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*Subsurface Exploration, Geologic Hazard, and Geotechnical Engineering Report*

# BRAVA LIGHT INDUSTRIAL

Mukilteo, Washington

Prepared For:

**ESTFIN, LLC**

Project No. 20190478E001

June 9, 2020


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June 9, 2020
Project No. 20190478E001

ESTFIN, LLC
c/o ProGranite Surfaces, LLC
12303 Cyrus Way, Suite 103
Mukilteo, Washington 98275

Attention: Mr. Andrew Shubin

Subject: Subsurface Exploration, Geologic Hazard, and Geotechnical Engineering Report
Brava Light Industrial
12313 Cyrus Way
Mukilteo, Washington

Dear Mr. Shubin:

We are pleased to present our geotechnical engineering report for the referenced project. This report summarizes the results of our subsurface exploration, geologic hazards, and geotechnical engineering studies, and offers preliminary recommendations for the design and development of the proposed project. Our recommendations are preliminary because project plans and construction details were not available at the time this report was written. We should be allowed to review the recommendations presented in this report and modify them, if needed, once final project plans have been formulated.

We have enjoyed working with you on this study and are confident that the recommendations presented in this report will aid in the successful completion of your project. If you should have any questions or if we can be of additional help to you, please do not hesitate to call.

Sincerely,
**ASSOCIATED EARTH SCIENCES, INC.**
**Kirkland, Washington**

Timothy J. Peter, L.E.G., L.Hg.
Senior Engineering Geologist

TJP/ld - 20190478E001-3

# SUBSURFACE EXPLORATION, GEOLOGIC HAZARD, AND GEOTECHNICAL ENGINEERING REPORT

# BRAVA LIGHT INDUSTRIAL

## Mukilteo, Washington

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# I. PROJECT AND SITE CONDITIONS

## 1.0 INTRODUCTION

This report presents the results of our subsurface exploration, geologic hazard, and preliminary geotechnical engineering study for the subject project. Our recommendations are preliminary in that project plans and construction details were not completed at the time this report was prepared. Our understanding of the project is based on review of a conceptual site plan prepared by Western Engineers & Surveyors, as well as on discussions with Mr. Jesse Jarrell with Western Engineers & Surveyors. The site location is shown on the "Vicinity Map," Figure 1. The approximate locations of the explorations completed for this study are shown on the "Site and Exploration Plan," Figure 2. Copies of the exploration logs are included in Appendix A.

### 1.1 Purpose and Scope

The purpose of this study was to provide subsurface data to be utilized in the design and development of the referenced project. Our study included reviewing available geologic literature, excavating 10 exploration pits at the site, and performing geologic studies to assess the type, thickness, distribution, and physical properties of the subsurface sediments and groundwater conditions. Geotechnical engineering studies were completed to assess geologic hazards and to formulate geotechnical recommendations for site preparation, grading, types of suitable foundations and floors, allowable foundation soil bearing pressures, anticipated foundation settlement, and drainage considerations. This report summarizes our fieldwork and offers preliminary recommendations based on our present understanding of the project. We recommend that we be allowed to review the recommendations presented in this report and revise them, if needed, when the project design has been finalized.

### 1.2 Authorization

Our study was accomplished in general accordance with our scope of work and cost proposal, dated May 11, 2020. This report has been prepared for the exclusive use of ESTFIN, LLC, and their agents, for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering and engineering geology practices in effect in this area at the time our report was prepared. No other warranty, express or implied, is made.

## 2.0 PROJECT AND SITE DESCRIPTION

The subject site consists of two adjoining parcels located in the 123XX block of Cyrus Way in Mukilteo, Washington (Snohomish County Tax Parcel Nos. 00441300004000 and 00441300003900). The address of the northern parcel is 12313 Cyrus Way. The parcels are currently undeveloped, rectangular in shape, and each occupies a reported area of 1.37 acres. Both parcels are vegetated by young, deciduous forest with some open, grassy areas in the south-central portion of the site. An area of wetland has been identified at the east end of the site. The topography of the site generally slopes down toward the northwest and the northeast from a relatively flat to gently sloping elevated area located in the southern portion of the property. Slope inclinations on the flanks of the elevated area generally range from approximately 25 to 35 percent but exceed 40 percent over maximum heights of approximately 14 feet in some areas.

It is our understanding that conceptual plans include the construction of two commercial buildings on each of the two parcels. The conceptual plans also include construction of an asphalt-paved driveway and parking areas, and a detention vault in the northeastern portion of the site. A grading plan for the project was not available at the time of our study; however, it is our understanding that grading for the project is anticipated to eliminate most of the steep slopes at the site. The exception will include an area of steep slope in the southeastern portion of the site that is located within the wetland buffer.

## 3.0 SUBSURFACE EXPLORATION

Our field study included excavating 10 exploration pits to gain subsurface information about the site. The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in Appendix A. The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. Our explorations were approximately located in the field relative to known site features shown on a topographic site plan provided by Western Engineers & Surveyors. The approximate locations of the exploration pits are shown on Figure 2.

The conclusions and recommendations presented in this report are based, in part, on the exploration pits completed for this study. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that subsurface conditions differing from those depicted on the logs may be present at the site due to the random nature of deposition and the alteration of topography by past grading and/or filling. The nature and extent of variations between the field explorations may not become fully evident until construction. If variations are observed at that time, it may be necessary to re-evaluate specific recommendations in this report and make appropriate changes.

### 3.1 Exploration Pits

The exploration pits were excavated using a track-mounted excavator. The pits permitted direct, visual observation of subsurface conditions. Materials encountered in the exploration pits were studied and classified in the field by an engineering geologist from our firm. All of the exploration pits were backfilled immediately after examination and logging. Samples collected from the exploration pits were classified in the field and representative portions placed in watertight containers. The samples were then transported to our laboratory for further visual classification and laboratory testing.

## 4.0 SUBSURFACE CONDITIONS

The subsurface conditions at the project site were inferred from the field explorations accomplished for this study, visual reconnaissance of the site, and review of applicable geologic literature. The natural sediments encountered in our explorations generally consisted of granular, glacial sediments of variable composition. Fill soils were encountered above the natural sediments in portions of the northern parcel. The following section presents more detailed subsurface information organized from the shallowest (youngest) to the deepest (oldest) sediment types. Copies of the exploration logs are included in Appendix A.

### 4.1 Stratigraphy

*Fill*

Fill soils (those not naturally placed) were encountered in exploration pits EP-4, EP-5, EP-7, EP-9, and EP-10. The fill generally consisted of loose to medium dense, grayish brown to dark brown, silty sand with variable gravel content. Portions of the fill also contained scattered to abundant quantities of debris including wood, metal, glass, composite shingles, plastic, and concrete. Where encountered, the fill extended to depths ranging from approximately 7 feet in exploration pit EP-9 to beyond the maximum depth explored of approximately 17 feet in exploration pit EP-10. Fill thicknesses encountered in our exploration pits are summarized below in Table 1. Due to its variable and typically low relative density and the presence of deleterious debris, the existing fill is not considered suitable for foundation support. Those portions of the existing fill that are free of organic debris and other deleterious materials are suitable for reuse as structural fill provided that the moisture content of the soil is suitable for achieving the specified level of compaction.

**Table 1**
**Summary of Fill Thicknesses**

| Exploration Pit No. | Location | Fill Thickness (Feet) |
|---|---|---|
| EP-4 | Detention Vault | 9 |
| EP-5 | NE Corner of Building on N. Parcel | 8 |
| EP-7 | NW Corner of Building on N. Parcel | 8.5 |
| EP-9 | Detention Vault | 7 |
| EP-10 | Detention Vault | >17 |

*Topsoil*

A surficial, organic topsoil horizon was encountered directly below the ground surface at the locations of exploration pits EP-2, EP-3, EP-6, and EP-8. A buried topsoil horizon was encountered below the fill at a depth of approximately 9 feet in exploration pit EP-4. Where encountered, the thickness of the topsoil horizon ranged from approximately 6 to 8 inches. The organic topsoil is not considered suitable for foundation support or for use as structural fill.

*Vashon Ice Contact Deposits*

Sediments encountered below the fill in exploration pits EP-7 and EP-9 generally consisted of loose to medium dense, reddish tan to mottled gray and tan, silty sand with minor to moderate quantities of gravel. We interpret these sediments to be representative of Vashon ice contact deposits. The Vashon ice contact deposits consist of sediments that were deposited by meltwater on, below, or marginal to the glacial ice during the Vashon Stade of the Fraser Glaciation, approximately 12,500 to 15,000 years ago. At the locations of exploration pits EP-7 and EP-9, the ice contact deposits extended beyond the maximum depths explored of approximately 15 feet and 12 feet, respectively. Properly prepared medium dense ice contact deposits are suitable for foundation support. These sediments are also suitable for reuse as structural fill provided that they are free of roots and other deleterious materials, and have a moisture content compatible with achieving the specified level of compaction.

