for this project. We recommend that stormwater runoff from impervious surfaces at this site be managed per City of Mukilteo regulations. We understand that stormwater from the proposed development will likely be directed into the existing stormwater detention vault located immediately to the north of the site.

walkways, patios, or pavement by a minimum of two feet and the resulting overexcavation backfilled with crushed rock or granular pit-run soils compacted to structural fill specifications. The stripped material should be removed from the site. If the exposed soils after overexcavating the minimum two feet are deemed loose, they should be compacted to a non-yielding condition. Areas observed to pump or weave during compaction should be additionally overexcavated and replaced with rock spalls. If significant surface water flow is encountered during construction, this flow should be diverted around areas to be developed and the exposed subgrade maintained in a semi-dry condition. In wet conditions, the exposed subgrade should not be compacted, as compaction of a wet subgrade may result in further disturbance of the soils. A layer of crushed rock may be placed over the prepared areas to protect them from further disturbance.

The site soils are considered moisture sensitive and will disturb easily when wet. We recommend that earthwork construction take place during periods of extended dry weather, and suspended during periods of precipitation if possible. If work is to take place during periods of wet weather, care should be taken during site preparation not to disturb the site soils. This can be accomplished by utilizing large excavators equipped with smooth buckets and wide tracks to complete earthwork, and diverting surface and groundwater flow away from the prepared subgrades. Also, construction traffic should not be allowed on the exposed subgrade. A blanket of rock spalls should be used in construction access areas if wet conditions are prevalent. The thickness of this rock spall layer should be based on subgrade performance at the time of construction. For planning purposes, we recommend a minimum one-foot thick layer of rock spalls.

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 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 nature and condition of the cut slopes, and able to monitor the subsurface materials and groundwater conditions encountered.

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.

the explorations, we recommend that one or more "test" piles be installed to verify design parameters and estimate an approximate depth of the piles that will be needed for budgeting purposes. The piles should be spaced a minimum of three feet apart to avoid a grouping effect on the piles.

Due to the relatively small slenderness ratio of pin piles, maintaining pin pile confinement and lateral support is essential in preventing pile buckling. Pin piles should be suitably embedded into the reinforced concrete. The structural engineer should design the connections of the piles to the foundations.

Vertically driven pin piles do not provide meaningful lateral capacity. Due to the rigid pile support, friction between the foundation and subgrade soil should not be considered as resisting lateral pressures on this structure. We recommend that all lateral loads be resisted on battered pin piles and/or passive resistance on the below-grade portions of the foundations. The upper foot of soil should be neglected when calculating the passive resistance. We recommend using an equivalent fluid density of 150 pcf for calculating the passive resistance.

Retaining Walls

We understand that retaining walls may be incorporated into project plans. 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.

These recommended lateral earth pressures are for a drained granular backfill and are based on the assumption of a horizontal ground surface behind the wall for a distance of at least the subsurface height of the wall, and do not account for 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, slopes, or other surface loads. Also, hydrostatic and buoyant forces should be included if the walls could not be drained. We could consult with the structural engineer regarding

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.

Basement Slab

As mentioned earlier, we recommend that the basement floor slab be designed as a structural slab and fully supported on pin piles. We recommend that slabs be underlain by at least six inches of free-draining gravel with less than three percent by weight passing the 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 may be used to protect the vapor barrier membrane and to aid in curing the concrete; however, this sand layer is optional and is intended to protect the vapor barrier membrane during construction. Other slabs and hard surfaces that may be supported on the existing soils should be underlain by a minimum of two feet of crushed rock or pit-run soils in addition to the capillary break and vapor barrier.

Pavement Subgrade and Other Exterior Hard Surfaces

Pavement and walkway subgrade preparation should be completed as recommended in the **Site Preparation and Grading** and **Structural Fill** subsections of this report. Due to the presence of undocumented fill soils and depending on tolerance to cracking, we recommend that at least the upper two feet of the existing material be removed and replaced with granular structural fill or crushed rock. If possible, the subgrades should be proof-rolled with a heavy, rubber-tired piece of equipment, to identify soft or yielding areas that may require repair prior to placing any structural fill and prior to placing the pavement base course. We should be retained to observe the proof-rolling and to recommend repairs prior to placement of the asphalt or hard surfaces. The hard surface section should be thickened and reinforced with rebar where applicable to further reduce the effects of settlement due to the loose/soft soils, but potential long-term cracking should still be expected. Some cracking and long-term settlement should still be anticipated.

