Earth Solutions NW LLC

Geotechnical Engineering
Construction Observation/Testing
Environmental Services

GEOTECHNICAL ENGINEERING STUDY
4407 – 84TH STREET NORTHEAST
MARYSVILLE, WASHINGTON

ES-8608

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PREPARED FOR

MSR COMMUNITIES, LLC

June 20, 2022

06/20/2022

Raymond A. Coglas, P.E.
Principal Engineer

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Important Information about This

Geotechnical-Engineering Report

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

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept*

responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include 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 personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

Telephone: 301/565-2733
e-mail: info@geoprofessional.org www.geoprofessional.org

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

June 20, 2022
ES-8608

MSR Communities, LLC
18323 Bothell-Everett Highway, Suite 310
Bothell, Washington 98012

Attention: Mr. Ravi Teja Gottapu

Dear Mr. Teja Gottapu:

Earth Solutions NW, LLC (ESNW) is pleased to present this report titled "Geotechnical Engineering Study, 4407 – 84th Street Northeast, Marysville, Washington". Although development plans and feasibility are currently being evaluated, we anticipate final site development activities will involve construction of a residential plat and related site infrastructure improvements. The subject property is roughly 2.76 acres and is identified as Snohomish County Parcel 30052100105200. A single residential structure and several outbuildings currently occupy the southerly end of the property along (and near) the 84th Street Northeast frontage. The remainder of the site is undeveloped and comprised of a fairly large and sparsely forested grass field open area. Overall topography is gently sloping to flat. Based on review of the City of Marysville Geologic Hazards mapping (2014), there are no geologic hazardous areas identified within or immediately adjacent to the subject site.

Onsite investigation completed in May (2022) suggests that sand deposits associated with the Marysville Sand Member are present at-depth throughout the entirety of the site. On this basis, and given the overall findings of this geotechnical engineering study, residential site development activities as planned are considered feasible from a geotechnical standpoint. Additional findings of this investigation and pertinent design criteria and recommendations are provided within this body of this geotechnical 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

Raymond A. Coglas, P.E.
Principal Engineer

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GEOTECHNICAL ENGINEERING STUDY
4407 – 84TH STREET NORTHEAST
MARYSVILLE, WASHINGTON

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INTRODUCTION

General

This geotechnical engineering study was prepared for the subject property located at 4407 – 84th Street Northeast in Marysville, Washington. The Vicinity Map (Plate 1) provided in this study illustrates the approximate location of the site. This study provides the results of site-specific subsurface investigation, site reconnaissance work, and geotechnical analyses. The scope of service for completing this geotechnical engineering study included the following:

- Review of available geotechnical information and maps relevant to the site and surrounding area;
- Site specific subsurface investigation (excavation of 5 test pits);
- Site reconnaissance and observations of overall existing conditions;
- Review of a currently available geologic maps, critical areas mapping, and other relevant surveys and studies, and;
- Preparation of this final geotechnical study presenting the results of our investigation and recommendations for design.

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

- City of Marysville, Geologic Hazards (Map), 2014;
- City of Marysville Municipal Code, Ch. 22E.010 (Article IV);
- Faults and Earthquakes In Washington State, Jessica L. Czajkowski1 and Jeffrey D. Bowman;
- Geologic map of the Marysville Quadrangle, Snohomish County, Washington, Miscellaneous Field Studies Map 1743, By: J.P. Minard, and;
- Web Soil Survey (WSS) online resource, maintained by the Natural Resources Conservation Service (NRCS) under the United States Department of Agriculture.

Project Description

Although development plans and feasibility are currently being evaluated, we anticipate final site development activities will involve construction of a residential plat and related site infrastructure improvements. An existing single-family residence positioned at the south end of the site and remaining areas of the site to the north would likely be entirely cleared to make way for the new development. Due to the relatively flat existing grade, we anticipate site mass grading activities will only necessitate relatively minor cuts and fill (generally less than 5 feet). Stormwater may incorporate some form of infiltration into the natural sand deposits identified onsite. Otherwise, detention and discharge to established offsite conveyance will be utilized. Building design loads are expected to be relatively light, with wood frame wall loads of roughly 2 kips per foot and slab-on-grade loading of 150 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 verify the geotechnical recommendations provided in this report have been incorporated into the plans.

SITE CONDITIONS

Surface

The subject property is roughly 2.76 acres and is identified as Snohomish County Parcel 30052100105200 (see Vicinity Map – Plate 1 for site location). A single residential structure and several outbuildings currently occupy the southerly end of the property along (and near) the 84th Street Northeast frontage. The remainder of the site is undeveloped and comprised of a fairly large and sparsely forested grass field open area. Overall topography is gently sloping to flat. Based on review of the City of Marysville Geologic Hazards mapping (2014), there are no geologic hazardous areas identified within or immediately adjacent to the subject site.

