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Earth Solutions NW LLC

Geotechnical Engineering
Construction Observation/Testing
Environmental Services

GEOTECHNICAL ENGINEERING STUDY
EMIL'S WALK
MAPLE AVENUE AND LINCOLN AVENUE
SNOHOMISH, WASHINGTON

ES-6354

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PREPARED FOR

EMIL'S WALK, LLC

October 24, 2018

For: **Adam Z. Shier, G.I.T.**
Staff Geologist

RAYMOND A COGLAS
STATE OF WASHINGTON
36018
REGISTERED
PROFESSIONAL ENGINEER

10/24/18

Raymond A. Coglas, P.E.
Principal Engineer

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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 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

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Earth Solutions NW LLC
Geotechnical Engineering, Construction
Observation/Testing and Environmental Services

October 24, 2018
ES-6354

Emil's Walk, LLC
21412 – 107th Street Southeast
Snohomish, Washington 98290

Attention: Mr. Korbett Miller

Dear Mr. Miller:

Earth Solutions NW, LLC (ESNW) is pleased to present this report titled "Geotechnical Engineering Study, Emil's Walk, Maple Avenue and Lincoln Avenue, Snohomish, Washington". Based on the results of our investigation, the proposed project is feasible from a geotechnical standpoint. Our study indicates the site is underlain predominately by sand and gravel older alluvium deposits. During our subsurface exploration completed on September 27, 2018, groundwater seepage was not encountered. However, it is our opinion the contractor should be prepared to respond to zones of groundwater seepage during construction.

The proposed residential structures can be constructed on a conventional continuous and spread footing foundation bearing on competent native soil, recompacted native soil, or new structural fill placed directly on competent native soil. Competent native soil, suitable for support of the new foundations, will likely be encountered beginning at depths of 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.

We understand onsite infiltration facilities are being pursued. Based on our investigation of the subject site, infiltration is feasible from a geotechnical standpoint. Infiltration recommendations are provided in this report.

Pertinent geotechnical 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

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

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GEOTECHNICAL ENGINEERING STUDY
EMIL'S WALK
MAPLE AVENUE AND LINCOLN AVENUE
SNOHOMISH, WASHINGTON

ES-6354

INTRODUCTION

General

This geotechnical engineering study was prepared for the proposed townhomes to be constructed northeast of the intersection of Maple Avenue and Lincoln Avenue in Snohomish, 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:

- Subsurface exploration for purposes of characterizing site soils;
- Laboratory testing of soil samples collected at the test pit locations;
- Engineering analyses and recommendations for the proposed development, and;
- Preparation of this report.

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

- Site Plan, prepared by Eagle Country Construction, dated September 13, 2018;
- Geologic Map of the Snohomish Quadrangle, Snohomish County, Washington, compiled by J.P. Minard, dated 1985;
- Snohomish Municipal Code;
- Snohomish County Geologic Hazards Erosion Hazard Areas, prepared for Snohomish County, Washington, dated February 1, 2016;
- Snohomish County Liquefaction Susceptibility, endorsed by the Washington State Department of Natural Resources, October 2009;
- Web Soil Survey, online resource maintained by the Natural Resources Conservation Service under the United States Department of Agriculture, and;
- Department of Ecology Stormwater Management Manual for Western Washington, Volume III Hydrologic Analysis and Flow Control BMPs, dated August 2012.

Project Description

Preliminary site layout indicates the subject site will be developed with two townhome structures and associated infrastructure improvements. Ingress and egress will be provided by Lincoln Avenue. Stormwater will likely be managed by individual lot infiltration (such as gravel-filled trenches and/or drywells).

At the time of report submission, specific building load and grading plans were not available for review; however, we anticipate the proposed structures will be two to three stories in height and constructed utilizing relatively lightly loaded wood framing supported on a conventional foundation system. Perimeter footing loads will likely be 1 to 2 kips per lineal foot. Slab-on-grade loading is anticipated to be approximately 150 pounds per square foot (psf).

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 our geotechnical recommendations been incorporated into the plans.

SITE CONDITIONS

Surface

The subject site is located immediately northeast of the intersection of Maple Avenue and Lincoln Avenue in Snohomish, Washington. The site consists of one tax parcel (Snohomish County parcel number 004359-002-004-00) totaling approximately 0.40 acres of land. The site is currently undeveloped and ESNW understands the subject site was previously owned by the BNSF Railway Company. We understand the site will likely be developed with a duplex and a quadplex residential structures, an access roadway, and associated infrastructure improvements. The site is relatively level, with total elevation change on the order of five feet or less.

Subsurface

A representative of ESNW observed, logged, and sampled three test pits, excavated at accessible locations within the site boundaries, on September 27, 2018 using a mini-trackhoe and operator retained by ESNW. The explorations 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 explorations 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 general accordance with Unified Soil Classification System (USCS) and United States Department of Agriculture (USDA) methods and procedures.

