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# Preliminary Geotechnical Study Report for San Ramon Canyon Storm Drain System, City of Rancho Palos Verdes, California

**Prepared For**
**HARRIS & ASSOCIATES**

November 10, 2010

GMU Project No. 10-036-00

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# TRANSMITTAL

**HARRIS & ASSOCIATES**
34 Executive Park, Suite 150
Irvine, CA 92614

DATE: November 10, 2010

PROJECT: 10-036-00

ATTENTION: Mr. Randall Berry

SUBJECT: Preliminary Geotechnical Study Report for San Ramon Canyon Storm Drain System, City of Rancho Palos Verdes

WE ARE SENDING THE FOLLOWING:

One (1) wet signature copy of our "Preliminary Geotechnical Study Report for San Ramon Canyon Storm Drain System, City of Rancho Palos Verdes, California," dated November 10, 2010.

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## INTRODUCTION

This report is intended to provide a summary of our preliminary geotechnical investigation and evaluation of the feasibility of design alternatives for the proposed San Ramon Canyon Storm Drainage System project within the City of Rancho Palos Verdes, California. Our report is based on our understanding of the design alternatives prepared by Harris & Associates and presented in their conceptual plans, dated September, 2010 (see References).

## SCOPE OF WORK

Our scope of work for the preliminary geotechnical investigation and feasibility evaluation of the design alternatives was generally as described in our proposal to Harris & Associates, dated February 23, 2010.

1. Background Review and Technical Study – including review of available geologic and geotechnical data and historical aerial photographs, surface mapping of San Ramon Canyon, preparation of geologic cross-sections, and attendance at team meetings.

2. Evaluation of Palos Verdes Drive East Switchbacks – including drilling two bucket auger borings on the outside of the switchbacks, completion of a laboratory testing program, and revision of the geologic cross-sections to incorporate the collected data.

3. Evaluation of Tunnel Design Alternative – including drilling two continuous core borings along the conceptual tunnel alignment and performing geophysical logging of the borings, completion of a laboratory testing program, and geotechnical analyses of the data collected. In addition to the scope described in our proposal, one additional bucket auger boring was drilled near the launch pit for the southernmost portion of the tunnel alignment, and corresponding additional laboratory testing and analyses were performed.

4. Evaluation of Canyon Design Alternatives – including drilling one hollow-stem auger boring within San Ramon Canyon just upstream from 25$^{th}$ Street, completion of a laboratory testing program, revision of the geologic cross-sections as required, and geotechnical analyses of the data collected.

5. Deliverables and Technical Support – including preparing both a draft and final preliminary geotechnical report (herein), and attendance at meetings as necessary to facilitate understanding and support of the project from governing agencies.

## SITE LOCATION

The project site is located within the eastern portion of the City of Rancho Palos Verdes. In general, the site is bounded by Palos Verdes Drive East (PVDE) on the west, Calle Aventura and Tarapaca Road to the north, the City of Los Angeles boundary to the east, and the Pacific Ocean to the south. It should be noted that the site is bisected by Palos Verdes Drive South, which is named 25th Street within the City of LA. For the purposes of this report, this street is referred to as "25th Street". A Location Map showing the specific limits of the project site is included in this report as Plate 1.

## EXISTING SITE CONDITIONS AND HISTORY

In general, the project site is in an undeveloped condition, except for the PVDE and 25th Street roadways. Some areas that bound the site are developed, such as the residences upslope of the upper portions of San Ramon Canyon, and the Palos Verdes Shores mobile home park to the south of 25th Street. The location of the park and other major features are shown on Plate 2.

The major topographical feature within the project site is San Ramon Canyon, which trends generally north-south. Prior to development, this canyon extended to the Pacific Ocean. However, during the construction of 25th Street, the lower portion of the canyon was buried and the flow of water was collected into a storm drain system that begins at 25th Street and extends down to the ocean. Currently, the inlet structure that was the upstream beginning of the system has been buried by debris.

The remaining portions of the project site consist of gentle to very steep slopes, with the steeper slopes found within the canyon. The topography of the project site is generally controlled by the large ancient landslide that comprises the majority of the site. This landslide, the South Shores landslide, is considered dormant and is discussed in further detail in subsequent sections of this report.

The need for this storm drain project has been prompted by the episodic flooding of 25th Street that occurs during moderate to heavy rainfall periods and the concern for the stability of PVDE. The flooding of the 25th Street area is primarily due to the clogged and buried storm drain inlet, which does not collect surface water. During a rain event, surface water flowing down the canyon is carried downstream and directly onto the roadway. In addition, erosion of the canyon and slope movement are contributing to the problem, causing mudflows and debris to be washed down the canyon.

Our review of historical aerial photographs (listed in References) indicates that 25th Street and the associated storm drain under the roadway were constructed prior to 1954. Residential construction at the top of the canyon began in the late 1950s and continued intermittently through the 1990s.

Residential construction south of the project site (i.e., south of 25th Street) occurred in the 1970s. In addition, failure of the slope at the head of San Ramon Canyon and the subsequent repair occurred in the early 2000s. This failure, while outside the influence of the project site, is discussed in a subsequent section of this report.

Areas of increased erosion within San Ramon Canyon were noted in the photos from 1970, 1978, 1979, 1988, and 1992. Surficial failures, slumps, and small landslides were noted on the photos within the canyon. The Tarapaca landslide, located on the east side of the canyon, is first noted on the photos in 1978 as increasing erosion, with scarps observed in the 1988 photos. Further detailed discussion of the Tarapaca landslide is included in subsequent sections of this report.

The buildup of silt and debris within the lower portions of the canyon, upstream from 25th Street, is first observed within the 1988 photos and continues through the present. Based on the erosion observed within the photos and the currently observed site conditions, it appears the canyon has widened over time, with increasingly steepened side walls.

## PREVIOUS GEOTECHNICAL INVESTIGATIONS

No site-specific investigations for a storm drain within San Ramon Canyon have been completed prior to the current geotechnical investigation by GMU Geotechnical, Inc. (GMU). However, numerous studies by geologists have been done on the South Shores landslide, and several geotechnical reports for single-family residences have been published for properties upslope of San Ramon Canyon. A complete list of reports and publications reviewed as part of this investigation is included in the References section of this report. In addition, where appropriate, data from these previous investigations, as well as data from regional publications, have been incorporated into this preliminary geotechnical report.

In general, the primary focus of previous studies in the area pertains to the South Shores landslide. These studies conclude that the landslide is approximately 16,200 years old (Ray, 1982), and may have failed in one event. Various authors disagree on the eastern limits of the landslide, and different interpretations of the available data have resulted in several opinions as to the depth and toe of the landslide. Dibblee (1999) maps the toe of the landslide within the bluff face above sea level, while Ray (1982) and others map the toe below sea level and the current beach. It appears that the majority of authors on the subject of the South Shores landslide agree that the landslide is dormant and has not moved in historic time.

Site-specific reports for single-family residential developments were also reviewed for this investigation, including reports by Ehlert (1997, 1998), and T.I.N. Engineering Company (2006) for residences upslope of the project site. Geologic data from these reports, including boring and trenching data, were included in our Geotechnical Map and Cross-Sections (Plates 3, 4, and 5). However, much of the data shown on the geologic maps within thee reports references boring or trench logs that were not available for our review. Where available, these logs are included in Appendix A of this report. Logs that were not available are indicated on the legend of our Geotechnical Map, Plate 3.

## PROPOSED DESIGN ALTERNATIVES

Based on our review of the conceptual plans by Harris & Associates (2010), we understand there are two main alternatives for this project, with a third alternative that is considered to be an option for the first two alternatives. These alternatives are described below, and shown generally on Plate 6.

### ALTERNATIVE 1

In order to significantly reduce the erosion and flooding within San Ramon Canyon from surface water, Alternative 1 proposes to construct an inlet structure within the canyon which will carry runoff water through a subsurface storm drain system to the west of the canyon, exiting through an outlet structure at the toe of the bluffs at the ocean. The storm drain system would be constructed with tunnel and open trench methods, and would be located entirely within the City of Rancho Palos Verdes. The general location of the storm drain system proposed for Alternative 1 is detailed in conceptual plans prepared by Harris & Associates. In addition to the construction of the storm drain system, a gravity-type buttress would be constructed within the canyon in order to reduce the potential for future deep-seated movement within the actively failing portion of the canyon (i.e., the Tarapaca landslide).

### ALTERNATIVE 2

This alternative includes construction of a subsurface drainage system within the canyon, with an inlet structure in approximately the same location as Alternative 1. This structure will collect surface water into a subsurface storm drain system consisting of a 48-inch-diameter pipe system with a 12-inch-diameter underlying subdrain system. Construction of the storm drain system would include placing fill within the majority of the canyon in order to restore the ground surface to "pre-erosion" conditions and to mitigate the over-steepened canyon walls and failing areas. This storm drain system would tie into the existing system that underlies 25$^{th}$ Street. The general location and details of this alternative are presented in the conceptual plans prepared by Harris & Associates.

## ALTERNATIVE B (OPTION FOR ALTERNATIVES 1 AND 2)

The third alternative consists of an optional upstream extension of the storm drain system that would apply to either Alternative 1 or 2. This option would consist of connecting the proposed storm drain systems (either within the canyon or to the west of the canyon) to the existing storm drain system for the residences at the head of the canyon. The existing storm drain system currently outlets into the canyon at the toe of the graded cut slope at the head of San Ramon Canyon.

# GEOLOGIC EXPLORATION AND SURFACE MAPPING

## FIELD EXPLORATION

Our field exploration program was designed to provide preliminary data for evaluation of the feasibility of the design alternatives described above. In order to accomplish this, our investigation consisted of multiple types of subsurface exploration as well as surface geologic mapping. All aspects of our field investigation were performed by a Certified Engineering Geologist.

### Surface Mapping

Geologic mapping of exposed materials was performed across the project site. Exposures of ancient and recent landslide debris, alluvium, and bedrock were observed and geologic structure recorded where observed, generally within San Ramon Canyon and at the bluff descending to the ocean at the southern edge of the project site. Our geologic observations and mapping were incorporated into our data and analyses and are shown as mapped on the Geotechnical Map, Plate 3, and where appropriate on our Cross-Sections, Plates 4 and 5.

### Subsurface Exploration

Our subsurface exploration program included drilling, sampling, and logging small-diameter hollow-stem, large-diameter bucket auger, and continuous diamond core borings. Each boring type was selected in order to provide the optimal data retrieval methods for the soil and bedrock conditions anticipated, and to provide the appropriate data type for the proposed alternative. Each method of subsurface exploration is discussed below, and geologic discussion of materials encountered is presented in a subsequent section of this report. Detailed logs of each boring are presented within Appendix A of this report. The approximate location of each of these borings is shown on our Geotechnical Map, Plate 3, and the associated geologic structure is shown on the Cross-Sections, Plates 4 and 5, where appropriate. Backfill of all exploratory borings was completed immediately after logging, and consisted of backfilling and tamping with native materials or backfilling with concrete slurry, where appropriate.

Small-diameter Hollow-Stem Auger Boring

One hollow-stem auger boring was drilled within San Ramon Canyon, just north of 25th Street, within the City of Los Angeles easement. This boring was drilled to a maximum depth of 46.5 feet, and was intended to evaluate the recently deposited alluvial materials at the upstream intersection of San Ramon Canyon and 25th Street. Drive and bulk samples were collected and Standard Penetration Tests (SPTs) were performed in order to geotechnically evaluate the materials encountered.

Large-diameter Bucket Auger Borings

Three bucket auger borings were drilled as part of our investigation. Boring DH-1 was located in the southern portion of the project site, near the proposed launch pit area for the storm drain alignment in Alternative 1, and was intended to evaluate the materials to be encountered at the launch pit as well as geologic structure of the materials exposed in the bluff face. This boring was drilled to approximately 103 feet, where refusal was encountered on very hard material. In addition, the boring was downhole logged by a Certified Engineering Geologist to about 93 feet.

Boring DH-2 was located just east of the lower switchback of PVDE, adjacent to the descending slope to San Ramon Canyon, and was intended to evaluate the geologic structure of the materials underlying the switchback. This boring was drilled to 63 feet, where refusal was encountered due to severe caving of highly fractured material. In addition, the boring was downhole logged by a Certified Engineering Geologist to about 55 feet.

Boring DH-3 was located adjacent to the upper switchback, on the east side of the roadway, and was intended to evaluate the geologic structure of the materials underlying the switchback. This boring was drilled to 60 feet, where refusal was encountered due to severe caving of highly fractured material. In addition, the boring was downhole logged by a Certified Engineering Geologist to about 22 feet, where severe caving precluded further logging of the boring. Drive and bulk samples were collected in each of these bucket auger borings in order to geotechnically evaluate the materials encountered. These borings were backfilled with native materials and tamped in place to properly backfill the borings to minimize settlement potential.

Continuous Diamond Core Borings

Two continuous core borings were drilled as part of our investigation. Boring C-1 was drilled on the "inside" of the lower switchback of PVDE, near the conceptual storm drain alignment of Alternative 1. This boring was intended to primarily evaluate the materials within the South Shores landslide at the storm drain location and to evaluate the geologic structure of this area. This boring was drilled to approximately 149 feet. The continuous core samples collected during drilling were logged by a Certified Engineering Geologist, and geophysical testing of the borings was performed.

Boring C-2 was drilled on the southern shoulder of 25th Street adjacent to the City boundary, near the conceptual storm drain alignment of Alternative 1. This boring was also intended to primarily evaluate the materials within the South Shores landslide at the storm drain location and to evaluate the geologic structure of this area. This boring was drilled to approximately 104 feet. The continuous core samples collected during drilling were logged by a Certified Engineering Geologist, and geophysical testing of the borings was performed.

### Geophysical Testing

The geophysical testing performed for Borings C-1 and C-2 included caliper measurements, optical televiewer, and Suspension P- and S-wave velocities. It should be noted that during the logging of Boring C-1, water levels would not rise above 103 feet despite water added to the boring by the drillers via a gravity hose from a water truck. Therefore, Suspension logging could not be performed above 103 feet. The results of the geophysical testing, performed by Norcal Geophysical Consultants, Inc., are attached to this report as Appendix D, and are incorporated into our findings, analyses, conclusions, and recommendations as discussed in this report.

## LABORATORY TESTING PROGRAM

Our laboratory program was designed to include testing on representative samples of all geologic materials encountered in order to provide a preliminary geotechnical database for the project site in light of the three alternatives. Our testing program included geotechnical index testing of typical onsite soils as well as direct shear testing of a variety of materials at critical locations to provide a compilation of strength values for the onsite materials. Detailed discussion of each type of testing performed as well as testing results are presented in Appendix B of this report. In addition, further discussion of testing results is included in subsequent sections of this report.

# GEOLOGIC FINDINGS

## REGIONAL GEOLOGY

Published regional data and our experience in the Palos Verdes Peninsula indicate the peninsula is underlain by Tertiary sedimentary units over basement rock of the Catalina Schist. These geologic materials have been uplifted over time through folding and faulting to create a large-scale anticline that comprises the peninsula, generally trending northwest-southeast. Tectonic uplift in the area may be primarily due to movement on the Cabrillo and Palos Verdes fault zones. Quaternary sediments overlie the Tertiary materials in much of the lower portions of the peninsula due to deposition of sediments by wave action during uplift and through sediment deposition due to gravity, erosion, or in situ weathering.

The geologic features of primary interest within the Palos Verdes Peninsula are the numerous landslides that exist mainly on the ocean (southwesterly) side of the peninsula, generally coincident with southwesterly dipping regional bedding. The two most significant landslide features in the Palos Verdes area are the Portuguese Bend landslide, located approximately 2 miles west of the project site, and the South Shores landslide, located partially within the project site. Further discussion of landsliding and impacts to the project alternatives are discussed in a subsequent section of this report.

## MATERIALS ENCOUNTERED

Geologic soil and bedrock materials encountered during our field investigation are described below and within our boring logs. In addition, the lateral extent of these materials is shown on the Geotechnical Map, Plate 3. The geologic structure of these materials is shown on the Cross-Sections, Plates 4 and 5.

### Topsoil

Topsoil was observed during our field investigation as a thin veneer across much of the project site. While topsoil was not encountered within our borings, it was observed within drill pad and access road excavations, as well as during surface mapping of the site. Where observed, the topsoil consisted of dark brown silty clay, dry to damp, with no soil structure. Due to the thin nature of the topsoil (i.e., less than three feet in thickness), this geologic unit is not shown on our Geotechnical Map or Cross-Sections.

### Recent Alluvium (Qal)

These materials are generally located within San Ramon Canyon, on the canyon floor and in a relatively thick deposit on the northern side of the intersection of the canyon and 25$^{th}$ Street. Where encountered in Boring DH-4, and during surface mapping, the recent alluvium generally consisted of dark brown clay with fine- to medium-grained sand. These materials were generally moist, very soft to soft, with scattered to abundant bedrock fragments and organic materials (i.e., plant debris). The thickest deposit of these recent alluvial materials was found to be about 31 feet thick.

### Artificial Fill (Qaf)

These materials are generally located underlying and adjacent to the paved roadways, PVDE, and 25$^{th}$ Street and, as such, were likely placed during grading of these roads pre-1950s. Where observed, these fill materials were dark brown, dry to damp, soft to firm silty clay and sandy silt with fragments of bedrock. Visible lifts were not observed within the downhole logged boring, DH-3, nor were they observed within the core samples recovered within C-2. The maximum thickness of these fill soils was observed to be about 18 feet. However, there may be deeper fill soil deposits within the project site, particularly adjacent to or underlying roadway areas.

**Older Alluvium (Qoal)**

Deposits of older alluvium were observed within the upper portions of San Ramon Canyon during surface mapping. Where observed within the canyon bottom and sidewalls, these materials consisted on dark brown clayey silt with scattered to abundant bedrock fragments and rare charcoal fragments. These soils were moderately well-developed, with a blocky to columnar structure and local porosity. Structure within these soils was difficult to identify, with some local areas showing subtle textural layers. Given that no borings were drilled within the older alluvium, the maximum thickness of these deposits is unknown; however, it is estimated to be less than 50 feet.

**Recent Landslide Debris (Qlsr)**

Recently failed materials derived from bedrock and ancient landslide debris were observed during our field exploration on the east wall of San Ramon Canyon. These materials are referred to in geologic publications as the Tarapaca landslide. This landslide is considered to be actively moving. Where observed during surface mapping, the materials of the Tarapaca landslide consist of loose bedrock fragments up to cobble-sized with a soil matrix. Pockets of topsoil with organic debris were observed within the landslide mass. Further discussion of this recent landslide is provided within the "Landslides and Geologic Structure" section of this report.

**Ancient Landslide Debris (Qols)**

These materials, known as the South Shores landslide, underlie the majority of the project site, and were encountered within all of our borings. Where observed, these materials consisted of remnant blocks of bedrock up to 10 feet thick within a silty clay matrix. These materials are varicolored, soft to hard, dry to moist, and contain blocks of siliceous siltstone that can be very hard. Further discussion of the South Shores landslide is provided within the "Landslides and Geologic Structure" section of this report.

**Altamira Shale Member, Monterey Formation (Tma)**

Bedrock of the Altamira Shale member of the Monterey Formation underlies the project site at depth, and is exposed within portions of San Ramon Canyon. Where observed, the Altamira Shale member consisted of interbedded siltstone and siliceous siltstone with tuffaceous siltstone, bentonitic tuff, and bentonite. These beds are generally thinly to thickly bedded, planar, with some local soft sediment deformation. The materials are generally gray to olive brown, damp to moist, firm to very hard, with scattered fracturing and jointing. Further discussion of the geologic structure of the bedrock underlying the project site is included in the section below.

## LANDSLIDES AND GEOLOGIC STRUCTURE

Regional geologic publications and site-specific geotechnical reports for properties adjacent to the project site indicate the area around the project site may form a geologic "bowl" structure. Bedding inclinations to the north of the site are generally oriented towards the south. Bedding inclinations to the east of the site are generally oriented to the west, and inclinations west of the site are generally oriented to the east. This synclinal geologic structure likely contributed to and controlled the lateral extent of the failure of the South Shores landslide, which dominates the project site.

The South Shores landslide is considered to be approximately 16,200 years old, and failed as a block glide type failure (Ray, 1982). While the authors of publications on the South Shores landslide agree the landside is dormant, there is some disagreement on the limits of the landslide, in particular the eastern edge of the landslide. Some geologists include the currently active Tarapaca landslide as part of the South Shores landslide, while others map the active landslide as originating upslope of the limits of the dormant landslide mass.

Our interpretation of the limits of the South Shores landslide are based on our review of existing geologic data, our observations during our field investigation, and our review of historic aerial photographs. All of our borings encountered the ancient landslide debris, with all three of the large-diameter borings excavated entirely within the landslide. Observations made during downhole logging suggest the South Shores landslide has variable composition, depending on location within the landslide mass. Borings drilled in the upper middle of the landslide (Borings DH-2 and DH-3) encountered large remnant blocks of siltstone and siliceous siltstone that appeared to be highly fractured, sheared, and laterally discontinuous. Continuous beds of bentonite or bentonitic tuff were not observed within either of these two borings. The geologic structure within the landslide mass in the area of the lower switchback of PVDE generally consists of discontinuous remnant fragments and small blocks of bedrock within the debris matrix. The geologic structure of the landslide mass in the area of the upper switchback appears to be more continuous, but moderately to severely folded with some faulting and discontinuities.

Our large-diameter boring DH-1 was drilled near the mapped toe of the South Shores landslide, at the top of the bluff above the beach. Observations made during downhole logging of this boring suggest this area is comprised of generally intact bedrock materials with continuous, planar bedding. The materials were moderately to rarely fractured, with little to no shearing observed. Bentonite or bentonitic tuff beds were not observed within this boring. Surface mapping along the bluff below indicates this continuous, intact bedrock material continues along the bluff face within the project area. Based on this limited subsurface data and the surface geologic mapping, it appears that this lower area may be either a separate, older landslide that failed as a generally intact block, or intact bedrock that has not failed as previously thought. However, very limited data was collected during our investigation, and the presence of a deep-seated landslide rupture surface as previously published cannot be ruled out.

Our Cross-Section 7-7' illustrates the general structure of the older landslide and the postulated rupture surfaces. At least two significant rupture surfaces may exist; one rupture surface at the base of the upper, chaotic debris, and a basal rupture surface at the postulated landslide/bedrock contact below the relatively continuous material noted in DH-1 and the bluff face.

The Tarapaca landslide appears to have failed on a continuous, planar bedding plane surface within the Altamira Shale bedrock east of the South Shores landslide. It is our opinion that the Tarapaca landslide is not a part of the South Shores landslide, as discussed above. As discussed in the "Slope Stability" section of this report, this bedding plane surface does not appear to be a bentonite bed, based on back-calculations performed of the landslide. The most likely scenario for the failure of the Tarapaca landslide is an over-steepening of the canyon walls, resulting in a "daylighted" adverse bedding condition. Given the steep nature of the failure plane, and the continuous erosion of the toe of the landslide by surface water flow down the canyon, movement of the Tarapaca landslide is expected to continue. This episodic movement and failure of the landslide material into the canyon bottom is causing increased erosion of the opposite canyon walls, as discussed below.

The failure that occurred at the head of the San Ramon Canyon area in the early 2000s occurred due to undercutting of oversteepened bedrock, and was subsequently repaired by grading a buttress fill and installing a new storm drain system outlet. It should be noted that this failure area, while shown on our Geotechnical Map, is not within the project site. None of the proposed design alternatives will adversely impact this repaired area.

## EROSION

While erosion due to wind and water is a common geologic phenomenon over all of southern California, the impacts of water-driven erosion are significant within the project site in the area of San Ramon Canyon. Erosion within this canyon ranges from moderate to severe. The areas of severe erosion are generally in the area of the Tarapaca landslide and downstream.

The episodic and active downslope movement of the Tarapaca landslide is forcing the flowline of the canyon to shift westerly, causing increased erosion of the western walls of the canyon. These areas are directly downslope of the switchbacks of PVDE, in particular the lower switchback. Erosional scars can be seen on the topographic map used as the base for our Geotechnical Map, Plate 3. Based on our review of historical aerial photographs and our experience in the Palos Verdes area, it appears that these areas of the canyon are eroding at an average rate of about 5 feet per year. Continued annual erosion of these areas may cause stability issues with PVDE. Further discussion of the current and future stability of PVDE is discussed in subsequent sections of this report.

Moderate to severe erosion of the canyon walls and floor due to heavy flow of surface water and flash flooding during rains has caused deep cutting of the canyon, in some areas generating vertical cuts up to 30 feet in height. Instability of these cuts is triggering surficial failures and topple of the vertical walls. Further discussion of the impact of erosion on the Tarapaca landslide and the PVDE switchbacks is provided in other sections of this report.

## GROUNDWATER

In general, groundwater was not observed during our investigation. Boring C-1 encountered water at 103 feet; however, this water appeared to be seepage or a perched zone, as samples collected at lower depths were not saturated. The hollow-stem and bucket auger borings did not encounter significant seepage or groundwater. Surface mapping during our investigation did not encounter surface water within San Ramon Canyon; however, it is likely water flows in this canyon during the winter months. Further exploration will likely be required to evaluate the impact of groundwater on the proposed Alternative 1 storm drain alignment. The impact of ground and surface water on Alternatives 2 and 3 will be greatly dependent on the time of year work was performed and the rainfall patterns at the time of work.

## SEISMIC HAZARDS

### Faulting, Ground Rupture, and Seismic Shaking

The site is not within an Alquist-Priolo Earthquake Fault Zone, and no known active faults are shown on current geologic maps as crossing the site. The nearest known active fault is the Palos Verdes fault, which is located approximately 5.4 kilometers from the site and is capable of generating a maximum earthquake magnitude ($M_w$) of 7.3. The site is also located within 15.6 kilometers of the Newport-Inglewood fault, which is capable of generating a maximum earthquake magnitude ($M_w$) of 7.1. Given the proximity of the site to these and numerous other active and potentially active faults, the site will likely be subject to earthquake ground motions in the future.

In order to evaluate to evaluate the likelihood of future earthquake ground motions occurring at the site, a probabilistic seismic hazard analysis (PSHA) of horizontal ground shaking was performed using the commercial computer program EZ-FRISK ver. 7.43. The PSHA utilized seismic sources and next generation attenuation (NGA) equations consistent with the 2008 USGS National Seismic

Hazard Mapping Project. Assuming a risk level of 10 percent probability of exceedance in 50 years (i.e., ~475 year ARP), the PHGA is 0.35g.

**Seismically-Induced Landsliding**

Given that the site is predominately underlain by a large, dormant landslide, and that the existing walls and slopes of San Ramon Canyon are generally over-steepened due to erosion, the potential for further landsliding due to a large seismic event is high. However, the three design alternatives proposed are intended to reduce the rate of erosion within the canyon, reduce the flow of water and debris down canyon, and reduce the movement of the Tarapaca landslide. Therefore, construction of any of the design alternatives would likely reduce the potential impact of seismically-induced landsliding.

**Liquefaction and Lateral Spreading**

Given the depth to groundwater and the well-consolidated nature of the landslide and bedrock materials on site, the potential for liquefaction and lateral spreading of these materials is low. However, localized areas where the canyon is underlain by recent alluvium or colluvium may be subject to these seismic hazards should these surficial soils be saturated at the time of the seismic event.

**Tsunami**

Based on our review of the Torrance/San Pedro Quadrangle of the Tsunami Inundation Map for Emergency Planning prepared by the California Geological Survey (CGS, 2009), the area at the toe of the bluff within the project site may be susceptible to tsunami inundation. Therefore, the storm drain outlet structure of Alternative 1 would be susceptible to impact by tsunami during a seismic event.

**Seiche**

Given that a seiche, by definition, is restricted to a confined body of water, and no confined or semi-confined bodies of water are found on the project site or upstream of the project site, the probability of impact from a seiche is considered to be nil.

**Seismic Design**

No active or potentially active faults are known to cross the site; therefore, the potential for primary ground rupture due to faulting on-site is very low to negligible. However, the site will likely be subject to seismic shaking at some time in the future.

Wall and Tunnel Design

The above PSHA derived PGA should be considered in the design of tunnel and retaining elements at the site.

Building Structure Design

Site-specific seismic design parameters were determined using the USGS computer program titled "Seismic Hazard Curves and Uniform Hazard Response Spectra, Version 5.0.9a." The site coordinates used in the analysis were 33.7295° North Latitude and 118.3297° West Longitude. On-site structures should be designed in accordance with the following 2007 CBC criteria:

| Parameter | Factor | Value |
|---|---|---|
| Mapped Spectral Response Acceleration (0.2 sec Period) | $S_S$ | 1.61g |
| Mapped Spectral Response Acceleration (1.0 sec Period) | $S_1$ | 0.66g |
| Site Class | Site Class | D |
| Site Coefficient | $F_a$ | 1.0 |
| Site Coefficient | $F_v$ | 1.5 |
| Maximum Considered Earthquake Spectral Response Acceleration (0.2 sec Period) | $S_{MS}$ | 1.61g |
| Maximum Considered Earthquake Spectral Response Acceleration (1.0 sec Period) | $S_{M1}$ | 0.98g |
| Design Spectral Response Acceleration (0.2 sec Period) | $S_{DS}$ | 1.07g |
| Design Spectral Response Acceleration (1.0 sec Period) | $S_{D1}$ | 0.66g |

It should be recognized that much of southern California is subject to some level of damaging ground shaking as a result of movement along the major active (and potentially active) fault zones that characterize this region. Design utilizing the 2007 CBC is not meant to completely protect against damage or loss of function. Therefore, the preceding parameters should be considered as <u>minimum</u> design criteria.

# GEOTECHNICAL ENGINEERING CHARACTERISTICS

## GEOPHYSICAL TESTING

P-wave velocities from the geophysical testing performed for Borings C-1 and C-2 ranged from 3458 fps to 5860 fps (Appendix D). These velocities are characteristic of weathered shale. Structural data obtained from geologic logging of the core samples and the OPTV Image logs was utilized in the determination of a Rock Mass Rating (RMR).

