Earth Solutions NW LLC

- Geotechnical Engineering
- Construction Monitoring
- Environmental Sciences

March 17, 2016
ES-4316

Ms. Jennifer Brenes
2675 – 74th Avenue Southeast
Mercer Island, Washington 98040

**Subject: Geotechnical Consulting Services**
**Proposed Single-Family Residential Improvements**
**2675 – 74th Avenue Southeast**
**Mercer Island, Washington**

Reference: Kathy G. Troost and Aaron P. Wisher
Geologic Map of Mercer Island, October 2006

King County Flood Control District
Liquefaction Susceptibility for King County, May 2010

C & C Surveying
Topographic Survey, dated October 2, 2013

United States Department of Agriculture
Natural Resources Conservation Service
Online Web Soil Survey (WSS) resource

Dear Ms. Brenes:

Earth Solutions NW, LLC (ESNW) has prepared this letter summarizing our geotechnical consulting services performed on the subject site. This letter was prepared in general accordance with the scope of services outlined in our proposal dated January 20, 2016 and authorized by you on the same date. A summary of our subsurface exploration and geotechnical recommendations pertinent to the proposed activities are provided in this letter.

## Project Description

We understand you wish to complete several improvements to your existing residence and associated property space. ESNW was retained at your request to provide geotechnical consulting services, in an effort to better characterize the subsurface conditions underlying your property in support of the proposed improvements. As we understand, such improvements include, but may not limited to, the following:

- Teardown of the existing timber crib retaining wall (located to the west of the residence) and construction of a new retaining wall;

- Construction of a new garage to replace the existing garage-carport structure;

- Expansion of the southwestern wing of the residence, and;

- Possible construction of a deck to wrap around the northern portion of the residence.

Where the existing residence is expanded, we anticipate the construction will be consistent with the existing number of stories. As such, perimeter footing loads were assumed to be on the order of 1 to 2 kips per lineal foot (klf). Slab-on-grade loading was estimated to be approximately 150 pounds per square foot (psf).

If the design assumptions outlined in this section are incorrect or change, or if construction conditions differ from those encountered during our fieldwork, ESNW should be contacted to review the recommendations and conclusions provided in this letter, which has been prepared for the exclusive use of Ms. Jennifer Brenes and her representatives. No warranty, expressed or implied, is made. This letter was prepared in a manner 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.

## Site Conditions

The subject site is located west of the intersection between Southeast 27$^{th}$ Street and 74$^{th}$ Avenue Southeast in Mercer Island, Washington. The approximate location of the property is depicted on Plate 1 (Vicinity Map). The subject property is comprised of one tax parcel (King County Parcel No. 531510-0392) totaling approximately 0.22 acres. The site is surrounded to the north, west, and south by single-family residences and to the east by 74$^{th}$ Avenue Southeast.

### Surface

The site is occupied primarily by a single-family residence, detached garage, and related infrastructure improvements. Site topography descends from the southwest to the northeast, and we estimate total site elevation change is on the order of 45 to 50 feet. The central portion of the site, where existing improvements are located, is comparatively flat to the remainder of the property. Existing vegetation is comprised mostly of grass, landscaping features, and scattered trees.

### Subsurface

An ESNW representative observed, logged, and sampled four soil borings, advanced within accessible areas of the property, on February 2 and 3, 2016 using a limited-access drill rig and operators retained by our firm. The borings were completed for purposes of assessing soil conditions, classifying site soils, and characterizing subsurface groundwater conditions within accessible areas of the property. The approximate locations of the borings 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. Select soil samples collected at the boring locations were analyzed in accordance with both Unified Soil Classification System (USCS) and United States Department of Agriculture (USDA) methods and procedures, where applicable.

Topsoil was encountered within the upper 6 to 12 inches of existing grades at the boring locations. The topsoil was characterized by brown to dark brown color, the presence of fine organic material, and small root intrusions. Fill was not explicitly encountered at the boring locations during our fieldwork, but may be present near areas of existing structural improvements. As necessary, ESNW can evaluated fills encountered during future site activities upon request.

Native soils encountered at the boring locations were classified as either mass wastage deposits or Lawton Clay. The mass wastage deposits were encountered generally within the upper 10 to 15 feet of existing grades and were characterized primarily as very loose to medium dense, clayey sand (USCS: SC) with and/or without significant gravel content. Underlying the mass wastage deposits, very stiff to hard Lawton Clay was encountered. Sandy interbeds were encountered within the native clays at various depths. Native soils were encountered generally in a moist condition, extending to the maximum exploration depth of 31.5 feet below the existing ground surface (bgs).

### Geologic Setting

The referenced geologic map resource identifies Lawton Clay (Qvlc) as the primary geologic feature of the site subsurface. Vashon advance outwash (Qva) is mapped across the topographically higher portion of First Hill, and nonglacial deposits of pre-Fraser glaciation age (Qpfn) are mapped immediately east of the site. The site is mapped within a "mass wastage deposits" (Qmw) overprint.

According to the geologic map resource, Lawton Clay is typically "laminated to massive silt, clayey silt, and silty clay." Vashon advance outwash is typically a well-sorted sand and gravel deposit which was formed by streams issuing from the advancing ice sheet. Nonglacial deposits of pre-Fraser glaciation age may contain "sand, gravel, silt, clay, and organic deposits of inferred nonglacial origin." Mass wastage deposits are comprised primarily of "colluvium, soil, landslide debris, and organic matter with indistinct morphology." Such deposits are "common on steep slopes, most notably around the south end of the island, along the east-central side of the island, and around First Hill." The referenced WSS resource suggests Kitsap silt loam (Map Unit Symbol: KpB and KpD) underlies the site and surrounding areas. The Kitsap series was formed in terraces. Based on our field observations, native soils underlying subject site are consistent with the geologic setting outlined in this section. Soils most likely to be encountered during subsequent construction activities will be comprised primarily of mass wastage deposits (clayey sand).

## Groundwater

During our subsurface exploration completed on February 2 and 3, 2016, groundwater seepage was encountered at depths of approximately 7 to 15 feet bgs at the boring locations. Based on our field observations, groundwater seepage may be encountered within site excavations depending on the time of year construction takes place. Seepage rates and elevations fluctuate depending on many factors, including precipitation duration and intensity, the time of year, and soil conditions. In general, groundwater flow rates are higher during the wetter, winter months.

## Site Development Recommendations

Based on the results of our investigation, construction of the proposed improvements is feasible from a geotechnical standpoint. The primary geotechnical considerations associated with the proposed construction include foundation support and/or slab-on-grade subgrade support and the suitability of using on-site soils as structural fill (where necessary). Maintenance of slope stability through sound construction and grading techniques is also an important geotechnical consideration.

### Earthwork

From a geotechnical standpoint, our field observations indicate on-site soils likely to be encountered during construction will be fine grained and generally unsuitable for use as structural fill.

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. During wet weather conditions, imported soil intended for use as structural fill should consist of a well-graded granular soil with a fines content of 5 percent or less (where the fines content is defined as the percent passing the Number 200 sieve, based on the minus three-quarter-inch fraction).

Foundation and slab subgrade surfaces should be compacted in situ to a minimum depth of one foot below the design subgrade elevation. Uniform compaction of the foundation and slab subgrade areas will establish a relatively consistent subgrade condition below the foundation and slab elements. ESNW should observe the compacted subgrade prior to placing formwork. Supplementary recommendations for subgrade improvement may be provided at the time of construction and would likely include further mechanical compaction or overexcavation and replacement with suitable structural fill.

Structural fill is defined as compacted soil placed in foundation, slab-on-grade, and roadway areas. Fills placed to construct permanent slopes and throughout retaining wall and utility trench backfill areas are also considered structural fill. Soils placed in structural areas should be placed in loose lifts of 12 inches or less and compacted to a relative compaction of 90 percent, based on the laboratory maximum dry density as determined by the Modified Proctor Method (ASTM D1557). The upper one foot of structural fill placed in pavement and sidewalk subgrade areas should be compacted to 95 percent. More stringent compaction specifications may be required for utility trench backfill zones depending on the responsible utility district or jurisdiction.

**Slope Stability**

We evaluated slope stability across the subject property with specific focus on the northern portion of the property where grades are steepest. Slope stability analyses were completed for the existing site configuration. One representative cross-section was completed where the slope stability analyses were performed. The existing topography, as shown on the referenced survey, was utilized in preparation of Plate 3 (Cross Section A-A').

Global stability analyses were completed using the 2007 GeoStudio Slope/W (Version 7.23) software modeling program. Slip surface entry and exit ranges were established near the top and toe of the slope, respectively, and the modeling program searched for the critical slip surface. Selected modeling parameters for site soils were primarily based on our experience with similar projects in similar soil settings. Laboratory test results, as well as Standard Penetration Test (SPT) data collected during the fieldwork, were also considered. The following table summarizes the soil modeling parameters utilized during our slope stability analyses:

| Soil Type | USCS Classification | Unit Weight (pcf) | Cohesion (psf) | Coefficient of Friction (degrees) |
|---|---|---|---|---|
| Mass-wastage Deposits | SC | 120 | 100 | 28 |
| Lawton Clay | CH | 115 | 500 | 26 |

The results of our analyses, as well as additional modeling parameters, are attached to this letter. The factor-of-safety (FOS) values indicated on the attached Slope/W computer output are representative of the critical slip surfaces. Both seismic and static conditions were modeled for the existing configuration. In accordance with the 2012 International Building Code and utilizing 2008 United States Geologic Survey (USGS) hazard data, a peak horizontal ground acceleration (PGA) value of 0.418 *g* was used for site-specific modeling. The pseudostatic coefficient used in the stability analyses was equivalent to one-half of the PGA, or 0.209 *g*. Analyses yielded minimum FOS values greater than 1.2 for seismic conditions and 1.5 for static conditions with respect to the existing configuration.