*Vashon Lodgement Till*

Natural sediments encountered directly either below the ground surface or below the surficial topsoil horizon in exploration pits EP-1, EP-2, EP-3, and EP-6 generally consisted of loose to medium dense, reddish tan to tan, silty to very silty sand with moderate to high gravel content. These sediments became dense to very dense and grayish tan below depths of approximately 2 to 5 feet. Similar sediments were encountered below the fill in exploration pit EP-5. We interpret these sediments to be representative of Vashon lodgement till. The Vashon lodgement till was deposited directly from basal, debris-laden glacial ice during the Vashon

Stade of the Fraser Glaciation. The high relative density characteristic of the Vashon lodgement till is due to its consolidation by the massive weight of the glacial ice from which it was deposited. The reduced density observed in the upper several feet of the till is typical of till that has been exposed at the ground surface and is interpreted to be due to weathering. Dense, unweathered lodgement till sediments were encountered directly below the topsoil horizon in exploration pit EP-8, which suggests that the weathered till horizon in this area has been removed by previous grading. Where encountered in our explorations, the lodgement till extended beyond the maximum depths explored of approximately 7 to 12 feet. The medium dense to very dense lodgement till sediments are suitable for foundation support. Excavated lodgement till sediments are also suitable for reuse as structural fill provided that they are free of roots and other deleterious materials, and have a moisture content compatible with achieving the specified level of compaction.

*Vashon Advance Outwash*

Natural sediments encountered below the buried topsoil horizon in exploration pit EP-4 (below a depth of approximately 9.5 feet) generally consisted of loose, grayish brown, silty sand with moderate gravel content. Below a depth of approximately 11 feet, these sediments became dense, gray, and very gravelly with trace quantities of silt. We interpret these sediments to be representative of Vashon advance outwash. The Vashon advance outwash was deposited by meltwater streams that flowed off the advancing glacial ice during the Vashon Stade of the Fraser Glaciation approximately 12,500 to 15,000 years ago. The high relative density characteristic of the Vashon advance outwash is due to its consolidation by the massive weight of the glacial ice that overrode these sediments subsequent to their deposition. The reduced density observed in the upper 1.5 feet of the advance outwash is interpreted to be due to weathering. At the location of exploration pit EP-4, the advance outwash extended beyond the maximum depth explored of approximately 13 feet. The medium dense to dense Vashon advance outwash sediments are suitable for foundation support. Excavated advance outwash sediments are also suitable for reuse as structural fill provided they are free of roots and other deleterious materials and have a moisture content compatible with achieving the specified level of compaction.

## 4.2 Geologic Map Review

Review of the regional geologic map titled *Distribution and Description of Geologic Units in the Mukilteo Quadrangle, Washington* by James Minard (1982) indicates that site is underlain by Vashon lodgement till. Our interpretation of the sediments encountered in our explorations is generally consistent with the regional geologic map.

## 4.3 Groundwater

Moderately rapid groundwater seepage was encountered within unweathered advance outwash sediments in exploration pit EP-4 below a depth of approximately 11 feet. No groundwater seepage was encountered in any of the other explorations advanced on the subject site. In areas underlain by lodgement till, it is common for shallow perched seepage to accumulate seasonally at the base of the weathered till horizon. This perched seepage, known as “interflow” occurs when stormwater infiltrates through the relatively permeable, weathered till horizon and becomes perched atop the underlying, dense, low-permeability, unweathered till. Although no interflow was encountered in any of our exploration pits, mottling was observed at some locations in the weathered till horizon and in the upper portion of the underlying unweathered till. Such mottling may be an indication of seasonal saturation. It should be noted that the depth or occurrence of groundwater seepage below the site may vary in response to such factors as changes in season, precipitation, and site use. No emergent seepage was observed during our reconnaissance of the project area.

## II. GEOLOGIC HAZARDS AND MITIGATIONS

The following discussion of potential geologic hazards is based on the geologic conditions as observed and discussed herein.

### 5.0 LANDSLIDE HAZARDS AND RECOMMENDED MITIGATION

The *Mukilteo Municipal Code* (MMC) defines landslide hazard as:

1. Areas that exhibit all of the following characteristics:
    - Slopes steeper than 15 percent;
    - Hillsides with intersecting geologic contacts; and,
    - Springs or emergent groundwater seepage.
2. Areas of known landslides, earth movement, or containing evidence of past landslides or earth movement.
3. Areas that are underlain or covered by mass wastage debris or landslide materials.
4. Slopes that have forty percent or steeper gradients and having a vertical relief greater than 10 feet, excluding constructed slopes.

The topography of the site generally slopes down toward the northwest and the northeast from a relatively flat to gently sloping elevated area located in the southern portion of the property. Slope inclinations on the flanks of the elevated area generally range from approximately 25 to 35 percent but exceed 40 percent over maximum heights of approximately 14 feet in some areas. With the exception of an area at the southeast corner of the southern parcel, areas of the site with slope inclinations exceeding 40 percent are limited to portions of the area below and adjacent to the proposed building and detention vault areas on the northern parcel. Exploration pits excavated in the area of the proposed detention vault and along the north side of the proposed building locations on this parcel encountered significant thicknesses of fill soil, indicating that the steep slopes in this area were created by previous grading.

Light Detection and Ranging (LIDAR) is a remote sensing technology that can be used to generate a detailed expression of ground surface topography even in densely vegetated areas. For this reason, LIDAR-based topographic imagery can be helpful in distinguishing surface features that may otherwise not be easily recognizable. A copy of a LIDAR-based shaded relief image of the site is included in Appendix B. Review of this image indicates that the northern parcel appears terraced, suggesting that most or all of the northern parcel has been previously graded. This is also supported by the subsurface conditions encountered in exploration pit EP-8, where the weathered till horizon was found to be absent.

A copy of an aerial photograph from July of 1990 is included in Appendix C. This aerial photograph shows that the majority of the northern parcel, including the areas of steep slope had been cleared at that time and a circular dirt road had been constructed in this area. A disturbed area located adjacent to the east side of the circular dirt road coincides with the area of fill encountered in the proposed detention vault area. The steep slopes currently present on the northern parcel are located along the edges of the dirt road. Based on this data, we conclude that the steep slopes on the northern parcel are the result of previous grading and therefore do not classify as Landslide Hazard Areas under the MMC.

Conceptual project plans include elimination of the steep slopes on the northern parcel during grading. Therefore, landslide hazard risks associated with these slopes will be eliminated. The remaining area of steep slope on the site is located in the southeastern corner of the southern parcel. This steep slope area is located in a wetland buffer and is approximately 60 feet from nearest proposed building location. Given the subsurface and topographic conditions in this area, it is our opinion that the proposed building setback from this slope provides suitable mitigation of landslide risks.

## 6.0 SEISMIC HAZARDS AND RECOMMENDED MITIGATION

Earthquakes occur in the Puget Sound Lowland with great regularity. The vast majority of these events are small and are usually not felt by people. However, large earthquakes do occur as evidenced by the most recent 6.8-magnitude event on February 28, 2001, near Olympia Washington; the 1965 6.5-magnitude event; and the 1949 7.2-magnitude event. The 1949 earthquake appears to have been the largest in this area during recorded history. Evaluation of return rates indicates that an earthquake of the magnitude between 5.5 and 6.0 is likely within a given 20-year period.

Generally, there are four types of potential geologic hazards associated with large seismic events: 1) surficial ground rupture, 2) seismically induced landslides, 3) liquefaction, and 4) ground motion. The potential for each of these hazards to adversely impact the proposed project is discussed below.

## 6.1 Surficial Ground Rupture

The site is located in the vicinity of the South Whidbey Island Fault Zone (SWIFZ). A study by the U.S. Geological Survey (USGS) (Sherrod et al., 2005, *Holocene Fault Scarps and Shallow Magnetic Anomalies Along the Southern Whidbey Island Fault Zone near Woodinville, Washington*, Open-File Report 2005-1136, March 2005) indicates that "strong" evidence of prehistoric earthquake activity has been observed along two fault strands thought to be part of the southeastward extension of the SWIFZ. The study suggests as many as nine earthquake events along the SWIFZ may have occurred within the last 16,400 years. The data pertaining to this fault splay is limited with the studies still ongoing. The recurrence interval of movement along this fault system is still unknown, although it is hypothesized to be in excess of one thousand years. Due to the suspected long recurrence interval it is our opinion that the potential for damage to the proposed structures by surficial ground rupture along the SWIFZ is considered to be low.

## 6.2 Seismically Induced Landslides

It is our opinion that the potential risk of damage to the proposed structures by seismically induced slope failures is low. Landsliding was discussed in greater detail in the "Landslide Hazards and Recommended Mitigation" section of this report.

