LIU & ASSOCIATES, INC.

Geotechnical Engineering | Engineering Geology | Earth Science

May 5, 2015

Mr. Mike Appleby
Clearwater Homes, LLC
14227 Evergreen Way
Stanwood, WA 98292

Dear Mr. Appleby:

Subject: Geotechnical Investigation
Southend - Woodinville
NE 205th Street & 132nd Avenue NE
Woodinville, Washington
L&A Job No. 15-028

INTRODUCTION

We understand that a residential development project is proposed for the subject property, located at the southeast corner of the intersection of NE 205th Street and 132nd Avenue NE in Woodinville, Washington. We also understand the proposed development is to plat the site into nine single-family building lots with supporting infrastructure. The wetland located on the central south side of the project site is to remain undisturbed. At your request, we have completed a geotechnical investigation for the subject development project. The purpose of this investigation is to explore and characterize subsurface conditions of the project site and provide geotechnical recommendations of grading, site stabilization, onsite stormwater disposal, erosion mitigation, surface and ground water drainage control, and foundation support to buildings for the proposed development. Presented in this report are our findings of the site conditions, conclusion, and geotechnical recommendations.

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PROJECT DESCRIPTION

For our use in this investigation, you provided us with a topographic survey and plat plan of the proposed development. According to this plan, a wetland is outlined on the central south side of the project site where a south-trending trough is located. The tract at the northeast corner of the site is reserved for stormwater disposal. The remaining area of the site is to be platted into 9 lots with a paved driveway off NE 205th Street to access the central and eastern lots. The western lots will be accessed from 132nd Avenue SE. The project site slopes down generally easterly with the central south side slopes down to the south. There will be minor to some cut and fill for site grading. Stormwater collected over impervious surfaces will be disposed on site in the tract at the northeast corner of the site. The residential buildings to be built on the lots will be above-grade, wood-framed structures.

SCOPE OF SERVICES

Our scope of services for this study comprises specifically the following:

1. Review geologic and soil conditions at and in the vicinity of the project site based on a published geologic map.

2. Explore subsurface (soil and groundwater) conditions of the site with test pits to depths where a firm bearing soil layer and/or an infiltratable soil stratum is encountered or to the maximum depth (about 10 feet) capable by the backhoe used in subsurface exploration, whichever is encountered first.

3. Conduct laboratory soil particle size distribution test in accordance with ASTM D422 on two to four soil samples obtained from targeted soil layers in test pits

suitable for stormwater disposal by infiltration. The results of the tests will be used in determining design infiltration rates of the soil layers in accordance with the USDA Texture Triangle and the 2012 Stormwater Management Manual for Western Washington by Washington State Department of Ecology.

4. Perform necessary geotechnical engineering analyses based on subsurface data obtained from test pits.

5. Prepare a written report to present our findings, conclusion, and geotechnical recommendations.

SITE CONDITIONS

SURFACE CONDITION

The general location of the project site is shown on Plate 1 – Vicinity Map. The site is situated on a broad, gentle to moderately-steep, easterly-to-southeasterly declining slope. It is located at the southeast corner of the intersection of NE 205th Street and 132nd Avenue NE, and is adjoined by residential development to the east and south. The ground within the site generally slopes down very gently to gently to the east with it central south side, where the wetland is, sloping moderately to steeply to the south.

An existing house and a storage shed occupy the southwest quadrant of the site. The open space of the site is mostly covered by lawn grass with brush growing along the east boundary. Scattered trees dot the north and west boundaries of the site.

GEOLOGIC SETTING

The Geologic Map of King County, Washington, by Derek B. Booth, Kathy A. Troost and Aaron P. Wisher (2007) was referenced for the geologic and soil conditions at the property. According to this publication, the surficial geologic units at and in the vicinity of the project site are mapped Vashon Till (Q_{vt}) underlain by Advance Outwash (Q_{va}).

The geology of the Puget Sound Lowland has been modified by the advance and retreat of several glaciers in the past one million years or so and the subsequent deposits and erosions. The latest glacier advanced to the Puget Sound Lowland is referred to as the Vashon Stade of the Fraser Glaciation which had occurred during the later stages of the Pleistocene Epoch, and retreated from the region some 12,500 years ago.

The deposits of the Vashon till soil unit were plowed directly under glacial ice during the most recent glacial period as the glacier advanced over an eroded, irregular surface of older formations and sediments. This soil unit is composed of a mixture of unsorted clay, silt, sand, gravel, and scattered cobbles and boulders. The Vashon till soil over the top two to three feet is normally weathered to a medium-dense state, and is moderately permeable and compressible. The underlying fresh till deposit, commonly referred to as "hard pan", is very-dense and cemented. The fresh till soil possesses a compressive strength comparable to that of low-grade concrete and can remain stable on steep natural slopes or man-make cuts for a long period. The fresh till deposit can provide excellent foundation support with little or no settlement, but is also of extremely low permeability and would hardly allow stormwater to seep through.

The deposits of the advance outwash soil unit, normally underlying the Vashon till soil unit, are composed of stratified sand and gravel with very minor amount of silt and clay, deposited by the meltwater of advancing glacial ice of the last glacier then overridden by the still advancing glacier. Due to their generally granular composition, the advance outwash deposits are of moderately high permeability and drains fairly well. The advance outwash deposits are generally dense to very dense in their natural, undisturbed state. The underlying fresh advance outwash deposits in their native, undisturbed state can provide good foundation support with little settlement expected for light to moderately heavy structures.

SOIL CONDITION

Subsurface conditions of the project site were explored with five test pits. The test pits were excavated on March 23, 2015, with a rubber-track backhoe to depths from 8.0 to 11.0 feet. The approximate locations of the test pits are shown on Plate 2 - Site and Exploration Location Plan. The test pits were located with either a tape measure or by visual reference to existing topographic features in the field and on the topographic survey map, and their locations should be considered as only accurate to the measuring method used.

A geotechnical engineer from our office was present during subsurface exploration, examined the soil and geologic conditions encountered, and completed logs of the test pits. Soil samples obtained from each soil layer in the test pits were visually classified in general accordance with United Soil Classification System, a copy of which is presented on Plate 3. Detailed descriptions of soils encountered during site exploration are presented in test pit logs on Plates 4 through 6.

Test Pits 1 and 2, located on the east and west sides of the site, respectively, encountered a layer of loose, organic, fill/topsoil about 2 feet thick. More and thicker fill may exist along the east side of the site and near the wetland. Test Pits 1, 4 and 5 encountered a layer of loose, organic topsoil, about 12 to 16 inches, mantling the site. A thin layer of relic topsoil was found underlying the fill in Test Pit 3. The fill and topsoil are underlain by a layer of weathered soil of brown to light-brown to light-gray, medium-dense, silty fine sand with trace gravel, about 1.5 to 3.4 feet thick. The weathered soil layer is underlain by a layer of glacial till soil of light-gray, very-dense, gravelly, silty, fine sand with occasional cobble, about 2.4 to 3.0 feet thick. Underlying the glacial till soil to the depths explored is an advance outwash deposit of light-gray, dense, gravelly, silty, fine to medium sand.