## GEOMECHANICS CLASSIFICATION (RMR)

The geomechanics classification of the rock mass rating (RMR) system was developed on the basis of experience in shallow tunnels in sedimentary rocks. The purpose of the RMR is to classify the rock into groups with specific characteristics relative to tunnel performance and support requirements. RMR values are based on six parameters: 1) uniaxial compressive strength of the intact rock material, 2) rock quality designation, 3) joint or discontinuity spacing, 4) joint condition, 5) groundwater condition, and 6) joint orientation (i.e., relative to the tunnel alignment). Points are assigned for each category and added numerically to obtain an overall RMR for the rock mass that can be correlated with several tunneling characteristics.

### Uniaxial Compressive Strength

Based on Schmidt hammer readings taken from the rock cores, unconfined compressive strengths for the remnant blocks of siltstone within the South Shores landslide and intact siltstone of the Altamira Shale member of the Monterey Formation is expected to range from about 100 to about 7000 psi depending on the degree of weathering and disturbance. This corresponds to RMR ratings ranging from 0 to 7.

The above uniaxial compressive strengths are not representative of hard siliceous zones within the South Shores landslide which may be encountered during tunneling and excavation. These zones may have unconfined compressive strengths of in the range of 7,500 to 15,000 psi.

### Rock Quality Designation (RQD)

Calculated values of RQD are contained on the logs for the continuous core borings. RQD values range from 0 to 86. In general, the upper 40 to 60 feet indicates RQD values of zero with a range of higher values below. This is summarized in the following table.

| Core Hole | Tunnel Invert Depth | Depth Range | RQD Range | Weighted RQD Average |
|---|---|---|---|---|
| C-1 | - | 0-39 feet | 0-13 | 1 |
| C-1 | 88 | 39-149 | 0-86 | 33 |
| C-2 | 50 | 0-58 | 0 | 0 |
| C-2 | - | 58-104 | 0-44 | 19 |

Based on the above table, RMR ratings for RQD would range from 3 to 8 (i.e., corresponding to weighted RQD values ranging from 0 to 33).

**Joint or Discontinuity Spacing**

Joint spacing ranges from about 6 inches to about 2 feet in the area of the proposed tunnel for Alternative 1. Consequently an RMR rating of 8-10 can be assumed.

**Joint Condition**

The joint condition ranges from "slightly rough and moderately to highly weathered, wall rock surface separation < 1mm" to "slickensided wall rock surface or 1-5mm thick gouge or 1-5mm wide continuous discontinuity". These conditions correspond to RMR ratings of 10-20.

**Groundwater Condition**

Boring and core logs indicate the landslide debris and bedrock materials are dry in the area of the proposed tunnel (Alternative 1). Consequently, a groundwater rating of 15 may be applied.

**Joint Orientation**

For the purposes of joint orientation, all geologic structural data (i.e., from bedding, joints, fractures, etc.) were treated the same. Based on a comparison of structural attitudes determined from the OPTV logs, the geologic structure is considered favorable. This results in an RMR rating of (-)2.

**Overall RMR**

Based on the above individual ratings, the overall RMR for the older landslide debris of the South Shores landslide ranges from 34 to 58. This corresponds to a classification of poor to fair rock. Additional continuous core borings should be performed to better define the range of RMR values along the final tunnel alignment should this design alternative be selected.

## GENERAL GEOTECHNICAL ENGINEERING CHARACTERISTICS

Based on the results of our field investigation and laboratory testing, preliminary geotechnical properties of the onsite soils are anticipated to be as discussed below. Additional exploration along the selected design alternative is recommended to further evaluate these construction conditions.

- In general, we anticipate all onsite soil and bedrock materials can be excavated with conventional trenching and tunneling methods. Hard to very hard and oversize materials may be encountered in local areas.

- Based on our preliminary laboratory testing, we anticipate the onsite soils will be highly expansive. These materials include recent and older alluvium, existing artificial fill, recent and ancient landslide debris, and bedrock.

- Based on our preliminary laboratory testing (See appendix B), we anticipate the onsite soils and rock will have the following corrosion potential:

    - Potential Soil Corrosion to Concrete
        - Recent/Older Alluvium/Topsoil – negligible
        - Existing Artificial Fill - negligible
        - Recent/Ancient Landslide Debris and bedrock – negligible

    - Potential Soil Corrosion to Ferrous Metals
        - Recent/Older Alluvium – severe
        - Existing artificial Fill - severe
        - Recent/Ancient Landslide Debris and bedrock – severe

- Based on our preliminary laboratory testing, we anticipate the onsite surficial soils (i.e., alluvium, older alluvium, topsoil, etc.) will be moderately to highly compressible. Removal and re-compaction of these materials will likely be required in local areas, depending on the design alternative selected. It is anticipated the landslide debris and bedrock will be generally slightly to non-compressible.

## SUMMARY OF SLOPE STABILITY ANALYSES

The following project areas were analyzed for slope stability: Tarapaca landslide, descending slope below the switchbacks of PVDE, and the bluff area along the beach at the proposed outlet structure location for Alternative 1. Slope stability results along with details of the strength model used at each section are contained in Appendix C. A summary of the results of the analyses is contained below.

**Tarapaca Landslide**

To evaluate how much fill is required in the canyon bottom to act as a gravity buttress, Cross-Sections 2-2' and 3-3' (drawn through the Tarapaca landslide) were analyzed with various gravity buttress heights. The results of these analyses indicate that approximately 10 to 20 feet of fill (10 feet at the upper end and 20 feet at the lower end) will be required to obtain a safety factor of approximately 1.25. Approximately 20 to 30 feet of fill placed in the canyon at the toe of the landslide would be required to obtain a safety factor of approximately 1.5. Given the relatively small fill height differential required to obtain a 1.5 safety factor, it is recommended that strong consideration be given to designing a buttress that achieves the 1.5 safety factor.

The fill could be placed in various configurations to obtain the required safety factors. The exact configuration of the buttress fill will be developed at the design stage of the project and once the final safety factor is decided upon.

**Lower Switchback PVDE**

Cross-Section 3-3' was analyzed to evaluate the existing slope stability safety factor at the lower switchback of PVDE and to estimate how much additional erosion would be required to impact the existing roadway (i.e., a safety factor of 1.0). Based on the strength model and assumptions provided in Appendix C, a safety factor of approximately 1.4 was obtained for existing conditions. Parametric analyses were performed by progressively moving the existing canyon wall and slope face back until a safety factor of 1.0 was achieved. These analyses indicate that the existing slope face would have to be eroded back approximately 35 feet before the roadway would be in a state of imminent failure. The probability that the existing slope face would be eroded back 35 feet should be evaluated by the project civil engineer to determine if any remediation is warranted. Based on our preliminary analyses and erosion rate assumptions, it appears that it would take approximately 7 years for the roadway to be impacted by erosion. It should be noted that the existing sewer line and utility easement would be impacted prior to this distance and time. Given the poor quality of the as-built sewer plans on file at the City, the exact location of the sewer line is not known; however, it appears this line is located between 5 and 10 feet closer to the canyon than the roadway.

**Upper Switchback PVDE**

Cross-Section 1-1' was analyzed to evaluate the existing slope stability safety factor at the upper switchback of PVDE and to estimate how much additional erosion would be required to impact the existing roadway (i.e., a safety factor of 1.0). Based on the strength model and assumptions provided in Appendix C, a safety factor of approximately 1.3 was obtained for existing conditions. Parametric analyses were performed by progressively moving the existing canyon wall and slope face back until a safety factor of 1.0 was achieved. These analyses indicate that the existing slope face would have to be eroded back approximately 40 feet before the roadway would be in a state of imminent failure. The probability that the existing slope face would be eroded back 40 feet should be evaluated by the project civil engineer to determine if any remediation is warranted. Based on our preliminary analyses and erosion rate assumptions, it appears that it would take approximately 8 years for the roadway to be impacted by erosion. The existing sewer line and easement are located very close to the currently eroding areas, as shown on our Geotechnical Map, Plate 3. We strongly recommend this active line be protected from damage as soon as possible by the pipeline owner to prevent damage to the line.

**Bluff Stability**

The existing bluff conditions were analyzed for deep seated stability. The results of the analyses indicate that the bluff likely has a safety factor ranging from about 1.2 to over 1.4. Given that a slope failure would have to cut across large blocks of intact siltstone and siliceous siltstone and that the strength of these materials was not considered in the analyses, the actual safety factor is likely closer to the higher end of the range. Slope instability of the bluff face is not considered to be a geotechnical constraint for the project. However, surficial instability in the form of local slumps or "pop outs" may occur and will require further evaluation should this design alternative be selected.

## PVDE SWITCHBACKS STABILITY DISCUSSION

As discussed in previous sections of this report, our analyses indicates an additional lateral erosion of the canyon walls of 35 to 40 feet will result in a reduction of stability of the switchbacks to the point of incipient failure. In addition, lesser erosion is necessary to impact the existing 8-inch sewer line that is located between the canyon and the switchbacks. Regardless of the anticipated rate of erosion in this area, the existing sewer line should be protected by the owner as soon as possible in order to prevent failure of the line, particularly in the area of the lower switchback, where the line appears to be very close to the top of the eroded canyon wall.

If hydraulic calculations indicate the switchbacks will require stabilization prior to construction of the chosen design alternative for the storm drain system, three potential repair solutions are discussed below:

- Installation of caissons (CIDH piles) on the outside of the switchbacks – this option would be the most costly due to the construction materials, staging and construction area grading, and the difficulty of drilling in the ancient landslide debris. The bucket-auger borings in these areas encountered very difficult drilling due to hard zones and severe caving, and ultimately were abandoned due to refusal by the drilling equipment. However, this work would be within the City's property, and environmental constraints may be minimal.

- Installation of riprap or similar type of revetment in the canyon bottom – this option would be significantly less costly than caissons; however, the riprap would require grouting, and the flow velocities in the canyon may cause damage to the riprap in a major storm. In addition, continued failure of the Tarapaca landslide would likely bury the riprap, causing additional maintenance, repairs, or replacement. Finally, access to the area of the canyon with equipment to install the riprap would be difficult.

- Installation of a gravity buttress at the toe of the Tarapaca landslide with a flexible pipe system – this option would include installation of a flexible pipe (i.e., butt-fused, high strength HDPE) along the canyon bottom between the upper switchback and the boundary with the City of Los Angeles, with fill placement above the pipe to reduce movement of the Tarapaca landslide and erosion of the western canyon wall. This option would likely reduce the erosion in this area, significantly reduce (and potentially ultimately stop) the movement of the Tarapaca landslide, and significantly reduce the debris moving down canyon towards 25$^{th}$ street. It should be noted that this option differs from Alternative 2 in that there is no permanent storm drain relocation solution.

Should the City wish to pursue one of these options, additional geotechnical analyses would likely be required in order to provide detailed recommendations for construction.

## CANYON WALL STABILITY DISCUSSION

The results of the stability analyses for the slopes below the switchbacks indicate that where continuous adversely oriented bedding planes are not exposed in the bluff face, the in situ safety factor of the canyon walls is likely in the range of 1.3 to 1.4. Where adversely oriented bedrock exists relative to the canyon wall – such as in the area of the Tarapaca landslide – failure has either already occurred or the current safety factor is in the range of just above 1.0 to 1.2. In addition, local occurrences of adversely oriented planar bedrock surfaces may also result in local small failures.

## CONCLUSIONS

Based on the results of our investigation and analyses, we present the following conclusions:

1. Design Alternatives 1, 2, and 3 are considered to be feasible, provided the design considerations and recommendations for additional work presented in this report are followed.

2. The site is predominately underlain by the South Shores landslide, an ancient, dormant landslide complex.

3. The site includes the Tarapaca landslide, a currently failing mass that appears to have failed along continuous adversely oriented bedding due to erosion of the canyon wall.

4. None of the design alternatives will adversely impact the repaired San Ramon Canyon failure area, located offsite to the north.

5. Groundwater should not be a significant impact to any of the design alternatives for the project.

6. The site will be subject to seismic hazards in the future; however, none of the design alternatives will increase the likelihood or magnitude of these impacts.

7. The Tarapaca landslide can be stabilized with a reduction of erosion at the toe and construction of a gravity-type buttress.

8. The switchbacks of PVDE are currently considered to have safety factors at or greater than 1.3. Approximately 35 to 40 feet of lateral erosion/failure would occur before the factor of safety is reduced to 1.0 (imminent failure).

9. The existing 8-inch sewer line should be relocated as soon as possible in order to avoid damage to the line from canyon wall erosion.

10. The conceptual access road will require significant corrective grading and/or stabilization of the cuts. Should these construction constraints become cost prohibitive, consideration should be given to relocation of the road to a more favorable site.

## DESIGN ALTERNATIVE GEOTECHNICAL CONSIDERATIONS

## ALTERNATIVE 1

As discussed in a previous section of this report, Alternative 1 consists of constructing a storm drain system to divert runoff water to the west of San Ramon Canyon, as shown on Plate 6 and in the Harris (2010) plans. It is our understanding this storm drain system would be constructed with a combination of open trench and tunneling methods.

In addition, excavation spoils and any local import would be utilized to grade a "gravity-type" buttress at the toe of the Tarapaca landslide. As discussed in our "Slope Stability" section, it is anticipated that up to 30 vertical feet of engineered fill would be required in order to reduce the movement of the landslide to static levels and bring the factor of safety up to 1.5.

### Anticipated Construction Methods

We understand the open trench method would be utilized in the portion of the system adjacent to the inlet structure in the canyon, and in the portion south of 25$^{th}$ Street. Tunneling methods would be utilized in the remaining portions of the system, including near the bluff, connecting to the outlet structure. In addition, the system will require construction of an inlet structure within the upper San Ramon Canyon and an outlet structure at the toe of the bluff ascending from the ocean. It is anticipated the entire system will encounter ancient landslide debris of the South Shores landslide.

#### Pipe Design Considerations

The South Shores landslide is considered to be dormant, and has not shown signs of movement in historic time. However, design of the pipe and appurtenant structures (i.e., manholes, etc.) should take into consideration potential movement of the landslide mass, particularly during a seismic event. Minor movement along internal rupture or shear surfaces within the landslide mass may occur during the life of the storm drain system. Consideration should be given to choosing a high-strength flexible pipe material without joints (such as Butt-fused High Density Poly Ethylene Pipe) that can accommodate these possible minor movements.

### Preliminary Geotechnical Considerations for Open Trench Segments

#### Trench Excavation

Based on our preliminary evaluation and the results of our field exploration, variable stability conditions will be encountered in the trench walls during construction. Some local areas may be temporarily unstable, particularly within the deeper areas of the trench; therefore, shoring or trench wall lay-back will likely be required. Further exploration and analyses will be required in order to provide detailed shoring and temporary stability recommendations. However, for preliminary design alternative evaluation purposes, trench walls excavated at 1:1 (horizontal to vertical) should be anticipated to be temporarily stable.

Backfill and Pipe Bedding

We anticipate the onsite soils will be suitable for backfill of the trench above the pipe bedding zone. Some oversize materials will likely be encountered, and will not be suitable for placement within the backfill.

**Preliminary Geotechnical Considerations for Tunnel Segments**

Based on the RMR, visual observations and geophysical logging of cores, downhole geologic logging, and geologic observations of older landslide debris exposed in the canyon walls, the following preliminary observations can be made. Further evaluation of these considerations may be warranted, if this alternative is selected.

- Currently, the geologic structure is oriented favorably with respect to the tunnel alignment. Any modifications to the tunnel alignment should consider the geologic structure. Further core holes are recommended to further define the geologic structure along the tunnel alignment.

- Groundwater is not anticipated to be encountered during tunneling. However future borings drilled below the tunnel invert elevation are recommended to further evaluate this condition.

- The overall RMR ratings do not consider the presence of hard siliceous zones which may be encountered during tunneling. Hard siliceous zones or blocks of materials should be expected to be encountered during tunneling.

- Some of the Altamira Shale member bedrock cores swelled after being exposed to the air for several days. The swelling is attributed to air drying and potentially secondary mineral crystal growth. The swelling will create pressure on the ground supports installed for the tunnel construction.

- Tunneling may also encounter local zones of adversely oriented geologic discontinuities that may be lined with bentonite. These zones may produce local stability problems during tunneling.

- Based on the RMR ratings:
  - The proposed tunnel will be excavated through Fair to Poor rock.
  - Approximate stand-up time during tunneling is expected to range from:
    - 10 hours to 1 week for an 8-foot to 15-foot span.

**Preliminary Geotechnical Considerations for Canyon Inlet Structure**

Design Considerations

Based on our understanding of Alternative 1 and our review of the conceptual plans by Harris & Associates (2010), the conceptual location of the inlet structure is anticipated to be founded on bedrock or ancient landslide debris. Design of this structure should take into consideration the geotechnical characteristics of these materials (i.e., high expansion, etc.). In addition, further investigation at the location of the structure may be required in order to evaluate temporary stability of excavations and to provide site-specific design values for the structure walls as well as recommendations for foundation design and wall drainage.

Temporary Stability and Shoring

While the canyon slopes in the area of the possible inlet structure location may be grossly stable during construction (see "Upper Switchback" portion of the "Slope Stability" section, above), surficial slumping or localized "pop outs" are likely to occur. Further investigation of the inlet structure location will be required in order to provide specific recommendations in regards to temporary stability. However, for the purposes of this study of Alternative 1, it can be assumed that shoring or other stability methods (i.e., caissons, sheet piles, etc.) will likely be required for temporary stability.

Maintenance

Regular maintenance of the inlet structure will be critical to keep the drain system clear. A maintenance schedule should be established and followed regularly with, at a minimum, annual inspection, repair, and cleanout of the structure. Additional inspections should be considered after heavy rain events.

Access Road and Retaining Wall Construction

Based on our review of the Harris (2010) conceptual access road plans, it is our understanding that an access road would be constructed from the cul-de-sac of Tarapaca Road to the inlet structure in order to provide maintenance access. The Harris (2010) plans indicate this road would be mostly in cut bedrock materials, and would require a retaining wall against the ascending cut slope. Cross-Sections 8-8' and 9-9' were drawn to illustrate the conceptual road location and the subsurface geologic structure. Based on our review of previous geotechnical reports for adjacent properties (see Reference list), bedding orientations in this area will result in adversely oriented bedrock exposed during grading of this road. In addition, this road would be located upslope of the currently moving Tarapaca landslide, and directly downslope of existing residential development.

Wall design will need to accommodate adverse structure, and temporary instability will require corrective grading, shoring, and structural support such as tiebacks. In addition, alternative paving may be considered, including concrete, pavers, or other designs that may accommodate the expansive soils and slope creep. Further field investigation and analyses of this area will be required for this possible access road location in order to obtain site-specific geologic and geotechnical data to evaluate these potential issues.

Should these construction measures become cost prohibitive, consideration should be given to relocating this road to an area with more favorable geologic conditions, such as the western side of the canyon near the existing PVDE switchbacks.

**Preliminary Geotechnical Considerations for Bluff Face Outlet Structure**

<u>Design Considerations</u>

Based on our understanding of Alternative 1 and our review of the conceptual plans by Harris & Associates (2010), the conceptual location of the outlet structure at the toe of the bluff is anticipated to be founded on bedrock or ancient landslide debris (Cross-Section 6-6'). Design of this structure should take into consideration the geotechnical characteristics of these materials (i.e., high expansion, etc.). In addition, further investigation at the location of the structure will likely be required in order to evaluate temporary stability of excavations and to provide site-specific design values for the structure walls as well as recommendations for foundation design and wall drainage.

<u>Temporary Stability and Shoring</u>

While the bluff in the area of the possible outlet structure location may be grossly stable during construction (see "Slope Stability" section, above), minor surficial slumping or localized "pop outs" may potentially occur. These local instabilities are anticipated to be less significant than those of the canyon inlet structure due to the generally intact bedrock materials exposed in the bluff face. Further investigation of the outlet structure location may be required in order to provide specific recommendations in regards to temporary stability. However, for the purposes of this study of Alternative 1, it can be assumed that shoring or other stability methods (i.e., caissons, sheet piles, etc.) may be required for temporary stability of the bluff face during construction.

## ALTERNATIVE 2

As discussed in a previous section of this report, Alternative 2 consists of constructing a storm drain system to collect runoff water in upper San Ramon Canyon, as shown on Plate 6 and in the reference (1) plans, and carry it via storm drain piping to the existing inlet structure under 25th Street. It is our understanding this storm drain system would likely be constructed using open trench and supporting grading methods. It is anticipated this construction would encounter ancient landslide, bedrock, and alluvial soils. Based on our preliminary data, the majority of the pipe trench would be founded on bedrock or ancient landslide debris. It should be noted that significant trenching within the canyon bottom is not anticipated for this alternative.

In addition, construction of the storm drain system within the canyon would include construction of a "gravity-type" buttress at the toe of the Tarapaca landslide, similar to Alternative 1.

Pipe Design Considerations

Design of the pipe and appurtenant structures (i.e., manholes, etc.) should take into consideration potential movement of the South Shores landslide mass and the adjacent Tarapaca landslide, particularly during a seismic event. Consideration should be given to choosing a flexible pipe material without joints (such as butt-fused HDPE pipe) that can accommodate these possible minor movements.

### Preliminary Geotechnical Considerations for Open Trench Segments

Trench Excavation

Based on our preliminary evaluation and the results of our field exploration, variable stability conditions will be encountered in the trench walls during construction. Some local areas may be temporarily unstable, particularly within the deeper areas of the trench; therefore, shoring will likely be required. In addition, our slope stability analyses indicate the canyon walls are likely to be grossly stable; however, surficial slumps and local failures may occur during construction. Efforts should be made to design the pipe and trench such that excavation into the bedrock within the canyon bottom is kept to a minimum. Further exploration and analyses will be required in order to provide detailed shoring and temporary stability recommendations.

Backfill and Pipe Bedding

We anticipate the onsite soils will be suitable for backfill of the trench above the pipe bedding zone. Some oversize materials will likely be encountered, and will not be suitable for placement within the backfill.

**Preliminary Geotechnical Considerations for Canyon Inlet Structure**

Design Considerations

Based on our understanding of Alternative 2 and our review of the conceptual plans by Harris & Associates (reference (1)), the conceptual location of the inlet structure is the same as Alternative 1, and is anticipated to be founded on bedrock or ancient landslide debris. Design of this structure should take into consideration the geotechnical characteristics of the soil (i.e., high expansion, etc.). In addition, further investigation at the location of the structure may be required in order to evaluate temporary stability of excavations and to provide site-specific design values for the structure walls as well as recommendations for foundation design and wall drainage.

Temporary Stability and Shoring

While the canyon slopes in the area of the possible inlet structure location may be grossly stable during construction (see "Slope Stability" section, above), surficial slumping or localized "pop outs" may potentially occur. Further investigation of the inlet structure location will be required in order to provide specific recommendations in regards to temporary stability. However, for the purposes of this study of Alternative 1, it can be assumed that shoring or other stability methods (i.e., caissons, sheet piles, etc.) will likely be required for temporary stability.

Access Road and Retaining Wall Construction

Based on our review of the Harris (2010) conceptual access road plans, it is our understanding that an access road would be constructed from the cul-de-sac of Tarapaca Road to the inlet structure in order to provide maintenance access. The Harris (2010) plans indicate this road would be mostly in cut bedrock materials, and would require a retaining wall against the ascending cut slope. Cross-Sections 8-8' and 9-9' were drawn to illustrate the conceptual road location and the subsurface geologic structure. Based on our review of previous geotechnical reports for adjacent properties (see Reference list), bedding orientations in this area will result in adversely oriented bedrock exposed during grading of this road. In addition, this road would be located upslope of the currently moving Tarapaca landslide, and directly downslope of existing residential development.

Wall design will need to accommodate adverse structure, and temporary instability will require corrective grading, shoring, and structural support such as tiebacks. In addition, alternative paving may be considered, including concrete, pavers, or other designs that may accommodate the expansive soils and slope creep. Further field investigation and analyses of this area will be required for this possible access road location in order to obtain site-specific geologic and geotechnical data to evaluate these potential issues.

Should these construction measures become cost prohibitive, consideration should be given to relocating this road to an area with more favorable geologic conditions, such as the western side of the canyon near the existing PVDE switchbacks.

**Preliminary Geotechnical Considerations for Canyon Outlet Structure/Tie-In to City Inlet**

The area of the canyon where the Alternative 2 storm drain system connects to the existing City system is underlain by recent alluvium over landslide debris of the South Shores landslide. Should this alternative be selected, it is likely the alluvial soils underlying the pipe trench and the connection area will require corrective grading to remove compressible alluvial soils. However, further detailed investigation of this area may be required to fully evaluate the alluvial soils below the pipe depth.

## ALTERNATIVE B (OPTION TO ALTERNATIVES 1 AND 2)

As discussed in a previous section of this report, Alternative B consists of extending the storm drain systems described within Alternatives 1 and 2 up the canyon to connect to the existing storm drain system that outlets at the head of the canyon. Geotechnical considerations for this alternative are similar to that of Alternative 2. However, for ease of evaluation, these considerations are reproduced below.

Pipe Design Considerations

Design of the pipe and appurtenant structures (i.e., manholes, etc.) should take into consideration potential movement of the South Shores landslide mass and the adjacent Tarapaca landslide, particularly during a seismic event. Consideration should be given to choosing a flexible pipe material without joints (such as butt-fused HDPE pipe) that can accommodate these possible minor movements.

**Preliminary Geotechnical Considerations for Open Trench Segments**

Trench Excavation

Based on our preliminary evaluation and the results of our field exploration, variable stability conditions will be encountered in the trench walls during construction. Some local areas may be temporarily unstable, particularly within the deeper areas of the trench; therefore, shoring will likely be required. In addition, our slope stability analyses indicate the canyon walls are likely to be grossly stable; however, surficial slumps and local failures may occur during construction. Efforts should be made to design the pipe and trench such that excavation into the bedrock within the canyon bottom is kept to a minimum. Further exploration and analyses will be required in order to provide detailed shoring and temporary stability recommendations.

Backfill and Pipe Bedding

We anticipate the onsite soils will be suitable for backfill of the trench above the pipe bedding zone. Some oversize materials will likely be encountered, and will not be suitable for placement within the backfill.

**Preliminary Geotechnical Considerations for Tie-In to Existing Outlet**

The area of the canyon where this alternative system would tie into the existing outlet is anticipated to be underlain by bedrock of the Altamira Shale. Should this alternative be selected, field investigation at this location may be required to evaluate the underlying materials and any temporary construction slopes and/or trench walls.

## FUTURE TASKS

Once the design alternative is selected, we recommend our office be retained to perform future geotechnical investigations to provide design-level geotechnical recommendations for final design and construction of the chosen alternative. These future tasks will include:

- Additional field exploration at the chosen storm drain system alignment, including drilling additional borings and performing additional laboratory testing;
- Further specific quantitative analyses of foundation and retaining wall design, slope stability, surficial stability, temporary stability, and shoring design;
- Preparation of a final design report to support the chosen design alternative final plans.

## LIMITATIONS

All parties reviewing or utilizing this report should recognize that the findings, conclusions, and recommendations presented represent the results of our professional geological and geotechnical engineering efforts and judgements. Due to the inexact nature of the state of the art of these professions and the possible occurrence of undetected variables in subsurface conditions, we cannot guarantee that the conditions actually encountered during grading will be identical to those observed and sampled during our study or that there are no unknown subsurface conditions which could have an adverse effect on the use of the property. We have exercised a degree of care comparable to the standard of practice presently maintained by other professionals in the fields of geotechnical engineering and engineering geology, and believe that our findings present a reasonably representative description of geotechnical conditions and their probable influence on the grading and use of the property.

## SUPPORTING DATA

The following Plates and Appendices that complete this report are listed in the Table of Contents.

