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Updated Geotechnical Engineering Report
Briggs Village
Proposed Residential Development
xxx – Eagle Bend Drive SE
Olympia, Washington
PN: 37030000015
Doc ID: SCJAlliance.BriggsWestKettle.RG

INTRODUCTION

This updated geotechnical report summarizes our site observations, subsurface explorations, laboratory testing and engineering analyses and provides geotechnical recommendations and design criteria for the proposed residential development to be located on the east side of the Briggs Village community in Olympia, Washington. The site is currently undeveloped. We previously completed *Geotechnical Engineering Report* for the Briggs Village development dated July 9, 2005 that was approved by the City. Because of the time between our original report and the current proposed development, the city has requested an update to our original report. The general location of the site is shown on the attached Site Vicinity Map, Figure 1. The proposed development includes the area west of the central and southern kettles, as shown on the site vicinity map, Figure 2a.

Our understanding of the project is based on our discussions with you, a review of the preliminary plans provided by you, our subsurface explorations, our original May 23, 2005 site visit and recent July 5, 2017 site visit, our understanding of the City of Olympia development codes, and our experience in the project area since 2005. We understand that the proposed development will include the construction of 46 residential lots on the site with paved roadways, and associated utilities. We anticipate the new residences will consist of conventional wood-framed structures supported on conventional spread footings, with associated utilities and driveways. The existing site configuration is illustrated on the attached Site & Exploration Plan, Figure 2b.

SCOPE

The purpose of our services is to evaluate the surface and subsurface conditions across the site as a basis for providing geotechnical recommendations and design criteria for the proposed development as well as the stability of the slope below the proposed residences. Specifically, the scope of services for this project will include the following:

1. Reviewing the available geological, hydrogeological and geotechnical literature for the site area including our 2005 test pit logs;
2. Exploring subsurface conditions across the site by drilling 2 hollow stem auger borings at select locations across the site to depths of 50 feet, and excavating 3 hand augers on the slope below the proposed development;
3. Describing surface and subsurface conditions, including soil type, depth to groundwater, and estimate high groundwater;
4. Addressing the City of Olympia Critical Areas Ordinance in accordance with Title 18.32 of the City of Olympia Municipal Code (COMC) including a slope stability analysis;
5. Performing a slope stability analysis and providing building setbacks, as are determined to be appropriate;
6. Updating our 2005 Report to the current guidelines and site development codes; and
7. Preparing a written Geotechnical Engineering Report summarizing our site observations and conclusions, and our geotechnical recommendations and design criteria, along with the supporting data.

The above scope of work was summarized in our *Proposal for Geotechnical Engineering Services* dated June 23, 2017. We received written authorization to proceed on June 25, 2017.

SITE CONDITIONS

Surface Conditions

The site is located at xxx - Eagle Bend Drive SE (PN: 37030000015) in the City of Olympia, Washington, within an area of existing residential development. The site consists of a flagpole lot. The body of the site is irregular in shape, measures about 600 to 1115 feet deep (east to west) by about 460 to 905 feet wide (north to south); while the flagpole portion of the site measures about 230 feet long (east to west) by about 35 feet wide (north to south), and extends to the east from the southeastern corner of the body of the site. The entire site encompasses approximately 20.15 acres. The proposed development will occur on the western portion of the site. The site is currently undeveloped, is bounded by Briggs Drive Southeast and existing residential development to the east, by Yelm Highway Southeast to the south, by existing residential development to the north, east, and west.

The site is situated in an area of relatively flat to gently sloping terrain with scattered kettles. Kettles are depressions or potholes where sediment from the reseating ice-mass encompassed a large remnant piece of ice. The ice eventually melts, leaving a depression. The western portion of the site is generally flat, with an inclination of approximately 1 to 3 percent. There is a localized slope at the southwestern corner of the site with an approximately 70 percent slope. The vertical relief of the localized slopes is on the order of 10 feet. The kettle is located at the eastern portion of the site, with sidewalls of approximately 25 to 50 percent slopes. Standing water was observed in the kettle at the time of our site visit. No springs or seeps were observed on the face of the slopes at the time of our site visit. Total topography relief across the site is on the order of 82 feet. The existing site configuration and topography is shown on the Site and Exploration Plan, included as Figure 2b.

Vegetation varies across the site. The western portion of the site generally consists of tall grasses, scattered coniferous and deciduous trees with a moderate of native and invasive plants; while vegetation around the kettle generally consists of moderate to dense stand of coniferous and deciduous trees with a dense understory of native and invasive groundcover and shrubs. No evidence of erosion or slope instability was observed at the time of our site visit.

Site Soils

The USDA Natural Resource Conservation Service (NRCS) Web Soil Survey maps the lower, bottom at the kettle as being underlain by Mukiteo muck (69), while the flatten uplands and kettle clopes are mapped as being underlain by Yelm fine sandy loam (126 & 127) soils. The Mukiteo soils are typically derived from herbaceous organic material, form on slopes of 0 to 2 percent, have "none" erosion hazard, and are included in hydrologic soils group B/D. The Yelm soils are typically derived from glacial outwash, have a "slight" erosion hazard when exposed, and are included in hydrologic soils group B. The Yelm (126) and Yelm (127) soils form on slopes of 0 to 3 percent and slopes of 3 to 15 percent, respectively. A copy of the SCS soils map for the site area is included as Figure 3.

Site Geology

According to the *Geologic Map of the Tumwater 7.5-minute Quadrangle, Thurston County, Washington* (Walsh, Logan, Schasse, and Polenz) maps the site is being underlain by latest vashon recessional sand and minor silt (Qgos), also called as recessional outwash. These glacial soils were deposited during the most recent Vashon Stade of the Fraser Glaciation, about 12,000 to 15,000 years ago. The recessional outwash typically consists of poorly stratified sand and gravel with occasional lenses of silt that was deposited by meltwater streams emanating from the retreating continental ice mass. These soils are considered to be normally consolidated and generally have moderate strength and compressibility characteristics. No areas of landslide deposits or mass wasting are noted on the referenced map within the immediate vicinity of the site. An excerpt of the above reference geologic map is attached as Figure 4.

Subsurface Explorations

On July 5, 2017, a field engineer from GeoResources visited the site and explored the subsurface conditions onsite by monitoring the drilling of two hollow stem auger borings to depths of 51.5 feet below the existing ground surface, and by monitoring the excavation of three hand auger explorations to depths of 8.5 to 10 feet below the existing ground surface. The borings were drilled by a licensed driller operating a small track-mounted drill rig under contract to GeoResources, LLC. In the spring of 2005, GeoResources excavated a total of 47 test pits on the Briggs Village site as part of the original *Geotechnical Engineering Report* for the development. Nine of the test pits (TP-1 through TP-8, TP-11) were excavated on the area west of the central and southern kettle.

The specific number, locations, and depths of our explorations were selected by GeoResources personnel based on the configuration of the proposed development and were adjusted in the field based on site access limitations. A field representative form our office continuously monitored the explorations, maintained logs of the subsurface conditions encountered, obtained representative soil samples, and observed pertinent site features.

Representative soil samples obtained from the explorations were placed in sealed plastic bags and taken to a laboratory for further examination and testing as deemed necessary. Each boring was then backfilled with bentonite chips and abandoned. Each hand auger holes was then backfilled with the excavated soils.

During drilling, soil samples were obtained at 2½- and 5-foot depth intervals in accordance with Standard Penetration Test (SPT) as per the test method outlined by ASTM: D-1586. The SPT method consists of driving a standard 2-inch-diameter split-spoon sampler 18-inches into the soil with a 140-pound hammer. The number of blows required to drive the sampler through each 6-inch interval is counted, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or "SPT blow count". The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils.

The subsurface explorations excavated as part of this evaluation indicate the subsurface conditions at specific locations only, as actual subsurface conditions can vary across the site. Furthermore, the nature and extent of such variation would not become evident until additional explorations are performed or until construction activities have begun. Based on our experience in the area and extent of prior explorations in the area, it is our opinion that the soils encountered in the explorations are generally representative of the soils at the site. The soils encountered were visually classified in accordance with the Unified Soil Classification System (USCS) and ASTM D: 2488. The USCS is included in Appendix A as Figure A-1. The approximate locations of our borings and hand auger explorations are indicated on the attached Site and Exploration Plan, Figure 2, while the descriptive logs of our borings and hand auger explorations are included in Appendix A. Table 1, below, summarizes the approximate functional locations, surface elevations, and termination depths of our borings and hand auger explorations.

TABLE 1:
APPROXIMATE LOCATIONS, ELEVATIONS, AND DEPTHS OF EXPLORATIONS

Boring and Hand Auger Number	Functional Location	Surface Elevation[1] (feet)	Termination Depth (feet)	Termination Elevation[1] (feet)
B-1	Top of slope (profile A-A')	191	51½	139½
B-2	Top of slope (profile B-B')	194	51½	142½
HA-1	Middle of slope (profile A-A')	165	10	155
HA-2	Middle of slope (profile A-A')	147	9	138
HA-3	Middle of slope (profile B-B')	151	8½	142½
TP-1	Proposed Roadway C (lot 21)	190	5	185
TP-2	Proposed Roadway B (lot 17)	190	8	182
TP-3	Proposed Roadway A (lot 12)	189	4	185
TP-4	Proposed lot 24	189	7	182
TP-5	Proposed Roadway A (lot 8)	190	4	186
TP-6	Proposed Roadway A (lot 4)	180	8	182
TP-7	Proposed Roadway C (lot 30)	189	10	179
TP-8	Proposed Roadway C (lot 33)	189	6	183
TP-11	Proposed Roadway C	185	5	180

Notes: 1 = Elevation datum: Preliminary site plan prepared by SCJ Alliance, dated June 28, 2017

Subsurface Conditions

The subsurface conditions encountered in our 2005 test pits varied slightly across the site but generally confirmed the mapped geologic stratigraphy. The unstripped portions of the site had ½ to 1 foot of topsoil mantling loose fine to medium sand with varying amounts of silt. These surficial soils were generally underlain by a loose to medium dense fine to medium sand with varying amounts of silt. We noted that this sand would occasionally grade from medium coarse sand to fine sandy silty at depth. This sand was encountered to the full depth explored in our test pits and is generally consistent with the mapped description of the recessional outwash sand with minor silt.

Our recent borings encountered fairly uniform subsurface conditions. In general, our borings encountered about 20 feet of tan fine sandy silt in a loose, moist to saturated condition mantling grey coarse sand with gravel in a loose to medium dense, moist condition to the full depth explored. We interpret both the shallow and deeper soils to be recessional outwash deposits. Hand augers HA-1, HA-2 and HA-3 encountered about 1.0 to 1.5 feet of dark brown forest duff/top soil mantling about 2.0 to 3.5 feet of brown to tan fine sandy silt in a loose, moist condition. These surficial soils were underlain by tan fine sandy silt in a loose, moist condition to the full depth explored. Table 2 summarizes the approximate thicknesses, depths, and elevations of selected soil layers.

TABLE 2:
APPROXIMATE THICKNESS, DEPTHS, AND ELEVATION OF SOIL TYPES ENCOUNTERED IN EXPLORATIONS

Boring Number	Thickness of Topsoil (feet)	Thickness of Fine Sandy Silt/Silty Sand (feet)	Depth to Top of Coarse Sand (feet)	Elevation[1] of Top of Coarse Sand (feet)
B-1	-	20	20	171
B-2	-	20	20	174
HA-1	1½	8½	-	-
HA-2	½	8	-	-
HA-3	½	8½	-	-
TP-1	1	4	-	-
TP-2	½	7½	-	-
TP-3	½	3½	-	-
TP-4	½	6½	-	-
TP-5	½	3½	-	-
TP-6	½	7½	-	-
TP-7	1	9½	-	-
TP-8	½	5½	-	-
TP-11	1*	4½	-	-

Notes: 1 = Elevation datum: Preliminary site plan prepared by SCJ Alliance, dated June 28, 2017
* = Thickness of fill (feet)

Laboratory Testing

Geotechnical laboratory tests were performed on select samples retrieved from the borings to determine soil index and engineering properties encountered. Laboratory testing included visual soil classification per ASTM D: 2488, moisture content determinations per ASTM D: 2216, and grain size analyses per ASTM D: 422 standard procedures. The results of the laboratory tests are included in Appendix B, and summarized below in Table 3.

TABLE 3
LABORATORY TEST RESULTS

Sample	Soil Type	Lab ID Number	Gravel Content (percent)	Sand Content (percent)	Silt/Clay Content (percent)	D10 Ratio (mm)
B-1, 40'	Outwash	092801	2.0	93.1	4.9	0.1919
B-2, 5'	Outwash	092803	0.0	39.2	60.8	ND
B-2, 12½'	Outwash	092802	0.0	2.5	97.5	ND
TP-1, 3-5'	Outwash	SP-1	1.4	52.0	46.6	ND
TP-2, 4-6'	Outwash	SP-2	-	78.8	21.2	ND
TP-3, ½-2'	Outwash	SP-3	-	77.1	22.9	ND
TP-4, 5-7'	Outwash	SP-4	-	29.4	70.6	ND
TP-5, 2-4'	Outwash	SP-5	-	93.5	6.5	0.0972
TP-6, 5-8'	Outwash	SP-6	-	92.2	7.8	0.0832
TP-7, 8-10'	Outwash	SP-7	-	13.2	86.8	ND
TP-8, 4-6'	Outwash	SP-8	-	7.4	92.6	ND
TP-11, 2½-5 '	Outwash	SP-11	-	41.1	58.9	ND
ND = Not determined						

Groundwater Conditions

Evidence of groundwater was observed at in all of our borings B-1 and B-2 at the time of drilling. In 2005, no groundwater seepage was encountered in test pits TP-1 through TP-8 and TP-11 at the time of excavation. Perched groundwater typically develops when the vertical infiltration of precipitation through a more permeable soil is slowed at depth by a deeper, less permeable soil type. No groundwater seepage was observed in our hand augers HA-1, HA-2 and HA-3; however, mottling was observed in all of our hand augers at about 6 to 8 feet below the existing ground surface. Mottling is typically indicative of a seasonal perched groundwater table, which generally develops when a low permeability soil is overlain by a higher permeability soil. We anticipate fluctuations in the local groundwater levels will occur in response to precipitation patterns, off-site construction activities, and site utilization. Below, Table 4 summarizes our depth to and elevation of groundwater encountered in our borings.

TABLE 4:
Approximate Depths and Elevations of Groundwater Encountered in Explorations

Exploration Number	Depth to Groundwater (feet)	Elevation of Groundwater$_1$ (feet)	Date Observed
B-1	12½	178½	July 5, 2017 (ATD)
B-2	10	184	July 5, 2017 (ATD)
Notes: 1 = Elevation datum: Preliminary site plan prepared by SCJ Alliance, dated June 28, 2017 ATD = At time of drilling			

ENGINEERING CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our data review, site reconnaissance, subsurface explorations and our experience in the area, it is our opinion that that the proposed residential development is feasible at the site from a geotechnical standpoint, provided the recommendations included herein are incorporated into the final design. Pertinent conclusions and geotechnical recommendations regarding the design and construction of the proposed development are presented below.

Landslide Hazard Areas per COMC Chapter 18.32 Section 18.32.605

Chapter 18 of the City of Olympia Municipal Code defines a landslide hazard area as an area potentially subject to risk of mass movement due to a combination of geologic, topographic, and hydrologic; and where the vertical height is ten (10) feet or more. The following areas are considered to be subject to landslide hazards:

1. Steep slopes of forty (40) percent or greater.
2. Slopes of fifteen (15) percent or greater with:
   a) Impermeable subsurface material frequently interbedded with granular soils, and
   b) Springs or seeping groundwater during the wet season (November to February).
3. Any area located on a landslide feature which has shown movement during the past ten thousand years or which is underlain by mass wastage debris from that period of time.

Some of the slopes around the kettle do appear to be steeper than 40 percent slopes with a vertical height of 10 feet or more. While the soils generally consist of fine sand with occasional silt lens, we do not infer that the slopes are comprised of impermeable clays and silts underlying more permeable sands and gravels. This is based on lack of seepage zones on the slopes of the kettles. Finally, no areas of mapped historic mass wasting or movement are located on the subject parcel. Based on the topographic criteria and presence of greater than 40 percent slopes, we conclude that the site does meet the technical criteria for a landslide hazard area because of the steepness of slopes around the kettle.

Slope Stability Analysis

We analyzed the global slope stability of the existing slope geometry using subsurface profile A-A’ and B-B’, as indicated on Figure 2b. This original cross section was selected as the most critical section given the height and steepness of the slopes, relative to the proximity of the proposed residential lots. The cross section and slope stability results using both static and dynamic conditions are included as Appendix "C".

We used the computer program SLIDE version 7.0 from RocScience, 2015, to perform the slope stability analyses. The computer program SLIDE uses a number of methods to estimate the factor of safety (FS) of the stability of a slope by analyzing the shear and normal forces acting on a series of vertical "slices" that comprise a failure surface. Each vertical slice is treated as a rigid body; therefore, the forces and/or moments acting on each slice are assumed to satisfy static equilibrium (i.e., a limit equilibrium analysis). The FS is defined as the ratio of the forces available to resist movement to the forces of the driving mass. A FS of 1.0 means that the driving and resisting forces are equal; a FS less than 1.0 indicates that the driving forces are greater than the resisting forces (indicating failure).

In order to evaluate the site soil properties, we performed a seismic back calculation based on the Nisqually earthquake that occurred in 2001. A nearby ground motion station in Olympia reported a peak horizontal ground acceleration (PGA) of 0.255g. We back calculated soil properties to obtain a FOS of slightly over 1.0 with a 0.20g PGA. These properties were then used with the IBC design event with ½ of the PGA of 0.225g to determine the minimum setback. The minimum setback required to satisfy a FOS of 1.1 was determined to be 60 feet from the top of the slope.

We used the Bishops method, which satisfies both moment and force equilibrium, to search for the location of the most critical failure surfaces and their corresponding FS. Based on the site plan provided by SCJ Alliance, there are two different slope conditions. Cross section AA' is representative of the slope below lots 34 through 37, while cross section BB' is representative of the slope below lots 38 and 39. The most critical surfaces are those with the lowest FS for a given loading condition, and are therefore the most likely to move. To determine the required building setback, a critical surface with a factor of safety 1.1 furthest from the top of the top of slope. On the cross section for AA', the critical factor of safety was about 10 feet back from the top of the slope (which is less than the 15-foot rear yard setback). For cross section BB', the critical surface daylighted about 60 feet back from the top of the slope. Since the top of slope is about 25 feet from the property line, the 60-foot top of slope setback would result in the residence on Lots 38 and 39 being 35 feet back from the rear property line. If this distance does not allow sufficient room for residence on these parcels, the foundations on these two parcels may be deepened (using small diameter pin piles), thereby providing a structural setback as described below. Details of the slope stability analyses are included in Appendix "C".

Structural Setback

The International Building Code (IBC) section 1808.7 requires a building setback from slopes that are steeper than 3H:1V (Horizontal: Vertical) or 33 percent with greater than 10 feet in vertical height unless evaluated and reduced, and/or a structural setback is provided, by a licensed geotechnical engineer. The typical IBC setback from the top of the slope equals one third the height of the slope while a setback from the toe of the slope equals one half the height of the slope.

Given the steep slopes around the kettle is on the order of 80 feet in vertical height, the IBC will require a building setback of 27 feet from the top of the slopes. However, the slope stability analysis discussed above, indicates that the top of slope setback for the lots 34 to 37, which has a flatter, shallower slope, may be reduced to 10 feet, while the top of slope setback for lots 38 and 30 should be expended to 60 feet. The revised setback distances meet the IBC criteria of having factors of safety greater than 1.5 and 1.1 for the static and seismic condition, respectively.

Where this setback distance cannot be met, the foundation elements of the structure can be extended vertically to meet the horizontal setback distance. Where the foundation can be extended vertically, we recommend that the setback be measured horizontally from the lower outside edge of the foundation element to the face of the slope. This "structural setback" is based on the foundation elements extending to the dense to very dense native soils. A detail showing the "structural setback" is attached as Figure 6. For lots 38 and 39, in order to using a building envelope that includes the standard rear yard setback of 15 feet (total setback from top of slope of 40 feet on these two lots), the foundation would need to be deepened about 20 feet. This can be accomplished by using small diameter driven pin piles (needle piles).