GROUNDWATER CONDITION

Groundwater was encountered in the advance outwash deposit in all test pits but Test Pit 5. Groundwater seepage varied from a trickle at 9.5 feet deep in Test Pits 1 and 2, to 1 to 2 gallons per minute at 8.0 to 9.5 feet deep in Test Pits 3 and 4. The test pits were excavated in late winter to early spring when the groundwater level is normally at its highest.

The very-dense, cemented, fresh till deposit underlying the site at shallow depth is of extremely low permeability and would perch stormwater infiltrating into the more permeable surficial soils, but this shallow perched groundwater was not encountered by the test pits. The advance outwash deposit underlying the till soil layer is of moderately high permeability and would allow stormwater to seep through. The amount of and the depth to the near-surface groundwater perched on the glacial till soil layer would fluctuate seasonally, depending on precipitation, surface runoff, ground vegetation cover, site utilization, and other factors.

GEOLOGIC HAZARDS AND MITIGATION

Landslide Hazard

The site is underlain at shallow depth by very-dense till and dense advance outwash soils. These deposits are of very-high to high shear strength and are highly resistant against slope failures. Also, the site is gently to moderately sloped. Therefore, the potential for deep-seated slides to occur on the site should be minimal.

Erosion Hazard

The surficial fill, topsoil, and weathered soil are of low resistance against erosion, while the underlying very-dense till deposits are of high resistance against erosion. The weaker surficial soils on steeper areas of the site could be gradually eroded if they are devoid of vegetation cover and saturated. However, because the site is gentle to moderate-steep, the erosion hazard of the site should be minimal. To further mitigated erosion hazard of the site, vegetation cover outside of construction areas should be protected and maintained and concentrated stormwater should not be discharged uncontrolled onto the ground within the site. Stormwater over impervious surfaces, such as roofs and paved driveways, should be captured by underground drain line systems connected to roof downspouts and catch basins installed in paved areas. Water collected into these drain line systems should be tightlined to discharge into a storm sewer or suitable stormwater disposal facilities, such as infiltration trenches.

Seismic Hazard

The Puget Sound region is in an active seismic zone. The project site is underlain at shallow depth by very-dense till and dense advance outwash deposits of very-high to high shear strength. Therefore, the potential for seismic hazards, such as landslides, liquefaction, lateral soil spreading, to occur on the site should be minimal if the erosion mitigation, drainage control, and site stabilization measures recommended in this report are fully implemented. The proposed residential buildings, however, should be designed for seismic forces induced by strong earthquakes. Based on the soil conditions encountered by the test pits, it is our opinion that Seismic Use Group I and Site Class C should be used in the seismic design of the proposed residences in accordance with the 2012 International Building Code (IBC).

DISCUSSION AND RECOMMENDATIONS

GENERAL

Based on the soil conditions encountered by test pits excavated on the site, it is our opinion that the project site is suitable for the proposed development from the geotechnical engineering viewpoint, provided that the recommendations in this report are fully implemented and observed during and following completion of construction. Conventional footing foundations constructed on or into the underlying very-dense fresh till and/or dense advance outwash soil may be used to support the proposed residential buildings. Unsuitable surficial fill, topsoil, and weathered soil should be stripped within footprint of driveways and areas of structural fill.

The fill, surficial topsoil, and weathered soil contain a high percentage of fines and can be easily disturbed when saturated. Grading work in wet winter months may cause complication and difficulty. Therefore, earth work should be scheduled and completed between April 1 and October 31, if possible. Otherwise, erosion protection and drainage control measures recommended in this report should be implemented for site stabilization and to facilitate earthwork if grading work is to be carried out beyond the above dryer period.

TEMPORARY DRAINAGE AND EROSION CONTROL

The onsite surficial weak soils are sensitive to moisture and can be easily disturbed by construction traffic. A layer of clean, 2-to-4-inch quarry spalls should be placed over areas of frequent traffic, such as the entrances to the site, as required, to protect the subgrade soils from disturbance by construction traffic.

A silt fence should be installed along the downhill sides of construction areas to minimize transport of sediment by storm runoff onto neighboring properties or the street. The bottom of the filter cloth of the silt fences should be anchored in a trench filled with onsite soil.

Intercepting ditches or trench drains should be installed around construction areas, as required, to intercept and drain away storm runoff and near-surface groundwater seepage.

Water captured by such ditches or trench drains should be stored in temporary holding and settling pits onsite. Only clear and clean water may be discharged into the wetland within the site. Discharged water should dispersed over a well vegetated area through a perforated spreader pipe of sufficient length to keep discharged water from causing erosion problem.

Spoil soils should be hauled off of the site as soon as possible. Spoil soils and imported structural fill material to be stored onsite should be stockpiled in areas where the ground is no steeper than 15% grade. Stockpiled spoil soils should be securely covered with plastic tarps, as required, for protection against erosion.

SITE PREPARATION AND GENERAL GRADING

Vegetation within construction limits should be cleared and grubbed. Existing structures to be demolished should have their foundations removed, too. Loose fill, topsoil, and weak weathered soil should be completely stripped down to the very-dense glacial till and/or dense advance outwash soil within the building pads of the proposed residences; while fill, topsoil and unsuitable soil in the root zone should be stripped down to the medium-dense weathered soil, and/or very-dense glacial till, and/or dense advance outwash soil within paved driveways. The exposed soils should be compacted to a non-yielding state with a mechanical compactor and proof-rolled with a piece of heavy earthwork equipment prior to driveway construction.

EXCAVATION AND FILL SLOPES

Under no circumstance should excavation slopes be steeper than the limits specified by local, state and federal safety regulations if workers have to perform construction work in excavated areas. Unsupported temporary cuts greater than 4 feet in height should be no steeper than 1H:1V in fill, topsoil, weathered soil, and may be vertical in the underlying very-dense fresh till and dense advance outwash soils if the overall depth of cut does not exceed 15 feet. Otherwise, cut in fresh till and advance outwash soils should be no steeper than 3/4H:1V. Permanent cut banks should be no steeper than 2-1/4H:1V in fill, topsoil and weathered soil, and no steeper than 1-1/2H:1V in the underlying very-dense fresh till and dense advance outwash soils. The soil units and the stability of cut slopes should be observed and verified by a geotechnical engineer during excavation.

Permanent fill embankments required to support structural or traffic load should be constructed with compacted structural fill placed over undisturbed, proof-rolled, firm, native soils after the surficial unsuitable soils are completely stripped. The slope of permanent fill embankments should be no steeper than 2-1/4H:1V. Upon completion, the sloping face of permanent fill embankments should be thoroughly compacted to a non-yielding state with a hoe-pack. Permanent fill embankments constructed over ground of 15% or more should be structurally supported laterally.

