PREPARED FOR

DUKE REALTY

January 30, 2019

Terry J. Dunn
Staff Geologist

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Principal Engineer

GEOTECHNICAL ENGINEERING STUDY
PROPOSED COMMERCIAL DEVELOPMENT
9 ACRE SUMNER
1510 PUYALLUP STREET
SUMNER, WASHINGTON

ES-5903.01

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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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January 30, 2019
ES-5903.01

Duke Realty
200 Spectrum Center Drive, Suite 1600
Irvine, California 92618

Attention: Mr. Adam Schmid

Dear Mr. Schmid:

Earth Solutions NW, LLC (ESNW) is pleased to present this report titled "Geotechnical Engineering Study, Proposed Commercial Development, 9 Acre Sumner, 1510 Puyallup Street, Sumner, Washington". Based on the conditions encountered during our fieldwork, the proposed project is feasible from a geotechnical standpoint. Our study indicates the site is underlain predominately by alluvial deposits. During our subsurface exploration completed on January 14, 2019, groundwater was encountered at depths of about 7.5 to 10 feet below the existing ground surface. As such, the contractor should be prepared to manage groundwater during construction.

Based on the results of our study, the proposed warehouse building can be supported on conventional continuous and spread footing foundations bearing on at least two feet of structural fill after completion of a preload and/or surcharge program. Where loose or unsuitable soil conditions are exposed at foundation subgrade elevations, additional overexcavation and replacement with a suitable structural fill material, will be necessary.

We understand infiltration is being considered to accommodate stormwater runoff from new impervious surfaces. Based on our field observations of the alluvial deposits across the site, in our opinion, infiltration is not recommended from a geotechnical standpoint. Conventional methods of stormwater management, such as, dispersion, detention, and connecting to an existing stormwater collections system, may prove more practical.

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

Terry J. Dunn
Staff Geologist

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INTRODUCTION

General

This geotechnical engineering study (study) was prepared for the proposed commercial warehouse development to be completed at 1510 Puyallup Street, in Sumner, Washington. The purpose of this study was to provide geotechnical recommendations for the proposed development. Our scope of services for completing this geotechnical engineering study included the following:

- Subsurface explorations for purposes of characterizing site soils;
- Laboratory testing of soil samples collected at the boring locations;
- Engineering analyses, and;
- Preparation of this report.

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

- Liquefaction Susceptibility Map of Pierce County, Washington, by Stephen P. Palmer, et.al., dated September 2004;
- Surficial Geology and Geomorphology of the Lake Tapps Quadrangle, Washington, by D.R. Crandell, 1963, and;
- Online Web Soil Survey (WSS) resource, provided by the United States Department of Agriculture (USDA), Natural Resources Conservation Service.

Project Description

We understand that the subject site will be redeveloped with a new warehouse building, truck access, and associated improvements. The existing warehouse building will be removed and a new warehouse building will be constructed on-site. The building will utilize concrete tilt-up panel construction with dock-high slab-on-grade floors and will be supported on conventional spread and continuous footing foundations. At the time of report submission, specific building load and grading plans were not available for review; however, based on our experience with similar developments, we anticipate the proposed structure will use a dock-high configuration to accommodate truck dock loading areas. Foundation loads will be on the order of 4 to 7 kips per lineal foot and column loads on the order of 80 to 120 kips. Slab-on-grade loading will likely be on the order of 350 pounds per square foot (psf). Pavement is anticipated to support areas of heavy truck traffic and areas for passenger vehicle parking. Ingress and egress to the warehouse building will be provided from Puyallup Street and Williams Avenue.

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 approximately 100 feet south of the intersection between Tacoma Avenue and Puyallup Street, in Sumner, Washington. The approximate location of the property is illustrated on Plate 1 (Vicinity Map). The property is comprised of six tax parcels (Pierce County Parcel No. 0420241124, 9675000030, 9675000040, 9675000091, 9675000100, and 9675000110) and is approximately 9.01 acres. The site is bordered to the north by Puyallup Street, to the south by Hubbard Street, to the east by Williams Avenue, and to the west by Western Beer Distributing. A warehouse building, outbuildings, and associated infrastructure improvements currently occupy the site. Vegetation, along the eastern portion of the site, primarily consists of grass, brambles, and trees. Site topography is relatively level with little discernible change in elevation across the property.

Subsurface

A representative of ESNW observed, logged, and sampled three borings, advanced at accessible locations within the site boundaries, on January 14, 2019 using a drill rig 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 (Boring Location Plan). Please refer to the boring logs provided in Appendix A for a more detailed description of subsurface conditions. Representative soil samples collected at the boring 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

Along the eastern portion of the site, topsoil extended to depths of about 6 to 12 inches. Topsoil is generally characterized by the observed dark brown hue, the presence of fine organics, and small root intrusions.

Fill was not encountered at the test locations during our January fieldwork; however, fill should be anticipated around the perimeter of the existing buildings and infrastructure improvements. Fill encountered during grading should be evaluated by ESNW, as necessary.

Native Soil

Underlying the topsoil and fill, native deposits consisted primarily of very loose to medium dense alluvial soils with varying amounts of silt and sand (USCS: ML, SM, and SP-SM). Occasional organic and gravel interbeds were observed within the native layers. The native soils were generally encountered in a damp to wet condition and extended to the maximum exploration depth of 26.5 feet bgs.

Geologic Setting

The referenced geologic map resource identifies alluvial (Qa) deposits as the primary native soil unit underlying the subject site. As reported on the geologic map resource, alluvial soils typically consist of sand and pebble to cobble gravel, except in the Puyallup Valley, where it is mostly sand. The referenced WSS resource identifies Briscot loam, Snohomish silty clay loam, and Sultan silt loam (Map Unit Symbols: 6A, 39A, and 42A) as the primary soil units underlying the subject site. The Briscot, Snohomish, and Sultan series were formed in flood plains. Based on our field observations, on-site native soils are generally consistent with alluvial (Qa) deposits.

Groundwater

During our subsurface exploration completed on January 14, 2019, groundwater was encountered at depths of about 7.5 to 10 feet bgs at the boring locations. As such, it is our opinion the contractor should anticipate, and be prepared to manage, zones of perched groundwater seepage during construction, and the groundwater table within site excavations. 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 wet season (October through April).