Seismic Site Class

Based on our observations and the subsurface units mapped at the site, we interpret the structural site conditions for the native soils to correspond to a seismic Site Class "E" in accordance with the 2015 IBC (International Building Code) documents and ASCE 7-10 Chapter 20 Table 20.3-1. This is based on the range of SPT (Standard Penetration Test) blow counts for the soils encountered in our borings. These conditions were assumed to be representative for the subsurface conditions for the site in general.

For design of seismic structures using the 2015 IBC, mapped short-period and 1-second period spectral accelerations, S_S and S_1, respectively, are required. S_S and S_1 are for a maximum considered earthquake, which corresponds to ground motions with a 2 percent probability of exceedance in 50 years or about a 2,500-year return period (with a deterministic maximum cap in some regions). The U.S. Geological Survey (USGS) completed probabilistic seismic hazard analyses (PSHA) for the entire country in November 1996, which were updated and republished in 2002 and 2008. The PSHA ground motion results can be obtained from the USGS website. The results of the updated USGS PSHA were referenced to determine S_S and S_1 for this site. The results are summarized below in Table 5 with the relevant parameters necessary for 2015 IBC design.

TABLE 5:
2015 IBC Parameters for Design of Seismic Structures

Spectral Response Acceleration (SRA) and Site Coefficients	Short Period	1 Second Period
Mapped SRA	S_s = 1.313	S_1 = 0.540
Site Coefficients	F_a = 0.9	F_v = 2.4
Maximum Considered Earthquake SRA	S_{MS} = 1.182	S_{M1} = 1.295
Design SRA	S_{DS} = 0.788	S_{D1} = 0.863

Seismic Hazards

Liquefaction is a phenomenon where there is a reduction or complete loss of soil strength due to an increase in pore water pressure. The increase in pore water pressure is induced by seismic vibrations. Liquefaction mainly affects geologically recent deposits of loose, fine-grained sands that are below the groundwater table. Based on the density and nature of the glacial soils observed on the site, it is our opinion that the risk for liquefaction to occur at this site during an earthquake is negligible. Provided the design criteria listed below are followed, the proposed structures should have no greater seismic risk damage than other appropriately designed structures in the Puget Sound area.

Erosion Hazards

Typically, soil erosion hazard areas are identified by the presence or absences of natural vegetative cover, soils texture, slope, and rainfall pattern, such as areas with slopes of 15 percent or greater and that are classified as having severe or very severe erosion potential by the USDA Soil Conservation Service Soil Survey for Thurston County. The subject property is located in an area mapped by several different SCS soil types. The mapped soil type number, name, erosion potential, and development limitations are listed below in Table 6.

TABLE 6

SCS SOIL SURVEY MAP SUMMARY

Mapped Soil Type	Soil Type Name	Slope Inclinations (percent)	Classified Erosion Potential
69	Mukilteo Muck	0 to 2	None
126	Yelm fine sandy loam	0 to 3	Slight
127	Yelm fine sandy loam	3 to 15	Slight
128	Yelm fine sandy loam	15 to 30	Slight

The site does not appear to met the criteria of an erosion hazard. The final plans will include a temporary erosion and sediment control (TESC) plan that will provide recommendations for preventive and controlling erosion during construction.

Foundation Support

Based on the encountered subsurface soil conditions encountered across the site and the preliminary building plans, we recommend that spread footings be founded on the dense to medium dense native glacial outwash encountered at depth, or on structural fill that extends to suitable native soils. The proposed daylight basement configuration should eliminate any existing fill soils within the foundation footprint.

The soil at the base of the excavations should be disturbed as little as possible. All loose, soft or unsuitable material should be removed. A representative from our firm should observe the foundation excavations to determine if suitable bearing surfaces have been prepared.

We recommend a minimum width of 2 feet for isolated footings and at least 16 inches for continuous wall footings. All footing elements should be embedded at least 18 inches below grade for frost protection. Footings founded on the native, undisturbed outwash or on structural fill can be designed using for an allowable soil bearing capacity of 2,000 psf (pounds per square foot) for combined dead and long-term live loads. The weight of the footing and any overlying backfill may be neglected. The allowable bearing value may be increased by one-third for transient loads such as those induced by seismic events or wind loads.

Lateral loads may be resisted by friction on the base of footings and floor slabs and as passive pressure on the sides of footings. We recommend that an allowable coefficient of friction of 0.35 be used to calculate friction between the concrete and the underlying soil. Passive pressure may be determined using an allowable equivalent fluid density of 400 pcf (pounds per cubic foot). Factors of safety have been applied to these values.

We estimate that settlements of footings designed and constructed as recommended will be less than 1-inch, for the anticipated load conditions, with differential settlements between comparably loaded footings of 1/2 inch or less. Most of the settlements should occur essentially as loads are being applied. However, disturbance of the foundation subgrade during construction could result in larger settlements than predicted.

Pin Piling Design Criteria

Pin or needle piles should be driven to meet both the structural setback criteria and refusal criteria, as determined by the pile contractor. Provided the building area can be accessed by equipment, we recommend that 3 or 4-inch needle piling be considered, as these are typically more cost effective. If access is limited, smaller 2-inch diameter needle piling can be installed with hand operated equipment. A representative from our firm should observe the foundation support installation to determine if suitable bearing/refusal criteria have been achieved.

Pin piles consist of small diameter Schedule-80 steel pipe that is driven into the underlying soils to refusal and/or minimum depths required to meet setback criteria. The steel pipe diameters range from 2 to 6-inches. Individual pipe segments typically range from about 5 to 10 feet long and are successively joined with external threaded couplings, internal slip couplings, or butt welded as pile driving progresses.

Refusal criteria should be based on load test data from the contractor for the given pile diameter and hammer type. We anticipate that the pin piles will meet refusal in the dense glacial soils that underlie the fill material. However, because refusal depths are difficult to predict and because soil conditions could vary significantly across the site, the contractor should be prepared for variable pile lengths. Also, it may be necessary to modify pile layouts if rocks or other obstructions are encountered during pile-driving, especially when driven near the existing lower retaining wall.

A properly installed 2-inch-diameter to 4-inch-diameter needle pile driven to refusal will provide the following allowable axial capacities. These capacities assume a minimum pile spacing (center to center) of six diameters, and a maximum length to diameter ratio of 180.

	Allowable Value		
	2-inch-diameter	**3-inch-diameter**	**4-inch-diameter**
Static Compressive Capacity	4,000 pounds	12,000 pounds	20,000 pounds
Transient Compressive Capacity	5,300 pounds	16,000 pounds	26,000 pounds

When refusal and the minimum embedment depth has been achieved, the pin piles can be cut to a predetermined height or elevation. To provide a good bond between the piles and the pile cap, reinforcing bars with 90-degree bends can be welded to the top of the pile or, alternatively, the top of the pile can be splayed apart. A structural engineer should be responsible for designing the reinforced steel and foundation elements. Typically, the footing is designed as a grade beam.

Verification load tests are typically performed on installed 3 and 4-inch diameter piles in accordance with special inspection requirements. Typically, 5 percent, or a minimum of 2, of the installed piles should have verification load testing. The piles should be load tested using the ASTM D: 1143 Quick Load Test method. As indicated above, all footing elements supported on needle piling should be constructed as engineered grade beams by the project structural engineer.

Floor Slab Support

We anticipate that the lower level of underground parking will consist of a slabs-on-grade floor. Slab-on-grade floors should be supported on the still native soils or on structural fill prepared as described above. Areas of old fill material should be evaluated during grading activity for suitability of structural support. Areas of significant organic debris should be removed.

We recommend that floor slabs be directly underlain by a minimum 4-inch thick pea gravel or washed 5/8-inch crushed rock. This layer should be placed and compacted to an unyielding condition and should contain less than 2 percent fines.

A synthetic vapor retarder is recommended to control moisture migration through the slabs. This is of particular importance where the foundation elements are underlain by the silty till or lake sediments, or where moisture migration through the slab is an issue, such as where adhesives are used to anchor carpet or tile to the slab.

A subgrade modulus of 350 kcf (kips per cubic foot) may be used for floor slab design. We estimate that settlement of the floor slabs designed and constructed as recommended, will be 1/2 inch or less over a span of 50 feet.

Pavement and Driveway Areas

The pavement sections in our original 2005 report are still appropriate for the site soils and proposed development.

Subgrade/Basement Walls

Adequate drainage behind retaining structures is imperative. Positive drainage which controls the development of hydrostatic pressure can be accomplished by placing a zone of drainage behind the walls. Granular drainage material should contain less than 2 percent fines and at least 30% greater than the #4 sieve. A geocomposite drain mat may also be used instead of free draining soils, provided it is installed in accordance with the manufacturer’s instructions. A soil drainage zone should extend horizontally at least 18 inches from the back of the wall. The drainage zone should also extend from the base of the wall to within 1 foot of the top of the wall. The soil drainage zone should be compacted to approximately 90 percent of the MDD. Over-compaction should be avoided as this can lead to excessive lateral pressures. Typical wall drainage and backfilling details are shown in Figure 4. Recommended earth pressures for the native and fill soils are shown in Figure 5

A minimum 4-inch diameter perforated or slotted PVC pipe should be placed in the drainage zone along the base and behind the wall to provide an outlet for accumulated water and direct accumulated water to an appropriate discharge location. We recommend that a nonwoven geotextile filter fabric be placed between the soil drainage material and the remaining wall backfill to reduce silt migration into the drainage zone. The infiltration of silt into the drainage zone can, with time, reduce the permeability of the granular material. The filter fabric should be placed such that it fully separates the drainage material and the backfill, and should be extended over the top of the drainage zone.

Lateral loads may be resisted by friction on the base of footings and as passive pressure on the sides of footings and the buried portion of the wall, as described in the "**Foundation Support**" section. We recommend that an allowable coefficient of friction of 0.35 be used to calculate friction between the concrete and the underlying soil. Passive pressure may be determined using an allowable equivalent fluid density of 350 pcf (pounds per cubic foot). Factors of safety have been applied to these values.

Temporary Excavations

All job site safety issues and precautions are the responsibility of the contractor providing services/work. The following cut/fill slope guidelines are provided for planning purposes only. Temporary cut slopes will likely be necessary during grading operations or utility installation.

All excavations at the site associated with confined spaces, such as utility trenches and retaining walls, must be completed in accordance with local, state, or federal requirements. Based on current Washington State Safety and Health Administration (WSHA) regulations, the upper weathered outwash on the site would be classified as Type C soils, whereas the deeper, unweathered outwash soils would be classified as Type B soils because of their granular nature.

According to WSHA, for temporary excavations of less than 20 feet in depth, the side slopes in Type A soils should be laid back at a slope inclination of 0.75H:1V (Horizontal: Vertical) or flatter from the toe to the crest of the slope whereas the lower type B soils should be sloped at a maximum inclination of 1H:1V. All exposed slope faces should be covered with a durable reinforced plastic membrane during construction to prevent slope raveling and rutting during periods of precipitation. These guidelines assume that all surface loads are kept at a minimum distance of at least one half the depth of the cut away from the top of the slope and that significant seepage is not present on the slope face. Flatter cut slopes will be necessary where significant raveling or seepage occurs, or if construction materials will be stockpiled along the slope crest.

Where it is not feasible to slope the site soils back at these inclinations, a retaining structure should be considered. Where retaining structures are greater than 4-feet in height (bottom of footing to top of structure) or have slopes of greater than 15 percent above them, they should be engineered per Washington Administrative Code (WAC 51-16-080 item 5). This information is provided solely for the benefit of the owner and other design consultants, and should not be construed to imply that GeoResources assumes responsibility for job site safety. It is understood that job site safety is the sole responsibility of the project contractor.

Site Drainage

All ground surfaces, pavements and sidewalks at the site should be sloped away from the structures. Surface water runoff should be controlled by a system of curbs, berms, drainage swales, and or catch basins, and conveyed to an appropriate discharge point.

We recommend that footing drains are installed for the residence in accordance with IBC 1807.4.2, and basement walls (if utilized) have a wall drain as describe above. The roof drain should not be connected to the footing drain. Figure 5 shows typical wall drainage and backfilling details. If the basement cut extends below the adjacent municipal stormwater system, a sump and pump system may be required.

EARTHWORK RECOMMENDATIONS

Site Preparation

All structural areas on the site to be graded should be stripped of vegetation, organic surface soils, and other deleterious materials including existing structures, foundations or abandoned utility lines. Organic topsoil is not suitable for use as structural fill, but may be used for limited depths in non-structural areas. Typical stripping depths ranging from 6 to 12 inches should be expected to remove these surficial topsoil. Undocumented fill encountered in test pits TP-7 and TP-11 should also be removed if it will be under houses, roadways, or other structural areas. The undocumented fill varies in depth of 1 to 3 feet. Areas of thicker topsoil or organic debris may be encountered in areas of heavy vegetation or depressions.

Where placement of fill material is required, the stripped/exposed subgrade areas should be compacted to a firm and unyielding surface prior to placement of any fill. Excavations for debris removal should be backfilled with structural fill compacted to the densities described in the "**Structural Fill**" section of this report.

We recommend that a member of our staff evaluate the exposed subgrade conditions after removal of vegetation and topsoil stripping is completed and prior to placement of structural fill. The exposed subgrade soil should be proof-rolled with heavy rubber-tired equipment during dry weather or probed with a 1/2-inch-diameter steel rod during wet weather conditions.

Soft, loose or otherwise unsuitable areas delineated during proofrolling or probing should be recompacted, if practical, or over-excavated and replaced with structural fill. The depth and extent of overexcavation should be evaluated by our field representative at the time of construction. The areas of old fill material should be evaluated during grading operations to determine if they need mitigation; recompaction or removal.

Structural Fill

All material placed as fill associated with mass grading, as utility trench backfill, under building areas, or under roadways should be placed as structural fill. The structural fill should be placed in horizontal lifts of appropriate thickness to allow adequate and uniform compaction of each lift. Structural fill should be compacted to at least 95 percent of MDD (maximum dry density as determined in accordance with ASTM D-1557).

The appropriate lift thickness will depend on the structural fill characteristics and compaction equipment used. We recommend that the appropriate lift thickness be evaluated by our field representative during construction. We recommend that our representative be present during site grading activities to observe the work and perform field density tests.

The suitability of material for use as structural fill will depend on the gradation and moisture content of the soil. As the amount of fines (material passing US No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult to achieve. During wet weather, we recommend use of well-graded sand and gravel with less than 5 percent (by weight) passing the US No. 200 sieve based on that fraction passing the 3/4-inch sieve, such as *Gravel Backfill for Walls* (WSDOT 9-03.12(2)). If prolonged dry weather prevails during the earthwork and foundation installation phase of construction, higher fines content (up to 10 to 12 percent) may be acceptable.

Material placed for structural fill should be free of debris, organic matter, trash and cobbles greater than 6-inches in diameter. The moisture content of the fill material should be adjusted as necessary for proper compaction.

Suitability of On-Site Materials as Fill

During dry weather construction, non-organic on-site soil may be considered for use as structural fill; provided it meets the criteria described above in the "**Structural Fill"** section and can be compacted as recommended. If the soil material is over-optimum in moisture content when excavated, it will be necessary to aerate or dry the soil prior to placement as structural fill. We generally did not observe the site soils to be excessively moist at the time of our subsurface exploration program.

The previously placed fill encountered at shallow depths in test pits TP-7 and TP-11 across the site consist of a mixture of sand, silt, and some debris. We do not anticipate that these soils will be suitable for use as structural because of their fines content and the presence of debris. The deeper outwash is generally comparable to "common borrow" material and will be suitable for use as structural fill provided the moisture content is maintained within 2 percent of the optimum moisture level.

We recommend that completed graded-areas be restricted from traffic or protected prior to wet weather conditions. The graded areas may be protected by paving, placing asphalt-treated base, a layer of free-draining material such as pit run sand and gravel or clean crushed rock material containing less than 5 percent fines, or some combination of the above.

Erosion Control

The Contractor should employ and maintain proper erosion control measures during wet weather condition and/or once site activity is initiated, and especially during construction activity. Special care is required during wet weather conditions. Covering work areas, soil stockpiles, or slopes with plastic sheeting held down with sandbags, use sumps to remove accumulations of rainwater, and other measures should be employed as necessary to permit proper completion of the work. Geotextile silt fences, and drain inlet sediment screens/collection systems should be appropriately located to control sediment movement and soil erosion. Best management practice should be included in the project plans and specifications per the City of Olympia Municipal Code and 2016 Drainage Design and Erosion Control Manual.

Wet Weather Earthwork Recommendations

In the Puget Sound area, wet weather generally begins about mid-October and continues through about May, although rainy periods could occur at any time of year. It is encouraged that earthwork be scheduled during the dry weather months of June through September. Some of the soils at the site contain sufficient fines to produce an unstable mixture when wet. Such soil is highly susceptible to changes in water content and tends to become unstable and impossible to proof-roll and compact if the moisture content exceeds the optimum.

In addition, during wet weather months, the groundwater levels could increase, resulting in seepage into site excavations. Performing earthwork during dry weather would reduce these problems and costs associated with rainwater, construction traffic, and handling of wet soil. However, should wet weather/wet condition earthwork be unavoidable, the following recommendations are provided:

- The ground surface in and surrounding the construction area should be sloped as much as possible to promote runoff of precipitation away from work areas and to prevent ponding of water.
- Work areas or slopes should be covered with plastic. The use of sloping, ditching, sumps, dewatering, and other measures should be employed as necessary to permit proper completion of the work.
- Earthwork should be accomplished in small sections to minimize exposure to wet conditions. That is, each section should be small enough so that the removal of unsuitable soils and placement and compaction of clean structural fill could be accomplished on the same day. The size of construction equipment may have to be limited to prevent soil disturbance. It may be necessary to excavate soils with a backhoe, or equivalent, and locate them so that equipment does not pass over the excavated area. Thus, subgrade disturbance caused by equipment traffic would be minimized.
- Fill material should consist of clean, well-graded, sand and gravel, of which not more than 5 percent fines by dry weight passes the No. 200 mesh sieve, based on wet sieving the fraction passing the ¾-inch mesh sieve. The gravel content should range from between 20 and 50 percent retained on a No. 4 mesh sieve. The fines should be non-plastic.
- No exposed soil should be left uncompacted and exposed to moisture. A smooth-drum vibratory roller, or equivalent, should roll the surface to seal out as much water as possible.
- In-place soil or fill soil that becomes wet and unstable and/or too wet to suitably compact should be removed and replaced with clean, granular soil (see soil gradation requirements in the "**Structural Fil**l" section of this report).
- Excavation and placement of structural fill material should be observed on a full-time basis by a geotechnical engineer (or representative) experienced in wet weather/wet condition earthwork to determine that all work is being accomplished in accordance with the project specifications and our recommendations.
- Grading and earthwork should not be accomplished during periods of heavy, continuous rainfall.

We recommend that the above requirements for wet weather/wet condition earthwork be incorporated into the contract specifications.

LIMITATIONS

We have prepared this report for use by Mr. Gordie Gill, SCJ Alliance and other members of the design team, for use in the design of a portion of this project. The data used in preparing this report and this report should be provided to prospective contractors for their bidding or estimating purposes only. Our report, conclusions and interpretations are based on our subsurface explorations, data from others and limited site reconnaissance, and should not be construed as a warranty of the subsurface conditions.

Variations in subsurface conditions are possible between the explorations and may also occur with time. A contingency for unanticipated conditions should be included in the budget and schedule. Sufficient monitoring, testing and consultation should be provided by our firm during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork and foundation installation activities comply with contract plans and specifications.

The scope of our services does not include services related to environmental remediation and construction safety precautions. Our recommendations are not intended to direct the contractor's methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design.

If there are any changes in the loads, grades, locations, configurations or type of facilities to be constructed, the conclusions and recommendations presented in this report may not be fully applicable. If such changes are made, we should be given the opportunity to review our recommendations and provide written modifications or verifications, as appropriate.

◆ ◆ ◆

We have appreciated the opportunity to be of service to you on this project. If you have any questions or comments, please do not hesitate to call at your earliest convenience.