The above recommended cut slopes and fill embankments are under the condition that groundwater seepage would not be encountered during construction. If groundwater is encountered, the grading work should be immediately halted and the slope stability re-evaluated. The slopes may have to be flattened and other measures taken to stabilize the slopes. Stormwater should not allowed to flow uncontrolled over cut slopes and fill embankments. Temporary cuts should be covered by plastic sheets, as required, for erosion protection. Permanent cut slopes or fill embankments should be seeded and vegetated as soon as possible for erosion protection and long-term stability, and should be covered with clear plastic sheets, as required, to protect them from erosion until the vegetation is fully established.

STRUCTURAL FILL

Structural fill is the fill that supports structural or traffic load. Structural fill should consist of clean granular soils free of organic, debris and other deleterious substances and with particles not larger than three inches. Structural fill should have a moisture content within one percent of its optimum moisture content at the time of placement. The optimum moisture content is the water content in the soils that enable the soils to be compacted to the highest dry density for a given compaction effort. Onsite soils meeting the above requirements may be used as structural fill. Imported material to be used as structural fill should be clean, free-draining, granular soils containing no more than 5 percent by weight finer than the No. 200 sieve based on the fraction of the material passing No. 4 sieve, and should have individual particles not larger than three inches.

The ground over which structural fill is to be placed should be prepared in accordance with recommendations in the SITE PREPARATION AND GENERAL GRADING and EXCAVATION AND FILL SLOPES sections of this report. Structural fill should be placed in lifts no more than 10 inches thick in its loose state, with each lift compacted to a minimum percentage of the maximum dry density determined by ASTM D1557 (Modified Proctor Method) as follows:

Application	% of Maximum Dry Density
Within building pads and under foundations	95%
Roadway/driveway subgrade	95% for top 3 feet and 90% below
Retaining/foundation wall backfill	92%
Utility trench backfill	95% for top 4 feet and 90% below

In-situ density of structural fill should be tested with a nuclear densometer by a testing agency specialized in fill placement and construction work. Testing frequency should be one test per every 250 square feet per lift of fill.

ONSITE STORMWATER DISPOSAL

General

The advance outwash deposit underlying the project site is of moderately high permeability, and disposal of stormwater onsite by infiltrating into this soil deposit is feasible. Soil samples were obtained from the advance outwash deposit in the test pits. Soil Particle Size Distribution test was conducted on selected soil samples to determine design infiltration rate of the advance outwash deposit.

Soil Samples

Three soil samples, one from each of Test Pits 1, 3, and 5 in the advance outwash deposit were selected for Soil Particle Size Distribution test. These soil samples are described in the table below:

LIST OF SOIL SAMPLES

Sample No.	Test Pit No.	Depth feet	Soil Description
1	TP-1	8 - 9	Dark olive-brown, silty SAND
2	TP-3	7 - 8	Dark-brown, poorly-graded, SAND with silt and gravel
3	TP-5	8 - 9	Olive-brown, silty SAND

The percentages of clay, silt and sand/gravel of the soil samples determined from the soil particle size distribution tests are summarized on Plate A-1. Based on these percentages the soil samples were classified according to the USDA (U.S. Department of Agriculture) Texture Triangle chart, a copy of which is shown on Plate A-2 in the attached Appendix. The classifications of soil samples are presented in the table below:

USDA TEXTURE TRIANGLE CLASSIFICATION OF SOIL SAMPLES

Sample No.	Test Pit No.	Percentage Clay	Percentage Silt	Percentage Sand/Gravel	USDA Texture Triangle Classification
1	TP-1	1.7	11.8	86.5	Sand
2	TP-3	1.6	5.5	92.9	Sand
3	TP-5	2.5	10.6	86.9	Sand

Infiltration Rates

Volume III, Section 3.3.6, Article 3 - Soil Grain Size Analysis Method, of the 2012 Stormwater Management Manual for Western Washington, published by Washington State Department of Ecology, was used to determine estimated design infiltration rates of the targeted advance outwash deposit. This method uses D_{10} , D_{60}, D_{90}, and f_{fines} in calculating the saturated infiltration rate (conductivity), K_{sat} in cm/sec; where D_{10} , D_{60}, D_{90} are the sizes in millimeters of soil particles of 10%, 60%, and 90%, respectively, passing by weight, and f_{fines} is the fraction of the fines passing the No. 200 sieve by weight (i.e., the sum of clay and silt). The values of D_{10} , D_{60}, D_{90}, and f_{fines} are shown or obtained from test result on Plate A-1, and the determination of K_{sat} for the three soil samples are shown in the table below:

ESTIMATED INITIAL INFILTRATION RATES, K_{sat}

Sample No.	Test Pit No.	D_{10} Size	D_{60} Size	D_{90} Size	f_{fines}	[a] K_{sat} cm/sec	K_{sat} in/hour	Design K_{sat} in/hour
1	TP-1	0.0308	0.35	0.91	0.135	0.0158	22.39	5.6
2	TP-3	0.1038	2.06	14.04	0.071	0.0214	30.33	7.58
3	TP-5	0.0282	0.40	7.51	0.131	0.0131	18.71	4.68

[a] $\log_{10}(K_{sat}) = -1.57 + 1.90(D_{10}) + 0.015(D_{60}) - 0.013(D_{90}) - 2.08(f_{fines})$

Recommended Design Infiltration Rate

By applying a factor of safety of 4.0 to K_{sat} values, the design infiltration rates of the soil samples, Design K_{sat}, are determined and presented in the table above. On conservative side, we recommend a design infiltration rate of the advance outwash deposit not to exceed 2.75 iph (inches per hour) be used for the design of infiltration trenches to be used for onsite stormwater disposal for the subject project.

Infiltration Trench Construction

Infiltration trenches should be set back at least 5 feet from property lines and 10 feet from nearby building footing foundations or utility trenches. Infiltration trenches should be located on the downhill side of adjacent residential buildings. The bottom of infiltration trenches should be cut at least one foot into the surface of the advance outwash deposit, but no less than one foot lower than the adjacent footing foundations and utility trenches. Soil condition at bottom of infiltration trenches should be verified by a geotechnical engineer. Stability of trench cut banks should also be verified by a geotechnical engineer during excavation. Impervious collars or clay dams should be installed in tightline trenches to prevent backflow of water from the infiltration trenches to the residences.