Topsoil and Fill

Where encountered at surface grades, topsoil extended to depths of about 8 to 10 inches. The topsoil was characterized by dark brown color, the presence of fine organic material, and small root intrusions. Topsoil is neither suitable for foundation support nor for use as structural fill. Topsoil may be used in non-structural areas if desired.

Fill was encountered at test pit locations TP-1 and TP-3 extending to depths of one and one-half to three feet below the existing ground surface (bgs), respectively. The fill encountered at TP-1 was observed to consist of loose to medium dense silty sand and the fill at TP-3 appears to be the remnants of an old burn pit, and consisted primarily of coal, ash, and miscellaneous garbage debris. It is possible that burn piles or other rubbish heaps may be encountered underlying existing grades; however, we anticipate fill and debris to be relatively surficial in depth. ESNW should observe areas of fill encountered during site excavations in order to provide supplement recommendations as necessary.

Native Soil

Native soils generally consist of sand and gravel (USCS: SP and GP, respectively) older alluvium deposits. Fines content generally decreased with depth. The in-situ density of the native deposits was generally described as medium dense. Native soils were primarily encountered in a damp condition and extended to a maximum exploration depth of approximately eight feet bgs.

Geologic Setting

The referenced geologic map resource identifies older alluvium (Qoal) deposits as the primary native soil unit underlying the subject site. As reported on the geologic map resource, the "Qoal" older alluvium consists of mostly clean, oxidized, medium- to coarse-grained sand and gravel. Additionally, recessional outwash (Qvr) deposits are mapped directly west of the subject site. As reported on the geologic map resource, the "Qvr" recessional outwash consists of well-drained stratified outwash sand and gravel deposited by the receding Vashon glacier. Additionally, the referenced WSS resource identifies Tokul gravelly medial loam (Map Unit Symbol: 72) across the subject site. The Tokul series was formed in till plains and hillslopes. Based on our field observations, on-site native soils are generally consistent with older alluvium deposits.

Groundwater

During our subsurface exploration completed on September 27, 2018, groundwater seepage was not encountered and extensive groundwater will likely not impact proposed infiltration facilities. However, it is our opinion the contractor should anticipate, and be prepared to respond to, zones of perched groundwater seepage during construction, especially within deeper site excavations. Groundwater seepage is common within relatively permeable lenses and/or atop dense to very dense deposits. It should be noted that 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.

Geologic Hazardous Areas

Based on review of available geologic critical area maps of the Snohomish area and Chapter 14 of the Snohomish Municipal Code, the subject site does not appear to be within or immediately adjacent to mapped geologic critical areas, with the exception of potential erosion hazards. In our opinion, site susceptibility to erosion hazards may be considered minimal due to the gently sloping topography and medium dense native soil conditions encountered at the test pit locations. Additional Best Management Practices (BMPs), as specified by the project civil engineer and indicated on the plans, should be incorporated into construction activities to reduce the potential for erosion hazards.

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 foundation support, slab-on-grade subgrade support, the suitability of using native soils as structural fill, and installation of infiltration facilities. Given the gravelly nature and relatively low percentage of fines of the older alluvium deposits across the site, infiltration is feasible from a geotechnical standpoint.

The proposed structures can be constructed on conventional continuous and spread footing foundations bearing on competent native soil, recompacted native soil, or new structural fill placed directly on competent native soil. Competent native soil, suitable for support of the new foundations, will likely be encountered beginning at depths of two to three feet bgs. 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.

This study has been prepared for the exclusive use of Emil's Walk, LLC and their representatives. A warranty is neither expressed nor implied. 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. Subsequent earthwork procedures will involve grading and related infrastructure improvements.

Temporary Erosion Control

Temporary construction entrances and drive lanes, consisting of at least six inches of quarry spalls, should be considered to both minimize off-site soil tracking and provide a stable access surface for construction vehicles. Geotextile fabric should be placed below the quarry spalls for greater stability of the temporary construction entrance. Erosion control measures should include 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 and indicated on the plans, should be incorporated into construction activities.

Stripping

Topsoil was encountered within the upper 8 to 10 inches of existing grades at the test pit locations. ESNW should be retained to provide site stripping recommendations at the time of construction. Over-stripping of the site surface should be avoided. Topsoil and/or organic-rich soil is not considered suitable for use in structural areas or for use as structural fill. If desired, topsoil and/or organic-rich soil may be used in non-structural areas.

Excavations and Slopes

Excavation activities are likely to expose medium dense coarse-grained soils. Based on the soil conditions observed at the test pit locations, the following allowable temporary slope inclinations, as a function of horizontal to vertical (H:V) inclination, may be used. The applicable Federal Occupation Safety and Health Administration (OSHA) and Washington Industrial Safety and Health Act (WISHA) soil classifications are also provided:

- Loose soil — 1.5H:1V (Type C)
- Areas containing groundwater seepage — 1.5H:1V (Type C)
- Medium dense to dense native soil — 1H:1V (Type B)

Permanent slopes should be planted with vegetation to enhance stability and to minimize erosion, and should maintain a gradient of 2H:1V or flatter. The presence of perched groundwater may cause localized sloughing of temporary slopes due to excess seepage forces. An ESNW representative 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. If the recommended temporary slope inclinations cannot be achieved, temporary shoring may be necessary to support excavations.

