Earth Solutions NW LLC

Geotechnical Engineering
Geology
Environmental Scientists
Construction Monitoring

GEOTECHNICAL ENGINEERING STUDY
HARMS ESTATE
RESIDENTIAL DEVELOPMENT
3601 SEATTLE HILL ROAD
MILL CREEK, WASHINGTON

ES-3694

1805 - 136th Place N.E., Suite 201 Bellevue, WA 98005
(425) 449-4704 Fax (425) 449-4711
www.earthsolutionsnw.com

PREPARED FOR

GEONERCO PROPERTIES WA, LLC

January 15, 2015

Henry T. Wright, E.I.T.
Staff Engineer

Kyle R. Campbell, P.E.
Principal

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Earth Solutions NW, LLC
1805 - 136th Place Northeast, Suite 201
Bellevue, Washington 98005
Phone: 425-449-4704 Fax: 425-449-4711
Toll Free: 866-336-8710

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 overrely 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* preface 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 Geotechncial 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 you ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@asfe.org www.asfe.org

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January 15, 2015
ES-3694

Earth Solutions NW LLC

- Geotechnical Engineering
- Construction Monitoring
- Environmental Sciences

Geonerco Properties WA, LLC
1441 North 34th Street, Suite 200
Seattle, Washington 98103

Attention: Mr. Dane Thiessen

Dear Mr. Thiessen:

Earth Solutions NW, LLC (ESNW) is pleased to present this report titled "Geotechnical Engineering Study, Harms Estate Residential Development, 3601 Seattle Hill Road, Mill Creek, Washington".

The site is underlain primarily by glacial till deposits. In our opinion, the proposed residential structures can be supported on conventional continuous and spread footing foundations bearing on competent native soils, re-compacted native soils, or new structural fill. Competent soils suitable for support of foundations should be encountered at depths of approximately one to three feet below existing grades. Where loose or unsuitable soil conditions are exposed at foundation subgrade elevations, compaction of the soils to the specifications of structural fill, or overexcavation and replacement with a suitable structural fill material will be necessary.

Recommendations for foundation design, retaining wall 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 call.

Sincerely,

EARTH SOLUTIONS NW, LLC

Henry T. Wright, E.I.T.
Staff Engineer

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GEOTECHNICAL ENGINEERING STUDY
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INTRODUCTION

General

This geotechnical engineering study was prepared for the residential development to be constructed at 3601 Seattle Hill Road in Mill Creek, Washington. The purpose of this study was to explore subsurface conditions across the site and develop geotechnical recommendations for the proposed project. Our scope of services for completing this geotechnical engineering study included the following:

- Subsurface exploration and characterization of soil and groundwater conditions by excavating a series of test pits within accessible locations of the property;
- Laboratory testing of soil samples obtained during subsurface exploration, including soil textural analyses;
- Engineering analyses and recommendations for the proposed development, and;
- Preparation of this report.

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

- Road and Storm Drainage Plan, prepared by D.R. Strong Consulting Engineers, dated December 2, 2014;
- Geologic Map of the Bothell Quadrangle, Snohomish and King Counties, Washington, prepared by James P. Minard, dated 1985, and;
- Stormwater Management in Western Washington, Volume III, prepared by Washington State Department of Ecology Water Quality Program, dated February 2005.

Project Description

Based on the referenced road and storm drainage plan, the subject site will be developed with 28 residential lots, an access roadway, and a storm vault. Given the topography of the site, we anticipate grading activities will likely involve cuts and fills on the order of two to six feet in some locations to establish the final design grades. Retaining walls or rockeries may also be utilized to accommodate the planned grading.

The proposed residential structures are anticipated to consist of relatively lightly-loaded wood framing supported on conventional foundations. Based on our experience with similar developments, we estimate wall loads on the order of two kips per lineal foot and slab-on-grade loading of 150 pounds per square foot (psf).

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

SITE CONDITIONS

Surface

The subject site is located at 3601 Seattle Hill Road in Mill Creek, Washington, as illustrated on the Vicinity Map (Plate 1). The site consists of one residential parcel (Snohomish County parcel numbers 2705040020-1600 and 2705040020-1602) covering approximately 7.13 acres of land area. The site is currently developed with of a single-family residence and associated outbuildings. The site is mostly cleared land. A wetland area is mapped in the western portion of the site, and a wetland buffer is mapped in the northeast corner of the site. The site gently descends to the east. The site is bordered to the north by a residential development, to the east and west by single-family residences, and to the south by Seattle Hill Road. The Test Pit Location Plan (Plate 2) illustrates the approximate local topography and limits of the property.

Subsurface

Six test pits were excavated on accessible portions of the site on December 23, 2014 for the purpose of assessing the soil and groundwater conditions. Please refer to the test pit logs provided in Appendix A for a more detailed description of the subsurface conditions.

Topsoil

Topsoil was observed in the upper approximately two to eight inches. The topsoil was characterized by dark brown color and the presence of fine organic material.

Fill

Existing fill was not encountered at the test pit locations. However, fill should be anticipated within the existing building pad and driveway areas.

Native Soil

Underlying the topsoil, native soils consisting primarily of medium dense to dense silty sand and sandy silt (Unified Soil Classification SM and ML) glacial till deposits were encountered extending to the maximum exploration depth of nine and one-half feet below existing grades. The density of the native soil generally increased with depth. Unweathered till was generally encountered at depths of two to five feet below existing grades.

Geologic Setting

The referenced geologic map resource indicates the western portion of the site is underlain by glacial till (Qvt) deposits and the eastern portion of the site is underlain by advance outwash (Qva) deposits. The native soil conditions observed at the test pit locations are generally consistent with glacial till deposits.

The National Resources Conservation Service (NRCS) Soil Survey identifies Alderwood gravelly sandy loam across the site. The soil conditions observed are generally consistent with Alderwood gravelly sandy loam soils.