DISCUSSION AND RECOMMENDATIONS

General

In our opinion, construction of the proposed warehouse building is feasible from a geotechnical standpoint. The proposed building can be constructed on conventional continuous and spread footing foundations bearing on at least two feet of structural fill after completion of a preload and/or surcharge program. 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 infiltration is being considered to accommodate stormwater runoff from new impervious surfaces. Given the relatively high percentage of fines of the alluvial deposits across the site, in our opinion, infiltration is not recommended from a geotechnical standpoint. Conventional methods of stormwater management, such as, dispersion, detention, and connecting to an existing stormwater collections system, may prove more practical.

This study has been prepared for the exclusive use of Duke Realty and their representatives. No warranty, expressed or implied, is made. This study has been prepared in a manner consistent with the level of care and skill ordinarily exercised by other members of the profession currently practicing under similar conditions in this area.

Site Preparation and Earthwork

Initial site preparation activities will consist of removing the existing warehouse building, outbuildings, and related improvements, installing temporary erosion control measures, establishing grading limits, and performing site clearing in preparation for mass grading activities. Subsequent earthwork procedures will involve grading and related infrastructure improvements. Grading activities should be observed by ESNW to confirm adequate removal of any vegetation, organics, and/or unsuitable fill material.

Temporary Erosion Control

The following temporary erosion control measures are applicable:

- 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 entrance surface. Placing geotextile fabric underneath the quarry spalls will provide greater stability, if needed.
- Silt fencing should be placed around the site perimeter.
- When not in use, soil stockpiles should be covered or otherwise protected, especially during periods of wet weather to reduce the potential for soil erosion.
- Temporary measures for controlling surface water runoff, such as interceptor trenches, sumps, or interceptor swales, should be installed prior to beginning earthwork activities.
- Dry soils disturbed during construction should be wetted to minimize dust and airborne soil erosion.
- When appropriate, permanent planting or hydroseeding will help to stabilize site soils.

Additional Best Management Practices (BMPs), as specified by the project civil engineer and indicated on the plans, should be incorporated into construction activities. Temporary erosion control measures may be modified during construction as site conditions require, as approved by the site erosion control lead.

Excavations and Slopes

Based on the soil conditions observed at the boring 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 and medium dense soil or fill — 1.5H:1V (Type C)
- Areas with groundwater seepage — 1.5H:1V (Type C)

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.

Structural Fill

Structural fill is defined as compacted soil placed in foundation, slab-on-grade, roadway, permanent slopes, retaining wall, and utility trench backfill areas. 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 D1557). For soil placed in utility trenches underlying structural areas, compaction requirements are dictated by the local city, county, or utility district, and are typically specified to a relative compaction of at least 95 percent.

In-situ and Imported Soils

From a geotechnical standpoint, it is our opinion in-situ soils may not be suitable for use in structural fill applications, unless 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.

If the on-site soils cannot be successfully compacted, the use of an imported soil may be necessary. In our opinion, a contingency should be provided in the project budget for export of soil that cannot be successfully compacted as structural fill, particularly if grading activities take place during periods of extended rainfall activity. In general, soils with fines contents greater than 5 percent typically degrade rapidly when exposed to periods of rainfall.

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).

Subgrade Preparation

Following removal of existing structures, fills will primarily be completed to establish proposed subgrade elevations across the site. ESNW should observe the subgrade areas during initial site preparation activities to confirm soil conditions are as anticipated and to provide supplementary recommendations for subgrade preparation. The process of removing existing structures may produce voids where old foundations may have been present. Complete restoration of voids resulting from previous or current demolition activities must be executed as part of overall subgrade and building pad preparation activities. The following guidelines for preparing building subgrade areas should be incorporated into the final design:

- Where voids and related demolition disturbances extend below planned subgrade elevations, restoration of these areas should be completed. Structural fill should be used to restore voids or unstable areas resulting from the removal of existing structural elements.

- Recompact, or overexcavate and replace, areas of existing fill, if present, exposed at building subgrade elevations. Overexcavations should extend into competent native soils and structural fill should be utilized to restore subgrade elevations as necessary.

- ESNW should confirm subgrade conditions, as well as the required level of recompaction and/or overexcavation and replacement, during site preparation activities. ESNW should also evaluate the overall suitability of prepared subgrade areas following site preparation activities.

Surcharge and Preload Recommendations

Given the compressible nature of the site soils, a preload and/or surcharge will be necessary to reduce post construction settlements to tolerable levels. A preload and/or surcharge program consists of placement of fill to the recommended elevation then monitoring the settlement induced by the weight of the soil. In general, if the finish floor elevation is two and one-half feet higher than the existing grades, a preload placed to the finish floor is recommended. If the finish floor elevation is less than two and one-half feet higher than the existing grades, a surcharge should be used. Preload and surcharge fill soils should extend a minimum of five feet beyond the proposed building footprint, measured from the top of the fill slope.

A settlement monitoring program should be implemented to measure both the rate and amount of settlement of the compressible soils. The settlement monitoring program should consist of placing settlement markers on the exiting subgrade prior to any fill placement. The markers should then be monitored throughout the fill placement. A settlement marker detail is provided as Plate 5.

ESNW should review the grading plans to confirm the preload and surcharge recommendations remain applicable. The following recommendations for surcharge and preload programs should be incorporated into the design:

Surcharge Program

A surcharge program should be used for structures where the finish floor elevation is less than two-and-one-half feet above existing grades. The following recommendations are applicable for a surcharge program:

- Surcharge fill height — Three feet above floor elevation (350 psf design slab load)
- Surcharge duration — Estimated two to four weeks
- Surcharge settlements — Estimated three to five inches

Preload Program

A preload program should be used for structures where the finish floor elevation is more than two-and-one-half feet above existing grades. The following recommendations are applicable for a preload program:

- Preload fill height — Finish floor elevation
- Preload duration — Estimated two to four weeks
- Preload settlements — Estimated two to four inches

Combination Surcharge/Preload

Based on review of the conceptual site layout, it is possible that structures may be located along the transition between areas requiring a surcharge and areas requiring a preload. In areas where this transition between surcharge and preload occurs, the surcharge fill should be extended over the transition line in order to reduce the potential for differential settlement across the transition line. Surcharge fill should extend a minimum of five feet horizontally past the transition line. Fill should then be sloped on a maximum gradient of 4H:1V to the elevation of the preload grade.