**Foundations**

Where applicable, the proposed structural additions may be supported on a conventional continuous and spread footing foundation bearing on competent native soils, recompacted native soils (where feasible), or new structural fill. In general, competent native soils, suitable for support of foundations, will likely be encountered within the upper three to five feet of existing grades. Where loose or unsuitable soil conditions are exposed at foundation subgrade elevations, compaction of soils to the specifications of structural fill, or overexcavation and replacement with a suitable structural fill material, will be necessary.

Provided the structural foundation(s) will be supported as described above, the following parameters may be used for design:

- Allowable soil bearing capacity — 2,500 psf
- Passive earth pressure — 225 pcf (equivalent fluid)
- Coefficient of friction — 0.35

A one-third increase in the allowable soil bearing capacity may be assumed for short-term wind and seismic loading conditions. The above passive pressure and friction values include a factor-of-safety of at least 1.5. With structural loading as expected, total settlement in the range of one inch and differential settlement of about one-half inch is anticipated. The majority of settlement should occur during construction as dead loads are applied.

**Seismic Design**

The 2012 International Building Code recognizes the American Society of Civil Engineers (ASCE) for seismic site class definitions. In accordance with Table 20.3-1 of the ASCE Minimum Design Loads for Buildings and Other Structures manual, Site Class D should be used for design.

The referenced liquefaction susceptibility map indicates the site and surrounding areas maintain very low liquefaction susceptibility. Liquefaction is a phenomenon where saturated or loose soils suddenly lose internal strength and behave as a fluid. This behavior is in response to increased pore water pressures resulting from an earthquake or other intense ground shaking. In our opinion, site susceptibility to liquefaction may be characterized as low. Relatively consistent soil densities at depth and the absence of a uniformly established, shallow groundwater table were the primary bases for this characterization.

**Slab-on-Grade Floors**

Where necessary, new slab-on-grade floors should be supported on a firm and unyielding subgrade. Where feasible, native soils exposed at the slab-on-grade subgrade level can likely be compacted in situ to the specifications of structural fill. Unstable or yielding areas of the subgrade should be recompacted, or overexcavated and replaced with suitable structural fill, prior to construction of the slab.

A capillary break consisting of a minimum of four inches of free-draining crushed rock or gravel should be placed below the slab. The free-draining material should have a fines content of 5 percent or less (percent passing the Number 200 sieve, based on the minus three-quarter inch fraction). Installation of a vapor barrier below the slab should be considered in areas where slab moisture is undesirable. If utilized, the vapor barrier 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) | 45 pcf (equivalent fluid) |
| • At-rest earth pressure (restrained condition) | 65 pcf |
| • Passive earth pressure | 225 pcf (equivalent fluid) |
| • Coefficient of friction | 0.35 |
| • Seismic surcharge | 8H* |

* *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 relevant loads should be included in the retaining wall design.

Retaining walls should be backfilled with free-draining material that extends along the height of the wall and a distance of at least 18 inches behind the wall. The upper 12 inches of the wall backfill may consist of a less permeable soil, if desired. A perforated drain pipe should be placed along the base of the wall and connected to an approved discharge location. If drainage is not provided, hydrostatic pressures should be included in the wall design.

**Drainage**

Based on our field observations, significant perched groundwater seepage flows are not likely to interfere with construction activities; nonetheless, discrete zones of perched seepage may be encountered within site excavations depending on the time of year construction takes place. ESNW should be consulted during preliminary grading to identify areas of seepage and provide supplementary recommendations, where necessary. Finish grades must be designed to direct surface drain water away from the proposed structure, and water must not be allowed to pond adjacent to the structure. In our opinion, foundation drains should be installed along the perimeter footings of new structural improvements (where applicable).

**Excavations and Slope Layback**

The Federal Occupation Safety and Health Administration (OSHA) and the Washington Industrial Safety and Health Act (WISHA) provide soil classification in terms of temporary slope inclinations. Soils that exhibit a high compressive strength are allowed steeper temporary slope inclinations than are soils that exhibit a lower compressive strength. Based on the conditions encountered at the boring locations, soil likely to be encountered during construction, as well as any area where groundwater seepage is exposed, is classified as Type C by OSHA and WISHA. Temporary slopes over four feet in height in Type C soils must be sloped no steeper than one-and-one-half horizontal to one vertical (1.5H:1V).

Where encountered, the presence of perched groundwater may cause caving of the temporary slopes due to hydrostatic pressure. ESNW should observe site excavations to confirm soil types and allowable slope inclinations. If the recommended temporary slope inclinations cannot be achieved, temporary shoring may be necessary to support excavations. In any event, due to relative proximity to property lines and/or existing structures, temporary shoring may become necessary depending on the extent of excavations. ESNW can provide supplementary recommendations to aid with temporary shoring design upon request. Temporary shoring for this project would likely include ecology block wall installation or construction of a relatively "limited" soldier pile wall.

**Existing Timber Crib Retaining Wall**

We understand you desire to replace the existing timber crib retaining wall, located to the west of the residence, with a new retaining wall. We observed the existing wall during our January 14, 2016 site reconnaissance. Based on our field observations, the existing wall is approximately 10 to 12 feet in height and appears to be in a generally fair condition. Timber rot was noted at various locations along the wall. Relatively light groundwater seepage was observed through the face of the wall at a few locations.

In our opinion, a modular block retaining wall would likely be feasible for replacement of the existing timber crib wall. Depending on both the required wall height and the soil conditions in proximity to the wall location, mechanically stabilized earth (MSE) considerations may need to be incorporated into the design. A two-tiered configuration may also be feasible depending on final dimensioning and the available space for reconstruction. ESNW can provide additional consulting services, including a retaining wall design and supporting calculations, upon request. In any event, the retaining wall should be supported on a firm and unyielding subgrade. Adequate drainage should be installed immediately behind the wall face(s) and directed to an appropriate discharge location. ESNW should be retained to observe wall demolition and/or reconstruction activities so as to confirm the stability of the cut and provide supplementary geotechnical recommendations, where necessary.

**Additional Services**

ESNW should be consulted to review final site designs and/or project plans to ensure appropriate geotechnical provisions have been incorporated. ESNW should also be retained to provide testing and consultation services during construction.

We appreciate the opportunity to be of service and trust this letter meets your current needs. Should you have questions regarding the content herein, please call.