Subsurface

To complete the site subsurface investigation, five test pits were excavated throughout representative locations of the subject property. Plate 2 of this study (Test Pit Location Plan) illustrates the approximate locations of the test sites. With the exception of the existing developed areas of the site, sod and topsoil comprise the vast majority of the surface condition. The topsoil depth exposed at the test locations generally did not exceed 12 inches. Native sand with silt transitioning to clean sands at-depth were identified below the topsoil at each test site. Please see the test pit logs included in Appendix A of this study for a more detailed description of the encountered subsurface condition.

Geologic Setting

The referenced Geologic Map of the Marysville Quadrangle identifies the Marysville Sand Member (Qvrm) underlies the entirety of the subject site and surrounding areas. According to the referenced geologic map, the Marysville Sand Member deposits fill a broad, flat, north-south valley in the Marysville area. These deposits consist primarily of well-drained, stratified to massive outwash sand, some fine gravel, and local sequences of silt and clay. The sand deposit was laid down by meltwater emanating from the north receding (and stagnating) Vashon glacier.
With respect to the NRCS soil survey, Ragnar fine sandy loam, 0 to 8 percent slopes is identified throughout the site and surrounding areas. The Ragnar fine sandy loam is characterized by the NRCS as Hydrologic Group A with depth to water of more than 80 inches.

Groundwater

Groundwater was identified at several test pit locations during the May 2022 site investigation. In general, the groundwater table that resides at depth regionally within the Marysville Sand Member was identified at depths of roughly 7.5 to 8.5 feet below the existing ground surface. In our experience, seasonal fluctuations of several feet are typical within the native sand member. On this basis, winter season monitoring of groundwater fluctuations (or review of available data in the area) is generally recommended if an infiltration approach to accommodating site storm water is pursued. In any case, the contractor should be prepared to dewater deeper excavations (such as utility installation) during the course of the site development activities. Typical of the Puget Sound area, groundwater levels and seepage rates are generally higher during the wet season (generally October through May).

Critical Areas Assessment

Based on review of the referenced Marysville Geologic Hazard Map (2014), steep slope, landslide, or seismic hazard areas are not identified on the site. Further these hazards are not identified on surrounding properties within 500 feet of the subject property. As such, no further geotechnical assessment of geologic hazards is deemed necessary for the future development.

DISCUSSION AND RECOMMENDATIONS

General

Provided the recommendations of this geotechnical engineering study are incorporated into final development plans, residential construction and related site improvements at the subject property are considered feasible from a geotechnical standpoint. Based on the identified subsurface condition, future building structures may be supported on conventional foundations bearing on a well compacted subgrade comprised of the native sand or equivalent structural fill material. The following sections of this study provide geotechnical recommendations for purposes of assisting with the final site designs.

This study has been prepared for the exclusive use of MSR Communities, LLC and their representatives. No warranty, expressed or implied, is made. This report 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 site clearing and stripping (as necessary), installing temporary erosion control measures, and establishing grading limits. An ESNW representative should be onsite during stripping activities to evaluate and document the necessary stripping depths (over stripping of site surfaces should be avoided). Additionally, it should be noted that voids present around areas of demolition (if applicable) should be restored with structural fill.

Temporary Erosion Control

Temporary construction entrances and drive lanes consisting of at least six inches of quarry spalls should be considered in order to minimize off-site soil tracking and to provide a stable access entrance surface. Geotextile fabric may also be considered underlying the quarry spalls for greater stability of the temporary construction entrance. Erosion control measures should consist of silt fencing or similar sediment barriers placed around the perimeter, especially down gradient portions of the site. Soil stockpiles should be covered or otherwise protected to reduce soil erosion during inclement weather. Temporary measures for controlling surface water runoff during construction should be established prior to beginning earthwork activities. Additional BMPs should be incorporated into construction activities as specified on the TESC plan, and as recommended by the geotechnical engineer or CESCL.

Wet Season Grading

Soils excavated and stockpiled during mass grading activities should be protected from excessive moisture or extended rainfall. As such, if grading takes place during the wetter winter, spring, or early summer months, a contingency should be included in the project budget to address managing and protecting soil stockpiles from wet weather. Similarly, consideration should also be given to including a contingency in the project budget for export of soils that become too wet and unsuitable for use as structural fill. Soil amendment and related cement treatment of saturated soils may also be an option for this project.

In-situ Soils

From a geotechnical standpoint, the native soils deposits may be suitable for use as structural fill provided the moisture content of the soil is at or near the (field) optimum level at the time of placement and compaction. Remedial measures, such as soil aeration, may be necessary as part of site grading and earthwork activities. If the on-site soils cannot be successfully compacted, the use of an imported soil may be necessary. As such, a contingency should be provided in the project budget for export of soil that cannot be successfully compacted as structural fill. Such a contingency would most likely be necessary if grading activities take place during extended periods of rainfall activity (wet season). It should be noted that soils with fines contents greater than 5 percent typically degrade rapidly when exposed to periods of extended rainfall during active grading operations.

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 (where the fines content is defined as the percent passing the Number 200 sieve, based on the minus three-quarter-inch fraction). The geotechnical engineer (or his representative) should work with the contractor to evaluate suitability of imported soil proposed for use in structural fill areas.