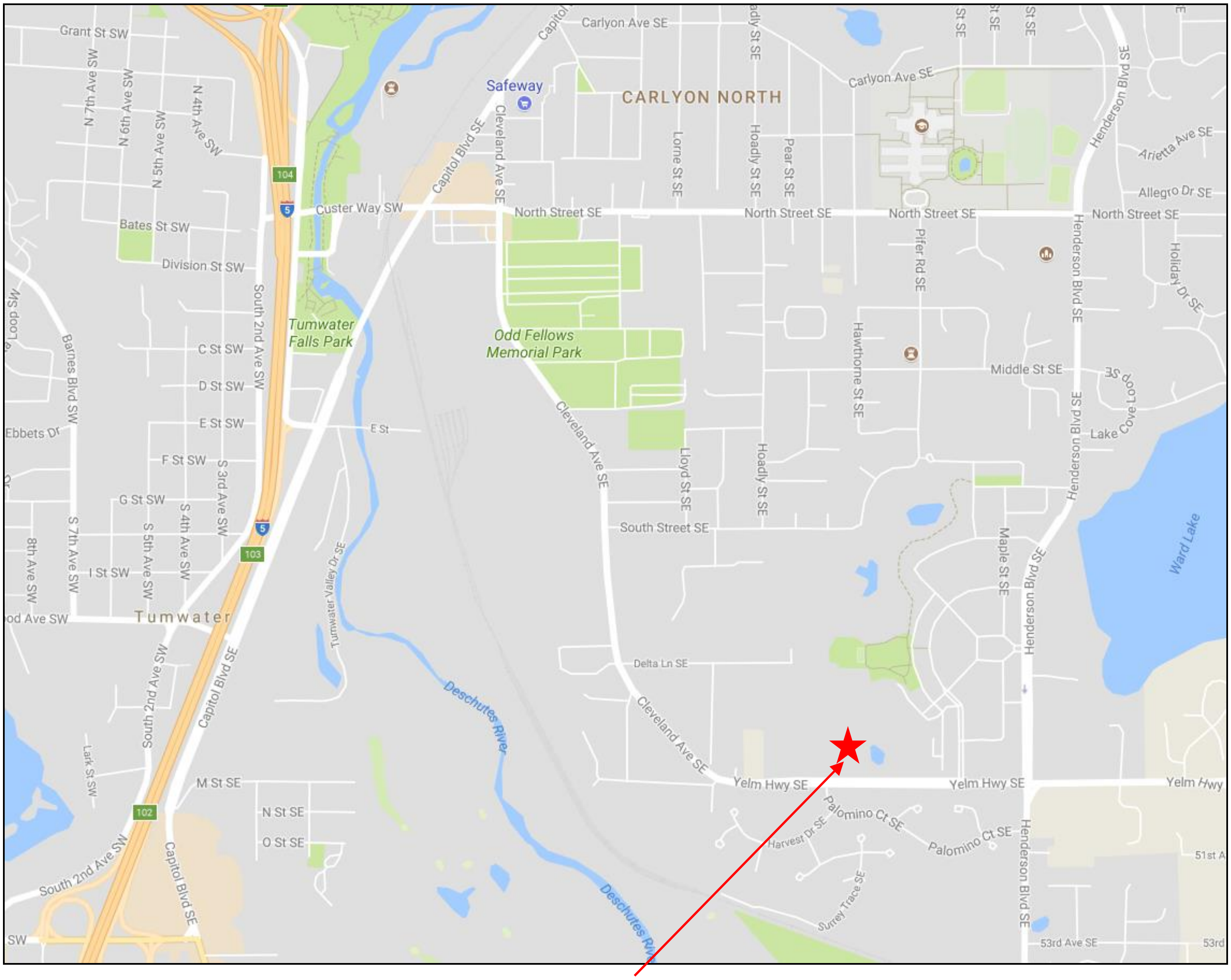
Respectfully submitted,
GeoResources, LLC

Carson Cheung, EIT
Geotechnical Staff

Keith S. Schembs, LEG
Principal

Dana C. Biggerstaff, PE
Senior Geotechnical Engineer

KSS:DCB/cc
DocID: SCJAlliance.BriggsWestKettle.RG
Attachments:
Figure 1: Site Location Map
Figure 2a: Site Vicinity Map
Figure 2b: Site & Exploration Plan
Figure 3: NRCS Soils Map
Figure 4: USGS Map
Figure 5: Structural Setback
Figure 6: Typical Wall Drainage and Backfill
Appendix "A" – Subsurface Explorations
Appendix "B" – Laboratory Test results
Appendix "D" – Slope Stability Analysis



Approximate Site Location

(map created from Google Maps https://www.google.com/maps/)

Not to Scale

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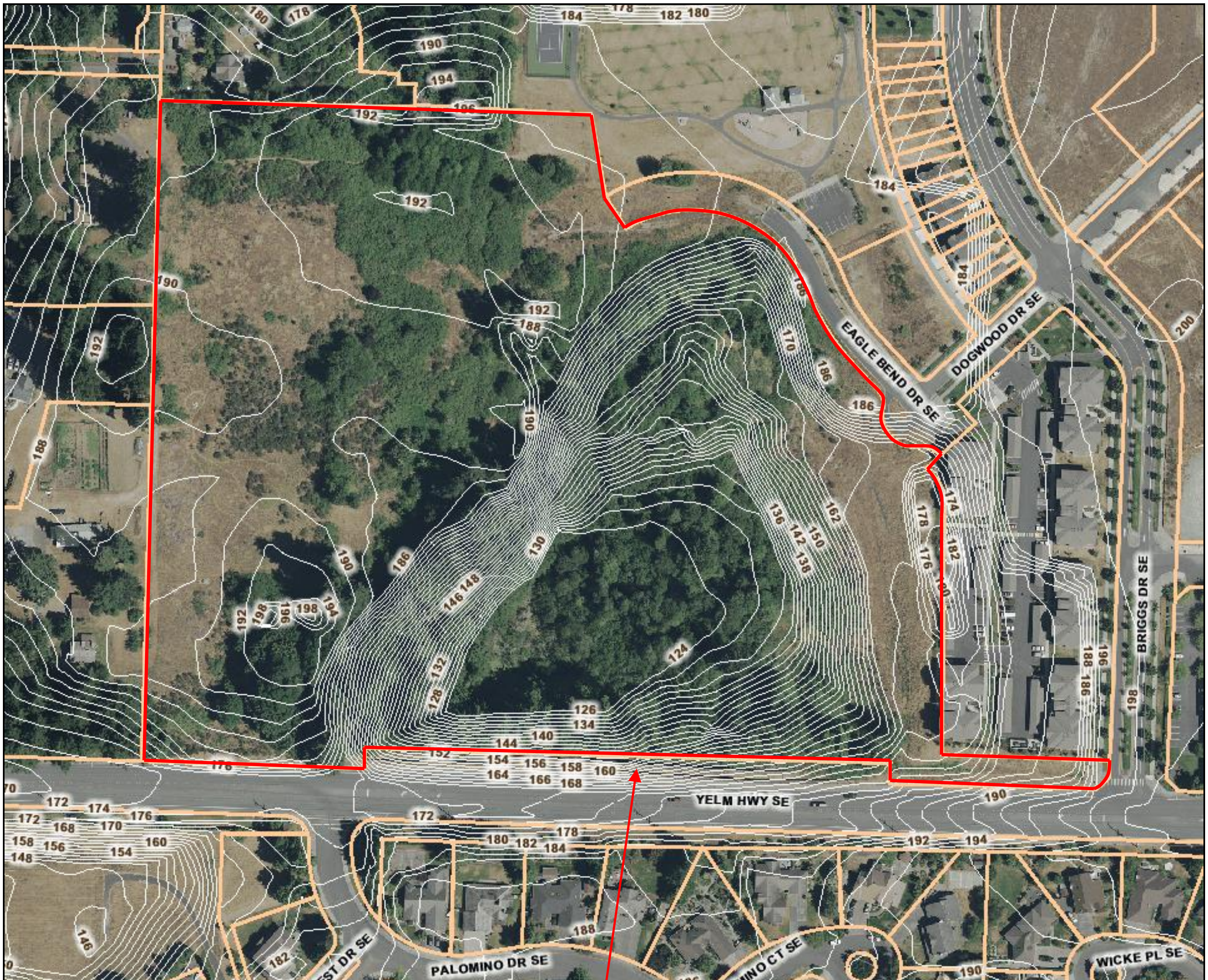
Site Location Map

Proposed Residential Development
xxx - Eagle Bend Drive Southeast
Olympia, Washington
PN: 37030000015

DocID: SCJAlliance.BriggsWestKettle.F	July 2017	Figure 1



Approximate Site Location

(map created from Thurston County Public GIS https://geodata.org/website/cadastral/viewer.htm)

N W E S

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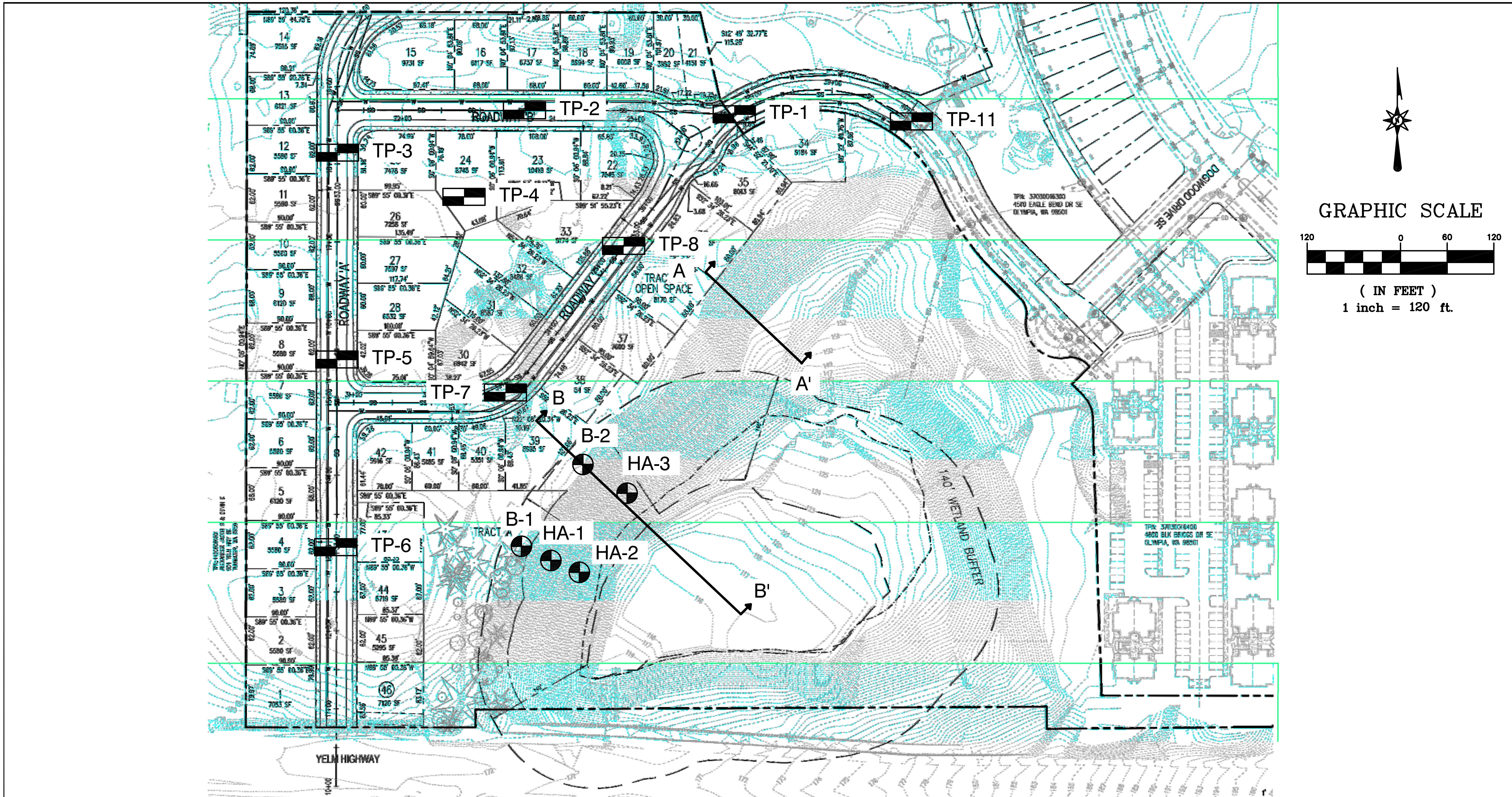
Site Vicinity Map

Proposed Residential Development
xxx - Eagle Bend Drive Southeast
Olympia, Washington
PN: 37030000015

DocID: SCJAlliance.BriggsWestKettle.F	July 2017	Figure 2a



Approximate Location of Subsurface Explorations

TP-01 (Test Pit By GeoResources, 2005)

B-01 (Boring By GeoResources, 2017)

HA-01 (Hand Auger By GeoResources, 2017)

Cross Section

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Site and Exploration Plan
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Olympia, Washington
PN: 37030000015

Doc ID: SCJAlliance.BriggsWestKettle.F	July 2017	Figure 2b

Approximate Site Location

Map created from Web Soil Survey (http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx)

Soil Type	Soil Name	Parent Material	Slopes	Erosion Hazard	Hydrologic Soils Group
69	Mukiteo muck	Herbaceous organic material	0 to 2	None	B/D
126	Yelm fine sandy loam	Glacial outwash	0 to 3	Slight	B
127	Yelm fine sandy loam	Glacial outwash	3 to 15	Slight	B
128	Yelm fine sandy loam	Glacial outwash	15 to 30	Slight	B

N W E S

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NRCS Soils Map

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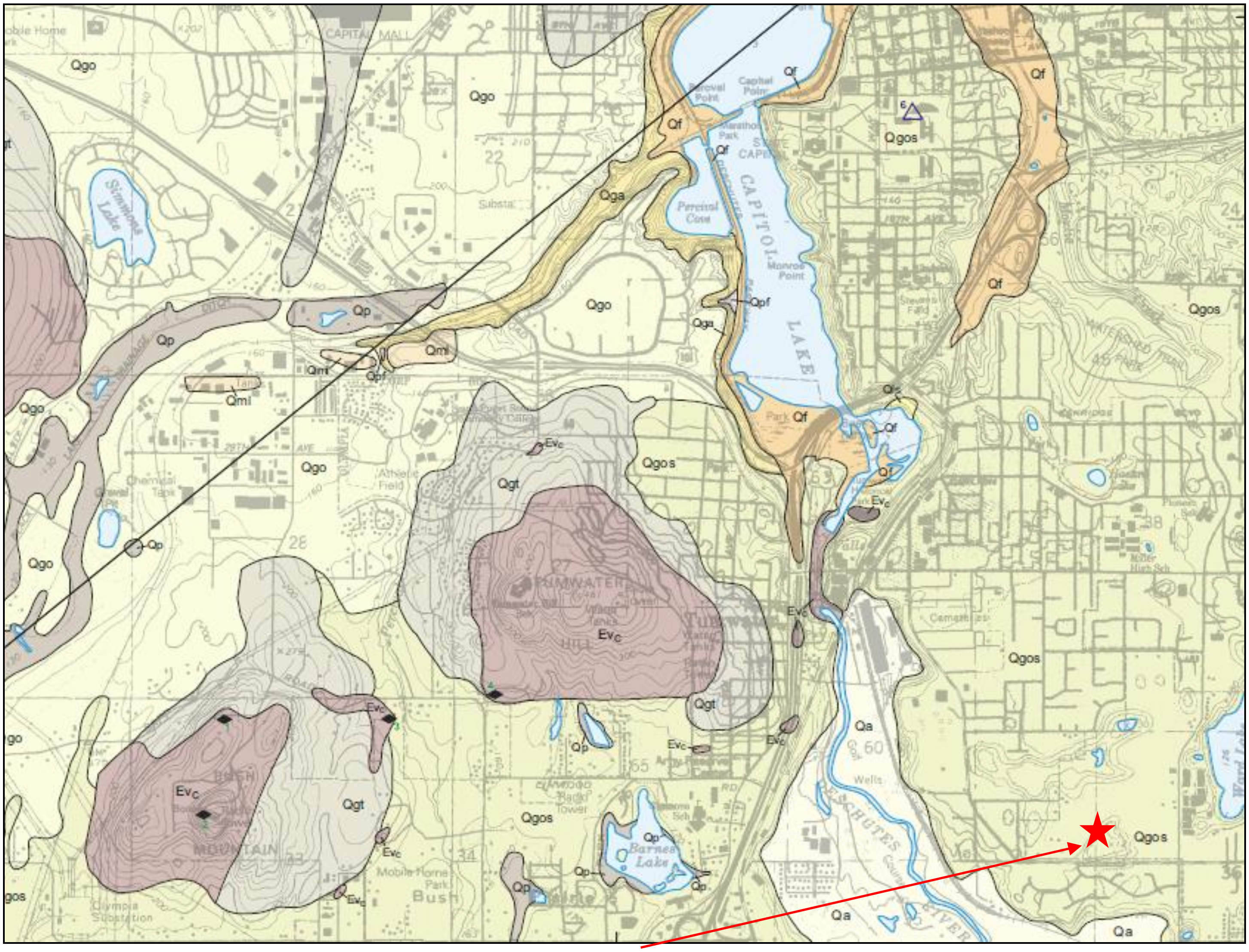

Approximate Site Location

(An excerpt from the *Geologic Map of the Tumwater 7.5-minute Quadrangle, Thurston County, Washington* by Walsh, Logan, Schasse, and Polenz, 2009)

Qgos	Latest Vashon recessional sand and minor silt
Qa	Alluvium

N
W E
S

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USGS Geologic Map

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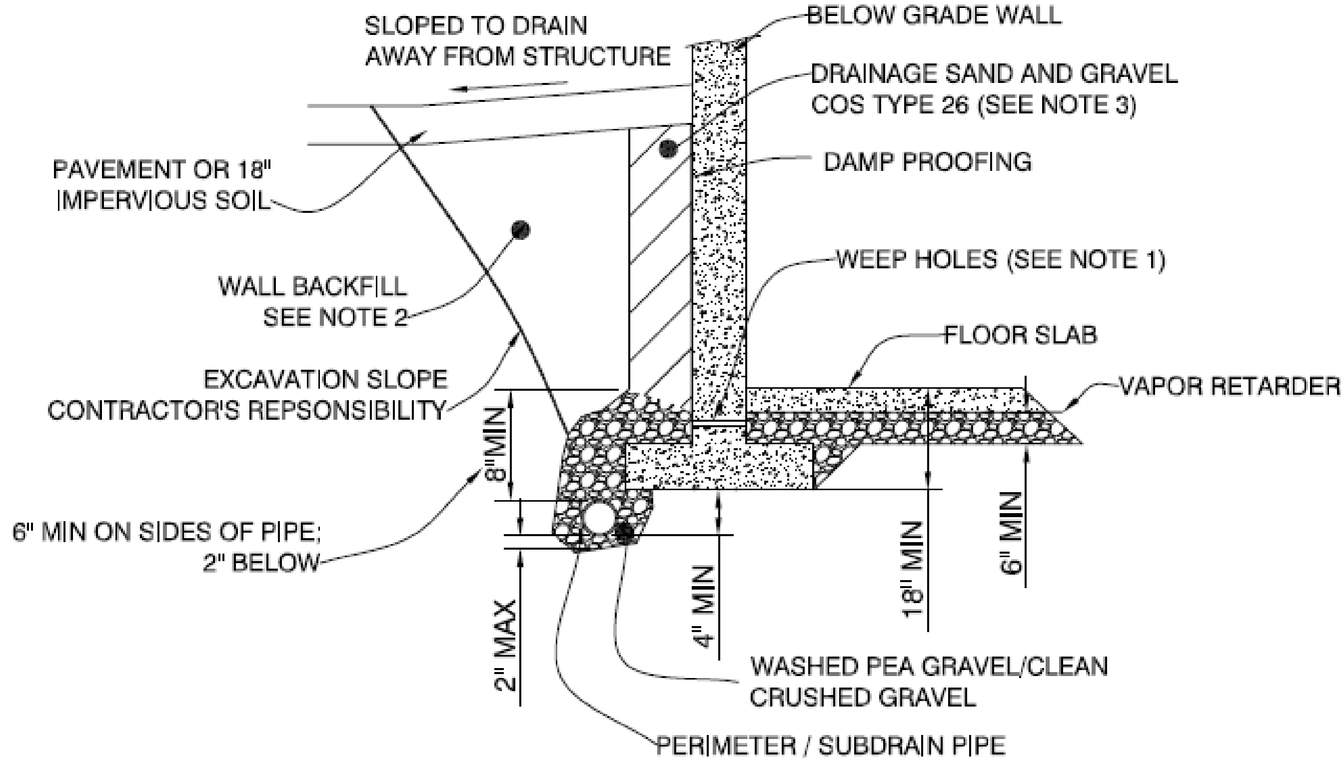
DocID: SCJAlliance.BriggsWestKettle.F	July 2017	Figure 4



NOTES

1. Washed pea gravel/crushed rock beneath floor slab could be hydraulically connected to perimeter/subdrain pipe. Use of 1" diameter weep holes as shown is one applicable method. Crushed gravel should consist of 3/4" minus. Washed pea gravel should consist of 3/8" to No. 8 standard sieve.