The infiltration trenches should be at least 24 inches wide. The side walls of the trenches should be lined with a layer of non-woven filter fabric, such as MIRAFI 140NS. The trenches are then filled with clean, 3/4 to 1-1/2 inch, washed gravel or crushed rock to within about 10 inches of the finish grade. The dispersion pipes should be constructed of 4-inch, rigid, perforated, PVC pipes, and laid level in the gravel or crushed rock filled trenches at about 16 inches or more below the top of trenches. The top of the gravel or crushed rock fill should also be covered with the filter fabric liner. The remaining trenches should then be backfilled with compacted clean onsite soils. The gravel or crushed rock fill should be placed in lifts no more than 10 inches thick in loose state, with each lift compacted to a non-yielding state with a vibratory mechanical compactor. The compaction and densification of trench fill is critical if it is to support driveways. Stormwater captured over paved driveways should be routed into catch basins equipped with an oil-water separator before being released into the infiltration trenches.

BUILDING FOUNDATIONS

Conventional footing foundations may be used to support the proposed residential buildings. The footing foundations should be constructed on or into the underlying, very-dense fresh till and/or dense advance outwash soil, or on structural fill placed over these undisturbed competent basal soils. Water should not be allowed to accumulate in excavated footing trenches. Disturbed soils in footing trenches should be completely removed down to native, undisturbed, fresh till and/or advance outwash soil prior to pouring concrete for the footings.

If the above recommendations are followed, our recommended design criteria for footing foundations are as follows:

- The allowable soil bearing pressure for design of footing foundations, including dead and live loads, should be no greater than 3,000 psf if constructed on or into very-dense fresh till and/or advance outwash soil, and no greater than 2,500 psf if constructed on structural fill placed over these competent basal soils. The footing bearing soils should be verified by a geotechnical engineer after the footing trenches are excavated and before the footings poured.

- The minimum depth to bottom of perimeter footings below adjacent final exterior grade should be no less than 18 inches. The minimum depth to bottom of the interior footings below top of floor slab should be no less than 12 inches.

- The minimum width should be no less than 16 inches for continuous footings, and no less than 24 inches for individual footings, except those footings supporting light-weight decks or porches.

A one-third increase in the above recommended allowable soil bearing pressure may be used when considering short-term, transitory, wind or seismic loads. For footing foundations designed and constructed per recommendations above, we estimate that the maximum total post-construction settlement of the buildings should be 1/2 inch or less and the differential settlement across building width should be 3/8 inch or less.

Lateral loads on the proposed buildings may be resisted by the friction force between the foundations and the subgrade soils or the passive earth pressure acting on the below-grade portion of the foundations. For the latter, the foundations must be poured "neat" against undisturbed soils or backfilled with a clean, free-draining, compacted structural fill. We recommend that an equivalent fluid density (EFD) of 300 pcf (pounds per cubic foot) for the passive earth pressure be used for lateral resistance. The above passive pressure assumes that the backfill is level or inclines upward away from the foundations for a horizontal distance at least twice the depth of the foundations below the final grade. A coefficient of friction of 0.55 between the foundations and the subgrade soils may be used. The above soil parameters are unfactored values, and a proper factor of safety should be used in calculating the resisting forces against lateral loads on the buildings.

SLAB-ON-GRADE FLOORS

Slab-on-grade floors, if used for the residential buildings, should be placed on firm subgrade soil prepared as outlined in the SITE PREPARATION AND GENERAL

EARTHWORK and the STRUCTURAL FILL sections of this report. Where moisture control is critical, the slab-on-grade floors should be constructed on a capillary break which is in turn placed on the compacted subgrade. The capillary break should consist of a minimum 4-inch layer of clean, free-draining, 7/8-inch crushed rock, containing no more than 5 percent by weight passing the No. 4 sieve. A vapor barrier, such as a 6-mil plastic membrane, may be placed over the capillary break, as required, to keep moisture from migrating upwards.

CAST-IN-PLACE CONCRETE WALLS

Building foundation walls restrained at the top from lateral movement are considered unyielding and should be designed for a lateral soil pressure under the at-rest condition. Retaining walls unrestrained at the top from lateral movement may be designed for active soil pressure. For static loading condition, we recommend that an at-rest soil pressure of 50 pcf EFD (equivalent fluid density) and an active soil pressure of 35 pcf EFD be used for the design of building foundation walls and retaining walls, respectively, with a level or descending backslope. For walls with ascending backslope, an additional pressure of 0.75 pcf per degree of the backslope angle above the horizontal should be added to the above design pressures. To counter the above active or at-rest pressure, a passive lateral soil pressure of 300 pcf EFD may be used. This passive pressure value is applicable only to walls with a level or ascending backslope away from the walls for a horizontal distance at least 1.5 times the wall height. For seismic loading condition (100-year earthquake), an additional uniform distribution pressure of 8H psf should be added to the above pressures for wall design. H is the height of walls in feet. To resist against sliding, the friction force between the footings and the subgrade soils may be calculated based on a coefficient of friction of 0.55. The above soil parameters are ultimate values based on a fully drained condition of the walls, and proper factors of safety should be applied in the design of the retaining and basement walls against sliding and overturning failures for static and seismic loadings.

A vertical drainage blanket, at least 12-inch-thick horizontally, consisting of clean, free-draining, pea gravel or washed gravel should be placed against the back of foundation and retaining walls to within 18 inches of the finish grade to prevent accumulation of groundwater behind and buildup of hydrostatic pressure against the walls. This drainage blanket fill should be compacted to a non-yielding state with a vibratory compactor. Structural fill should be used for the remaining wall backfill. The top 18 inches of the backfill may consist of compacted, clean, sandy soils. Heavy compaction equipment should not be allowed within the walls of a horizontal distance equal to that of the wall heights. A 4-inch perforated PVC footing drain pipe, as recommended in the DRAINAGE CONTROL section of this report, should be provided for the basement and retaining walls. The drain lines should be hydraulically connected to the drainage blanket behind the walls and tightlined to a storm sewer.

PAVED DRIVEWAYS

Performance of driveway pavement, including the joint-use driveway from NE 205th Street NE to the project site, is critically related to the conditions of the underlying subgrade soils. We recommend that the subgrade soils under the driveways be treated and prepared as described in the SITE PREPARATION AND GENERAL EARTHWORK section of this report. Prior to placing base material, the subgrade soils should be compacted to a non-yielding state with a vibratory roller compactor and proof-rolled with a piece of heavy construction equipment, such as a fully-loaded dump truck. Any areas with excessive flexing or pumping should be over-excavated and re-compacted or replaced with a structural fill or crushed rock placed and compacted in accordance with the recommendations provided in the STRUCTURAL FILL section of this report.

We recommend that a layer of compacted, 7/8-inch crushed rock base (CRB), be placed for the driveways. This crushed rock base should be at least 6 inches thick for the joint-use driveway and 4 inches thick for the private driveways of the residences. This crushed rock base should be overlain with a 3-inch asphalt treated base (ATB) topped by a 2-inch-thick Class B asphalt concrete (AC) surficial course for the joint-use driveway, and overlain by a 3-inch-thick Class B asphalt concrete (AC) surficial course for the private driveways of the residences.