Sincerely,

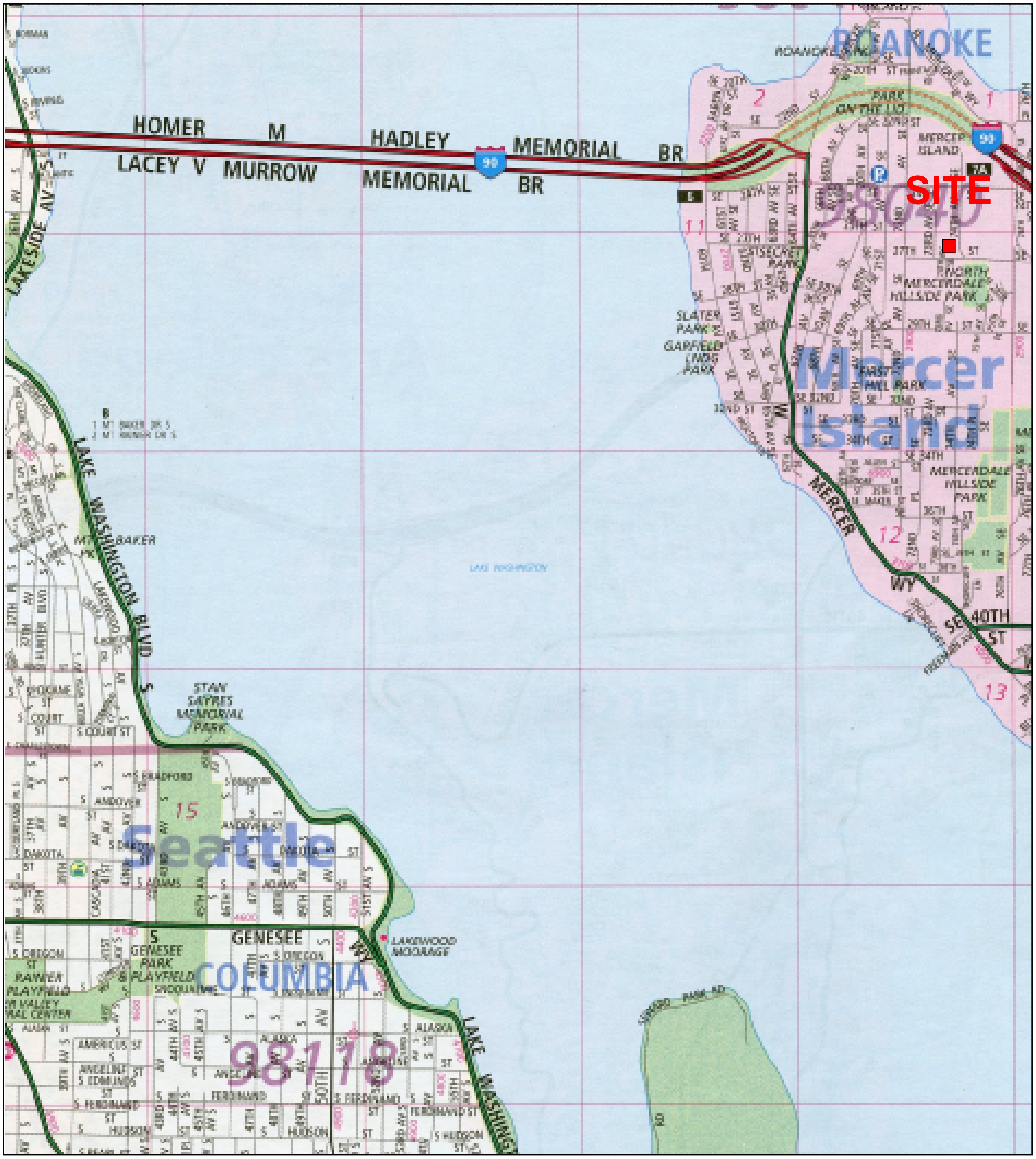
**EARTH SOLUTIONS NW, LLC**

FOR: Keven D. Hoffmann, E.I.T.
Project Engineer

RAYMOND A. COGLAS
STATE OF WASHINGTON
36018
REGISTERED
PROFESSIONAL ENGINEER
3/17/16

Raymond A. Coglas, P.E.
Principal

Attachments: Plate 1 – Vicinity Map
Plate 2 – Boring Location Plan
Plate 3 – Cross Section A-A'
Boring Logs
Laboratory Sieve Analyses
Slope/W Computer Output




Reference:
King County, Washington
Map 595
By The Thomas Guide
Rand McNally
32nd Edition

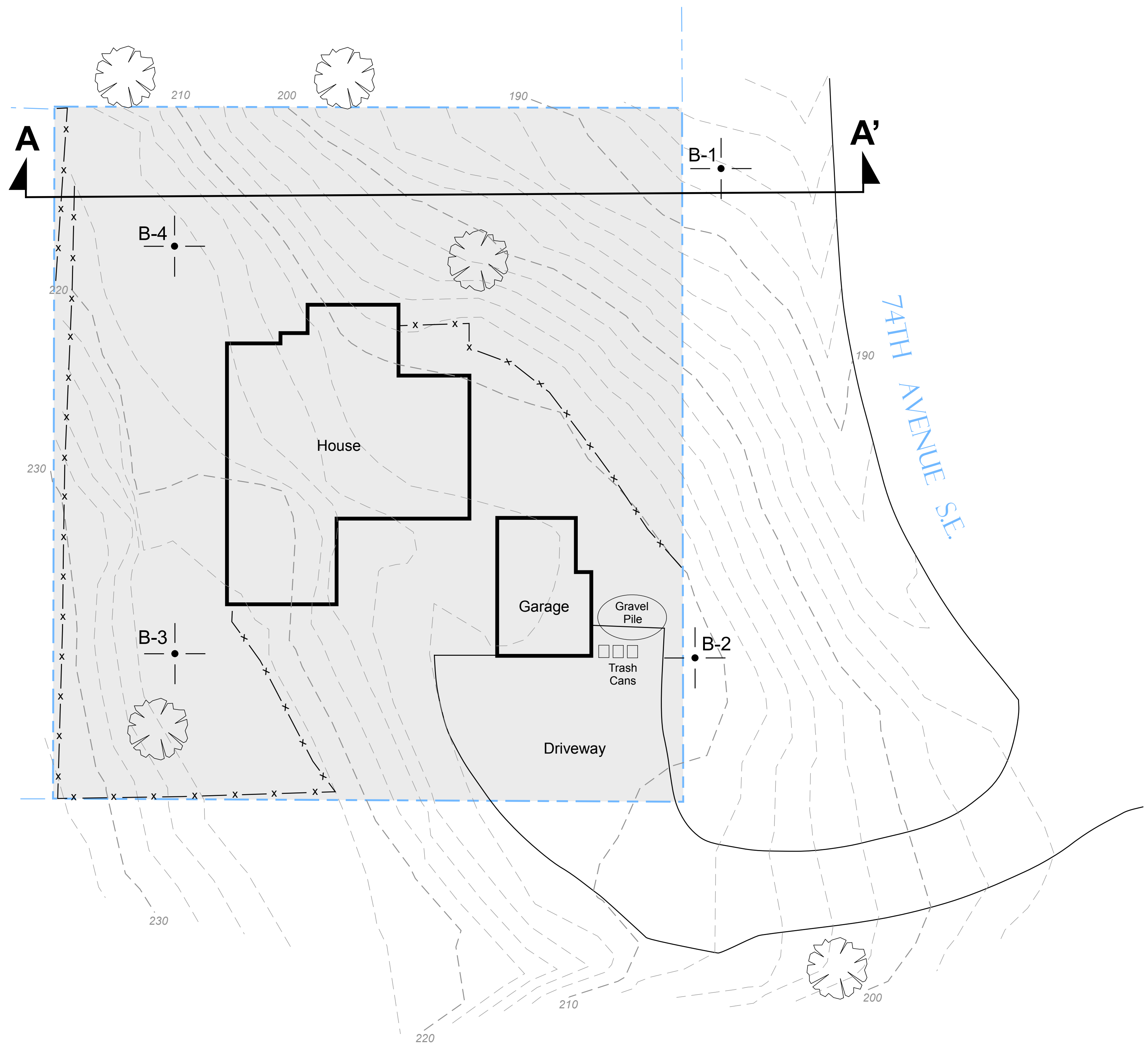
NORTH

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

Vicinity Map
Brenes Property
Mercer Island, Washington

| | | |
|---|---|---|
| Drwn. MRS | Date 03/15/2016 | Proj. No. 4316 |
| Checked KDH | Date Mar. 2016 | Plate 1 |

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.




## LEGEND

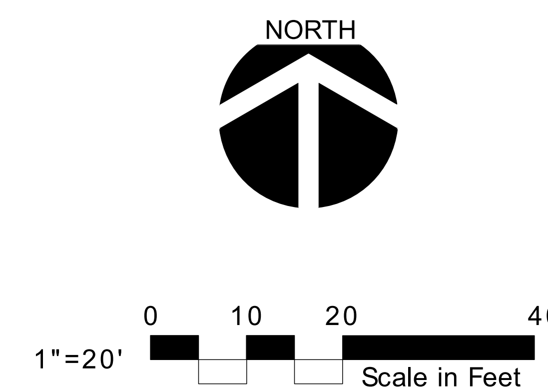
B-1 — Approximate Location of ESNW Boring, Proj. No. ES-4316, Feb. 2016

Subject Site

Existing Building

Existing Tree

Cross Section Line (See Plate 3)



