GEOTECHNICAL ENGINEERING STUDY
PROPOSED KUSAK CLUSTER SUBDIVISION
436™ AVENUE SOUTHEAST AND SOUTHEAST 147™ LANE
KING COUNTY (NORTH BEND), WASHINGTON

ES-5642
PREPARED FOR
KUSAK TREE FARM, LLC

January 3, 2018

Adam Z. Shier, G.I.T.
Staff Geologist

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GEOTECHNICAL ENGINEERING STUDY
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Important Information About Your Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. And no one—not even you—should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

• not prepared for you,
• not prepared for your project,
• not prepared for the specific site explored, or
• completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

• the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
• elevation, configuration, location, orientation, or weight of the proposed structure,
• composition of the design team, or
• project ownership.

As a general rule, always inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. Do not rely on a geotechnical engineering report whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. Always contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report’s Recommendations Are Not Final

Do not overly on the construction recommendations included in your report. Those recommendations are not final, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual
subsurface conditions revealed during construction. The geotechnical engineer who developed your report cannot assume responsibility or liability for the report’s recommendations if that engineer does not perform construction observation.

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members’ misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team’s plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer’s Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, but recognize that separating logs from the report can elevate risk.

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, but prefaced it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report’s accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled “limitations” many of these provisions indicate where geotechnical engineers’ responsibilities begin and end, to help others recognize their own responsibilities and risks. Read these provisions closely. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a geoenvironmental study differ significantly from those used to perform a geotechnical study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations, e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Unanticipated environmental problems have led to numerous project failures. If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. Do not rely on an environmental report prepared for someone else.

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the express purpose of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; none of the services performed in connection with the geotechnical engineer’s study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.

Rely, on Your ASFE-Member Geotechnical Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

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January 3, 2018
ES-5642

Kusak Tree Farm, LLC
3910 – 46th Avenue South
Seattle, Washington 98188-1210

Attention: Mr. Jim Kusak

Dear Mr. Kusak:

Earth Solutions NW, LLC (ESNW) is pleased to present this report titled “Geotechnical Engineering Study, Proposed Kusak Cluster Subdivision, 436th Avenue Southeast and Southeast 147th Lane, King County (North Bend), Washington”. Based on the results of our investigation, the proposed project is feasible from a geotechnical standpoint. Our field observations indicate the site is underlain primarily by alluvium deposits. During our subsurface exploration completed on November 10, 2017, groundwater seepage was not encountered at the test pit locations.

In our opinion, the proposed residential structures can be constructed on conventional continuous and spread footing foundations bearing on competent native soil, recompacted native soil, or new structural fill. In general, competent native soil suitable for support of foundations will likely be encountered beginning at depths of about two to three feet below existing grades. Where loose or unsuitable soil conditions are exposed at foundation subgrade elevations, compaction of soils to the specifications of structural fill, or overexcavation and replacement with suitable structural fill, will be necessary. Based on current plans, cuts of approximately 10 feet or less will be required to accommodate the proposed grade changes across the site.

With respect to site infiltration, the native gravelly sand encountered at relatively shallow depths possesses a moderate to high infiltration capacity. In our opinion, infiltration is feasible for accommodating site stormwater runoff, provided the recommendations within this report are incorporated into the final design.

Recommendations for foundation design, site preparation, drainage, and other pertinent recommendations are provided in this study. We appreciate the opportunity to be of service to you on this project. If you have questions regarding the content of this geotechnical engineering study, please contact us.

Sincerely,

EARTH SOLUTIONS NW, LLC

Adam Z. Shier, G.I.T.
Staff Geologist
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INTRODUCTION

General

This geotechnical engineering study was prepared for the proposed residential development to be completed directly west of the intersection between 436th Avenue Southeast and Southeast 147th in King County (North Bend), Washington. The purpose of this study was to provide geotechnical recommendations for currently proposed development plans. Our scope of services for completing this study included the following:

- Completing subsurface explorations for purposes of characterizing site soils and groundwater conditions;
- Completing laboratory testing of soil samples collected at the test pit locations;
- Conducting engineering analyses, and;
- Preparation of this report.

The following documents and maps were reviewed as part of our report preparation:

- Preliminary Water Plan, provided by Barghausen Consulting Engineers, Inc., dated November 11, 2017;
- King County Code, Title 21A, Critical Areas;
- Web Soil Survey (WSS) online resource, maintained by the Natural Resources Conservation Service under the United States Department of Agriculture;
- Liquefaction Susceptibility for King County (Map 11-5), incorporating data from the Washington State Department of Natural Resources, May 2010;
- 2009 King County Surface Water Design Manual (2009 KCSWDM), by King County, Washington, and;
- Joe D. Dragovich, Timothy J. Walsh, Megan L. Anderson, & et al, Geologic Map of the North Bend 7.5-minute Quadrangle, King County, Washington, February 2009.
Project Description

The preliminary site layout indicates the site will be developed with 11 single-family residences, open spaces, and access and/or drive tracts. ESNW understands that stormwater will likely be managed by full dispersion and/or relatively shallow infiltration facilities (where feasible).