In-situ and Imported Soils

From a geotechnical standpoint, it is our opinion in-situ soils may be suitable for use in structural fill applications, provided the moisture content of the soil is at (or slightly above) the optimum moisture content at the time of placement and compaction. Successful use of native soils as structural fill will largely be dictated by in-situ moisture contents during construction.

Where necessary, 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. 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).

Structural Fill

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

Foundations

The proposed building structures can be constructed on a conventional continuous and spread footing foundation bearing on competent native soil, recompacted native soil, or new structural fill placed directly on competent native soils. Competent native soil, suitable for support of the new foundation, will likely be encountered beginning at depths of two to three feet bgs. 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. Provided the foundations will be supported as prescribed, 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. Based on the soil conditions encountered at the test pit locations, 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.

The referenced liquefaction susceptibility map indicates the site and surrounding areas maintain "low to moderate" liquefaction susceptibility. Liquefaction is a phenomenon where saturated and loose soils suddenly lose internal strength in response to increased pore water pressures resulting from an earthquake or other intense ground shaking. In our opinion, site susceptibility to liquefaction may be considered low. The compact nature of the site soils and the absence of a uniformly established, shallow groundwater table were the primary bases for this consideration.

Slab-on-Grade Floors

Slab-on-grade floors for the proposed residential structures should be supported on firm and unyielding subgrades comprised of competent native soil, compacted structural fill, or new structural fill. Unstable or yielding areas of the subgrades should be recompacted, or over-excavated and replaced with suitable structural fill, prior to slab construction.

Capillary breaks, 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 (where the fines content is defined as the percent passing the Number 200 sieve, based on the minus three-quarter-inch fraction). If relatively free-draining sand and gravel is exposed throughout slab subgrade areas, a capillary break may not be necessary; ESNW should evaluate the need for a capillary break during construction. In areas where slab moisture is undesirable, installation of vapor barriers below the slabs 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 (unrestrained 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 psf**

* *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 or suitable sheet drain 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

Zones of perched groundwater seepage should be anticipated in site excavations depending on the time of year grading operations take place, particularly within deeper excavations for utilities. Temporary measures to control surface water runoff and groundwater during construction would likely involve interceptor trenches and sumps.

Finish grades must be designed to direct surface water away from the new structures and/or slopes. Water must not be allowed to pond adjacent to the new structure and/or slopes. In our opinion, foundation drains should be installed along the building perimeter footings. A typical foundation drain detail is provided on Plate 4. If footing excavations expose relatively free-draining sand and gravel soils, omission of footing drains can be considered; omission of footing drains should be evaluated by ESNW during construction.

Infiltration Evaluation

As indicated in the *Subsurface* section of this report, native soils encountered during our fieldwork were characterized primarily as medium dense older alluvium sands and gravels. Based on the results of USDA textural analyses performed on representative soil samples, the sands and gravels can be further classified as extremely gravelly coarse sand to very gravelly coarse sand.

Based on the soil conditions observed during subsurface exploration, in our opinion, infiltration within the native soils is feasible. Our infiltration evaluation consisted of classifying representative soils using the USDA textural analysis scheme and the Soil Grain Size Analysis method using the 2012 DOE Stormwater Management Manual for Western Washington (SMMWW). Correction factors must be applied in order to determine a long-term design rate. The correction factors outlined below were used in accordance with Table III-3.3.1 of the 2012 SMMWW 3. The correction factors, along with the grain size analysis rate, were incorporated into the following equation: K_{sat} *design* = K_{sat} *initial x* CF_V *x* CF_t *x* CF_m. Based on review of the soil data and SMMWW, the following infiltration rate is recommended for design:

• Measured (K_{sat} initial)	16 inch per hour
• Site variability	CF_v = 0.75
• Test method	CF_t = 0.4
• Degree of influent control	CF_m = 0.9
Long-term design infiltration rate (K_{sat} design)	**4.0 inch per hour**

The above recommended infiltration rate is based on infiltration within the poorly graded sand and gravel soils. ESNW should be retained to observe the construction of infiltration facilities on the subject site in order to confirm soil conditions are as anticipated and perform confirmation infiltration testing at the infiltration design depth and location. Supplementary geotechnical recommendations may be provided at the time of construction, where necessary. It is our opinion that an emergency overflow should be incorporated into facility designs and should be directed to an approved discharge location; if an overflow is not feasible, the design infiltration rate should be reduced by half.

Utility Support and Trench Backfill

In our opinion, native soils will generally be suitable for support of utilities. Both organic-rich soil and fill are considered unsuitable for direct support of utilities and should be removed at utility grades, if encountered. Remedial measures, such as overexcavation and replacement with structural fill and/or installation of geotextile fabric, may be necessary in some areas to provide support for utilities. Groundwater may be encountered within deeper utility excavations, and caving of trench walls may occur where groundwater is encountered. Temporary construction dewatering, as well as temporary trench shoring, may be necessary during utility excavation and installation as conditions warrant.