Respectfully submitted,

**GMU GEOTECHNICAL, INC.**

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lbs/10-036-00-00R (11-10-10)

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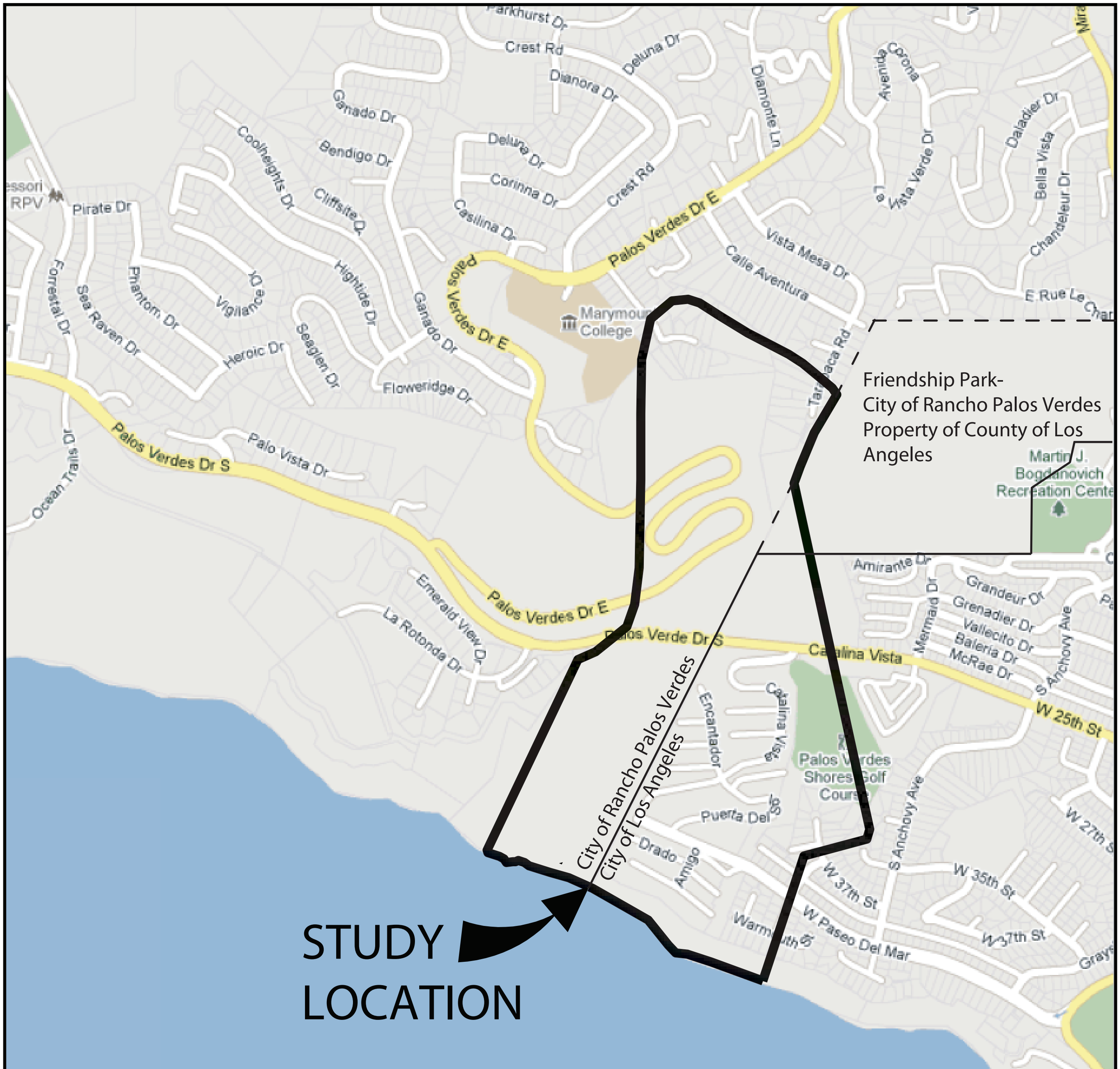
## AERIAL PHOTOGRAPHS

| Date | Flight No. | Frame No. | Date | Flight No. | Frame No. |
|---|---|---|---|---|---|
| 8-31-54 | 19K | 16, 17, 18 | 1-27-86 | F | 363, 364 |
| 2-20-58 | CAA-9 | 14, 15 | 7-7-88 | n/a | 19275, 19279 |
| 9-18-68 | 8-4 | 79, 80, 81 | 1-24-92 | C85-9 | 34, 35 |
| 1-31-70 | 61-9 | 185, 186 | 5-14-93 | C91-11 | 122 |
| 2-16-73 | 121M | 18-01, 19-01 | 1-28-95 | C102-37 | 4, 5 |
| 11-6-74 | 152G | 3-1 | 10-16-97 | C118-37 | 4, 5 |
| 3-17-78 | 78049 | 202, 203 | 2-24-99 | C134-37 | 205, 206 |
| 5-12-79 | FCLA-12 | 139, 140 | | | |




NT S

## Study Location Map

| GMU GEOTECHNICAL, INC. | Date: | November 10, 2010 | Plate |
|---|---|---|---|
| | Project No.: | 10-036-00 | 1 |


GMU GEOTECHNICAL, INC.

**STUDY AREA MAP**

| | | |
|---|---|---|
| Date: | November 10, 2010 | Plate 2 |
| Project No.: | 10-036-00 | |

# APPENDIX A

## Exploration Logs

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## APPENDIX A

## GMU GEOTECHNICAL EXPLORATION PROCEDURES, BORING LOGS, CONE PENETRATION TESTS, AND TEST PIT LOGS

Our exploration at the subject site consisted of three bucket auger borings, one hollow stem auger boring, and two continuous core borings. The estimated locations of the borings are shown on Plate 2. Our bucket auger and hollow stem auger borings were logged, and undisturbed samples were taken using a 3.0-inch outside-diameter drive sampler which contains a 2.416-inch-diameter brass sample sleeve 6 inches in length. In addition, blow counts recorded during sampling from the drive sampler are shown on the drill hole logs. Standard Penetration Tests (SPT) were also taken in hollow stem drill hole. Small bulk samples of the material were collected, and blow counts for each SPT were recorded on the logs. Continuous core samples were collected in the core borings. The logs of all GMU borings are contained in Appendix A-1 and the Legend to Logs is presented as Plate A-1. Logs of subsurface investigations performed by others are contained in Appendix A-2.

The geologic and engineering field descriptions and classifications that appear on these logs are prepared according to Corps of Engineers and Bureau of Reclamation standards. Major soil classifications are prepared according to the Unified Soil Classification System as modified by ASTM Standard No. 2487. Since the description and classification that appear on the Log of Drill Hole are intended to be that which most accurately describe a given interval of a drill hole (frequently an interval of several feet), discrepancies do occur in the Unified Soil Classification System nomenclature between that interval and a particular sample in that interval. For example, an 8-foot-thick interval in the Log of Drill Hole may be identified as silty sand (SM) while one sample taken within the interval may have individually been identified as sandy silt (ML). This discrepancy is frequently allowed to remain to emphasize the occurrence of local textural variations in the interval.

The descriptive terminology of the logs is modified from current ASTM Standards to suit the purposes of this study and is summarized as follows:

| | | |
|---|---|---|
| a. | Soil Type | - per Legend to Logs |
| b. | Color | - at field moisture |
| c. | Moisture | - (as estimated during drilling) |
| | "dry" | |
| | "damp" | - some moisture but less than optimum for compaction |
| | "moist" | - near optimum |
| | "wet" | - above optimum |
| | "saturated" | - containing free moisture |

d. Grain size - "fine," "medium" and "coarse"

e. Density (granular soils) – "loose," "medium dense" and "dense"

f. Consistency (cohesive soils)

| | |
|---|---|
| "very soft" | Thumb will penetrate soil more than 1 inch (25 mm). |
| "soft" | Thumb will penetrate soil about 1 inch (25 mm). |
| "firm" | Thumb will indent soil about 3 inch (5 mm). |
| "hard" | Thumb will not indent soil but readily indented with thumbnail. |
| "very hard" | Thumbnail will not indent soil. |

# APPENDIX A-1

## GMU Geotechnical Boring Logs

| MAJOR DIVISIONS | | | Group Letter | Symbol | TYPICAL NAMES |
|---|---|---|---|---|---|
| **COARSE-GRAINED SOILS**<br>More Than 50% Retained On No.200 Sieve<br><br>Based on The Material Passing The 3-Inch (75mm) Sieve.<br><br>Reference:<br>ASTM Standard D2487 | **GRAVELS**<br>50% or More of Coarse Fraction Retained on No.4 Sieve | Clean Gravels | GW | | Well Graded Gravels and Gravel-Sand Mixtures, Little or No Fines. |
| | | | GP | | Poorly Graded Gravels and Gravel-Sand Mixtures Little or No Fines. |
| | | Gravels With Fines | GM | | Silty Gravels, Gravel-Sand-Silt Mixtures. |
| | | | GC | | Clayey Gravels, Gravel-Sand-Clay Mixtures. |
| | **SANDS**<br>More Than 50% of Coarse Fraction Passes No.4 Sieve | Clean Sands | SW | | Well Graded Sands and Gravelly Sands, Little or No Fines. |
| | | | SP | | Poorly Graded Sands and Gravelly Sands, Little or No Fines. |
| | | Sands With Fines | SM | | Silty Sands, Sand-Silt Mixtures. |
| | | | SC | | Clayey Sands, Sand-Clay Mixtures. |
| **FINE-GRAINED SOILS**<br>50% or More Passe The No.200 Sieve<br><br>Based on The Material Passing The 3-Inch (75mm) Sieve.<br><br>Reference:<br>ASTM Standard D2487 | **SILTS AND CLAYS**<br>Liquid Limit Less Than 50% | | ML | | Inorganic Silts, Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts With Slight Plasticity. |
| | | | CL | | Inorganic Clays of Low To Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays. |
| | | | OL | | Organic Silts and Organic Silty Clays of Low Plasticity |
| | **SILTS AND CLAYS**<br>Liquid Limit 50% or Greater | | MH | | Inorganic Silts, Micaceous or Diatomaceous Fine Sandy or Silty Soils, Elastic Silts. |
| | | | CH | | Inorganic Clays of High Plasticity, Fat Clays. |
| | | | OH | | Organic Clays of Medium To High Plasticity, Organic Silts. |
| **HIGHLY ORGANIC SOILS** | | | PT | | Peat and Other Highly Organic Soils. |

## ADDITIONAL TESTS

DS = Direct Shear
HY = Hydrometer Test
TC = Triaxial Compression Test
UC = Unconfined Compression
CN = Consolidation Test
(T) = Time Rate
EX = Expansion Test
CP = Compaction Test
PS = Particle Size Distribution
EI = Expansion Index
SE = Sand Equivalent Test
AL = Atterberg Limits
FC = Chemical Tests
RV = Resistance Value
SG = Specific Gravity
SU = Sulfates
CH = Chlorides
MR = Minimum Resistivity
pH
(N) = Natural Undisturbed Sample
(R) = Remolded Sample

## SAMPLE SYMBOLS

Undisturbed Sample (California Sample)
Undisturbed Sample (Shelby Tube)
Bulk Sample
Unsuccessful Sampling Attempt
SPT Sample
Nuclear Density Test and Bag for Moisture

10. 10 Blows for 12-Inches Penetration
6/4: 6 Blows Per 4-Inches Penetration
P: Push
(13): Uncorrected Blow Counts ("N" Values) for 12-Inches Penetration- Standard Penetration Test (SPT)

## GEOLOGIC NOMENCLATURE

B = Bedding S = Shear
C = Contact F = Fracture
J = Joint Flt = Fault
RS = Rupture Surface

▼ = Groundwater

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## LEGEND TO LOGS

ASTM Designation: D 2487
(Based on Unified Soil Classification System)

Plate X

P13a-Log Exp (04-158-00)

| Project: San Ramon Canyon | Log of Drill Hole DH-1 |
|---|---|
| Project Location: 25th Street, Rancho Palos Verdes | Sheet 1 of 5 |
| Project Number: 10-036-00 | |

| | | | | | |
|---|---|---|---|---|---|
| Date(s) Drilled | 6/15 - 6/16/10 | Logged By | WAD | Checked By | LBS |
| Drilling Method | Bucket Auger | Drilling Contractor | Alroy Drilling Services, Inc. | Total Depth of Drill Hole | 103.0 feet |
| Drill Rig Type | EZ Bore | Diameter(s) of Hole, inches | 30 | Approx. Surface Elevation, ft MSL | 145.0 |
| Groundwater Depth [Elevation], feet | N/A [] | Sampling Method(s) | Open drive sampler with 6-inch sleeve | Drill Hole Backfill | Native, Tamped |
| Remarks | Refusal at 103 feet; Not downhole logged below 93 feet due to low oxygen levels | | | Driving Method and Drop | Kelly |

| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | NUMBER OF BLOWS | DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | DRY UNIT WEIGHT, pcf | ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **SOUTH SHORES LANDSLIDE (Qols)** Upper 5.1 feet of hole cased due to fractured cherty siltstone and caving | | CLAYEY SILT (ML), gray, light brown to brown, damp, hard to very hard | | | | | | |
| 140 | 5 | | Intact remnant bedrock - large block of remnant Altamira Shale member of Monterey Formation; clayey siltstone with interbeds of siliceous siltstone, siliceous siltstone beds up to 2 inches thick | B: N70W, 10S | Becomes very firm to hard at 5 feet | | 2 | 4800 | 36 | 72 | |
| | | | Bedding on siliceous siltstone bed at 6 feet Zone of siliceous siltstone, 3 feet thick, fractured, well-bedded at 7 feet | | SILT (ML), gray, damp, very hard | | | | | | |
| 135 | 10 | | Interbedded clayey siltstone, siltstone, siliceous siltstone, moderately defined bedding at 10 feet | B: N70W, 10S | CLAYEY SILT (ML), gray to light brown, damp, very firm to hard | | 5 | 4800 | 41 | | |
| | | | Clayey siltstone interbedded with siliceous siltstone, joints are randomly oriented, infilled with gypsum, up to 1/8-inch thick at 12.5 feet | | Becomes light brown to brown at 12.5 feet | | | | | | |
| 130 | 15 | | Interbedded clayey siltstone, siltstone, and siliceous siltstone, fractured and jointed; two prominent joints with gypsum infilling, up to 1/4-inch thick, at 15 feet | J: N17E, 74NW J: N5W, 84E | Becomes damp to moist at 15 feet | | 3 | 4800 | 60 | 64 | FC |
| | | | Moderately defined bedding at 16.5 feet | B: N87W, 8S | | | | | | | |
| | | | Siliceous siltstone zone, 0.75 feet thick, highly fractured, orange staining on joint and bedding surfaces, gypsum infilling up to 1/4-inch thick at 17.5 feet | | SILT (ML), brownish gray, damp, very hard | | | | | | |
| | | | Interbedded siltstone and clayey siltstone at 19 feet | B: N58W, 6SW | CLAYEY SILT (ML), brown and light gray, damp to moist, very firm to hard | | | | | | |

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**Project:** San Ramon Canyon
**Project Location:** 25th Street, Rancho Palos Verdes
**Project Number:** 10-036-00

# Log of Drill Hole DH-1



| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | SAMPLE DATA: NUMBER OF BLOWS | SAMPLE DATA: DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | TEST DATA: DRY UNIT WEIGHT, pcf | TEST DATA: ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | ■ | 4 | 4800 | 44 | 75 | |
| | | | Interbedded siltstone and siliceous siltstone, gypsum infilling up to 1/4-inch predominately on bedding, rarely on joints, well-defined bedding, dark brown staining on bedding and joints at 22 feet | | | | | | | | |
| | | | Siliceous siltstone bed, 1-foot thick, at 24 feet | | SILT (ML), gray, damp, very hard | | | | | | |
| 120 | 25 | | Bedding at 25 feet | B: N74E, 8S | CLAYEY SILT (ML), gray and brown, moist, hard to very hard | ■ | 6 | 4800 | 40 | 75 | DS |
| | | | | B: N82W, 9S | | | | | | | |
| | | | Siliceous siltstone zone, well defined beds up to 8-inches thick, gypsum infilling along bedding planes, moderately fractured at 28.5 feet | | SILT (ML), gray, damp, very hard<br>Using core bucket during drilling at 29 feet | | | | | | |
| 115 | 30 | | Siltstone, poorly defined bedding at 30 feet<br>Silty clay bed, gypsum infilling along joint that crosses bed, bed is up to 3/4-inch thick, at 27 feet | | CLAYEY SILT (ML), gray and brown, moist, hard to very hard<br>Too hard to sample at 30 feet | | | | | | |
| | | | Increase in density, difficult to excavate at 32.5 feet | | Becomes very hard at 32.5 feet | | | | | | |
| 110 | 35 | | Clayey siltstone, massive, 2-feet thick at 34.5 feet | | CLAYEY SILT (ML), brown to orange brown, damp to moist, hard to very hard | ■ | 7 | 3350 | 24 | 82 | |
| | | | | | SILT (ML), gray and brown, moist, hard to very hard | | | | | | |
| | | | Bedding at 38.5 feet | B: N38E, 4SE | | | | | | | |
| 105 | 40 | | | | | ■ | 4 | 3350 | 43 | 79 | |
| | | | Siliceous siltstone zone, 6-inches thick at 43 feet; below is poorly defined bedding | | Becomes very hard at 43 feet<br>Becomes hard at 43.5 feet | | | | | | |
| | | | Subparallel joint set at 44 feet | J: N18W, 62SW | | | | | | | |

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GMU GEOTECHNICAL, INC.

**Project:** San Ramon Canyon
**Project Location:** 25th Street, Rancho Palos Verdes
**Project Number:** 10-036-00

# Log of Drill Hole DH-1



| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | SAMPLE DATA: NUMBER OF BLOWS | SAMPLE DATA: DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | TEST DATA: DRY UNIT WEIGHT, pcf | TEST DATA: ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 12 | 3350 | 28 | 105 | |
| | | | Siliceous siltstone zone, moderately fractured, open joints up to 1/3-inch (may be mechanical), lined with gypsum, massive, zone is 1-foot thick, below 46.5 feet | | SILT (ML), gray, moist, very hard | | | | | | |
| | | | Interbedded siltstone, clayey siltstone with moderately defined laminations at 47.5 feet | | CLAYEY SILT (ML), gray and orange brown, moist, hard | | | | | | |
| 95 | 50 | | | | | | 8 | 3350 | 36 | 85 | |
| | | | Clayey siltstone, massive, random gypsum infilling at 52 feet | | Becomes grayish brown at 52 feet | | | | | | |
| 90 | 55 | | Siliceous siltstone zone, dark brown staining on joint surfaces at 55 feet | | SILT (ML), gray and brown, moist, hard to very hard<br>Too hard to sample at 55 feet | | | | | | |
| | | | Very minor seepage on NE wall, along joint surfaces at 58 feet | | Becomes moist to wet at 58 feet | | | | | | |
| | | | Bedding at 59.5 feet | B: N79E, 8S | CLAYEY SILT (ML), gray and brown, moist, hard to very hard | | | | | | |
| 85 | 60 | | | | | | 11 | 2045 | 44 | 99 | |
| | | | | | | | | | | | FC |
| | | | Discontinuous lenses of unoxidized material up to 2-inches thick, no bedding observed, gypsum-filled veins up to 1/8-inch thick below 63 feet | | Becomes orange brown with dark bluish gray at 63 feet | | | | | | |
| 80 | 65 | | | | Too hard to sample at 65 feet | | | | | | |
| | | | Increase in density, very difficult to excavate at 65.5 feet | | Becomes very hard at 65.5 feet | | | | | | |
| | | | Grading to unoxidized siltstone, no bedding observed, very finely laminated, slight seepage along joints, difficult to excavate below 66.5 feet | | SILT (ML), very dark brown, moist, very hard | | | | | | |
| | | | Unoxidized clayey siltstone, massive, random gypsum veins below 67.5 feet | | Becomes very dark gray at 67.5 feet | | | | | | |
| | | | Prominent joint at 69.5 feet | J: N34W, 84SW | | | | | | | |



GMU GEOTECHNICAL, INC.

Project: San Ramon Canyon
Project Location: 25th Street, Rancho Palos Verdes
Project Number: 10-036-00

# Log of Drill Hole DH-1



| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | SAMPLE DATA: NUMBER OF BLOWS | SAMPLE DATA: DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | TEST DATA: DRY UNIT WEIGHT, pcf | TEST DATA: ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 15 | 2045 | 36 | 82 | |
| | | | Siltstone, massive, prominent joint at 73.5 feet | J: N4W, 87W | | | | | | | |
| 70 | 75 | | | | | | 16 | 2045 | 30 | 86 | DS |
| | | | Continues massive, difficult to excavate at 75.5 feet | | Becomes dark bluish gray at 75.5 feet | | | | | | |
| | | | | | Becomes dark gray at 77.5 feet | | | | | | |
| 65 | 80 | | Poorly defined bedding, very difficult to excavate to 81.5 feet, used core bucket during drilling at 80 feet | | Too hard to sample at 80 feet | | | | | | |
| 60 | 85 | | | | | | 23 | 2045 | 34 | 85 | |
| | | | Finely laminated, very difficult to excavate below 86.5 feet | | | | | | | | |
| | | | Bedding at 88.5 feet | B:N70W, 8S | | | | | | | |
| 55 | 90 | | | | Too hard to sample below 90 feet | | | | | | |
| | | | End of downhole log due to lack of oxygen in boring at 93 feet | | | | | | | | |

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| Project: San Ramon Canyon | Log of Drill Hole DH-1 |
|---|---|
| Project Location: 25th Street, Rancho Palos Verdes | Sheet 5 of 5 |
| Project Number: 10-036-00 | |

| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | SAMPLE DATA: NUMBER OF BLOWS | SAMPLE DATA: DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | TEST DATA: DRY UNIT WEIGHT, pcf | TEST DATA: ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | 100 | | | | | | | | | | |

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Drill Hole DH-1

| | |
|---|---|
| **Project: San Ramon Canyon**<br>**Project Location: 25th Street, Rancho Palos Verdes**<br>**Project Number: 10-036-00** | # Log of Drill Hole DH-2<br>Sheet 1 of 3 |

| | | | | | |
|---|---|---|---|---|---|
| Date(s) Drilled | **6/28/10** | Logged By | **LBS** | Checked By | **N/A** |
| Drilling Method | **Bucket Auger** | Drilling Contractor | **Alroy Drilling Services, Inc.** | Total Depth of Drill Hole | **63.0 feet** |
| Drill Rig Type | **EZ Bore** | Diameter(s) of Hole, inches | **30** | Approx. Surface Elevation, ft MSL | **560.0** |
| Groundwater Depth [Elevation], feet | **N/A** | Sampling Method(s) | **Open drive sampler with 6-inch sleeve** | Drill Hole Backfill | **Native, Tamped** |
| Remarks | **Refusal at 63 feet due to severe caving below 55 feet; not downhole logged below 55 feet** | | | Driving Method and Drop | **Kelly** |

| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | NUMBER OF BLOWS | DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | DRY UNIT WEIGHT, pcf | ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **SOUTH SHORES LANDSLIDE (Qols)** Remnant blocks of bedrock, interbedded cherty siltstone and siltstone with some bentonitic tuff, scattered pockets of topsoil and remolded clayey silt, abundant rootlets below 0 feet | | CLAYEY SILT (ML), light gray to light brown, dry to damp, soft to firm, locally hard | | | | 36 | | PS, HY, AL, CP, DS |
| | | | Bedding at 2 feet | B: N-S, 32E | | | | | | | |
| 555 | 5 | | | | Poor sample, very disturbed, loose, rocky at 5 feet | | P | 4800 | 39 | | |
| | | | Bedding at 8 feet | B: N20W, 26NE | Increase in density during drilling at 8 feet | | | | | | |
| 550 | 10 | | | | | | 3 | 4800 | 23 | 101 | |
| | | | Grades to siltstone and bentonitic tuff, jumbled and chaotic, no continuous structure below 13 feet | | Becomes light gray and orange brown, damp to moist, firm at 13 feet | | | | | | |
| | | | Siliceous zone with minor interbedded bentonitic tuff, bedding highly discontinuous and folded below 14 feet | | SILT (ML), with some CLAY (CL), light gray and orange brown, damp, moist, firm to hard | | | | | | |
| 545 | 15 | | Bedding at 15 feet | B: N40W, 34NE | | | 3 | 4800 | 42 | 68 | DS |
| | | | | | Increase in density, difficult drilling between 17 and 19 feet | | | | | | |
| | | | Interbedded siliceous siltstone, siltstone, and bentonitic tuff, some shearing along | | CLAYEY SILT (ML), light gray to light brown with orange brown, moist, firm to | | | | | | |

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| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | SAMPLE DATA: NUMBER OF BLOWS | SAMPLE DATA: DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | TEST DATA: DRY UNIT WEIGHT, pcf | TEST DATA: ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | bedding below 19 feet | | hard<br>Too hard to sample at 20 feet | | | | | | |
| | | | Bedding at 22 feet | B: N28W, 37NE | | | | | | | |
| 535 | 25 | | | | | | 2 | 4800 | 38 | | |
| | | | Siliceous siltstone zone between 25.5 and 27 feet | B: N20W, 27NE | SILT (ML), gray, damp to moist, hard | | | | | | |
| | | | Sheared zone of predominately siltstone and bentonitic tuff fragments, jumbled, fractured, chaotic, no structure observed, abundant orange and black staining below 27 feet | | CLAYEY SILT (ML), light gray to light brown, dry to damp, firm to very firm | | | | | | |
| 530 | 30 | | | | | | 3 | 3350 | 33 | 65 | DS |
| | | | Remnant blocks of siliceous siltstone up to 2 feet long within sheared debris matrix, very fractured, contorted, randomly oriented fragments and blocks, between 33.5 and 39 feet | | SILT (ML), with some CLAY, gray, light brown, orange brown, damp, firm to hard | | | | | | |
| 525 | 35 | | | | | | 5 | 3350<br>3350 | 29 | 81 | PS, HY, AL, CP, FC, DS |
| | | | | | Increase in density, begin using crowds during drilling at 37 feet | | | | | | |
| | | | Remnant fragments of bedrock, jumbled, chaotic, highly sheared, no continuous structure, scattered open fractures, many appear to be mechanical, below 39 feet | | CLAYEY SILT (ML), light gray to light brown, orange brown, damp to moist, firm to very firm | | | | | | |
| 520 | 40 | | | | | | 3 | 3350 | 23 | 78 | |

**Project:** San Ramon Canyon
**Project Location:** 25th Street, Rancho Palos Verdes
**Project Number:** 10-036-00

# Log of Drill Hole DH-2



| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | NUMBER OF BLOWS | DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | DRY UNIT WEIGHT, pcf | ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Remnant blocks of siliceous siltstone up to 2 feet long within sheared debris matrix, very fractured, contorted, randomly oriented fragments and blocks, between 45 and 49 feet | | SILT (ML), with some CLAY, gray, light brown, orange brown, damp, firm to hard | | 3 | 3350 | 24 | 76 | |
| | | | General fabric or texture of debris trending E-W and dipping 20 S at 46 feet | J: N36W, 84NE | | | | | | | |
| | | | Prominent joint set within remnant blocks of siliceous siltstone, 2 to 6-inch spacing, at 47 feet | | | | | | | | |
| 510 | 50 | | Siliceous siltstone, jumbled and chaotic, on NW wall is block of relatively intact partially oxidized clayey siltstone, block is about 2-feet wide and 2.5 feet wide, ragged edges, bound by debris between 49 and 51.5 feet | B: N70W, 43NE | CLAYEY SILT (ML), light gray to light brown and brown to dark brown, damp, very firm to hard | | 8 | 3350 | 28 | 77 | |
| | | | Moderate caving of siliceous siltstone blocks below 51.5 feet | | SILT (ML), gray, damp, very firm to hard | | | | | | |
| 505 | 55 | | Severe caving of siliceous siltstone blocks, some diatomaceous siltstone in cuttings, hole belled out to about 5-feet diameter; not downhole logged below 55 feet | | Sample is siliceous/diatomaceous and rocky at 55 feet | | 3 | 3350 | 15 | 76 | |
| 500 | 60 | | | | | | | 3350 | 25 | 67 | DS |
| | | | Probable base of caving, cuttings are clayey siltstone, siltstone, bentonitic tuff and some siliceous siltstone fragments, below 62 feet | | CLAYEY SILT (ML), gray to brown, damp to moist, very firm | | | | | | |

| | |
|---|---|
| **Project:** San Ramon Canyon | **Log of Drill Hole DH-3** |
| **Project Location:** 25th Street, Rancho Palos Verdes | Sheet 1 of 3 |
| **Project Number:** 10-036-00 | |

| | | | | | |
|---|---|---|---|---|---|
| Date(s) Drilled | 6/29 - 6/30/10 | Logged By | LBS | Checked By | N/A |
| Drilling Method | Bucket Auger | Drilling Contractor | Alroy Drilling Services, Inc. | Total Depth of Drill Hole | 60.0 feet |
| Drill Rig Type | EZ Bore | Diameter(s) of Hole, inches | 30 | Approx. Surface Elevation, ft MSL | 663.0 |
| Groundwater Depth [Elevation], feet | N/A [] | Sampling Method(s) | Open drive sampler with 6-inch sleeve | Drill Hole Backfill | Native, Tamped |
| Remarks | Refusal at 60 feet due to severe caving below 53 feet; not downhole logged below 22 feet due to severe caving | | | Driving Method and Drop | Kelly |

| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | SAMPLE DATA: NUMBER OF BLOWS | SAMPLE DATA: DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | TEST DATA: DRY UNIT WEIGHT, pcf | TEST DATA: ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | | **ARTIFICIAL FILL (Qaf)** Upper 3.5 feet of hole cased due to caving and rocky fill soils | | SANDY CLAY (CL), dark brown, orange mottled, dry to damp, firm | | | | | | |
| 660 | 3 | | | | | X | | | 17 | | PS, HY, AL |
| | | | Vari-colored fill soils from road grading, abundant rock fragments to 8-inches diameter, no visible lifts observed below 3.5 feet | | | | | | | | |
| | 5 | | | | | ■ | 2 | 4800 | 30 | | |
| | | | | | | X | | | | | |
| 655 | | | | | | | | | | | |
| | 10 | | | | | ■ | P | 4800 | | | |
| 650 | | | Abundant siliceous siltstone fragments within fill soils up to 18-inches diameter, between 13 and 15 feet | | Abundant gravel, cobble, and boulder-sized rock fragments at 13 feet | | | | | | |
| | 15 | | | | | ■ | 2 | 4800 | 34 | 72 | |
| | | | Lower contact is diffuse and generally horizontal at 16 feet | | | | | | | | |
| | | | **SOUTH SHORES LANDSLIDE (Qols)** Soil matrix of sandy clay with abundant siliceous siltstone fragments up to 12-inches diameter, abundant staining, scattered small pockets of reddish orange bentonitic tuff, weathered, sheared, no continuous structure below 16 feet | | SANDY CLAY (CL) with SILT (ML), light brown with black, orange, and white staining, damp, firm | | | | | | |
| 645 | | | | | | | | | | | |
| | | | Abundant siliceous siltstone fragments within landslide matrix, chaotic, no | | | X | | | | | FC |

DH_REV3 10-036-00.GPJ GMULAB.GPJ 10/05/10

**Drill Hole DH-3**

GMU GEOTECHNICAL, INC.

| Project: San Ramon Canyon | Log of Drill Hole DH-3 |
|---|---|
| Project Location: 25th Street, Rancho Palos Verdes | Sheet 2 of 3 |
| Project Number: 10-036-00 | |

| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | SAMPLE DATA: NUMBER OF BLOWS | SAMPLE DATA: DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | TEST DATA: DRY UNIT WEIGHT, pcf | TEST DATA: ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | observed structure below 19 feet<br>Large block of siliceous siltstone on west wall, moderately bedded, general remnant bedding at 20 feet | B: N20E, 18SE | | | 1 | 4800 | 38 | 62 | DS |
| 640 | | | Severe caving on west wall, belled out about 2 to 3 feet, within siliceous siltstone zone, fractured, discontinuous layers and lenses at 22 feet<br>Not downhole logged below 22 feet due to severe caving | | SILT (ML), gray, damp, hard | | | | | | |
| | 25 | | Blocks of interbedded clayey siltstone, bentonitic tuff and siliceous siltstone within landslide matrix, fractured, abundant brown and orange staining, some shearing observed in sample at 25 feet | | CLAYEY SILT (ML), light brown, yellow brown, light gray, damp, firm to very firm with local hard areas | | 2 | 4800 | 24 | 84 | |
| 635 | | | | | | | | | | | |
| | 30 | | | | | | 3 | 3350 | 28 | 81 | DS |
| 630 | | | | | | | | | | | |
| | 35 | | Increase in density, using crowds during drilling below 35 feet | | Becomes light brown to light gray with orange at 35 feet | | 3 | 3350 | 36 | 63 | |
| 625 | | | | | | | | | | | |
| | 40 | | Increase in siliceous siltstone content, siliceous fragments in sample are fractured, fractures lined with brown staining, randomly oriented at 40 feet | | Becomes light gray, light brown, yellow gray, firm at 40 feet | | 1 | 3350 | 37 | 72 | |
| 620 | | | | | | | | | | | |

DH_REV3 10-036-00.GPJ GMULAB.GPJ 10/05/10

GMU GEOTECHNICAL, INC.