At the time of report submission, specific building load plans were not available for review; however, based on our experience with similar developments, the proposed residential structures will likely be two to three stories in height and constructed using relatively lightly loaded wood framing supported on conventional foundations. Perimeter footing loads will likely be about 1 to 3 kips per lineal foot (klf). Slab-on-grade loading is anticipated to be approximately 150 pounds per square foot (psf).

Cuts and/or fills of 10 feet or less are anticipated to achieve lot finish grades. Retaining walls and/or rockeries may be incorporated into final designs to accommodate grade transitions, where necessary.

If the above design assumptions are incorrect or change, ESNW should be contacted to review the recommendations provided in this report. ESNW should review final designs to confirm that appropriate geotechnical recommendations have been incorporated into the plans.

SITE CONDITIONS

Surface

The subject site is located along the west side of 436th Avenue Southeast, near the intersection with Southeast 147th Lane, in the North Bend area of unincorporated King County, Washington. The approximate location of the property is illustrated on Plate 1 (Vicinity Map). The site consists of five tax parcels (King County Parcel Nos. 222308-9002, -9018, -9019, -9026, and -9055) covering approximately 57.4 acres of land area.

The site is bordered to the north by Cascade Golf Course, to the east by 436th Avenue Southeast, to the south by the South Fork of the Snoqualmie River, and to the west by single-family residences and open undeveloped areas. The subject site is undeveloped, with vegetation comprised of mature trees and brush. Site topography can be characterized as generally flat, with total elevation change of about 15 feet or less.

Subsurface

An ESNW representative observed, logged, and sampled 13 test pits, excavated at accessible locations within the property boundaries, on November 10, 2017 using a mini-trackhoe and operator provided by the client. The test pits were completed for purposes of assessment and classification of site soils as well as characterization of groundwater conditions within areas proposed for new development. The approximate locations of the test pits are depicted on Plate 2 (Test Pit Location Plan). Please refer to the test pit logs provided in Appendix A for a more detailed description of subsurface conditions. Representative soil samples collected at the test pit locations were evaluated in accordance with both Unified Soil Classification System (USCS) and United States Department of Agriculture (USDA) methods and procedures.
Topsoil and Fill

Topsoil was encountered generally within the upper 2 to 12 inches of existing grades at the test pit locations. The topsoil was characterized by dark brown color, the presence of fine organic material, and small root intrusions. Based on our field observations, we estimate topsoil will be encountered across the site with an average thickness of 8 inches. Deeper pockets of topsoil, however, may be encountered locally throughout the site.

Fill was not encountered at the test pit locations during our fieldwork. Fill may be present to some extent in proximity to the existing improvements and, where encountered, should be evaluated by ESNW for use as structural fill during the appropriate phase of construction.

Native Soil

Underlying the topsoil, native soils consisted primarily of two to seven feet of medium dense, silty sand (USCS: SM). Poorly graded sand with gravel and poorly graded gravel with sand (USCS: SP and GP, respectively) were encountered at depth at the test pit locations. Native soils were encountered primarily in a damp to moist condition, extending to the maximum exploration depth of about nine feet below the existing ground surface (bgs).

Geologic Setting

The referenced geologic map resource identifies alluvial deposits (Qa) across the site and surrounding areas. Alluvial deposits consist of gravel and sand deposited by the Snoqualmie River, overlain by thin silt. Additionally, the referenced WSS resource identifies Si silt loam (Map Unit: 236) as being present across the majority of the site and surrounding areas, which were formed in floodplains. In our opinion, the soils encountered during the subsurface exploration are consistent with the referenced geologic and soil mapping resources.

Groundwater

Groundwater was not encountered at the test pit locations at the time of our exploration. In our opinion, discrete zones of perched groundwater seepage will likely be encountered within site excavations, likely due to the adjacent Snoqualmie River. Seepage rates and elevations fluctuate depending on many factors, including precipitation duration and intensity, the time of year, and soil conditions. In general, groundwater flow rates are higher during the wetter, winter months.
GEOLOGICALLY HAZARDOUS AREAS

The site and proposed development areas were evaluated for the presence of geologically hazardous areas. The primary geologic hazard associated with the subject site is related to possible liquefaction-induced settlement resulting from strong seismic shaking.

Seismic Hazard Areas

Based on our review of the referenced liquefaction susceptibility map, the site maintains a moderate to high liquefaction susceptibility. Liquefaction is a phenomenon where saturated or loose soils suddenly lose internal strength and behave as a fluid. This behavior is in response to increased pore water pressures resulting from an earthquake or other intense ground shaking.