## 6.3 Liquefaction

Liquefaction is a process through which unconsolidated soil loses strength as a result of vibrations, such as those which occur during a seismic event. During normal conditions, the weight of the soil is supported by both grain-to-grain contacts and by the fluid pressure within the pore spaces of the soil below the water table. Extreme vibratory shaking can disrupt the grain-to-grain contact, increase the pore pressure, and result in a temporary decrease in soil shear strength. The soil is said to be liquefied when nearly all of the weight of the soil is supported by pore pressure alone. Liquefaction can result in deformation of the sediment and settlement of overlying structures. Areas most susceptible to liquefaction include those areas underlain by non-cohesive silt and sand with low relative densities, accompanied by a shallow water table. In our opinion, the potential risk of damage to the proposed structures by liquefaction is low due to the lack of adverse groundwater conditions and the presence of dense, glacially consolidated sediments at a relatively shallow depth. No mitigation of liquefaction hazards is recommended.

## 6.4 Ground Motion/Seismic Site Class (2018 *International Building Code*)

Structural design of the structures should follow 2018 *International Building Code* (IBC) standards. We recommend that the project be designed in accordance with Site Class "D" as defined in IBC Table 20.3-1 of *American Society of Civil Engineers* (ASCE) *7 – Minimum Design Loads for Buildings and Other Structures*.

## 7.0 EROSION HAZARDS AND RECOMMENDED MITIGATION

The sediments underlying the subject site contain large percentages of silt and fine sand and will be sensitive to erosion, particularly in the more steeply sloping areas. Section 17.52A.020(A) of the MMC classifies areas rated by the United States Department of Agriculture Natural Resources Conservation Service (NRCS) as having a "moderate to severe" or higher erosion hazard rating as Geologic Sensitive Areas. Review of the NRCS *Web Soil Survey* indicates that the soil type in the project area is mapped by the NRCS as "*Everett very gravelly sandy loam, 15 to 30 percent slopes*." The NRCS erosion hazard rating for this soil type is "moderate." This erosion hazard rating is one step below the "moderate to severe" rating. Therefore, the site does not classify as a Geologic Sensitive Area under the MMC on the basis of the NRCS erosion hazard rating.

In order to mitigate erosion hazards and the potential for off-site sediment transport, we recommend the following best management practices (BMPs):

1. To the extent practical, earthwork should be avoided during the wet season.

2. The winter performance of a site is dependent on a well-conceived plan for control of site erosion and stormwater runoff. The site plan should include ground-cover measures and staging areas. The contractor should be prepared to implement and maintain the required measures to reduce the amount of exposed ground.

3. Temporary erosion and sedimentation control (TESC) elements and perimeter flow control should be established prior to the start of grading.

4. During the wetter months of the year, or when significant storm events are predicted during the summer months, the work area should be stabilized so that if showers occur, it can receive the rainfall without excessive erosion or sediment transport. The stabilization process should include establishing temporary stormwater conveyance channels through work areas to route runoff to the approved treatment/discharge facilities.

5. All areas of disturbed soil should be revegetated as soon as possible. If it is outside of the growing season, the disturbed areas should be covered with mulch. Straw mulch provides a cost-effective cover measure and can be made wind-resistant with the application of a tackifier after it is placed.

6. Surface runoff and discharge should be controlled during and following development. Uncontrolled discharge may promote erosion and sediment transport.

7. Soils that are to be reused around the site should be stored in such a manner as to reduce erosion from the stockpile. Protective measures may include, but are not limited to, covering stockpiles with plastic sheeting, or the use of silt fences around pile perimeters.

8. Projects that involve disturbance of one acre or more of land are required to obtain a Construction Stormwater General Permit per the Washington State Department of Ecology. Under this permit, a Certified Erosion and Sediment Control Lead (CESCL) will be required to make weekly site visits to monitor erosion control, BMPs, and levels for turbidity and pH. Associated Earth Sciences, Inc. (AESI) is available to help prepare permit application documents and can provide CESCL monitoring as requested.

It is our opinion that with the proper implementation of the TESC plan and by field-adjusting appropriate erosion mitigation (BMPs) throughout construction, the potential adverse impacts from erosion hazards on the project may be mitigated.

# III. PRELIMINARY DESIGN RECOMMENDATIONS

## 8.0 INTRODUCTION

Our exploration indicates that, from a geotechnical engineering standpoint, the proposed project is feasible provided the recommendations contained herein are properly followed. Sediments suitable for foundation support are present at a relatively shallow depth over much of the site and conventional spread footing foundations may be used in these areas. Significant thicknesses of existing, uncontrolled fill are present in portions of the northern parcel. Because the existing fill is not suitable for foundation support, use of spread footing foundations in these areas may be impractical. Options for deep foundation support in these areas are provided in the "Foundations" section of the report.

## 9.0 SITE PREPARATION

Site preparation should include removal of all sod, trees, brush, debris, and any other deleterious materials. Existing topsoil should be stripped from all structural areas. After stripping, any remaining roots and stumps should also be removed. All soils disturbed by stripping and grubbing operations should be recompacted as described below for structural fill.

### 9.1 Temporary and Permanent Cut Slopes

In our opinion, stable construction slopes should be the responsibility of the contractor and should be determined during construction based on the local conditions encountered at that time. For planning purposes, we anticipate that temporary, unsupported cut slopes in the loose to medium dense fill and natural glacial sediments can be made at a maximum slope of 1.5H:1V (Horizontal:Vertical). Temporary, unsupported cut slopes in the dense to very dense glacial sediments can be planned at 1H:1V. Steeper inclinations may be achievable for temporary cuts up to a maximum of 4 feet in height.

As is typical with earthwork operations, some sloughing and raveling may occur, and cut slopes may have to be adjusted in the field. In addition, WISHA/OSHA regulations should be followed at all times. Given the thickness of the fill, we do not anticipate that the natural advance outwash sediments underlying the fill will be encountered during excavation activity for the proposed project.

Permanent cut or fill slopes should not exceed an inclination of 2H:1V.

### 9.2 Site Disturbance

The on-site sediments contain a high percentage of silt and clay-sized particles and are considered to be moisture-sensitive and subject to disturbance when wet. The contractor must use care during site preparation and excavation operations so that the underlying soils are not softened. If disturbance occurs, the softened soils should be removed and the area brought to grade with structural fill.

Consideration should be given to protecting access and staging areas with an appropriate section of crushed rock or asphalt treated base (ATB). If crushed rock is considered for the access and staging areas, it should be underlain by engineering stabilization fabric (such as Mirafi 500X or approved equivalent) to reduce the potential of fine-grained materials pumping up through the rock during wet weather and turning the area to mud. The fabric will also aid in supporting construction equipment, thus reducing the amount of crushed rock required. We recommend that at least 10 inches of rock be placed over the fabric. Crushed rock used for access and staging areas should have a particle size of 2 inches.

### 9.3 Pavement Subgrades

After stripping of the site has been completed, we recommend that the soil exposed in pavement areas be recompacted to a firm and unyielding condition using a 20-ton (minimum) vibratory roller. The recompacted area should then be proof-rolled with a fully-loaded tandem-axle dump truck. Any soft or yielding areas identified during proof-rolling should be overexcavated and backfilled with structural fill.

## 10.0 STRUCTURAL FILL

Placement of structural fill may be necessary to establish desired grades or to backfill utility trenches, retaining walls, or place around foundations. All references to structural fill in this report refer to subgrade preparation, fill type, and placement and compaction of materials as discussed in this section. If a percentage of compaction is specified under another section of this report, the value given in that section should be used.

### 10.1 Subgrade Compaction

After overexcavation/stripping has been performed to the satisfaction of the geotechnical engineer/engineering geologist, the exposed ground should be recompacted to a firm and unyielding condition. If the subgrade contains too much moisture, suitable recompaction may be difficult or impossible to attain and should probably not be attempted. In lieu of recompaction, the area to receive fill should be blanketed with washed rock or quarry spalls to act as a capillary break between the new fill and the wet subgrade. Where the exposed ground remains soft and further overexcavation is impractical, placement of an engineering stabilization fabric may be necessary to prevent contamination of the free-draining layer by silt migration from below.

After the exposed ground is approved, or a free-draining rock course is laid, structural fill may be placed to attain desired grades.

## 10.2 Structural Fill Compaction

Structural fill is defined as non-organic soil, acceptable to the geotechnical engineer, placed in maximum 8-inch loose lifts, with each lift being compacted to at least 95 percent of the modified Proctor maximum dry density using *ASTM International* (ASTM) D-1557 as the standard. Utility trench backfill should be placed and compacted in accordance with applicable municipal codes and standards. The top of the compacted fill should extend horizontally a minimum distance of 3 feet beyond footings or pavement edges before sloping down at an angle no steeper than 2H:1V. Fill slopes should either be overbuilt and trimmed back to final grade or surface-compacted to the specified density.