In general, native soils should be suitable for use as structural backfill throughout utility trench excavations, provided the soils are at (or slightly above) the optimum moisture content at the time of placement and compaction. Structural trench backfill should not be placed dry of the optimum moisture content. Each section of the site utility lines must be adequately supported in appropriate bedding material. Utility trench backfill should be placed and compacted to the specifications of structural fill as previously detailed in this report, or to the applicable specifications of the City of Snohomish or other responsible jurisdiction or agency.

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 proof rolling 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 over-excavation and/or placement of thicker crushed rock or structural fill sections, prior to pavement.

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 rock base (CRB), or;

- A minimum of two inches of HMA placed over three inches of asphalt treated base (ATB).

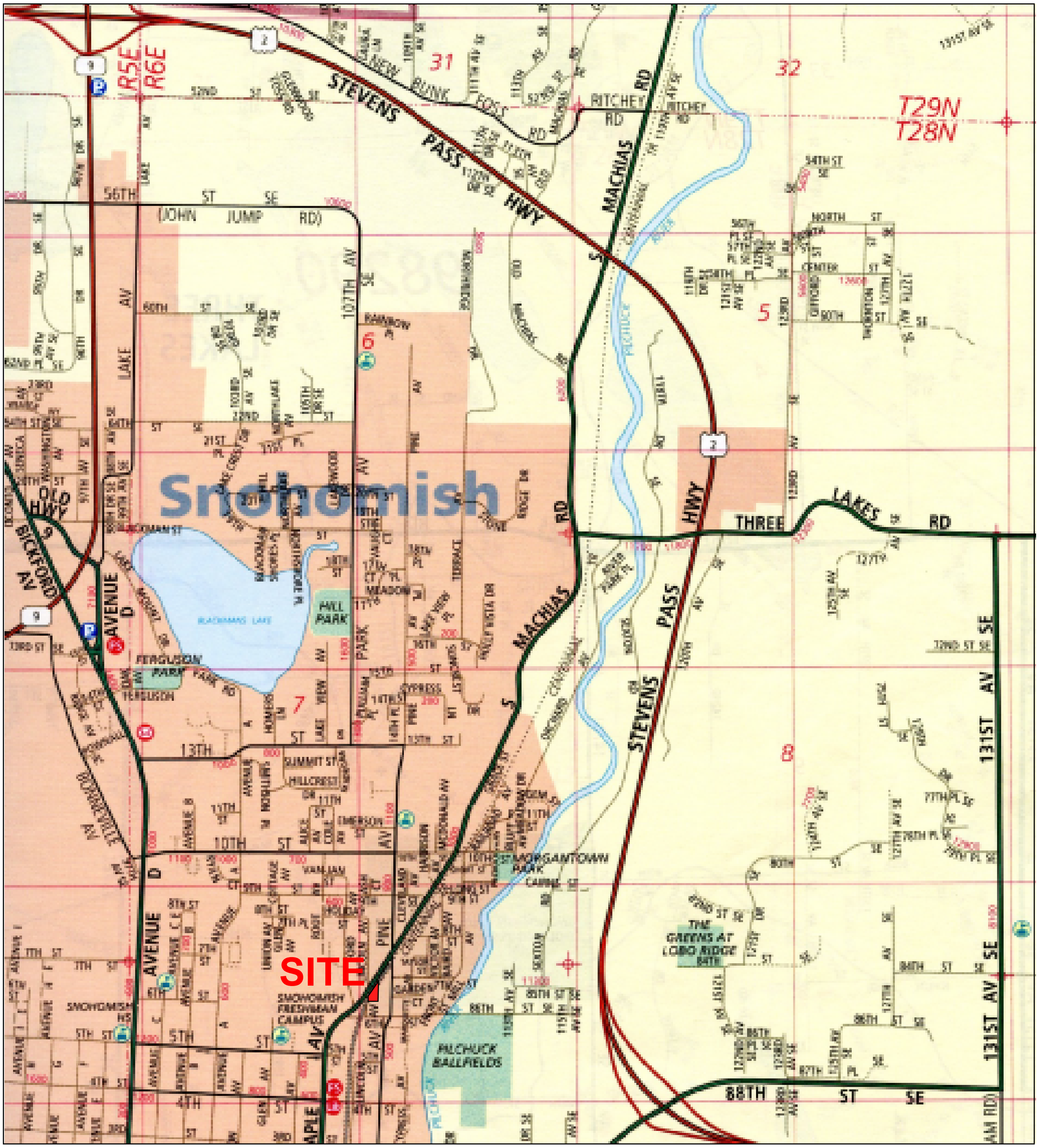
The HMA, ATB and CRB materials should conform to WSDOT specifications. All soil base material should be compacted to a relative compaction of 95 percent, based on the laboratory maximum dry density as determined by ASTM D1557. Final pavement design recommendations, including recommendations for heavy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

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 neither expressed nor 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.