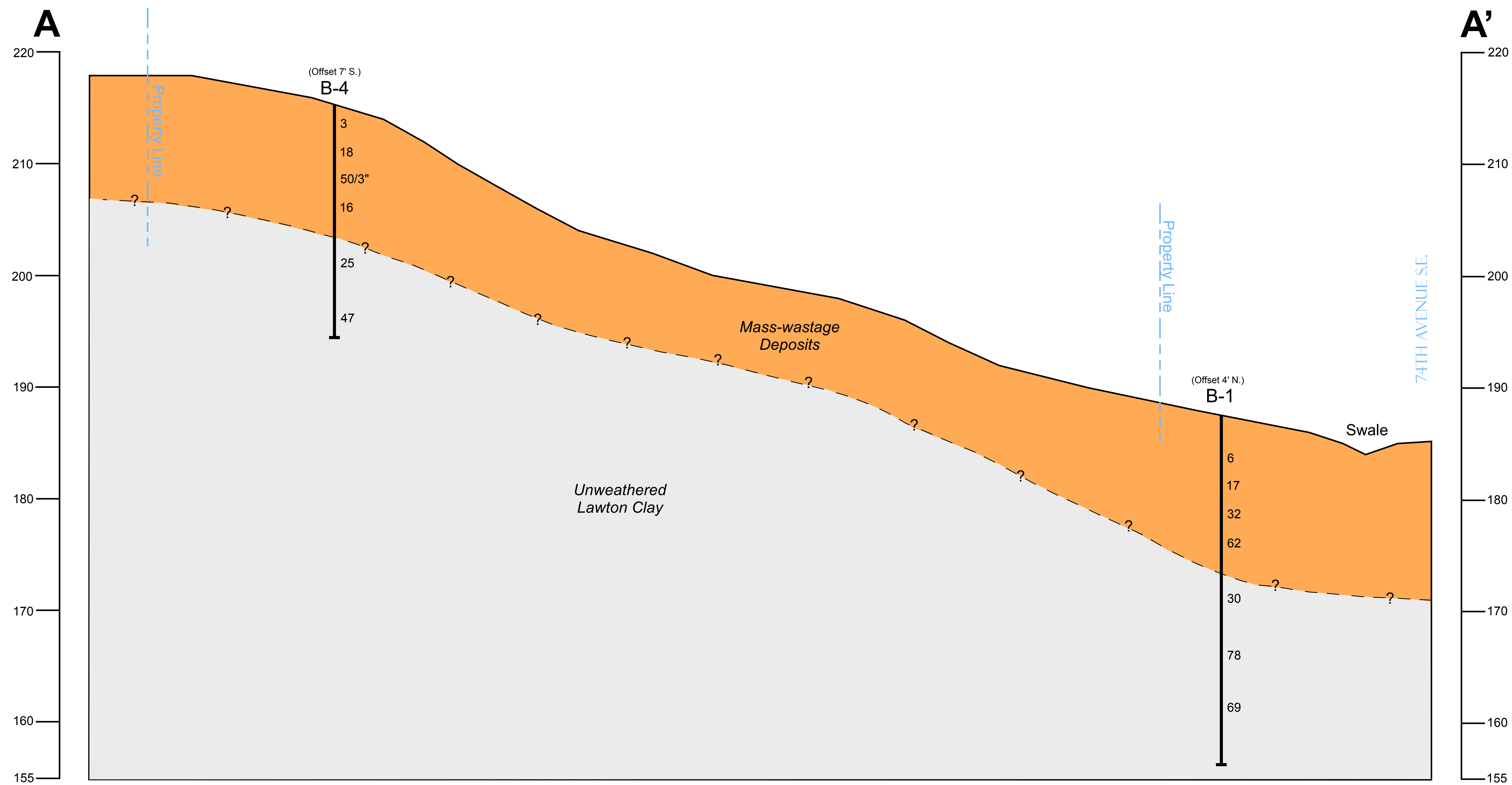

NOTE: The graphics shown on this plate are not intended for design purposes or precise scale measurements, but only to illustrate the approximate test locations relative to the approximate locations of existing and / or proposed site features. The information illustrated is largely based on data provided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

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

| | |
|---|---|
| Drwn. By | MRS |
| Checked By | KDH |
| Date | 03/15/2016 |
| Proj. No. | 4316 |
| Plate | 2 |




Horizontal 1"=10' — 0 5 10 20 Scale in Feet

Vertical 1"=10' — 0 5 10 20 Scale in Feet

NOTE: The stratification lines shown on this cross section represent the approximate boundaries between soil types. The actual transitions may be either more gradual or more severe. They are based on our interpretation of the subsurface conditions encountered at the individual test locations and our judgement and experience. ESNW cannot be responsible for the interpretation of the data by others.

NOTE: The graphics shown on this plate are not intended for design purposes or precise scale measurements, but only to illustrate the approximate test locations relative to the approximate locations of existing and / or proposed site features. The information illustrated is largely based on data provided by the client at the time of our study. ESNW cannot be responsible for subsequent design changes or interpretation of the data by others.

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

Cross Section A-A'
Brenes Property
Mercer Island, Washington

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

| | |
|---|---|
| Drwn. By | MRS |
| Checked By | KDH |
| Date | 03/16/2016 |
| Proj. No. | 4316 |
| Plate | 3 |

# Earth Solutions NW LLC

## SOIL CLASSIFICATION CHART

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

DUAL SYMBOLS are used to indicate borderline soil classifications.

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

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

# BORING NUMBER B-1



**CLIENT** Ms. Jennifer Brenes
**PROJECT NAME** Brenes Property
**PROJECT NUMBER** 4316
**PROJECT LOCATION** Mercer Island, Washington
**DATE STARTED** 2/2/16 **COMPLETED** 2/2/16
**GROUND ELEVATION** 186 ft **HOLE SIZE**
**DRILLING CONTRACTOR** Boretec1, Inc.
**GROUND WATER LEVELS:**
**DRILLING METHOD** HSA
**AT TIME OF DRILLING** ---
**LOGGED BY** KDH **CHECKED BY** KDH
**AT END OF DRILLING** ---
**NOTES** Surface Conditions: duff
**AFTER DRILLING** ---

| DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | TPSL | | Dark brown TOPSOIL |
| 1.0 | | | | | | | (185.0) Tan fat CLAY, stiff, moist<br>-trace sand interbeds |
| | SS | 72 | 2-3-5 (8) | MC = 38.80%<br>$N_{60}$=6 | CH | | -becomes very stiff |
| 5 | SS | 6 | 15-10-12 (22) | MC = 42.20%<br>$N_{60}$=17 | | | -minimal recovery<br>-water added to borehole at 6' |
| 7.5 | | | | | | | (178.5) Gray clayey SAND with gravel, dense, moist |
| | SS | 67 | 19-21-21 (42) | MC = 18.40%<br>$N_{60}$=32 | SC | | |
| 10 | SS | 78 | 19-33-50/6" | MC = 10.30%<br>$N_{60}$=62 | | | -becomes very dense |
| 14.0 | | | | | | | (172.0) Gray fay CLAY, hard, moist |
| 15 | SS | 100 | 13-16-19 (35) | MC = 32.00%<br>LL = 57<br>PL = 24<br>Fines = 98.40%<br>$N_{60}$=30 | CH | | -groundwater seepage at 15' |
| 20 | | | | | | | |

(Continued Next Page)

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



**CLIENT** Ms. Jennifer Brenes

**PROJECT NAME** Brenes Property

**PROJECT NUMBER** 4316

**PROJECT LOCATION** Mercer Island, Washington

| DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 20 | SS | 100 | 18-32-50/6" | MC = 44.50% $N_{60}$=78 | CH | | Gray fay CLAY, hard, moist *(continued)* |
| 25 | SS | 100 | 21-32-41 (73) | MC = 26.00% $N_{60}$=69 | | | -becomes sandy fat clay |
| 30 | SS | 100 | 24-38-50/5" | MC = 25.10% | | 31.4 | 154.6 |
| | | | | | | | Boring terminated at 31.4 feet below existing grade. Groundwater seepage encountered at 15.0 feet during drilling. Boring backfilled with bentonite. |
| | | | | | | | Bottom of hole at 31.4 feet. |

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

# BORING NUMBER B-2



**CLIENT** Ms. Jennifer Brenes
**PROJECT NAME** Brenes Property
**PROJECT NUMBER** 4316
**PROJECT LOCATION** Mercer Island, Washington
**DATE STARTED** 2/2/16 **COMPLETED** 2/2/16
**GROUND ELEVATION** 210 ft **HOLE SIZE**
**DRILLING CONTRACTOR** Boretec1, Inc.
**GROUND WATER LEVELS:**
**DRILLING METHOD** HSA
**AT TIME OF DRILLING** ---
**LOGGED BY** KDH **CHECKED BY** KDH
**AT END OF DRILLING** ---
**NOTES** Surface Conditions: grass
**AFTER DRILLING** ---

| DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | TPSL | 0.5 | Dark brown TOPSOIL 209.5 |
| | | | | | SC | | Brown clayey SAND, very loose, moist |
| | SS | 17 | 2-3-2 (5) | MC = 24.60% $N_{60}$=4 | | | -iron oxide staining |
| 5 | SS | 28 | 2-2-2 (4) | MC = 24.80% LL = 36 PL = 23 Fines = 44.00% $N_{60}$=3 | | | |
| | | | | | | | -becomes wet |
| | | | | | | | -groundwater seepage at 7' |
| | SS | 78 | 2-2-3 (5) | MC = 15.50% $N_{60}$=4 | | | -increased sand content |
| 10 | SS | 22 | 4-5-9 (14) | MC = 14.40% $N_{60}$=11 | | | -becomes medium dense, moist to wet |
| | | | | | | | -scattered gravel |
| | | | | | | | -hard drilling from 11' to 14' |
| | | | | | | | -becomes clayey fine sand, medium dense, moist to wet |
| 15 | SS | 83 | 10-13-17 (30) | MC = 24.20% $N_{60}$=26 | | | |
| 20 | | | | | | 20.0 | 190.0 |

*(Continued Next Page)*

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

# BORING NUMBER B-2



**CLIENT** Ms. Jennifer Brenes
**PROJECT NAME** Brenes Property
**PROJECT NUMBER** 4316
**PROJECT LOCATION** Mercer Island, Washington

| DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 20 | SS | 83 | 12-14-16 (30) | MC = 27.20% $N_{60}$=29 | SC | | Brown clayey SAND, medium dense, moist<br>-clay interbeds<br>-becomes dense |
| 25 | SS | 83 | 14-16-25 (41) | MC = 28.30% $N_{60}$=39 | | 26.5 | 183.5 |
| | | | | | | | Boring terminated at 26.5 feet below existing grade. Groundwater encountered at 7.0 feet during drilling. Boring backfilled with bentonite chips.<br>Bottom of hole at 26.5 feet. |