Groundwater

Groundwater seepage was generally observed at depths of approximately two and one-half to eight and one-half feet below existing grades during our fieldwork on December 23, 2014. Heavy seepage was observed in test pits TP-1 and TP-6 at depths of eight and one half and seven feet, respectively. Groundwater seepage should be expected in site excavations, especially at the contact between the weathered and unweathered till soils. Groundwater seepage rates and elevations fluctuate depending on many factors, including precipitation duration and intensity, the time of year, and soil conditions. In general, groundwater elevations and flow rates are higher during the winter, spring and early summer months.

DISCUSSION AND RECOMMENDATIONS

General

In our opinion, construction of the proposed single-family residential structures and related stormwater and infrastructure improvements at this site is feasible from a geotechnical standpoint. In our opinion, the proposed structures can be supported on conventional continuous and spread footing foundations bearing on competent native soils, re-compacted native soils, or new structural fill. Slab-on-grade floors should be supported on dense native soil, re-compacted native soil, or new structural fill. Competent soils suitable for support of foundations should be encountered at depths of approximately one to three feet below existing grades across the majority of the site. Where existing fill, loose or unsuitable soil conditions are exposed at foundation subgrade elevations, compaction of the soils to the specifications of structural fill, or overexcavation and replacement with a suitable structural fill material will be necessary. Organic material exposed at subgrade elevations must be removed below design elevation and grades restored with structural fill. Recommendations for foundation design, retaining wall design, site preparation, drainage, and other pertinent recommendations are provided in the following sections of this study.

This study has been prepared for the exclusive use of Geonerco Properties WA, 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

Site preparation activities will include demolishing existing structures, clearing activities and installing temporary erosion control measures. Voids remaining after removal of existing foundations should be restored with structural fill.

Site Stripping Recommendations

Stripping will likely be limited to about two to eight inches. Topsoil and organic-rich soil is not suitable for foundation support, nor is it suitable for use as structural fill. Topsoil or organic-rich soil can be used in non-structural areas if desired. The geotechnical engineer should observe stripping operations to confirm the necessary stripping depth. Care should be taken to avoid over-stripping.

Temporary Erosion Control

Temporary construction entrances and drive lanes, consisting of at least one foot of quarry spalls can be considered in order to minimize off-site soil tracking and to provide a stable access entrance surface. Erosion control measures should consist of silt fencing placed along the edge of the site as well as at the edge of the wetland buffers. Soil stockpiles should be covered or otherwise protected to reduce soil erosion. Temporary sedimentation ponds or other approaches for controlling surface water runoff should be in place prior to beginning significant earthwork activities.

In-Situ Soils

The soils encountered at the test pit locations have a high sensitivity to moisture and were generally in a moist to wet condition at the time of the exploration on December 23, 2014. In general, soils encountered during site excavations that are excessively over the optimum moisture content will require aeration or treatment prior to placement and compaction. Conversely, soils that are substantially below the optimum moisture content will require moisture conditioning through the addition of water prior to use as structural fill. If the in-situ soils are determined to not be suitable for use as structural fill, then use of a suitable imported soil may be necessary.

Wet Season Grading

If grading takes place during the wetter winter or spring months, a contingency in the project budget should be included to allow for possible export of native soil and/or existing fill and import of structural fill as described below.

Imported Soils

Imported soil intended for use as structural fill should consist of a well-graded granular soil with a moisture content that is at or near 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 defined as the percent passing the Number 200 sieve, based on the minus three-quarter inch fraction.

Building and Pavement Subgrade Preparation

Subgrade conditions expected to be exposed throughout the majority of the proposed building and pavement areas will likely be comprised of native silty sand and sandy silt soils. The soils exposed throughout subgrade areas should be confirmed to be competent prior to constructing the foundation, slab, and pavement elements.

The subgrade throughout pavement areas should be compacted as necessary and exhibit a firm and unyielding condition when subjected to proofrolling with a loaded dump truck. Structural fill soils placed throughout foundation, slab, and pavement areas should be placed over a firm base. Organic material encountered in building and pavement subgrade areas will need to be overexcavated prior to placing structural fill. Loose or otherwise unsuitable areas of native soil exposed at subgrade elevations should be compacted to structural fill requirements or overexcavated and replaced with a suitable structural fill material. Where structural fill soils are used to construct foundation subgrade areas, the soil should be compacted to the requirements of structural fill described in the following section. Foundation subgrade areas should be protected from disturbance, construction traffic, and excessive moisture. Where instability develops below structural fill areas, use of a woven geotextile below the structural fill areas may be required. A representative of ESNW should observe excavations and structural fill placement in foundation, slab, and pavement areas, and provide supplemental recommendations, as necessary.

Structural Fill

Structural fill is defined as compacted soil placed in foundation, slab-on-grade, and roadway areas. Fills placed to construct permanent slopes and throughout retaining wall and utility trench backfill areas are 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 D-1557). For soil placed in utility trenches underlying structural areas compaction requirements are dictated by the local city, county or utility district, and in general are specified as 95 percent relative compaction. Soil placed throughout foundation subgrade areas as well as the upper 12 inches of slab-on-grade and pavement area subgrade should also be compacted to a relative compaction of at least 95 percent.

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. Loose native soils or where fill and/or groundwater seepage is exposed are classified as Type C by OSHA/WISHA. Temporary slopes over four feet in height in Type C soils must be sloped no steeper than 1.5H:1V (Horizontal:Vertical). Medium dense weathered native soils encountered in the upper approximately two to five feet where no groundwater seepage is exposed would be classified as Type B by OSHA/WISHA. Temporary slopes over four feet in height in Type B soils must be sloped no steeper than 1H:1V. Dense, unweathered glacial till soils encountered below approximately two to five feet would be classified as Type A by OSHA/WISHA. Temporary slopes over four feet in height in Type A soils must be sloped no steeper than 0.75H:1V. The presence of perched groundwater may cause caving of the temporary slopes due to hydrostatic pressure. ESNW should observe site excavations to confirm the soil type and allowable slope inclination are appropriate for the soil exposed by the excavation. If the recommended temporary slope inclination cannot be achieved, temporary shoring may be necessary to support excavations.

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

Rockeries and Modular Block Walls

We anticipate that rockeries or modular block walls may be utilized as part of the proposed development. In our opinion, the use of rockeries or modular block walls at this site is feasible from a geotechnical standpoint. Rockeries or modular block walls over four feet in exposed height will require an engineered design. ESNW can provide engineered rockery and modular block wall designs, upon request.