# Log of Drill Hole DH-3



| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | SAMPLE DATA: NUMBER OF BLOWS | SAMPLE DATA: DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | TEST DATA: DRY UNIT WEIGHT, pcf | TEST DATA: ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Some gypsum infilling in sample at 45 feet | | | | 3 | 3350 | 43 | 70 | |
| 615 | | | | | | | | | | | |
| | 50 | | Siliceous siltstone and siltstone, continued fractured in sample at 50 feet | | SILT (ML), gray, damp, firm to very firm | | 1 | 3350 | 41 | 66 | |
| 610 | | | Siliceous siltstone, difficult drilling, severe caving due to fractured siliceous material; inspection from surface indicates hole is belled out between 5 and 7 feet; below 53 feet | | Becomes hard to very hard at 53 feet | | | | | | |
| | 55 | | | | | | | | | | |
| 605 | | | | | | | | | | | |
| | 60 | | | | | | | | | | |

DH_REV3 10-036-00.GPJ GMULAB.GPJ 10/05/10

GMU GEOTECHNICAL, INC.

| Project: San Ramon Canyon<br>Project Location: 25th Street, Rancho Palos Verdes<br>Project Number: 10-036-00 | **Log of Drill Hole DH-4**<br>Sheet 1 of 3 |
|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Date(s) Drilled | 7/8/10 | Logged By | LBS | Checked By | N/A |
| Drilling Method | Hollow Stem Auger | Drilling Contractor | 2R Drilling, Inc. | Total Depth of Drill Hole | 46.5 feet |
| Drill Rig Type | CME 75 | Diameter(s) of Hole, inches | 10 | Approx. Surface Elevation, ft MSL | 403.0 |
| Groundwater Depth [Elevation], feet | N/A [] | Sampling Method(s) | Open drive sampler with 6-inch sleeve/SPT | Drill Hole Backfill | Concrete Slurry |
| Remarks | | | | Driving Method and Drop | Auto Hammer |

| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | SAMPLE DATA: NUMBER OF BLOWS | SAMPLE DATA: DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | TEST DATA: DRY UNIT WEIGHT, pcf | TEST DATA: ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | RECENT ALLUVIUM (Qal)<br>Upper 2 to 3 feet clast-supported material with abundant subangular to subrounded fragments of bedrock with minor sandy clay soils | | CLAY (CL/CH) with SAND, dark brown, moist, soft | | | | | | |
| | | | | | Sample very disturbed at 2.5 feet | | 10 | 140 | 27 | | |
| 400 | | | Debris from canyon mud and debris flows; no structure, abundant bedrock fragments, unconsolidated below 3 feet | | | | | | 46 | | PS, HY, AL, FC |
| | 5 | | | | Becomes dark brown and orange brown at 5 feet | | (10) | 140 | | | |
| 395 | | | | | With scattered plant fragments, soft to firm at 7.5 feet | | 26 | 140 | 36 | 83 | |
| | 10 | | | | CLAY (CL/CH) with trace SAND, dark brown, moist to wet, soft | | (9) | 140 | | | |
| 390 | | | | | With scattered bedrock fragments at 12.5 feet | | 26 | 140 | 32 | 84 | CN |
| | 15 | | | | | | (38) | 140 | | | |
| 385 | | | | | | | 24 | 140 | 38 | 76 | CN |

DH_REV3 10-036-00.GPJ GMULAB.GPJ 10/05/10

GMU GEOTECHNICAL, INC.

| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA: SAMPLE | SAMPLE DATA: NUMBER OF BLOWS | SAMPLE DATA: DRIVING WEIGHT, lbs | TEST DATA: MOISTURE CONTENT, % | TEST DATA: DRY UNIT WEIGHT, pcf | TEST DATA: ADDITIONAL TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | (9) | 140 | 35 | | PS, HY, AL |
| 380 | | | | | | | 26 | 140 | 40 | 74 | CN |
| | 25 | | | | | | (9) | 140 | | | |
| 375 | | | | | Poor sample, very disturbed at 27.5 feet | | 17 | 140 | 23 | | |
| | 30 | | | | | | (40) | 140 | | | |
| | | | **SOUTH SHORES LANDSLIDE (Qols)** Remnant blocks of bedrock within silty clay matrix; blocks range from relatively intact to highly disturbed below 31 feet | | SANDY SILT (ML), orange brown, moist, very firm, fine grained | | | | | | |
| 370 | | | | | Disturbed sample, soft, at 32.5 feet | | 49 | 140 | 29 | 81 | |
| | 35 | | Abrupt significant increase in density reported by driller at 34.5 feet | | SANDY CLAY (CL), with some SILT, reddish brown, orange brown, pale gray, moist, very firm | | (25) | 140 | | | |
| 365 | | | | | | | 88 | 140 | 32<br>35 | 89<br>83 | |
| | 40 | | | | | | (23) | 140 | | | |
| 360 | | | | | | | 42 | 140 | 42<br>34 | 80<br>80 | |

| ELEVATION, feet | DEPTH, feet | GRAPHIC LOG | GEOLOGICAL CLASSIFICATION AND DESCRIPTION | ORIENTATION DATA | ENGINEERING CLASSIFICATION AND DESCRIPTION | SAMPLE DATA | | | TEST DATA | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SAMPLE | NUMBER OF BLOWS | DRIVING WEIGHT, lbs | MOISTURE CONTENT, % | DRY UNIT WEIGHT, pcf | ADDITIONAL TESTS |
| | | | | | Becomes yellow brown to reddish brown at 45 feet | | (31) | 140 | | | |
| 355 | | | | | | | | | | | |

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GMU GEOTECHNICAL, INC.

| Project: San Ramon Canyon | Log of Core Hole C-1 |
|---|---|
| Project Location: 25th Street, Rancho Palos Verdes | Sheet 1 of 10 |
| Project Number: 10-036-00 | |

| | | | | | |
|---|---|---|---|---|---|
| Date(s) Drilled | 06/22/10 | Logged By | WAD | Checked By | LBS |
| Drilling Method | Continuous Core | Drilling Contractor | Ruen Drilling, Inc. | Total Depth of Drill Hole | 149.0 feet |
| Drill Rig Type | | Drill Bit Size/Type | HQ | Approx. Surface Elevation, ft MSL | |
| Groundwater Level and Date Measured | | Backfill | Slurry | Inclination from Horizontal/Bearing | 90 |
| Comments | | | | | |

| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 53 | | 0 | | | <u>SOUTH SHORES LANDSLIDE (Qols)</u> CLAYEY SILT (CL); dark brown, rock fragments (Tma) up to 1" in diameter, moist, moderately stiff | 1401 | |
| | 3 | 2 | 1 | 28 | | 0 | | | 3/4" thick in diameter fragment of Tma<br>Tma pieces: SHALE and SILICIOUS SANDSTONE; grey and tan in matrix of SILTY CLAY (CL); dark brown, moist, moderately stiff, largest fragment is 2.5" | 1405 | S-Hammer= 26, R2 |
| | ~6.3 | | | | | | | | rock fragments | | |
| | 7 | 3 | | 38 | | 13 | | | matrix: SILTY CLAY (CL); dark brown, minor Tma shale fragments up to 3/4" in diameter, moist, stiff | 1424 | |
| | ~11.7 | 4 | | 100 | | 0 | | | same as above, gradational lower contact | 1442 | |
| | ~12.2 | | | | | | | | SILTY CLAY/CLAYEY SILT (CL); brown and tan,slightly moist, very firm, siltstone fragments up to 1/2" in diameter | | |
| | 13 | | | | | | | | | | |

**Project:** San Ramon Canyon
**Project Location:** 25th Street, Rancho Palos Verdes
**Project Number:** 10-036-00

# Log of Core Hole C-1



| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | | 1 | | | | 1 | | 1) 5° irregular fracture along siltstone fragment | | |
| | | | | | | | | | | 1452 | |
| | 14 | | | | | | | | SILTY CLAY (CL); gray, brown, and tan, slightly moist, very firm | | |
| | 15 | | | | | | | | irregular contact | | |
| | | | | | | | | | SILTY CLAY (CL); dark brown, slightly moist, very firm, orange to brown rock fragments up to 1/2" in diameter | | |
| | 16 | | | | | | | | irregular contact | | |
| | | 5 | | 77 | | 0 | | | | | |
| | 17 | | | | | | 2 | | 2) 15° ash beds?, CLAY (CL); orange brown, orange, white, slightly moist, very firm, tight, no infilling | | |
| | 18 | | | | | | | | highly fractured chert, less then 1/2" in diameter pieces | | |
| | 19 | | | | | | | | | | |
| | 20 | | | | | | | | | | |
| | 21 | 6 | | 14 | | 0 | | | | | |
| | 22 | | | | | | | | | | |
| | 23 | | 2 | | | | | | | | |
| | 24 | | | | | | | | | 1509 | |
| | 25 | 7 | | 0 | | 0 | | | | | |
| | 26 | | | | | | | | | | |
| | | | | | | | | | | 1525 | |
| | 27 | | | | | | | | In the tip only: SILTY CLAY (CL) with Siltstone fragments, tan, moist | | |
| | 28 | 8 | | 0 | | 0 | | | | | |
| | 29 | | | | | | | | | | |

**Project:** San Ramon Canyon
**Project Location:** 25th Street, Rancho Palos Verdes
**Project Number:** 10-036-00

# Log of Core Hole C-1



| Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Number | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|
| 29 | | | | | | | SILTY CLAY (CL); brown and tan mottled, moist, very firm | 1533/0752 | |
| 30 | 9 | | 100 | | 0 | | SILTSTONE (ML); grey, highly fractured (mechanical), hard, moist | | |
| 31 | | 2 | | | | 1 | CLAYEY SILT (CL); brown and grey to brown | 0755 | |
| | | | | | | | 1) 20° B, no infilling, tight, siltstone, grey, hard | | |
| 32 | | | | | | | CLAYEY SILT (CL); brown and grey mottled, no bedding gypsum crystals up to 1/4" | | |
| 33 | 10 | | 90 | | 0 | | | | |
| 34 | | | | | | 2 | CLAYEY SILT (CL); brown and orange brown, subtle bedding, hard, slightly moist | | |
| | | | | | | | 2) 15° B, subtle bedding, tight, no infilling, marked by color changes | | |
| | | | | | | | highly fractured siltstone, grey | | |
| 35 | | | | | | | SILTSTONE; grey with orange brown staining on joints, highly fractured | | |
| | | | | | | | CLAYEY SILT (CL); mottled grey, orange brown, and brown, slightly moist, hard, subtle bedding 5° | | |
| 37 | 11 | | 100 | | 0 | | color changes to orange brown and grey | | |
| | | | | | | | subtle bedding, color changes brown and dark brown | | |
| 38 | | | | | | 1 | 1) 5° B, infilled with gyp, 0.1" thick | | |
| | | | | | | 2 | 2) 15° B, subtle layering, tight | | |
| 39 | | | | | | B | SILTSTONE; gray and brown, hard, subtle bedding, moist | 0842 | |
| | | | | | | | B) 5° B, tight, indistinct | | |
| 40 | | 3 | | | | 1 | 1) 7° B, tight, no infilling, orange brown staining | | |
| | | | | | | 2 | 2) 20° J gyp infilled, 0.5" thick | | |
| 41 | | | | | | 3 | 3) 12° B clay seam, 0.15" thick, tight, sticky | | |
| | 12 | | 88 | | 22 | | CLAYEY SILTSTONE; brown and orange brown mottled, no bedding observed, slightly moist, hard | | |
| | | | | | | 4 | 4) 70° J, tight, orange brown and black staining, no infilling | | |
| 42 | | | | | | 7 | SILTSTONE; grey, very hard, massive | | S. Hammer= 38, R2 |
| | | | | | | | 7) 65° J, gyp infilling 0.1" thick | | |
| | | | | | | 5 | 5) 65° J, gyp infilling, 0.1" thick, orange brown and black staining | | |
| | | | | | | 6 | 6) 15° J, gyp infilling 0.1" thick | | |
| 44 | | | | | | 1 | 1) 55° J, gyp infilling to 0.05" | | |
| | | | | | | 2 | 2) 11° B, subtle, tight | | |
| | | | | | | | SILTSTONE; grey, very hard, subtle bedding, black bed/lense, gradational change to a CLAYEY SILTSTONE; grey and orange | | |
| 45 | | | | | | | | | |

| Project: San Ramon Canyon<br>Project Location: 25th Street, Rancho Palos Verdes<br>Project Number: 10-036-00 | **Log of Core Hole C-1**<br>Sheet 4 of 10 |
|---|---|

| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 45 | | | | | | 1 | | brown, very subtle bedding, hard, slightly moist | | |
| | | | | | | | | | 1) 12° B, no infilling, subtle | | |
| | 46 | 13 | | 62 | | 42 | 2 | | 2) 8° B, no infilling, tight, black staining on surface<br>SILTSTONE; grey, hard, interbedded with CLAYEY SILTSTONE, gray and orange brown | | S. Hammer= 38, R2 |
| | 47 | | | | | | | | | | |
| | 48 | | | | | | 3 | | 3) 23° J, gypsum infilled up to 0.2", loose, fr, highly fractured | | |
| | | | | | | | 1 | | 1) 7° B, tight, no infilling | 0906 | |
| | 49 | | | | | | | | interbedded SILTSTONE; grey and brown gray, very hard, with clayey siltstone, dark brown, hard, slightly moist | | |
| | 50 | | | | | | 1 | | subtle horizontal bedding | | |
| | | | | | | | 2 | | CLAYEY SILTSTONE; very dark brown, hard, subtle bedding, rare orange brown veins | | |
| | | | 4 | | | | 2 | | 2) 0° V, gypsum, 1.3" thick | | |
| | 51 | 14 | | 94 | | 15 | | | CLAY to SILTY CLAY (CL) right orange mottled with tan and yellow, no bedding apparent, random gypsum veins, irregular and discontinuous, deformed, no regular bedding or jointing, very mottled | | |
| | 52 | | | | | | 3 | | 3) 8° B, subtle, finely laminated, tight, no infilling<br>SILTSTONE, very dark brown, hard, subtle laminations | | |
| | 53 | | | | | | 4 | | 4) 34° J, gypsum infilling 0.2" thick | | |
| | | | | | | | | | SILTSTONE; grey and brown, interbedded hard and very hard<br>BENTONITE and GYPSUM; orange, pink, and white, slighty moist, sticky, firm | 0921 | |
| | 54 | | | | | | 1 | | 55° J, gyp. infilled, variable 0.1" to 0.4" thick, loose, deformed/disturbed | | |
| | | | | | | | 9 | | SILTSTONE; dark brown and grey brown, hard to very hard | | |
| | 55 | | | | | | 2 | | SILTSTONE; grey, very hard, massive<br>9) <5° B, clay seam, tan to brown, sticky, 0.2" to 0.3" thick<br>2) 68° J, tight, no infilling, black and orange brown staining on surface | | |
| | | | | | | | 3 | | 3) 5° B, no infilling, narrow | | |
| | | | | | | | 4 | | 4) 65° J, 0.05" gypsum infilling, vary narrow, orange brown staining | | |
| | 56 | 15 | | 92 | | 0 | 6 | | 6) 25° J, narrow, orange brown staining, no infilling | | |
| | | | | | | | 7 | | 7) 33° J, narrow, orange brown staining, no infilling | | |
| | 57 | | | | | | 8 | | 8) 20° J, narrow, orange brown staining, no infilling<br>SILTSTONE; grey brown, becoming dark brown below clay seam | | |
| | | | | | | | 5 | | 5) 10° B, clay seam, tan, sticky, 0.4" thick, soft | | |
| | | | | | | | | | subtle bedding,hard, slightly moist | | |
| | 58 | | | | | | | | | | |
| | 59 | | | | | | 1 | | 8° B, gypsum infilling 0.2" thick | 0935 | |
| | | | | | | | | | interbedded SILTSTONE; grey and dark brown, hard and very hard, subtle bedding, tight | | |
| | 60 | | 5 | | | | 2 | | 2) 12° B, tight, CLAYEY SILTSTONE, finely laminated, subtle | | |
| | | | | | | | 3 | | 3) 0° B, CLAY (CL) seam, brown, sticky, 0.2" thick, soft, slightly moist | | |
| | 61 | | | | | | | | | | |

| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 61 | 16 | | 98 | | 45 | 4 | | 4) 8° B, tight, no infilling | | |
| | 62 | | | | | | | | gradational change to SILTSTONE; tan, slightly moist, hard, massive, minor very fine sand | | S. Hammer= 18, R1 |
| | 63 | | 5 | | | | 5 | | 5) 65° J, narrow, no infilling, irregular surface | | |
| | 64 | | | | | | | | interbedded SILTSTONE and CLAYEY SILTSTONE; orange brown, brown and gray, slightly moist, hard to very hard. | | |
| | 65 | | | | | | 1 | | 1) 8° B, dark orange, clayey silt bed, tight | | |
| | | | | | | | 2 | | 2) 35° V, irregular, gypsum, < 0.1" | | |
| | | | | | | | 3 | | CLAY (CL); orange and grey, mottled, deformed/distorted, slightly moist, firm | | |
| | 66 | | | | | | 3 | | 3) 25° B, tight, no infilling | | |
| | | 17 | | 100 | | 31 | | | Irregular contacts: CLAY (CL); bright red, orange and white, sticky, slightly moist, firm | | |
| | 67 | | | | | | 4 | | 4) 20° B, tight, narrow | | |
| | 68 | | | | | | 5 | | 5) 15° B, tight, narrow | | |
| | | | | | | | 5 | | Interbedded CLAY (CL) and SILTSTONE, no well defined bedding, irregular clay veins | | |
| | 69 | | | | | | | | SILTSTONE to CLAYEY SILTSTONE, brown and orange brown, slightly moist, hard | 1002 | |
| | | | 6 | | | | 1 | | 1) 7°-12° B, clay seams, tan, 0.1 to 0.4" thick | | |
| | 70 | | | | | | | | SILTY CLAYSTONE; pale tan, very firm, slightly sticky, tight, 0.7 to 1.5" thick, interbedded with tan clay seams, 0.1 to 0.4" thick | | |
| | 71 | | | | | | | | | | S. Hammer= 10, R1 |
| | | 18 | | 100 | | 86 | | | | | |
| | 72 | | | | | | | | | | |
| | 73 | | | | | | 2 | | 2) 30° J, gyp, up to 0.1" | | |
| | | | | | | | 3 | | 3) 30° J, gyp up to 0.2" | | |
| | | | | | | | | | SILTSTONE; dark brown and gray, subtle bedding, hard to very hard | | |
| | 74 | | | | | | | | SILTSTONE, very dark brown, very hard, fractured, rare gypsum veins up to 0.05" thick, irregular | 1113 | |
| | 75 | | | | | | | | | | |
| | 76 | | 7 | | | | 1 | | 1) 5° B, narrow, no infilling, orange brown staining | | |
| | | 19 | | 68 | | 22 | | | | | |
| | 77 | | | | | | | | | | |

| Project: San Ramon Canyon | Log of Core Hole C-1 |
|---|---|
| Project Location: 25th Street, Rancho Palos Verdes |  |
| Project Number: 10-036-00 | |

| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 77 | | | | | | 2 | | 2) 21° J, tight, no infilling | | |
| | | | | | | | 3 | | 3) 40° J, tight, no infilling, orange brown staining on surface | | |
| | | | | | | | | | SILTSTONE, grey and brown, hard, slightly moist, subtle bedding | | |
| | 78 | | | | | | 4, 4, 4 | | 4) 18° B, color changes: orange, black, orange brown beds <0.1" thick, tight, otherwise bedding very subtle | | |
| | 79 | | | | | | | | SILTSTONE; grey and brown, highly fractured, very hard | | |
| | | | 7 | | | | 1 | | 1) 60° J, no infilling | | |
| | 80 | 20 | | 89 | | 0 | | | SILTSTONE; very dark brown, subtle bedding, hard, rare, irregular gypsum veins <0.1" thick | | |
| | | | | | | | 2 | | 2) 5° B, tight, orange brown, CLAYEY SILTSTONE, up to 1" thick, irregular upper contact | | |
| | 81 | | | | | | | | CLAYEY SILTSTONE; dark brown, slightly moist, very firm to hard, no bedding observed | 1149 | |
| | | | | | | | 1 | | 1) 5° B, CLAY (CL) seam, brown up to 0.4" thick, irregular | | |
| | 82 | | | | | | 2, 1 | | 2) 53° J, gypsum infilling, 0.05" thick, orange brown staining | | |
| | 83 | 21 | | 96 | | 25 | | | SILTSTONE and CLAYEY SILTSTONE; brown and grey, subtle bedding, hard to very hard | | |
| | 84 | | | | | | 3 | | 3) 12° B, subtle bedding, grey, orange brown, tan beds, ≤ 0.1" | | |
| | | | | | | | 4 | | 4) 70° J, gypsum infilling up to 0.05" thick, tight | | |
| | 85 | | | | | | | | | | |
| | 86 | | | | | | | | SILTSTONE; dark brown, no bedding observed, highly fractured, slightly moist, hard to very hard | 1203 | |
| | 87 | | | | | | 1 | | 1) 45° J, gypsum infilling < 0.05" thick, tight | | |
| | | 22 | | 100 | | 26 | 2 | | 2) 38° B, contact with orange tan, clay, very stiff, slightly moist | | |
| | 88 | | | | | | 3 | | 3) highly irregular contact with tan and yellow tan SILTY CLAY (CL), slightly moist, hard, interbeds of brownish tan clay, irregular, up to 0.4" thick | | |
| | 89 | | | | | | 1 | | 1) 70° tight, gypsum infilling up to 0.05" | | |
| | 90 | | | | | | 2, 3 | | 2) irregular 0° B, gypsum infilling up to 0.3" | | |
| | | | | | | | | | BENTONITE; orange and grey with tan, very firm, mottled/deformed, tight, tight, no shearing, irregular lower contact (3) with a SILTSTONE; very dark brown, highly fractured, many discontinuous gypsum veins, up to 0.1" thick, no distinct bedding to subtle bedding < 5° B | | |
| | 91 | 23 | | 100 | | 32 | | | | | |
| | 92 | | 8 | | | | 4 | | 4) 10° to 15° irregular BENTONITE bed up to 0.5" thick, tan with orange mottling | | |
| | | | | | | | | | SILTSTONE; dark brown, highly fractured, hard gypsum veins, discontinuous | | |
| | 93 | | | | | | 5 | | SILTSTONE; grey and dark grey, very hard, massive | | |

**Project:** San Ramon Canyon
**Project Location:** 25th Street, Rancho Palos Verdes
**Project Number:** 10-036-00

# Log of Core Hole C-1



| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 93 | | | | | | 6, 7 | | 5) 15° B, subtle color changes observed to mark bedding<br>6) 50° J, trace of gypsum<br>7) 65° J, traces of gypsum<br>CLAYSTONE and CLAY lens; distorted, clay lens up to 0.4" thick | | |
| | 94 | | 8 | | | | 1, 1 | | <u>ALTAMIRA SHALE MEMBER OF THE MONTEREY FORMATION (Tma)</u><br>SILTSTONE; grey, very hard, massive<br>1) 26° B, tight, no infilling, bedding marked by subtle color changes | | S. Hammer= 34, R2 |
| | 95 | | | | | | | | | | |
| | 96 | 24 | | 100 | | 80 | | | | | |
| | 97 | | | | | | | | | | |
| | 98 | | | | | | 2 | | 2) 28° J, gypsum infilling up to 0.05" | | |
| | 99 | | | | | | 1, 2 | | SILTSTONE; tan and gray, hard to very hard, subtle bedding<br>1) 14° B | | |
| | 100 | | 9 | | | | 3, 3, 5, 3, 3, 4 | | 2) 25° J, gypsum up to 0.4" thick<br>3) 20° B, colored beds, grey, orange brown, tan, mark bedding<br>5) 30° J gypsum up to 0.4" thick | | |
| | 101 | 25 | | 90 | | 32 | 6 | | 4) 5° B CLAY (CL) seam, brown/tan, 0.2" thick<br>6) 20° J, gypsum up to 0.2" thick | | |
| | 102 | | | | | | | | SILTSTONE; dark brown, subtle bedding, slightly moist, hard<br>Mottled grey, tan and orange CLAYEY SILTSTONE | | |
| | 103 | | | | | | | | contact between oxidized (above) and unoxidized (below) bedding<br>SILTSTONE; dark grey, very hard, rare gypsum veins, up to 0.1" thick, random | | |
| | 104 | | | | | | 1 | | CLAYEY SILTSTONE; dark grey, slightly moist, massive, rare gypsum veins up to 0.1", hard, sticky in areas<br>1) 34° J, tight<br>Interbeds of very hard SILTSTONE up to 1" thick (2) | 1254 | |
| | 105 | | | | | | | | | | |
| | 106 | 26 | 10 | 100 | | 62 | 2 | | 2) 5° B, interbedded very hard SILTSTONE | | S. Hammer= 32, R2 |
| | 107 | | | | | | | | | | |
| | 108 | | | | | | | | mechanically fractured | | |
| | 109 | | | | | | | | | | |

**Project:** San Ramon Canyon
**Project Location:** 25th Street, Rancho Palos Verdes
**Project Number:** 10-036-00

# Log of Core Hole C-1



| Elevation, feet | Depth, feet | ROCK CORE: Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 109 | | | | | | 1 | | 1) 43° J, no infilling | | |
| | | | | | | | 2 | | 2) 50° J, no infilling, slightly wavy surface, narrow | | |
| | 110 | | | | | | | | SILTSTONE; very dark grey, very hard, laminated, highly fractured | | |
| | | | 10 | | | | 3 | | | | |
| | 111 | 27 | | 98 | | 10 | | | 3) 24° B, grey beds up to 0.1" thick, laminated | | |
| | 112 | | | | | | | | CLAYEY SILTSTONE; very dark grey, interbedded with very hard, dark grey SILTSTONE, highly fractured | | |
| | 113 | | | | | | | | | 1328 | |
| | 114 | | | | | | 1 | | 1) 6° B, grey beds up to 0.1" thick, laminated | | |
| | 115 | 28 | | 92 | | 0 | | | | | |
| | 116 | | | | | | 2 | | 2) 10° B, subtle bedding marked by lighter and dark grey | | |
| | 117 | | | | | | | | CLAYEY SILTSTONE; very dark grey, minor discontinuous gypsum veins up to 0.1", highly fractured, no bedding observed | | |
| | 118 | | | | | | | | SILTSTONE; dark grey and grey interbedded, beds up to 1" thick, moderate discontinuous fractures | 1348 | |
| | 119 | | | | | | 1 | | 1) 17° B | | |
| | | | | | | | | | Minor interbeds of grey CLAYEY SILTSTONE up to 0.75" thick | | |
| | 120 | | 11 | | | | 1 | | Very tight, few fractures, very consistent bedding | | |
| | 121 | 29 | | 100 | | 52 | | | | | S. Hammer= 38, R2 |
| | 122 | | | | | | | | | | |
| | 123 | | | | | | 1 | | 1) 7° B, very tight, very consistent bedding, few fractures | | |
| | 124 | | | | | | | | | | |
| | 125 | | | | | | | | | | |

| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 125 | | 11 | | | | | | | | |
| | 126 | 30 | | 100 | | 37 | 2 | | more fractured zone<br>50° J, tight, no infilling, wavy | | S. Hammer= 16, R1 |
| | 127 | | | | | | | | | | |
| | 128 | | | | | | 3 | | 3) 22° B, very consistent bedding, beds <0.1" thick<br>abundant Mn staining on irregular joints, Mn staining is very shiny may be 0.05" thick, void open to 0.4", lined with Mn | | |
| | 129 | | | | | | | | SILTSTONE; dark grey, very hard, very fractured, heavy Mn staining on joint surfaces<br>Core caught in barrel and retrieve disturbed | | |
| | 130 | 31 | | 14 | | 0 | | | | 1453 | |
| | 131 | | | | | | | | | 1405 | |
| | | 32 | | 0 | | 0 | | | | | |
| | 132 | | 12 | | | | 1<br>2 | | SILTSTONE; very dark grey, hard, moist<br>1) 8° B, clay seam, dark grey, 0.4" thick, sticky, no shearing observed | 0738 | |
| | 133 | 33 | | 100 | | 0 | 2 | | 2) 18° B, interbedded SILTSTONE and fine grained SANDY SILTSTONE, bedding very consistent, bedding planes cleave easily, beds 0.5" to 2" thick | | |
| | 134 | | | | | | 2<br>2 | | | | |
| | 135 | | | | | | 1<br>2 | | SILTSTONE; very dark grey, very hard, interbedded with SANDY SILTSTONE and SILTY SANDSTONE, very fine grained, grey and dark grey. Beds range from laminations to 1" thick and well defined<br>1) 26° B<br>2) 22° B | 0755 | |
| | 136 | | | | | | 3 | | 3) 62° J, narrow, no infilling | | |
| | 137 | 34 | | 100 | | 23 | 4 | | 4) 73° F, offset 0.5", irregular surface infilled with up to 0.2" clay gouge | | |
| | 138 | | | | | | 6<br>5 | | 6) 43° J, tight<br>5) 23° B | | |
| | 139 | | | | | | 1 | | CLAY (CL); bluish grey, sticky, moist, stiff<br>SILTSTONE; dark gray and bluish grey, scattered clay seams <0.05" | | |
| | 140 | 35 | 13 | 83 | | 22 | 2<br>3 | | 1) 4° B clay seam<br>2) 6° B clay seam<br>3) 10° B clay seam | | |
| | 141 | | | | | | | | | | |