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# BORING NUMBER B-3



**CLIENT** Ms. Jennifer Brenes
**PROJECT NAME** Brenes Property
**PROJECT NUMBER** 4316
**PROJECT LOCATION** Mercer Island, Washington
**DATE STARTED** 2/3/16 **COMPLETED** 2/3/16
**GROUND ELEVATION** 224 ft **HOLE SIZE**
**DRILLING CONTRACTOR** Boretec1, Inc.
**GROUND WATER LEVELS:**
**DRILLING METHOD** HSA
**AT TIME OF DRILLING** ---
**LOGGED BY** KDH **CHECKED BY** KDH
**AT END OF DRILLING** ---
**NOTES** Surface Conditions: grass
**AFTER DRILLING** ---

| DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | SC | | Brown clayey SAND, very loose, moist |
| | SS | 22 | 1-1-3 (4) | MC = 19.40%<br>$N_{60}$=3 | | | -trace sand interbeds |
| 5 | SS | 67 | 8-10-11 (21) | MC = 21.40%<br>Fines = 25.90%<br>$N_{60}$=16 | | | -becomes medium dense<br>[USDA Classification: loamy fine SAND] |
| | SS | 83 | 34-40-45 (85) | MC = 19.00%<br>$N_{60}$=64 | | | -becomes very dense<br>-light groundwater seepage at 7.5'<br>-trace gravel lens |
| 10 | SS | 89 | 24-34-37 (71) | MC = 24.20%<br>$N_{60}$=53 | | | -increased poorly graded sand content<br>-becomes wet |
| 13.5 | | | | | | | 210.5 |
| | | | | | CH | | Gray fat CLAY, very stiff, moist |
| 15 | SS | 100 | 8-11-12 (23) | MC = 37.00%<br>$N_{60}$=20 | | | |
| 20 (20.0) | | | | | | | 204.0 |

*(Continued Next Page)*

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Fax: 425-449-4711

# BORING NUMBER B-3



**CLIENT** Ms. Jennifer Brenes
**PROJECT NAME** Brenes Property
**PROJECT NUMBER** 4316
**PROJECT LOCATION** Mercer Island, Washington

| DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 20 | SS | 100 | 12-17-21 (38) | MC = 27.00% $N_{60}$=32 | CH | | Gray fat CLAY, hard, moist |
| 25 | SS | 100 | 18-25-29 (54) | MC = 28.90% $N_{60}$=51 | | 26.5 | 197.5 |
| | | | | | | | Boring terminated at 26.5 feet below existing grade. Groundwater seepage encountered at 7.5 feet during drilling. Bottom of hole at 26.5 feet. |

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# BORING NUMBER B-4



**CLIENT** Ms. Jennifer Brenes
**PROJECT NAME** Brenes Property
**PROJECT NUMBER** 4316
**PROJECT LOCATION** Mercer Island, Washington
**DATE STARTED** 2/3/16 **COMPLETED** 2/3/16
**GROUND ELEVATION** 216 ft **HOLE SIZE**
**DRILLING CONTRACTOR** Boretec1, Inc.
**GROUND WATER LEVELS:**
**DRILLING METHOD** HSA
**AT TIME OF DRILLING** —
**LOGGED BY** KDH **CHECKED BY** KDH
**AT END OF DRILLING** —
**NOTES** Surface Conditions: grass
**AFTER DRILLING** —

| DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | SC | | Brown clayey SAND, very loose, moist |
| | SS | 56 | 2-2-2 (4) | MC = 25.10% $N_{60}$=3 | | | |
| 5 | SS | 67 | 4-13-11 (24) | MC = 17.30% $N_{60}$=18 | | | -becomes medium dense |
| | SS | 67 | 50/3" | MC = 24.10% | | | |
| | | | | | | | -water added to borehole at 9' |
| 10 | SS | 67 | 7-12-9 (21) | MC = 28.70% $N_{60}$=16 | | | |
| 12.5 | | | | | CH | | 203.5 Gray fat CLAY with sand, very stiff, moist |
| 15 | SS | 100 | 12-12-17 (29) | MC = 54.90% LL = 90 PL = 29 Fines = 84.90% $N_{60}$=25 | | | |
| 20 | | | | | | 20.0 | 196.0 |

*(Continued Next Page)*

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

# BORING NUMBER B-4



**CLIENT** Ms. Jennifer Brenes **PROJECT NAME** Brenes Property

**PROJECT NUMBER** 4316 **PROJECT LOCATION** Mercer Island, Washington

| DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | TESTS AND REMARKS | U.S.C.S. | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 20 | | | | | | | |
| | SS | 100 | 17-21-28 (49) | MC = 48.20% $N_{60}$=47 | CH | | Gray fay CLAY with sand, hard, moist |
| 21.5 | | | | | | | 194.5 |
| | | | | | | | Boring terminated at 21.5 feet below existing grade. No groundwater encountered during drilling.<br>Bottom of hole at 21.5 feet. |

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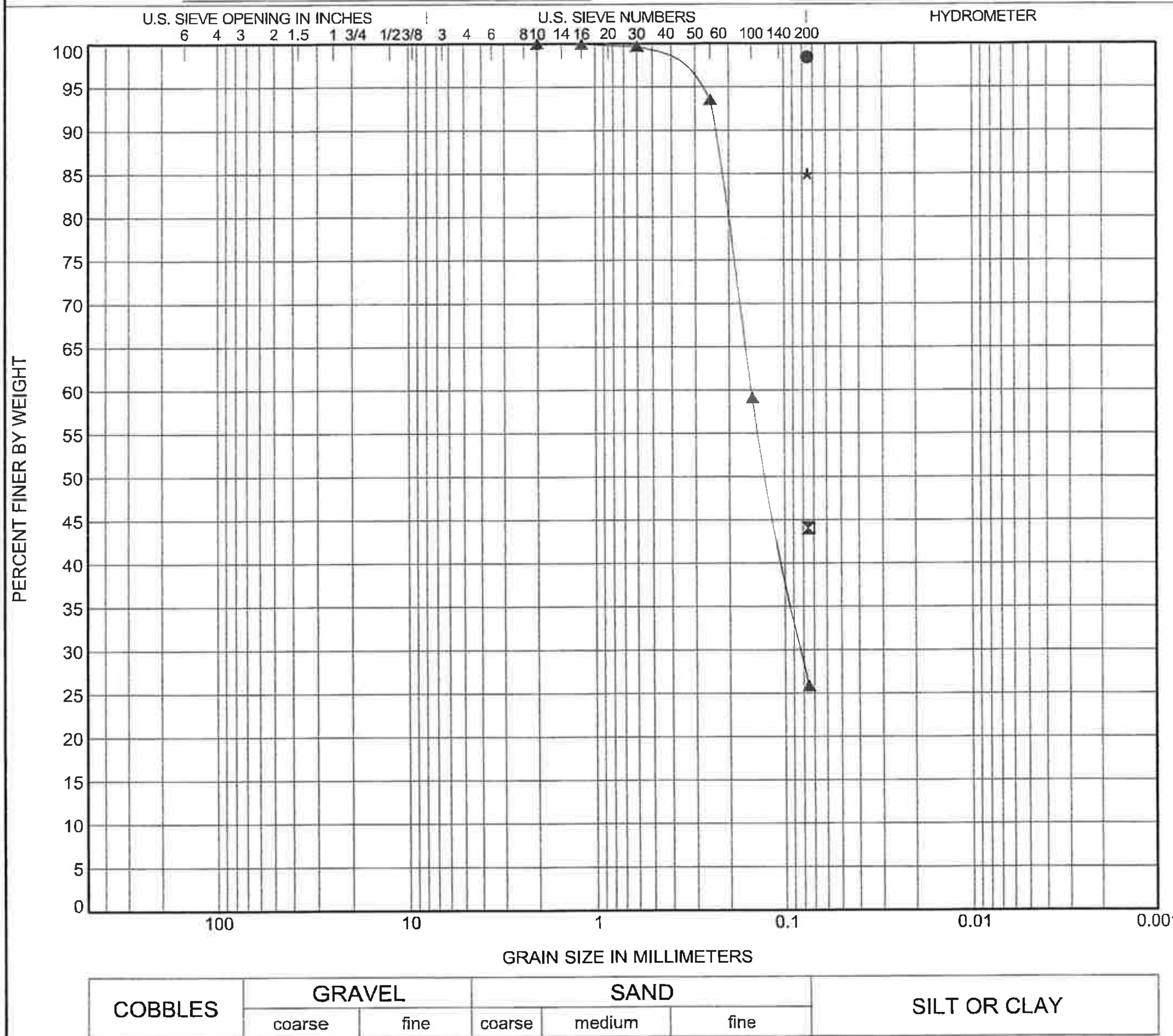
Telephone: 425-284-3300