Structural Fill

Structural fill is defined as compacted soil placed in foundation, slab-on-grade, reinforced fill zones, 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 95 percent, based on the laboratory maximum dry density as determined by the Modified Proctor Method (ASTM D-1557). If deemed appropriate by the geotechnical engineer, a minimum relative compaction of 90 percent may also be acceptable during overall mass grading activities depending on the specific application. Additionally, where structural fill will be placed on an existing slope surface, a series of keyway excavations should be constructed to better secure to the fill to the native slope surface. With respect to soil placed in utility trenches, pavement areas and in the upper 12 inches of slab-on-grade areas, a relative compaction of at least 95 percent should be obtained. Additionally, specifications for utility trench backfill and compaction may also be dictated by the responsible utility district or jurisdiction.

Excavations and Slopes

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

Based on the identified soil conditions, Type C soil conditions are likely to be most prevalent across the site. Temporary slopes over four feet in height in Type C soils must be sloped no steeper than 1.5H:1V (Horizontal:Vertical). Type A soils may also be exposed in excavations advanced within the underlying glacial deposits. The geotechnical engineer (or his representative) should observe site excavations to confirm the soil type and allowable slope inclination are appropriate for the soil exposed by the excavation.

As a general rule, permanent slopes should maintain a gradient of 2H:1V, or flatter, and should be planted with vegetation to enhance stability and to minimize erosion. In some instances, permanent slope inclinations steeper than 2H:1V may be permissible pending further assessment by the geotechnical and civil engineers. In any case, the geotechnical engineer (or 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.

Gravity and/or Mechanically Stabilized Landscape Walls

The planned site grading activities may incorporate construction of gravity or mechanically stabilized earth landscape walls of limited height for the purpose of facilitating grade transitions. In our opinion, application of these wall systems is considered feasible from a geotechnical standpoint. A formal wall design with supporting calculations should be prepared (where applicable) as part of final design and preparation of the construction plan set. Rockery, segmental, and block style wall types are considered feasible for site applications, pending preparation of an engineered design.

Foundations

Based on the results of our study, future residential structures may be supported on a conventional foundation system bearing on a properly prepared and well compacted subgrade comprised of the native sand deposits or equivalent structural fill material. Assuming preparation of a suitable subgrade surface (as confirmed by the engineer or his representative during construction), the following values may be used for foundation design:

- Allowable soil bearing capacity — 2,500 psf
- Passive earth pressure — 350 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 approximately one-half inch is anticipated. The majority of anticipated settlement should occur during construction as dead loads are applied.

Slab-on-Grade Floors

Slab-on-grade floors should be supported on a firm and unyielding (well compacted) subgrade. Unstable or yielding areas of the subgrade should be recompacted, or overexcavated and replaced with suitable structural fill prior to placement of the slab capillary break material. 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 crushed rock or gravel 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). In areas where slab moisture is undesirable, installation of a vapor barrier below the slab should be considered. If a vapor barrier is to be utilized, it should be a material specifically designed for use as a vapor barrier and should be installed in accordance with the specifications of the manufacturer.

Seismic Design

The 2018 International Building Code (IBC) recognizes the American Society of Civil Engineers (ASCE) for seismic site class definitions (ASCE 7-16). As such, and based on geologic mapping and soil conditions identified at the exploration sites, Site Class D (stiff soil profile) should be used for design. Liquefaction is a phenomenon where saturated or loose soils suddenly lose internal strength and behave as a fluid. This behavior is in response to increased pore water pressures resulting from an earthquake or other intense ground shaking. As previously discussed, City of Marysville Geologic Hazard mapping does not identify the site or surrounding areas as prone to liquefaction. Additionally, based on the identified soil condition, it is our professional opinion that the site possesses a low susceptibility to liquefaction. It should also be noted that based on review of the referenced "Faults and Earthquakes In Washington State" mapping, there are no identified faults located near the site or surrounding properties.

Cast-In-Place Retaining Walls

Cast-in-place retaining walls must be designed to resist earth pressures and applicable surcharge loads. The following parameters may be used for design:

- Active earth pressure (yielding condition) — 35 pcf (equivalent fluid)
- At-rest earth pressure (restrained condition) — 50 pcf
- Traffic surcharge (passenger vehicles) — 70 psf (rectangular distribution)
- Passive earth pressure — 350 pcf (equivalent fluid)
- Coefficient of friction — 0.40
- Seismic surcharge — 6H psf*

** 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.

Retaining walls should be backfilled with free-draining material that extends along the height of the wall and a distance of at least 18 inches behind the wall. The upper 12 inches of the wall backfill may consist of a less permeable soil, if desired. It should be noted that some wall backfill applications may allow for use of a sheet drain material in lieu of free draining rock or gravel. The geotechnical engineer should be consulted where such applications are proposed to confirm acceptability. 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 pressure should be considered in the wall design.

Drainage

Temporary measures to control surface water runoff during construction would likely involve interceptor trenches, berms, temporary ponds, or other pertinent BMP's. With respect to groundwater, the contractor should be prepared to dewater deeper site excavations (such as deeper utility trench excavations) during construction. Finish grades must be designed to direct surface water away from structures and slopes. Water must not be allowed to pond adjacent to structures or slopes. In our opinion, foundation drains should be installed along building perimeter footings. A typical foundation drain detail is provided on Plate 4.