Foundations

Based on the results of our study, the proposed single-family residential structures can be supported on conventional spread and continuous footings bearing on competent native soils, re-compacted native soils, or new structural fill. Based on the soil conditions encountered at the test sites, competent native soils suitable for support of foundations should be encountered at depths of approximately one to three feet below existing grades. Where loose or unsuitable soil conditions are exposed at foundation subgrade elevations, compaction of the soils to the specifications of structural fill, or overexcavation and replacement with structural fill will be necessary. Organic material exposed at foundation subgrade elevations must be removed and grades restored with structural fill.

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

- 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 can 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 Considerations

The 2012 IBC recognizes ASCE for seismic site class definitions. If the project will be permitted under the 2012 IBC, in accordance with Table 20.3-1 of ASCE, Minimum Design Loads for Buildings and Other Structures, Site Class D, should be used for design.

In our opinion, liquefaction susceptibility at this site is low. The relative density of the site soils and the absence of a uniform, shallow groundwater table are the primary bases for this designation.

Slab-On-Grade Floors

Slab-on-grade floors constructed at this site should be supported on a firm and unyielding subgrade. Where feasible, the existing native soils exposed at the slab-on-grade subgrade level can be compacted in place to the specifications of structural fill. Unstable or yielding areas of the subgrade should be recompacted or overexcavated and replaced with structural fill prior to construction of the slab. A capillary break consisting of a minimum of four inches of free-draining crushed rock or gravel should be placed below the slab. The free-draining material should have a fines content of 5 percent or less defined as 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 manufacturer's specifications.

Retaining Walls

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

• Active earth pressure (unrestrained condition)	35 pcf
• At-rest earth pressure (restrained condition)	55 pcf
• Traffic surcharge (passenger vehicles)	70 psf (rectangular distribution)
• Passive earth pressure	300 pcf
• Coefficient of friction	0.40
• Seismic surcharge	6H* (active condition) 11H* (at-rest condition)

*Where H equals the retained height

Additional surcharge loading from adjacent foundations, sloped backfill, or other loads should be included in the retaining wall design. Drainage should be provided behind retaining walls such that hydrostatic pressures do not develop. If drainage is not provided, hydrostatic pressures should be included in the wall design.

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 one foot of the wall backfill can consist of a less permeable soil, if desired. A perforated drain pipe 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.

Drainage

Groundwater seepage was generally observed at depths of approximately two and one-half to eight and one-half feet below existing grades during our fieldwork on December 23, 2014. Groundwater seepage should be expected in site excavations, especially at the contact between the weathered and unweathered till soils. Temporary measures to control surface water runoff and groundwater during construction would likely involve interceptor trenches and sumps.

Surface grades must be designed to direct water away from buildings. The grade adjacent to buildings should be sloped away from the buildings at a gradient of at least 2 percent for a horizontal distance of ten feet. In our opinion, perimeter footing drains should be installed at or below the invert of the building footings. A typical footing drain detail is provided on Plate 4 of this report.

Infiltration

The observed dense cemented glacial till soil deposits at relatively shallow depths generally exhibit poor soil infiltration characteristics. Based on the observed shallow depth to dense cemented glacial till deposits and shallow groundwater seepage, we do not recommend utilizing infiltration systems for the proposed development.

Dispersion

Wetland "A" is mapped within the western portion of the site. In our opinion, dispersion to Wetland "A" is feasible from a geotechnical standpoint. If utilized, ESNW should review the proposed dispersion plans.

Preliminary Storm Vault Design

We understand a storm vault will be constructed near the southeast site corner. Vault foundations should be supported on competent native soil or crushed rock placed atop competent native soil. Final storm vault designs must incorporate adequate buffer space from property boundaries such that temporary excavations to construct the vault structure can be successfully completed. Perimeter drains should be installed around the vault and conveyed to an approved discharge point. The presence of perched groundwater seepage should be anticipated during excavation activities for the vault.

The following parameters can be used for preliminary stormwater vault design:

- Allowable soil bearing capacity (dense native soil) 5,000 psf
- Active earth pressure (unrestrained) 35 pcf
- Active earth pressure (unrestrained, hydrostatic) 80 pcf
- At-rest earth pressure (restrained) 55 pcf
- At-rest earth pressure (restrained, hydrostatic) 100 pcf
- Coefficient of friction 0.40
- Passive earth pressure 300 pcf

Retaining walls should be backfilled with free-draining material or suitable sheet drainage that extends along the height of the walls. The upper one foot of the wall backfill can consist of a less permeable soil, if desired. A perforated drain pipe should be placed along the base of the wall and connected to an approved discharge location. If the elevation of the vault bottom is such that gravity flow to an outlet is not possible, the portion of the vault below the drain should be designed to include hydrostatic pressure. Design values accounting for hydrostatic pressure are included above.

ESNW should observe grading operations for the vault and the subgrade conditions prior to concrete forming and pouring to confirm conditions are as anticipated, and to provide supplemental recommendations as necessary. Additionally, ESNW should be contacted to review final vault designs to confirm that appropriate geotechnical parameters have been incorporated.

Utility Support and Trench Backfill

In our opinion, the soils anticipated to be exposed in utility excavations should generally be suitable for support of utilities. Existing fill, organic or highly compressible soils encountered in the trench excavations should not be used for supporting utilities. The native soils are moisture sensitive and will therefore be difficult to use as structural trench backfill. Moisture conditioning of the soils will likely be necessary prior to use as structural backfill. Utility trench backfill should be placed and compacted to 95 percent of the modified proctor, or to the applicable city or utility district specifications.

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 detailed in the *Site Preparation and Earthwork* section of this report. It is possible that soft, wet, or otherwise unsuitable subgrade areas may still exist after base grading activities. Areas of unsuitable or yielding subgrade conditions may require remedial measures such as overexcavation and thicker crushed rock or structural fill sections prior to pavement. Cement treatment of the subgrade soil can also be considered for stabilizing pavement subgrade areas.