DRAINAGE CONTROL

Building Footprint Excavation

Footprint excavation for the proposed residential buildings, if encountering groundwater seepage, should have bottom of excavation sloped slightly and ditches excavated along bases of the cut banks to direct collected groundwater into sump pits from which water can be pumped out. A layer of 2-inch crushed rock should be placed over footing bearing subgrade soils, as required, to protect the soils from disturbance by construction traffic. This crushed rock base should be built to a few inches above groundwater level, but not less than 6 inches thick. The crush rock base should be compacted in 12-inch lifts to a non-yielding state with a vibratory mechanical compactor.

Runoff over Impervious Surfaces

Storm runoff over impervious surfaces, such as roofs and paved driveways, should be collected by underground drain line systems connected to downspouts and by catch basins installed in paved roadways, driveways and parking areas. Stormwater thus collected should be tightlined to discharge into a storm sewer or suitable stormwater disposal facilities.

Building Footing Drains

A subdrain should be installed around the perimeter footings of each residential building. The subdrains should consist of a 4-inch-minimum-diameter, perforated, rigid, drain pipe, laid a few inches below bottom of the perimeter footings of the buildings. The trenches and the drain lines should have a sufficient gradient (0.5% minimum) to generate flow by gravity. The drain lines should be wrapped in a non-woven filter fabric sock and completely enclosed in clean washed gravel. The remaining trenches may be backfilled with clean onsite soils. Water collected by the perimeter footing subdrain systems should be tightlined, separately from the roof and surface stormwater drain lines, to discharge into a storm sewer or suitable stormwater disposal facilities.

Surface Drainage

Water should not be allowed to stand in any areas where footings, on-grade slabs, or pavement is to be constructed. Finish ground surface should be graded to direct surface runoff away from the residential buildings. We recommend the finish ground be sloped at a gradient of 3 percent minimum for a distance of at least 10 feet away from the townhome buildings, except in the areas to be paved.

Cleanouts

Sufficient number of cleanouts at strategic locations should be provided for underground drain lines. The underground drain lines should be cleaned and maintained periodically to prevent clogging.

RISK EVALUATION STATEMENT

The subject site is underlain at shallow depth by very-dense fresh till and dense advance outwash soils. These deposits are of very-high and high shear strength and the site should be quite stable. It is our opinion that if the recommendations in this report are fully implemented and observed during and following the completion of construction, the areas disturbed by construction will be stabilized and will remain stable, and will not increase the potential for soil movement. In our opinion, the risk for damages to the proposed development and from the development to adjacent properties from soil instability should be minimal.

LIMITATIONS

This report has been prepared for the specific application to this project for the exclusive use by Clearwater Homes, LLC, and its associates, representatives, consultants and contractors. We recommend that this report, in its entirety, be included in the project contract documents for the information of prospective contractors for their estimating and bidding purposes and for compliance with the recommendations in this report during construction. The conclusions and interpretations in this report, however, should not be construed as a warranty of the subsurface conditions. The scope of this study 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 this report for design considerations. All geotechnical construction work should be monitored and inspected by a geotechnical engineer during construction.

Our recommendations and conclusions are based on the geologic and soil conditions encountered in the test pits, and our experience and engineering judgment. The conclusions and recommendations are professional opinions derived in a manner consistent with the level of care and skill ordinarily exercised by other members of the profession currently practicing under similar conditions in this area. No warranty, expressed or implied, is made.

The actual subsurface conditions of the site may vary from those encountered by the test pits excavated on the site. The nature and extent of such variations may not become evident until construction starts. If variations appear then, we should be retained to re-evaluate the recommendations of this report, and to verify or modify them in writing prior to proceeding further with the construction of the proposed development of the site.

CLOSURE

We are pleased to be of service to you on this project. Please feel free to call us if you have any questions regarding this report or need further consultation.