Reference:
Snohomish County, Washington
Map 417
By The Thomas Guide
Rand McNally
32nd Edition

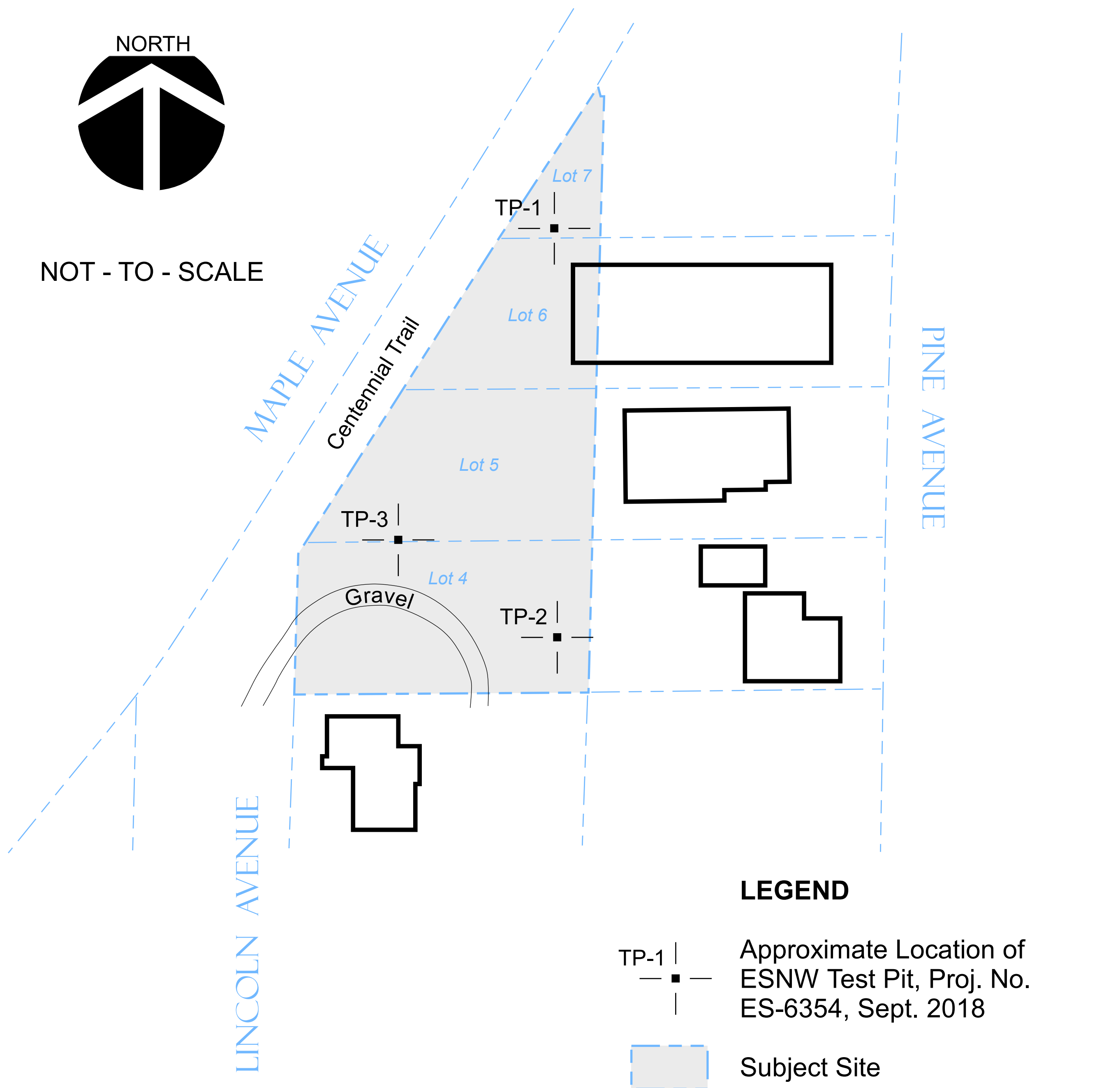
NORTH

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 Observation/Testing and Environmental Services

Vicinity Map
Emil's Walk
Snohomish, Washington

Drwn. CAM	Date 10/09/2018	Proj. No. 6354
Checked AZS	Date Oct. 2018	Plate 1



LEGEND

TP-1 — Approximate Location of ESNW Test Pit, Proj. No. ES-6354, Sept. 2018

Subject Site

Existing Building

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.