Project: San Ramon Canyon
Project Location: 25th Street, Rancho Palos Verdes
Project Number: 10-036-00

# Log of Core Hole C-1



| Elevation, feet | Depth, feet | ROCK CORE: Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 141 | | | | | | | | SILTSTONE; dark grey, very hard, tight bedding, few joints, scattered SILTY SANDSTONE beds, fine grained | | |
| | 142 | | | | | | 1 | | 1) 26° B, clay lined <)>05" thick | | |
| | 143 | 36 | 13 | 100 | | 70 | 2 | | 2) 12° B, clay bed, 0.4" thick, bluish grey, stiff, sticky | | |
| | | | | | | | | | Bedding below clay bed opposite dip appears core rotated about 180° on clay | | |
| | 144 | | | | | | 3 | | 3) 24° B<br>CLAYEY SILTSTONE; dark bluish grey, very hard, subtle bedding | | |
| | | | | | | | 5 | | 5) 22° B, SILTSTONE and SILTY SANDSTONE, dark grey brown | | |
| | 145 | | | | | | 4 | | 4) 73° J, narrow, no infilling, very hard, tight, well bedded | | |
| | 146 | | | | | | | | SILTSTONE; very dark brownish grey, very hard, well bedded, beds generally <0.5" thick | 0846 | |
| | | | | | | | 1 | | 1) 16° B, very consistent bedding | | S. Hammer= 22, R1 |
| | 147 | 37 | | 100 | | 25 | 1 | | | | |
| | | | 14 | | | | 1 | | | | |
| | 148 | | | | | | | | SILTY SANDSTONE, dark brownish grey, fine grained, very hard, well bedded | | |
| | 149 | | | | | | | | | 0858 | |
| | | | | | | | | | T.D. 149 | | |
| | 150 | | | | | | | | | | |
| | 151 | | | | | | | | | | |
| | 152 | | | | | | | | | | |
| | 153 | | | | | | | | | | |
| | 154 | | | | | | | | | | |
| | 155 | | | | | | | | | | |
| | 156 | | | | | | | | | | |
| | 157 | | | | | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Date(s) Drilled | 06/25/10 | Logged By | WAD | Checked By | LBS |
| Drilling Method | Continuous Core | Drilling Contractor | Ruen Drilling, Inc. | Total Depth of Drill Hole | 103.8 feet |
| Drill Rig Type | | Drill Bit Size/Type | HQ | Approx. Surface Elevation, ft MSL | |
| Groundwater Level and Date Measured | | Backfill | Slurry | Inclination from Horizontal/Bearing | 90 |
| Comments | | | | | |

| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | | | AC pavement section, 0.7' thick, aggregate up to 1" in asphalt | 856 | |
| | 1 | | | | | | | | ARTIFICIAL FILL (Qaf) SANDY SILT (SM) and SILTY CLAY (CL) matrix with abundant gravel, rare rock fragments up to 6". Tan, slightly moist, very firm, gravel is angular, no layering observed | | |
| | 2 | 1 | | 2 | | 0 | | | | | |
| | 3 | | | | | | | | | | |
| | 4 | | | | | | | | | | |
| | 5 | | | | | | | | | | |
| | 6 | | | | | | | | | | |
| | | 2 | | 100 | | 0 | | | matrix becomes brown and grey brown | | |
| | 7 | | 1 | | | | | | | | |
| | 8 | | | | | | | | | | |
| | 9 | 3 | | 100 | | 0 | | | | | |
| | 10 | | | | | | | | | | |
| | 11 | 4 | | 85 | | 0 | | | | | |
| | 12 | | | | | | | | | | S. Hammer= R2, 44 in Silicious Siltstone chunk |
| | 13 | | | | | | | | | | |

Project: San Ramon Canyon
Project Location: 25th Street, Rancho Palos Verdes
Project Number: 10-036-00

# Log of Core Hole C-2



| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | | | | | | | | | | |
| | 14 | | | | | | | | Abundant angular gravel in SILTY CLAY (CL) and SANDY SILT (SM) matrix. Matrix is grayish brown, slightly moist, stiff/ firm to moderately loose. No layering observed | | |
| | 15 | | | | | | | | | | |
| | 16 | 5 | | 57 | | 0 | | | | | |
| | 17 | | | | | | | | | | |
| | 18 | | 2 | | | | | | | | |
| | 19 | | | | | | | | **RECENT LANDSLIDE DEBRIS (Qlsr)** CLAYEY SILT (ML) with SAND (SP); loose, slightly moist, dark brown CLAYEY SILT (ML) with SAND (SP) ; dark brown, slightly moist, medium firm, rare caliche, scattered angular rock fragments of Monterey formation | | |
| | 20 | | | | | | | | | | |
| | 21 | 6 | | 90 | | 0 | | | | | |
| | 22 | | | | | | | | | | |
| | 23 | | | | | | | | | | |
| | 24 | | | | | | | | SANDY SILT (SM) with CLAY (CL); grey tan, moist, firm, abundant rock fragments up to 3", roots and rootlets | | |
| | 25 | | | | | | | | Gradually becomes tan, SANDY SILT (SM) minor CLAY (CL), very firm, abundant gravel fragments, scattered cobble size fragments, no layering | | |
| | 26 | 7 | | 92 | | 0 | | | | | |
| | 27 | | 3 | | | | | | | | |
| | 28 | | | | | | | | | 1050 | |
| | 29 | | | | | | | | | | |

| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 29–33 | 8 | 3 | 91 | | 0 | | | SANDY SILT (SM); tan, slightly moist, very firm, abundant gravel sized rock fragments, rare rock fragments up to 6" | | S. Hammer= 32, R2 |
| | 33–38 | 9 | 3 | 98 | | 0 | | | SANDY SILT (SM) and CLAYEY SILT (ML); tan, slightly moist, very firm, abundant gravel sized rock fragments up to 6" | 1116 | |
| | 38–43 | 10 | 4 | 100 | | 0 | 1 | | 1) 26° Sh: Highly polished surface, slightly wavy, no striations<br>**SOUTH SHORES LANDSLIDE (Qols)**<br>Distorted bentonite clay beds and lenses, orange, tan, and grey, slightly moist, very stiff, waxy, highly irregular<br>SANDY SILT (SM) and CLAYEY SILT (ML); tan and grey, slightly moist, firm to very firm, abundant angular rock fragments | | |
| | 43–45 | | 4 | | | | 1 | | CLAYEY SILTSTONE; orange brown with grey mottling, slightly moist, hard<br>Scattered black mottling, subtle distorted bedding, beds 0.1" thick to 0.5" thick | | |

Project: San Ramon Canyon
Project Location: 25th Street, Rancho Palos Verdes
Project Number: 10-036-00

# Log of Core Hole C-2



| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 45 | 11 | | 88 | | 0 | | | 1) Approximately 1° B on undulatory/distorted bedding | | |
| | 46 | | | | | | | | | | |
| | 47 | | | | | | | | | | |
| | 48 | | | | | | | | BENTONITIC CLAY and altered ASH beds, interbedded, soft sediment, deformation, clay beds up to 0.2" thick, orange, white, grey and orange brown | | |
| | 49 | | | | | | 1, 2 | | 1) approximately 7° to 10° B<br>2) 25° B | | |
| | 50 | 12 | | 92 | | 0 | 3 | | SILTSTONE, CLAYEY SILTSTONE interbedded<br>Gray and orange brown, moist hard to very hard | | |
| | 51 | | 5 | | | | 4 | | 3) 7° B, very hard siltstone bed<br>4) 55° J, orange brown and black staining, no infilling, irregular surface | | |
| | 52 | | | | | | | | | | |
| | 53 | | | | | | | | SILTSTONE and CLAYEY SILTSTONE, tan and grey mottled, subtle distorted bedding, minor black and orange brown staining, hard to very hard, very hard areas highly fractured | | |
| | 54 | | | | | | | | | | |
| | 55 | 13 | | 86 | | 0 | 1 | | 1) 27° B, very hard SILTSTONE bed, 0.4" thick | | |
| | 56 | | | | | | | | | | |
| | 57 | | | | | | | | | | |
| | 58 | | 6 | | | | 1 | | SILTSTONE; tan, slightly moist, hard, grey mottles, interbeds of brown and tan clay 0.3" to 0.6" thick, each bed has a slightly variable thickness | | |
| | 59 | | | | | | 2 | | SILTSTONE; tan, highly fractured, very hard, black staining on joint surfaces, interbedded with clayey siltstone and sandy siltstone, grey, orange brown, hard | | |
| | 60 | 14 | | 98 | | 31 | 3 | | SANDSTONE; very fine grained, grey and tan, very hard, subtle bedding<br>ASH bed; pale tan, SILTY CLAY (CL), slightly moist, hard | | |
| | 61 | | | | | | | | | | |

| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 61 | | | | | | | | 3) 21° B | | |
| | 62 | | | | | | 4 | | Finely bedded SILTSTONE and CLAYEY SILTSTONE, tan, brown and gray, very hard, consistent bedding<br>4) 12° B | | |
| | 63 | | 6 | | | | | | SILTSTONE, orange brown and grey, hard to very hard, poorly defined bedding, slightly moist | 1239 | |
| | 64 | | | | | | | | | | |
| | 65 | | | | | | | | | | |
| | 66 | 15 | | 58 | | 0 | 1 | | 1) 15° B | | |
| | 67 | | | | | | | | | | |
| | 68 | | | | | | 1 | | SILTSTONE, tan, slightly moist, hard with brown clay interbeds up to 0.5" thick<br>1) 10° B | | |
| | 69 | | | | | | | | SILTSTONE, gray, very hard, fractured | | |
| | | | | | | | 2 | | Finely bedded orange brown, tan, and gray, SILTSTONE, and CLAYEY SILTSTONE<br>2) 10° B | | |
| | 70 | | | | | | 3 | | 3) 65° J<br>SANDSTONE, very fine grained, tan and grey, very hard, few joints or fractures, massive | | |
| | 71 | 16 | | 92 | | 44 | | | Interbedded SILTSTONE, SANDY SILTSTONE, CLAYEY SILTSTONE; tan, brown, orange brown, indistinct bedding, hard to very hard, slightly moist | | S. Hammer= 16, R1 |
| | 72 | | 7 | | | | | | | | |
| | 73 | | | | | | | | subtle bedding | | |
| | 74 | | | | | | 1 | | 1) 12° B | | |
| | 75 | | | | | | 2 | | 2) 18° B<br>SILTSTONE bed, gray, very hard | | |
| | 76 | 17 | | 94 | | 12 | 3 | | 3) 13° B<br>Contact with bright orange CLAY (CL), waxy, very stiff, slightly moist, interbedded with grey brown and tan siltstone, deformed in clay portion, highly fractured in siltstone portion | | |
| | 77 | | | | | | | | | | |

CORE_LOG 10-036-00.GPJ GM&U.GDT 10/05/10

| Project: San Ramon Canyon<br>Project Location: 25th Street, Rancho Palos Verdes<br>Project Number: 10-036-00 | Log of Core Hole C-2<br>Sheet 6 of 7 |
|---|---|

| Elevation, feet | Depth, feet | Run No. (ROCK CORE) | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 77 | | | | | | 4 | | 4) 63° J | | |
| | 78 | | 7 | | | | | | | | |
| | 79 | | | | | | | | Bright orange clay with white mottling | | |
| | | | | | | | 1 | | Interbedded SILTSTONE; gray and tan, hard to very hard, highly fractured and CLAY (cl); brown, slightly moist, sticky, very stiff<br>1) 5° B | | |
| | 80 | | | | | | | | Orange, white, and gray mottled BENTONITE CLAY; slightly moist, waxy, very stiff | | |
| | | | | | | | | | SANDSTONE; very fine grained, massive, very hard | | |
| | 81 | 18 | | 98 | | 24 | 2 | | 2) 78° J | | |
| | 82 | | 8 | | | | 3 | | SILTSTONE; grey and tan, very hard, slightly moist, subtle fine laminations interbedded with orange, grey, and white bentonite CLAY (CL), slightly moist, very stiff, waxy<br>3) 18° B | | |
| | 83 | | | | | | | | | | |
| | 84 | | | | | | | | BENTONITE CLAY; pale grey, tan, orange brown, waxy, very stiff, tight, slightly moist, no bedding observed | 1331 | |
| | 85 | | | | | | | | | | |
| | 86 | 19 | | 100 | | 0 | | | becomes crumbly | | |
| | 87 | | | | | | | | | | |
| | 88 | | | | | | | | | | |
| | 89 | | 9 | | | | | | SILTY CLAY (CL) and CLAYEY SILT (ML); tan and brown, rock fragments up to 0.2", slightly moist, slightly sticky, no bedding observed, very firm, no discernible bedding, layering, or gradation, scattered very hard siltstone, does not appear to be in place. No jointing or bedding. | | |
| | 90 | | | | | | | | | | |
| | 91 | 20 | | 85 | | 0 | | | | | |
| | 92 | | | | | | | | | | |
| | 93 | | | | | | | | | | |

Project: San Ramon Canyon
Project Location: 25th Street, Rancho Palos Verdes
Project Number: 10-036-00

# Log of Core Hole C-2



| Elevation, feet | Depth, feet | Run No. | Box No. | Recovery, % | Fractures per Foot | R Q D, % | Fracture Drawing Number | Lithology | GEOLOGIC AND ENGINEERING DESCRIPTION | Drill Time [Rate, ft/hr] | FIELD NOTES AND LAB TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 93 | | | | | | | | | | |
| | 94 | | | | | | | | | 434 | |
| | 95 | | | | | | 5 | | 5) 13° irregular/wavy contact, no striations observed | | |
| | | | 9 | | | | | | | | |
| | 96 | | | | | | 1 | | 1) 37° B SILTSTONE, grey and dark grey, very hard, tight, few joints, rarely broken along bedding planes | | |
| | | 21 | | 86 | | 36 | 2 | | 2) 32° B | | |
| | 97 | | | | | | 3 | | 3) 40° B | | |
| | | | | | | | | | | | S. Hammer= 54, R3 |
| | 98 | | | | | | 4 | | 4) 55° B<br>SILTSTONE; tan, well defined, consistent bedding, slightly moist, very hard, minor black staining on joints | | |
| | 99 | | | | | | 1 | | 1) 35° to 37° B | | |
| | 100 | | | | | | | | | | |
| | 101 | 22 | 10 | 96 | | 27 | 2 | | 2) 90° J | | |
| | 102 | | | | | | | | | | |
| | 103 | | | | | | | | | | |
| | 104 | | | | | | | | | 1459 | |
| | 105 | | | | | | | | | | |
| | 106 | | | | | | | | | | |
| | 107 | | | | | | | | | | |
| | 108 | | | | | | | | | | |
| | 109 | | | | | | | | | | |

# APPENDIX A-2

Exploration by Others

Ehlert, 1997

# LOG OF BORING

**BORING 1**

PROJECT NO. P.N.3891-97 LOG NO. PAGE 1 of 2

Project 2700 1/2 SAN RAMON DRIVE, RANCHO PALOS VERDES, CA

Method of Drilling 24" BUCKET AUGER Ground Elevation

Location SEE SITE PLAN Logged by DL Date Observed

| Depth (Ft.) | GRAPHIC LOG | DESCRIPTION | Symbol | Remarks |
|---|---|---|---|---|

Depth (Ft.): 0, 5, 10, 15, 20, 25, 30, 35, 40

**NATURAL SOIL**: 0 to 2.5 feet of depth

Natural soil consists of dark brown silty clay containing scattered pebble sized rock fragments, firm, moist, gradational contact with underlying slope wash.

**TERRACE DEPOSITS**: 2.5 to 19.5 feet of depth

material consists of dark brown silty clay mottled with abundant angular rock fragment, abundant white caliche staining, firm and tight.

At 6.0 feet color changes to a light pale gray brown clayey silt matrix containing sub-rounded rock fragments to pebble and cobble size, firm, tight.

At 14.0 feet material consists of pale gray brown clayey silt matrix containing scattered sub-rounded pebble and cobble sized rock fragments, very firm and tight.

At 18.0 feet start a gradational contact with highly weathered bedrock, contact consists of hard siliceous siltstone boulders that are encased in a dark brown silty clay matrix. In place bedrock occurs at a depth of 19.5 feet.

**BEDROCK**: MONTEREY FORMATION, 19.5 to 76.5 feet of depth

Bedrock consists of light gray siliceous siltstone, well bedded, firm, tight.

Bedding attitude at 21.0 feet of depth is N51W 28SW.

Bedrock consists of thinly layered cherty siltstone, green gray to orange brown in color, bedding layers are 1/4 inch thick or less, fish scales to 1/4 inch in diameter, very firm and tight.

Between 23 feet to 26 feet of depth bedrock consists of extremely hard dolostone, light gray in color, breaks our in boulder sized blocks, coring required, well bedded.

Bedding attitude at 26 feet of depth is N64W 29SW.

Starting at 26 feet below dolostone layer bedrock consists of pale brown, greenish brown, orange brown siliceous siltstone, well bedded, thinly bedded with beds on the order of 1/8 inch thick, very tight, firm.

Bedding attitude at 30 feet of depth is N62W 27SW.

From 30.0 to 33.5 feet of depth siltstone becomes cherty, brittle, very hard, well bedded, and jointed.

At 33.5 feet of depth bedrock changes back into a pale brown firm siliceous siltstone, not cherty, firm, tight, well bedded.

Bedding attitude at 35.5 feet of depth is N55W 27SW.

# LOG OF BORING

BORING 1

PROJECT NO. P.N.3891-97 LOG NO. PAGE 2 of 2

Project 2700 1/2 SAN RAMON DRIVE, RANCHO PALOS VERDES, CA

Method of Drilling 24" BUCKET AUGER Ground Elevation

Location SEE SITE PLAN Logged by DL Date Observed

| Depth (Ft.) | GRAPHIC LOG | DESCRIPTION | Symbol | Remarks |
|---|---|---|---|---|
| 40 | | Bedrock consists of light gray to light yellow brown siltstone, firm, tight, very well bedded with beds on the order of 1/8 inch thick, scattered fish scales to 1/4 inch in diameter. | | |
| | | Bedding attitude at 41 feet of depth is N56W 29SW. | | |
| 45 | | Bedrock consists of the same pale orange brown to light gray siliceous siltstone, firm tight, abundant fish scales, bedding is well defined. | | |
| | | Staring at 42.0 feet and 7.0 inches seepage is observed around sides of boring, water appears to be percolating through bedding layers and is dripping slowly down side of boring. | | |
| 50 | | Between 43.0 feet and 4.0 inches to 44.0 feet 3.0 inches is a bentonitic layer, light green to gray brown, contains discontinuous polished surfaces that are dipping parallel to bedding, slick and wet. At a depth of 44.0 feet, bentonitic material is dry and it appears that water is traveling along the top of the bentonitic layer, but is not present in the lower portion of the bentonitic layer. No continuous polished slip surfaces observed, appears to be somewhat jointed, bedding attitude at a depth of 44.0 feet 3.0 inches is N45W 24SW and was taken at the base of the bentonitic layer. | | |
| 55 | | Bedding attitude at 46.5 feet of depth is N60W 30SW. | | |
| | | Bedrock consists of light orange brown, pale gray siliceous siltstone, locally cherty layers, no fish scales observed at this depth, very firm to locally hard, tight, thinly bedded. | | |
| 60 | | At 48.5 feet of depth bedrock becomes very cherty and brittle, light orange brown, very hard, thinly bedded. At 50 feet of depth bedrock changes back into pale orange gray siliceous siltstone. | | |
| | | Bedding attitude at 50 feet of depth is N54W 29SW. | | |
| | | Bedding attitude at 52 feet of depth is N58W 40SW. | | |
| | | Between 50 and 52 feet of depth bedrock appears slightly folded and is dipping steeper and more westerly than above. | | |
| 65 | | Bedding attitude at 55.5 feet of depth is N82W 33SW. | | |
| | | Bedrock consists of pale orange gray brown siliceous siltstone, firm, tight, well bedded, thinly bedded on the order of 1/8 inch thick. | | |
| | | Bedding attitude at 61 feet of depth is N87E 40SE. | | |
| 70 | | Bedding attitude at 64 feet of depth is N75W 42SW. | | |
| | | A light gray dolostone layer starts at 64 feet and extends down to 66 feet of depth, this layer is extremely hard and required coring, well bedded, blocky appearance. | | |
| | | Bedding attitude at 68 feet of depth is N56E 38SW. | | |
| 75 | | Bedrock consists of light orange brown pale gray siliceous siltstone, very firm, tight, well bedded. | | |
| | | Bedding attitude at 71 feet of depth is N51W 46SW. | | |
| | | Bedding attitude at 75 feet of depth is N54W 47SW. | | |
| 80 | | | | |

# LOG OF BORING

**BORING 2**

PROJECT NO. **P.N.3891-97** LOG NO. **PAGE 1 of 1**

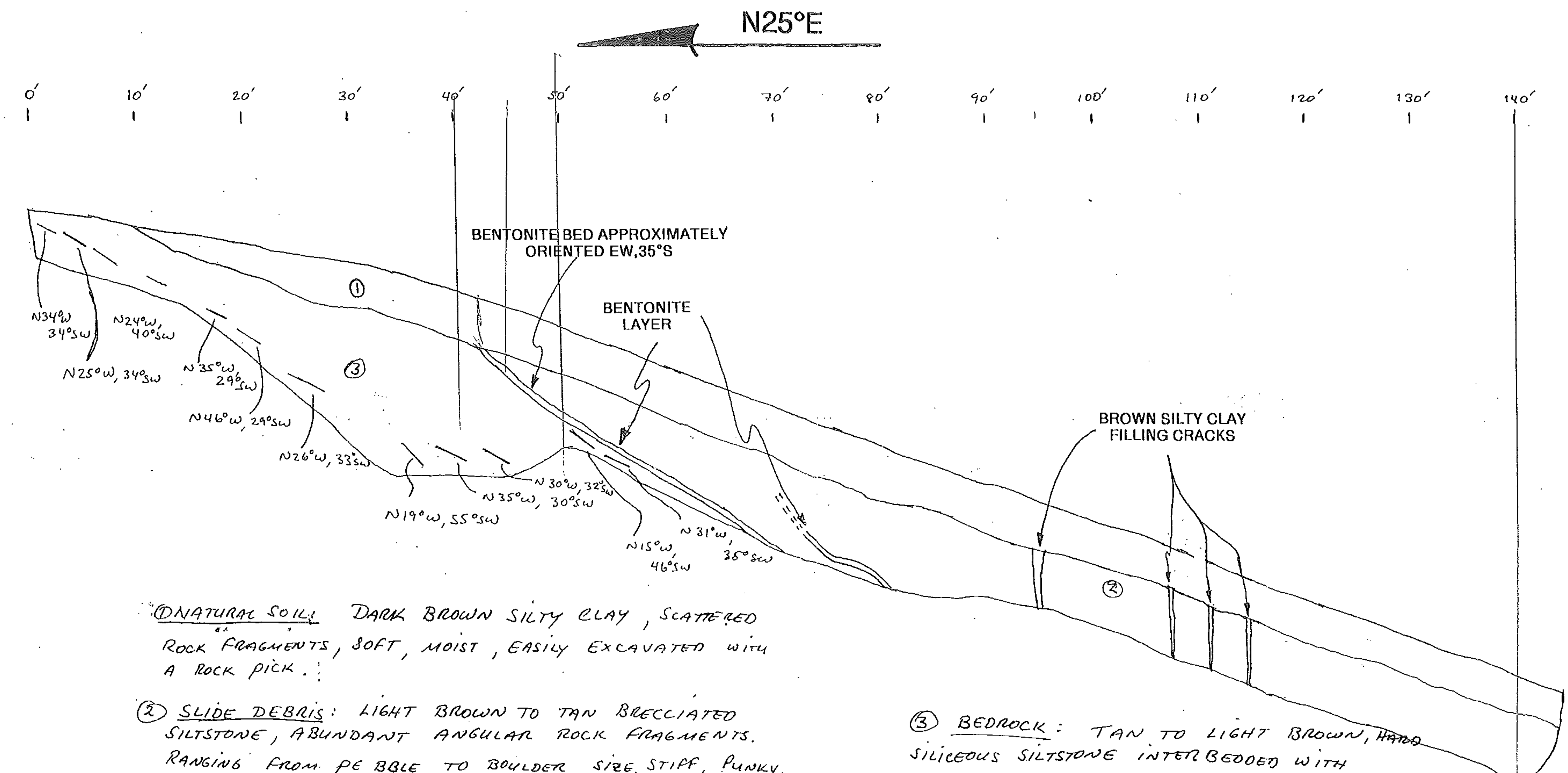
Project **2700 1/2 SAN RAMON DRIVE, RANCHO PALOS VERDES, CA**

Method of Drilling **24" BUCKET AUGER** Ground Elevation —

Location **SEE SITE PLAN** Logged by **DL** Date Observed

| Depth (Ft.) | GRAPHIC LOG | DESCRIPTION | Symbol | Remarks |
|---|---|---|---|---|
| 0 | | **NATURAL SOIL**: 0 to 1.0 feet of depth<br><br>Natural soil consists of dark brown silty clay containing scattered pebble sized rock fragments, firm, moist, gradational contact with underlying slope wash. | | |
| 5 | | **TERRACE DEPOSITS**: 1.0 to 2.5 feet of depth<br><br>Light brown to gray silty clay containing scattered angular rock fragments with white caliche mottling, gradational change into bedrock, firm, tight. | | |
| 10 | | **BEDROCK**: MONTEREY FORMATION, 2.5 to 30.0 feet of depth<br><br>Upper portion of bedrock is highly weathered to a depth of 15.0 feet, very hard, siliceous siltstone, barite crystals on faces of bedrock, bedding is very poorly defined.<br><br>Grades downward into less weathered bedrock that is pale gray siliceous siltstone, very hard, tight, required coring. | | |
| 15 | | Bedding attitude at 16 feet of depth is N70W 20SW.<br><br>Bedding attitude at 19 feet of depth is N54W 53SW.<br><br>Bedding attitude at 20 feet of depth is N47W 45SW. | | |
| 20 | | | | |
| 25 | | Bedding attitude at 25 feet of depth is N52W 60SW.<br><br>Bedrock is very hard siliceous siltstone, light gray to light orange brown, coring was required for most of boring in bedrock. Moderately well defined bedding. | | |
| 30 | | | | |
| 35 | | | | |
| 40 | | | | |

Ehlert, 1998




① NATURAL SOIL: DARK BROWN SILTY CLAY, SCATTERED ROCK FRAGMENTS, SOFT, MOIST, EASILY EXCAVATED WITH A ROCK PICK.

② SLIDE DEBRIS: LIGHT BROWN TO TAN BRECCIATED SILTSTONE, ABUNDANT ANGULAR ROCK FRAGMENTS. RANGING FROM PEBBLE TO BOULDER SIZE, STIFF, PUNKY, HEAVILY CALICHEFIED, SLIGHTLY MOIST. SEVERAL FISSURES FILLED WITH DARK BROWN CLAY (SOIL), ABUNDANT KROTOVINA.

③ BEDROCK: TAN TO LIGHT BROWN, ~~HARD~~ SILICEOUS SILTSTONE INTERBEDDED WITH ORANGE-BROWN WELL-BEDDED SILTSTONE. BEDS ARE ON THE ORDER OF 1/4 INCH THICK, HARD, TIGHT, MODERATELY JOINTED.

SCALE: 1"=10'

SKETCH LOG OF TRENCH 1 BY EHLERT, 1998

P.N. 3844-98

# APPENDIX B

## GMU Geotechnical Laboratory Test Results

GMU GEOTECHNICAL, INC.

# APPENDIX B

## GEOTECHNICAL LABORATORY PROCEDURES AND TEST RESULTS

**Moisture and Density.** Field moisture content and in-place density were determined for each 6-inch sample sleeve of undisturbed soil material obtained from the drill holes. The field moisture content was determined in general accordance with ASTM Test Method D 2216 by obtaining one-half the moisture sample from each end of the 6-inch sleeve. The in-place dry density of the sample was determined by using the wet weight of the entire sample.

At the same time the field moisture content and in-place density were determined, the soil material at each end of the sleeve was classified according to the Unified Soil Classification System. The results of the field moisture content and in-place density determinations are presented on the right-hand column of the Log of Drill Hole and are summarized on Table B-1. The results of the visual classifications were used for general reference.

**Particle Size Distribution.** As part of the engineering classification of the materials underlying the site, samples were tested to determine the distribution of the particle sizes. The distribution was determined in general accordance with ASTM Test Method D 422 using U.S. Standard Sieve Openings 3", 1.5", 3/4, 3/8 and U.S. Standard Sieve Nos. 4, 10, 20, 40, 60, 100, and 200. In addition, on some samples a standard hydrometer test was also performed to determine the distribution of particle sizes passing the No. 200 sieve (i.e., silt and clay-size particles). The results of the tests are contained in Appendix B. Key distribution categories (% gravel; % sand, etc.) are contained on Table B-1.