Infiltration

The Marysville sand deposits identified throughout the site are considered conducive to infiltration. Groundwater was observed at depths of roughly 7.5 to 8.5 feet below existing grade at the time of our May 2022 investigation. As such, facility design would need to consider appropriate separation between the seasonal high groundwater level and any future infiltration device. It should be noted that the identified groundwater level(s) at the time of our May 2022 investigation is not what we would consider the seasonally high level. Further assessment of the seasonal high groundwater level (and possible winter monitoring) will be needed to ascertain a seasonal high water level for design purposes. In any case, for preliminary design purposes, an allowable infiltration rate of 1.5 inches per hour can be assumed at this time. This preliminary rate should be confirmed through insitu infiltration testing during the design phase of the project.

Utility Support and Trench Backfill

In our opinion, on-site soils will generally be suitable for support of utilities. Remedial measures may be necessary in some areas in order to provide support for utilities such as overexcavation and replacement with structural fill, or placement of geotextile fabric. In general, on-site soils may be suitable for use as structural backfill throughout utility trench excavations. Such suitability will largely be dictated by the moisture content of the soil at the time of placement and compaction. Moisture conditioning of the soils may be necessary at some locations prior to use as structural fill. In any case, each section of the utility lines must be adequately supported in the 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 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 exhibit 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 overexcavation and/or placement of thicker crushed rock or structural fill sections, prior to pavement.

Where applicable, and for preliminary purposes, the following pavement sections may be considered for the site access drive roadway:

- 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).

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 governing jurisdiction may supersede the recommendations provided in this report. 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.

LIMITATIONS

The recommendations and conclusions provided in this study are professional opinions consistent with the level of care and skill that is typical of other members in the profession currently practicing under similar conditions in this area. A warranty is not expressed or implied. Variations in the soil and groundwater conditions identified 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.

NORTH

Reference:
Snohomish County, Washington
OpenStreetMap.org

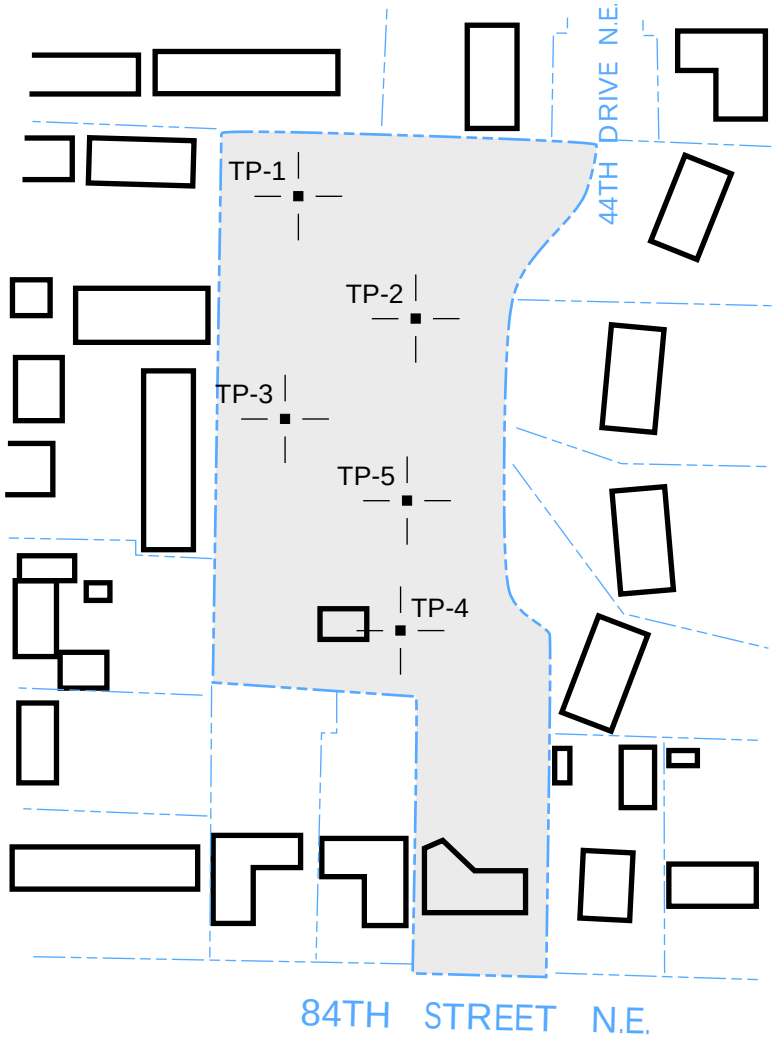
NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.

Earth Solutions NW LLC

Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Vicinity Map
4407 - 84th Street N.E.
Marysville, Washington

Drwn. CAM	Date 06/20/2022	Proj. No. 8608
Checked RAC	Date June 2022	Plate 1



LEGEND

TP-1 — Approximate Location of ESNW Test Pit, Proj. No. ES-8608, May 2022

Subject Site

Existing Building

NORTH

NOT - TO - SCALE

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.