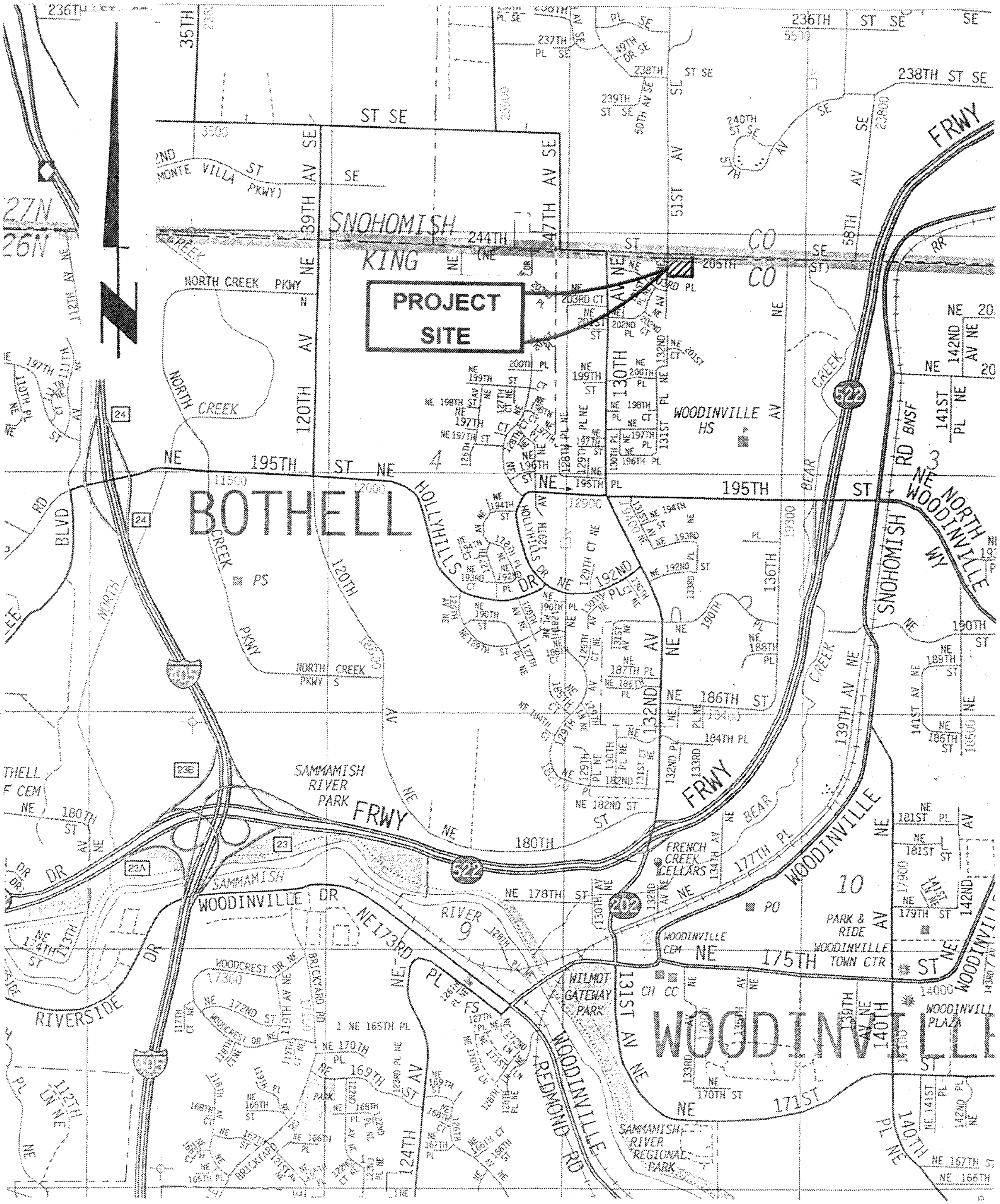
TEONG S. LIU
STATE OF WASHINGTON
27589
REGISTERED
PROFESSIONAL ENGINEER

5/5/2015

Yours very truly,
LIU & ASSOCIATES, INC.

J. S. (Julian) Liu, Ph.D., P.E.
Consulting Geotechnical Engineer

Attach.: Six plates and appendix



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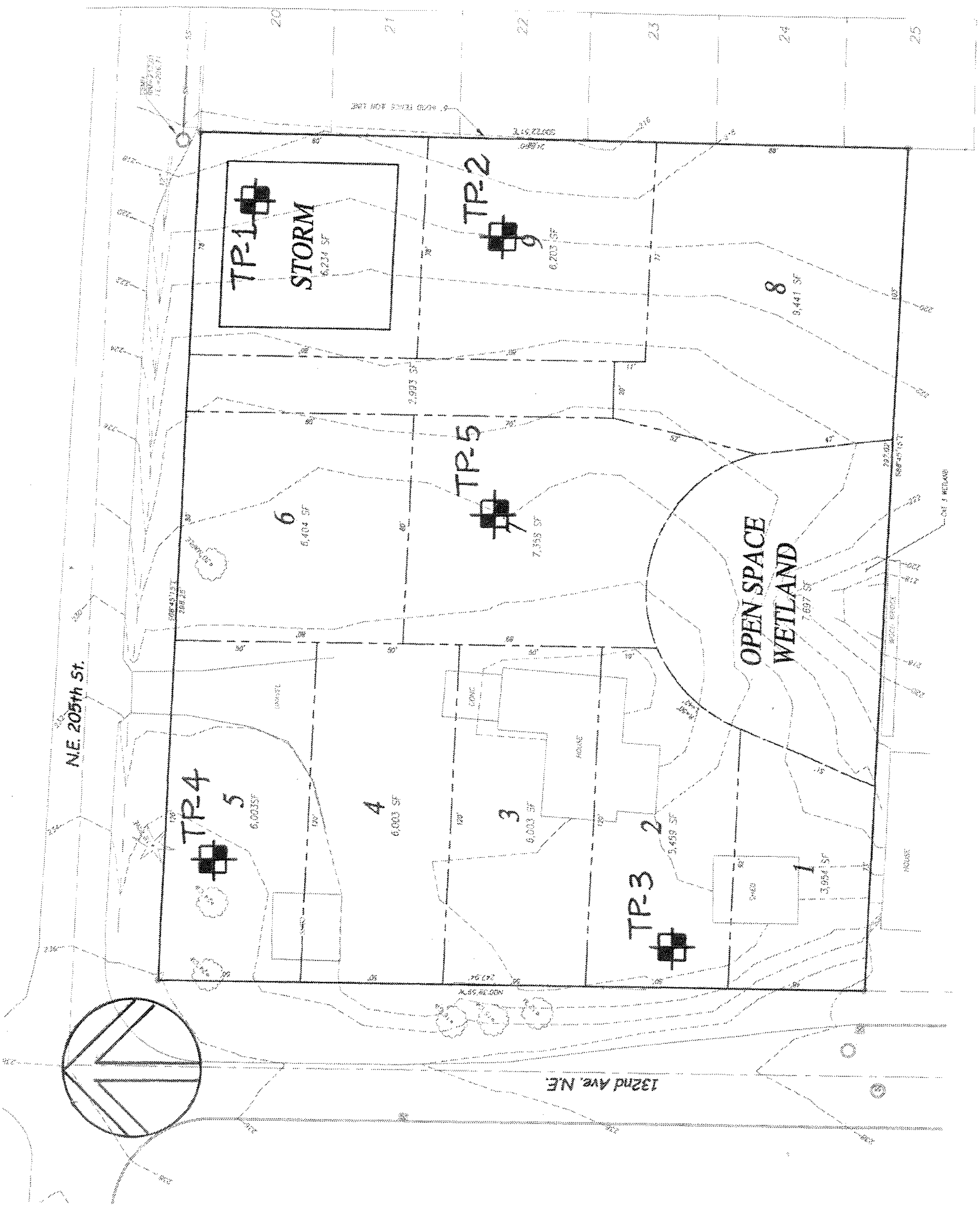
VICINITY MAP
SOUTHEND - WOODINVILLE
NE 205TH STREET & 132ND AVENUE NE
WOODINVILLE, WASHINGTON

JOB NO. 15-028	DATE 4/21/2015	PLATE 1



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SITE AND EXPLORATION LOCATION PLAN
SOUTHEND - WOODINVILLE
NE 205TH STREET & 132ND AVENUE NE
WOODINVILLE, WASHINGTON

JOB NO. 15-028	DATE 4/21/2015	PLATE 2

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS MORE THAN 50% RETAINED ON THE NO. 200 SIEVE	GRAVEL MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50% OF COARSE FRACTION PASSING 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% PASSING ON THE NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50%	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILTY 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 SILT, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT AND OTHER HIGHLY ORGANIC SOILS

NOTES:

1. FIELD CLASSIFICATION IS BASED ON VISUAL EXAMINATION OF SOIL IN GENERAL ACCORDANCE WITH ASTM D2488-83.
2. SOIL CLASSIFICATION USING LABORATORY TESTS IS BASED ON ASTM D2487-83.
3. DESCRIPTIONS OF SOIL DENSITY OR CONSISTENCY ARE BASED ON INTERPRETATION OF BLOW-COUNT DATA, VISUAL APPEARANCE OF SOILS, AND/OR TEST DATA.