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.

USE OF THIS REPORT

NGA has prepared this report for David and Joan Loney 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.

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.

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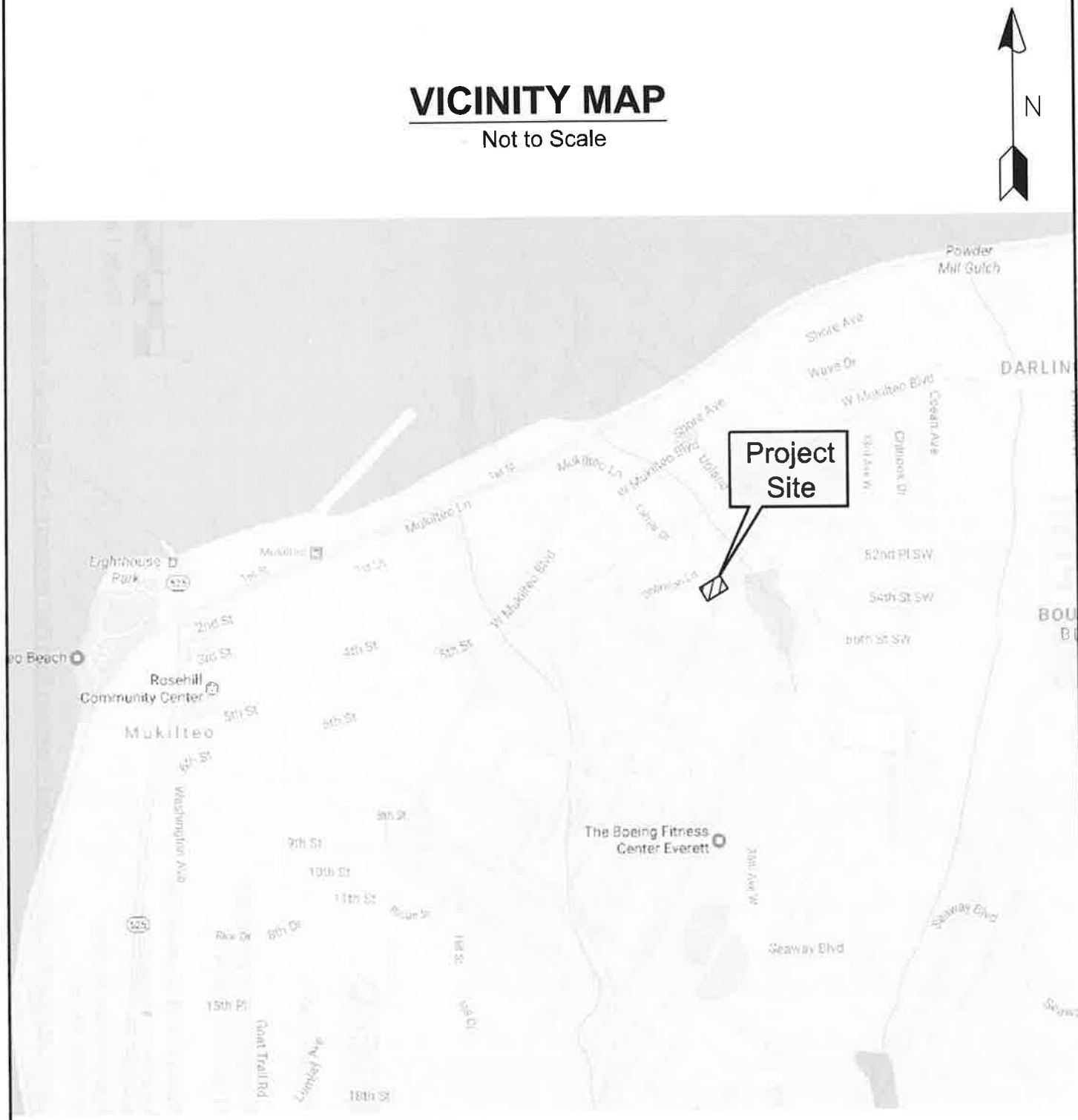
VICINITY MAP