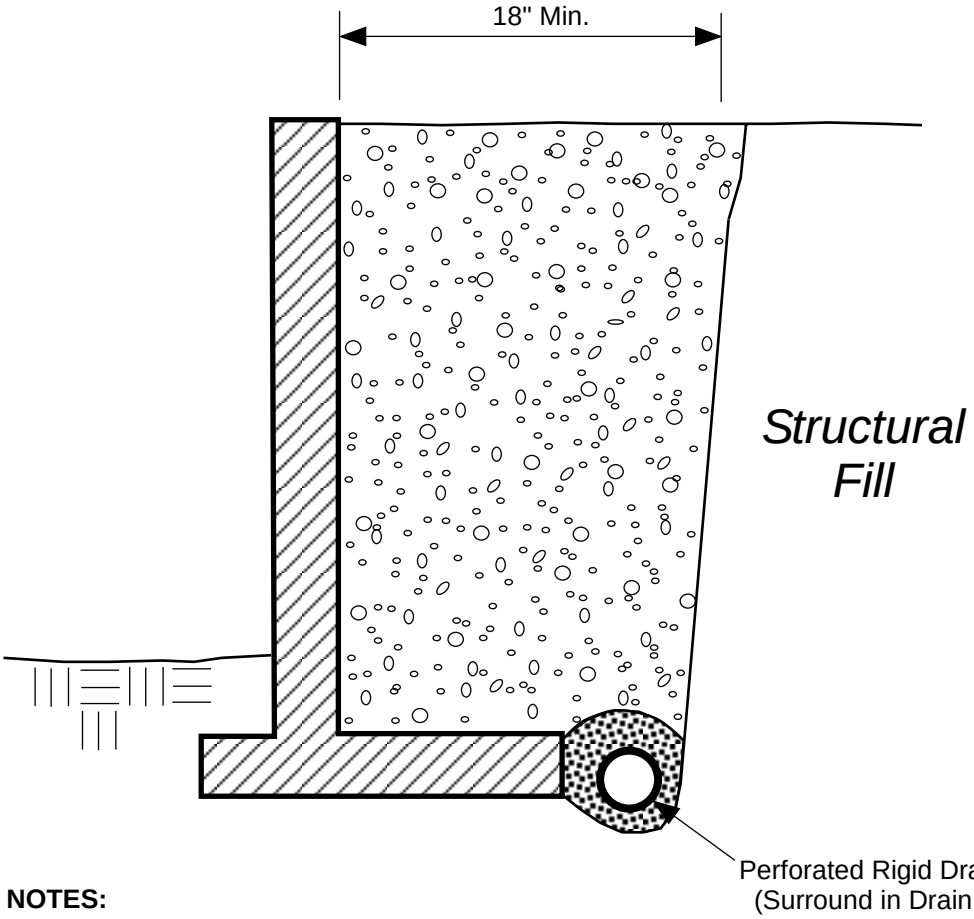
NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.

Earth Solutions NW LLC

Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Test Pit Location Plan
4407 - 84th Street N.E.
Marysville, Washington

Drwn. CAM	Date 06/20/2022	Proj. No. 8608
Checked RAC	Date June 2022	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