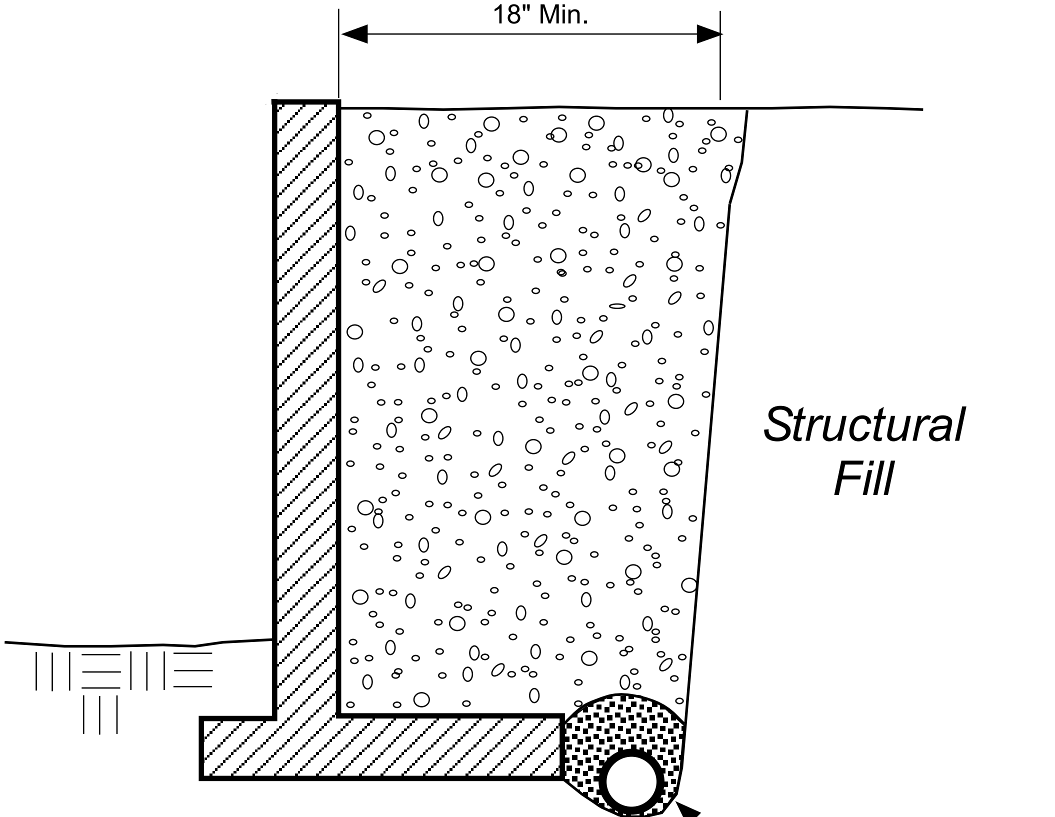
NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.

Earth Solutions NW LLC

Earth Solutions NWLLC
Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Test Pit Location Plan
Emil's Walk
Snohomish, Washington

Drwn. CAM	Date 10/09/2018	Proj. No. 6354
Checked AZS	Date Oct. 2018	Plate 2

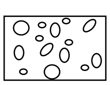


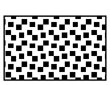
NOTES:

- 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.

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING

LEGEND:

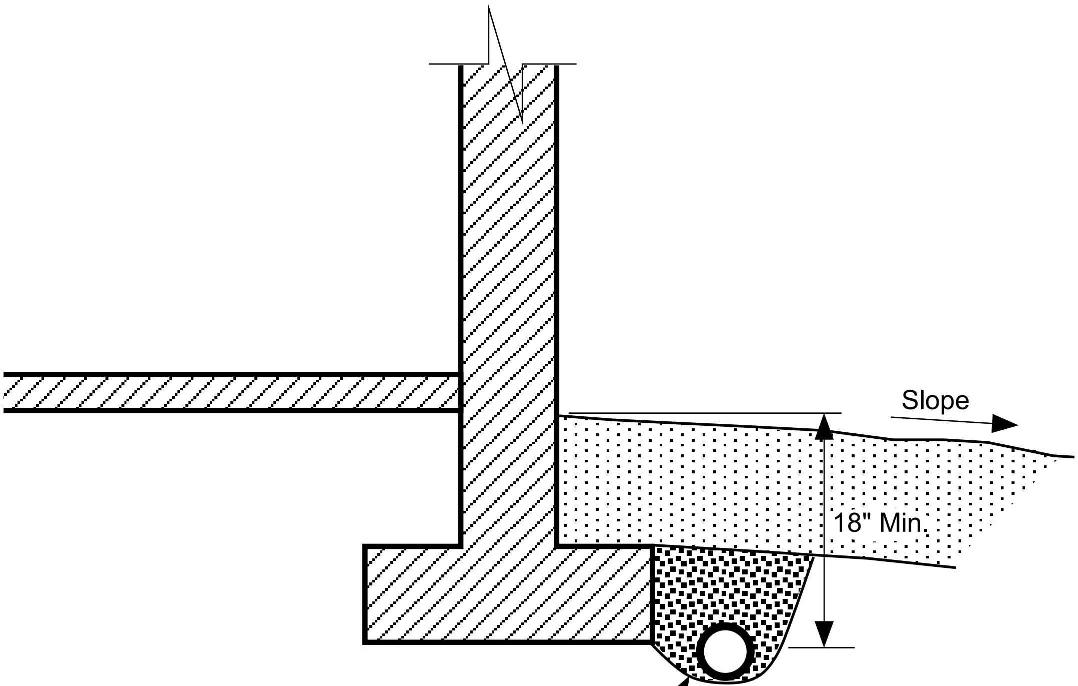

Free-draining Structural Backfill


1-inch Drain Rock

Earth Solutions NWLLC
Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Retaining Wall Drainage Detail
Emil's Walk
Snohomish, Washington

Drwn. CAM	Date 10/09/2018	Proj. No. 6354
Checked AZS	Date Oct. 2018	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.