Not to Scale



Mukilteo, WA

Project Number 971416	Loney Residence Development Vicinity Map	NELSON GEOTECHNICAL ASSOCIATES, INC. NGA GEOTECHNICAL ENGINEERS & GEOLOGISTS 17311-135th Ave. NE A-500 Woodinville, WA 98072 (425) 486-1669 / Fax 481-2510 Snohomish County (425) 339-1869 Wenatchee/Chelan (509) 885-7696 www.nelsongeotech.com
Figure 1		

No.	Date	Revision	By	CK
1	10/7/16	Original	DPN	ABR

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Project Number 971416

Figure 3

Loney Residence Development
Cross-Section A-A'

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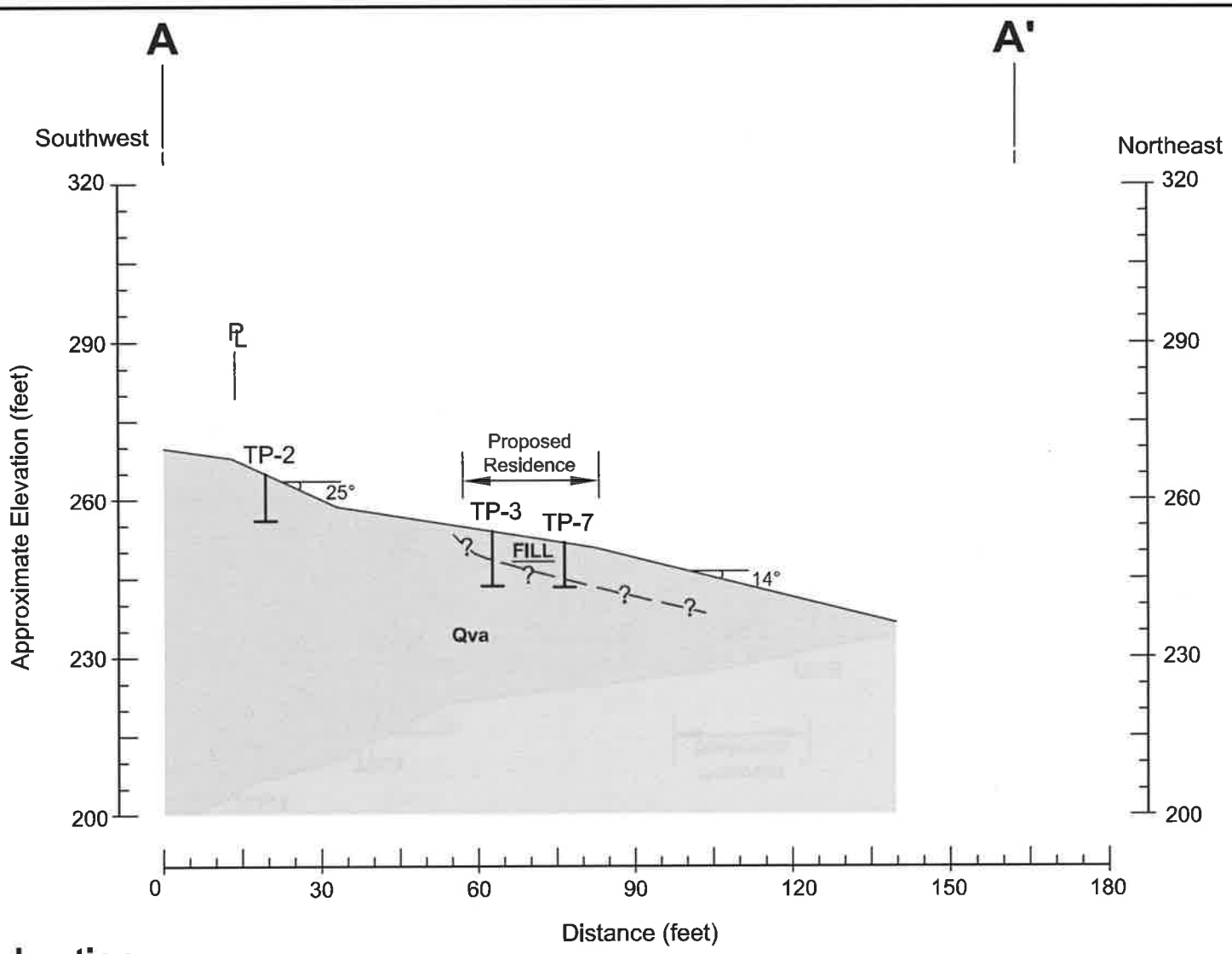
1	10/7/16	Original	DPN	ABR