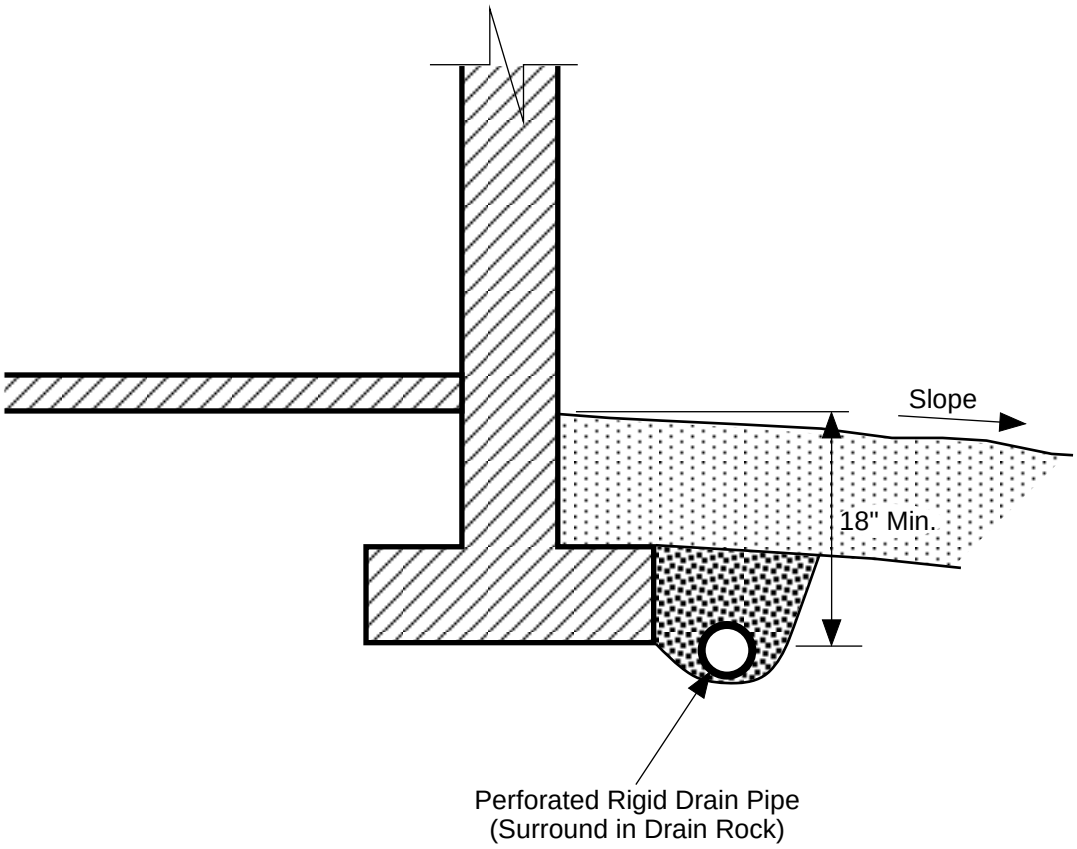
1-inch Drain Rock

Earth Solutions NW LLC

Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Retaining Wall Drainage Detail
4407 - 84th Street N.E.
Marysville, Washington

Drwn. CAM	Date 06/20/2022	Proj. No. 8608
Checked RAC	Date June 2022	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
4407 - 84th Street N.E.
Marysville, Washington

Drwn. CAM	Date 06/20/2022	Proj. No. 8608
Checked RAC	Date June 2022	Plate 4

Appendix A

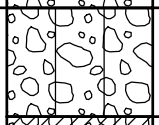
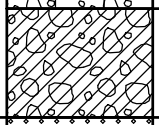
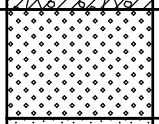
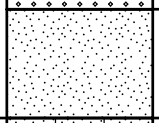
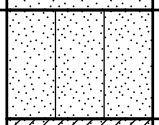
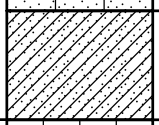
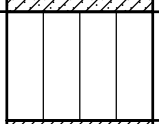
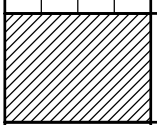
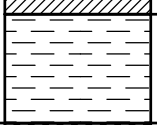
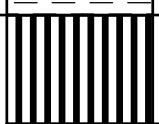
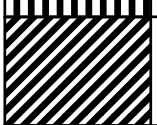
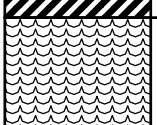
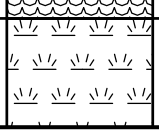
Subsurface Exploration
Test Pit Logs

ES-8608

The subsurface conditions at the site were explored by excavating five test pits. The approximate locations of the test pits are depicted on the Test Pit Location Plan (Plate 2). The subsurface test pit logs are provided in this Appendix. 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		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, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-1

PROJECT NUMBER ES-8608 **PROJECT NAME** 4407 - 84th Street N.E.

DATE STARTED 5/6/22 **COMPLETED** 5/6/22 **GROUND ELEVATION**

EXCAVATION CONTRACTOR Loren Harris **LATITUDE** **LONGITUDE**

LOGGED BY WR **CHECKED BY** RAC **GROUND WATER LEVEL:**

NOTES ▽ **AT TIME OF EXCAVATION** 8.5 ft

SURFACE CONDITIONS Sod/Topsoil **AFTER EXCAVATION**

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0			TPSL		Sod and TOPSOIL
				0.7	
			SP-SM		Brown poorly graded SAND with silt, loose to medium dense, moist
	GB	MC = 10.0% Fines = 5.9%			
2.5				2.0	
			SP		Grades to brown poorly graded SAND, medium dense, moist [USDA Classification: slightly gravelly SAND]
5.0					
7.5	GB	MC = 22.1%			
					▽ -groundwater table
				9.0	

Test pit terminated at 9.0 feet below existing grade. Groundwater table encountered at 8.5 feet during excavation. No caving observed.

LIMITATIONS: Ground elevation (if listed) is approximate; the test location was not surveyed. Coordinates are approximate and based on the WGS84 datum. Do not rely on this test log as a standalone document. Refer to the text of the geotechnical report for a complete understanding of subsurface conditions.

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-2

PROJECT NUMBER ES-8608 **PROJECT NAME** 4407 - 84th Street N.E.

DATE STARTED 5/6/22 **COMPLETED** 5/6/22 **GROUND ELEVATION**

EXCAVATION CONTRACTOR Loren Harris **LATITUDE** **LONGITUDE**

LOGGED BY WR **CHECKED BY** RAC **GROUND WATER LEVEL:**

NOTES ▽ **AT TIME OF EXCAVATION**

SURFACE CONDITIONS Sod/Topsoil **AFTER EXCAVATION**

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0			TPSL		Sod and TOPSOIL
0.5			SM		Brown silty fine SAND, loose, wet
1.5	GB	MC = 16.8% Fines = 14.0%	SP		Grades to brown poorly graded SAND, loose to medium dense, moist [USDA Classification: slightly gravelly SAND]
2.5					
5.0	GB	MC = 9.3%			
7.0					

Test pit terminated at 7.0 feet below existing grade. No groundwater encountered during excavation. No caving observed.