We determined the peak ground acceleration (PGA) using the USGS online calculation program. Using this resource, a design PGA of 0.40g was used for site susceptibility screening. This site is predicted to experience low to moderate settlement resulting from liquefaction occurring after the site is subjected to the design PGA. We used this assessment to aid in developing foundation support recommendations that would reduce impacts from differential settlement and maintain adequate levels of life safety subsequent to a design earthquake event. We expect total settlements in the range of one to two inches and differential settlements of between one to two inches may result from the design seismic event as defined by the 2015 International Building Code.

Based on our field observations, it is our opinion the overall site susceptibility to liquefaction during a seismic event may be considered low. The majority of the alluvial sand and gravel soils encountered at the exploratory locations were in a medium dense state, and a uniformly established, shallow groundwater table was absent. The gravel encountered at the site is not typically susceptible to liquefaction during a seismic event. If liquefaction was to occur at depth, minimal surface impact would be observed, as about 10 feet of non-liquefiable soil is present across the subject site. Providing a uniform subgrade (as recommended in this report) will help maintain soil bearing capacity and reduce the potential for differential settlement that might occur during a strong seismic event. We do not anticipate life safety will be compromised during a strong seismic event; however, some damage should be expected depending on the magnitude and duration of shaking.

ESNW should be contacted to provide additional recommendations for mitigation of liquefaction-related effects, which would likely include structural fill underlying the proposed footings.

Lateral Spread

Lateral spread is the lateral displacement of liquefied (loose and saturated) soil that occurs during an earthquake or other intense ground shaking. The potential for lateral spread is present near slopes or free faces (such as riverbanks). Because the Snoqualmie River lies about 200 feet of the site margin, and based on our understanding of the local geology, it is our opinion the risk of lateral spread affecting the proposed development is low.
DISCUSSION AND RECOMMENDATIONS

General

Based on the results of our investigation, construction of the proposed residential development is feasible from a geotechnical standpoint. The primary geotechnical considerations associated with the proposed development include site drainage, foundation support, slab-on-grade subgrade support, and the suitability of using native soils as structural fill.

In our opinion, the proposed structures may be constructed on conventional continuous and spread footing foundations bearing upon competent native soil, recompacted native soil, or new structural fill placed directly on competent native soil. In general, competent native soil, suitable for support of new foundations, will likely be encountered at depths of about two to three feet below existing grades. Where loose or unsuitable soil conditions are exposed at foundation subgrade elevations, compaction of soils to the specifications of structural fill, or overexcavation and replacement with a suitable structural fill material, will be necessary.

Use of full dispersion and/or relatively shallow infiltration facilities for controlling stormwater is feasible from a geotechnical standpoint. Concerning infiltration feasibility, it is our opinion the native alluvium sand and gravel deposits should generally be considered suitable for accommodation of infiltration facilities.

This study has been prepared for the exclusive use of Kusak Tree Farm, LLC and their representatives. No warranty, expressed or implied, is made. This study has been prepared 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.

Site Preparation and Earthwork

Initial site preparation activities will consist of installing temporary erosion control measures, establishing grading limits, and performing site clearing and site stripping (as necessary). Subsequent earthwork procedures will involve mass grading and related infrastructure improvements.

Temporary Erosion Control

Prior to the installation of either initial or final pavement sections, temporary construction entrances and drive lanes, consisting of at least six inches of quarry spalls, should be placed to both minimize off-site soil tracking and provide a stable access surface for construction vehicles. Geotextile fabric may also be placed below the quarry spalls for greater stability of the temporary construction entrance. Erosion control measures should consist of silt fencing placed around appropriate portions of the site perimeter. Soil stockpiles should be covered or otherwise protected to reduce the potential for soil erosion during periods of wet weather. Temporary approaches for controlling surface water runoff should be established prior to beginning earthwork activities. Additional Best Management Practices (BMPs), as specified by the project civil engineer, should be incorporated into construction activities, as necessary.
Stripping

Topsoil was encountered generally within the upper 2 to 12 inches of existing grades at the test pit locations. ESNW should be retained to observe site stripping activities at the time of construction to assess the required degree of stripping. Over-stripping of the site should be avoided. Topsoil and organic-rich soil is neither suitable for foundation support nor for use as structural fill. Topsoil and organic-rich soil may be used in non-structural areas, if desired.

In-situ and Imported Soils

From a geotechnical standpoint, near-surface native soils may not be suitable for use as structural fill unless the soils are near the optimum moisture content at the time of placement and compaction. Based on relatively appreciable fines content, native soils should be considered moisture sensitive. On-site sand and gravel soils exhibit a low to moderate sensitivity to moisture. Successful use of native soils as structural fill will largely be dictated by the moisture content at the time of placement and compaction. If the on-site soils cannot be successfully compacted, the use of an imported soil may be necessary. Soils with fines contents greater than 5 percent typically degrade rapidly when exposed to periods of rainfall.

Imported soil intended for use as structural fill should consist of a well-graded, granular soil with a moisture content that is at (or slightly above) the optimum level. During wet weather conditions, imported soil intended for use as structural fill should consist of a well-graded, granular soil with a fines content of 5 percent or less (where the fines content is defined as the percent passing the Number 200 sieve, based on the minus three-quarter-inch fraction).