2. Wall backfill should meet WSDOT Gravel Backfill for walls Specification 9-03-12(2).

3. Drainage sand and gravel backfill within 18" of wall should be compacted with hand-operated equipment. Heavy equipment should not be used for backfill, as such equipment operated near the wall could. Increase lateral earth pressures and possibly damage the wall. The table below presents the drainage sand and gravel gradation.

4. All wall backfill should be placed in layers not exceeding 4" loose thickness for light equipment and 8" for heavy equipment and should be densely compacted. Beneath paved or sidewalk areas, compact to at least 95% Modified Proctor maximum density (ASTM: 01557-70 Method C). In landscaping areas, compact to 90% minimum.

5. Drainage sand and gravel may be replaced with a geocomposite core sheet drain placed against the wall and connected to the subdrain pipe. The geocomposite core sheet should have a minimum transmissivity of 3.0 gallons/minute/foot when tested under a gradient of 1.0 according to ASTM 04716.

6 The subdrain should consist of 4" diameter (minimum), slotted or perforated plastic pipe meeting the requirements of AASHTO M 304; 1/8-inch maximum slot width; 3/16- to 3/8-inch perforated pipe holes in the lower half of pipe, with lower third segment unperforated for water flow; tight joints; sloped at a minimum of 6"/100' to drain; cleanouts to be provided at regular intervals.

7. Surround subdrain pipe with 8 inches (minimum) of washed pea gravel (2" below pipe) or 5/8" minus clean crushed gravel. Washed pea gravel to be graded from 3/8-inch to No.8 standard sieve.

8. See text for floor slab subgrade preparation.

Materials

Drainage Sand and Gravel

Sieve Size	% Passing by Weight
3/4 "	100
No 4	28-56
No 8	20-50
No 50	3-12
No 100	0-2

3/4" Minus Crushed Gravel

Sieve Size	% Passing by Weight
3/4 "	100
1/2"	75 - 100
1/4"	0 - 25
No 100	0 - 2
(by wet sieving)	(non-plastic)

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Typical Drainage and Backfill Detail

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Appendix A

Subsurface Explorations

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS More than 50% Retained on No. 200 Sieve	GRAVEL More than 50% Of Coarse Fraction Retained on No. 4 Sieve	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND More than 50% Of Coarse Fraction Passes No. 4 Sieve	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% Passes No. 200 Sieve	SILT AND CLAY Liquid Limit Less than 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY Liquid Limit 50 or more	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-90.

2. Soil classification using laboratory tests is based on ASTM D2487-90.

3. Description of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and or test data.

SOIL MOISTURE MODIFIERS:

Dry- Absence of moisture, dry to the touch

Moist- Damp, but no visible water

Wet- Visible free water or saturated, usually soil is obtained from below water table

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Unified Soils Classification System

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PN: 37030000015

Hand Auger HA-1
Location:
Approximate Elevation: 165’

Depth (ft)			Soil Type	Soil Description
0	-	1.5	-	Dark brown forest duff/top soil (loose, moist)
1.5	-	3.5	ML	Brown to tan fine sandy silt (loose, moist)
3.5	-	10.0	ML	Tan fine sandy silt (loose, moist)

Terminated at 10.0 feet below ground surface.
No caving observed at the time of excavation.
No groundwater seepage observed at the time of excavation.
Mottling observed at approximately 8.0 feet below ground surface.

Hand Auger HA-2
Location:
Approximate Elevation: 147’

Depth (ft)			Soil Type	Soil Description
0	-	1.0	-	Dark brown forest duff/top soil (loose, moist)
1.0	-	4.5	ML	Brown to tan fine sandy silt (loose, moist)
4.5	-	9.0	ML	Tan fine sandy silt (loose, moist)

Terminated at 9.0 feet below ground surface.
No caving observed at the time of excavation.
No groundwater seepage observed at the time of excavation.
Mottling observed at approximately 7.5 feet below ground surface.

Hand Auger HA-3
Location:
Approximate Elevation: 151’

Depth (ft)			Soil Type	Soil Description
0	-	1.0	-	Dark brown forest duff/top soil (loose, moist)
1.0	-	4.5	ML	Brown to tan fine sandy silt (loose, moist)
4.5	-	8.5	ML	Tan fine sandy silt (loose, moist)

Terminated at 8.5 feet below ground surface.
No caving observed at the time of excavation.
No groundwater seepage observed at the time of excavation.
Mottling observed at approximately 6.0 feet below ground surface.

Logged by: CC **Excavated on: July 5, 2017**

TOTAL DEPTH:	51.5feet	**EXCAVATION METHOD:**	HSA	**LOGGED BY:**	CC
TOP ELEVATION:	192	**EXCAVATION COMPANY:**	Bortec1, Inc.	**HAMMER TYPE:**	Cathead
LATITUDE:		**EQUIPMENT:**		**HAMMER WEIGHT:**	140lb
LONGITUDE:		**NOTES:**	Top of slope about 50 feet to the northeast of transformer		

(new title)

TEST RESULTS

Test Results

Plastic Limit ├──┤ Liquid Limit; % Water Content ●; % Fines (<0.075mm) ◇; Penetration - ▲ (blow per foot) 10 20 30 40 50

Depth	Elevation	SOIL DESCRIPTION	Drilling Notes	Sample	Blow Count	Ground Water
0		Topsoil/forest duff				
	190	Brown silty fine SAND (loose, moist)		1	1 1 1	
5		Brown becomes tan silty fine SAND (loose, moist)		2	2 1 1	
	185	Tan silty fine SAND (loose, moist)		3	2 1 3	
10		Tan fine sandy SILT (loose, moist)		4	2 3 3	
	180			5	3 3 3	
15		Tan fine sandy SILT with interbedded fine sand layer (loose, moist to damp)		6	2 2 4	
	175					
20		Brown grey coarse SAND with gravel (loose to medium dense, moist)	Gravel in shoe	7	15 10 7	
	170					
25		Brown grey coarse SAND with more gravel (loose to medium dense, moist)	Gravel in shoe	8	6 10 7	
	165					
30		Brwon grey coarse SAND with less/no gravel (less to medium dense, moist)		9	5 5 7	

NOTES
1. Refer to log key for definition of symbols, abbreviations and codes
2. USCS designation is based on visual manual classification and selected lab testing
3. Groundwater level, if indicated, is for the date shown and may vary
4. N.E. = Not Encountered

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LOG OF BORING B-1

JOB:

Sheet 1 of 2

GeoResources, LLC **FIG.**

TOTAL DEPTH: 51.5feet	**EXCAVATION METHOD:** HSA	**LOGGED BY:** CC
TOP ELEVATION: 192	**EXCAVATION COMPANY:** Bortec1, Inc.	**HAMMER TYPE:** Cathead
LATITUDE:	**EQUIPMENT:**	**HAMMER WEIGHT:** 140lb
LONGITUDE:	**NOTES:** Top of slope about 50 feet to the northeast of transformer	

(new title)

TEST RESULTS

Test Results: Plastic Limit ├─┤ Liquid Limit; % Water Content ●; % Fines (<0.075mm) ◇; Penetration - ▲ (blow per foot) 10 20 30 40 50

Depth	Elevation	SOIL DESCRIPTION	Drilling Notes	Sample	Blow Count	Ground Water
	160					
35		Brown grey corase SAND (loose to medium dense, moist)		10	6 7 9	
	155					
40				11	5 7 8	
	150					
45				12	6 7 6	
	145					
50				13	6 7 7	
	140					
55		Bottom of Boring Completed7/5/2017				
	135					
60						
	130					

NOTES
1. Refer to log key for definition of symbols, abbreviations and codes
2. USCS designation is based on visual manual classification and selected lab testing
3. Groundwater level, if indicated, is for the date shown and may vary
4. N.E. = Not Encountered

SCJAlliance.BriggsWestKettle

LOG OF BORING B-1

JOB:

GeoResources, LLC **FIG.**

TOTAL DEPTH:	51.5feet	**EXCAVATION METHOD:**	HSA	**LOGGED BY:**	CC
TOP ELEVATION:	186	**EXCAVATION COMPANY:**	Bortec1, Inc.	**HAMMER TYPE:**	Cathead
LATITUDE:		**EQUIPMENT:**		**HAMMER WEIGHT:**	140lb
LONGITUDE:		**NOTES:**	Top of slope about 150 feet to the northeast of transformer		

(new title)

TEST RESULTS

Test Results

Plastic Limit ├──┤ Liquid Limit; % Water Content ●; % Fines (<0.075mm) ◇

Penetration - ▲ (blow per foot) 10 20 30 40 50

Depth	Elevation	SOIL DESCRIPTION	Drilling Notes	Sample	Blow Count
0	185	Topsoil/forest duff			
		Brwon becomes tan silty fine SAND (loose, moist)		1	1 1 1
5	180	Tan silty fine SAND (loose, moist)		2	3 4 5
		Tan fine sandy SILT (loose, moist to damp)		3	3 3 3
10	175			4	2 2 4
				5	2 2 3
15	170			6	1 2 4
20	165	Brown grey coarse SAND with gravel (loose to medium dense, moist)		7	6 7 8
25	160	Brown grey coarse SAND with more gravel (loose to medium dense, moist)	Gravel in shoe	8	5 8 19
30	155	Brown grey coarse SAND with less/no gravel (loose to medium dense, moist)		9	4 5 5

Ground Water

NOTES
1. Refer to log key for definition of symbols, abbreviations and codes
2. USCS designation is based on visual manual classification and selected lab testing
3. Groundwater level, if indicated, is for the date shown and may vary
4. N.E. = Not Encountered

SCJAlliance.BriggsWestKettle

LOG OF BORING B-2

JOB:

Sheet 1 of 2

GeoResources, LLC **FIG.**

TOTAL DEPTH:	51.5feet	**EXCAVATION METHOD:**	HSA	**LOGGED BY:**	CC
TOP ELEVATION:	186	**EXCAVATION COMPANY:**	Bortec1, Inc.	**HAMMER TYPE:**	Cathead
LATITUDE:		**EQUIPMENT:**		**HAMMER WEIGHT:**	140lb
LONGITUDE:		**NOTES:**	Top of slope about 150 feet to the northeast of transformer		

(new title)

TEST RESULTS

Test Results

Plastic Limit ├──┤ Liquid Limit
% Water Content ●
% Fines (<0.075mm) ◇

Penetration - ▲ (blow per foot) 10 20 30 40 50

Depth	Elevation	SOIL DESCRIPTION	Drilling Notes	Sample	Sampler	Symbol	Blow Count	Ground Water
35	150	Brown grey coarse SAND (loose to medium dense, moist)		10			4 6 6	
40	145			11			4 6 9	
45	140			12			9 10 11	
50	135			13			6 9 9	
55	130	Bottom of Boring Completed7/5/2017						
60	125							

NOTES
1. Refer to log key for definition of symbols, abbreviations and codes
2. USCS designation is based on visual manual classification and selected lab testing
3. Groundwater level, if indicated, is for the date shown and may vary
4. N.E. = Not Encountered

SCJAlliance.BriggsWestKettle

LOG OF BORING B-2

JOB:

Sheet 2 of 2

GeoResources, LLC **FIG.**

Previous Subsurface Explorations
(GeoResources, 2005)

TEST PIT LOGS
BRIGGS VILLAGE WEST
OLYMPIA, WASHINGTON

TEST PIT 1 - Located 50 feet northeast of intersection of Rhododendron Avenue and Park Dr
Elevation: 190 feet

Depth (ft.)	Soil Type	Description
0.0 - 1.0		Topsoil
1.0 - 3.0	SM	Gry SAND w/ tr silt (soft-med, moist)
3.0 - 5.0	SM	Lt Brn silty SAND (mott) (med stiff, moist) (SP-1)

No caving observed
No groundwater seepage observed
(rust belt @ 3')

TEST PIT 2 - Located 100 feet east of intersection of Rhododendron Avenue and Camelia Court
Elevation: 190 feet

Depth (ft.)	Soil Type	Description
0.0 - 0.5		Topsoil
0.5 - 2.0	ML	Lt brn sandy SILT w/ tr org (soft, moist)
2.0 - 4.0	SM	Lt Brn silty SAND (soft-med, moist)
4.0 - 6.0	SM	Gry SAND w/ tr silt (soft, moist) (SP-2)
6.0 - 8.0	SM	Gry silty SAND (mott) (med stiff, moist)

No caving observed
No groundwater seepage observed

TEST PIT 3 - Located on Rhododendron Avenue 750 feet north of Yelm Highway
Elevation: 189 feet

Depth (ft.)	Soil Type	Description
0.0 - 0.5		Topsoil
0.5 - 2.0	SM	Lt Brn SAND w/ tr silt and org (soft-med, moist) (SP-3)
2.0 - 4.0	SM	Gry SAND w/ tr silt and org. (med stiff, moist)

No caving observed
No groundwater seepage observed

TEST PIT 4 - Located 150 feet south west of intersection of Rhododendron Aveue and Rose Dr
Elevation: 189 feet

Depth (ft.)	Soil Type	Description
0.0 - 0.5		Topsoil
0.5 - 3.0	SM	Lt Brn SAND w/ silt (soft, moist)
3.0 - 5.0	SM	Gry SAND w/ tr silt (soft-med, moist)
5.0 - 7.0	ML	Gry sandy SILT (med stiff, moist) (SP-4)

No caving observed
No groundwater seepage observed

TEST PIT 5 - Located on Rhododendron Avenue 500 feet north of Yelm Highway
Elevation: 190 feet

Depth (ft.)	Soil Type	Description
0.0 - 0.5		Topsoil
0.5 - 2.0	ML	Gry sandy SILT (med stiff, moist)
2.0 - 4.0	SM	Gry SAND w/ tr silt (soft-med, moist) (SP-5)

No caving observed
No groundwater seepage observed

TEST PIT 6 - Located on Rhododendron Avenue 250 feet north of Yelm Highway
Elevation: 180 feet

Depth (ft.)	Soil Type	Description
0.0 - 0.5		Topsoil
0.5 - 2.0	SM	Lt Brn SAND w/ silt (med stiff, moist)
2.0 - 5.0	SM	Gry SAND w/ silt (soft-med, moist)
5.0 - 8.0	SM	Gry SAND w/ tr silt (med stiff, moist) (SP-6)

No caving observed
No groundwater seepage observed

TEST PIT 7 - Located 200 feet east of Rhododendron Blvd and Park Dr
Elevation: 189 feet

Depth (ft.)	Soil Type	Description
0.0 - 1.0		Fill
1.0 - 2.0	SM	Dk Brn SAND w/ silt (soft-med, moist)
2.0 - 5.0	SM	Gry SAND w/ tr silt (med-stiff, moist)
5.0 - 8.0	SM	Gry silty SAND (stiff, moist)
8.0 - 10.0	ML	Lt Brn SILT w/ sand (stiff, moist) (SP-7)

No caving observed
No groundwater seepage observed

TEST PIT 8 - Located 200 feet southwest of intersection of Rhododendron Avenue and Park Drive
Elevation: 189 feet

Depth (ft.)	Soil Type	Description
0.0 - 0.5		Topsoil
0.5 - 2.0	SM	Lt Brn SAND w/ silt and org (med stiff, moist)
2.0 - 4.0	SM	Gry SAND w/ silt (soft-med, moist)
4.0 - 6.0	ML	Lt Brn SILT w/ tr sand (med stiff, moist) (SP-8)

No caving observed
No groundwater seepage observed

TEST PIT 9 - Located on Camelia Court 200 feet north of Rhododendron Avenue
Elevation: 180 feet

Depth (ft.)	Soil Type	Description
0.0 - 1.0		Topsoil
1.0 - 2.0	ML	Brn silty SAND w/ org (mott) (med stiff, moist)
2.0 - 4.0	SM	Lt Brn SAND w/ silt and roots (soft-med, moist)
4.0 - 5.0	ML	Lt Brn sandy SILT (med stiff, moist) (SP-9)
5.0 - 8.0	SM	Gry SAND w/ silt (loose-med, moist

No caving observed
No groundwater seepage observed

TEST PIT 10 - Located on Camelia Court 450 feet north of Rhododendron Avenue
Elevation: 155 feet

Depth (ft.)	Soil Type	Description
0.0 - 3.0		Fill
3.0 - 4.0	SM	Lt Brn SAND w/ silt and tr grvl (mott) (med stiff, moist)
4.0 - 6.0	SM	Lt Brn silty SAND (med stiff, moist) (SP-10)

No caving observed
No groundwater seepage observed

TEST PIT 11 - Located 300 feet northwest of intersection of Park Drive and Dogwood Drive
Elevation: 185 feet

Depth (ft.)	Soil Type	Description
0.0 - 1.0		Fill
1.0 - 2.5	SM	Lt Brn silty SAND (med stiff, moist)
2.5 - 5.0	SM	Lt Brn SAND w/ silt (med stiff, moist) (SP-11)

No caving observed
No groundwater seepage observed

TEST PIT 12 - Located at the intersection of Park Drive and Dogwood Drive
Elevation: 185 feet

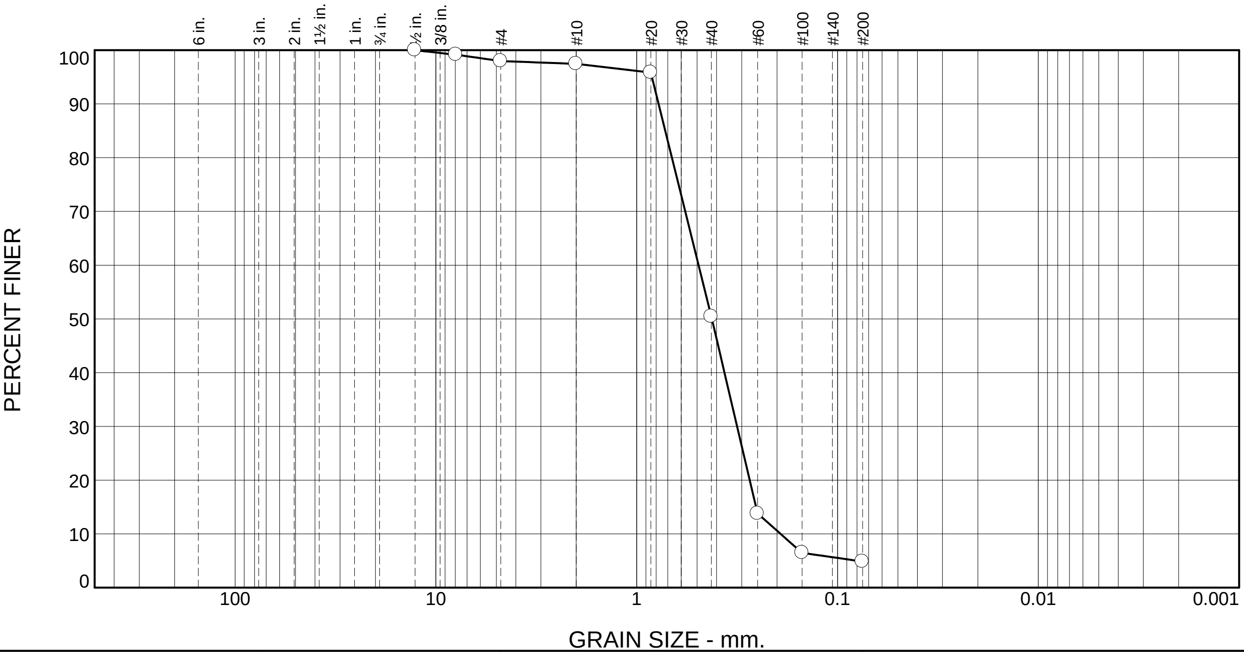
Depth (ft.)	Soil Type	Description
0.0 - 1.0	SM	Lt Brn med SAND w/ tr silt (stiff, moist)
1.0 - 3.0	ML	Lt Brn sandy SILT (med stiff, moist)
3.0 - 5.0	SM	Gry SAND w/ silt (med stiff, moist)
5.0 - 6.0	SM	Gry SAND w/ tr silt (soft-med, moist) (SP-12)