For relatively lightly-loaded pavements subjected to automobiles and occasional truck traffic, the following sections can be considered for preliminary design purposes:

- Two inches of hot mix asphalt (HMA) placed over four inches of crushed rock base (CRB), or;
- Two inches of HMA placed over three inches of asphalt treated base (ATB).

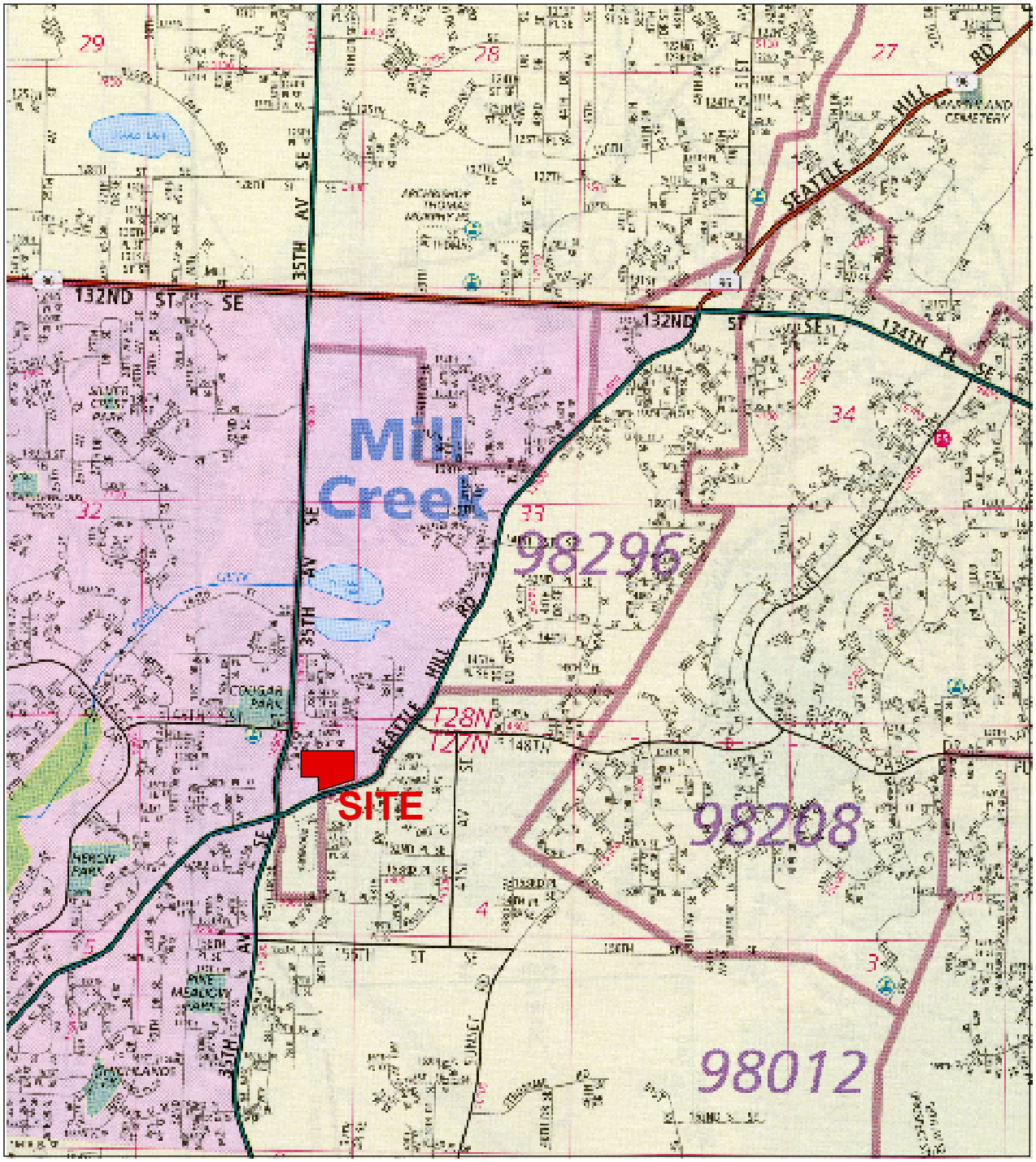
The HMA, ATB and CRB materials should conform to WSDOT specifications.

LIMITATIONS

The recommendations and conclusions provided in this geotechnical engineering 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 locations may exist, and may not become evident until construction. ESNW should reevaluate the conclusions in this geotechnical engineering study if variations are encountered.

Additional Services

ESNW should have an opportunity to review the final design with respect to the geotechnical recommendations provided in this report. ESNW should also be retained to provide testing and consultation services during construction.



Reference:
Snohomish County, Washington
Map 436
By the Thomas Guide
Rand McNally
32nd Edition