LIMITATIONS: Ground elevation (if listed) is approximate; the test location was not surveyed. Coordinates are approximate and based on the WGS84 datum. Do not rely on this test log as a standalone document. Refer to the text of the geotechnical report for a complete understanding of subsurface conditions.

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-3

PROJECT NUMBER ES-8608 **PROJECT NAME** 4407 - 84th Street N.E.

DATE STARTED 5/6/22 **COMPLETED** 5/6/22 **GROUND ELEVATION**

EXCAVATION CONTRACTOR Loren Harris **LATITUDE** **LONGITUDE**

LOGGED BY WR **CHECKED BY** RAC **GROUND WATER LEVEL:**

NOTES ▽ **AT TIME OF EXCAVATION** 7.5 ft

SURFACE CONDITIONS Sod/Topsoil **AFTER EXCAVATION**

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0			TPSL		Sod and TOPSOIL
				0.5	
			SP-SM		Brown poorly graded SAND with silt, loose, moist to wet
				1.5	
	GB	MC = 10.6%	SP		Grades to brown poorly graded SAND, medium dense, moist
2.5					
5.0	GB	MC = 6.6% Fines = 0.8%			[USDA Classification: slightly gravelly SAND]
7.5					▽ -groundwater table
				8.0	

Test pit terminated at 8.0 feet below existing grade. Groundwater table encountered at 7.5 feet during excavation. No caving observed.

LIMITATIONS: Ground elevation (if listed) is approximate; the test location was not surveyed. Coordinates are approximate and based on the WGS84 datum. Do not rely on this test log as a standalone document. Refer to the text of the geotechnical report for a complete understanding of subsurface conditions.

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-4

PROJECT NUMBER ES-8608 **PROJECT NAME** 4407 - 84th Street N.E.

DATE STARTED 5/6/22 **COMPLETED** 5/6/22 **GROUND ELEVATION**

EXCAVATION CONTRACTOR Loren Harris **LATITUDE** **LONGITUDE**

LOGGED BY WR **CHECKED BY** RAC **GROUND WATER LEVEL:**

NOTES ▽ **AT TIME OF EXCAVATION**

SURFACE CONDITIONS Sod/Topsoil **AFTER EXCAVATION**

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0			TPSL		Sod and TOPSOIL
				0.5	
			SP-SM		Brown poorly graded SAND with silt, loose, moist
				1.5	
	GB	MC = 7.4%	SP		Grades to brown poorly graded SAND, medium dense, moist
2.5					
5.0	GB	MC = 10.4% Fines = 2.5%			[USDA Classification: slightly gravelly coarse SAND]
				7.0	

Test pit terminated at 7.0 feet below existing grade. No groundwater encountered during excavation. No caving observed.

LIMITATIONS: Ground elevation (if listed) is approximate; the test location was not surveyed. Coordinates are approximate and based on the WGS84 datum. Do not rely on this test log as a standalone document. Refer to the text of the geotechnical report for a complete understanding of subsurface conditions.

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-5

PROJECT NUMBER ES-8608 **PROJECT NAME** 4407 - 84th Street N.E.

DATE STARTED 5/6/22 **COMPLETED** 5/6/22 **GROUND ELEVATION**

EXCAVATION CONTRACTOR Loren Harris **LATITUDE** **LONGITUDE**

LOGGED BY WR **CHECKED BY** RAC **GROUND WATER LEVEL:**

NOTES ▽ **AT TIME OF EXCAVATION**

SURFACE CONDITIONS Sod/Topsoil **AFTER EXCAVATION**

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0			TPSL		Sod and TOPSOIL
0.5					Brown poorly graded SAND with silt, loose, moist
2.5	GB	MC = 7.8%	SP-SM		
5.0	GB	MC = 18.3% Fines = 5.3%			[USDA Classification: slightly gravelly SAND]
7.0					

Test pit terminated at 7.0 feet below existing grade. No groundwater encountered during excavation. No caving observed.

LIMITATIONS: Ground elevation (if listed) is approximate; the test location was not surveyed. Coordinates are approximate and based on the WGS84 datum. Do not rely on this test log as a standalone document. Refer to the text of the geotechnical report for a complete understanding of subsurface conditions.