Subgrade Preparation

Foundation and slab subgrade surfaces should be placed on a competent bearing subgrade, recompacted native soil, or new structural fill. Loose or unsuitable soil conditions encountered below areas of footing and slab elements should be compacted in situ as recommended in this report. Uniform compaction of the foundation subgrade areas will establish a relatively consistent support below the foundation elements. ESNW should observe the foundation and slab subgrade prior to placing formwork. Supplementary recommendations for subgrade improvement may be provided at the time of construction and would likely include further mechanical compaction effort and/or overexcavation and replacement with suitable structural fill.

Structural Fill

Structural fill is defined as compacted soil placed in foundation, slab-on-grade, pavement, and roadway areas. Fill placed to construct permanent slopes and throughout retaining wall and utility trench backfill areas is also considered structural fill. Soils placed in structural areas should be placed in loose lifts of 12 inches or less and compacted to a relative compaction of 90 percent, based on the laboratory maximum dry density as determined by the Modified Proctor Method (ASTM D1557). The upper one foot of pavement areas should be compacted to 95 percent relative compaction. Additionally, more stringent compaction specifications may be required for utility trench backfill zones depending on the responsible utility district or jurisdiction.
Foundations

In our opinion, the proposed structures may be constructed on conventional continuous and spread footing foundations bearing upon competent native soil, recompacted native soil, or new structural fill placed directly on competent native soil. In general, competent native soil, suitable for support of new foundations, will likely be encountered at depths of approximately two to three feet below existing grades. Loose or unsuitable soil conditions exposed at foundation subgrade elevations should be compacted to the specifications of structural fill or overexcavated and replaced with a suitable structural fill. Organic material encountered at structural subgrade elevations should be removed, and grades should be restored with structural fill as necessary.

Provided the foundations will be supported as described above, the following parameters may be used for design:

- Allowable soil bearing capacity 2,500 psf
- Passive earth pressure 300 pcf (equivalent fluid)
- Coefficient of friction 0.40

A one-third increase in the allowable soil bearing capacity may be assumed for short-term wind and seismic loading conditions. The above passive pressure and friction values include a factor-of-safety of 1.5. With structural loading as expected, total settlement in the range of one inch and differential settlement of about one-half inch is anticipated. The majority of the settlements should occur during construction, as dead loads are applied.

Seismic Design

The 2015 International Building Code recognizes the American Society of Civil Engineers (ASCE) for seismic site class definitions. In accordance with Table 20.3-1 of the ASCE Minimum Design Loads for Buildings and Other Structures manual, Site Class D should be used for design. Please refer to the Geologically Hazardous Areas of this report for an assessment of liquefaction risk resulting from a seismic event.

Slab-on-Grade Floors

Slab-on-grade floors for the proposed residential structures should be supported on firm and unyielding subgrades. Native soils likely to be exposed at slab-on-grade subgrade levels can likely be compacted in situ to the specifications of structural fill. Unstable or yielding areas of the subgrades should be recompacted, or overexcavated and replaced with suitable structural fill, prior to slab construction.

A capillary break consisting of a minimum of four inches of free-draining crushed rock or gravel should be placed below the slabs. The free-draining material should have a fines content of 5 percent or less (percent passing the Number 200 sieve, based on the minus three-quarter-inch fraction). In areas where slab moisture is undesirable, installation of a vapor barrier below the slab should be considered. If a vapor barrier is to be utilized, it should be a material specifically designed for use as a vapor barrier and should be installed in accordance with the specifications of the manufacturer.
Retaining Walls

Retaining walls must be designed to resist earth pressures and applicable surcharge loads. The following parameters may be used for design:

- Active earth pressure (yielding condition) 35 pcf (equivalent fluid)
- At-rest earth pressure (restrained condition) 55 pcf
- Traffic surcharge (passenger vehicles) 70 psf (rectangular distribution)*
- Passive earth pressure 300 pcf (equivalent fluid)
- Coefficient of friction 0.40
- Seismic surcharge 6H**

*Where applicable
**Where H equals the retained height (in feet)

The above design parameters are based on a level backfill condition and level grade at the wall toe. Revised design values will be necessary if sloping grades are to be used above or below retaining walls. Additional surcharge loading from adjacent foundations, sloped backfill, or other loads should be included in the retaining wall design, where applicable.

Retaining walls should be backfilled with free-draining material that extends along the height of the wall and a distance of at least 18 inches behind the wall. The upper 12 inches of the wall backfill can consist of a less permeable soil, if desired. A perforated drainpipe should be placed along the base of the wall and connected to an approved discharge location. A typical retaining wall drainage detail is provided on Plate 3. If drainage is not provided, hydrostatic pressures should be included in the wall design.