**Atterberg Limits.** As part of the engineering classification of the soil underlying the site, samples of the on-site soil materials were tested to determine relative plasticity. This relative plasticity is based on the Atterberg limits determined in general accordance with ASTM Test Method D 4318. The results of this test are contained in Appendix B and also Table B-1.

**Chemical Tests.** The corrosion potential of typical on-site materials under long-term contact with both metal and concrete was determined by chemical and electrical resistance tests. The soluble sulfate test for potential concrete corrosion was performed in general accordance with California Test Method 417, the minimum resistivity tests for potential metal corrosion were performed in general accordance with California Test Method 643, and the concentration of soluble chlorides was determined in general accordance with California Test Method 422. The results of these tests are contained in Appendix B and also Table B-1.

**Compaction Tests.** A bulk sample representative of the underlying on-site materials was tested to determine the maximum dry density and optimum moisture content of the soil. These compactive characteristics were determined in general accordance with ASTM Test Method D 1557. The results of this test are contained in Appendix B and also Table B-1.

**Consolidation Tests.** The one-dimensional consolidation properties of "undisturbed" samples were evaluated in general accordance with the provisions of ASTM Test Method D 2435. Sample diameter was 2.421 inches and sample height was 1.00 inch. Water was added during the test at various normal loads to evaluate the potential for hydro-collapse and to produce saturation during the remainder of the testing. Consolidation readings were taken regularly during each load increment until the change in sample height was less than approximately 0.0001 inch over a two-hour period. The graphic presentation of consolidation data is a representation of volume change in change in axial load. In addition, time rate tests were performed for select samples. The results of these tests are contained in Appendix B.

**Direct Shear Strength Tests.** Direct shear tests were performed on typical on-site materials. The general philosophy and procedure of the tests were in accord with ASTM Test Method D 3080 - "Direct Shear Tests for Soils Under Consolidated Drained Conditions".

The tests are single shear tests and are performed using a sample diameter of 2.421 inches and a height of 1.00 inch. The normal load is applied by a vertical dead load system. A constant rate of strain is applied to the upper one-half of the sample until failure occurs. Shear stress is monitored by a strain gauge-type precision load cell and deflection is measured with a digital dial indicator. This data is transferred electronically to data acquisition software which plots shear strength vs. deflection. The shear strength plots are then interpreted to determine either peak or ultimate shear strengths. Residual strengths were obtained through multiple shear box reversals. A strain rate compatible with the grain size distribution of the soils was utilized. The interpreted results of these tests are shown in Appendix B.

# TABLE B-1
# SUMMARY OF SOIL LABORATORY DATA

| Sample Information | | | Geologic Unit | USCS Group Symbol | In Situ Water Content, % | In Situ Dry Unit Weight, pcf | In Situ Saturation, % | Sieve/Hydrometer | | | | Atterberg Limits | | | Compaction | | Expansion Index | R-Value | Chemical Test Results | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boring Number | Depth, feet | Elevation feet | | | | | | Gravel, % | Sand, % | <#200, % | <2μ, % | LL | PL | PI | Maximum Dry Unit Weight, pcf | Optimum Water Content, % | | | pH | Sulfate (ppm) | Chloride (ppm) | Min. Resistivity (ohm/cm) |
| DH-1 | 5 | 140.0 | Qols | ML | 36.0 | 72 | 74 | | | | | | | | | | | | | | | |
| DH-1 | 10 | 135.0 | Qols | ML | 41.4 | | | | | | | | | | | | | | | | | |
| DH-1 | 15 | 130.0 | Qols | ML | 59.7 | 64 | 99 | | | | | | | | | | | | 8 | 430 | 160 | 360 |
| DH-1 | 20 | 125.0 | Qols | ML | 43.9 | 75 | 97 | | | | | | | | | | | | | | | |
| DH-1 | 25 | 120.0 | Qols | ML | 39.8 | 75 | 87 | | | | | | | | | | | | | | | |
| DH-1 | 35 | 110.0 | Qols | ML | 24.3 | 82 | 64 | | | | | | | | | | | | | | | |
| DH-1 | 40 | 105.0 | Qols | ML | 42.9 | 79 | 105 | | | | | | | | | | | | | | | |
| DH-1 | 45 | 100.0 | Qols | ML | 28.2 | 105 | 131 | | | | | | | | | | | | | | | |
| DH-1 | 50 | 95.0 | Qols | ML | 35.5 | 85 | 99 | | | | | | | | | | | | | | | |
| DH-1 | 60 | 85.0 | Qols | ML | 44.3 | 99 | 173 | | | | | | | | | | | | | | | |
| DH-1 | 62 | 83.0 | Qols | ML | | | | | | | | | | | | | | | 7 | 563 | 390 | 170 |
| DH-1 | 70 | 75.0 | Qols | ML | 35.8 | 82 | 93 | | | | | | | | | | | | | | | |
| DH-1 | 75 | 70.0 | Qols | ML | 29.9 | 86 | 85 | | | | | | | | | | | | | | | |
| DH-1 | 85 | 60.0 | Qols | ML | 33.7 | 85 | 93 | | | | | | | | | | | | | | | |
| DH-2 | 1 | 559.0 | Qols | SM | 36.3 | | | 9 | 42 | 49 | 17 | 76 | 46 | 30 | 77.0 | 37.0 | | | | | | |
| DH-2 | 5 | 555.0 | Qols | ML | 39.0 | | | | | | | | | | | | | | | | | |
| DH-2 | 10 | 550.0 | Qols | ML | 23.0 | 101 | 96 | | | | | | | | | | | | | | | |
| DH-2 | 15 | 545.0 | Qols | ML | 41.5 | 68 | 78 | | | | | | | | | | | | | | | |
| DH-2 | 25 | 535.0 | Qols | ML | 37.9 | | | | | | | | | | | | | | | | | |
| DH-2 | 30 | 530.0 | Qols | ML | 33.1 | 65 | 57 | | | | | | | | | | | | | | | |
| DH-2 | 35 | 525.0 | Qols | ML | 28.9 | 81 | 73 | 12 | 29 | 60 | 26 | 72 | 48 | 24 | 87.8 | 28.0 | | | 7.8 | 4 | 230 | 300 |
| DH-2 | 40 | 520.0 | Qols | ML | 22.6 | 78 | 53 | | | | | | | | | | | | | | | |
| DH-2 | 45 | 515.0 | Qols | ML | 24.0 | 76 | 53 | | | | | | | | | | | | | | | |
| DH-2 | 50 | 510.0 | Qols | ML | 28.1 | 77 | 64 | | | | | | | | | | | | | | | |
| DH-2 | 55 | 505.0 | Qols | ML | 15.2 | 76 | 34 | | | | | | | | | | | | | | | |

GMU_TABLE_SOIL_LAB_DATA 10-036-00.GPJ FNC AB GWGN01.GDT 9/29/10

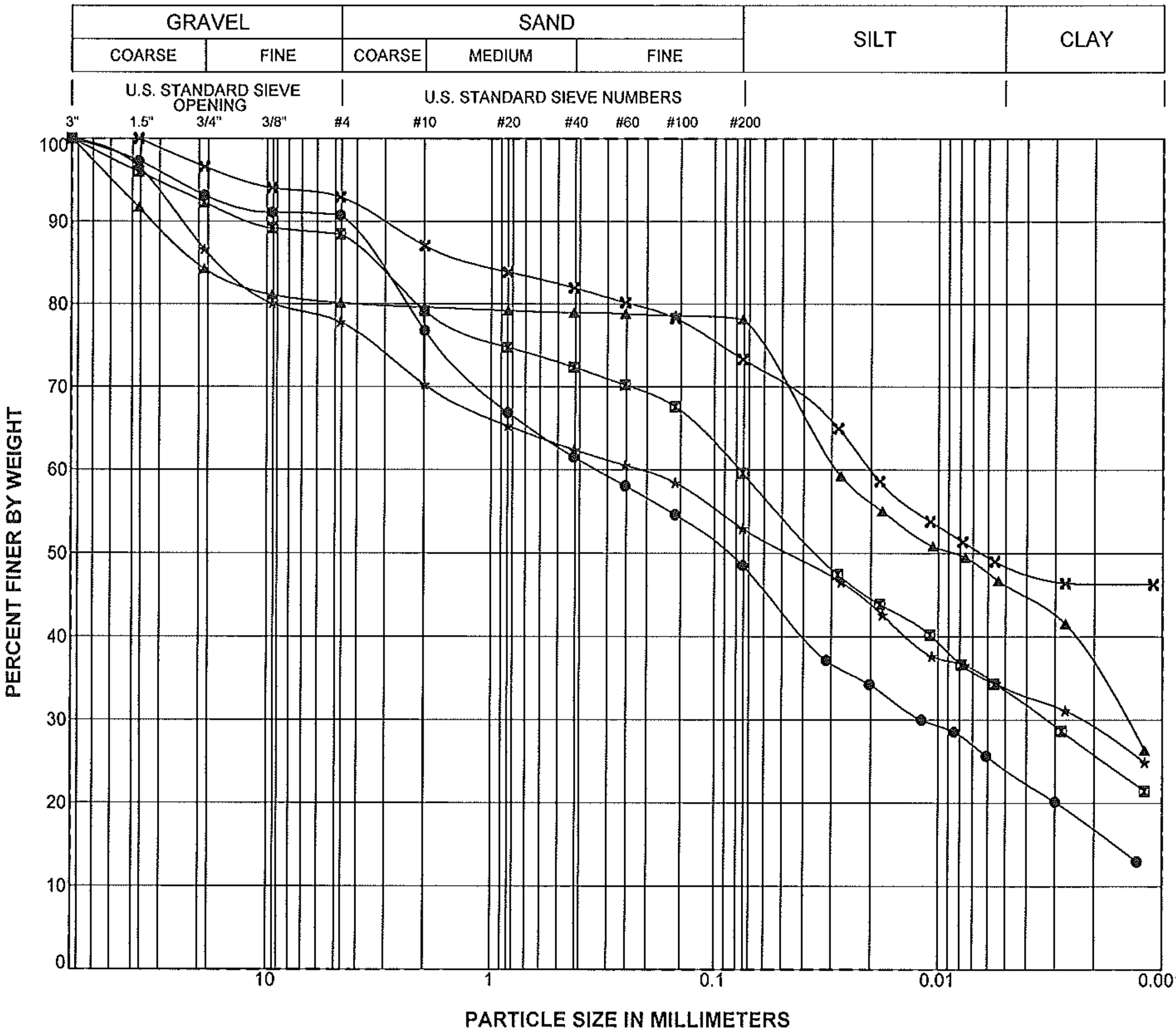
GMU
GEOTECHNICAL, INC.

Project: San Ramon Canyon
Project No. 10-036-00

# TABLE B-1
## SUMMARY OF SOIL LABORATORY DATA

| Sample Information | | | Geologic Unit | USCS Group Symbol | In Situ Water Content, % | In Situ Dry Unit Weight, pcf | In Situ Saturation, % | Sieve/Hydrometer | | | | Atterberg Limits | | | Compaction | | Expansion Index | R-Value | Chemical Test Results | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boring Number | Depth, feet | Elevation, feet | | | | | | Gravel, % | Sand, % | <#200, % | <2μ, % | LL | PL | PI | Maximum Dry Unit Weight, pcf | Optimum Water Content, % | | | pH | Sulfate (ppm) | Chloride (ppm) | Min. Resistivity (ohm/cm) |
| DH-2 | 60 | 500.0 | Qols | ML | 24.6 | 67 | 44 | | | | | | | | | | | | | | | |
| DH-3 | 3 | 660.0 | Qaf | CH | 16.6 | | | 20 | 2 | 78 | 36 | 83 | 36 | 47 | | | | | | | | |
| DH-3 | 5 | 658.0 | Qaf | CL | 29.9 | | | | | | | | | | | | | | | | | |
| DH-3 | 15 | 648.0 | Qaf | CL | 34.5 | 72 | 71 | | | | | | | | | | | | | | | |
| DH-3 | 19 | 644.0 | Qols | CL | | | | | | | | | | | | | | | 8.1 | 51 | 200 | 270 |
| DH-3 | 20 | 643.0 | Qols | CL | 37.5 | 62 | 59 | | | | | | | | | | | | | | | |
| DH-3 | 25 | 638.0 | Qols | ML | 23.6 | 84 | 64 | | | | | | | | | | | | | | | |
| DH-3 | 30 | 633.0 | Qols | ML | 28.5 | 81 | 73 | | | | | | | | | | | | | | | |
| DH-3 | 35 | 628.0 | Qols | ML | 35.8 | 63 | 58 | | | | | | | | | | | | | | | |
| DH-3 | 40 | 623.0 | Qols | ML | 37.5 | 72 | 76 | | | | | | | | | | | | | | | |
| DH-3 | 45 | 618.0 | Qols | ML | 43.1 | 70 | 83 | | | | | | | | | | | | | | | |
| DH-3 | 50 | 613.0 | Qols | ML | 41.5 | 66 | 72 | | | | | | | | | | | | | | | |
| DH-4 | 2.5 | 400.5 | Qal | MH | 27.4 | | | | | | | | | | | | | | | | | |
| DH-4 | 3 | 400.0 | Qal | MH | 45.6 | | | 22 | 25 | 53 | 29 | 69 | 41 | 28 | | | | | 8.1 | 110 | 290 | 480 |
| DH-4 | 7.5 | 395.5 | Qal | CH | 36.1 | 83 | 97 | | | | | | | | | | | | | | | |
| DH-4 | 12.5 | 390.5 | Qal | CH | 31.6 | 84 | 87 | | | | | | | | | | | | | | | |
| DH-4 | 17.5 | 385.5 | Qal | CH | 37.6 | 76 | 85 | | | | | | | | | | | | | | | |
| DH-4 | 20 | 383.0 | Qal | CH | 35.1 | | | 7 | 20 | 73 | 46 | 72 | 29 | 43 | | | | | | | | |
| DH-4 | 22.5 | 380.5 | Qal | CH | 40.3 | 74 | 87 | | | | | | | | | | | | | | | |
| DH-4 | 27.5 | 375.5 | Qal | CH | 22.7 | | | | | | | | | | | | | | | | | |
| DH-4 | 32.5 | 370.5 | Qols | CH | 28.8 | 81 | 73 | | | | | | | | | | | | | | | |
| DH-4 | 37.5 | 365.5 | Qols | SC | 32.5 | 89 | 99 | | | | | | | | | | | | | | | |
| DH-4 | 38 | 365.0 | Qols | SC | 34.8 | 83 | 92 | | | | | | | | | | | | | | | |
| DH-4 | 42.5 | 360.5 | Qols | SC | 41.7 | 80 | 104 | | | | | | | | | | | | | | | |
| DH-4 | 43 | 360.0 | Qols | SC | 33.5 | 80 | 83 | | | | | | | | | | | | | | | |

GMU_TABLE_SOIL_LAB_DATA 10-036-00.GPJ FNC AB GWGN01.GDT 9/29/10



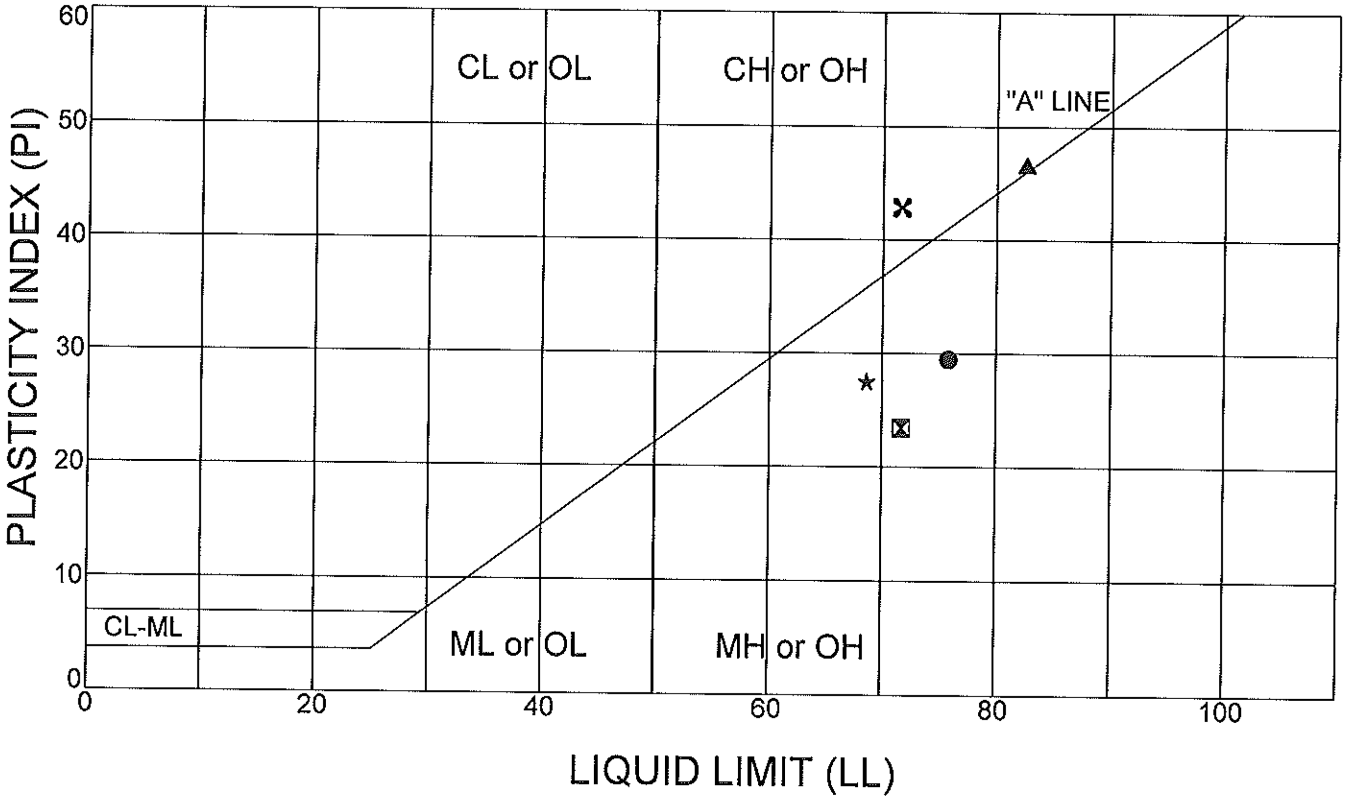

| Boring Number | Depth (feet) | Geologic Unit | Symbol | LL | PI | Classification |
|---|---|---|---|---|---|---|
| DH-2 | 1.0 | Qols | ● | 76 | 30 | Silty Sand (SM) |
| DH-2 | 35.0 | Qols | ⊠ | 72 | 24 | Silt (ML) |
| DH-3 | 3.0 | Qaf | ▲ | 83 | 47 | Fat Clay w/Gravel (CH) |
| DH-4 | 3.0 | Qal | ★ | 69 | 28 | Fat Clay w/Sand (CH) |
| DH-4 | 20.0 | Qal | ✖ | 72 | 43 | Fat Clay w/Sand (CH) |

GMU_GRAIN_SIZE 10-036-00.GPJ 8/30/10

# PARTICLE SIZE DISTRIBUTION

Project: San Ramon Canyon
Project No. 10-036-00

GMU GEOTECHNICAL, INC.




| Boring Number | Depth (feet) | Geologic Unit | Test Symbol | Insitu Water Content (%) | LL | PL | PI | Classification |
|---|---|---|---|---|---|---|---|---|
| DH-2 | 1.0 | Qols | ● | 36 | 76 | 46 | 30 | Silty Sand (SM) |
| DH-2 | 35.0 | Qols | ⊠ | 29 | 72 | 48 | 24 | Silt (ML) |
| DH-3 | 3.0 | Qaf | ▲ | 17 | 83 | 36 | 47 | Fat Clay w/Gravel (CH) |
| DH-4 | 3.0 | Qal | ★ | 46 | 69 | 41 | 28 | Sandy Silt (MH) |
| DH-4 | 20.0 | Qal | ✖ | 35 | 72 | 29 | 43 | Fat Clay w/Sand (CH) |
| | | | | | | | | |
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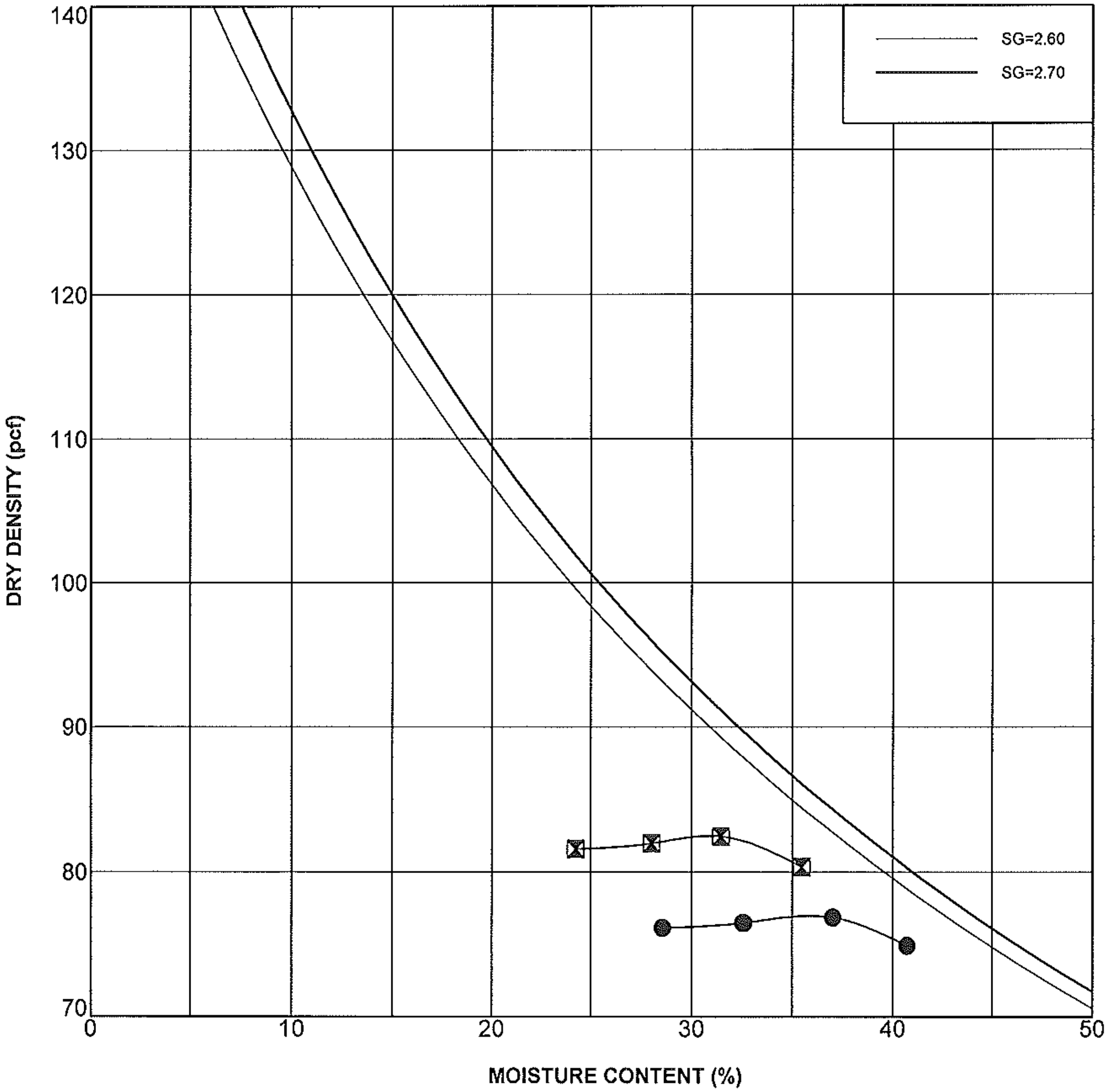
LIMITS 10-036-00.GPJ 9/29/10

# ATTERBERG LIMITS

Project: San Ramon Canyon
Project No. 10-036-00

GMU GEOTECHNICAL, INC.




| Boring Number | Depth (feet) | Geologic Unit | Symbol | Maximum Dry Density, pcf | Optimum Moisture Content, % | Classification |
|---|---|---|---|---|---|---|
| DH-2 | 1.0 | Qols | ● | 77 | 37 | Silty Sand (SM) |
| DH-2 | 35.0 | Qols | ⊠ | 87.8 | 28 | Silt (ML) |
| | | | | | | |
| | | | | | | |

DVTCOMP 10-036-00.GPJ 8/30/10

# COMPACTION TEST DATA

Project: San Ramon Canyon
Project No. 10-036-00

GMU
GEOTECHNICAL, INC.

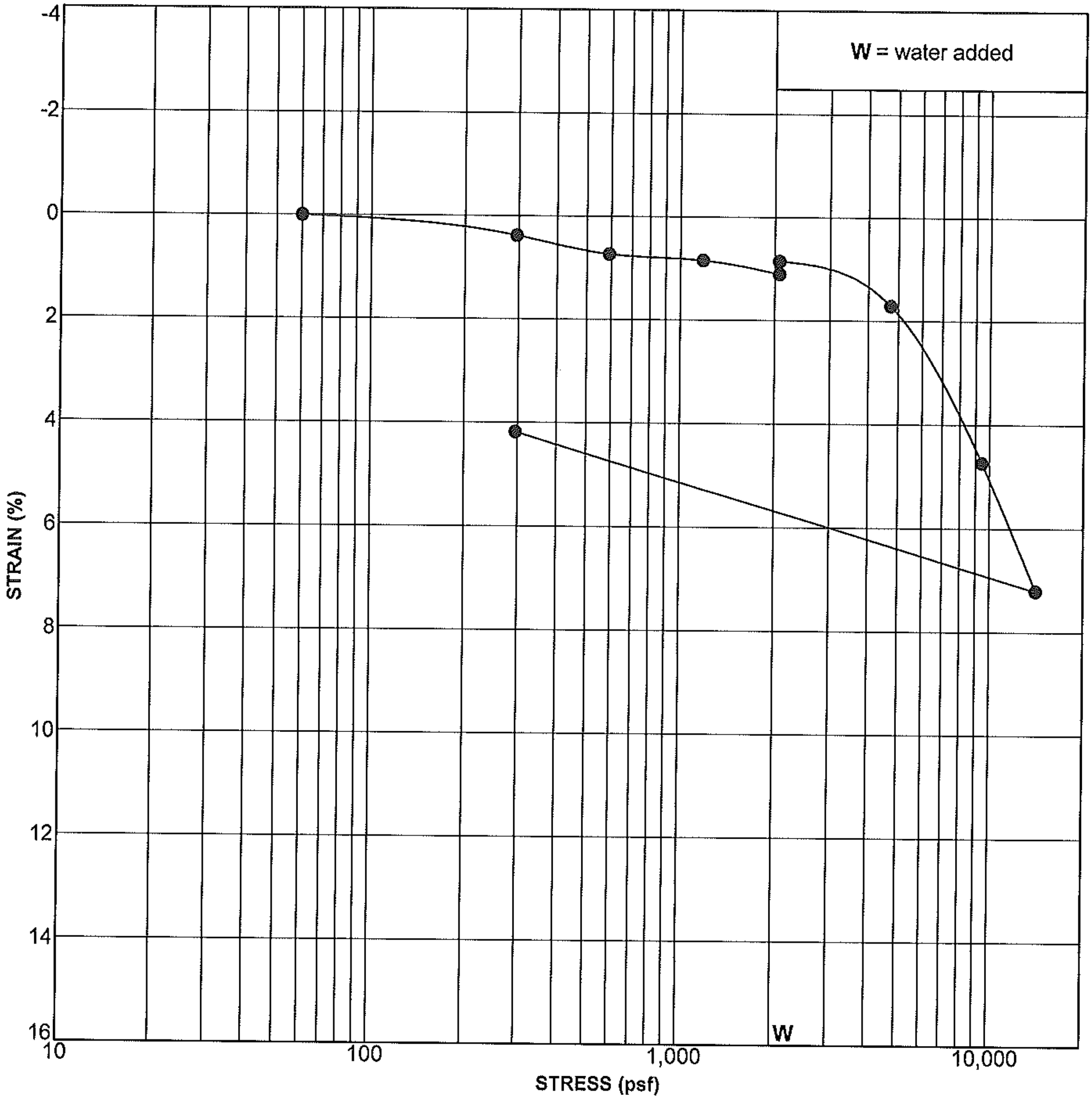
# CHEMICAL TEST RESULTS

| BORING | DEPTH (FT.) | Ph | SOLUBLE SULFATES (ppm) | SOLUBLE CHLORIDES (ppm) | MINIMUM RESISTIVITY ohm-cm |
|---|---|---|---|---|---|
| DH-1 | 15-17' | 8.0 | 430 | 160 | 360 |
| DH-1 | 62-64' | 7.0 | 563 | 390 | 170 |
| DH-2 | 35-37' | 7.8 | 4 | 230 | 300 |
| DH-3 | 19-21' | 8.1 | 51 | 200 | 270 |
| DH-4 | 3-5' | 8.1 | 110 | 290 | 480 |

PERFORMED IN GENERAL ACCORDANCE WITH CALTRANS TEST METHODS 417/422/643

GMU GEOTECHNICAL, INC.