Appendix B

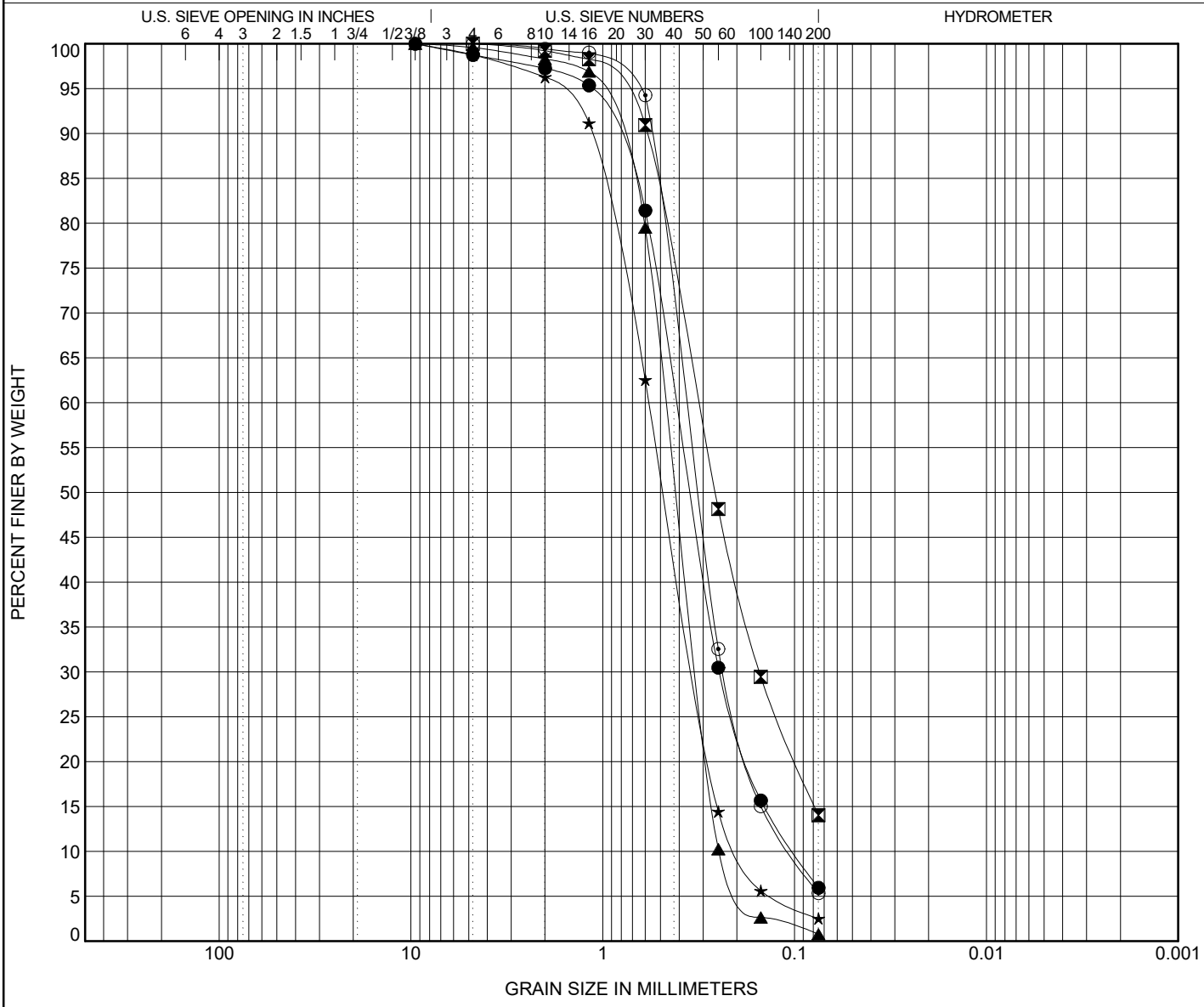
Laboratory Test Results

ES-8608

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

GRAIN SIZE DISTRIBUTION

PROJECT NUMBER ES-8608 **PROJECT NAME** 4407 - 84th Street N.E.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	Cc	Cu
●	TP-01	2.00ft.	USDA: Brown Slightly Gravelly Sand. USCS: SP-SM.	1.45	4.15
⊠	TP-02	2.00ft.	USDA: Brown Slightly Gravelly Sand. USCS: SM.		
▲	TP-03	6.00ft.	USDA: Gray-Brn Slightly Gravelly Sand. USCS: SP.	0.89	1.91
★	TP-04	6.00ft.	USDA: Gray-Brn Slightly Gravelly Coarse Sand. USCS: SP.	0.99	2.96
⊙	TP-05	6.00ft.	USDA: Gray-Brn Slightly Gravelly Sand. USCS: SP-SM.	1.39	3.53

Specimen Identification			D100	D60	D30	D10	LL	PL	PI	%Silt	%Clay
●	TP-01	2.0ft.	9.5	0.415	0.246	0.1				5.9	
⊠	TP-02	2.0ft.	4.75	0.319	0.152					14.0	
▲	TP-03	6.0ft.	9.5	0.469	0.321	0.246				0.8	
★	TP-04	6.0ft.	9.5	0.573	0.332	0.193				2.5	
⊙	TP-05	6.0ft.	4.75	0.369	0.232	0.105				5.3	

Report Distribution

ES-8608

EMAIL ONLY

MSR Communities, LLC
18323 Bothell-Everett Highway, Suite 310
Bothell, Washington 98012

Attention: Mr. Ravi Teja Gottapu