SOIL MOISTURE MODIFIERS:

DRY - ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH

SLIGHTLY MOIST - TRACE MOISTURE, NOT DUSTY

MOIST - DAMP, BUT NO VISIBLE WATER

VERY MOIST - VERY DAMP, MOISTURE FELT TO THE TOUCH

WET - VISIBLE FREE WATER OR SATURATED, USUALLY SOIL IS OBTAINED FROM BELOW WATER TABLE

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UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE 3

TEST PIT NO. 1

Logged By: JSL   Date: 3/23/2015   Ground El. ±

Depth ft.		USCS CLASS.	Soil Description	Sample No.	W %	Other Test
1		OL	Dark-brown to brown, loose, organic, silty fine SAND, moist (TOPSOIL)			
2 3 4 5		SM	Brown to light-brown, medium-dense, silty fine SAND, trace gravel, moist			
6 7		SM	Light-gray, dense, gravelly, silty, fine SAND, weakly-cemented, moist GLACIAL TILL)			
8 9 10		SM	Light-gray, dense, gravelly, silty, fine to medium SAND, very moist (ADVANCE OUTWASH)			
11			Test pit terminated at 10.5 ft; trickle groundwater seepage @ 9.5 ft.			

TEST PIT NO. 2

Logged By: JSL   Date: 3/23/2015   Ground El. ±

Depth ft.		USCS CLASS.	Soil Description	Sample No.	W %	Other Test
1 2		OL	Dark-brown to brown, loose, organic, silty fine SAND, with logs and plastic bottles, moist (TOPSOIL/FILL)			
3 4		SM	Light-brown to light-gray, medium-dense, silty fine SAND, trace gravel, moist			
5 6 7		SM	Light-gray, very-dense, gravelly, silty, fine SAND, occasional cobble, cemented, moist (GLACIAL TILL)			
8 9 10 11		SM	Light-gray, dense, gravelly, silty, fine to medium SAND, very moist (ADVANCE OUTWASH)			
12			Test pit terminated at 11.0 ft; trickle groundwater seepage @ 9.0 ft.			

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TEST PIT LOGS
SOUTHEND - WOODINVILLE
NE 205TH STREET & 132ND AVENUE NE
WOODINVILLE, WASHINGTON

JOB NO. 15-028 | DATE 3/27/2015 | PLATE 4

TEST PIT NO. 3

Logged By: JSL Date: 3/23/2015 Ground El. ±

Depth ft.		USCS CLASS.	Soil Description	Sample No.	W %	Other Test
1		OL	Dark-brown to brown, loose, organic, silty fine SAND, some gravel, moist (TOPSOIL/FILL)			
2		OL	Dark-brown, loose, organic, silty fine SAND, moist (relic TOPSOIL)			
3		SM	Brown, medium-dense, silty fine SAND, some gravel, moist			
4–5		SM	Brown-gray, very-dense, gravelly, silty, fine SAND, occasional cobble, cemented, moist GLACIAL TILL)			
6–7		SM	Brown-gray, dense, gravelly, silty, fine to coarse SAND, very moist (ADVANCE OUTWASH)			
8						
9						
10						
11						
12			Test pit terminated at 11.0 ft; groundwater seepage @ 8.0 ft.			

TEST PIT NO. 4

Logged By: JSL Date: 3/23/2015 Ground El. ±

Depth ft.		USCS CLASS.	Soil Description	Sample No.	W %	Other Test
1		OL	Dark-brown, loose, organic, silty fine SAND, moist (TOPSOIL)			
1–2		SM	Light-brown, medium-dense, silty fine SAND, trace gravel, moist			
3						
4–5		SM	Light-gray, very-dense, gravelly, silty, fine SAND, occasional cobble, cemented, moist (GLACIAL TILL)			
6						
7–8		SM	Light-gray, dense, silty, fine to medium SAND, trace to some gravel, very moist (ADVANCE OUTWASH)			
9						
10						
11						
12			Test pit terminated at 11.0 ft; groundwater seepage @ 9.5 ft.			

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TEST PIT LOGS
SOUTHEND - WOODINVILLE
NE 205TH STREET & 132ND AVENUE NE
WOODINVILLE, WASHINGTON

JOB NO. 15-028 | DATE 3/27/2015 | PLATE 5

TEST PIT NO. 5

Logged By: JSL   Date: 3/23/2015   Ground El. ±

Depth ft.		USCS CLASS.	Soil Description	Sample No.	W %	Other Test
0–1.5		OL	Crushed rock in dark-brown, loose, organic, silty fine SAND matrix, moist (TOPSOIL)			
1.5–4.5		SM	Brown, medium-dense, silty fine SAND, trace gravel, moist			
4.5–7		SM	Light-gray, dense, silty fine SAND, trace gravel, weakly-cemented, moist (GLACIAL TILL)			
7–10.5		SM	Light-gray, dense, silty, fine to medium SAND, trace gravel, moist (ADVANCE OUTWASH)			
			Test pit terminated at 10.5 ft; groundwater not encountered.			

TEST PIT NO. ______

Logged By: ______   Date: ______   Ground El. ±

Depth ft.		USCS CLASS.	Soil Description	Sample No.	W %	Other Test

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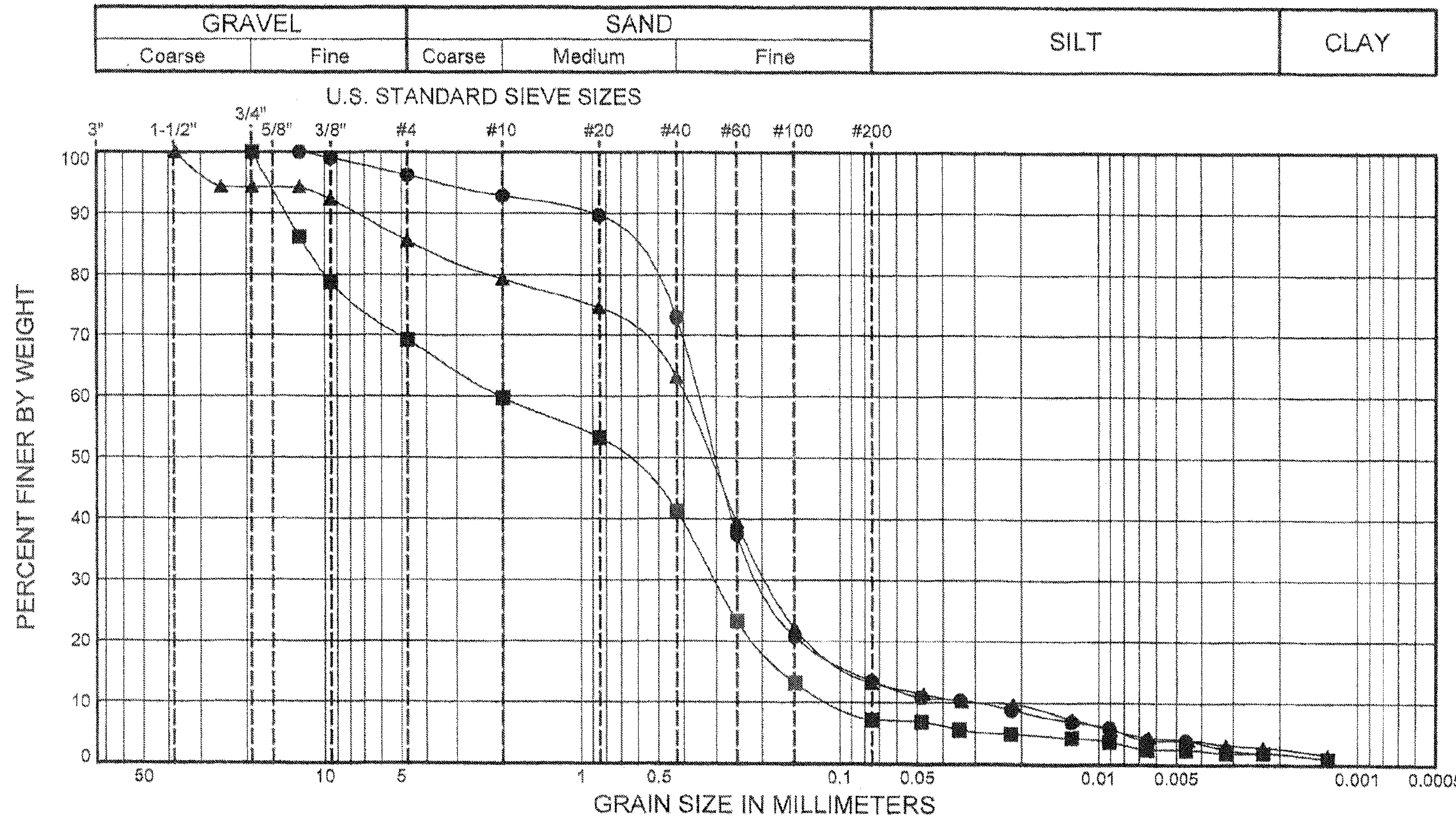
TEST PIT LOGS
SOUTHEND - WOODINVILLE
NE 205TH STREET & 132ND AVENUE NE
WOODINVILLE, WASHINGTON