No caving observed
No groundwater seepage observed

Appendix B

Laboratory Test Results

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.0	0.6	47.0	45.5	4.9	

Test Results (ASTM D 422 & ASTM C 117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.5	100.0		
.3125	99.1		
#4	98.0		
#10	97.4		
#20	95.8		
#40	50.4		
#60	13.8		
#100	6.5		
#200	4.9		

* (no specification provided)

Material Description

Grey poorly graded SAND
B-1 S-11 D@40'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 0.7775 D_{85}= 0.7204 D_{60}= 0.4919
D_{50}= 0.4224 D_{30}= 0.3162 D_{15}= 0.2544
D_{10}= 0.1919 C_u= 2.56 C_c= 1.06

Remarks

Date Received: **Date Tested:** 7/10/2017
Tested By: CC
Checked By:
Title:

Sample Number: 092801 **Date Sampled:** 7/5/2017

GeoResources, LLC

Fife, WA

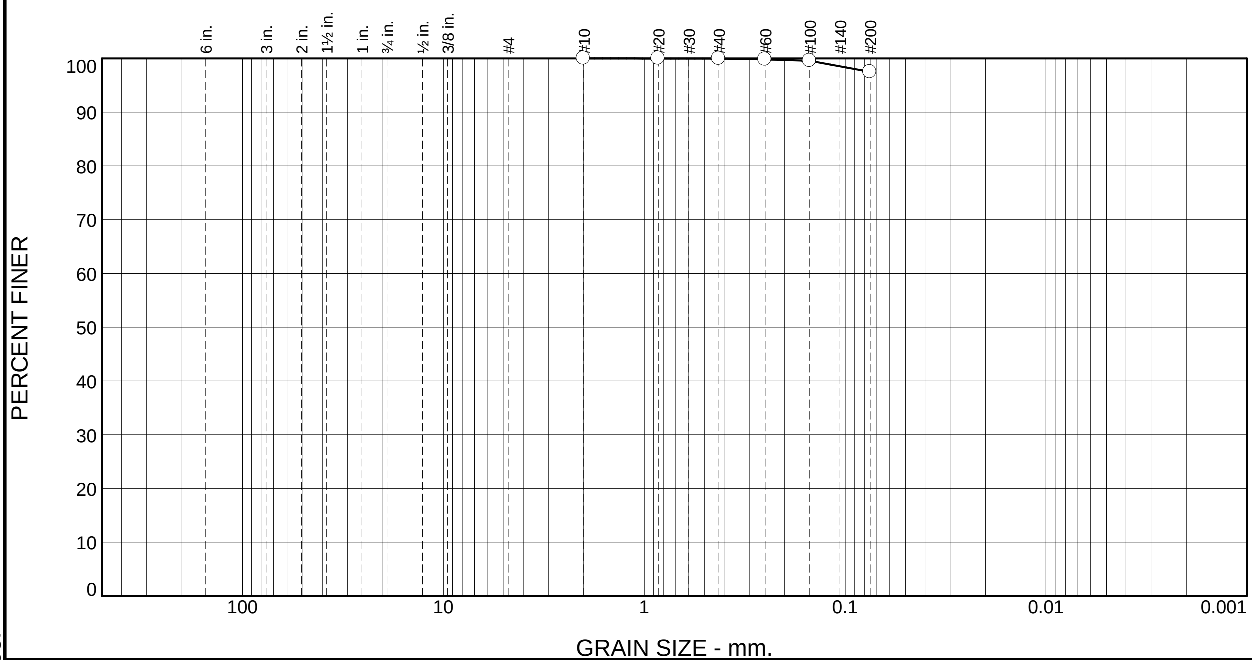
Client: SCJAlliance.BriggsWestKettle
Project: SCJAlliance.BriggsWestKettle

Project No: **Figure**

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

Tested By: ______ **Checked By:** ______

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	2.5	97.5	

Test Results (ASTM D 422 & ASTM C 117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	100.0		
#40	100.0		
#60	99.8		
#100	99.6		
#200	97.5		

* (no specification provided)

Material Description

Tan SILT
B-2 S-5 D@12.5'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 7/10/2017

Tested By: CC

Checked By:

Title:

Sample Number: 092802 **Date Sampled:** 7/5/2017

GeoResources, LLC

Fife, WA

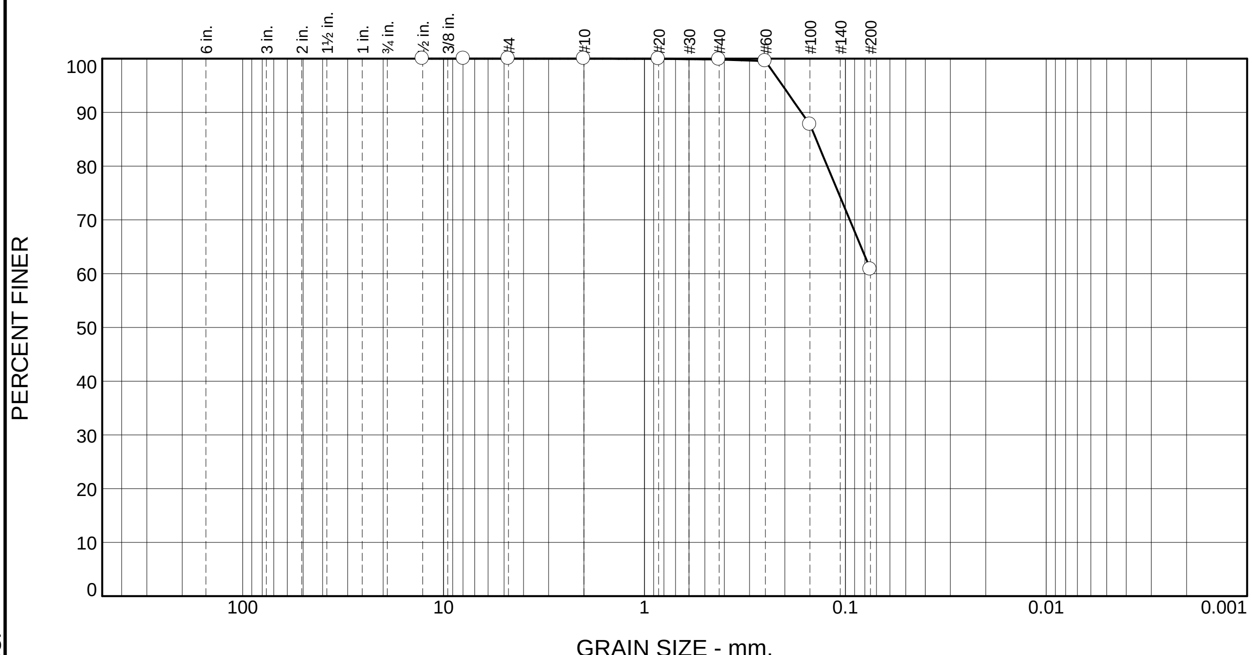
Client: SCJAlliance.BriggsWestKettle
Project: SCJAlliance.BriggsWestKettle

Project No: **Figure**

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

Tested By: ____________ **Checked By:** ____________

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	39.1	60.8	

Test Results (ASTM D 422 & ASTM C 117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.5	100.0		
.3125	100.0		
#4	100.0		
#10	100.0		
#20	100.0		
#40	99.9		
#60	99.5		
#100	87.7		
#200	60.8		

* (no specification provided)

Material Description

Tan grey sandy SILT
B-2 S-2 D@5'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.1654 D_{85}= 0.1398 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 7/10/2017
Tested By: CC
Checked By:
Title:

Sample Number: 092803 **Date Sampled:** 7/5/2017

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

GeoResources, LLC

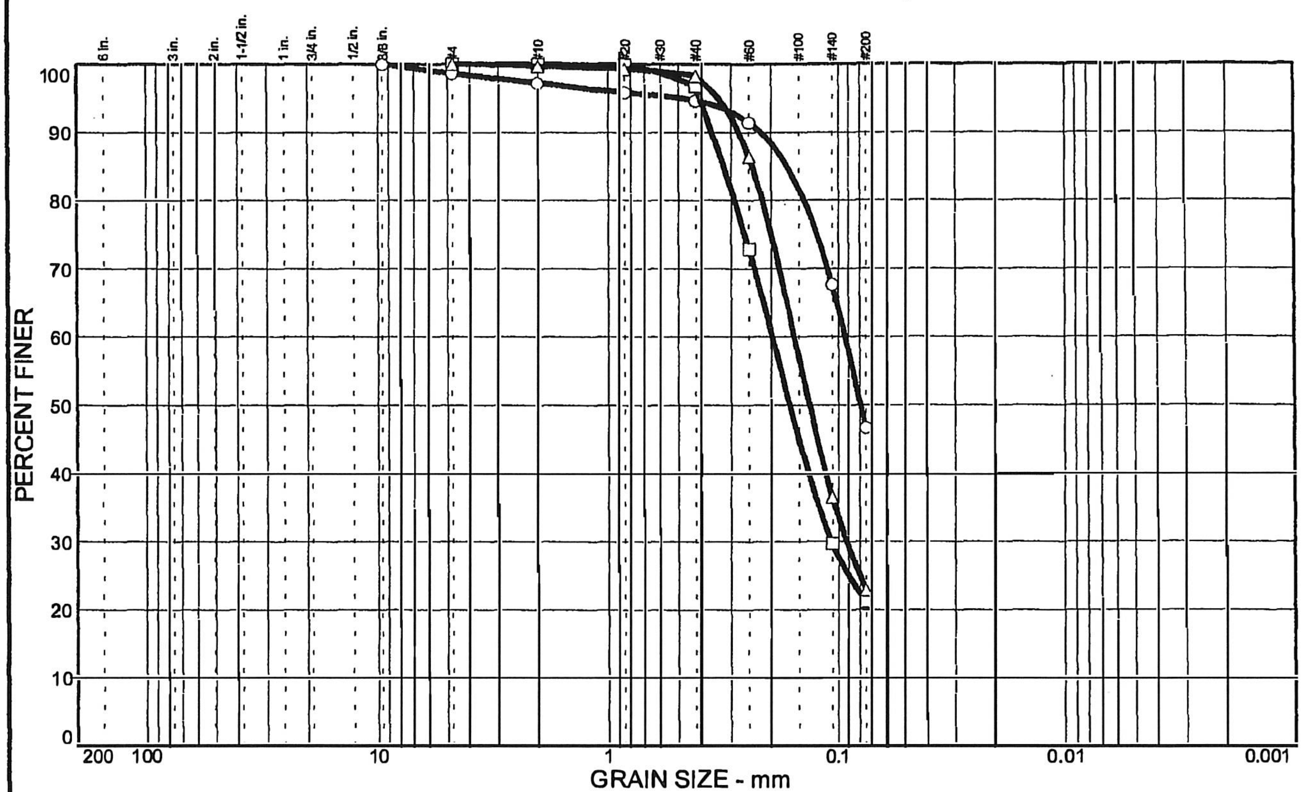
Fife, WA

Client: SCJAlliance.BriggsWestKettle
Project: SCJAlliance.BriggsWestKettle
Project No: **Figure**

Tested By: ______________ **Checked By:** ______________

Previous Laboratory Test Results
(GeoResources, 2005)

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		1.4	52.0	46.6		SM			
□			78.8	21.2		SM			
△			77.1	22.9		SM			

SIEVE inches size	PERCENT FINER ○	PERCENT FINER □	PERCENT FINER △
.375	100.0		
	GRAIN SIZE		
D_{60}	0.0927	0.197	0.157
D_{30}		0.107	0.0913
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	PERCENT FINER □	PERCENT FINER △
#4	98.6	100.0	100.0
#10	97.2	100.0	99.7
#20	95.8	99.9	99.3
#40	94.6	96.8	98.3
#60	91.4	72.9	86.4
#140	67.6	29.7	36.5
#200	46.6	21.2	22.9

SOIL DESCRIPTION

○ Silty sand

□ Silty sand

△ Silty sand

REMARKS:

○ Classification based on grainsize only

□ Classification based on grainsize only

△ Classification based on grainsize only

○ Source: TP-1 Sample No.: SP-1 Elev./Depth: 3-5

□ Source: TP-2 Sample No.: SP-2 Elev./Depth: 4-6

△ Source: TP-3 Sample No.: SP-3 Elev./Depth: 0.5-2

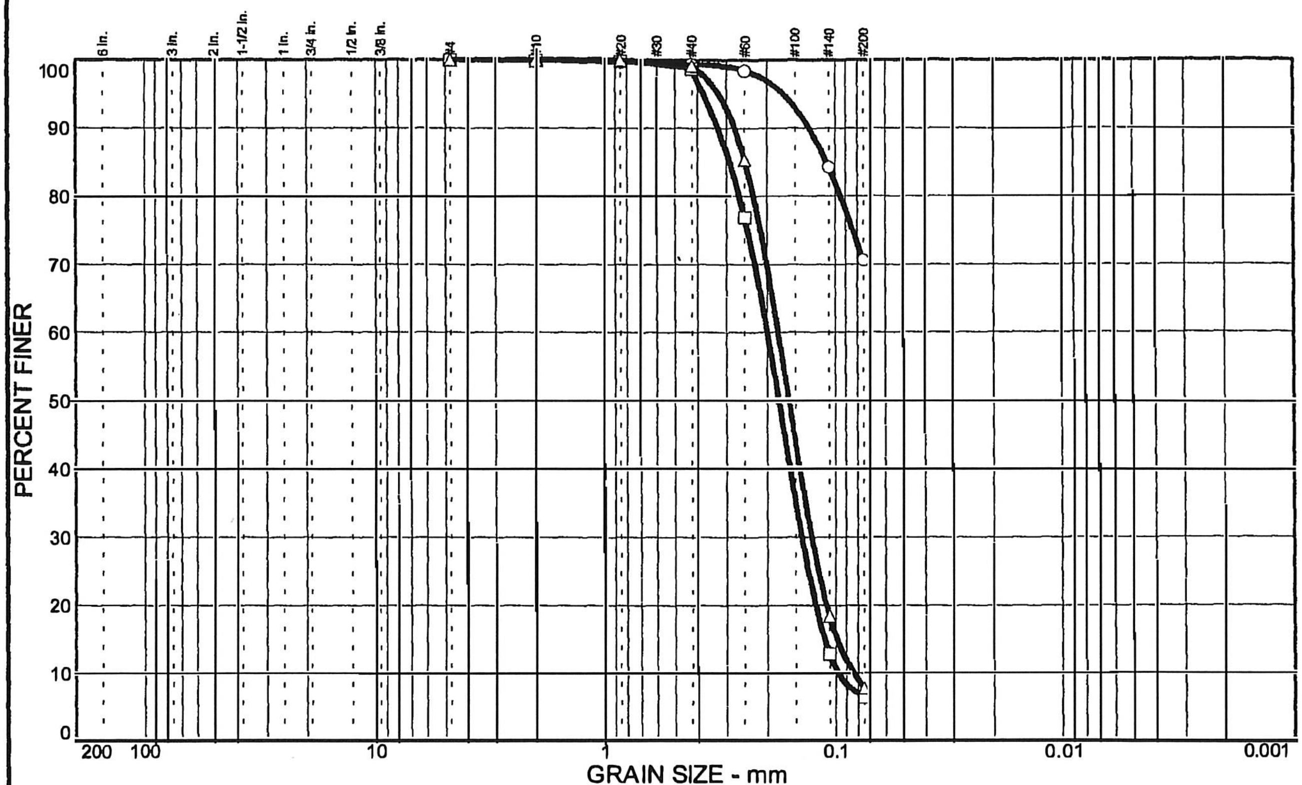
SOIL TECHNOLOGY

Client: GeoResources

Project: Briggs Villiage West

Project No.: 05-2089 Plate 1

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			29.4	70.6		ML			
□			93.5	6.5		SP-SM			
△			92.2	7.8		SP-SM			

SIEVE inches size	PERCENT FINER ○	□	△
GRAIN SIZE			
D_{60}		0.200	0.179
D_{30}		0.140	0.127
D_{10}		0.0972	0.0832
COEFFICIENTS			
C_c		1.01	1.08
C_u		2.06	2.15

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	100.0	100.0
#10	99.9	99.9	100.0
#20	99.7	99.8	100.0
#40	99.4	98.7	99.2
#60	98.4	76.9	85.4
#140	84.2	12.8	18.4
#200	70.6	6.5	7.8

SOIL DESCRIPTION

○ Silt with sand

□ Poorly graded sand with silt

△ Poorly graded sand with silt

REMARKS:

○ Classification based on grainsize only

□ Classification based on grainsize only

△ Classification based on grainsize only

○ Source: TP-4 Sample No.: SP-4 Elev./Depth: 5-7

□ Source: TP-5 Sample No.: SP-5 Elev./Depth: 2-4

△ Source: TP-6 Sample No.: SP-6 Elev./Depth: 5-8

SOIL TECHNOLOGY

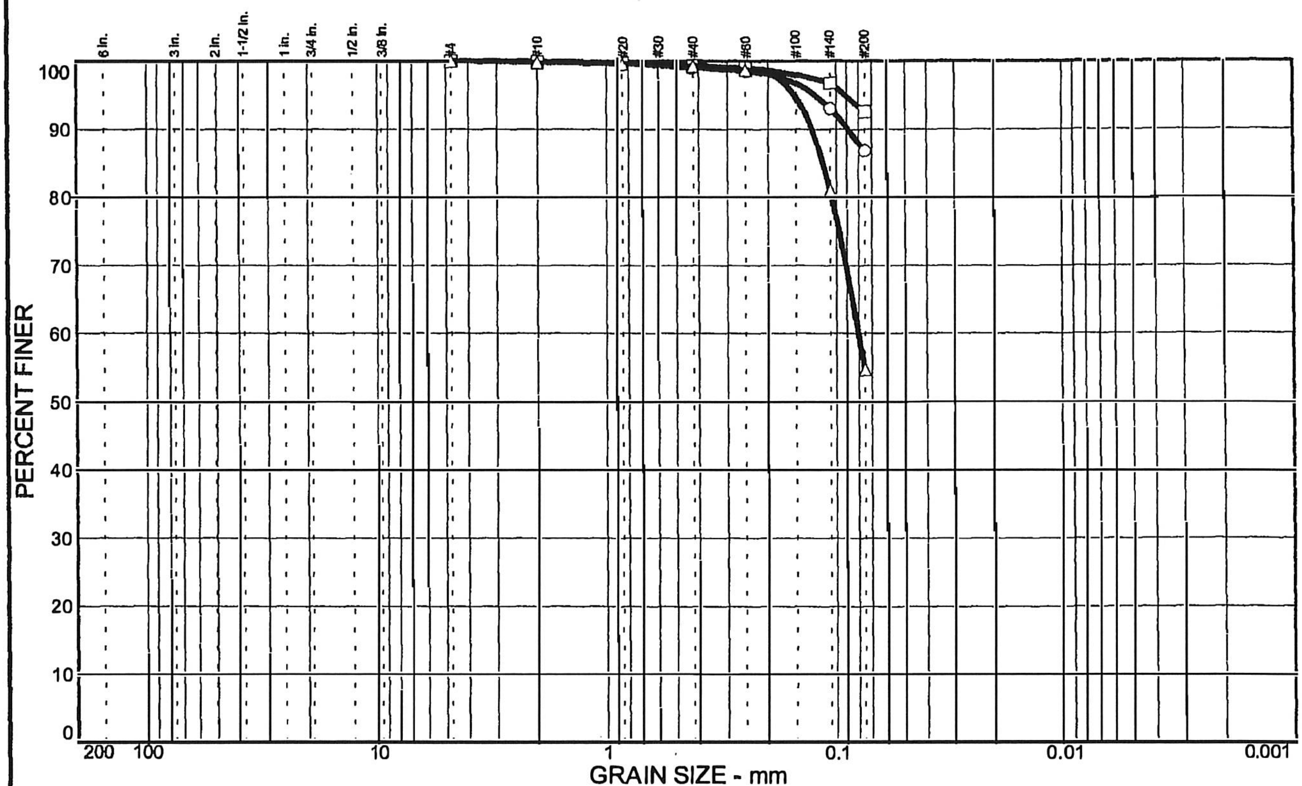
Client: GeoResources

Project: Briggs Villiage West

Project No.: 05-2089

Plate 2

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			13.2	86.8		ML			
□			7.4	92.6		ML			
△			45.3	54.7		ML			