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING

LEGEND:

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

1-inch Drain Rock

Earth Solutions NW LLC
Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Footing Drain Detail
Emil's Walk
Snohomish, Washington

Drwn. CAM	Date 10/09/2018	Proj. No. 6354
Checked AZS	Date Oct. 2018	Plate 4

Appendix A

Subsurface Exploration
Test Pit Logs

ES-6354

Subsurface conditions at the subject site were explored on September 27, 2018 by excavating three test pits using a trackhoe and operator retained by ESNW. The approximate locations of the test pits are illustrated on Plate 2 of this study. The test pit logs are provided in this Appendix. The maximum exploration depth was approximately eight 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

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	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
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	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
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	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
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	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

PROJECT NUMBER ES-6354 **PROJECT NAME** Emil's Walk
DATE STARTED 9/27/18 **COMPLETED** 9/27/18 **GROUND ELEVATION** **TEST PIT SIZE**
EXCAVATION CONTRACTOR NW Excavating **GROUND WATER LEVELS:**
EXCAVATION METHOD **AT TIME OF EXCAVATION** ---
LOGGED BY AZS **CHECKED BY** HTW **AT END OF EXCAVATION** ---
NOTES Depth of Topsoil & Sod 8": field grass **AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL	0.7	Dark brown TOPSOIL (Fill) -roots
		MC = 19.30%	SM	1.5	Brown silty SAND, medium dense, wet (Fill)
			TPSL	2.0	Dark brown TOPSOIL
		MC = 10.40%	SM	4.0	Gray silty SAND, medium dense, moist
5		MC = 3.30% MC = 2.70% Fines = 1.30% MC = 5.00%	SP	8.0	Gray poorly graded SAND with gravel, medium dense, damp -increasing gravels [USDA Classification: extremely gravelly coarse SAND]
					Test pit terminated at 8.0 feet below existing grade. No groundwater encountered during excavation. No caving observed. Bottom of test pit at 8.0 feet.

Earth Solutions NW
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Telephone: 425-449-4704
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TEST PIT NUMBER TP-2

PROJECT NUMBER ES-6354 **PROJECT NAME** Emil's Walk

DATE STARTED 9/27/18 **COMPLETED** 9/27/18 **GROUND ELEVATION** **TEST PIT SIZE**

EXCAVATION CONTRACTOR NW Excavating **GROUND WATER LEVELS:**

EXCAVATION METHOD **AT TIME OF EXCAVATION** ---

LOGGED BY AZS **CHECKED BY** HTW **AT END OF EXCAVATION** ---

NOTES Depth of Topsoil & Sod 10": field grass **AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL	0.9	Dark brown TOPSOIL -roots
			SM	1.5	Brown silty SAND, medium dense, damp
		MC = 2.10%	GP		Gray poorly graded GRAVEL with sand, medium dense, damp -caving from 2' to 6'
5		MC = 2.70% Fines = 3.70%			[USDA Classification: extremely gravelly coarse SAND]
		MC = 2.70%		7.0	
					Test pit terminated at 7.0 feet below existing grade. No groundwater encountered during excavation. Caving observed from 2.0 to 6.0 feet. Bottom of test pit at 7.0 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-3

PROJECT NUMBER ES-6354 **PROJECT NAME** Emil's Walk

DATE STARTED 9/27/18 **COMPLETED** 9/27/18 **GROUND ELEVATION** **TEST PIT SIZE**

EXCAVATION CONTRACTOR NW Excavating **GROUND WATER LEVELS:**

EXCAVATION METHOD **AT TIME OF EXCAVATION** ---

LOGGED BY AZS **CHECKED BY** HTW **AT END OF EXCAVATION** ---

NOTES Surface Conditions: field grass **AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0		MC = 17.20%	FILL	3.0	Coal/Ash/Trash (Fill)
		MC = 4.80%	SM	4.5	Brown silty SAND with gravel, medium dense, damp
5		MC = 2.50% MC = 2.30% Fines = 1.40%	SP	8.0	Gray poorly graded SAND with gravel, medium dense, damp -caving from 5' to BOH [USDA Classification: very gravelly coarse SAND]

Test pit terminated at 8.0 feet below existing grade. No groundwater encountered during excavation. Caving observed from 5.0 feet to BOH.
Bottom of test pit at 8.0 feet.