JOB NO. 15-028 | DATE 3/27/2015 | PLATE 6

APPENDIX

Soil Particle Size Distribution Test Report
Southend - Woodinville
NE 205th Street NE and 132nd Avenue NE
Woodinville, Washington
L&A Job No. 15-028

LIU & ASSOCIATES, INC.



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	D90	D60	D10	Gravel %	Sand %	Silt %	Clay %
●	TP-1	S-1	8.0 - 9.0	(SM) Dark olive brown, silty SAND	18	0.91	0.35	0.0308	3.8	82.7	11.8	1.7
■	TP-3	S-2	7.0 - 8.0	(SP-SM) Dark brown, poorly graded SAND with silt and gravel	13	14.04	2.06	0.1038	30.8	62.0	5.5	1.6
▲	TP-5	S-3	8.0 - 9.0	(SM) Olive brown, silty SAND	13	7.51	0.40	0.0282	14.5	72.4	10.6	2.5

HWA GEOSCIENCES INC.

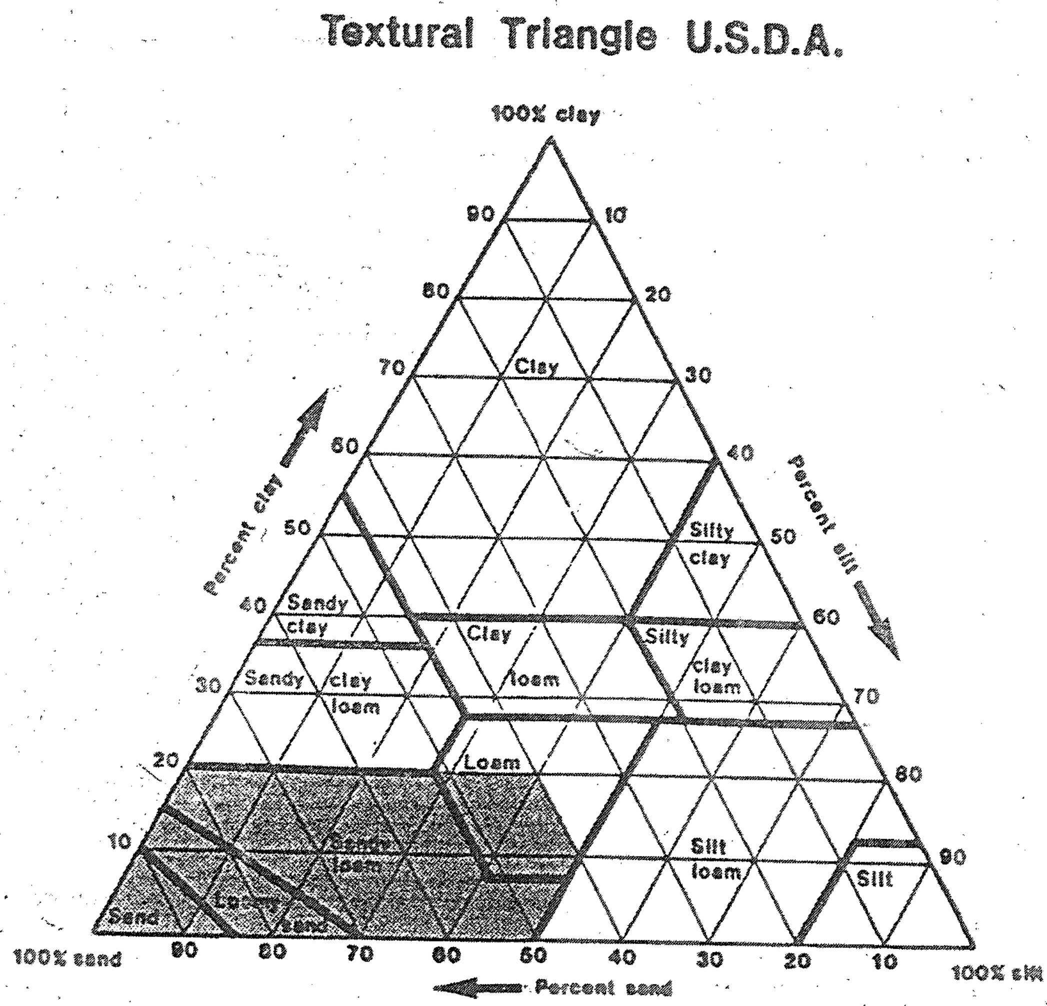
Laboratory Testing for Liu & Associates
R. Appleby Plat
Client Project #15-028

PLATE A-1

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2012-025 T6000 FIGURE: 1

HWA GRSZ D90-D60-D10 2012-025 T6000.GPJ 4/13/15



Shaded area is applicable for design of infiltration BMPs

Figure 3.27 USDA Textural Triangle

Source: U.S. Department of Agriculture

PLATE A-2