## 10.3 Moisture-Sensitive Fill

Soils in which the amount of fine-grained material (smaller than No. 200 sieve) is greater than approximately 5 percent (measured on the minus No. 4 sieve size) should be considered moisture-sensitive. Use of moisture-sensitive soil in structural fills should be limited to favorable dry weather conditions. Those portions of the existing fill or natural sediments that are free of organic debris and other deleterious materials and that have moisture contents suitable for achieving the recommended level of compaction may be used as structural fill. At the time of our field study, the moisture contents of portions of the sediments encountered in our explorations were above the optimum for achieving suitable compaction. These sediments are described as “very moist” on the exploration logs in Appendix A. Moisture-conditioning of sediments containing excess moisture could be achieved by aerating them during periods of dry weather. Moisture-conditioning of soils exhibiting over optimum moisture contents could also be achieved by using a cement admixture.

Construction equipment traversing the site when the silty on-site sediments are very moist or wet can cause considerable disturbance. If fill is placed during wet weather or if proper compaction of the natural sediments cannot be attained, a select import material consisting of a clean, free-draining gravel and/or sand should be used. Free-draining fill consists of non-organic soil with the amount of fine-grained material limited to 5 percent by weight when measured on the minus No. 4 sieve fraction.

## 10.4 Structural Fill Testing

The contractor should note that any proposed fill soils must be evaluated by AESI prior to their use in fills. This would require that we have a sample of the material at least 3 business days in advance to perform a Proctor test and determine its field compaction standard.

A representative from our firm should observe the stripped subgrade and be present during placement of structural fill to observe the work and perform a representative number of in-place density tests. In this way, the adequacy of the earthwork may be evaluated as filling progresses and any problem areas may be corrected at that time. It is important to understand that taking random compaction tests on a part-time basis will not assure uniformity or acceptable performance of a fill. As such, we are available to aid the owner in developing a suitable monitoring and testing frequency.

## 11.0 FOUNDATIONS

Sediments suitable for foundation support are present at a relatively shallow depth over much of the site and conventional spread footing foundations may be used in these areas. Significant thicknesses of existing, uncontrolled fill are present in portions of the northern parcel. Because the existing fill is not suitable for foundation support, use of spread footing foundations in these areas may be impractical. Three options for foundation support are presented below.

### Option 1. Spread Footings

Spread footings may be used for building support when founded either directly on the medium dense to very dense natural glacial sediments, or on structural fill placed over these materials. As previously discussed, existing fill soils were encountered in some of the explorations located in the proposed building and detention vault areas. Where existing fill soils underlie foundation areas, the existing fill should be removed and replaced with structural fill. We recommend that an allowable foundation soil bearing pressure of 2,500 pounds per square foot (psf) be used for design purposes, including both dead and live loads. An increase in the allowable bearing pressure of one-third may be used for short-term wind or seismic loading. Where the native sediments are disturbed during excavation we recommend that the upper 12 inches of the footing subgrades be recompacted to a firm and unyielding condition prior to footing placement. If structural fill is placed below footing areas, the structural fill should extend horizontally beyond the footing edges a distance equal to or greater than the thickness of the fill or 3 feet, whichever is less.

Perimeter footings for the proposed structures should be buried a minimum of 18 inches into the surrounding soil for frost protection. No minimum burial depth is required for interior footings; however, all footings must penetrate to the prescribed stratum, and no footings should be founded in or above loose, organic, or existing fill soils.

The area bounded by lines extending downward at 1H:1V from any footing must not intersect another footing or intersect a filled area that has not been compacted to at least 95 percent of ASTM D-1557. In addition, a 1.5H:1V line extending down from any footing must not daylight because sloughing or raveling may eventually undermine the footing. Thus, footings should not be placed near the edges of steps or cuts in the bearing soils.

Anticipated settlement of footings founded as described above should be on the order of 1 inch or less. However, disturbed soil not removed from footing excavations prior to footing placement could result in increased settlements.

All footing areas should be observed by AESI prior to placing concrete to verify that the exposed soils can support the design foundation bearing pressure and that construction conforms with the recommendations in this report. Foundation bearing verification may also be required by the City of Mukilteo.

Perimeter footing drains should be provided as discussed under the "Drainage Considerations" section of this report.

The thickness of the existing fill encountered in our explorations ranged from approximately 7 feet to greater than the maximum depth explored of approximately 17 feet. Given the large thickness of fill present, overexcavation and replacement of the existing fill with structural fill may not be practical in all areas. For this reason, two options for deep foundation systems are provided below.

<u>Option 2. Rock Trenches</u>

An alternative for foundation support would be to place the footings on rock-filled trenches that extend through the existing fill to the underlying competent glacial sediments. Rock-filled trenches should have a minimum width of 3 feet (or as designated by the field engineer/engineering geologist). Because of the potential for caving, actual trench widths may be greater than that specified. In order to reduce disturbance of the bearing soils exposed in the trench, <u>it is strongly recommended that the excavator use a smooth-edge bucket</u>.

To determine when suitable bearing has been achieved and to verify proper placement of the rock, the geotechnical engineer or their representative must be present on a <u>full-time basis</u> during trench excavation and backfill. Although groundwater seepage encountered in our explorations was limited to the location of exploration pit EP-4, we recommend that the contractor be equipped with a pump in the event that control of groundwater seepage is required to allow visual determination of the bearing soils. Any seepage entering the excavation on an overnight basis must be removed prior to commencing trench excavation the following day.

For trenches to be filled with crushed rock, we recommend the use of 2- to 4-inch-sized crushed rock or recycled concrete for backfill. The crushed rock must be tamped into place to achieve a tightly-packed mass; this may be done with either a “Hoepac” compactor or, more typically, with the bucket of the excavator itself. Staging areas should be maintained so that the rock is not contaminated by mud prior to placement in the trench.

Spread footings placed on rock trenches must be centered over the trenches. Any footing that is not centered over the trench must be further evaluated prior to concrete placement and may require additional trench excavation to obtain sufficient support. The allowable bearing pressure previously recommended for spread footing foundations would also apply to spread footings founded on rock-filled trenches.

Option 3. Pipe Piles

Another alternative would be to support the foundations on small-diameter pipe piles. Allowable axial capacities for small diameter driven pipe piles are provided below in Table 2.

**Table 2**
**Small Diameter Pipe Pile Recommendations**

| Nominal Pipe Diameter | Minimum Wall Thickness | Minimum Hammer Size | Allowable Axial Capacity | Driving Time (seconds/inch) |
|---|---|---|---|---|
| 2-inch | Schedule 80 | 90-Lb. Jackhammer | 6 kips | 60 |
| 3-inch | Schedule 40 | 850 Lbs. | 12 kips | 10 |
| 4-inch | Schedule 40 | 1,100 Lbs. | 17 kips | 10 |
| 6-inch | Schedule 40 | 3,000 Lbs. | 30 kips | 6 |

Lbs. = pounds

In order for the stated pile capacities to apply, the pipe piles should be driven to refusal, which is defined as less than 1 inch of penetration during the specified period of continuous driving. They should also completely penetrate the existing fill. This may require over-driving the pipes. Concrete debris was encountered within portions of the fill. The presence of the concrete debris could inhibit penetration of the fill. If concrete or other obstructions are encountered which prevent a pile from fully penetrating the fill, we recommend that the obstruction be removed with an excavator and the area backfilled prior to redriving the obstructed pile.

No lateral capacity would be provided by vertically installed pipe piles. Lateral capacity could be attained through the use of batter piles or passive resistance over the buried portions of the grade beams. Piles may be battered up to 15 degrees to develop additional lateral capacity. Lateral capacity of battered piles may be taken as the horizontal component of the axial pile load. Battered piles inclined up to 15 degrees should be designed with an allowable axial compressive capacity equal to that used for vertical piles. Pile spacing, locations, splicing details, foundation connection details, grade beam design, and any other structural design recommendations should be determined by a structural engineer.

Installation of the pipe piles should be observed by an AESI representative to verify that the refusal and embedment criteria are met and that materials, equipment, and procedures conform with our recommendations. This will likely be required by the City of Mukilteo.

If pipe piles larger than 2 inches in diameter are used, we recommend that load testing be conducted on a minimum of 3 percent of the piles (1 pile minimum, 5 piles maximum). The load tests should be conducted in accordance with the ASTM Quick Load Test procedure (ASTM D1143) to 200 percent of the allowable pile capacity.