# GRAIN SIZE DISTRIBUTION

**CLIENT** Jennifer Brenes **PROJECT NAME** Brenes Property

**PROJECT NUMBER** ES-4316 **PROJECT LOCATION** Mercer Island




| | Specimen Identification | | Classification | Cc | Cu |
|---|---|---|---|---|---|
| ● | B-1 | 15.00ft. | Gray Fat Clay, CH | | |
| ⧗ | B-2 | 5.00ft. | Brown Clayey Sand, SC | | |
| ▲ | B-3 | 5.00ft. | USDA: Brown Loamy Fine Sand. USCS: SM. | | |
| ★ | B-4 | 15.00ft. | Gray Fat Clay with Sand, CH | | |
| | | | | | |

| | Specimen Identification | | D100 | D60 | D30 | D10 | LL | PL | PI | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-1 | 15.0ft. | 0.075 | | | | 57 | 24 | 33 | 98.4 | |
| ⧗ | B-2 | 5.0ft. | 0.075 | | | | 36 | 23 | 13 | 44.0 | |
| ▲ | B-3 | 5.0ft. | 2 | 0.152 | 0.082 | | | | | 25.9 | |
| ★ | B-4 | 15.0ft. | 0.075 | | | | 90 | 29 | 61 | 84.9 | |
| | | | | | | | | | | | |

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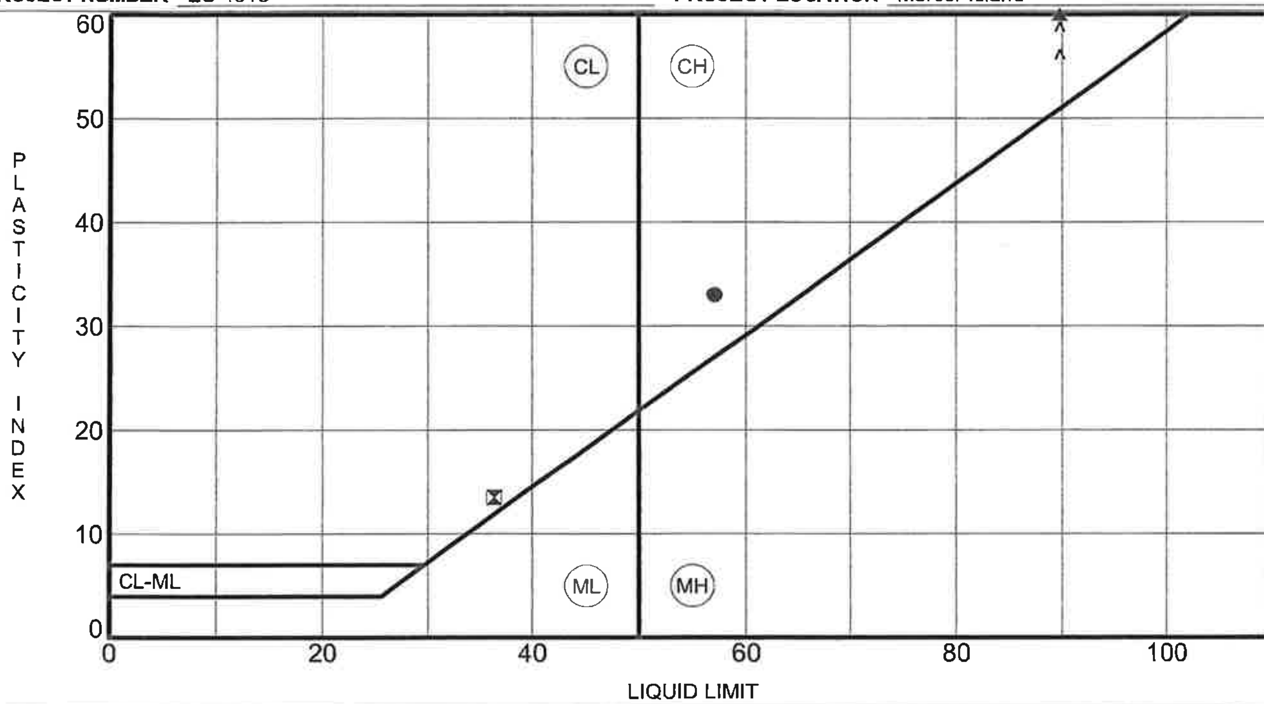
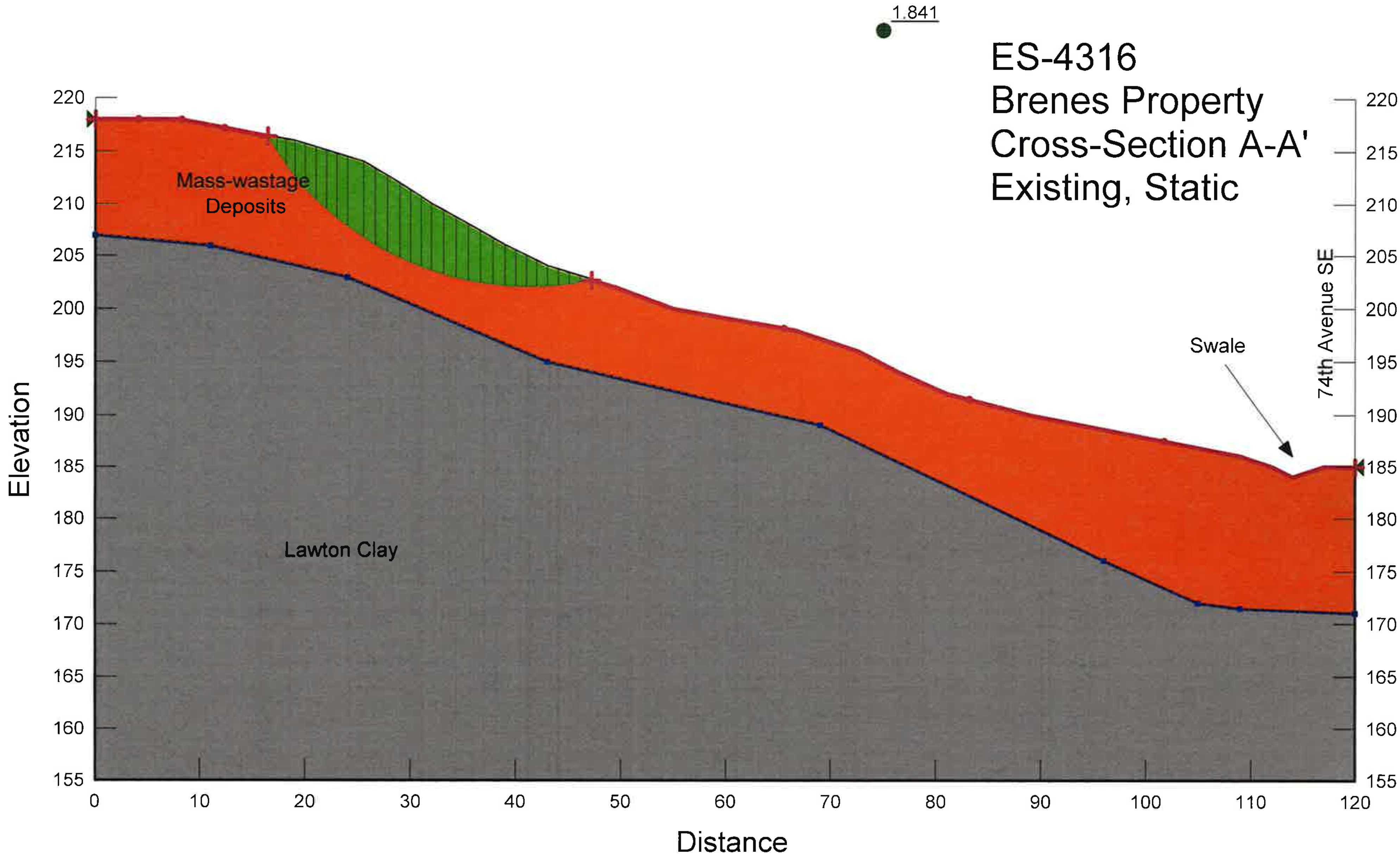
# ATTERBERG LIMITS' RESULTS

**CLIENT** Jennifer Brenes **PROJECT NAME** Brenes Property

**PROJECT NUMBER** ES-4316 **PROJECT LOCATION** Mercer Island




| | Specimen Identification | | LL | PL | PI | Fines | Classification |
|---|---|---|---|---|---|---|---|
| ● | **B-1** | **15.0** | **57** | **24** | **33** | **98.4** | **Gray Fat Clay, CH** |
| ⊠ | **B-2** | **5.0** | **36** | **23** | **13** | **44.0** | **Brown Clayey Sand, SC** |
| ▲ | **B-4** | **15.0** | **90** | **29** | **61** | **84.9** | **Gray Fat Clay with Sand, CH** |



ES-4316
Brenes Property
Cross-Section A-A'
Existing, Static
1.841
Mass-wastage
Deposits
Lawton Clay
Swale
74th Avenue SE
Elevation
Distance
220
215
210
205
200
195
190
185
180
175
170
165
160
155
0
10
20
30
40
50
60
70
80
90
100
110
120

# Existing, Static



## File Information

Title: Brenes Property
Created By: Keven Hoffmann
Revision Number: 119
Last Edited By: Keven Hoffmann
Date: 3/17/2016
Time: 9:47:25 AM
File Name: 4316.00 A-A.gsz
Directory: Y:\Keven's Inbox\Project Folders\4316\
Last Solved Date: 3/17/2016
Last Solved Time: 9:47:30 AM

## Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

## Analysis Settings

### Existing, Static

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Apply Phreatic Correction: No
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- FOS Distribution
  - FOS Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - Optimization Tolerance: 0.01
  - Minimum Slip Surface Depth: 0.1 ft