Surcharge and preload fill should extend beyond the perimeter of each structure a minimum of five feet. If future addition is planned, the preload and/or surcharge fills should extend 20 feet beyond the building footprint in the direction of the future addition. Where surcharge or preload fills are place, settlement markers should be installed to monitor the fill induced settlements (Plate 5). The settlement markers should be placed prior to beginning the fill placement and monitored daily during the fill placement. Following completion of the preload fill placement, readings should be acquired weekly until it is determined by ESNW that the estimated future settlement is within the range specified in the *Foundations* section of this report. ESNW should review the settlement data and provide supplemental recommendations for the surcharge/preload program, if necessary.

ESNW should be retained to implement and perform the surcharge/preload monitoring program. To improve the accuracy of the settlement readings, the integrity of the markers should be maintained. Damaged markers require replacement, which increases the costs for this phase of the project and can compromise the settlement data, resulting in longer durations for the preload and surcharge programs.

Non-Building Areas

In non-building areas where fill will be placed to establish grade for roads and parking areas, settlement resulting from the placement of the fill must be allowed to occur prior to installation of utilities. The settlement is anticipated to be complete within two to four weeks after fill has been placed to grade. These areas must be monitored as described above.

Foundations

The proposed warehouse building can be supported on conventional continuous and spread footing foundations bearing on at least two feet of structural fill following the successful implementation of a preload or surcharge program (see *Surcharge and Preload Recommendations* section). 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 foundations will be supported as described above, the following parameters can be used for design:

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

A one-third increase in the allowable soil bearing capacity can 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 in the range of one-half inch over a span of approximately 50 feet 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 boring locations, in accordance with Table 20.3-1 of the ASCE Minimum Design Loads for Buildings and Other Structures manual, Site Class E should be used for design.

The referenced liquefaction susceptibility map indicates the site maintains moderate to high liquefaction susceptibility. Liquefaction is a phenomenon where saturated or loose sandy 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 moderate to high. Given identified site conditions, foundation differential settlement would be the most likely effect of seismically induced liquefaction. Estimated settlements resulting from liquefaction are two to four inches for total settlement and one to three inches for differential settlement.

Slab-On-Grade Floors

Slab-on-grade floors for the proposed warehouse building should be supported on firm and unyielding subgrades comprised of undisturbed, competent native soils or compacted structural fill on competent native soil. Unstable or yielding areas of the subgrades should be recompacted, or overexcavated and replaced with suitable structural fill, prior to slab construction.

A capillary break, consisting of a minimum of four inches of free-draining crushed rock or gravel, should be placed below floor 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). 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 (yielding condition)	35 pcf (equivalent fluid)
• At-rest earth pressure (restrained condition)	55 pcf
• Traffic surcharge (passenger vehicles)	70 psf (rectangular distribution)*
• Passive earth pressure	300 pcf (equivalent fluid)
• Coefficient of friction	0.40
• Seismic surcharge	6H 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 drainage 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

Groundwater should be anticipated in site excavations, especially in utility trench excavations. Based on our subsurface exploration, groundwater was encountered between depths of approximately 7.5 to 10 feet bgs. Temporary measures to control surface water runoff and groundwater during construction would likely involve interceptor trenches and sumps. ESNW should be consulted during preliminary grading to identify areas of seepage and to provide recommendations to reduce the potential for instability related to seepage effects.

Finish grades must 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.

Infiltration Evaluation

As indicated in the *Subsurface* section of this study, native soils encountered during our fieldwork were characterized primarily as alluvial deposits. According to the results of USDA textural analyses performed on representative soil samples, the native soils primarily classify as loam. Based on the relatively high fines content of the alluvial deposits across the site, infiltration is not recommended from a geotechnical standpoint. Conventional methods of stormwater management, such as, dispersion, detention, and connecting to an existing stormwater collections system, may prove more practical.

Utility Support and Trench Backfill

In our opinion, native soils may not be suitable for support of utilities. Both organic-rich soil and loose/soft soil 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 utility excavations, and caving of trench walls may occur where groundwater is encountered. Caving of the trench walls will 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 may not be suitable for use as structural backfill throughout utility trench excavations, unless 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 Sumner or another 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 overexcavation 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:

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

Heavier traffic areas generally require thicker pavement sections depending on site usage, pavement life expectancy, and site traffic. For preliminary design purposes, the following pavement sections for heavily loaded, moderate to high truck traffic areas can be considered:

- Three inches of HMA placed over six inches of CRB, or;
- Three inches of HMA placed over four inches of ATB.