NORTH

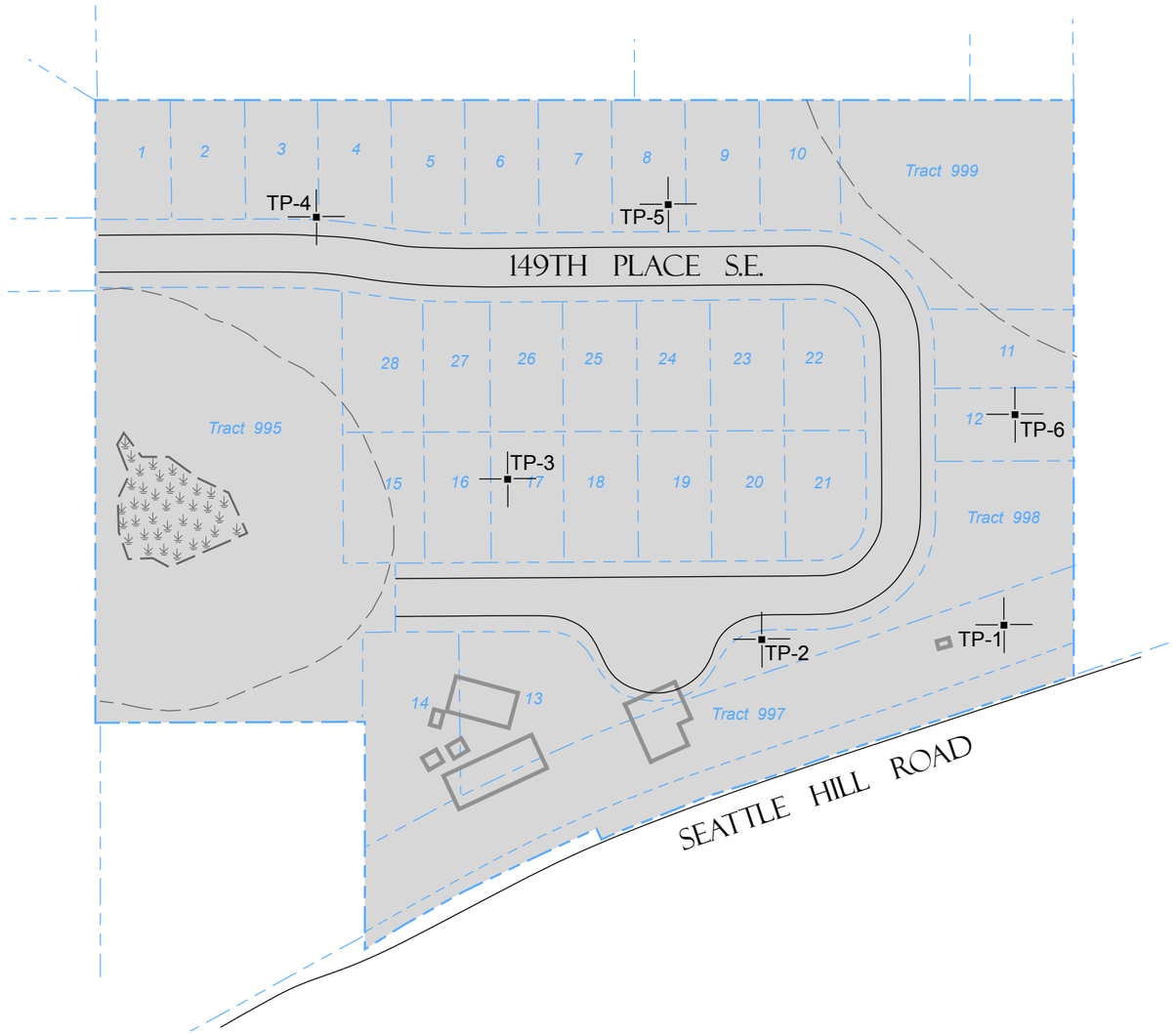
NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.

Earth Solutions NW LLC

Geotechnical Engineering, Construction Monitoring and Environmental Sciences

Vicinity Map
Harms Estate
Mill Creek, Washington

Drwn. GLS	Date 01/14/2015	Proj. No. 3694
Checked HTW	Date Jan. 2015	Plate 1



NORTH

1"=100'

0 50 100 200

Scale in Feet

LEGEND

TP-1 Approximate Location of ESNW Test Pit, Proj. No. ES-3694, Dec. 2014

Subject Site

Existing Building

12 Proposed Lot Number

Wetland Area (Delineated By Others)

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.

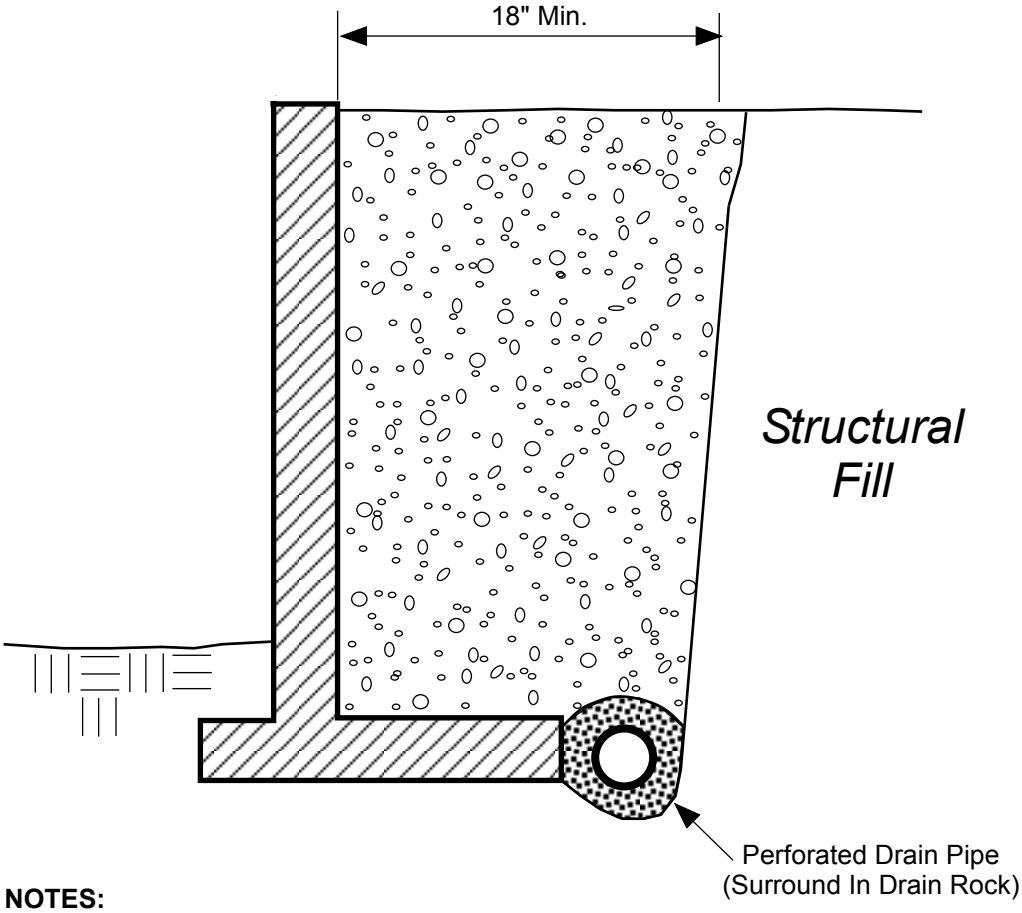
NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.