Drainage

Seepage may be encountered in deeper site excavations on the site, particularly during the winter, spring, and early summer months. Temporary measures to control surface water runoff and groundwater during construction would likely involve interceptor trenches and sumps. ESNW should be consulted during preliminary grading to identify areas of seepage and to provide recommendations to reduce the potential for instability related to seepage effects.

Finish grades must slope away from the residence at an inclination of at least 2 percent for a distance of at least five feet. In addition surface water should be controlled utilizing (BMPs) and after, construction on the subject site. The installation of footing drains should be considered as a part of the residential structures on the subject site. A typical foundation drain detail is provided as Plate 4.
Preliminary Infiltration Design

We evaluated the capacity for infiltration into native soils in accordance with our understanding of currently proposed project plans and the referenced (2009 KCSWDM). As stated in the Project Description section of this report, we understand dispersion and/or relatively shallow infiltration facilities may be constructed on site in accordance with stormwater management BMPs. Based on the identified soil conditions, infiltration for purposes of stormwater management is feasible. Our determination of site infiltration feasibility was based primarily on the following factors and/or test results:

- USDA textural analyses were performed on representative soil samples collected at the test pit locations during our fieldwork. Consistent with USDA nomenclature, the native soil was classified primarily as gravelly coarse sand. Irrespective of gravel content, the in-situ fines contents of the native soil were about 1 percent at the tested locations. The dominant particle size classification was “medium to coarse” for the tested samples.

- Our field observations of native soils indicate the subject site is underlain primarily by alluvium deposits. Additionally, groundwater was not encountered at the test pit locations at the time of our exploration. Given the coarse sand and gravel nature of the soil deposits, groundwater is not expected to influence infiltration system performance.

If infiltration facilities are utilized, we recommend a preliminary long-term infiltration rate of 14 inches per hour be used for feasibility and/or sizing purposes. This value was based on the results of the Soil Grain Size Analysis Method as outlined in the 2012 Stormwater Manual for Western Washington.

It is imperative that in situ testing be completed as part of the overall design of site infiltration facilities to confirm the preliminary recommendations provided in this section. The infiltration rate provided above is preliminary and is intended solely for feasibility purposes. Supplementary recommendations and/or design infiltration rates may be provided based on the results of in-situ testing. ESNW can provide further evaluation of, and recommendations for, stormwater flow control BMPs upon request. Where incorporated into final designs, infiltration facilities should include provisions for overflow.

Dispersion

Based on the referenced preliminary site plan and our understanding of the project, full dispersion is being considered as part of the storm drainage design for the proposed development. In our opinion, dispersion is feasible from a geotechnical standpoint based on the soil types observed. The erosion potential of the vegetated flow path can be considered low provided proper vegetation is provided. ESNW understands the system is being designed for sheet flow discharge; however, we expect a significant portion of the outflow to infiltrate into the near-surface outwash soil as interflow. This determination is based on the relatively free-draining and stable nature of the site soils.
Excavations and Slopes

The Federal Occupation Safety and Health Administration (OSHA) and the Washington Industrial Safety and Health Act (WISHA) provide soil classification in terms of temporary slope inclinations. Soils that exhibit high compressive strengths are allowed steeper temporary slope inclinations than are soils that exhibit lower strength characteristics.

Based on the soil conditions encountered at the test pit locations, in general, the alluvial deposits can be considered a Type C material by OSHA and WISHA. Temporary slopes over four feet in height in Type C soils must be sloped no steeper than one-and-one-half horizontal to one vertical (1.5H:1V). ESNW should observe site excavations to confirm soil types and allowable slope inclinations.

The presence of perched groundwater may cause localized sloughing of the temporary slopes due to excess seepage forces. ESNW should observe site excavations to confirm soil types and allowable slope inclinations. If the recommended temporary slope inclinations cannot be achieved, temporary shoring may be necessary to support excavations.

Permanent slopes should be planted with vegetation to enhance stability and to minimize erosion, and should maintain a gradient of 2H:1V or flatter. An ESNW representative should observe temporary and permanent slopes to confirm the slope inclinations are suitable for the exposed soil conditions. Supplementary excavation and slope recommendations may be provided at the time of construction, as necessary.

Preliminary Pavement Sections

The performance of site pavements is largely related to the condition of the underlying subgrade. To ensure adequate pavement performance, the subgrade should be in a firm and unyielding condition when subjected to proofrolling with a loaded dump truck. Structural fill in pavement areas should be compacted to the specifications previously detailed in this report. Soft, wet, or otherwise unsuitable subgrade areas may still exist after base grading activities. Areas containing unsuitable or yielding subgrade conditions will require remedial measures, such as cement treatment, overexcavation and/or placement of thicker crushed rock or structural fill sections, prior to pavement.