Appendix B

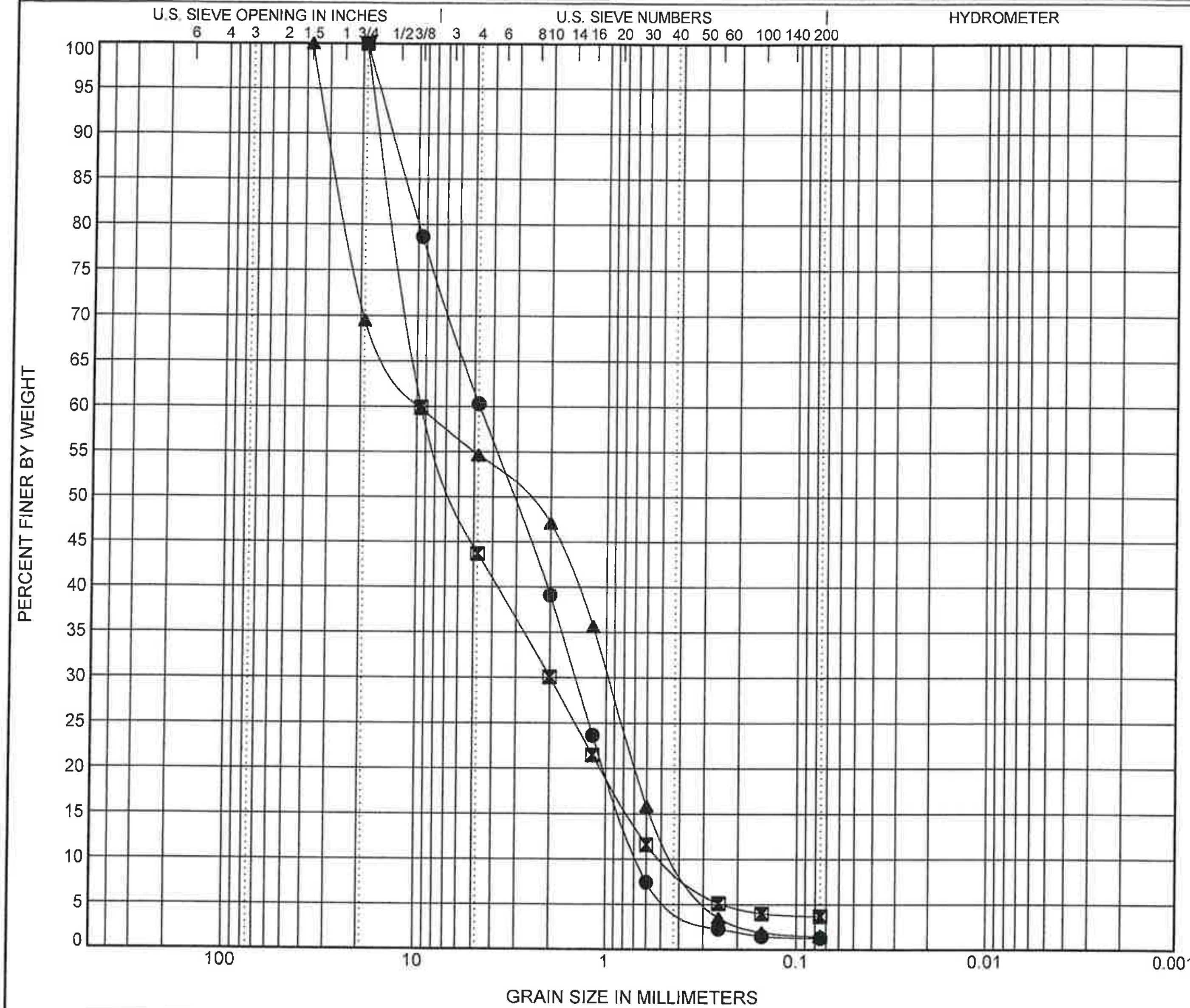
Laboratory Test Results

ES-6354

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

GRAIN SIZE DISTRIBUTION

PROJECT NUMBER ES-6354 **PROJECT NAME** Emil's Walk



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	Cc	Cu
●	TP-01	6.00ft.	USDA: Gray Extremely Gravelly Coarse Sand. USCS: SP with Gravel.	0.69	7.03
⊠	TP-02	5.00ft.	USDA: Gray Extremely Gravelly Coarse Sand. USCS: GP with Sand.	0.86	19.67
▲	TP-03	8.00ft.	USDA: Gray Very Gravelly Coarse Sand. USCS: SP with Gravel.	0.25	24.42

Specimen Identification			D100	D60	D30	D10	LL	PL	PI	%Silt	%Clay
●	TP-01	6.0ft.	19	4.695	1.466	0.667				1.3	
⊠	TP-02	5.0ft.	19	9.51	1.993	0.483				3.7	
▲	TP-03	8.0ft.	37.5	9.677	0.973	0.396				1.4	

GRAIN SIZE USDA ES-6354 EMIL'S WALK.GPJ GINT US LAB.GDT 10/8/18

Report Distribution

ES-6354

EMAIL ONLY

Emil's Walk, LLC
21412 – 107th Street Southeast
Snohomish, Washington 98290

Attention: Mr. Korbett Miller