Test Pit Location Plan
Harms Estate
Mill Creek, Washington

Earth Solutions NW LLC

Geotechnical Engineering, Construction Monitoring and Environmental Sciences

Drwn. By	GLS
Checked By	HTW
Date	01/14/2015
Proj. No.	3694
Plate	2



NOTES:

- Free Draining Backfill should consist of soil having less than 5 percent fines. Percent passing #4 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" Drain Rock.

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING

LEGEND:

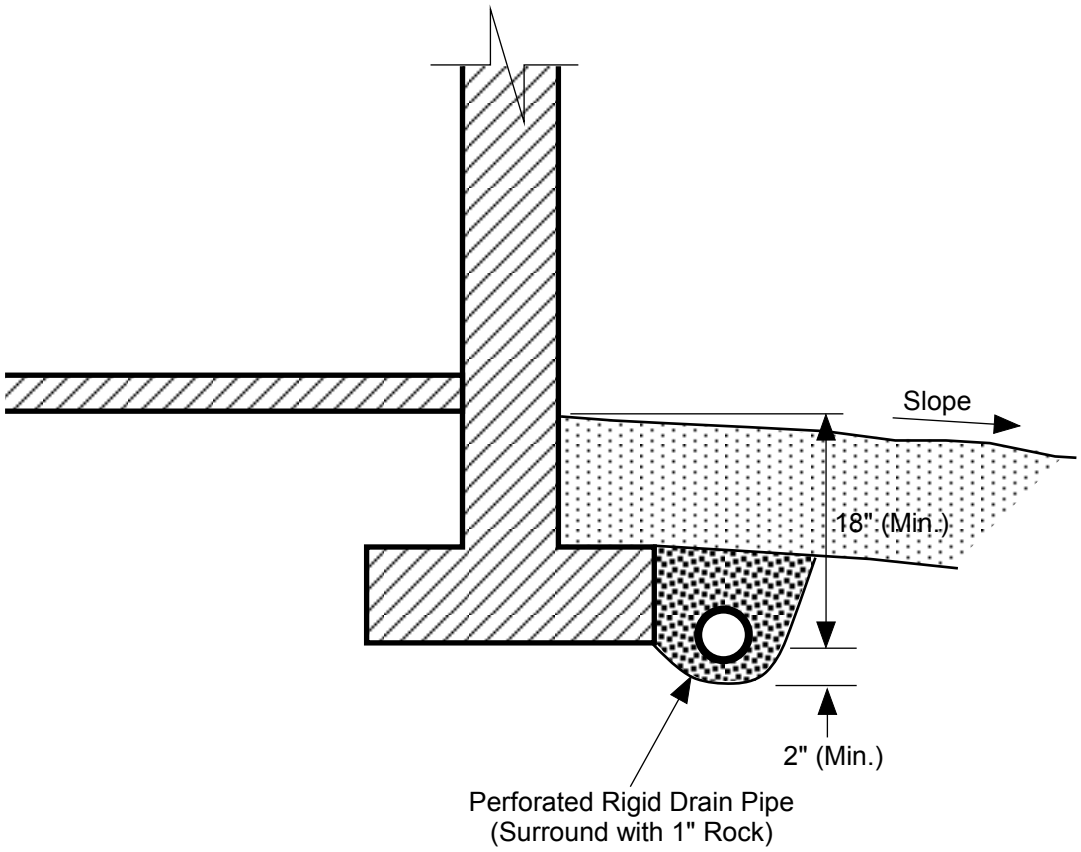
Free Draining Structural Backfill

1 inch Drain Rock

Earth Solutions NW LLC
Geotechnical Engineering, Construction Monitoring and Environmental Sciences

RETAINING WALL DRAINAGE DETAIL
Harms Estate
Mill Creek, Washington

Drwn. GLS	Date 01/15/2015	Proj. No. 3694
Checked HTW	Date Jan. 2015	Plate 3



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" Drain Rock

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING

Earth Solutions NW LLC
Geotechnical Engineering, Construction Monitoring and Environmental Sciences

FOOTING DRAIN DETAIL
Harms Estate
Milol Creek, Washington

Drwn. GLS	Date 01/15/2015	Proj. No. 3694
Checked HTW	Date Jan. 2015	Plate 4

Appendix A

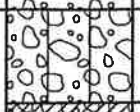
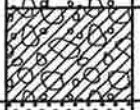
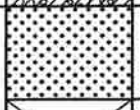
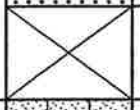
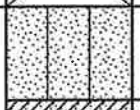
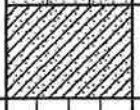
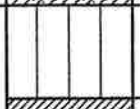
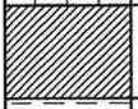
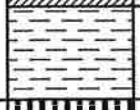
Subsurface Exploration

ES-3694

The subsurface conditions at the site were explored by excavating a total of six test pits across accessible portions of the property. The subsurface exploration was completed on December 23, 2014. The approximate test pit locations are illustrated on Plate 2 of this report. Logs of the test pits are provided in this Appendix.

Earth Solutions NW LLC

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

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.

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-1

CLIENT Geonerco Properties WA, LLC
PROJECT NAME Harms Estate
PROJECT NUMBER 3694
PROJECT LOCATION Mill Creek, Washington
DATE STARTED 12/23/14 **COMPLETED** 12/23/14
GROUND ELEVATION 404 ft **TEST PIT SIZE**
EXCAVATION CONTRACTOR NW Excavating
GROUND WATER LEVELS:
EXCAVATION METHOD
AT TIME OF EXCAVATION ---
LOGGED BY HTW **CHECKED BY** HTW
AT END OF EXCAVATION ---
NOTES Depth of Topsoil & Sod 8": brambles
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		0.5 TOPSOIL to 8" 403.5
		MC = 22.50%	SM		Orange - brown silty SAND with gravel, loose to medium dense, wet
					2.0 402.0
		MC = 15.30%	SM		Gray silty SAND, medium dense, wet
					3.0 401.0
			SM		-moderate seepage at 3' Gray silty SAND with gravel, dense, moist to wet (Unweathered Till)
5		MC = 12.00%			-weakly cemented
		MC = 11.90% Fines = 15.90%			[USDA Classification: gravelly loamy SAND]
		MC = 12.30%			-heavy seepage, water bearing
					9.5 394.5
					Test pit terminated at 9.5 feet below existing grade. Groundwater seepage encountered at 3.0 and 8.5 feet during excavation. Bottom of test pit at 9.5 feet.