SIEVE inches size	PERCENT FINER ○	□	△

	GRAIN SIZE ○	□	△
D_{60}			0.0799
D_{30}			
D_{10}			

	COEFFICIENTS ○	□	△
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	100.0	100.0
#10	100.0	99.9	99.8
#20	99.8	99.7	99.6
#40	99.0	99.4	99.3
#60	98.5	99.0	98.7
#140	93.0	96.8	81.0
#200	86.8	92.6	54.7

SOIL DESCRIPTION

○ Silt

□ Silt

△ Sandy silt

REMARKS:

○ Classification based on grainsize only

□ Classification based on grainsize only

△ Classification based on grainsize only

○ Source: TP-7 Sample No.: SP-7 Elev./Depth: 8-10

□ Source: TP-8 Sample No.: SP-8 Elev./Depth: 4-6

△ Source: TP-9 Sample No.: SP-9 Elev./Depth: 4-5

SOIL TECHNOLOGY

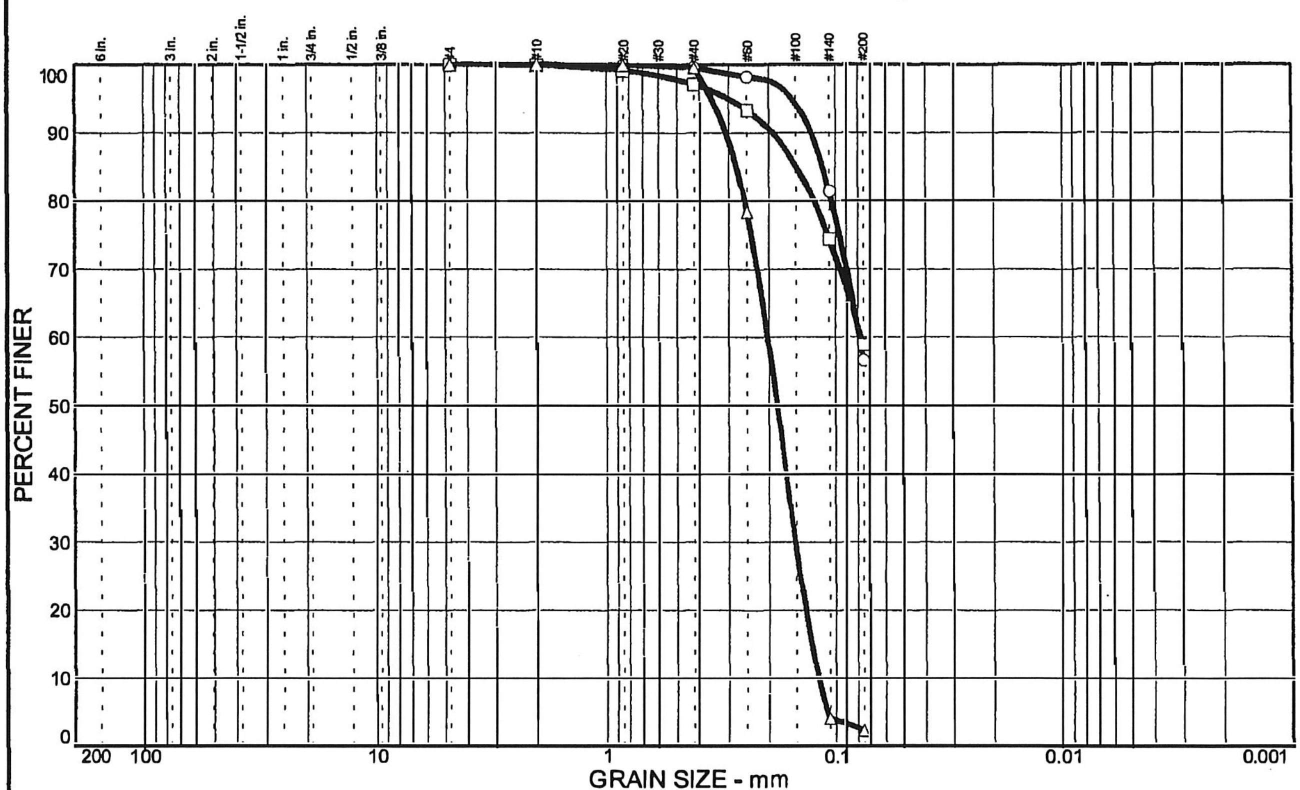
Client: GeoResources

Project: Briggs Villiage West

Project No.: 05-2089

Plate 3

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			43.4	56.6		ML			
□			41.1	58.9		ML			
△			97.7	2.3		SP			

SIEVE inches size	PERCENT FINER ○	□	△

GRAIN SIZE	○	□	△
D_{60}	0.0783	0.0767	0.203
D_{30}			0.151
D_{10}			0.119

COEFFICIENTS	○	□	△
C_c			0.95
C_u			1.70

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	100.0	100.0
#10	100.0	99.9	100.0
#20	99.9	99.1	99.9
#40	99.6	97.1	99.6
#60	98.2	93.3	78.4
#140	81.4	74.4	4.1
#200	56.6	58.9	2.3

SOIL DESCRIPTION

○ Sandy silt

□ Sandy silt

△ Poorly graded sand

REMARKS:

○ Classification based on grainsize only

□ Classification based on grainsize only

△ Classification based on grainsize only

○ Source: TP-10 Sample No.: SP-10 Elev./Depth: 4-6

□ Source: TP-11 Sample No.: S-11 Elev./Depth: 2.5-5

△ Source: TP-12 Sample No.: SP-12 Elev./Depth: 5-6

SOIL TECHNOLOGY

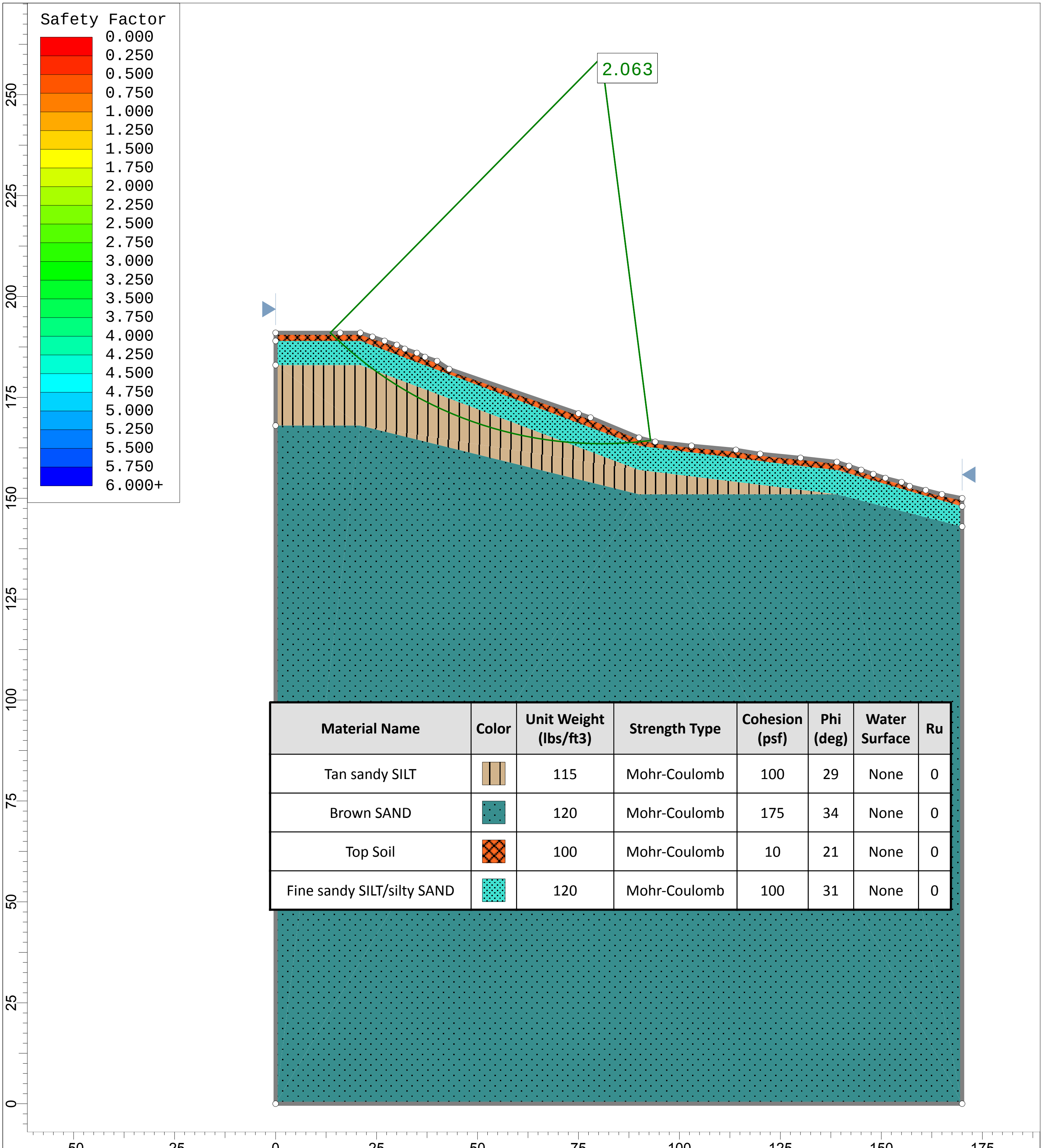
Client: GeoResources

Project: Briggs Villiage West

Project No.: 05-2089

Plate 4

Appendix C
Slope Stability Analysis



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Tan sandy SILT		115	Mohr-Coulomb	100	29	None	0
Brown SAND		120	Mohr-Coulomb	175	34	None	0
Top Soil		100	Mohr-Coulomb	10	21	None	0
Fine sandy SILT/silty SAND		120	Mohr-Coulomb	100	31	None	0

SLIDEINTERPRET 7.022

Project
SLIDE - An Interactive Slope Stability Program

Analysis Description

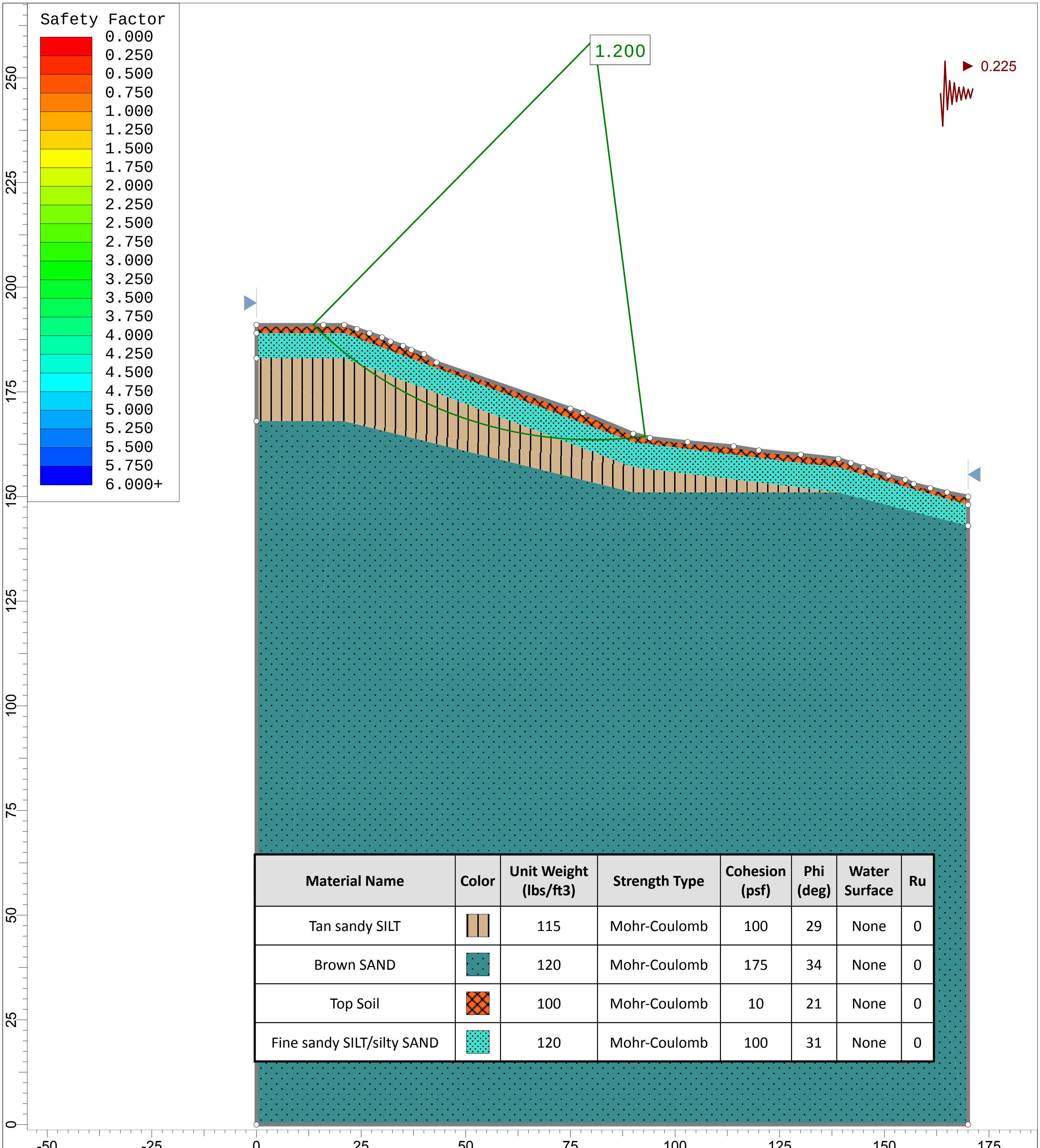
Drawn By

Scale 1:385

Company

Date 8/25/2017, 1:29:02 PM

File Name SCJAlliance.BriggsWestKettle.dcb.slide.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Tan sandy SILT		115	Mohr-Coulomb	100	29	None	0
Brown SAND		120	Mohr-Coulomb	175	34	None	0
Top Soil		100	Mohr-Coulomb	10	21	None	0
Fine sandy SILT/silty SAND		120	Mohr-Coulomb	100	31	None	0

SLIDEINTERPRET 7.022

Project
SLIDE - An Interactive Slope Stability Program

Analysis Description

Drawn By

Scale 1:371

Company

Date 8/25/2017, 1:29:02 PM

File Name SCJAlliance.BriggsWestKettle.dcb.slide.slmd

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name:	SCJAlliance.BriggsWestKettle.dcb.slide.slmd - A-A' - Existing - Seismic
Slide Modeler Version:	7.022
Project Title:	SLIDE - An Interactive Slope Stability Program
Date Created:	8/25/2017, 1:29:02 PM

General Settings

Units of Measurement:	Imperial Units
Time Units:	days
Permeability Units:	feet/second
Failure Direction:	Left to Right
Data Output:	Standard
Maximum Material Properties:	20
Maximum Support Properties:	20

Analysis Options

Slices Type:	Vertical

Analysis Methods Used	
	Bishop simplified
	Janbu simplified

Number of slices:	50
Tolerance:	0.005
Maximum number of iterations:	75
Check malpha < 0.2:	Yes
Create Interslice boundaries at intersections with water tables and piezos:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Groundwater Analysis

Groundwater Method:	Water Surfaces
Pore Fluid Unit Weight [lbs/ft3]:	9.81
Use negative pore pressure cutoff:	Yes
Maximum negative pore pressure [psf]:	0
Advanced Groundwater Method:	None

Random Numbers

Pseudo-random Seed:	10116
Random Number Generation Method:	Park and Miller v.3

Surface Options

Surface Type:	Circular
Search Method:	Slope Search
Number of Surfaces:	5000
Upper Angle:	Not Defined
Lower Angle:	Not Defined
Composite Surfaces:	Disabled
Reverse Curvature:	Invalid Surfaces
Minimum Elevation:	Not Defined
Minimum Depth [ft]:	3
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Seismic

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No

Loading

Seismic Load Coefficient (Horizontal): 0.225

Material Properties

Property	Tan sandy SILT	Brown SAND	Top Soil	Fine sandy SILT/silty SAND
Color				
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	115	120	100	120
Cohesion [psf]	100	175	10	100
Friction Angle [deg]	29	34	21	31
Water Surface	None	None	None	None
Ru Value	0	0	0	0

Global Minimums

Method: bishop simplified

FS	1.200240
Center:	80.691, 259.263
Radius:	95.748
Left Slip Surface Endpoint:	13.550, 191.000
Right Slip Surface Endpoint:	92.845, 164.289
Resisting Moment:	4.27145e+006 lb-ft
Driving Moment:	3.55883e+006 lb-ft
Total Slice Area:	630.287 ft2
Surface Horizontal Width:	79.295 ft
Surface Average Height:	7.94863 ft

Method: janbu simplified

FS	1.132000
Center:	74.699, 243.281
Radius:	81.923
Left Slip Surface Endpoint:	11.627, 191.000
Right Slip Surface Endpoint:	94.933, 163.896
Resisting Horizontal Force:	54166.1 lb
Driving Horizontal Force:	47849.8 lb
Total Slice Area:	855.018 ft2
Surface Horizontal Width:	83.3066 ft
Surface Average Height:	10.2635 ft

Valid / Invalid Surfaces

Method: bishop simplified

Number of Valid Surfaces: 4999
Number of Invalid Surfaces: 1

Error Codes:

Error Code -114 reported for 1 surface

Method: janbu simplified

Number of Valid Surfaces: 4999
Number of Invalid Surfaces: 1

Error Codes:

Error Code -114 reported for 1 surface

Error Codes

The following errors were encountered during the computation:

-114 = Surface with Reverse Curvature.