We anticipate new pavement sections will be subjected primarily to passenger vehicle traffic. For lightly loaded pavement areas subjected primarily to passenger vehicles, the following preliminary pavement sections may be considered:

- A minimum of two inches of hot mix asphalt (HMA) placed over four inches of crushed surfacing top course (CSTC), or;

- A minimum of two inches of HMA placed over three inches of asphalt treated base (ATB).
For relatively high volume, heavily loaded pavements areas subjected to occasional truck traffic, the following preliminary pavement sections may be considered:

- A minimum of three inches of HMA placed over six inches of CRB, or;
- A minimum of three inches of HMA placed over four inches of ATB.

The HMA, ATB and CSTC materials should conform to WSDOT specifications. All soil base material should be compacted to a relative compaction of 95 percent, based on the laboratory maximum dry density as determined by ASTM D1557. Final pavement design recommendations, including recommendations for heavy traffic areas, main access roads, and frontage improvement areas, can be provided once final traffic loading has been determined. Road standards utilized by King County may supersede the recommendations provided in this report.

**Utility Support and Trench Backfill**

In our opinion, the soils observed at the test pit locations are generally suitable for support of utilities. If existing fill is exposed at the bottom of utility trench excavations, the fill should be either be compacted in place or overexcavated and replaced with structural fill. In general, the native soils observed at the test pit locations should be suitable for use as structural backfill in the utility trench excavations, provided the soil is at or near the optimum moisture content at the time of placement and compaction. Moisture conditioning of the soils may be necessary at some locations prior to use as structural fill. Utility trench backfill should be placed and compacted to the specifications of structural fill provided in this report, or to the applicable requirements of presiding jurisdiction.

**LIMITATIONS**

The recommendations and conclusions provided in this study are professional opinions consistent with the level of care and skill that is typical of other members in the profession currently practicing under similar conditions in this area. A warranty is not expressed or implied. Variations in the soil and groundwater conditions observed at the test pit locations may exist and may not become evident until construction. ESNW should reevaluate the conclusions provided in this study if variations are encountered.

**Additional Services**

ESNW should have an opportunity to review final project plans with respect to the geotechnical recommendations provided in this study. ESNW should also be retained to provide testing and consultation services during construction.
NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.
NOTE: The graphics shown on this plate are not intended for design purposes or precise scale measurements, but only to illustrate the approximate test locations relative to the approximate locations of existing and/or proposed site features. The information illustrated is largely based on data provided by the client at the time of our study. ESNW cannot be responsible for subsequent design changes or interpretation of the data by others.

NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.
NOTES:

- Free-draining Backfill should consist of soil having less than 5 percent fines. Percent passing No. 4 sieve should be 25 to 75 percent.

- Sheet Drain may be feasible in lieu of Free-draining Backfill, per ESNW recommendations.

- Drain Pipe should consist of perforated, rigid PVC Pipe surrounded with 1-inch Drain Rock.

LEGEND:

- Free-draining Structural Backfill
- 1-inch Drain Rock

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING
NOTES:

- Do NOT tie roof downspouts to Footing Drain.
- Surface Seal to consist of 12" of less permeable, suitable soil. Slope away from building.

LEGEND:

Surface Seal: native soil or other low-permeability material.

1-inch Drain Rock

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING
Appendix A

Subsurface Exploration
Test Pit Logs

ES-5642

The subsurface conditions at the site were explored on November 10, 2017 by excavating 11 test pits. The approximate locations of the subsurface explorations are illustrated on Plate 2 of this study. The test pit logs are provided in this Appendix. The excavations were advanced to a maximum depth of about nine feet bgs.

The final logs represent the interpretations of the field logs and the results of laboratory analyses. The stratification lines on the logs represent the approximate boundaries between soil types. In actuality, the transitions may be more gradual.
Earth Solutions NW LLC
SOIL CLASSIFICATION CHART

<table>
<thead>
<tr>
<th>MAJOR DIVISIONS</th>
<th>SYMBOLS</th>
<th>TYPICAL DESCRIPTIONS</th>
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<tr>
<td></td>
<td>GRAPH</td>
<td>LETTER</td>
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<tr>
<td>CLEAN GRAVELS</td>
<td>GW</td>
<td>WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES</td>
</tr>
<tr>
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<td>POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES</td>
</tr>
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<td>GC</td>
<td>CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES</td>
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<td>WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES</td>
</tr>
<tr>
<td>SANDS WITH FINES (LITTLE OR NO FINES)</td>
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<td>POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES</td>
</tr>
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<td>SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)</td>
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<td>CL</td>
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<td>PT</td>
<td>PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS</td>
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</tbody>
</table>

DUAL SYMBOLS are used to indicate borderline soil classifications.