## 12.0 LATERAL WALL PRESSURES

All backfill behind walls or around foundations should be placed following our recommendations for structural fill and as described in this section of the report. Horizontally backfilled walls that are free to yield laterally at least 0.1 percent of their height may be designed using an equivalent fluid equal to 35 pounds per cubic foot (pcf). Fully restrained, horizontally backfilled, rigid walls that cannot yield should be designed for an equivalent fluid of 55 pcf. Walls that retain sloping backfill at a maximum angle of 50 percent should be designed for 45 pcf for yielding conditions and 65 pcf for restrained conditions. If areas to receive vehicle traffic (e.g., parking areas or driveways) are located adjacent to walls, a surcharge equivalent to 2 feet of retained soil should be added to the wall height in determining lateral design forces.

### 12.1 Wall Backfill

The lateral pressures presented above are based on the conditions of a uniform backfill consisting of either the on-site granular sediments or imported sand and gravel compacted to 90 to 95 percent of ASTM D-1557. A higher degree of compaction is not recommended, as this will increase the pressure acting on the walls. A lower compaction may result in unacceptable settlement behind the walls. Thus, the compaction level is critical and must be tested by our firm during placement.

### 12.2 Wall Drainage

It is imperative that proper drainage be provided so that hydrostatic pressures do not develop against the walls. This would involve installation of a minimum 1-foot-wide blanket drain for the full wall height using imported, washed gravel against the walls.

### 12.3 Passive Resistance and Friction Factor

Lateral loads can be resisted by passive earth pressure acting on the buried portions of the foundations. For foundation design, we recommend an allowable passive equivalent fluid of 250 pcf. The foundations/grade beams must be backfilled with compacted structural fill to achieve the passive resistance provided below. Base friction should be ignored for pile-supported foundations.

### 12.4 Seismic Surcharge

As required by the 2018 IBC, retaining wall design should include a seismic surcharge pressure in addition to the equivalent fluid pressures presented above. We recommend a seismic surcharge pressure of 10H and 12H psf where H is the wall height in feet for the “active” and “at-rest” loading conditions, respectively. The seismic surcharge should be modeled as a rectangular distribution with the resultant applied at the midpoint of the wall.

## 13.0 FLOOR SUPPORT

Significant thicknesses of loose fill underlie portions of the site, and support of slab-on-grade floors on competent natural sediments may not be practical in all areas. Three options for slab-on-grade floor support are provided below. Options 1 and 2 fully mitigate the risk of slab settlement, whereas Option 3 only partially mitigates the risk of settlement.

### Option 1. Support of Slab-On-Grade Floors on Competent Natural Sediments or Structural Fill

Slab-on-grade floors may be constructed either directly on the medium dense to dense, natural glacial sediments, or on structural fill placed over these materials. Areas of the slab subgrade that are disturbed (loosened) during construction should be recompacted to an unyielding condition prior to placing the pea gravel, as described below.

### Option 2. Support of Slab Floors on Pipe Piles or Rock Trenches

In those areas of the site where the thickness of the existing fill soil makes Option 1 impractical, an alternative option would be to support the slab floors on either driven pipe piles or rock trenches using the information previously presented in the "Foundations" section of this report. The spacing of the rock trenches or pipe piles would be determined by a structural engineer based on the amount of reinforcement included in the floor slab design and the amount of acceptable settlement for deflection of the slab.

Option 3. Floating Floor Slab

Another alternative would be to "float" the slab on a thin structural fill mat. This should be conducted by overexcavating the existing fill or loose, natural sediments below the floor slab areas to a minimum of 1 foot below the final planned floor subgrade. The exposed soils in the excavation should then be recompacted to a firm and unyielding condition. A structural fill mat with a minimum thickness of 1 foot should then be placed below the entire floor slab area. The floor slab should not be tied into the building's foundation, but should be free to settle independently. Floating floor slabs should contain sufficient bar-reinforcement to reduce differential movement across any cracks that might develop. This option should only be considered if some settlement and cracking of the floor slab can be tolerated.

Regardless of which floor support option is selected, the floor should be constructed atop a capillary break consisting of a minimum thickness of 4 inches of washed pea gravel or washed crushed rock. The capillary break should be overlain by a 10-mil (minimum thickness) plastic vapor retarder.

## 14.0 DRAINAGE CONSIDERATIONS

The existing fill and natural glacial sediments underlying the site contain significant amounts of silt and are considered to be moisture-sensitive. Traffic from vehicles and construction equipment across these sediments when they are very moist or wet will result in disturbance of the otherwise firm stratum. Therefore, prior to site work and construction, the contractor should be prepared to provide drainage and subgrade protection, as necessary.

### 14.1 Wall/Foundation Drains

All retaining and perimeter footing walls should be provided with a drain at the footing elevation. The drains should consist of rigid, perforated, polyvinyl chloride (PVC) pipe surrounded by washed gravel. The level of the perforations in the pipe should be set approximately 2 inches below the bottom of the footing, and the drains should be constructed with sufficient gradient to allow gravity discharge away from the buildings. All retaining walls should be lined with a minimum, 12-inch-thick, washed gravel blanket provided to within 1 foot of finish grade, and which ties into the footing drain. Roof and surface runoff should not discharge into the footing drain system, but should be handled by a separate, rigid, tightline drain.

Exterior grades adjacent to walls should be sloped downward away from the structures to achieve surface drainage. Final exterior grades should promote free and positive drainage away from the building at all times. Water must not be allowed to pond or to collect adjacent to the foundation or within the immediate building area. It is recommended that a gradient of at least 3 percent for a minimum distance of 10 feet from the building perimeter be provided, except in paved locations. In paved locations, a minimum gradient of 1 percent should be provided unless provisions are included for collection and disposal of surface water adjacent to the structure. Additionally, pavement subgrades should be crowned to provide drainage toward catch basins and pavement edges.

## 15.0 STORMWATER INFILTRATION

Because of their elevated silt content and high relative density, the dense to very dense, unweathered lodgement till sediments exhibit a low permeability and are not considered to be a suitable receptor soil for stormwater infiltration. The ice contact sediments and weathered till horizon also contain a high percentage of silt but exhibit a lower relative density than the underlying, unweathered till. The permeability of the ice contact deposits and weathered till is low, but somewhat higher than the underlying unweathered till. Because the ice contact deposits and weathered till horizon are relatively thin, water infiltrated into these deposits will tend to migrate laterally at shallow depth atop the buried, unweathered till surface. Because this can result in the water pooling up against building foundations or emerging on downslope properties, infiltration into the weathered till horizon and ice contact deposits is not recommended.

## 16.0 PROJECT DESIGN AND CONSTRUCTION MONITORING

Because project plans were not available at the time of our study, this report is considered to be preliminary. We recommend that we be allowed to review project plans when they are completed and to revise the recommendations presented in this report, if appropriate.

We are also available to provide geotechnical engineering and monitoring services during construction. The integrity of the foundation system depends on proper site preparation and construction procedures. In addition, engineering decisions may have to be made in the field in the event that variations in subsurface conditions become apparent.

We have enjoyed working with you on this study and are confident these recommendations will aid in the successful completion of your project. If you should have any questions or require further assistance please do not hesitate to call.