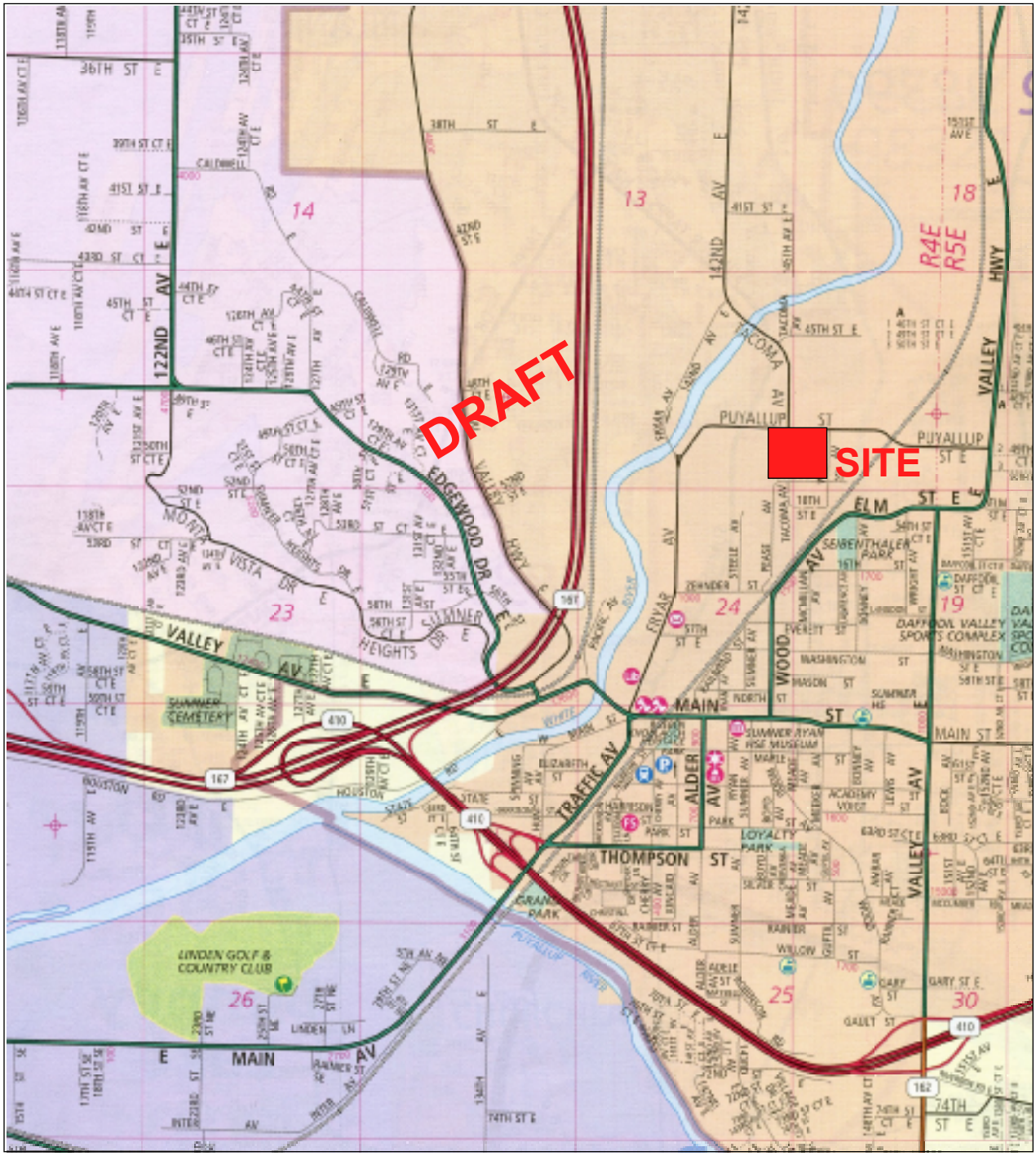
The HMA, ATB and CRB materials should conform to WSDOT specifications. All soil base material should be compacted to a relative compaction of 95 percent, based on the laboratory maximum dry density as determined by ASTM D1557. Final pavement design recommendations, including recommendations for heavy 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 Sumner may supersede the recommendations provided in this report.

LIMITATIONS

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

Additional Services

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



Reference:
Pierce County, Washington
Map 805
By The Thomas Guide
Rand McNally
32nd Edition

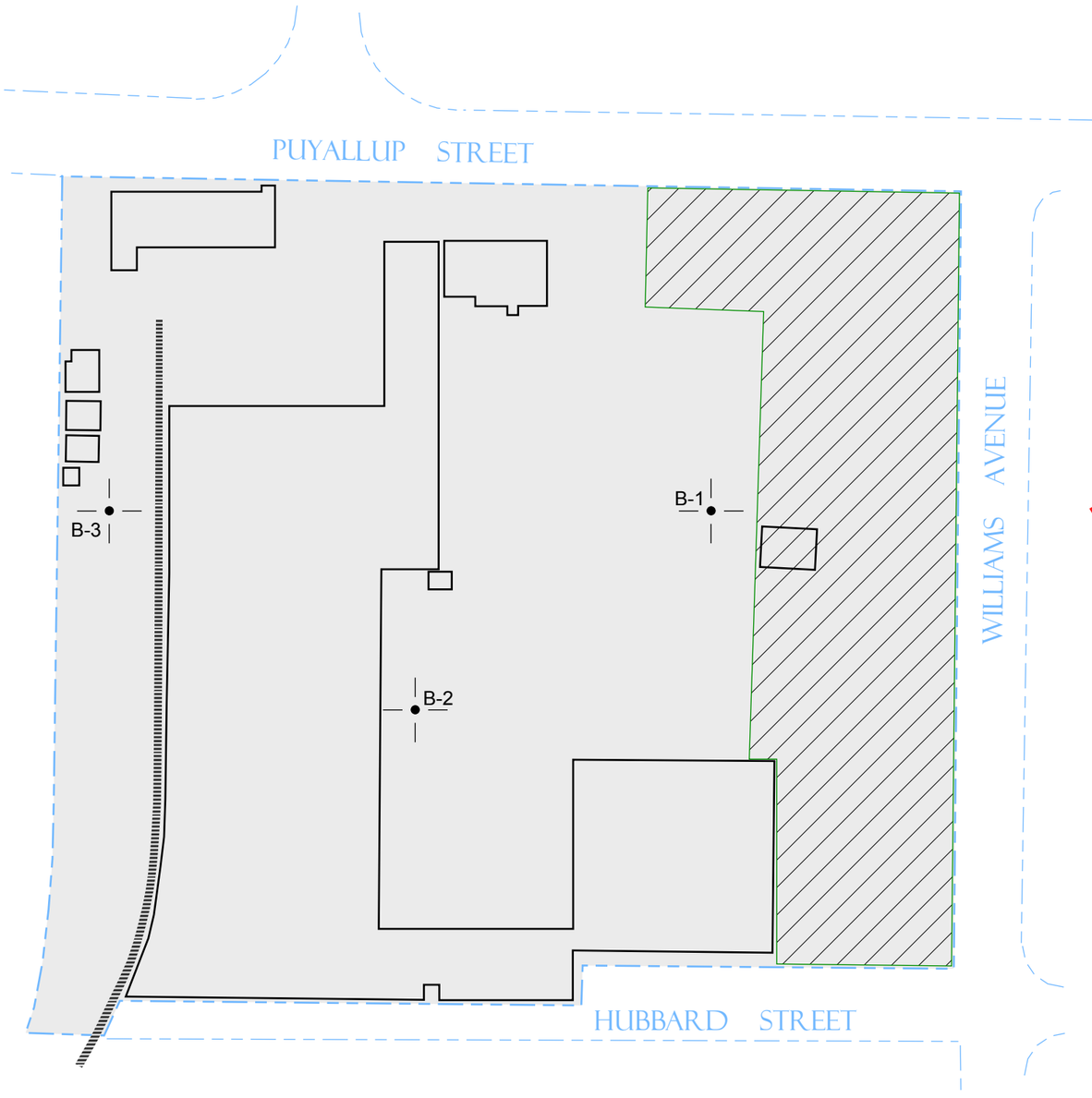
NORTH

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
9 Acre Sumner
Sumner, Washington