Slice Data

Global Minimum Query (bishop simplified) - Safety Factor: 1.20024

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	2.0959	209.59	-43.6587	Top Soil	10	21	30.8915	37.0772	70.5387	0	70.5387	100.017	100.017
2	1.50237	423.208	-42.1853	Fine sandy SILT/silty SAND	100	31	154.349	185.256	141.89	0	141.89	281.773	281.773
3	1.50237	663.597	-40.9831	Fine sandy SILT/silty SAND	100	31	212.201	254.692	257.45	0	257.45	441.804	441.804
4	1.50237	894.096	-39.8026	Fine sandy SILT/silty SAND	100	31	269.07	322.949	371.049	0	371.049	595.25	595.25
5	1.50237	1106.44	-38.6419	Fine sandy SILT/silty SAND	100	31	322.855	387.503	478.486	0	478.486	736.604	736.604
6	1.50237	1241.04	-37.4998	Fine sandy SILT/silty SAND	100	31	359.018	430.908	550.723	0	550.723	826.206	826.206
7	1.50237	1352.46	-36.3749	Fine sandy SILT/silty SAND	100	31	390.182	468.312	612.977	0	612.977	900.38	900.38
8	1.56306	1514.53	-35.244	Tan sandy SILT	100	29	400.267	480.417	686.291	0	686.291	969.109	969.109
9	1.56306	1613.67	-34.1065	Tan sandy SILT	100	29	426.718	512.164	743.563	0	743.563	1032.54	1032.54
10	1.56306	1704.74	-32.9841	Tan sandy SILT	100	29	451.696	542.144	797.649	0	797.649	1090.81	1090.81

11	1.56306	1781.09	-31.8759	Tan sandy SILT	100	29	473.623	568.461	845.125	0	845.125	1139.65	1139.65
12	1.56306	1821.57	-30.7808	Tan sandy SILT	100	29	487.497	585.113	875.165	0	875.165	1165.55	1165.55
13	1.56306	1880.27	-29.698	Tan sandy SILT	100	29	505.736	607.004	914.658	0	914.658	1203.1	1203.1
14	1.56306	1938.81	-28.6268	Tan sandy SILT	100	29	524.123	629.073	954.474	0	954.474	1240.55	1240.55
15	1.56306	1960.79	-27.5665	Tan sandy SILT	100	29	533.992	640.919	975.845	0	975.845	1254.61	1254.61
16	1.56306	1992.67	-26.5163	Tan sandy SILT	100	29	546.279	655.666	1002.45	0	1002.45	1275.01	1275.01
17	1.56306	2033.04	-25.4756	Tan sandy SILT	100	29	560.703	672.978	1033.68	0	1033.68	1300.83	1300.83
18	1.56306	2014.12	-24.4438	Tan sandy SILT	100	29	560.77	673.058	1033.82	0	1033.82	1288.72	1288.72
19	1.56306	1964.94	-23.4204	Tan sandy SILT	100	29	553.274	664.061	1017.59	0	1017.59	1257.25	1257.25
20	1.56306	1964.71	-22.4049	Tan sandy SILT	100	29	557.696	669.369	1027.17	0	1027.17	1257.09	1257.09
21	1.56306	1979.88	-21.3967	Tan sandy SILT	100	29	565.948	679.273	1045.04	0	1045.04	1266.79	1266.79
22	1.56306	1989.36	-20.3955	Tan sandy SILT	100	29	572.804	687.502	1059.88	0	1059.88	1272.85	1272.85
23	1.56306	1993.27	-19.4007	Tan sandy SILT	100	29	578.264	694.056	1071.7	0	1071.7	1275.35	1275.35
24	1.56306	1991.72	-18.412	Tan sandy SILT	100	29	582.327	698.932	1080.5	0	1080.5	1274.35	1274.35
25	1.56306	1984.79	-17.4289	Tan sandy SILT	100	29	584.989	702.127	1086.27	0	1086.27	1269.91	1269.91
26	1.56306	1972.58	-16.4511	Tan sandy SILT	100	29	586.246	703.636	1088.99	0	1088.99	1262.1	1262.1
27	1.56306	1955.17	-15.4782	Tan sandy SILT	100	29	586.093	703.452	1088.66	0	1088.66	1250.95	1250.95
28	1.56306	1932.64	-14.5098	Tan sandy SILT	100	29	584.522	701.567	1085.26	0	1085.26	1236.53	1236.53
29	1.56306	1905.05	-13.5457	Tan sandy SILT	100	29	581.527	697.972	1078.77	0	1078.77	1218.87	1218.87
30	1.56306	1872.46	-12.5854	Tan sandy SILT	100	29	577.097	692.655	1069.18	0	1069.18	1198.02	1198.02
31	1.56306	1834.95	-11.6288	Tan sandy SILT	100	29	571.222	685.604	1056.46	0	1056.46	1174.01	1174.01
32	1.56306	1792.55	-10.6754	Tan sandy SILT	100	29	563.89	676.803	1040.58	0	1040.58	1146.88	1146.88
33	1.56306	1745.31	-9.725	Tan sandy SILT	100	29	555.087	666.238	1021.52	0	1021.52	1116.65	1116.65
34	1.56306	1693.28	-8.7773	Tan sandy SILT	100	29	544.799	653.889	999.24	0	999.24	1083.36	1083.36
35	1.56306	1636.51	-7.83201	Tan sandy SILT	100	29	533.008	639.738	973.711	0	973.711	1047.03	1047.03
36	1.56306	1575.01	-6.88886	Tan sandy SILT	100	29	519.699	623.763	944.89	0	944.89	1007.68	1007.68
37	1.56306	1508.82	-5.94758	Tan sandy SILT	100	29	504.847	605.938	912.735	0	912.735	965.329	965.329
38	1.63598	1501.28	-4.98603	Fine sandy SILT/silty SAND	100	31	520.015	624.143	872.321	0	872.321	917.689	917.689
39	1.63598	1414.36	-4.00399	Fine sandy SILT/silty SAND	100	31	498.653	598.503	829.649	0	829.649	864.553	864.553
40	1.63598	1323.02	-3.02313	Fine sandy SILT/silty SAND	100	31	475.598	570.832	783.594	0	783.594	808.711	808.711
41	1.63598	1227.79	-2.04315	Fine sandy SILT/silty SAND	100	31	450.975	541.278	734.408	0	734.408	750.496	750.496
42	1.63598	1114.69	-1.06378	Fine sandy SILT/silty SAND	100	31	420.511	504.714	673.56	0	673.56	681.368	681.368
43	1.63598	986.224	-0.084709	Fine sandy SILT/silty SAND	100	31	384.821	461.877	602.265	0	602.265	602.834	602.834
44	1.63598	852.266	0.894333	Fine sandy SILT/silty SAND	100	31	346.823	416.271	526.363	0	526.363	520.949	520.949
45	1.63598	712.818	1.87364	Fine sandy SILT/silty SAND	100	31	306.458	367.823	445.733	0	445.733	435.708	435.708
46	1.63598	567.873	2.85349	Fine sandy SILT/silty SAND	100	31	263.664	316.46	360.25	0	360.25	347.108	347.108
47	1.63598	417.418	3.83417	Fine sandy SILT/silty SAND	100	31	218.371	262.098	269.775	0	269.775	255.14	255.14
48	1.64443	274.839	4.81853	Top Soil	10	21	63.4954	76.2097	172.482	0	172.482	167.13	167.13
49	1.64443	149.029	5.80685	Top Soil	10	21	38.5697	46.2929	94.5462	0	94.5462	90.6238	90.6238
50	1.64443	49.9173	6.79691	Top Soil	10	21	18.7545	22.5099	32.5894	0	32.5894	30.3541	30.3541

Global Minimum Query (janbu simplified) - Safety Factor: 1.132

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.71279	171.279	-49.4234	Top Soil	10	21	30.6448	34.6899	64.3195	0	64.3195	100.103	100.103
2	1.47082	437	-47.7377	Fine sandy SILT/silty SAND	100	31	155.486	176.01	126.502	0	126.502	297.605	297.605
3	1.47082	715.329	-46.2294	Fine sandy SILT/silty SAND	100	31	223.184	252.644	254.043	0	254.043	487.016	487.016
4	1.47082	979.544	-44.7615	Fine sandy SILT/silty SAND	100	31	289.754	328.002	379.458	0	379.458	666.81	666.81

5	1.47082	1230.71	-43.33	Fine sandy SILT/silty SAND	100	31	355.158	402.039	502.678	0	502.678	837.714	837.714
6	1.68598	1697.4	-41.8316	Tan sandy SILT	100	29	404.531	457.929	645.72	0	645.72	1007.81	1007.81
7	1.68598	1932.58	-40.2676	Tan sandy SILT	100	29	459.557	520.219	758.096	0	758.096	1147.38	1147.38
8	1.68598	2091.5	-38.7391	Tan sandy SILT	100	29	499.95	565.943	840.583	0	840.583	1241.68	1241.68
9	1.68598	2236.06	-37.2426	Tan sandy SILT	100	29	538.058	609.082	918.408	0	918.408	1327.45	1327.45
10	1.68598	2367.27	-35.7752	Tan sandy SILT	100	29	573.953	649.715	991.71	0	991.71	1405.28	1405.28
11	1.68598	2485.87	-34.3345	Tan sandy SILT	100	29	607.67	687.882	1060.57	0	1060.57	1475.63	1475.63
12	1.68598	2583.75	-32.9182	Tan sandy SILT	100	29	637.31	721.435	1121.1	0	1121.1	1533.68	1533.68
13	1.68598	2639.48	-31.5242	Tan sandy SILT	100	29	657.905	744.749	1163.16	0	1163.16	1566.7	1566.7
14	1.68598	2715.93	-30.1507	Tan sandy SILT	100	29	683.342	773.543	1215.1	0	1215.1	1612.03	1612.03
15	1.68598	2780.12	-28.7961	Tan sandy SILT	100	29	706.247	799.472	1261.88	0	1261.88	1650.08	1650.08
16	1.68598	2804.66	-27.4588	Tan sandy SILT	100	29	720.186	815.251	1290.35	0	1290.35	1664.59	1664.59
17	1.68598	2851.97	-26.1377	Tan sandy SILT	100	29	739.481	837.093	1329.75	0	1329.75	1692.62	1692.62
18	1.68598	2875.3	-24.8313	Tan sandy SILT	100	29	753.252	852.681	1357.87	0	1357.87	1706.42	1706.42
19	1.68598	2821.52	-23.5385	Tan sandy SILT	100	29	748.595	847.41	1348.36	0	1348.36	1674.46	1674.46
20	1.68598	2790.99	-22.2584	Tan sandy SILT	100	29	749.224	848.122	1349.65	0	1349.65	1656.29	1656.29
21	1.68598	2806.32	-20.9898	Tan sandy SILT	100	29	760.87	861.305	1373.43	0	1373.43	1665.35	1665.35
22	1.68598	2813.88	-19.732	Tan sandy SILT	100	29	770.634	872.358	1393.37	0	1393.37	1669.78	1669.78
23	1.68598	2813.36	-18.4839	Tan sandy SILT	100	29	778.398	881.146	1409.23	0	1409.23	1669.43	1669.43
24	1.68598	2804.96	-17.245	Tan sandy SILT	100	29	784.155	887.664	1420.99	0	1420.99	1664.4	1664.4
25	1.68598	2788.82	-16.0142	Tan sandy SILT	100	29	787.904	891.907	1428.64	0	1428.64	1654.78	1654.78
26	1.68598	2765.11	-14.7911	Tan sandy SILT	100	29	789.632	893.863	1432.17	0	1432.17	1640.67	1640.67
27	1.68598	2733.96	-13.5747	Tan sandy SILT	100	29	789.326	893.517	1431.54	0	1431.54	1622.13	1622.13
28	1.68598	2695.47	-12.3646	Tan sandy SILT	100	29	786.973	890.853	1426.74	0	1426.74	1599.26	1599.26
29	1.68598	2649.77	-11.1601	Tan sandy SILT	100	29	782.553	885.85	1417.71	0	1417.71	1572.09	1572.09
30	1.68598	2596.94	-9.96053	Tan sandy SILT	100	29	776.046	878.484	1404.42	0	1404.42	1540.71	1540.71
31	1.68598	2537.07	-8.76537	Tan sandy SILT	100	29	767.424	868.724	1386.81	0	1386.81	1505.14	1505.14
32	1.68598	2470.22	-7.57405	Tan sandy SILT	100	29	756.662	856.541	1364.84	0	1364.84	1465.45	1465.45
33	1.68598	2396.47	-6.38601	Tan sandy SILT	100	29	743.723	841.895	1338.42	0	1338.42	1421.65	1421.65
34	1.68598	2315.86	-5.20072	Tan sandy SILT	100	29	728.575	824.747	1307.48	0	1307.48	1373.79	1373.79
35	1.68598	2228.44	-4.01767	Tan sandy SILT	100	29	711.174	805.049	1271.94	0	1271.94	1321.89	1321.89
36	1.68598	2134.24	-2.83632	Tan sandy SILT	100	29	691.477	782.752	1231.72	0	1231.72	1265.98	1265.98
37	1.68598	2033.29	-1.65619	Tan sandy SILT	100	29	669.432	757.797	1186.7	0	1186.7	1206.05	1206.05
38	1.68598	1925.59	-0.476751	Tan sandy SILT	100	29	644.984	730.122	1136.77	0	1136.77	1142.14	1142.14
39	1.68598	1812.42	0.702482	Tan sandy SILT	100	29	618.436	700.07	1082.55	0	1082.55	1074.97	1074.97
40	1.68598	1693.99	1.88201	Tan sandy SILT	100	29	589.801	667.655	1024.07	0	1024.07	1004.69	1004.69
41	1.77079	1624.87	3.09206	Fine sandy SILT/silty SAND	100	31	592.331	670.519	949.503	0	949.503	917.506	917.506
42	1.77079	1446.17	4.33322	Fine sandy SILT/silty SAND	100	31	543.632	615.391	857.757	0	857.757	816.564	816.564
43	1.77079	1259.26	5.57643	Fine sandy SILT/silty SAND	100	31	491.185	556.021	758.944	0	758.944	710.987	710.987
44	1.77079	1064.09	6.82227	Fine sandy SILT/silty SAND	100	31	434.837	492.235	652.787	0	652.787	600.764	600.764
45	1.77079	860.619	8.07137	Fine sandy SILT/silty SAND	100	31	374.413	423.835	538.952	0	538.952	485.856	485.856
46	1.77079	648.762	9.32434	Fine sandy SILT/silty SAND	100	31	309.722	350.605	417.077	0	417.077	366.223	366.223
47	1.77079	432.712	10.5818	Fine sandy SILT/silty SAND	100	31	241.97	273.91	289.435	0	289.435	244.231	244.231
48	1.43525	228.666	11.7244	Top Soil	10	21	67.6042	76.528	173.311	0	173.311	159.281	159.281
49	1.43525	132.483	12.7516	Top Soil	10	21	43.461	49.1979	102.114	0	102.114	92.2786	92.2786
50	1.43525	38.4595	13.783	Top Soil	10	21	19.5415	22.121	31.5763	0	31.5763	26.7826	26.7826

Interslice Data

Global Minimum Query (bishop simplified) - Safety Factor: 1.20024

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	13.55	191	0	0	0
2	15.6459	189	123.526	0	0
3	17.1483	187.638	180.18	0	0
4	18.6506	186.333	346.892	0	0
5	20.153	185.081	608.543	0	0
6	21.6554	183.88	947.438	0	0
7	23.1577	182.727	1322.47	0	0
8	24.6601	181.621	1719.24	0	0
9	26.2232	180.516	2192.67	0	0
10	27.7862	179.458	2676.22	0	0
11	29.3493	178.443	3163.33	0	0
12	30.9124	177.471	3645.65	0	0
13	32.4754	176.54	4108.78	0	0
14	34.0385	175.649	4557.2	0	0
15	35.6015	174.796	4988.97	0	0
16	37.1646	173.98	5392.23	0	0
17	38.7277	173.2	5768.96	0	0
18	40.2907	172.455	6120.28	0	0
19	41.8538	171.745	6431.94	0	0
20	43.4168	171.068	6698.71	0	0
21	44.9799	170.423	6931.46	0	0
22	46.543	169.811	7132.86	0	0
23	48.106	169.23	7301.6	0	0
24	49.6691	168.679	7436.66	0	0
25	51.2321	168.159	7537.31	0	0
26	52.7952	167.668	7603.06	0	0
27	54.3583	167.207	7633.69	0	0
28	55.9213	166.774	7629.22	0	0
29	57.4844	166.369	7589.95	0	0
30	59.0474	165.993	7516.37	0	0
31	60.6105	165.644	7409.25	0	0
32	62.1736	165.322	7269.59	0	0
33	63.7366	165.027	7098.62	0	0
34	65.2997	164.759	6897.82	0	0
35	66.8627	164.518	6668.89	0	0
36	68.4258	164.303	6413.8	0	0
37	69.9889	164.114	6134.75	0	0
38	71.5519	163.951	5834.2	0	0
39	73.1879	163.809	5446.23	0	0
40	74.8239	163.694	5044.14	0	0
41	76.4598	163.608	4631.89	0	0
42	78.0958	163.549	4213.64	0	0
43	79.7318	163.519	3797.34	0	0
44	81.3678	163.517	3391.5	0	0
45	83.0038	163.542	3002.74	0	0
46	84.6397	163.596	2638.19	0	0
47	86.2757	163.677	2305.48	0	0
48	87.9117	163.787	2012.77	0	0
49	89.5561	163.926	1946.34	0	0
50	91.2006	164.093	1900.67	0	0
51	92.845	164.289	0	0	0

Global Minimum Query (janbu simplified) - Safety Factor: 1.132

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	11.6267	191	0	0	0
2	13.3395	189	114.839	0	0
3	14.8104	187.381	189.879	0	0
4	16.2812	185.846	413.548	0	0
5	17.752	184.387	762.482	0	0
6	19.2228	183	1215.98	0	0
7	20.9088	181.491	1892.29	0	0
8	22.5948	180.063	2637.23	0	0
9	24.2808	178.71	3404.32	0	0
10	25.9667	177.428	4180.02	0	0
11	27.6527	176.214	4952.55	0	0
12	29.3387	175.062	5711.63	0	0
13	31.0247	173.97	6445.22	0	0
14	32.7106	172.936	7135.95	0	0
15	34.3966	171.957	7788.22	0	0
16	36.0826	171.03	8395.87	0	0
17	37.7686	170.154	8946.69	0	0
18	39.4546	169.327	9445.36	0	0
19	41.1405	168.547	9885.32	0	0
20	42.8265	167.812	10252	0	0
21	44.5125	167.122	10551.7	0	0
22	46.1985	166.475	10792.4	0	0
23	47.8845	165.871	10972.6	0	0
24	49.5704	165.307	11091.2	0	0
25	51.2564	164.784	11147.7	0	0
26	52.9424	164.3	11142	0	0
27	54.6284	163.855	11074.2	0	0
28	56.3143	163.448	10945.2	0	0
29	58.0003	163.078	10756	0	0
30	59.6863	162.745	10508.1	0	0
31	61.3723	162.449	10203.6	0	0
32	63.0583	162.189	9844.84	0	0
33	64.7442	161.965	9434.56	0	0
34	66.4302	161.776	8976.03	0	0
35	68.1162	161.623	8472.91	0	0
36	69.8022	161.505	7929.35	0	0
37	71.4882	161.421	7349.97	0	0
38	73.1741	161.372	6739.9	0	0
39	74.8601	161.358	6104.81	0	0
40	76.5461	161.379	5450.55	0	0
41	78.2321	161.434	4783.43	0	0
42	80.0029	161.53	4012.32	0	0
43	81.7736	161.664	3262.72	0	0
44	83.5444	161.837	2547.56	0	0
45	85.3152	162.049	1880.89	0	0
46	87.086	162.3	1278.09	0	0
47	88.8568	162.591	755.921	0	0
48	90.6276	162.922	330.285	0	0
49	92.0628	163.219	233.362	0	0
50	93.4981	163.544	167.806	0	0
51	94.9333	163.896	0	0	0

List Of Coordinates

External Boundary

X	Y
0	0
170	0
170	143
170	148
170	150
165	151
161	152
157	153
155	154
151	155
148	156
145	157
142	158
139	159
130	160
120	161
114	162
103	163
94	164
90	165
78	170
75	171
43	182
40	184
37	185
35	186
32	187
30	188
27	189
24	190
21	191
16	191
0	191
0	189
0	183
0	168

Material Boundary

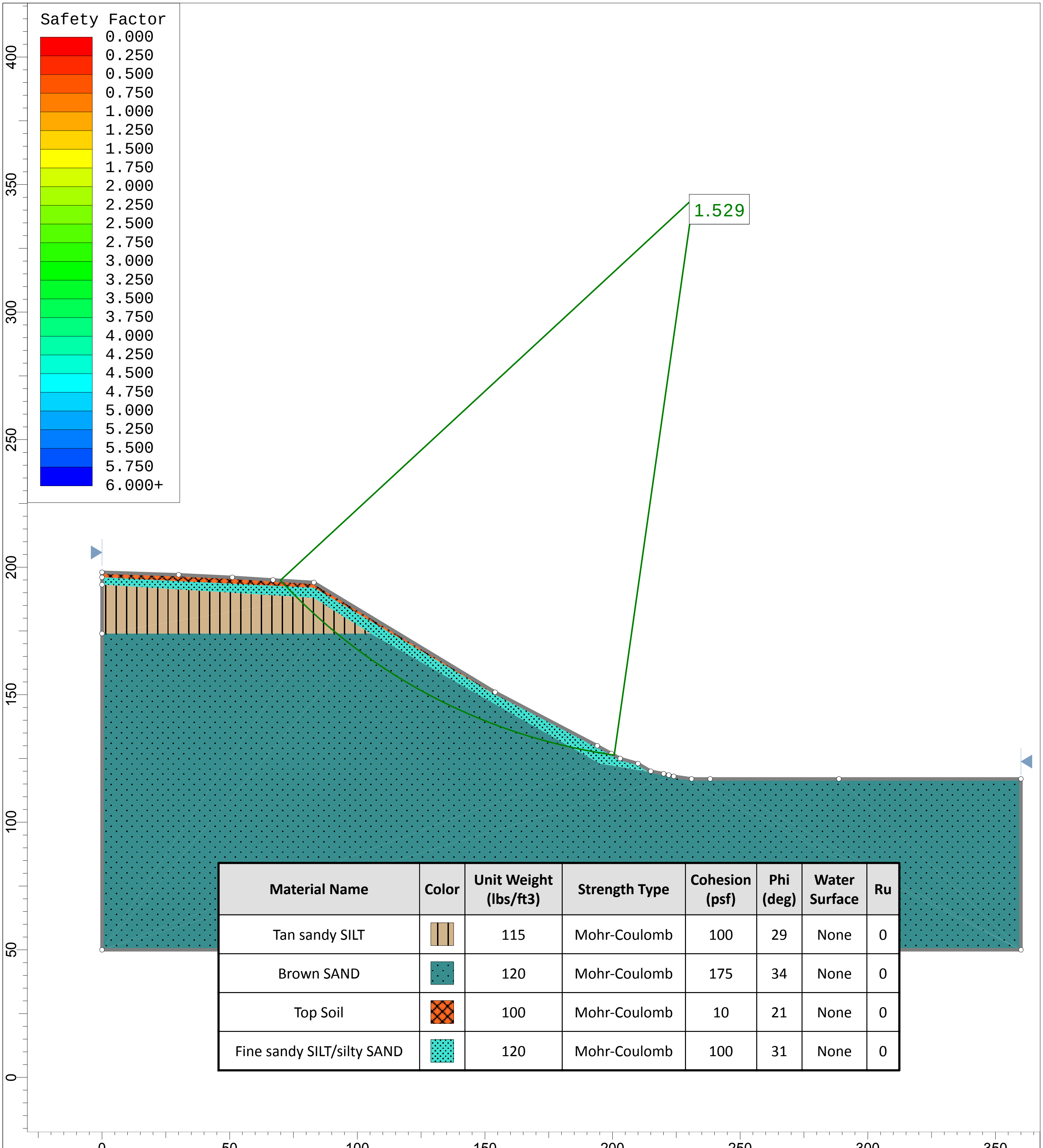
X	Y
0	189
21	189
90	163
130	158
139	157
170	148