Optimization Maximum Iterations: 2000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

# Materials

## Mass-wastage Deposits

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 100 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

## Lawton Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 500 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

# Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (0, 218) ft
Left-Zone Right Coordinate: (16.4092, 216.47105) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (47.21507, 202.70305) ft
Right-Zone Right Coordinate: (120, 185) ft
Right-Zone Increment: 4
Radius Increments: 4

# Slip Surface Limits

Left Coordinate: (0, 218) ft
Right Coordinate: (120, 185) ft

# Piezometric Lines

## Piezometric Line 1

### Coordinates

| | X (ft) | Y (ft) |
|---|---|---|

| | | |
|---|---|---|
| | 0 | 207 |
| | 11 | 206 |
| | 24 | 203 |
| | 43 | 195 |
| | 69 | 189 |
| | 96 | 176 |
| | 105 | 172 |
| | 109 | 171.5 |
| | 120 | 171 |

## Regions

| | Material | Points | Area (ft²) |
|---|---|---|---|
| Region 1 | Lawton Clay | 23,33,32,31,30,29,28,27,26,25,24 | 4167.25 |
| Region 2 | Mass-wastage Deposits | 22,23,24,25,26,27,28,29,30,31,21,19,18,20,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1 | 1281.75 |

## Points

| | X (ft) | Y (ft) |
|---|---|---|
| Point 1 | 8 | 218 |
| Point 2 | 19 | 216 |
| Point 3 | 25.5 | 214 |
| Point 4 | 29 | 212 |
| Point 5 | 32 | 210 |
| Point 6 | 35.5 | 208 |
| Point 7 | 39 | 206 |
| Point 8 | 43 | 204 |
| Point 9 | 49.5 | 202 |
| Point 10 | 55 | 200 |
| Point 11 | 66.5 | 198 |
| Point 12 | 72.5 | 196 |
| Point 13 | 76.5 | 194 |
| Point 14 | 81 | 192 |
| Point 15 | 89 | 190 |
| Point 16 | 99 | 188 |
| Point 17 | 109 | 186 |
| Point 18 | 114 | 184 |
| Point 19 | 117 | 185 |
| Point 20 | 112 | 185 |
| Point 21 | 120 | 185 |
| Point 22 | 0 | 218 |
| Point 23 | 0 | 207 |
| Point 24 | 11 | 206 |
| Point 25 | 24 | 203 |
| Point 26 | 43 | 195 |
| Point 27 | 69 | 189 |
| Point 28 | 96 | 176 |
| Point 29 | 105 | 172 |
| | | |

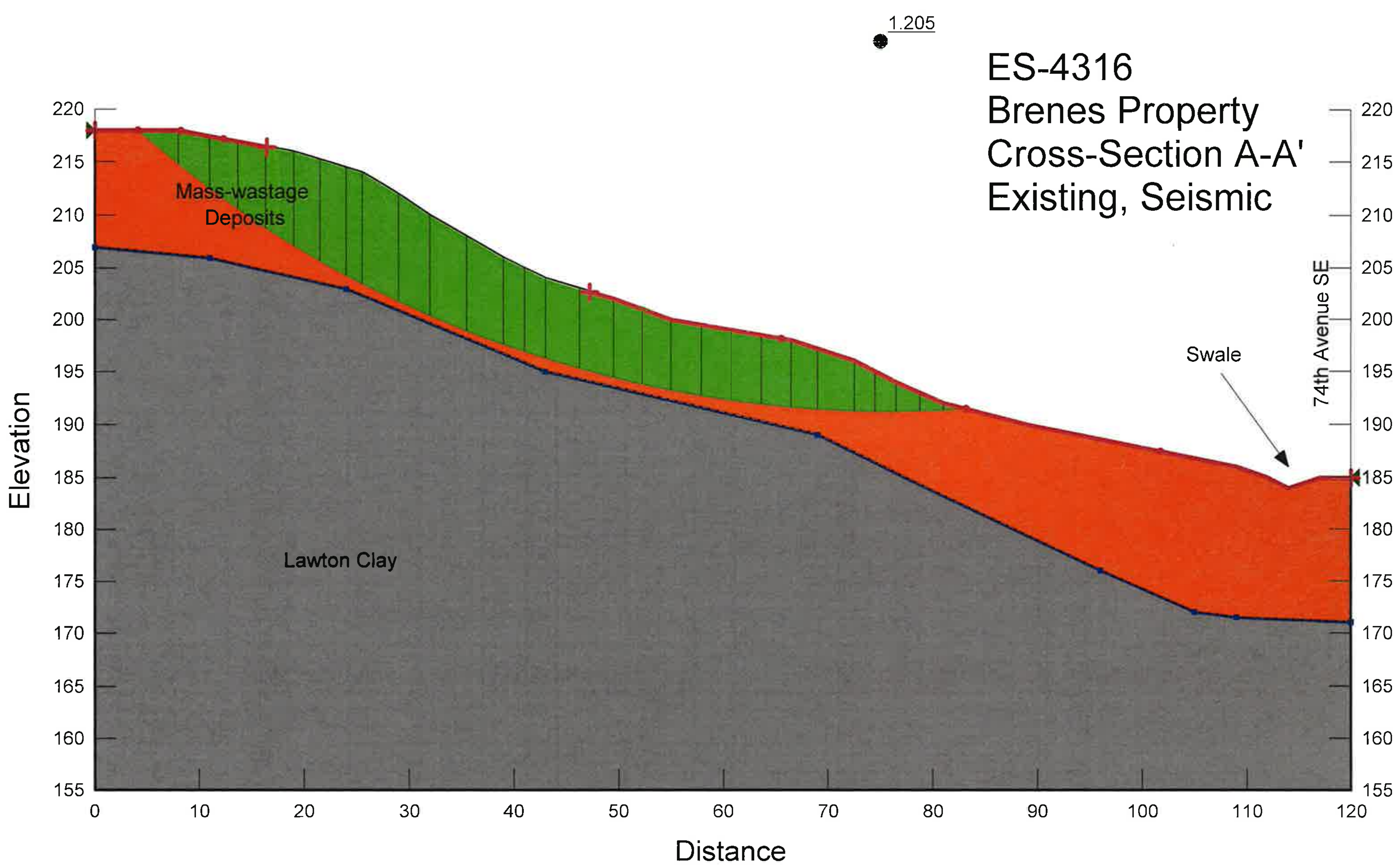
| | | |
|---|---|---|
| Point 30 | 109 | 171.5 |
| Point 31 | 120 | 171 |
| Point 32 | 120 | 155 |
| Point 33 | 0 | 155 |

# Critical Slip Surfaces

| | Slip Surface | FOS | Center (ft) | Radius (ft) | Entry (ft) | Exit (ft) |
|---|---|---|---|---|---|---|
| 1 | 103 | 1.841 | (41.313, 230.846) | 28.755 | (16.4092, 216.471) | (47.2151, 202.703) |

## Slices of Slip Surface: 103

| | Slip Surface | X (ft) | Y (ft) | PWP (psf) | Base Normal Stress (psf) | Frictional Strength (psf) | Cohesive Strength (psf) |
|---|---|---|---|---|---|---|---|
| 1 | 103 | 16.841 | 215.77015 | -693.75529 | -7.4598584 | -3.9664771 | 100 |
| 2 | 103 | 17.7046 | 214.4475 | -623.66729 | 94.977263 | 50.500307 | 100 |
| 3 | 103 | 18.5682 | 213.2671 | -562.45158 | 183.43122 | 97.532107 | 100 |
| 4 | 103 | 19.5 | 212.12575 | -504.64535 | 261.91881 | 139.2647 | 100 |
| 5 | 103 | 20.5 | 211.01825 | -449.93761 | 332.21801 | 176.64345 | 100 |
| 6 | 103 | 21.5 | 210.01775 | -401.9061 | 395.29111 | 210.18001 | 100 |
| 7 | 103 | 22.5 | 209.10935 | -359.62427 | 453.15592 | 240.94728 | 100 |
| 8 | 103 | 23.5 | 208.2819 | -322.39227 | 507.31161 | 269.74237 | 100 |
| 9 | 103 | 24.75 | 207.3583 | -291.65922 | 570.59141 | 303.38884 | 100 |
| 10 | 103 | 26.083335 | 206.465 | -270.95381 | 622.60057 | 331.04259 | 100 |
| 11 | 103 | 27.25 | 205.7734 | -258.45094 | 648.88589 | 345.01875 | 100 |
| 12 | 103 | 28.416665 | 205.1534 | -250.41405 | 672.03259 | 357.32607 | 100 |
| 13 | 103 | 29.5 | 204.63525 | -246.54587 | 685.68433 | 364.58483 | 100 |
| 14 | 103 | 30.5 | 204.2069 | -246.0887 | 689.22256 | 366.46613 | 100 |
| 15 | 103 | 31.5 | 203.82235 | -248.37084 | 688.2365 | 365.94184 | 100 |
| 16 | 103 | 32.583335 | 203.4549 | -253.90204 | 686.90751 | 365.2352 | 100 |
| 17 | 103 | 33.75 | 203.1099 | -263.02776 | 683.43224 | 363.38737 | 100 |
| 18 | 103 | 34.916665 | 202.8177 | -275.44931 | 670.48952 | 356.5056 | 100 |
| 19 | 103 | 36.083335 | 202.57665 | -291.05814 | 646.55986 | 343.78198 | 100 |
| 20 | 103 | 37.25 | 202.38545 | -309.77619 | 610.35421 | 324.53109 | 100 |
| 21 | 103 | 38.416665 | 202.2431 | -331.55301 | 560.9513 | 298.26309 | 100 |
| 22 | 103 | 39.5 | 202.1524 | -354.35307 | 507.70712 | 269.95267 | 100 |
| 23 | 103 | 40.5 | 202.1067 | -377.76889 | 453.17873 | 240.9594 | 100 |
| 24 | 103 | 41.5 | 202.09585 | -403.37153 | 389.62182 | 207.1656 | 100 |
| 25 | 103 | 42.5 | 202.11975 | -431.13224 | 317.91882 | 169.04043 | 100 |
| 26 | 103 | 43.526885 | 202.1811 | -455.68859 | 250.22093 | 133.04483 | 100 |
| 27 | 103 | 44.580655 | 202.28205 | -477.1553 | 187.40572 | 99.645387 | 100 |
| 28 | 103 | 45.63442 | 202.4224 | -501.08971 | 119.56351 | 63.573048 | 100 |
| 29 | 103 | 46.688185 | 202.6028 | -527.51887 | 48.225849 | 25.642139 | 100 |