Drwn. MRS	Date 01/25/2019	Proj. No. 5903.01
Checked TJD	Date Jan. 2019	Plate 1



DRAFT

LEGEND

B-1 — Approximate Location of ESNW Boring, Proj. No. ES-5903.01, Jan. 2019

Subject Site

Existing Building

Landscaped Area

NORTH

0 50 100 200

1"=100' Scale in Feet

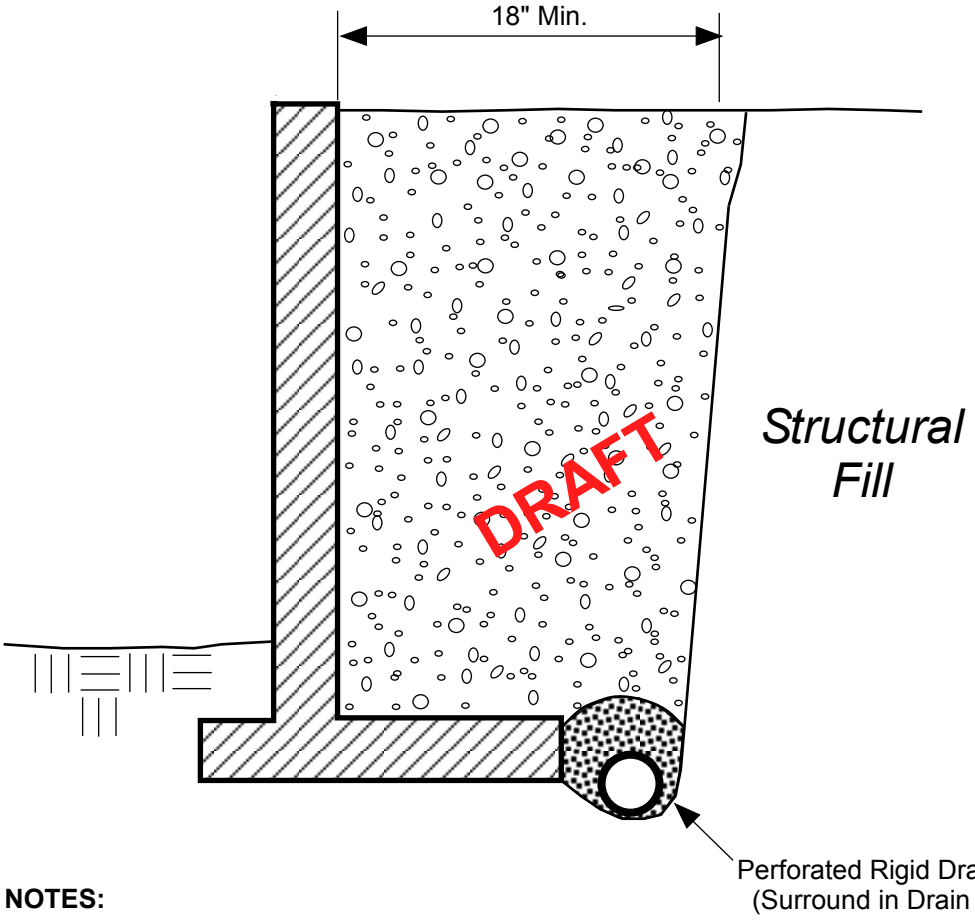
NOTE: The graphics shown on this plate are not intended for design purposes or precise scale measurements, but only to illustrate the approximate test locations relative to the approximate locations of existing and / or proposed site features. The information illustrated is largely based on data provided 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.

Boring Location Plan
9 Acre Sumner
Sumner, Washington

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

Drwn. By MRS
Checked By TJD
Date 01/25/2019
Proj. No. 5903.01
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:

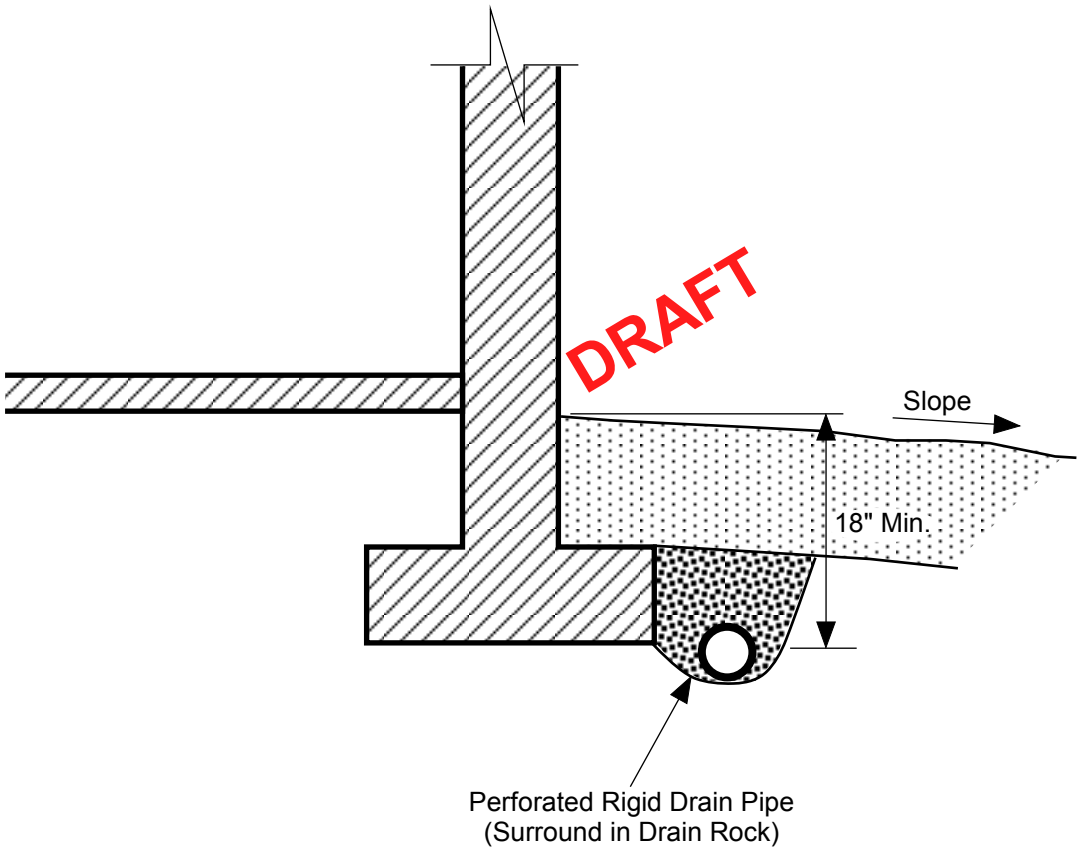
Free-draining Structural Backfill

1-inch Drain Rock

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

Retaining Wall Drainage Detail
9 Acre Sumner
Sumner, Washington

Drwn. MRS	Date 01/25/2019	Proj. No. 5903.01
Checked TJD	Date Jan. 2019	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.

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LEGEND:

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

1-inch Drain Rock

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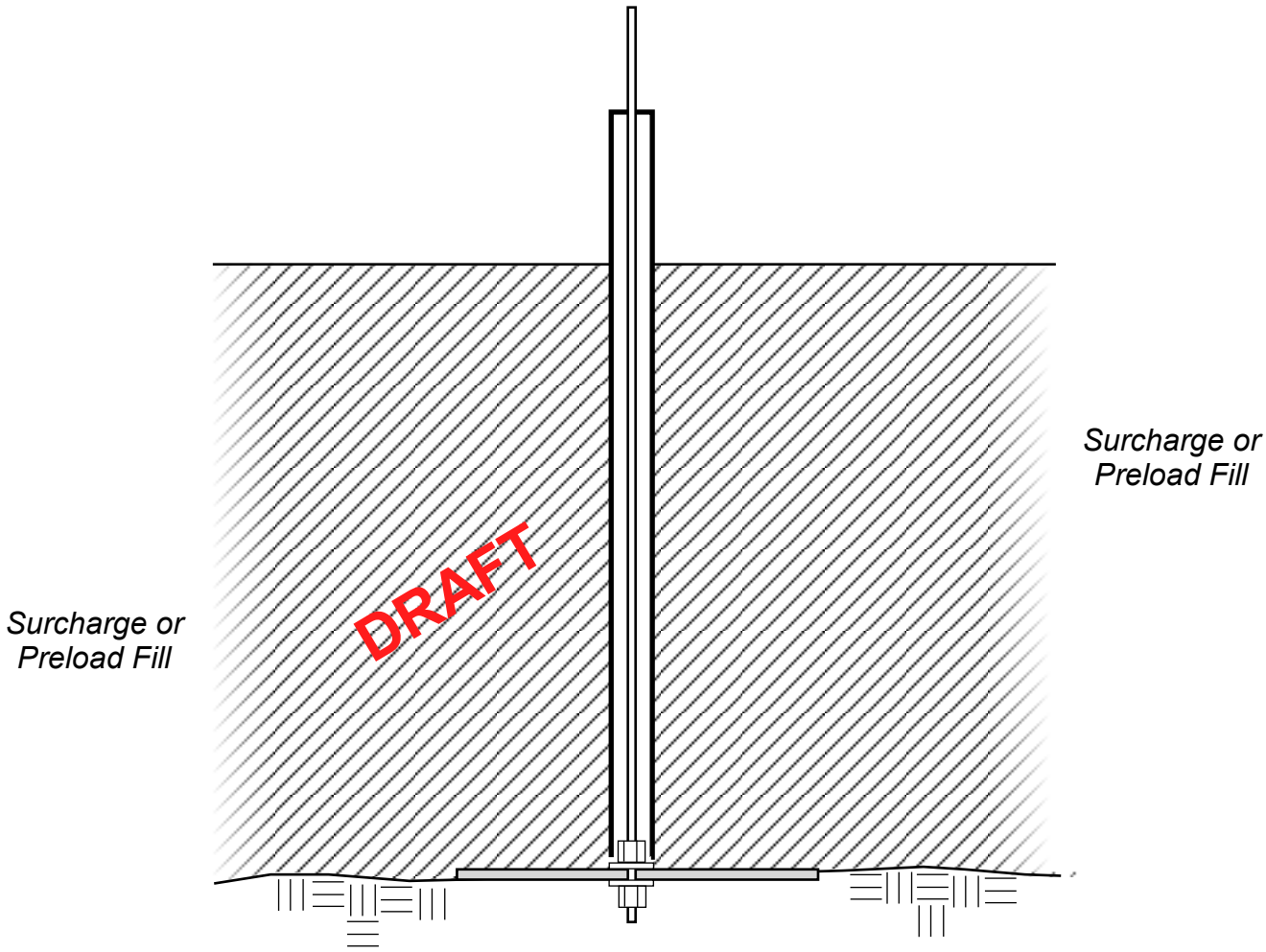
Footing Drain Detail
9 Acre Sumner
Sumner, Washington

Drwn. MRS	Date 01/25/2019	Proj. No. 5903.01
Checked TJD	Date Jan. 2019	Plate 4



STANDARD NOTES:

1) Base consists of 3/4 inch thick, 2 foot by 2 foot plywood with center drilled 5/8 inch diameter hole.

2) Bedding material, if required, should consist of Traction Sand.

3) Marker rod is 1/2 inch diameter steel rod threaded at both ends.