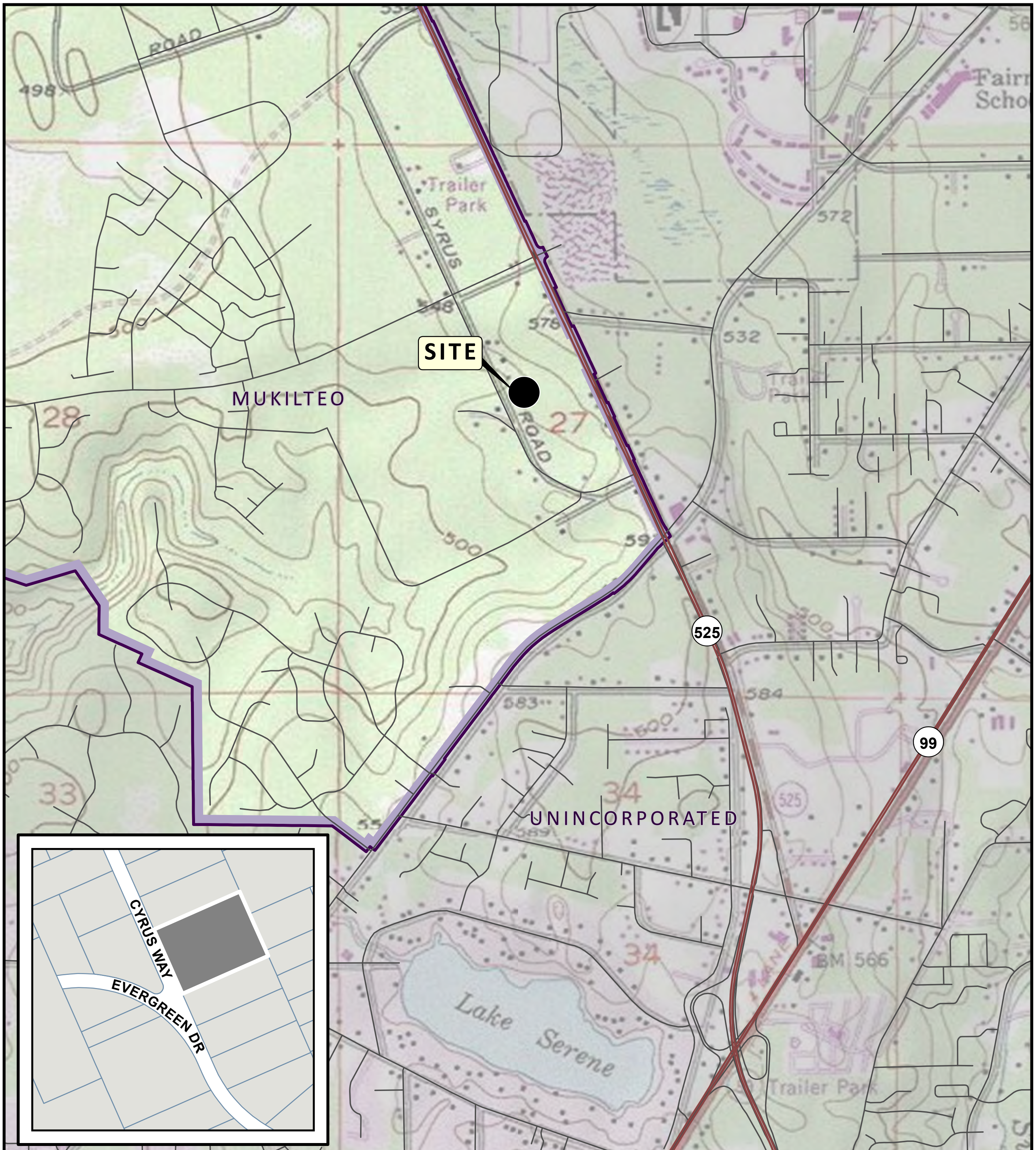
Sincerely,
**ASSOCIATED EARTH SCIENCES, INC.**
**Kirkland, Washington**

6-9-20

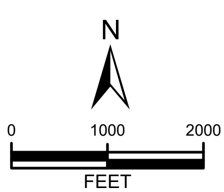
Timothy J. Peter, L.E.G., L.Hg.
Senior Engineering Geologist

Matthew A. Miller, P.E.
Principal Geotechnical Engineer

| | | |
|---|---|---|
| Attachments: | Figure 1: | Vicinity Map |
| | Figure 2: | Site and Exploration Plan |
| | Appendix A. | Exploration Logs |
| | Appendix B: | LIDAR Based Shaded Relief Image |
| | Appendix C: | July 1990 Aerial Photo |








DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NATIONAL GEOGRAPHIC SOCIETY 2013
SNOHOMISH CO: STREETS, CITY LIMITS, PARCELS, 4/20
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

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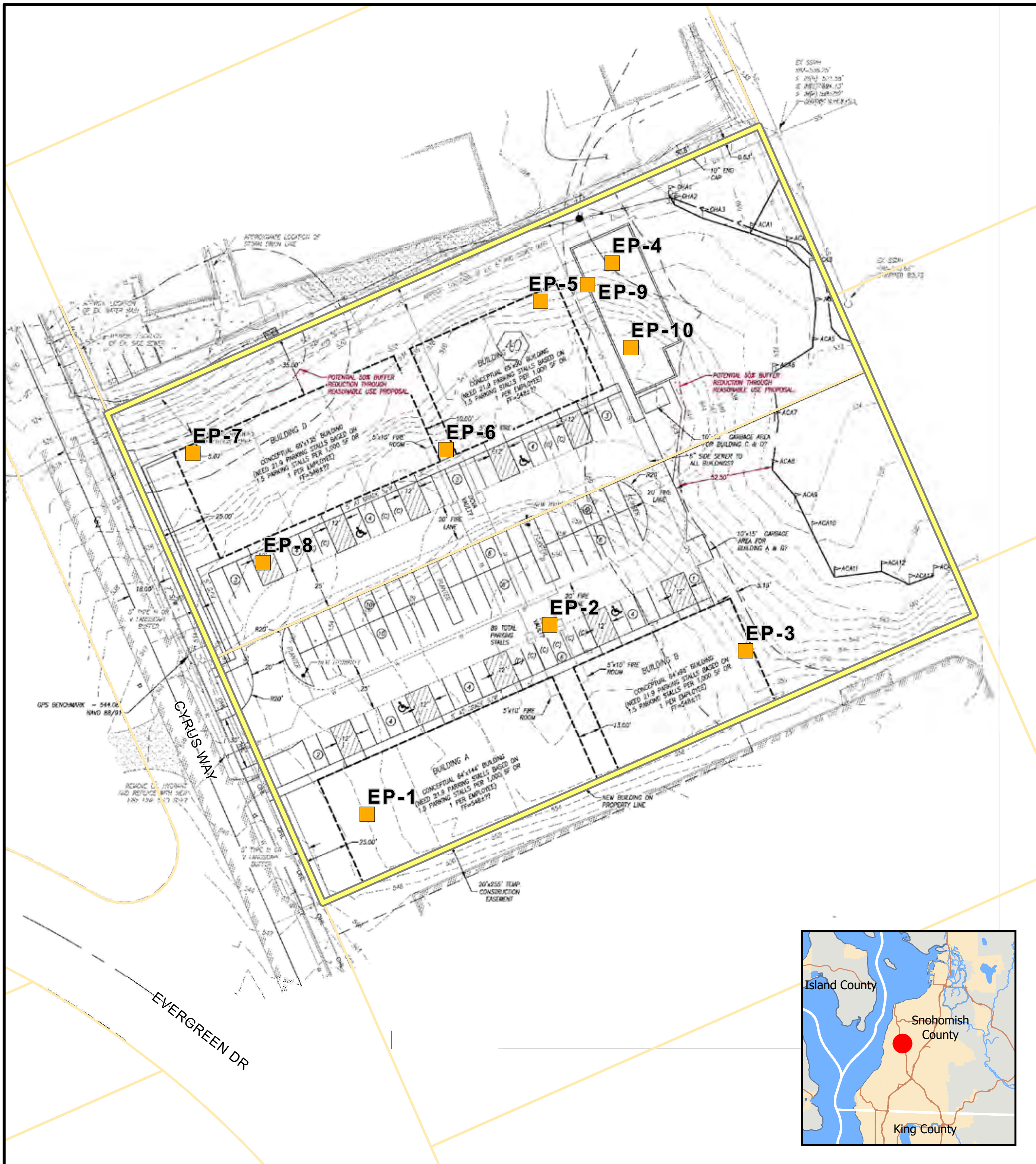
# VICINITY MAP

BRAVA LIGHT INDUSTRIAL
MUKILTEO, WASHINGTON

| PROJ NO. | DATE: | FIGURE: |
|---|---|---|
| 20190478E001 | 5/20 | 1 |

\\kirkfile2\GIS\GIS_Projects\aaY2019\190478 Brava Light Industrial\aprx\190478E001 F1 F2 Brava.aprx




SITE

EXPLORATION PIT

PARCEL

N

0 80

Feet

DATA SOURCES / REFERENCES:
SNOHOMISH CO: STREETS, PARCELS 4/20
DWG REFERENCE:
WESTERN ENGINEERS AND SURVEYORS, BRAVA LIGHT INDUSTRIAL, CONCEPT SITE PLAN, 2/19/20

LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

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# SITE AND EXPLORATION PLAN

## BRAVA LIGHT INDUSTRIAL
## MUKILTEO, WASHINGTON

| PROJ NO. | DATE: | FIGURE: |
|---|---|---|
| 20190478E001 | 5/20 | 2 |

\\kirkfile2\GIS\GIS_Projects\aaY2019\190478\aprx\190478E001 F1 F2 Brava.aprx

# APPENDIX A

# Exploration Logs

| | | | | |
|---|---|---|---|---|
| Coarse-Grained Soils - More than 50% [1] Retained on No. 200 Sieve | Gravels - More than 50% [1] of Coarse Fraction Retained on No. 4 Sieve | ≤5% Fines [5] | GW | Well-graded gravel and gravel with sand, little to no fines |
| | | | GP | Poorly-graded gravel and gravel with sand, little to no fines |
| | | ≥12% Fines [5] | GM | Silty gravel and silty gravel with sand |
| | | | GC | Clayey gravel and clayey gravel with sand |
| | Sands - 50% [1] or More of Coarse Fraction Passes No. 4 Sieve | ≤5% Fines [5] | SW | Well-graded sand and sand with gravel, little to no fines |
| | | | SP | Poorly-graded sand and sand with gravel, little to no fines |
| | | ≥12% Fines [5] | SM | Silty sand and silty sand with gravel |
| | | | SC | Clayey sand and clayey sand with gravel |
| Fine-Grained Soils - 50% [1] or More Passes No. 200 Sieve | Silts and Clays Liquid Limit Less than 50 | | ML | Silt, sandy silt, gravelly silt, silt with sand or gravel |
| | | | CL | Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay |
| | | | OL | Organic clay or silt of low plasticity |
| | Silts and Clays Liquid Limit 50 or More | | MH | Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt |
| | | | CH | Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel |
| | | | OH | Organic clay or silt of medium to high plasticity |
| Highly Organic Soils | | | PT | Peat, muck and other highly organic soils |