Exploration

Test Pit Designation → TP-1

Groundwater Level During Exploration →

Geologic Contact (approximate) → ?

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

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

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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, FLAT 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

Project Number 971416	Loney Residence Development Soil Classification Chart	NELSON GEOTECHNICAL ASSOCIATES, INC. NGA GEOTECHNICAL ENGINEERS & GEOLOGISTS	No.	Date	Revision	By	CK
Figure 5		17311-135th Ave. NE, A-500 Woodinville, WA 98072 (425) 486-1669 / Fax 481-2510 Snohomish County (425) 337-1669 Wenatchee/Chelan (509) 665-7696 www.nelsongeotech.com	1	10/7/16	Original	DPN	ABR

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LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
TEST PIT FOUR		
0.0 – 0.2		GRASS AND ROOTS
0.2 – 0.5		DARK BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, IRON-OXIDE STAINING, AND ROOTS (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL**)
0.5 – 9.0		BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, IRON-OXIDE WEATHERING, METAL SCRAPS, PLASTIC GARBAGE, AND IRON-OXIDE WEATHERING (LOOSE TO MEDIUM DENSE, MOIST) (**FILL**)
9.0 – 10.0		GRAY, SILT WITH FINE SAND INTERMIXED WITH BROWN, FINE TO MEDIUM SAND WITH SILT, WOOD DEBRIS (BURIED LOG) AND TRACE GRAVEL (LOOSE TO MEDIUM DENSE, MOIST) (**FILL**)
		SAMPLES WERE COLLECTED AT 2.5, 5.5, 8.3, AND 10.0 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT COMPLETED AT 10.0 FEET ON 10/6/16
TEST PIT FIVE		
0.0 – 0.2		GRASS AND ROOTS
0.2 – 1.0		DARK BROWN, SILTY FINE TO MEDIUM SAND WITH IRON-OXIDE STAINING, ROOTS, AND TRACE GRAVEL (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL**)
1.0 – 9.5		BROWN TO ORANGE-BROWN, FINE TO MEDIUM SAND WITH SILT, GRAVEL, WOOD DEBRIS, ORGANICS, AND INTERMIXED SILT WITH FINE SAND LAYERS (LOOSE TO MEDIUM DENSE, MOIST) (**FILL**)
9.5 – 10.5		GRAY-BROWN TO ORANGE BROWN, FINE TO MEDIUM SAND WITH SILT, GRAVEL, COARSE SAND POCKETS, AND IRON-OXIDE WEATHERING (MEDIUM DENSE TO DENSE) (**FILL**)
		SAMPLES WERE COLLECTED AT 4.0, 8.5, 9.4, AND 10.5 GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT COMPLETED AT 10.5 FEET ON 10/6/16
TEST PIT SIX		
0.0 – 0.2		GRASS AND ROOTS
0.2 – 0.8		DARK BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, IRON-OXIDE STAINING, AND ROOTS (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL**)
0.8 – 11.0		ORANGE-BROWN TO GRAY-BROWN, FINE TO MEDIUM SAND WITH SILT, INTERMIXED GRAVELLY FINE TO COARSE SAND POCKETS AND SILT WITH FINE SAND LENSES, ASPHALT GRINDINGS AT APPROXIMATELY 1.0 FEET, ORGANIC DEBRIS, BURIED LOG AT APPROXIMATELY 6.0 FEET, AND IRON-OXIDE STAINING (LOOSE TO MEDIUM DENSE, MOIST) (**FILL**)
		SAMPLES WERE COLLECTED AT 4.0, 6.0, 10.5, AND 11.0 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT COMPLETED AT 11.0 FEET ON 10/6/16