4) Marker rod is attached to base by nut and washer on each side of base.

5) Protective sleeve surrounding marker rod should consist of 2 inch diameter plastic tubing. Sleeve is NOT attached to rod or base.

6) Additional sections of steel rod can be connected with threaded couplings.

7) Additional sections of plastic sleeve can be connected with press-fit plastic couplings.

8) Steel marker rod should extend at least 6 inches above top of plastic sleeve.

9) Marker should extend at least 2 feet above top of fill surface.

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Settlement Marker Detail
9 Acre Sumner
Sumner, Washington

Drwn. MRS	Date 01/25/2019	Proj. No. 5903.01
Checked TJD	Date Jan. 2019	Plate 5

Appendix A

Subsurface Exploration
Boring Logs

ES-5903.01

The subsurface conditions at the site were explored on January 14, 2019 by advancing three borings using a drill rig and operator retained by ESNW. The approximate locations of the borings are illustrated on Plate 2 of this study. The d boring logs are provided in this Appendix. The maximum exploration depth was approximately 26.5 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 MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

DUAL SYMBOLS are used to indicate borderline soil classifications.

The discussion in the text of this report is necessary for a proper understanding of the nature of the material presented in the attached logs.

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

BORING NUMBER B-1

PROJECT NUMBER ES-5903.01 **PROJECT NAME** 9 acre sumner

DATE STARTED 1/14/19 **COMPLETED** 1/14/19 **GROUND ELEVATION** _____ **HOLE SIZE** _____

DRILLING CONTRACTOR Holocene Drilling **GROUND WATER LEVELS:**

DRILLING METHOD HSA ▽ **AT TIME OF DRILLING** 7.5 ft

LOGGED BY TJD **CHECKED BY** KRC **AT END OF DRILLING** ---

NOTES Surface Conditions: asphalt **AFTER DRILLING** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0					ML		Gray SILT, very loose, wet
	SS	67	2-1-2 (3)	MC = 69.80%			
5	SS	100	2-1-1 (2)	MC = 51.00%			
7.5 ▽							Gray fine-grained silty SAND, medium dense, wet
	SS	83	5-6-9 (15)	MC = 31.60%			-groundwater table
10	SS	83	5-7-8 (15)	MC = 26.30% Fines = 26.30%	SM		[USDA Classification: slightly gravelly loamy fine SAND]
15.0							Gray SILT, loose, wet
15	SS	67	2-1-4 (5)	MC = 49.90%			-wood organics
20					ML		
20.0							

(Continued Next Page)

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BORING NUMBER B-1

PROJECT NUMBER ES-5903.01 **PROJECT NAME** 9 acre sumner

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
20	SS	100	5-7-8 (15)	MC = 30.70%	SP-SM		Gray poorly graded SAND with silt, medium dense, wet
25	SS	100	4-3-4 (7)	MC = 43.00% MC = 33.60% MC = 74.60%			-becomes loose -interbedded silts and sands -organics
							26.5 Boring terminated at 26.5 feet below existing grade. Groundwater table encountered at 7.5 feet during drilling. Boring backfilled with bentonite chips and patch. Bottom of hole at 26.5 feet.

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Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

BORING NUMBER B-2

PROJECT NUMBER ES-5903.01 **PROJECT NAME** 9 acre sumner

DATE STARTED 1/14/19 **COMPLETED** 1/14/19 **GROUND ELEVATION** _____ **HOLE SIZE** _____

DRILLING CONTRACTOR Holocene Drilling **GROUND WATER LEVELS:**

DRILLING METHOD HSA ▽ **AT TIME OF DRILLING** 10.5 ft

LOGGED BY TJD **CHECKED BY** KRC **AT END OF DRILLING** ---

NOTES Surface Conditions: asphalt **AFTER DRILLING** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0							Gray silty SAND with gravel, very loose, wet
	SS	17	2-1-1 (2)	MC = 23.60%	SM		
5						5.0	[USDA Classification: slightly gravelly LOAM]
	SS	83	1-1-1 (2)	MC = 55.20% Fines = 83.70%			Gray SILT, very loose, wet -organics
	SS	100	1-1-1 (2)	MC = 43.00%	ML		
10						10.0	
	SS	67	5-6-4 (10)	MC = 31.80%			▽ Gray fine-grained silty SAND, medium dense, wet -groundwater table
15					SM	15.0	
	SS	89	2-6-8 (14)	MC = 40.50%			Gray sandy SILT, medium dense, wet -organics
20					ML	20.0	

(Continued Next Page)

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Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

BORING NUMBER B-2

PROJECT NUMBER ES-5903.01 **PROJECT NAME** 9 acre sumner

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
20	SS	67	1-3-5 (8)	MC = 70.30%	ML		Gray SILT, loose, wet -wood debris -increased sand content
25	SS	100	5-6-6 (12)	MC = 26.90% Fines = 5.80%	SP-SM		25.0 Gray poorly graded SAND with silt, medium dense, wet [USDA Classification: slightly gravelly SAND] 26.5 Boring terminated at 26.5 feet below existing grade. Groundwater table encountered at 10.5 feet during drilling. Boring backfilled with bentonite chips and patch. Bottom of hole at 26.5 feet.

Earth Solutions NW
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Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

BORING NUMBER B-3

PROJECT NUMBER ES-5903.01 **PROJECT NAME** 9 acre sumner

DATE STARTED 1/14/19 **COMPLETED** 1/14/19 **GROUND ELEVATION** _____ **HOLE SIZE** _____

DRILLING CONTRACTOR Holocene Drilling **GROUND WATER LEVELS:**

DRILLING METHOD HSA ▽ **AT TIME OF DRILLING** 10.0 ft

LOGGED BY TJD **CHECKED BY** KRC **AT END OF DRILLING** ---

NOTES Surface Conditions: asphalt **AFTER DRILLING** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0					ML		Gray SILT, very loose, wet
	SS	67	1-2-1 (3)	MC = 40.70%			
5	SS	100	1-1-1 (2)	MC = 123.30%			-roots, wood
7.5							
	SS	83	5-6-7 (13)	MC = 34.70%	SM		Gray fine-grained silty SAND, medium dense, wet
10							▽ -groundwater table
10.5	SS	100	0-1-1 (2)	MC = 43.50% MC = 43.90%			Gray SILT, very loose, wet
15	SS	100	1-1-1 (2)	MC = 42.60%	ML		
20							20.0