**San Ramon Canyon/Palos Verdes**
**10-036-00**
**August 2010**



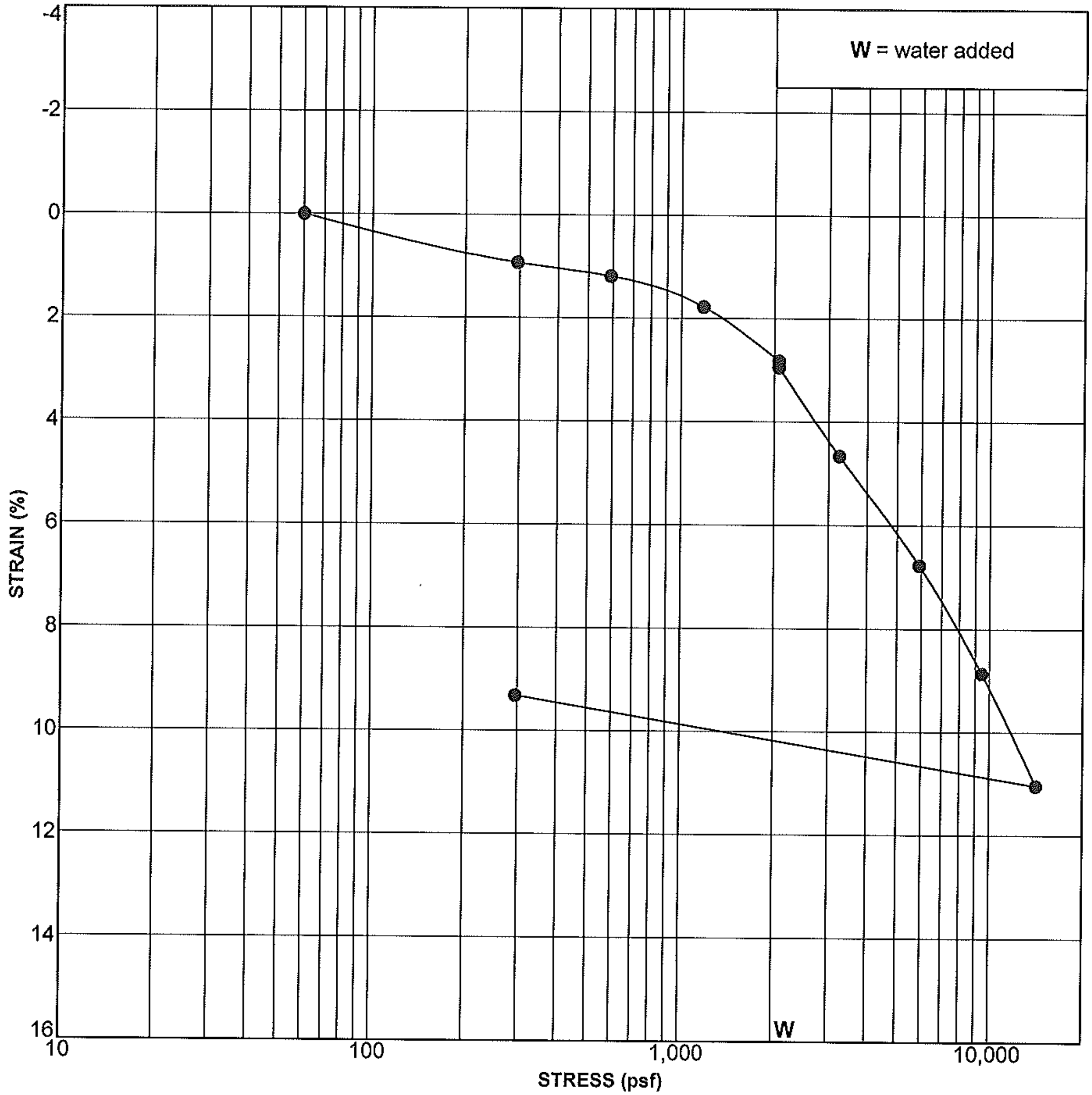

| Boring Number | Depth (feet) | Geologic Unit | Symbol | In Situ or Remolded Sample | % Hydro-Collapse | Classification |
|---|---|---|---|---|---|---|
| DH-4 | 12.5 | Qal | ● | In Situ | -0.25 | Fat Clay w/Sand (CH) |
| | | | | | | |
| | | | | | | |
| | | | | | | |



# CONSOLIDATION TEST DATA

Project: San Ramon Canyon
Project No. 10-036-00

GMU GEOTECHNICAL, INC.



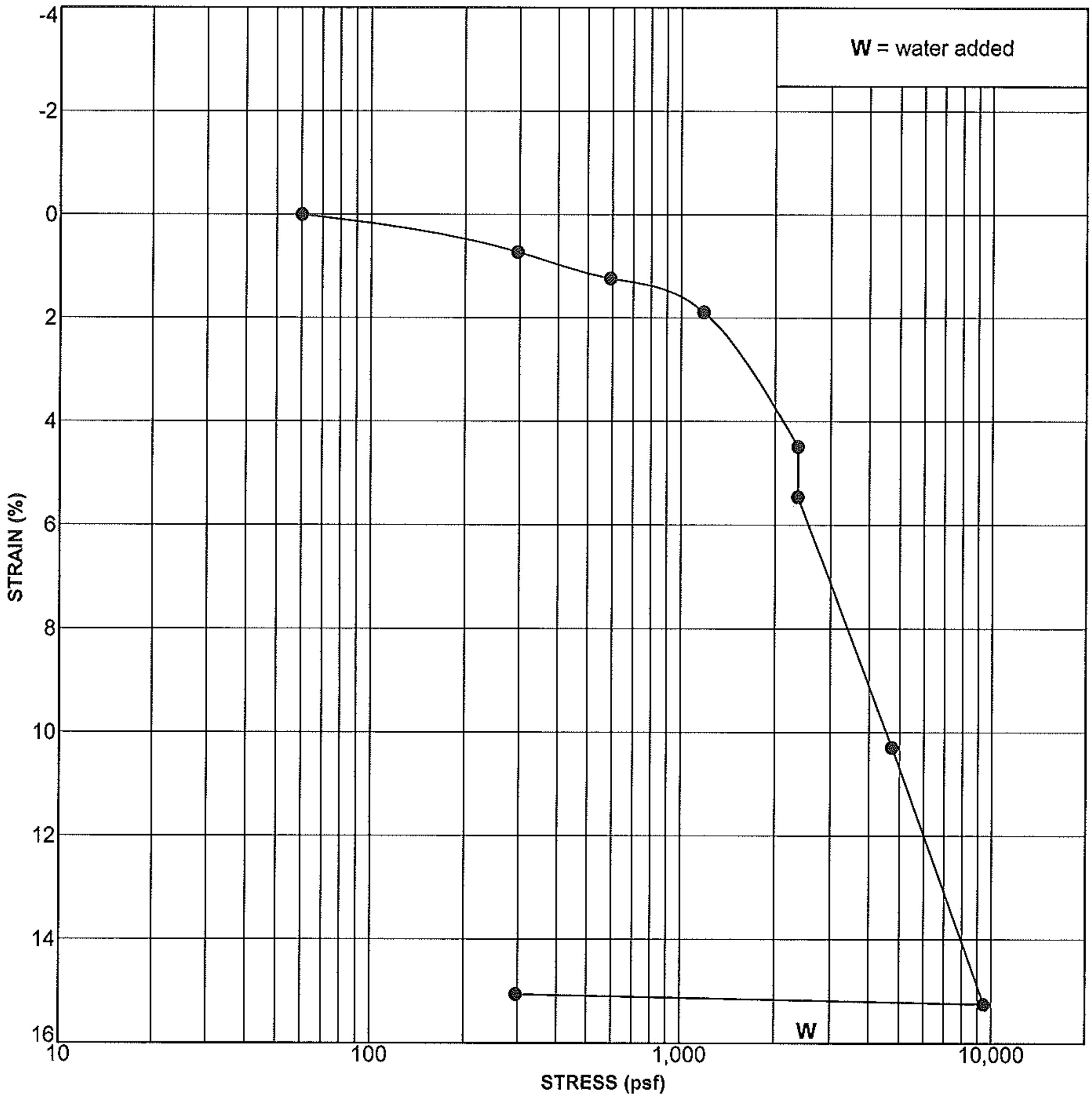

| Boring Number | Depth (feet) | Geologic Unit | Symbol | In Situ or Remolded Sample | % Hydro-Collapse | Classification |
|---|---|---|---|---|---|---|
| DH-4 | 17.5 | Qal | ● | In Situ | 0.13 | Fat Clay w/Sand (CH) |
| | | | | | | |
| | | | | | | |
| | | | | | | |

GMU_CONSOL 10-036-00.GPJ GM&U.GDT 9/29/10

# CONSOLIDATION TEST DATA

Project: San Ramon Canyon
Project No. 10-036-00

GMU GEOTECHNICAL, INC.




| Boring Number | Depth (feet) | Geologic Unit | Symbol | In Situ or Remolded Sample | % Hydro-Collapse | Classification |
|---|---|---|---|---|---|---|
| DH-4 | 22.5 | Qal | ● | In Situ | 0.97 | Fat Clay w/Sand (CH) |
| | | | | | | |
| | | | | | | |
| | | | | | | |

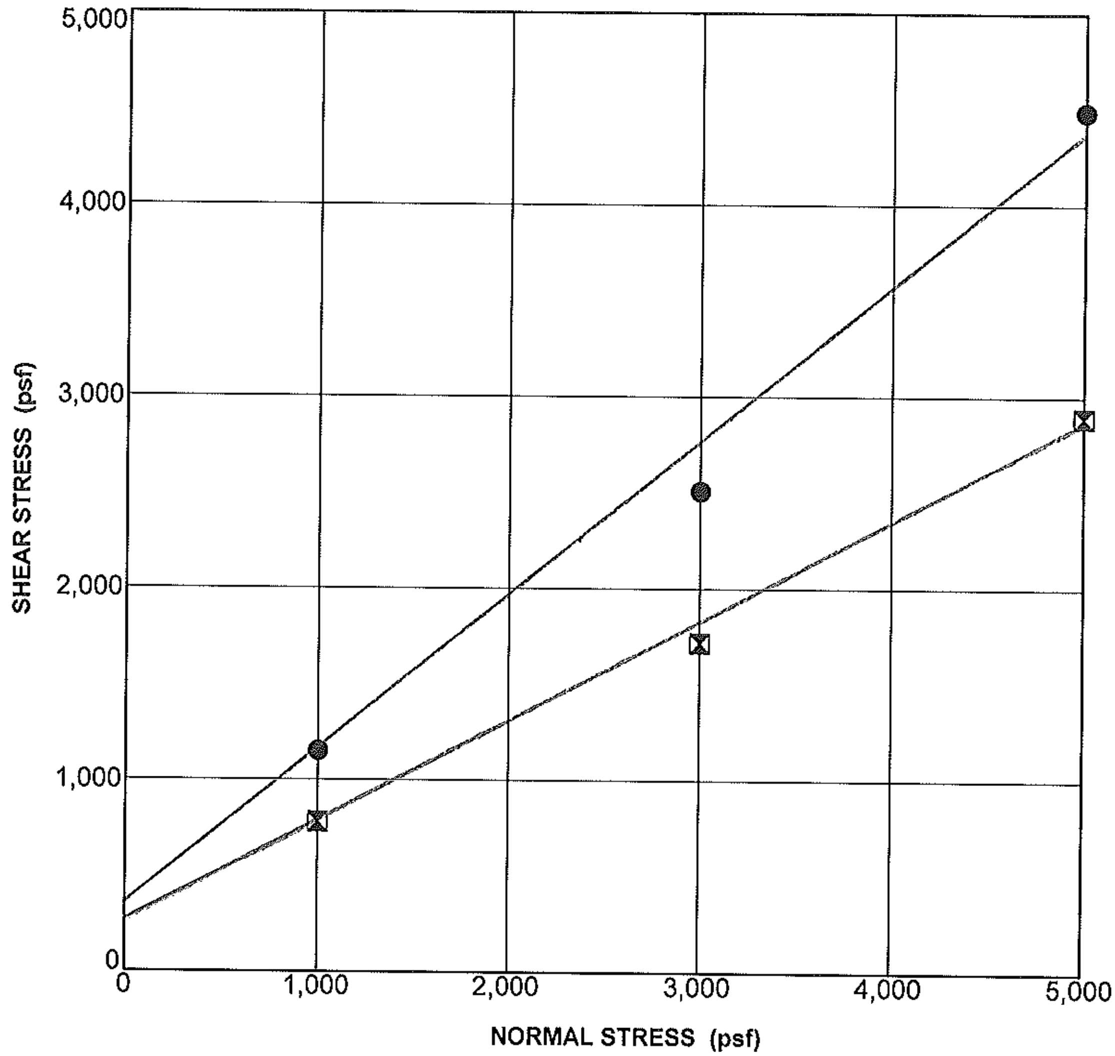
GMU_CONSOL 10-036-00.GPJ GM&U.GDT 9/29/10

# CONSOLIDATION TEST DATA

Project: San Ramon Canyon

Project No. 10-036-00

GMU GEOTECHNICAL, INC.




| SAMPLE AND TEST DESCRIPTION |
|---|
| **Sample Location:** DH-1 @ 25.0 ft **Geologic Unit:** Qols **Classification:** Clayey Silt (ML) |
| **Strain Rate (in/min):** 0.002 **Sample Preparation:** Undisturbed |
| **Notes:** Bluff |

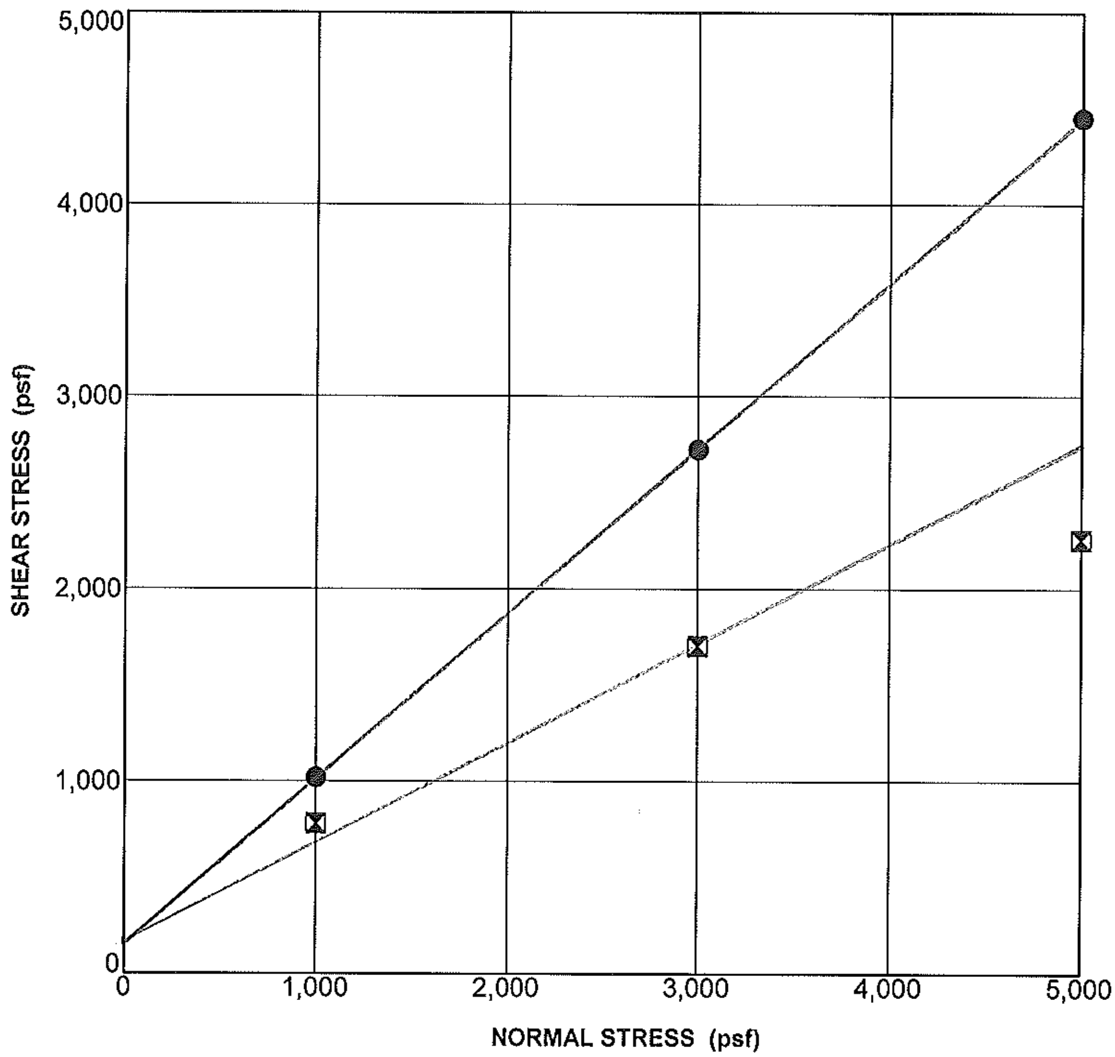
| STRENGTH PARAMETERS | | |
|---|---|---|
| STRENGTH TYPE | COHESION (psf) | FRICTION ANGLE (degrees) |
| ● Peak Strength | 360 | 38.0 |
| ⊠ Ultimate Strength | 280 | 27.0 |

# SHEAR TEST DATA

Project: San Ramon Canyon
Project No. 10-036-00

GMU GEOTECHNICAL, INC.

GMU_DIRECT_SHEAR 10-036-00.GPJ GM&U.GDT 9/29/10




| SAMPLE AND TEST DESCRIPTION |
|---|
| **Sample Location:** DH-1 @ 75.0 ft **Geologic Unit:** Qols **Classification:** Silt (ML) |
| **Strain Rate (in/min):** 0.002 **Sample Preparation:** Undisturbed |
| **Notes:** Bluff |

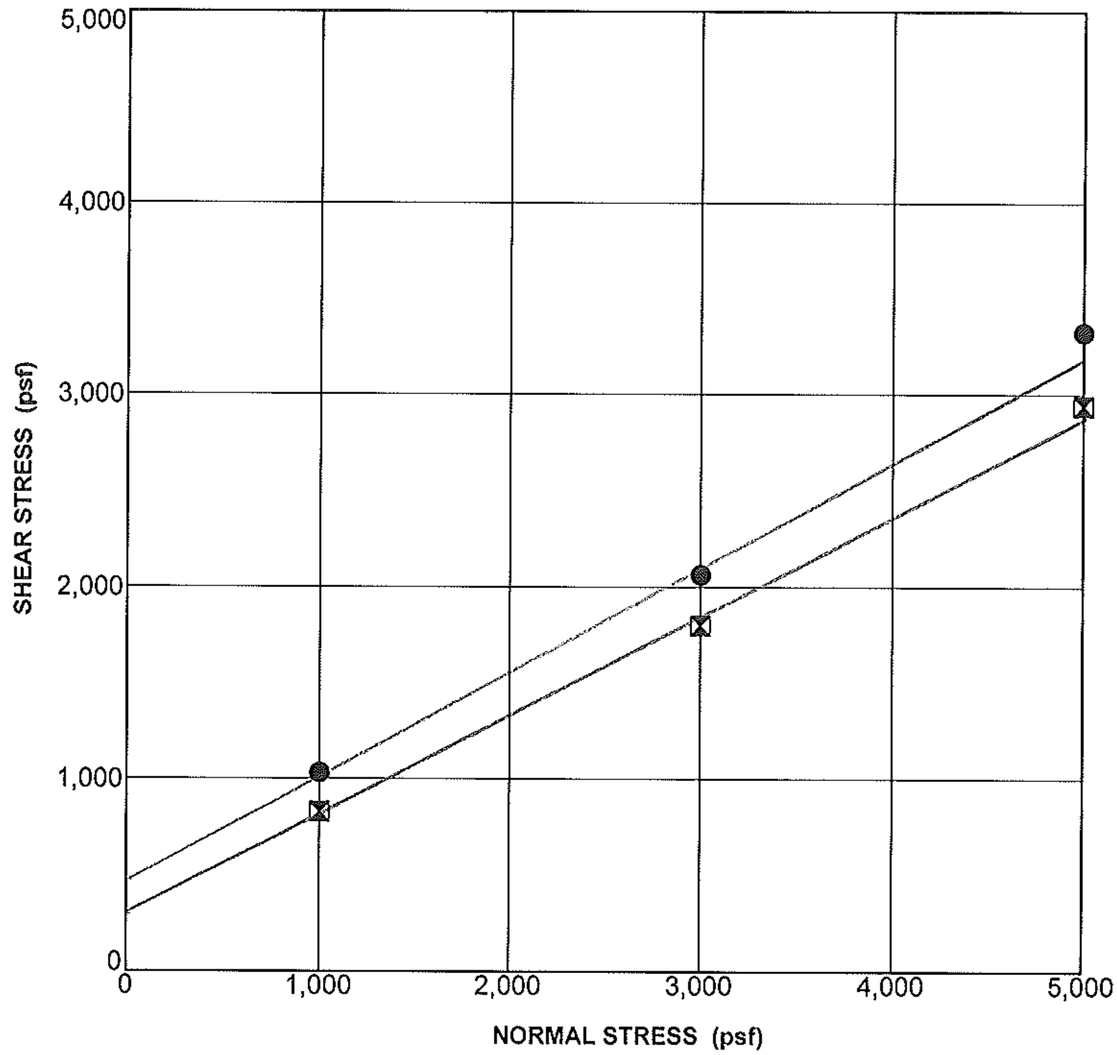
| STRENGTH PARAMETERS | | |
|---|---|---|
| STRENGTH TYPE | COHESION (psf) | FRICTION ANGLE (degrees) |
| ● Peak Strength | 160 | 40.0 |
| ⊠ Ultimate Strength | 160 | 27.0 |

# SHEAR TEST DATA

Project: San Ramon Canyon

Project No. 10-036-00

GMU GEOTECHNICAL, INC.




| SAMPLE AND TEST DESCRIPTION |
|---|
| **Sample Location:** DH-2 @ 1.0 ft **Geologic Unit:** Qols **Classification:** Silty Sand (SM) |
| **Strain Rate (in/min):** 0.002 **Sample Preparation:** Remolded |
| **Notes:** |

| STRENGTH PARAMETERS | | |
|---|---|---|
| STRENGTH TYPE | COHESION (psf) | FRICTION ANGLE (degrees) |
| ● Peak Strength | 480 | 28.0 |
| ☒ Ultimate Strength | 300 | 27.0 |

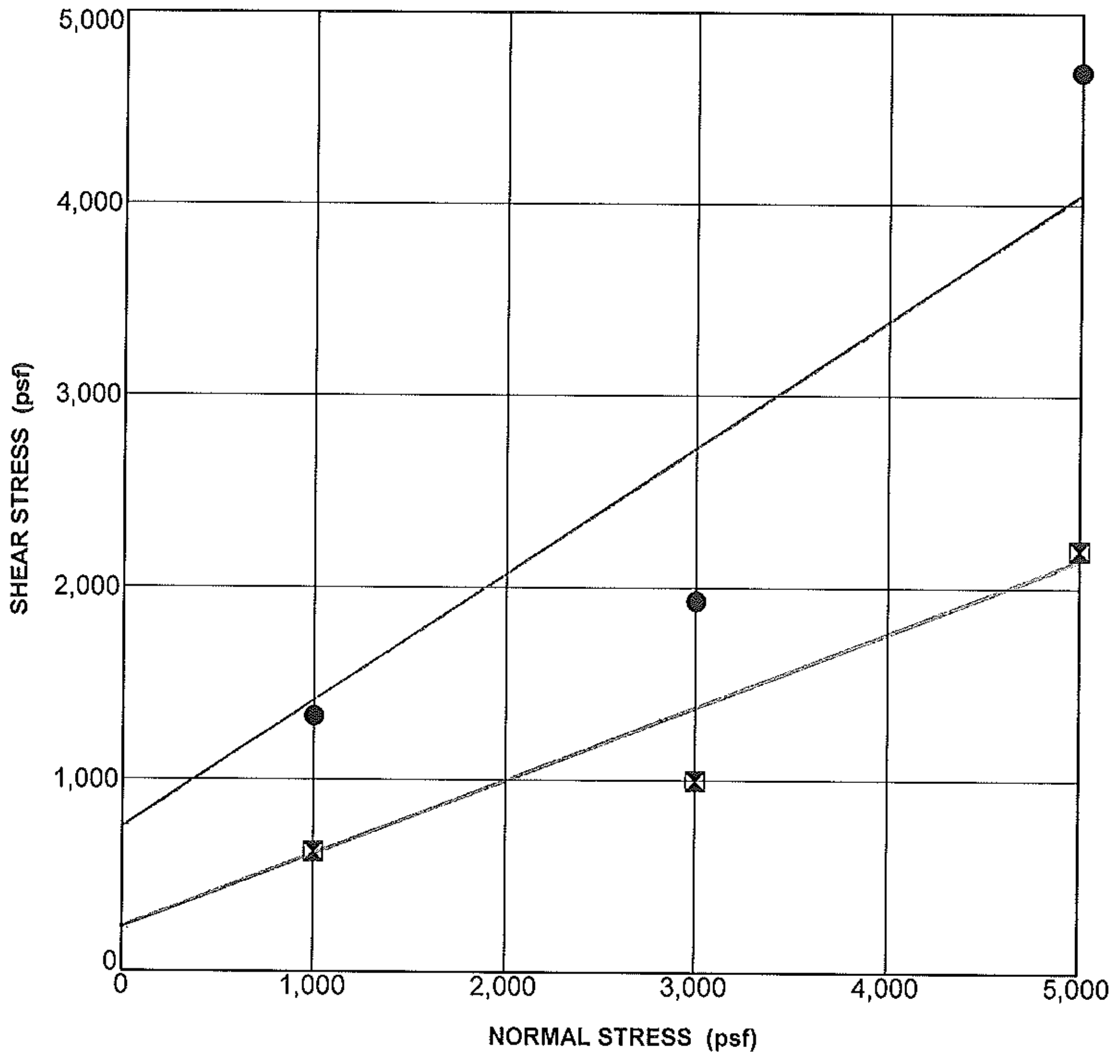
# SHEAR TEST DATA

Project: San Ramon Canyon

Project No. 10-036-00

GMU GEOTECHNICAL, INC.