## Terms Describing Relative Density and Consistency

| | Density | SPT [2] blows/foot |
|---|---|---|
| Coarse-Grained Soils | Very Loose | 0 to 4 |
| | Loose | 4 to 10 |
| | Medium Dense | 10 to 30 |
| | Dense | 30 to 50 |
| | Very Dense | >50 |

| | Consistency | SPT [2] blows/foot |
|---|---|---|
| Fine-Grained Soils | Very Soft | 0 to 2 |
| | Soft | 2 to 4 |
| | Medium Stiff | 4 to 8 |
| | Stiff | 8 to 15 |
| | Very Stiff | 15 to 30 |
| | Hard | >30 |

### Test Symbols

G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Chemical
DD = Dry Density
K = Permeability

## Component Definitions

| Descriptive Term | Size Range and Sieve Number |
|---|---|
| Boulders | Larger than 12" |
| Cobbles | 3" to 12" |
| Gravel | 3" to No. 4 (4.75 mm) |
| Coarse Gravel | 3" to 3/4" |
| Fine Gravel | 3/4" to No. 4 (4.75 mm) |
| Sand | No. 4 (4.75 mm) to No. 200 (0.075 mm) |
| Coarse Sand | No. 4 (4.75 mm) to No. 10 (2.00 mm) |
| Medium Sand | No. 10 (2.00 mm) to No. 40 (0.425 mm) |
| Fine Sand | No. 40 (0.425 mm) to No. 200 (0.075 mm) |
| Silt and Clay | Smaller than No. 200 (0.075 mm) |

## [3] Estimated Percentage

| Component | Percentage by Weight |
|---|---|
| Trace | <5 |
| Some | 5 to <12 |
| *Modifier* (silty, sandy, gravelly) | 12 to <30 |
| Very *modifier* (silty, sandy, gravelly) | 30 to <50 |

## Moisture Content

Dry - Absence of moisture, dusty, dry to the touch

Slightly Moist - Perceptible moisture

Moist - Damp but no visible water

Very Moist - Water visible but not free draining

Wet - Visible free water, usually from below water table

## Symbols

Sampler Type

Blows/6" or portion of 6"

2.0" OD Split-Spoon Sampler (SPT)

10 15 20

Bulk sample

Grab Sample

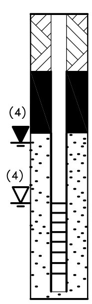
**Sampler Type Description**

3.0" OD Split-Spoon Sampler

3.25" OD Split-Spoon Ring Sampler

3.0" OD Thin-Wall Tube Sampler (including Shelby tube)

Portion not recovered



(4)

(4)

Cement grout surface seal

Bentonite seal

Filter pack with blank casing section

Screened casing or Hydrotip with filter pack

End cap

(1) Percentage by dry weight

(2) (SPT) Standard Penetration Test (ASTM D-1586)

(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)

(4) Depth of ground water

ATD = At time of drilling

Static water level (date)

(5) Combined USCS symbols used for fines between 5% and 12%

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

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# EXPLORATION LOG KEY

FIGURE A1

blocks \ dwg \ log_key.dwg LAYOUT: Layout 4 -2014 Qty Chng

# EXPLORATION PIT NO. EP-1

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

| Depth (ft) | DESCRIPTION |
|---|---|
| | **Weathered Vashon Lodgement Till** |
| 1 | Loose, moist, brown, silty, SAND, some gravel; abundant roots (SM). |
| 2 | |
| 3 | Medium dense, moist, tan, fine to medium SAND, some silt (SP-SM). |
| 4 | |
| | **Vashon Lodgement Till** |
| 5 | Dense, moist, mottled tan, silty, gravelly, SAND; nonstratified (SM). |
| 6 | |
| 7 | Becomes tannish gray below ~7 feet. |
| 8 | Becomes very dense below 8 feet. |
| 9 | |
| 10 | Bottom of exploration pit at depth 9.5 feet<br>No seepage. No caving. |
| 11 | |
| 12 | |
| 13 | |
| 14 | |
| 15 | |
| 16 | |
| 17 | |
| 18 | |
| 19 | |
| 20 | |



**Brava Light Industrial**
**Mukilteo, WA**

Logged by: TJP
Approved by: JHS

associated earth sciences incorporated

**Project No. 20190478E001**

**5/18/20**

# EXPLORATION PIT NO. EP-2

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

| Depth (ft) | DESCRIPTION |
|---|---|
| | **Sod / Topsoil - 6 inches** |
| | **Weathered Vashon Lodgement Till** |
| 1 | Loose, moist, reddish tan, silty, SAND, some gravel (SM). |
| 2 | |
| 3 | Becomes medium dense, grayish tan, and gravelly below 2.5 feet. |
| 4 | |
| 5 | **Vashon Lodgement Till** |
| 6 | Very dense, moist to very moist, tannish gray, very silty, SAND, some gravel; nonstratified (SM). |
| 7 | |
| 8 | |
| 9 | Bottom of exploration pit at depth 8 feet<br>No seepage. No caving. |
| 10 | |
| 11 | |
| 12 | |
| 13 | |
| 14 | |
| 15 | |
| 16 | |
| 17 | |
| 18 | |
| 19 | |
| 20 | |

**Brava Light Industrial**
**Mukilteo, WA**

Logged by: TJP
Approved by: JHS

associated earth sciences incorporated

**Project No. 20190478E001**
**5/18/20**

# EXPLORATION PIT NO. EP-3

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

| Depth (ft) | DESCRIPTION |
|---|---|
| | **Topsoil - 8 inches** |
| 1 | **Weathered Vashon Lodgement Till**<br>Loose to medium dense, moist, brown, very silty, SAND, some gravel; abundant roots (SM). |
| 2 | **Vashon Lodgement Till**<br>Very dense, moist, grayish tan, very silty, SAND, some gravel; nonstratified (SM). |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | Bottom of exploration pit at depth 7 feet<br>No seepage. No caving. |
| 9 | |
| 10 | |
| 11 | |
| 12 | |
| 13 | |
| 14 | |
| 15 | |
| 16 | |
| 17 | |
| 18 | |
| 19 | |
| 20 | |



**Brava Light Industrial**
**Mukilteo, WA**

Logged by: TJP
Approved by: JHS

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**Project No. 20190478E001**

**5/18/20**

# EXPLORATION PIT NO. EP-4

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

| Depth (ft) | DESCRIPTION |
|---|---|
| | **Fill** |
| 1 | Loose to medium dense, moist to very moist, brown to grayish brown, silty, SAND, some gravel; contains scattered pieces of concrete (SM). |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | Becomes very moist and gray with abundant wood debris below 8 feet. |
| 9 | **Topsoil** |
| | **Weathered Vashon Advance Outwash** |
| 10 | Loose, very moist, grayish brown, very silty, SAND, some gravel (SM). |
| 11 | **Vashon Advance Outwash** |
| 12 | Dense, wet, gray, very gravelly, SAND, trace silt (SP). |
| 13 | |
| 14 | Bottom of exploration pit at depth 13 feet<br>Moderately rapid seepage 11 to 13 feet. No caving. |
| 15 | |
| 16 | |
| 17 | |
| 18 | |
| 19 | |
| 20 | |

KCTP3 20190478E001.GPJ June 1, 2020

**Brava Light Industrial**
**Mukilteo, WA**

Logged by: TJP
Approved by: JHS

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**Project No. 20190478E001**

**5/18/20**

# EXPLORATION PIT NO. EP-5

| Depth (ft) | This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered. **DESCRIPTION** |
|---|---|
| | **Fill** |
| 1 | Loose, moist, dark brown, silty, SAND; abundant roots (SM). |
| 2 | |
| 3 | |
| 4 | Loose to medium dense, moist, tan, silty, gravelly, SAND (SM). |
| 5 | |
| 6 | |
| 7 | |
| 8 | **Weathered Vashon Lodgement Till** |
| 9 | Medium dense, very moist, mottled tan, very silty, gravelly, SAND; nonstratified (SM). |
| 10 | |
| 11 | **Vashon Lodgement Till** |
| 12 | Dense, very moist, grayish tan, silty, gravelly, SAND; nonstratified (SM). |
| 13 | Bottom of exploration pit at depth 12 feet<br>No seepage. No caving. |
| 14 | |
| 15 | |
| 16 | |
| 17 | |
| 18 | |
| 19 | |
| 20 | |