1.205
ES-4316
Brenes Property
Cross-Section A-A'
Existing, Seismic
Mass-wastage
Deposits
Lawton Clay
Swale
74th Avenue SE
Elevation
Distance
220
215
210
205
200
195
190
185
180
175
170
165
160
155
0
10
20
30
40
50
60
70
80
90
100
110
120

# Existing, Seismic



## File Information

Title: Brenes Property
Created By: Keven Hoffmann
Revision Number: 119
Last Edited By: Keven Hoffmann
Date: 3/17/2016
Time: 9:47:25 AM
File Name: 4316.00 A-A.gsz
Directory: Y:\Keven's Inbox\Project Folders\4316\
Last Solved Date: 3/17/2016
Last Solved Time: 9:47:29 AM

## Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

## Analysis Settings

### Existing, Seismic

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Apply Phreatic Correction: No
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- FOS Distribution
  - FOS Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - Optimization Tolerance: 0.01
  - Minimum Slip Surface Depth: 0.1 ft

Optimization Maximum Iterations: 2000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

# Materials

## Mass-wastage Deposits

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 100 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

## Lawton Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 500 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

# Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (0, 218) ft
Left-Zone Right Coordinate: (16.4092, 216.47105) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (47.21507, 202.70305) ft
Right-Zone Right Coordinate: (120, 185) ft
Right-Zone Increment: 4
Radius Increments: 4

# Slip Surface Limits

Left Coordinate: (0, 218) ft
Right Coordinate: (120, 185) ft

# Piezometric Lines

## Piezometric Line 1

### Coordinates

| | X (ft) | Y (ft) |
|---|---|---|

| | | |
|---|---|---|
| | 0 | 207 |
| | 11 | 206 |
| | 24 | 203 |
| | 43 | 195 |
| | 69 | 189 |
| | 96 | 176 |
| | 105 | 172 |
| | 109 | 171.5 |
| | 120 | 171 |

# Seismic Loads

Horz Seismic Load: 0.2091

Ignore seismic load in strength: No

# Regions

| | Material | Points | Area ($ft^2$) |
|---|---|---|---|
| Region 1 | Lawton Clay | 23,33,32,31,30,29,28,27,26,25,24 | 4167.25 |
| Region 2 | Mass-wastage Deposits | 22,23,24,25,26,27,28,29,30,31,21,19,18,20,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1 | 1281.75 |

# Points

| | X (ft) | Y (ft) |
|---|---|---|
| Point 1 | 8 | 218 |
| Point 2 | 19 | 216 |
| Point 3 | 25.5 | 214 |
| Point 4 | 29 | 212 |
| Point 5 | 32 | 210 |
| Point 6 | 35.5 | 208 |
| Point 7 | 39 | 206 |
| Point 8 | 43 | 204 |
| Point 9 | 49.5 | 202 |
| Point 10 | 55 | 200 |
| Point 11 | 66.5 | 198 |
| Point 12 | 72.5 | 196 |
| Point 13 | 76.5 | 194 |
| Point 14 | 81 | 192 |
| Point 15 | 89 | 190 |
| Point 16 | 99 | 188 |
| Point 17 | 109 | 186 |
| Point 18 | 114 | 184 |
| Point 19 | 117 | 185 |
| Point 20 | 112 | 185 |
| Point 21 | 120 | 185 |
| Point 22 | 0 | 218 |
| Point 23 | 0 | 207 |
| Point 24 | 11 | 206 |
| | | |

| | | |
|---|---|---|
| Point 25 | 24 | 203 |
| Point 26 | 43 | 195 |
| Point 27 | 69 | 189 |
| Point 28 | 96 | 176 |
| Point 29 | 105 | 172 |
| Point 30 | 109 | 171.5 |
| Point 31 | 120 | 171 |
| Point 32 | 120 | 155 |
| Point 33 | 0 | 155 |

# Critical Slip Surfaces

| | Slip Surface | FOS | Center (ft) | Radius (ft) | Entry (ft) | Exit (ft) |
|---|---|---|---|---|---|---|
| 1 | 37 | 1.205 | (75.933, 300.787) | 109.583 | (4.13677, 218) | (83.2149, 191.446) |

## Slices of Slip Surface: 37

| | Slip Surface | X (ft) | Y (ft) | PWP (psf) | Base Normal Stress (psf) | Frictional Strength (psf) | Cohesive Strength (psf) |
|---|---|---|---|---|---|---|---|
| 1 | 37 | 6.068383 | 216.4008 | -621.02377 | 90.747988 | 48.251561 | 100 |
| 2 | 37 | 9.5 | 213.6579 | -469.33672 | 303.48109 | 161.36376 | 100 |
| 3 | 37 | 12.333335 | 211.56375 | -366.37363 | 432.88153 | 230.16719 | 100 |
| 4 | 37 | 15 | 209.72115 | -289.80042 | 542.1447 | 288.26345 | 100 |
| 5 | 37 | 17.666665 | 207.9918 | -220.28912 | 642.79047 | 341.77776 | 100 |
| 6 | 37 | 20.25 | 206.41705 | -159.22443 | 721.55516 | 383.65768 | 100 |
| 7 | 37 | 22.75 | 204.9856 | -105.90014 | 780.6205 | 415.06328 | 100 |
| 8 | 37 | 24.75 | 203.8955 | -75.58243 | 826.85599 | 439.64713 | 100 |
| 9 | 37 | 27.25 | 202.6313 | -62.382818 | 842.44448 | 447.93568 | 100 |
| 10 | 37 | 30.5 | 201.07985 | -50.962018 | 827.44651 | 439.96111 | 100 |
| 11 | 37 | 33.75 | 199.66635 | -48.147219 | 807.68351 | 429.45294 | 100 |
| 12 | 37 | 37.25 | 198.27595 | -53.34538 | 794.27304 | 422.32247 | 100 |
| 13 | 37 | 40 | 197.26845 | -62.728353 | 785.33252 | 417.56871 | 100 |
| 14 | 37 | 42 | 196.59565 | -73.295756 | 782.63912 | 416.1366 | 100 |
| 15 | 37 | 44.625 | 195.78545 | -72.409731 | 803.17981 | 427.05828 | 100 |
| 16 | 37 | 47.875 | 194.8704 | -62.115866 | 844.263 | 448.9026 | 100 |
| 17 | 37 | 50.875 | 194.1169 | -58.296694 | 863.33482 | 459.04327 | 100 |
| 18 | 37 | 53.625 | 193.508 | -59.900428 | 858.72115 | 456.59013 | 100 |
| 19 | 37 | 56.4375 | 192.9622 | -66.339975 | 869.48426 | 462.31298 | 100 |
| 20 | 37 | 59.3125 | 192.48165 | -77.754098 | 895.01787 | 475.88944 | 100 |
| 21 | 37 | 62.1875 | 192.07925 | -94.047641 | 903.27697 | 480.28088 | 100 |
| 22 | 37 | 65.0625 | 191.7542 | -115.16121 | 892.68718 | 474.65019 | 100 |
| 23 | 37 | 67.75 | 191.51725 | -139.07852 | 841.04474 | 447.19142 | 100 |
| 24 | 37 | 70.75 | 191.34075 | -198.64021 | 730.46697 | 388.39617 | 100 |
| 25 | 37 | 73.5 | 191.2357 | -274.70728 | 593.9036 | 315.78415 | 100 |
| 26 | 37 | 75.5 | 191.2095 | -333.16233 | 459.18133 | 244.15104 | 100 |
| 27 | 37 | 77.625 | 191.2229 | -397.8415 | 318.44207 | 169.31865 | 100 |
| 28 | 37 | 79.875 | 191.2808 | -469.07403 | 172.78589 | 91.871887 | 100 |
| 29 | 37 | 82.10746 | 191.3838 | -542.5417 | 52.342923 | 27.831226 | 100 |