GENERAL BH / TP / WELL 3694.GPJ GINT US.GDT 1/15/15

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1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-2

CLIENT Geonerco Properties WA, LLC
PROJECT NAME Harms Estate
PROJECT NUMBER 3694
PROJECT LOCATION Mill Creek, Washington
DATE STARTED 12/23/14 **COMPLETED** 12/23/14
GROUND ELEVATION 417 ft **TEST PIT SIZE**
EXCAVATION CONTRACTOR NW Excavating
GROUND WATER LEVELS:
EXCAVATION METHOD
AT TIME OF EXCAVATION ---
LOGGED BY HTW **CHECKED BY** HTW
AT END OF EXCAVATION ---
NOTES Depth of Topsoil & Sod 4": field grass
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		0.5 TOPSOIL to 4" 416.5
		MC = 16.20%	SM		Orange - brown silty SAND with gravel, loose to medium dense, moist to wet
					2.0 415.0
		MC = 14.20%	SM		Olive- gray silty SAND, medium dense, wet
					-light seepage 3.5 413.5
		MC = 9.10%	SM		Gray silty SAND with gravel, dense, moist (Unweathered Till)
5					-moderately cemented
					5.5 411.5
					Test pit terminated at 5.5 feet below existing grade. Groundwater seepage encountered at 3.0 feet during excavation.
					Bottom of test pit at 5.5 feet.

GENERAL BH / TP / WELL 3694.GPJ GINT US.GDT 1/15/15

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-3

CLIENT Geonerco Properties WA, LLC
PROJECT NAME Harms Estate
PROJECT NUMBER 3694
PROJECT LOCATION Mill Creek, Washington
DATE STARTED 12/23/14 **COMPLETED** 12/23/14
GROUND ELEVATION 420 ft **TEST PIT SIZE**
EXCAVATION CONTRACTOR NW Excavating
GROUND WATER LEVELS:
EXCAVATION METHOD
AT TIME OF EXCAVATION ---
LOGGED BY HTW **CHECKED BY** HTW
AT END OF EXCAVATION ---
NOTES Depth of Topsoil & Sod 2": field grass
AFTER EXCAVATION —

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0					Orange - brown silty SAND with gravel, loose to medium dense, moist
		MC = 21.30%	SM		
2.0					418.0
		MC = 6.20%	SM		Olive - gray silty SAND with gravel, medium dense, moist -increasing sand content, very light seepage
3.0					417.0
		MC = 11.40% Fines = 17.80%			Gray silty SAND, dense, moist (Unweathered Till) [USDA Classification: gravelly loamy SAND]
5					-increasing silt content
			SM		
		MC = 9.20%			
9.5					410.5
					Test pit terminated at 9.5 feet below existing grade. Groundwater seepage encountered at 2.5 feet during excavation. Bottom of test pit at 9.5 feet.

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-4

CLIENT Geonerco Properties WA, LLC
PROJECT NAME Harms Estate
PROJECT NUMBER 3694
PROJECT LOCATION Mill Creek, Washington
DATE STARTED 12/23/14 **COMPLETED** 12/23/14
GROUND ELEVATION 423 ft **TEST PIT SIZE**
EXCAVATION CONTRACTOR NW Excavating
GROUND WATER LEVELS:
EXCAVATION METHOD
AT TIME OF EXCAVATION ---
LOGGED BY HTW **CHECKED BY** HTW
AT END OF EXCAVATION ---
NOTES Depth of Topsoil & Sod 2": brambles
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0		MC = 15.90%	SM		Orange - brown silty SAND with gravel, loose to medium dense, moist to wet
2.0					421.0
		MC = 10.60%	SM		Olive - gray silty SAND with gravel, medium dense, moist to wet
5		MC = 8.90%			-becomes dense
5.5					417.5
					Test pit terminated at 5.5 feet below existing grade. No groundwater encountered during excavation.
					Bottom of test pit at 5.5 feet.

GENERAL BH / TP / WELL 3694.GPJ GINT US.GDT 1/15/15

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-5

CLIENT Geonerco Properties WA, LLC
PROJECT NAME Harms Estate
PROJECT NUMBER 3694
PROJECT LOCATION Mill Creek, Washington
DATE STARTED 12/23/14 **COMPLETED** 12/23/14
GROUND ELEVATION 416 ft **TEST PIT SIZE**
EXCAVATION CONTRACTOR NW Excavating
GROUND WATER LEVELS:
EXCAVATION METHOD
AT TIME OF EXCAVATION ---
LOGGED BY HTW **CHECKED BY** HTW
AT END OF EXCAVATION ---
NOTES Depth of Topsoil & Sod 4"
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0			TPSL		0.5 TOPSOIL to 4"	415.5
		MC = 12.80% Fines = 12.50%	SM		Light brown silty SAND with gravel, loose to medium dense, moist 2.0 [USDA Classification: gravelly loamy SAND]	414.0
		MC = 6.70%	SM		Olive - gray silty SAND with gravel, medium dense, moist 4.5	411.5
5		MC = 7.50%	SM		Gray silty SAND with gravel, dense, moist (Unweathered Till) 8.0	408.0
					Test pit terminated at 8.0 feet below existing grade. No groundwater encountered during excavation. Bottom of test pit at 8.0 feet.	