The discussion in the text of this report is necessary for a proper understanding of the nature of the material presented in the attached logs.
# Test Pit Number TP-1

**Project Number:** ES-5642  
**Project Name:** Kusak Cluster Subdivision  
**Date Started:** 11/10/17  
**Completed:** 11/10/17  
**Ground Elevation:** 496 ft  
**Test Pit Size:**  
**Excavation Contractor:** OCI  
**Ground Water Levels:**  
**Excavation Method:**  
**Logged By:** AZS  
**Checked By:** SSR  
**Notes:** Depth of Topsoil & Sod 12"; forest duff

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<th>Depth (ft)</th>
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<td></td>
<td></td>
<td>0.0</td>
<td>Light brown silty SAND, medium dense, moist</td>
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<tr>
<td></td>
<td></td>
<td>[USDA Classification: slightly gravelly loamy SAND]</td>
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</tr>
<tr>
<td>5</td>
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<td>GP</td>
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**General B.H. / Trench:** 5642 GPJ  
**Plot:** US GDT 12/07/17
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<td></td>
<td></td>
<td>-trace roots</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Gray poorly graded SAND, medium dense, damp</td>
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Test pit terminated at 8.0 feet below existing grade. No groundwater encountered during excavation. Caving observed from 3.0 to 6.0 feet.
Bottom of test pit at 8.0 feet.
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<td></td>
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<td>GP</td>
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<td>Gray silty SAND, medium dense, moist to wet</td>
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<td></td>
<td>SP</td>
<td>8.0</td>
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<td>Gray poorly graded SAND, medium dense, damp - increasing gravel</td>
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Test pit terminated at 8.0 feet below existing grade due to caving. No groundwater encountered during excavation. Caving observed from 3.5 feet to BOH. Bottom of test pit at 8.0 feet.
<table>
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<th>DEPTH (ft)</th>
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<th>TESTS</th>
<th>U.S.C.S.</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
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<tbody>
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<td>-trace roots</td>
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<td>Brown poorly graded GRAVEL, medium dense, damp</td>
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<td>MC = 4.90%</td>
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<tr>
<td>5</td>
<td>GP</td>
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<td>Test pit terminated at 7.0 feet below existing grade due to caving. No groundwater encountered during excavation. Caving observed from 2.0 feet to BOH. Bottom of test pit at 7.0 feet.</td>
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<td>MC = 4.40%</td>
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Test pit terminated at 7.0 feet below existing grade due to caving. No groundwater encountered during excavation. Caving observed from 2.0 feet to BOH. Bottom of test pit at 7.0 feet.
<table>
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<th>DEPTH (ft)</th>
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<td></td>
<td></td>
<td>SM</td>
<td></td>
</tr>
<tr>
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<td></td>
<td>4.0</td>
<td>Brown poorly graded GRAVEL with sand, medium dense, damp</td>
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<td></td>
<td>[USDA Classification: extremely gravelly coarse SAND]</td>
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<td>7.0</td>
<td>Test pit terminated at 7.0 feet below existing grade due to caving. No groundwater encountered during excavation. Caving observed from 4.0 feet to BOH. Bottom of test pit at 7.0 feet.</td>
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</table>

**Notes:** Depth of Topsoil & Sod 4" forest duff
<table>
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<th>DEPTH (ft)</th>
<th>SAMPLE TYPE NUMBER</th>
<th>TESTS</th>
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<th>MATERIAL DESCRIPTION</th>
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<tbody>
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<td>TPSL</td>
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<td>GP</td>
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<td>MC = 4.90%</td>
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Test pit terminated at 6.0 feet below existing grade due to caving. No groundwater encountered during excavation. Caving observed from 1.0 foot to BOH. Bottom of test pit at 6.0 feet.
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<th>U.S.C.S. GRAPHIC LOG</th>
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<td>Dark brown TOPSOIL</td>
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<td>0.5</td>
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<td>Brown silty SAND, medium dense, wet</td>
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<td>-gravel</td>
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<td>[USDA Classification: very gravelly coarse SAND]</td>
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<tr>
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<td>8.0</td>
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<td>Test pit terminated at 8.0 feet below existing grade due to caving. No groundwater encountered during excavation. Caving observed from 5.5 feet to BOH. Bottom of test pit at 8.0 feet.</td>
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**TEST PIT NUMBER TP-9**

**PROJECT NUMBER**  ES-5642  
**PROJECT NAME**  Kusak Cluster Subdivision  
**DATE STARTED**  11/10/17  
**COMPLETED**  11/10/17  
**GROUND ELEVATION**  484 ft  
**TEST PIT SIZE**  
**EXCAVATION CONTRACTOR**  OCI  
**EXCAVATION METHOD**  
**LOGGED BY**  AZS  
**CHECKED BY**  SSR  
**GROUND WATER LEVELS:**  
**AT TIME OF EXCAVATION**  ---  
**AT END OF EXCAVATION**  ---  
**AFTER EXCAVATION**  ---  

**NOTES**  Depth of Topsoil & Sod 8": forest duff  

<table>
<thead>
<tr>
<th>DEPTH (ft)</th>
<th>SAMPLE TYPE NUMBER</th>
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<td></td>
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<td></td>
<td></td>
<td>MC = 45.50%</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>SM</td>
<td>7.0</td>
<td>Gray poorly graded SAND, medium dense, moist</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MC = 13.10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SP</td>
<td>9.0</td>
<td>Test pit terminated at 9.0 feet below existing grade due to caving. No groundwater encountered during excavation. Caving observed from 7.5 feet to BOH. Bottom of test pit at 9.0 feet.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MC = 22.80%</td>
</tr>
</tbody>
</table>