Material Boundary

X	Y
0	183
21	183
90	157
139	151
170	143

Material Boundary

X	Y
0	168
21	168
90	151
139	151



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Tan sandy SILT		115	Mohr-Coulomb	100	29	None	0
Brown SAND		120	Mohr-Coulomb	175	34	None	0
Top Soil		100	Mohr-Coulomb	10	21	None	0
Fine sandy SILT/silty SAND		120	Mohr-Coulomb	100	31	None	0

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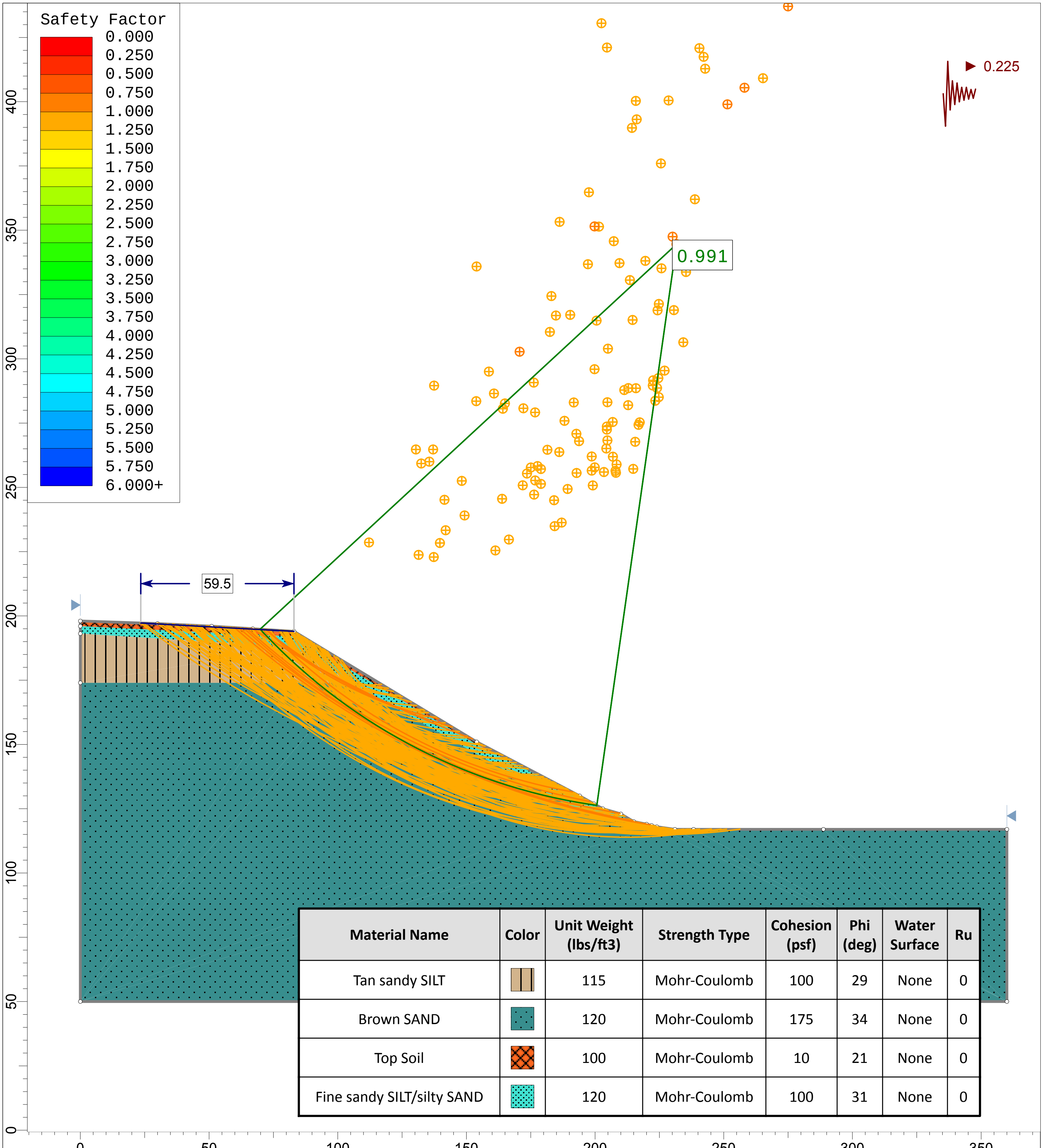
SLIDEINTERPRET 7.022

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description	SCJAlliance.BriggsWestKettle.BB'Static		
Drawn By CC	*Scale* 1:610	*Company*	GR
Date	7/21/2017, 10:32:46 AM	*File Name*	SCJAlliance.BriggsWestKettle.dcb.slide.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Tan sandy SILT		115	Mohr-Coulomb	100	29	None	0
Brown SAND		120	Mohr-Coulomb	175	34	None	0
Top Soil		100	Mohr-Coulomb	10	21	None	0
Fine sandy SILT/silty SAND		120	Mohr-Coulomb	100	31	None	0

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SLIDEINTERPRET 7.022

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	SCJAlliance.BriggsWestKettle.BB'Seismic

Drawn By	CC	*Scale*	1:605	*Company*	GR
Date	7/21/2017, 10:32:46 AM			*File Name*	SCJAlliance.BriggsWestKettle.dcb.slide.slmd

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name:	SCJAlliance.BriggsWestKettle.dcb.slide.slmd - B-B' - Existing IBC PGA - Seismic
Slide Modeler Version:	7.022
Project Title:	SLIDE - An Interactive Slope Stability Program
Analysis:	SCJAlliance.BriggsWestKettle.BB'Seismic
Author:	CC
Company:	GR
Date Created:	7/21/2017, 10:32:46 AM

General Settings

Units of Measurement:	Imperial Units
Time Units:	days
Permeability Units:	feet/second
Failure Direction:	Left to Right
Data Output:	Standard
Maximum Material Properties:	20
Maximum Support Properties:	20

Analysis Options

Slices Type:	Vertical

Analysis Methods Used	
	Bishop simplified

Number of slices:	50
Tolerance:	0.005
Maximum number of iterations:	75
Check malpha < 0.2:	Yes
Create Interslice boundaries at intersections with water tables and piezos:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Groundwater Analysis

Groundwater Method:	Water Surfaces
Pore Fluid Unit Weight [lbs/ft3]:	62.4
Use negative pore pressure cutoff:	Yes
Maximum negative pore pressure [psf]:	0
Advanced Groundwater Method:	None

Random Numbers

Pseudo-random Seed:	10116
Random Number Generation Method:	Park and Miller v.3

Surface Options

Surface Type:	Circular
Search Method:	Slope Search
Number of Surfaces:	5000
Upper Angle:	Not Defined
Lower Angle:	Not Defined
Composite Surfaces:	Disabled
Reverse Curvature:	Invalid Surfaces
Minimum Elevation:	Not Defined
Minimum Depth [ft]:	6
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Seismic

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No

Loading

Seismic Load Coefficient (Horizontal): 0.225

Material Properties

Property	Tan sandy SILT	Brown SAND	Top Soil	Fine sandy SILT/silty SAND
Color				
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	115	120	100	120
Cohesion [psf]	100	175	10	100
Friction Angle [deg]	29	34	21	31
Water Surface	None	None	None	None
Ru Value	0	0	0	0

Global Minimums

Method: bishop simplified

FS	0.991383
Center:	231.645, 344.553
Radius:	220.452
Left Slip Surface Endpoint:	69.843, 194.822
Right Slip Surface Endpoint:	200.686, 126.286
Resisting Moment:	2.59138e+007 lb-ft
Driving Moment:	2.61391e+007 lb-ft
Total Slice Area:	1536.05 ft2
Surface Horizontal Width:	130.843 ft
Surface Average Height:	11.7397 ft

Valid / Invalid Surfaces

Method: bishop simplified

Number of Valid Surfaces: 4153
Number of Invalid Surfaces: 847

Error Codes:

Error Code -105 reported for 1 surface
Error Code -106 reported for 1 surface
Error Code -112 reported for 2 surfaces
Error Code -114 reported for 832 surfaces
Error Code -115 reported for 11 surfaces

Error Codes

The following errors were encountered during the computation:

-105 = More than two surface / slope intersections with no valid slip surface.
-106 = Average slice width is less than 0.0001 * (maximum horizontal extent of soil region). This limitation is imposed to avoid numerical errors which may result from too many slices, or too small a slip region.
-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.
-114 = Surface with Reverse Curvature.
-115 = Surface too shallow, below the minimum depth.

Slice Data

Global Minimum Query (bishop simplified) - Safety Factor: 0.991383

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	2.15147	232.085	-46.8105	Top Soil	10	21	36.7311	36.4146	68.8126	0	68.8126	107.942	107.942
2	2.03217	680.315	-46.0216	Fine sandy SILT/silty SAND	100	31	186.707	185.098	141.627	0	141.627	335.114	335.114
3	2.03217	1157.4	-45.2661	Fine sandy SILT/silty SAND	100	31	276.94	274.554	290.506	0	290.506	570.031	570.031
4	2.65083	2188.1	-44.4087	Tan sandy SILT	100	29	363.599	360.466	469.895	0	469.895	826.066	826.066
5	2.65083	2918.18	-43.4519	Tan sandy SILT	100	29	468.603	464.565	657.692	0	657.692	1101.63	1101.63
6	2.65083	3590.93	-42.5101	Tan sandy SILT	100	29	567.791	562.898	835.091	0	835.091	1355.56	1355.56
7	2.65083	3916.93	-41.5823	Tan sandy SILT	100	29	620.003	614.66	928.472	0	928.472	1478.59	1478.59
8	2.65083	4135.92	-40.6676	Tan sandy SILT	100	29	657.802	652.134	996.078	0	996.078	1561.23	1561.23
9	2.65083	4332.62	-39.7653	Tan sandy SILT	100	29	692.905	686.934	1058.86	0	1058.86	1635.45	1635.45
10	2.62408	4475.53	-38.8791	Brown SAND	175	34	863.869	856.425	1010.25	0	1010.25	1706.79	1706.79
11	2.62408	4654.64	-38.0082	Brown SAND	175	34	903.703	895.916	1068.8	0	1068.8	1775.06	1775.06
12	2.62408	4813.64	-37.1476	Brown SAND	175	34	940.614	932.509	1123.05	0	1123.05	1835.67	1835.67
13	2.62408	4953.2	-36.2967	Brown SAND	175	34	974.61	966.212	1173.02	0	1173.02	1888.86	1888.86
14	2.62408	5073.97	-35.455	Brown SAND	175	34	1005.7	997.033	1218.71	0	1218.71	1934.88	1934.88
15	2.62408	5166.76	-34.622	Brown SAND	175	34	1032.16	1023.27	1257.61	0	1257.61	1970.23	1970.23
16	2.62408	5230.09	-33.7972	Brown SAND	175	34	1053.59	1044.51	1289.11	0	1289.11	1994.36	1994.36
17	2.62408	5276.24	-32.9804	Brown SAND	175	34	1072.06	1062.82	1316.25	0	1316.25	2011.93	2011.93
18	2.62408	5305.73	-32.171	Brown SAND	175	34	1087.56	1078.19	1339.04	0	1339.04	2023.14	2023.14
19	2.62408	5319	-31.3688	Brown SAND	175	34	1100.12	1090.64	1357.49	0	1357.49	2028.18	2028.18
20	2.62408	5316.46	-30.5733	Brown SAND	175	34	1109.72	1100.15	1371.6	0	1371.6	2027.18	2027.18
21	2.62408	5298.5	-29.7844	Brown SAND	175	34	1116.36	1106.74	1381.37	0	1381.37	2020.31	2020.31
22	2.62408	5265.5	-29.0016	Brown SAND	175	34	1120.06	1110.41	1386.8	0	1386.8	2007.7	2007.7
23	2.62408	5217.79	-28.2247	Brown SAND	175	34	1120.8	1111.15	1387.89	0	1387.89	1989.49	1989.49
24	2.62408	5155.7	-27.4534	Brown SAND	175	34	1118.59	1108.95	1384.64	0	1384.64	1965.79	1965.79
25	2.62408	5079.53	-26.6874	Brown SAND	175	34	1113.42	1103.82	1377.04	0	1377.04	1936.72	1936.72
26	2.62408	4989.56	-25.9266	Brown SAND	175	34	1105.28	1095.75	1365.07	0	1365.07	1902.4	1902.4
27	2.62408	4886.07	-25.1706	Brown SAND	175	34	1094.16	1084.73	1348.73	0	1348.73	1862.92	1862.92
28	2.62408	4769.32	-24.4194	Brown SAND	175	34	1080.06	1070.75	1328.01	0	1328.01	1818.38	1818.38
29	2.62408	4639.53	-23.6725	Brown SAND	175	34	1062.96	1053.8	1302.88	0	1302.88	1768.88	1768.88
30	2.62408	4496.93	-22.9299	Brown SAND	175	34	1042.86	1033.87	1273.33	0	1273.33	1714.5	1714.5
31	2.62408	4341.75	-22.1914	Brown SAND	175	34	1019.74	1010.95	1239.34	0	1239.34	1655.31	1655.31
32	2.62408	4174.17	-21.4567	Brown SAND	175	34	993.574	985.012	1200.89	0	1200.89	1591.41	1591.41
33	2.62408	3998.71	-20.7257	Brown SAND	175	34	965.252	956.934	1159.26	0	1159.26	1524.5	1524.5
34	2.62408	3860.3	-19.9982	Brown SAND	175	34	944.069	935.934	1128.13	0	1128.13	1471.71	1471.71
35	2.62408	3723.84	-19.2741	Brown SAND	175	34	922.86	914.908	1096.96	0	1096.96	1419.67	1419.67
36	2.62408	3575.68	-18.5531	Brown SAND	175	34	898.755	891.01	1061.53	0	1061.53	1363.17	1363.17
37	2.62408	3415.98	-17.8352	Brown SAND	175	34	871.728	864.216	1021.81	0	1021.81	1302.28	1302.28
38	2.62408	3244.88	-17.1202	Brown SAND	175	34	841.755	834.502	977.75	0	977.75	1237.03	1237.03
39	2.62408	3062.5	-16.4079	Brown SAND	175	34	808.811	801.841	929.329	0	929.329	1167.5	1167.5
40	2.62408	2868.98	-15.6982	Brown SAND	175	34	772.864	766.204	876.498	0	876.498	1093.71	1093.71
41	2.62408	2664.44	-14.991	Brown SAND	175	34	733.887	727.563	819.207	0	819.207	1015.73	1015.73
42	2.62408	2448.99	-14.2861	Brown SAND	175	34	691.845	685.883	757.416	0	757.416	933.586	933.586
43	2.62408	2222.72	-13.5834	Brown SAND	175	34	646.704	641.131	691.069	0	691.069	847.324	847.324
44	2.62408	1985.75	-12.8828	Brown SAND	175	34	598.428	593.271	620.112	0	620.112	756.981	756.981
45	2.81319	1853.43	-12.159	Fine sandy SILT/silty SAND	100	31	442.497	438.684	563.664	0	563.664	659.004	659.004
46	2.81319	1555.89	-11.4121	Fine sandy SILT/silty SAND	100	31	388.616	385.267	474.765	0	474.765	553.209	553.209
47	2.81319	1245.48	-10.6671	Fine sandy SILT/silty SAND	100	31	331.431	328.575	380.412	0	380.412	442.84	442.84
48	2.81319	920.591	-9.92397	Fine sandy SILT/silty SAND	100	31	270.564	268.233	279.987	0	279.987	327.325	327.325
49	2.81319	565.249	-9.18251	Fine sandy SILT/silty SAND	100	31	202.813	201.065	168.201	0	168.201	200.986	200.986
50	2.81319	191.967	-8.4426	Fine sandy SILT/silty SAND	100	31	130.507	129.383	48.9014	0	48.9014	68.2723	68.2723

Interslice Data

Global Minimum Query (bishop simplified) - Safety Factor: 0.991383

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	69.8433	194.822	0	0	0
2	71.9947	192.53	131.045	0	0
3	74.0269	190.424	203.624	0	0
4	76.0591	188.373	498.106	0	0
5	78.7099	185.777	1248.44	0	0
6	81.3607	183.265	2316.71	0	0
7	84.0116	180.835	3651.38	0	0
8	86.6624	178.483	5075.87	0	0
9	89.3132	176.206	6534.32	0	0
10	91.9641	174	8011.32	0	0
11	94.5881	171.884	8892.91	0	0
12	97.2122	169.833	9764.84	0	0
13	99.8363	167.845	10616.6	0	0
14	102.46	165.918	11439	0	0
15	105.084	164.049	12223.5	0	0
16	107.709	162.238	12960.8	0	0
17	110.333	160.481	13642	0	0
18	112.957	158.778	14262.3	0	0
19	115.581	157.128	14817.5	0	0
20	118.205	155.528	15304.2	0	0
21	120.829	153.978	15719.8	0	0
22	123.453	152.476	16062.3	0	0
23	126.077	151.021	16330.4	0	0
24	128.701	149.613	16523.3	0	0
25	131.325	148.25	16640.9	0	0
26	133.949	146.931	16683.6	0	0
27	136.573	145.655	16652.5	0	0
28	139.197	144.422	16548.9	0	0
29	141.822	143.23	16375	0	0
30	144.446	142.08	16133.3	0	0
31	147.07	140.97	15826.9	0	0
32	149.694	139.899	15459.2	0	0
33	152.318	138.868	15034.4	0	0
34	154.942	137.875	14556.7	0	0
35	157.566	136.92	14029.6	0	0
36	160.19	136.003	13456.7	0	0
37	162.814	135.122	12841.8	0	0
38	165.438	134.278	12189.7	0	0
39	168.062	133.469	11505.1	0	0
40	170.686	132.697	10793.6	0	0
41	173.31	131.959	10061.1	0	0
42	175.934	131.256	9313.83	0	0
43	178.559	130.588	8558.69	0	0
44	181.183	129.954	7802.94	0	0
45	183.807	129.354	7054.34	0	0
46	186.62	128.748	6570.37	0	0
47	189.433	128.18	6098.72	0	0
48	192.246	127.65	5649.79	0	0
49	195.059	127.158	5234.92	0	0
50	197.873	126.703	4869.04	0	0
51	200.686	126.286	0	0	0

List Of Coordinates

External Boundary

X	Y
0	198
0	196
0	193.125
0	174
0	50
360	50
360	117
288.711	117
238.28	117
231	117
224	118
221.989	118.503
220	119
215	120
210	123
203	125
199.539	126.923
194	130
154	151
83	194
67	195
51	196
30	197

Material Boundary

X	Y
0	196
83	192
154	150
199.539	126.923

Material Boundary

X	Y
0	174
83	174
105.212	174

Material Boundary

X	Y
0	193.125
83	187.94
105.212	174
194.98	123.007
221.989	118.503