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-6

CLIENT Geonerco Properties WA, LLC
PROJECT NAME Harms Estate
PROJECT NUMBER 3694
PROJECT LOCATION Mill Creek, Washington
DATE STARTED 12/23/14 **COMPLETED** 12/23/14
GROUND ELEVATION 406 ft **TEST PIT SIZE**
EXCAVATION CONTRACTOR NW Excavating
GROUND WATER LEVELS:
EXCAVATION METHOD
AT TIME OF EXCAVATION ---
LOGGED BY HTW **CHECKED BY** HTW
AT END OF EXCAVATION ---
NOTES Depth of Topsoil & Sod 2": field grass
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0		MC = 14.40% Fines = 49.80%	ML		Tan sandy SILT, medium dense, moist [USDA Classification: gravelly LOAM]
2.0					404.0
		MC = 13.40%	SM		Gray silty SAND with gravel, dense, moist (Unweathered Till) -cemented
5					-becomes wet
					-heavy seepage
		MC = 11.60%			
9.0					397.0
					Test pit terminated at 9.0 feet below existing grade. Groundwater seepage encountered at 7.0 feet during excavation. Bottom of test pit at 9.0 feet.

Appendix B

Laboratory Test Results

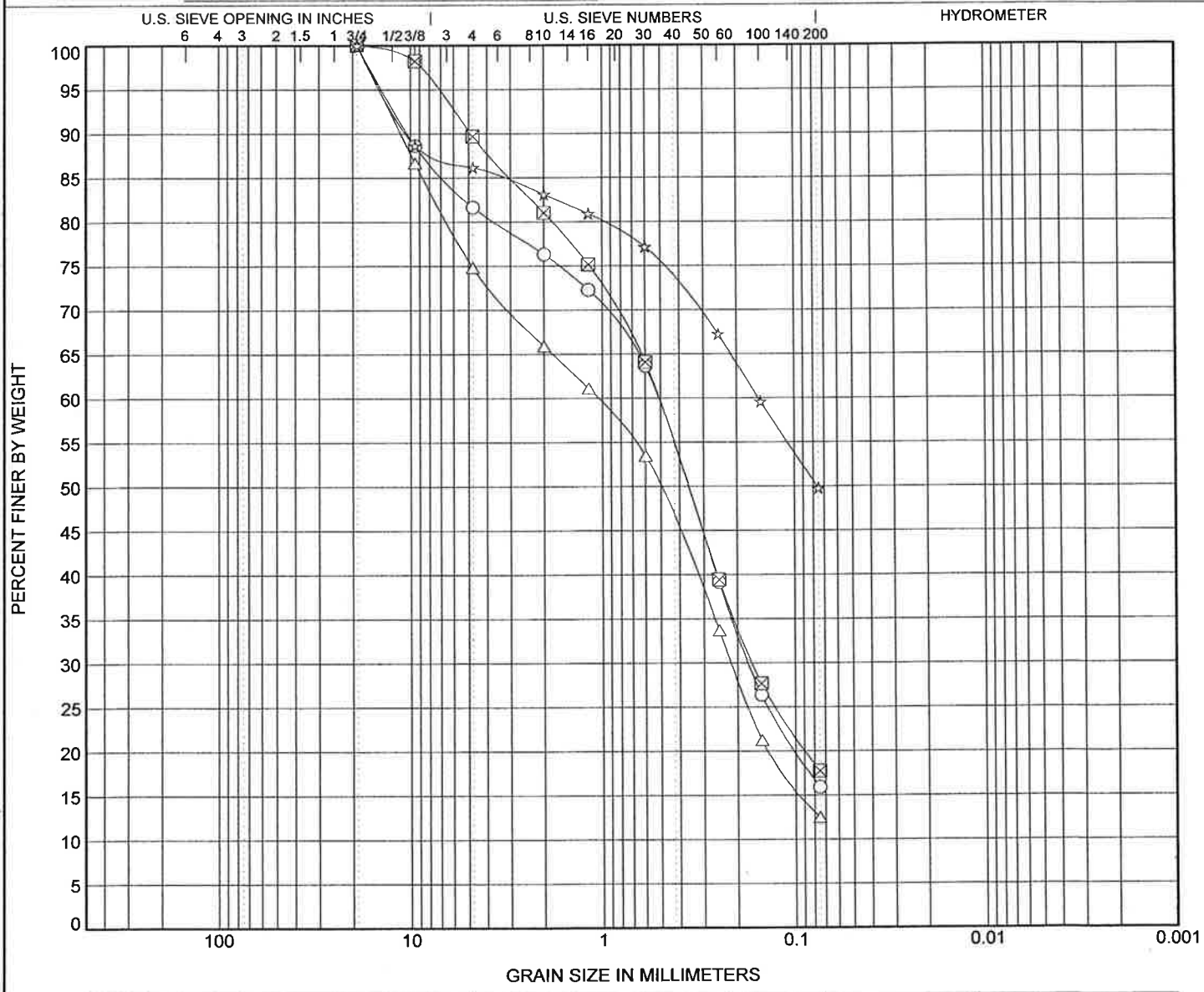
ES-3694

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, WA 98005
Telephone: 425-284-3300

GRAIN SIZE DISTRIBUTION

CLIENT Geonerco Properties WA LLC **PROJECT NAME** Harms Estate

PROJECT NUMBER ES-3694 **PROJECT LOCATION** Mill Creek



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	Cc	Cu
○	TP-1	8.0ft.	USDA: Gray Gravelly Loamy Sand. USCS: SM with Gravel.		
☒	TP-3	4.0ft.	USDA: Gray Gravelly Loamy Sand. USCS: SM.		
△	TP-5	1.5ft.	USDA: Light Brown Gravelly Loamy Sand. USCS: SM with Gravel.		
☆	TP-6	1.0ft.	USDA: Tan Gravelly Loam. USCS: SM.		

	Specimen Identification		D100	D60	D30	D10			%Silt	%Clay
○	TP-1	8.0ft.	19	0.526	0.173				15.9	
☒	TP-3	4.0ft.	19	0.519	0.166				17.8	
△	TP-5	1.5ft.	19	1.068	0.214				12.5	
☆	TP-6	1.0ft.	19	0.154					49.8	

GRAIN SIZE ES-3694.GPJ GINT US LAB.GDT 12/26/14

Report Distribution

ES-3694

EMAIL ONLY

Geonerco Properties WA, LLC
1441 North 34th Street, Suite 200
Seattle, Washington 98103

Attention: Mr. Dane Thiessen