**GENERAL H/V TP/WELL SN42-62J GAINT US SDT 12/15/17**
<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Type Number</th>
<th>Tests</th>
<th>U.S.C.S.</th>
<th>Graphic Log</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>TPSL</td>
<td>0.5</td>
<td>5.5</td>
<td>Dark brown TOPSOIL</td>
</tr>
<tr>
<td>MC = 36.00%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Brown silty SAND, medium dense, moist</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>SM</td>
<td>3.0</td>
<td></td>
<td>Gray poorly graded SAND, medium dense, damp</td>
</tr>
<tr>
<td>MC = 11.70%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>SP</td>
<td>7.5</td>
<td></td>
<td>Test pit terminated at 7.5 feet below existing grade. No groundwater encountered during excavation. Caving observed from 3.0 feet to BOH. Bottom of test pit at 7.5 feet.</td>
</tr>
<tr>
<td>MC = 5.50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEPTH (ft)</td>
<td>SAMPLE TYPE NUMBER</td>
<td>TESTS</td>
<td>U.S.C.S. GRAPHIC LOG</td>
<td>MATERIAL DESCRIPTION</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------</td>
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<td>---------------------</td>
<td>---------------------</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>TPSL</td>
<td>0.4</td>
<td>Dark brown TOPSOIL</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>SM</td>
<td>2.5</td>
<td>Brown silty SAND, medium dense, moist</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>GP</td>
<td>4.0</td>
<td>Gray poorly graded GRAVEL with sand, medium dense, damp</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>[USDA Classification: extremely gravelly coarse SAND]</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- Depth of Topsoil & Sod 4": forest duff
- Test pit terminated at 8.0 feet below existing grade due to caving. No groundwater encountered during excavation. Caving observed from 2.5 feet to BOH. Bottom of test pit at 8.0 feet.
### Test Pit Number TP-12

**Project Number:** ES-5642  
**Project Name:** Kusak Cluster Subdivision

**Date Started:** 11/10/17  
**Completed:** 11/10/17

**Excavation Contractor:** OCI

**Ground Elevation:** 486 ft  
**Test Pit Size:**

**Ground Water Levels:**
- **At Time of Excavation:** ---
- **At End of Excavation:** ---
- **After Excavation:** ---

**Notes:** Depth of Topsoil & Sod 8"; forest duff

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Type Number</th>
<th>Tests</th>
<th>U.S.C.S. Graphic Log</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>TPSL</td>
<td>0.7</td>
<td>Dark brown TOPSOIL</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SM</td>
<td>3.0</td>
<td>Brown silty SAND, medium dense, moist</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SP</td>
<td>7.0</td>
<td>Gray poorly graded SAND with gravel, medium dense, damp</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>MC</td>
<td>5.0</td>
<td>Brown silty SAND, medium dense, moist</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MC</td>
<td>3.0</td>
<td>Gray poorly graded SAND with gravel, medium dense, damp</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**General BH/WEL 9400 GPJ GNT US GDT 12/5/17**

Test pit terminated at 7.0 feet below existing grade due to caving. No groundwater encountered during excavation. Caving observed from 3.0 feet to BOH. Bottom of test pit at 7.0 feet.
<table>
<thead>
<tr>
<th>DEPTH (ft)</th>
<th>SAMPLE TYPE NUMBER</th>
<th>TESTS</th>
<th>U.S.C.S. GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>TPSL</td>
<td>0.7</td>
<td>Dark brown TOPSOIL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- trace roots</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SM</td>
<td>2.0</td>
<td>Brown silty SAND, medium dense, damp</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>MC = 3.30%</td>
<td></td>
<td>Gray poorly graded SAND with gravel, medium dense, damp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SP</td>
<td>4.0</td>
<td>Gray poorly graded GRAVEL with sand, medium dense, damp</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>GP</td>
<td>7.5</td>
<td>Test pit terminated at 7.5 feet below existing grade due to caving. No groundwater encountered during excavation. Caving observed from 2.0 feet to BOH. Bottom of test pit at 7.5 feet.</td>
</tr>
</tbody>
</table>

**NOTES**: Depth of Topsoil & Sod 8", forest duff.
Appendix B

Laboratory Test Results

ES-5642
Report Distribution
ES-5642

E-MAIL ONLY
Kusak Tree Farm, LLC
3910 – 46th Avenue South
Seattle, Washington 98118-1210
Attention: Mr. Jim Kusak

E-MAIL ONLY
Barghausen Consulting Engineers, Inc.
18218 – 72nd Avenue South
Kent, Washington 98032
Attention: Mr. Tom Barghausen