DRAFT

(Continued Next Page)

Earth Solutions NW
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Telephone: 425-449-4704
Fax: 425-449-4711

BORING NUMBER B-3

PROJECT NUMBER ES-5903.01 **PROJECT NAME** 9 acre sumner

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
20	SS	83	4-2-1 (3)	MC = 31.30% MC = 67.70%	SM		Gray fine-grained silty SAND, very loose, wet -wood debris
						21.0	
					ML		Gray SILT, very loose, wet
25						25.0	
					SP-SM		Gray poorly graded SAND with silt, medium dense, wet -interbedded silts and sands
	SS	100	6-7-8 (15)	MC = 33.70%		26.5	Boring terminated at 26.5 feet below existing grade. Groundwater table encountered at 10.0 feet during drilling. Boring backfilled with bentonite chips and patch. Bottom of hole at 26.5 feet.

Appendix B

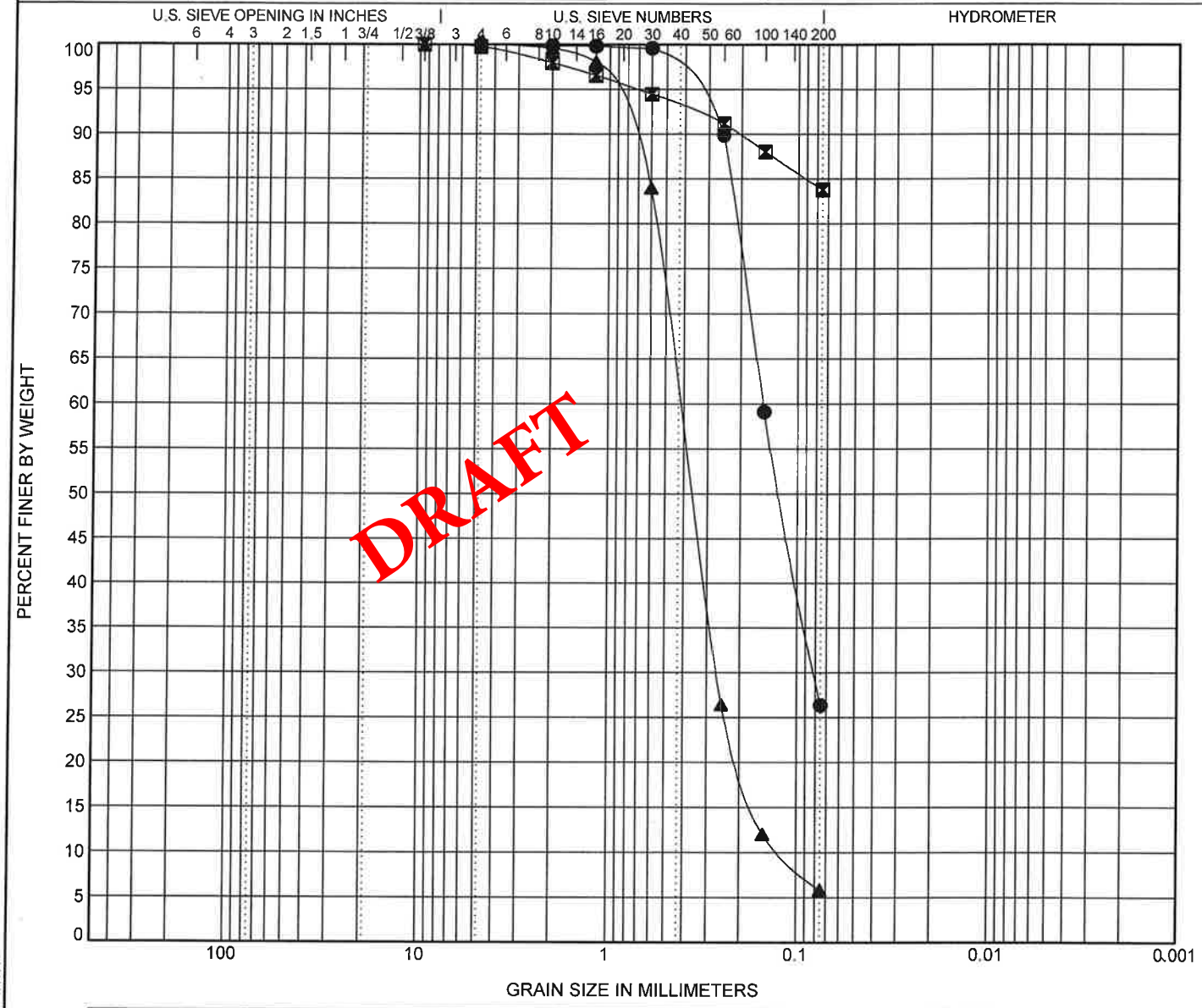
Laboratory Test Results

ES-5903.01

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-5903.01 **PROJECT NAME** 9 Acre Sumner



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	Cc	Cu
●	B-01 10.00ft.	USDA: Gray Slightly Gravelly Loamy Fine Sand. USCS: SM.		
⊠	B-02 5.00ft.	USDA: Gray Slightly Gravelly Loam. USCS: ML with Sand.		
▲	B-02 25.00ft.	USDA: Gray Slightly Gravelly Sand. USCS: SP-SM.	1.40	3.48

Specimen Identification		D100	D60	D30	D10	LL	PL	PI	%Silt	%Clay
●	B-01 10.0ft.	4.75	0.152	0.081					26.3	
⊠	B-02 5.0ft.	9.5							83.7	
▲	B-02 25.0ft.	4.75	0.417	0.264	0.12				5.8	

GRAIN SIZE USDA ES-5903.01 9 ACRE SUMNER.GPJ GINT US LAB.GDT 1/17/19

Report Distribution

ES-5903.01

EMAIL ONLY

Duke Realty
200 Spectrum Center Drive, Suite 1600
Irvine, California 92618

Attention: Mr. Adam Schmid