**Brava Light Industrial**
**Mukilteo, WA**

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Approved by: JHS

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**Project No. 20190478E001**

**5/18/20**

# EXPLORATION PIT NO. EP-6

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

| Depth (ft) | DESCRIPTION |
|---|---|
| | **Topsoil - 6 inches** |
| 1 | **Weathered Vashon Lodgement Till**<br>Loose to medium dense, moist, reddish tan, silty, gravelly, SAND (SM).<br>Abundant roots 0 to 2 feet. |
| 2 | |
| 3 | |
| 4 | **Vashon Lodgement Till**<br>Dense, moist, grayish tan, silty, gravelly SAND; nonstratified (SM). |
| 5 | |
| 6 | |
| 7 | Becomes very dense below 7 feet. |
| 8 | Bottom of exploration pit at depth 7 feet<br>No seepage. No caving. |
| 9 | |
| 10 | |
| 11 | |
| 12 | |
| 13 | |
| 14 | |
| 15 | |
| 16 | |
| 17 | |
| 18 | |
| 19 | |
| 20 | |

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# EXPLORATION PIT NO. EP-7

| Depth (ft) | This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.<br><br>**DESCRIPTION** |
|---|---|
| 1<br>2<br>3<br>4<br>5<br>6<br>7<br>8 | **Fill**<br>Loose, very moist, grayish brown, silty, SAND, some gravel; scattered concrete and plastic debris (SM).<br>Pockets of crushed rock 0 to 1 foot. |
| 9<br>10<br>11<br>12<br>13<br>14<br>15 | **Vashon Ice Contact Deposits**<br>Medium dense, moist to very moist, reddish tan, silty, SAND, some gravel (SM). |
| 16<br>17<br>18<br>19<br>20 | Bottom of exploration pit at depth 15 feet<br>No seepage. Intermittent caving 0 to 8.5 feet. |

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# EXPLORATION PIT NO. EP-8

| Depth (ft) | This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered. DESCRIPTION |
|---|---|
| | **Topsoil - 8 inches** |
| 1 | **Vashon Lodgement Till**<br>Dense, very moist, grayish tan, very silty, SAND, some gravel; nonstratified (SM). |
| 2 | Becomes very dense below 2 feet. |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | Bottom of exploration pit at depth 7 feet<br>No seepage. No caving. |
| 9 | |
| 10 | |
| 11 | |
| 12 | |
| 13 | |
| 14 | |
| 15 | |
| 16 | |
| 17 | |
| 18 | |
| 19 | |
| 20 | |

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# EXPLORATION PIT NO. EP-9

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

| Depth (ft) | DESCRIPTION |
|---|---|
| | **Fill** |
| 1 | Loose, moist, brown to grayish brown, silty, SAND, some gravel; scattered concrete, logs, and branches (SM). |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | **Vashon Ice Contact Deposits** |
| 8 | Loose, moist to very moist, reddish tan, silty, SAND, trace to some gravel; contains scattered roots (SM). |
| 9 | |
| 10 | |
| 11 | |
| 12 | Becomes medium dense, very moist, and mottled gray and tan with some gravel; no discernible stratification. |
| 13 | Bottom of exploration pit at depth 12 feet<br>No seepage. No caving. |
| 14 | |
| 15 | |
| 16 | |
| 17 | |
| 18 | |
| 19 | |
| 20 | |

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# EXPLORATION PIT NO. EP-10

| Depth (ft) | This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered. **DESCRIPTION** |
|---|---|
| | **Fill** |
| 1 | Loose, very moist, grayish brown, very silty, SAND, some gravel (SM). |
| 2 | Piece of sheet plastic at 1.5 feet. Loose, moist, tan, silty, SAND, some gravel (SM). |
| 3 | Becomes medium dense, very moist, and grayish tan below 3 feet. |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | Loose, moist, dark brown, silty, SAND; abundant wood debris; contains metal, plastic, composite shingles, concrete, and glass debris (SM). |
| 9 | |
| 10 | |
| 11 | |
| 12 | Abundant concrete 12 to 15 feet. |
| 13 | |
| 14 | |
| 15 | |
| 16 | |
| 17 | |
| 18 | Bottom of exploration pit at depth 17 feet<br>No seepage. No caving. |
| 19 | |
| 20 | |



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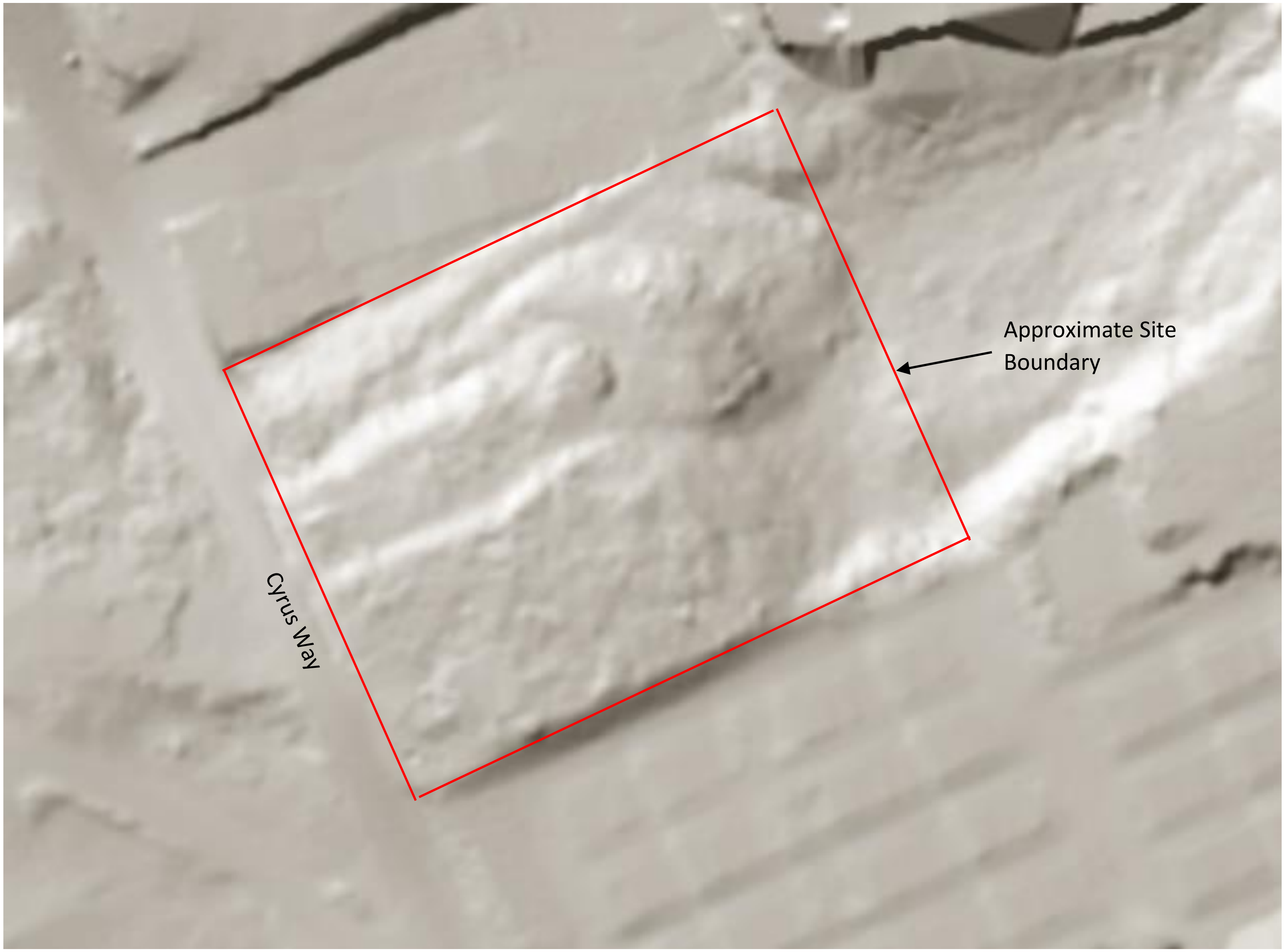
# APPENDIX B

# LIDAR Based Shaded Relief Image




LIDAR Based Shaded Relief Image

# APPENDIX C

# July 1990 Aerial Photo


July 1990 Aerial Photo (Source:  Google Earth)