GMU_DIRECT_SHEAR 10-036-00.GPJ GM&U.GDT 8/30/10




| SAMPLE AND TEST DESCRIPTION |
|---|
| **Sample Location:** DH-2 @ 15.0 ft  **Geologic Unit:** Qols  **Classification:** Silt (ML) |
| **Strain Rate (in/min):** 0.002  **Sample Preparation:** Undisturbed |
| **Notes:** |

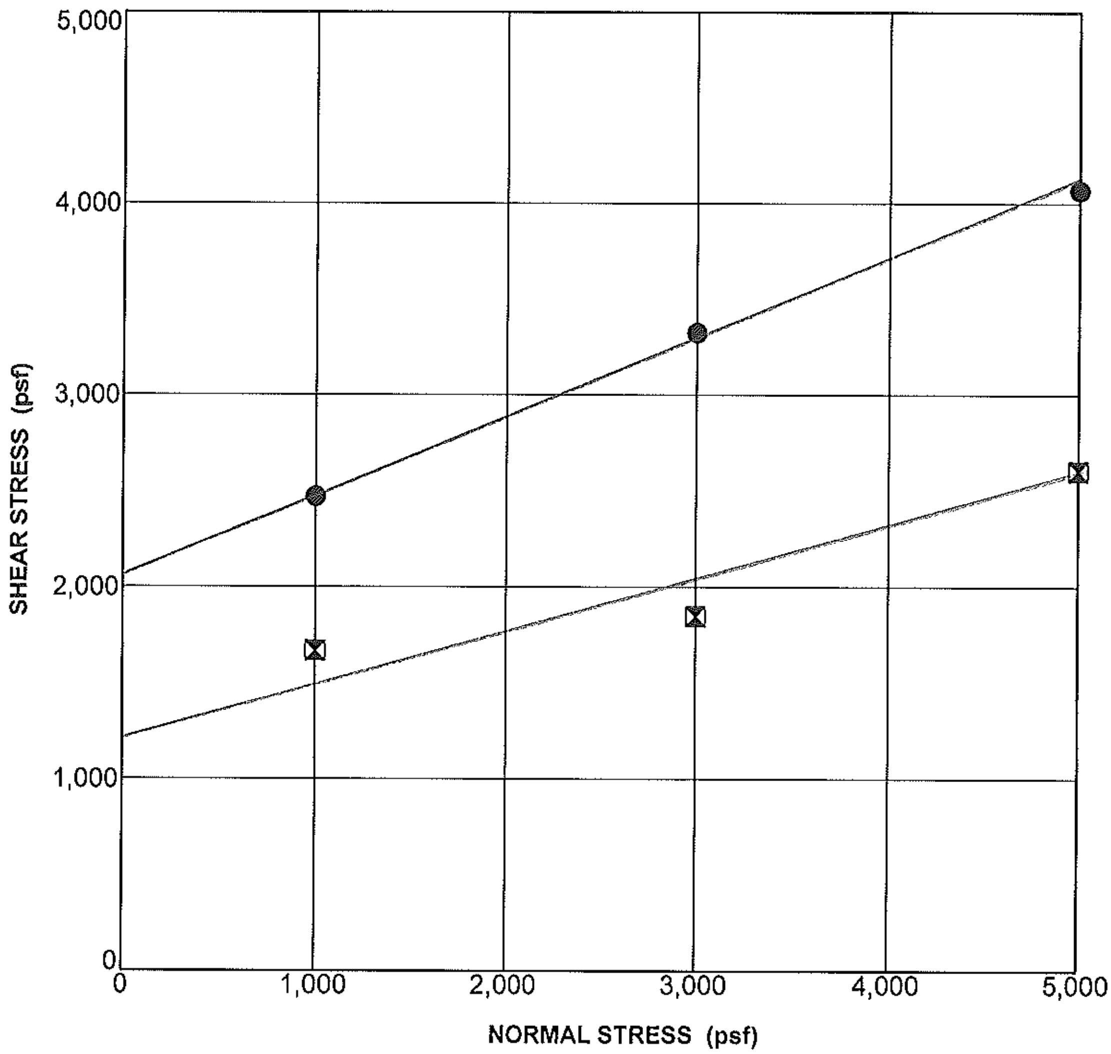
| STRENGTH PARAMETERS | | |
|---|---|---|
| STRENGTH TYPE | COHESION (psf) | FRICTION ANGLE (degrees) |
| ● Peak Strength | 760 | 33.0 |
| ⊠ Ultimate Strength | 220 | 21.0 |

# SHEAR TEST DATA

Project: San Ramon Canyon

Project No. 10-036-00

GMU GEOTECHNICAL, INC.




| SAMPLE AND TEST DESCRIPTION |
|---|
| **Sample Location:** DH-2 @ 30.0 ft **Geologic Unit:** Qols **Classification:** Clayey Silt (ML) |
| **Strain Rate (in/min):** 0.001 **Sample Preparation:** Undisturbed |
| **Notes:** |

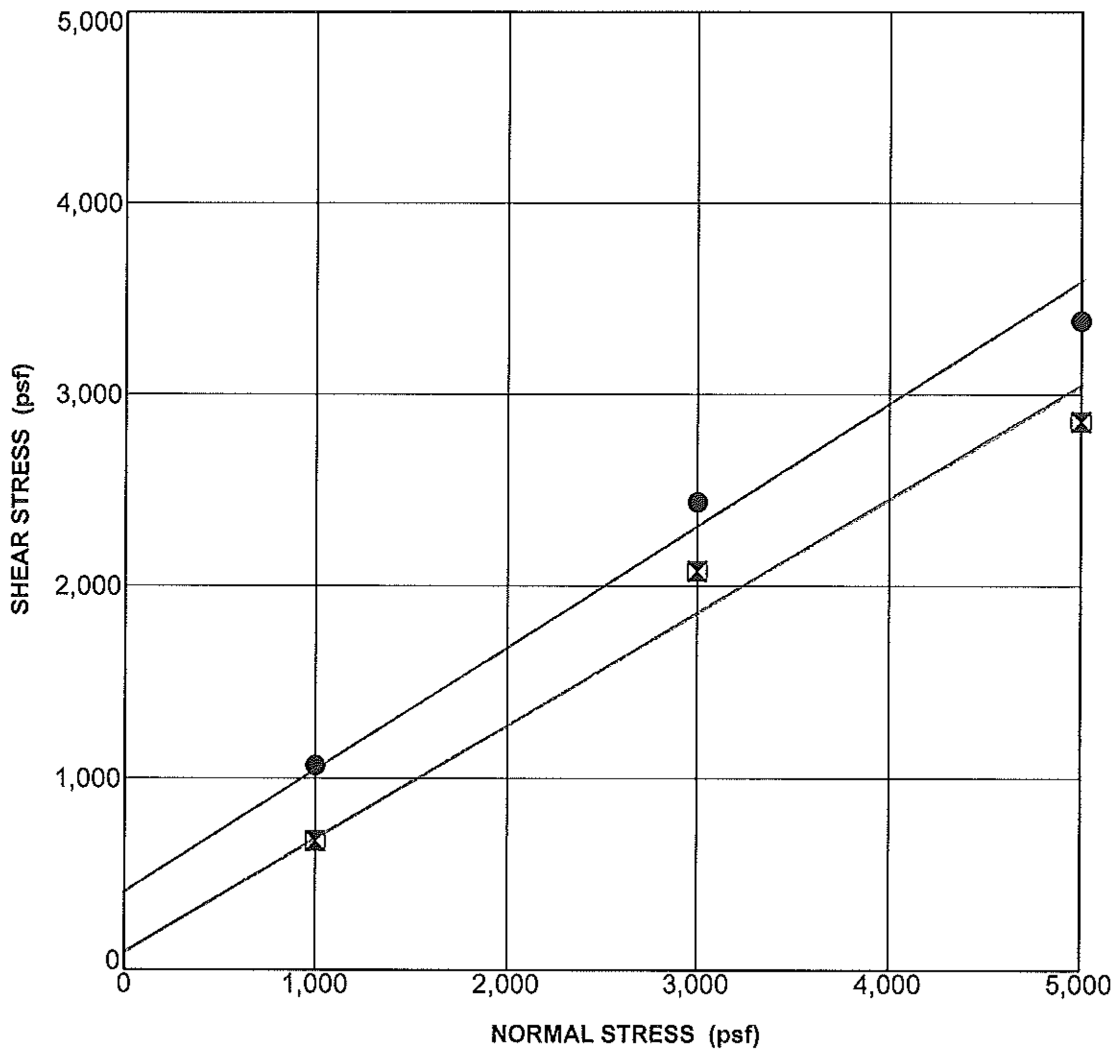
| STRENGTH PARAMETERS | | |
|---|---|---|
| STRENGTH TYPE | COHESION (psf) | FRICTION ANGLE (degrees) |
| ● Peak Strength | 2060 | 22.0 |
| ⊠ Ultimate Strength | 1200 | 15.0 |

# SHEAR TEST DATA

Project: San Ramon Canyon

Project No. 10-036-00

GMU GEOTECHNICAL, INC.



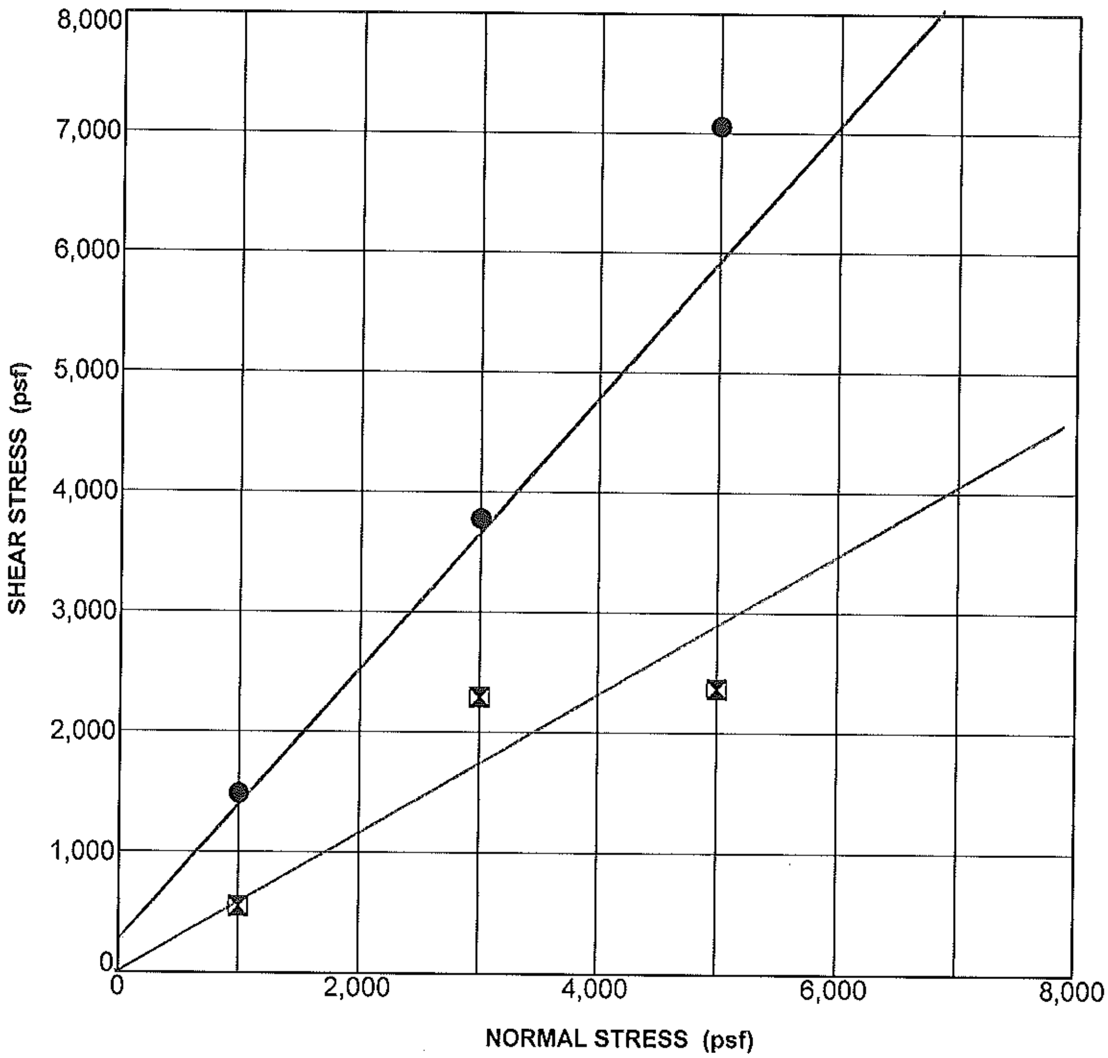

| SAMPLE AND TEST DESCRIPTION |
|---|
| **Sample Location:** DH-2 @ 35.0 ft **Geologic Unit:** Qols **Classification:** Silt (ML) |
| **Strain Rate (in/min):** 0.002 **Sample Preparation:** Remolded |
| **Notes:** |

| STRENGTH PARAMETERS | | |
|---|---|---|
| STRENGTH TYPE | COHESION (psf) | FRICTION ANGLE (degrees) |
| ● Peak Strength | 400 | 32.0 |
| ☒ Ultimate Strength | 100 | 30.0 |



# SHEAR TEST DATA

Project: San Ramon Canyon
Project No. 10-036-00




| SAMPLE AND TEST DESCRIPTION |
|---|
| **Sample Location:** DH-2 @ 60.0 ft **Geologic Unit:** Qols **Classification:** Silt (ML) |
| **Strain Rate (in/min):** 0.002 **Sample Preparation:** Undisturbed |
| **Notes:** |

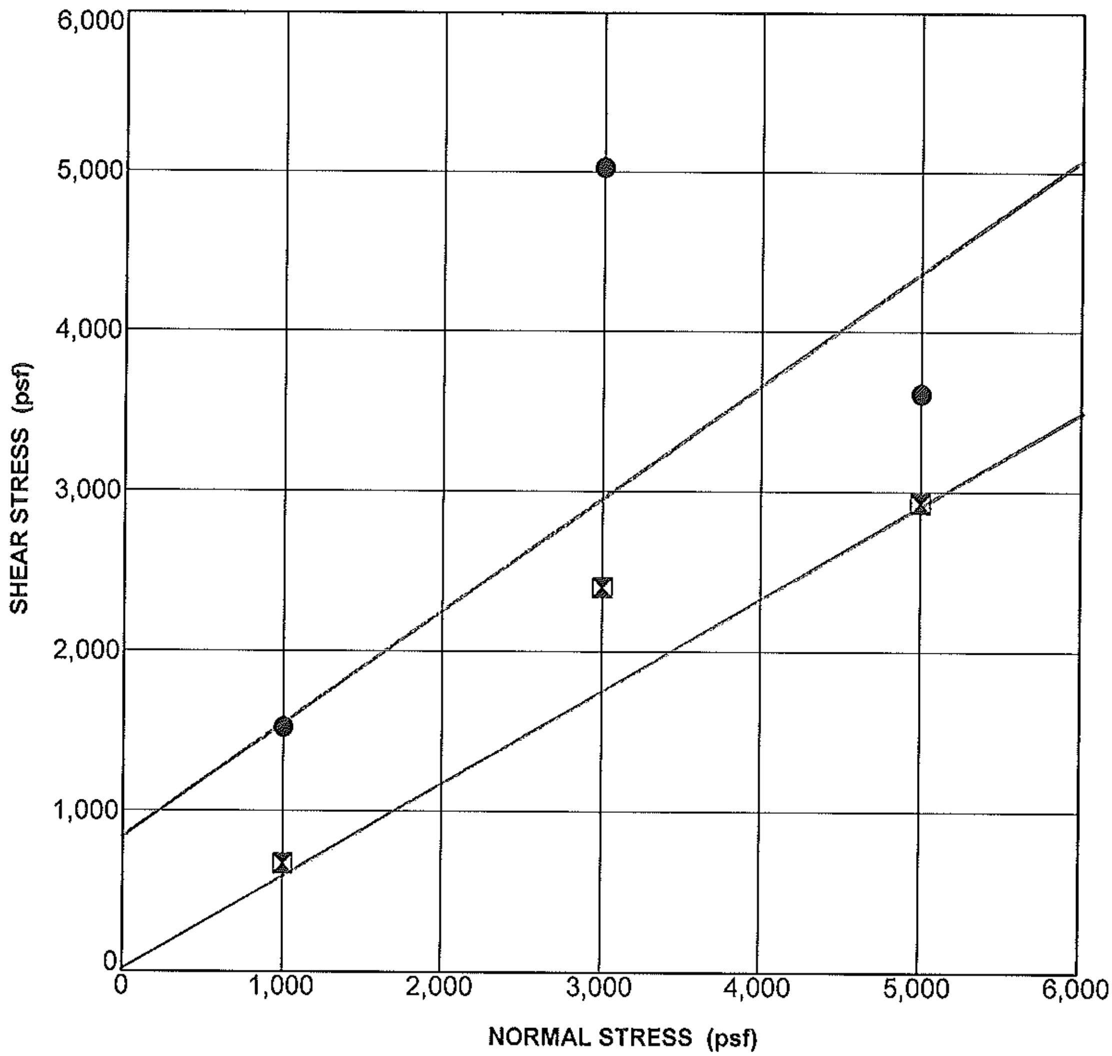
| STRENGTH PARAMETERS | | |
|---|---|---|
| STRENGTH TYPE | COHESION (psf) | FRICTION ANGLE (degrees) |
| ● Peak Strength | 400 | 48.0 |
| ⊠ Ultimate Strength | 0 | 30.0 |

# SHEAR TEST DATA

Project: San Ramon Canyon

Project No. 10-036-00

GMU GEOTECHNICAL, INC.




| SAMPLE AND TEST DESCRIPTION |
|---|
| **Sample Location:** DH-3 @ 20.0 ft **Geologic Unit:** Qols **Classification:** Sandy Clay w/Silt (SC)<br>**Strain Rate (in/min):** 0.002 **Sample Preparation:** Undisturbed<br>**Notes:** |

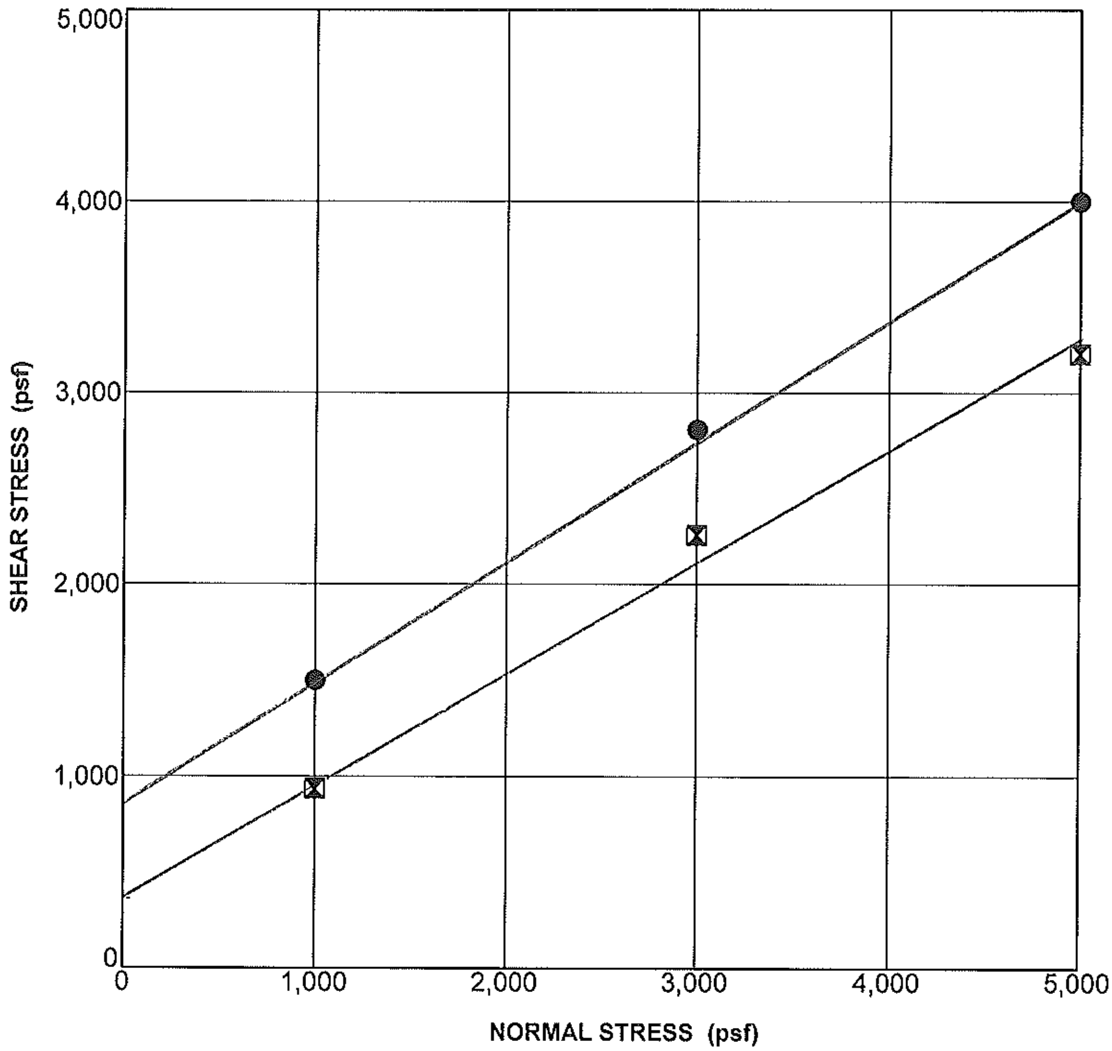
| STRENGTH PARAMETERS | | |
|---|---|---|
| STRENGTH TYPE | COHESION (psf) | FRICTION ANGLE (degrees) |
| ● Peak Strength | 830 | 35.0 |
| ☒ Ultimate Strength | 0 | 33.0 |

# SHEAR TEST DATA

Project: San Ramon Canyon
Project No. 10-036-00

GMU GEOTECHNICAL, INC.

GMU_DIRECT_SHEAR 10-036-00.GPJ GM&U.GDT 8/30/10




| SAMPLE AND TEST DESCRIPTION |
|---|
| **Sample Location:** DH-3 @ 30.0 ft **Geologic Unit:** Qols **Classification:** Clayey Silt (ML) |
| **Strain Rate (in/min):** 0.001 **Sample Preparation:** Undisturbed |
| **Notes:** |

| STRENGTH PARAMETERS | | |
|---|---|---|
| STRENGTH TYPE | COHESION (psf) | FRICTION ANGLE (degrees) |
| ● Peak Strength | 860 | 32.0 |
| ☒ Ultimate Strength | 360 | 30.0 |

GMU_DIRECT_SHEAR 10-036-00.GPJ GM&U.GDT 8/30/10

# SHEAR TEST DATA

Project: San Ramon Canyon

Project No. 10-036-00

GMU GEOTECHNICAL, INC.

# APPENDIX C

## Stability Analysis

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# APPENDIX C

# SLOPE STABILITY ANALYSES

## SHEAR STRENGTH PARAMETERS

### Altamira Shale Member, Monterey Formation (Intact and Landslide Affected)

Published Strength for South Shores Landslide Basal Rupture Surface (Bentonite)

The article entitled "Geologic Investigation, Grading Stabilization Measures, and Development of the South Shores Landslide" by Ray (1982), indicates a strength of phi = 8 degrees and c = 100psf for samples "considered representative of the slide plane". Given that the basal rupture surface is thought to be composed of bentonite, this strength is considered representative of bentonite-lined surfaces.

Published Strength for Altamira Shale Member, Monterey Formation

We have reviewed the geotechnical report prepared by SWN Soiltech Consultants, Inc. (1996) for the proposed residence at 30764 Tarapaca Road. More specifically, we have reviewed SWN's laboratory testing results and slope stability analyses and find the shear strengths used for this adjacent property are generally consistent with the shear strengths used in our analyses, as discussed below.

Back-Calculation of Strength Along Rupture Surface – Tarapaca Landslide

Back-calculation analyses were performed on the portions of Cross-Sections 2-2' and 3-3' that go through the Tarapaca landslide. Because seepage was not seen at the toe of the landslide during geologic reconnaissances and mapping exercises, no groundwater was assumed in the analyses. This assumption will yield the most conservative value.

The results of the analyses indicate a strength of phi = 21 to 24 degrees for Cross Sections 2 and 3, respectively. Assuming a symmetrical weighting, an average residual phi angle of 22.5 degrees can be assumed.

Direct Shear Testing Results

Several shear strength tests were performed on samples retrieved from bucket-auger borings drilled in the switchback and bluff face areas (DH-2 and DH-3). The shear strength data from the switchback area was separated from those obtained from the bluff area and are summarized below:

| Switchback Area | | |
|---|---|---|
| Strength Type | Phi | C (psf) |
| Peak (average) | 37 | 960 |
| Ultimate/Fully Softened (average) | 23 | 570 |
| Bluff Area | | |
| Strength Type | Phi | C (psf) |
| Peak (average) | 39 | 520 |
| Ultimate/Fully Softened (average) | 27 | 220 |

Stark Correlations

Liquid limit and grain size data were utilized to determine strengths via correlations from Stark (2005). Based on a liquid limit of 72 and a clay fines fraction of 26%, the following strength correlations were determined. An average value between residual and fully softened was calculated as first time slides usually occur at strengths between fully softened and residual.

| Strength Type | Strength (no correction) Degrees | Strength (w/ ball mill correction) Degrees |
|---|---|---|
| Residual | 17 | 12 |
| Ultimate/Fully Softened | 28 | 26 |
| Average | 22.5 | 19 |

Back-Calculation to Evaluate Cross Bedding Strength in Bluff Area

A circular failure search was performed to evaluate the cross bedding strength in the bluff area. Both ultimate/fully softened and peak strength values were utilized from the direct shear testing results of samples from Boring DH-1. Safety factors of 0.8 and 1.3 were obtained for both ultimate and peak strengths, respectively.

Conclusions

The following conclusions can be reached from the above strength testing results:

1. The Tarapaca landslide failed along continuous bedding planes that were not bentonite lined.
2. The average uncorrected strength from the Stark method correlates well with the overall back-calculated strength. This suggests the ball mill correction factors should not be applied at this site.
3. Cross bedding strength in the bluff area appears to be close to the peak strength determined from the direct shear testing.

**Engineered Fill**

The following average strengths were determined from direct shear testing on remolded samples of representative on-site soil and bedrock materials.

| Engineered Fill | | |
|---|---|---|
| Strength Type | Phi | C (psf) |
| Peak (average) | 30 | 490 |
| Ultimate/Fully Softened (average) | 28 | 250 |

## STRENGTH AND STABILITY MODELS

Based on the above strength test results and back-calculations, the following strength models were assigned to each cross-section based on the local geologic conditions.

**Cross Section 3-3' (Lower Switchback PVDE)**

Geologic Description Relating to Stability

- Highly contorted older landslide debris.
- Bottom part of slope contains no continuous planar bedding or sheared surface.
- Upper portion of slope contains possible along bedding conditions.

Strength Model

- Bottom portion of slope contains no continuous plane of weakness.
- Upper portion of slope contains possible along bedding conditions.

Stability Model

- Fully softened/Ultimate strength from direct shear testing in lower portion of slope (phi =23; c = 570 psf).
- Residual strength along bedding in upper portion of slope (phi = 17).
- Translation and rotational critical failure searches.
- No groundwater.

**Cross Section 1-1' (Upper Switchback PVDE)**

Geologic Description

- Highly folded bedding throughout slope section.
- No continuous planar bedding condition.
- Approximate 50/50 mix of across and along bedding conditions (phi =23; c = 570 psf).

Strength Model

- Fully softened/Ultimate strengths from direct shear testing was utilized.

Stability Model

- Circular failure search was performed to obtain safety factors.
- No groundwater.

**Cross Sections 2-2' and 3-3' (Tarapaca Landslide)**

Geologic Description

- The Tarapaca landslide is an actively moving landslide.

Strength Model

- Back-calculated strengths were used for each cross section (phi = 21 and 24 degrees).
- Ultimate remolded fill strengths were utilized for postulated fill to be placed in the canyon (phi = 28 and c = 250 psf).

Stability Model

- Failure surface confined to basal rupture surface and allowed to search through passively through a toe buttress composed of engineered fill.

**Cross Section 6-6' (Bluff Stability)**

<u>Geologic Description</u>

- The bluff is composed of relatively intact and less weathered Altamira Shale member, Monterey Formation bedrock.
- Planar continuous bedding planes are currently interpreted in this area.

<u>Strength Model</u>

- Cross bedding strength was modeled using peak strengths as determined from the direct shear testing in the bluff area (phi = 39 and c = 520 psf).
- A residual strength of phi = 17 degrees was assumed for along bedding conditions.

<u>Stability Model</u>

- Translational failure searches along bedding at various heights above the toe of slope were performed.

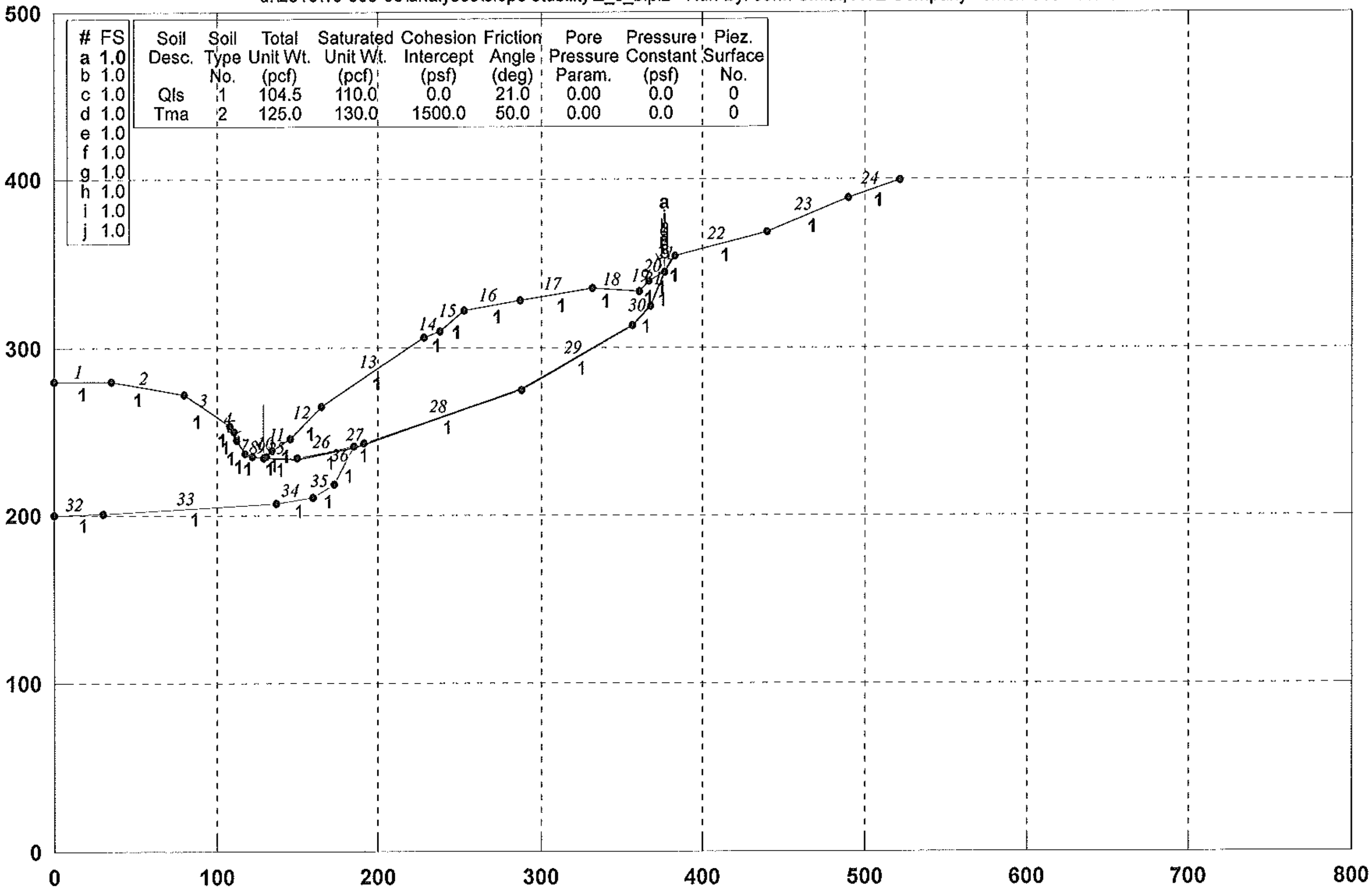
## SUMMARY OF STABILITY ANALYSES RESULTS

| Analysis Description | Cross Section | Strengths | Static Factor of Safety |
|---|---|---|---|
| Back-Calculation of Tarapaca Landslide | 2 | Phi = 21 deg. | 1.0 |
| Back-Calculation of Tarapaca Landslide | 3 | Phi = 24 deg. | 1.0 |
| Back-Calculation of Cross Bedding Strength for Bluff Slope | 6 | Phi = 27 c = 220 | 1.3 |
| Back-Calculation of Cross Bedding Strength for Bluff Slope | 6 | Phi = 39 c = 520 | 0.8 |
| Lower Switch Back – Existing Condition Stability (Translation Search at Road) | 3 | Phi = 17 along bedding – upper slope Phi = 23; c=570 - Lower slope | 1.9 |
| Lower Switch Back – Existing Condition Stability (Circular Search at Road) | 3 | Phi = 17 along bedding – upper slope Phi = 23; c=570 - Lower slope | 1.6 |
| Lower Switch Back – Existing Condition Stability (Circular Search at Bluff Face) | 3 | Phi = 23; c = 570 | 1.4 |

| | | | |
|---|---|---|---|
| Lower Switchback – Amount of Bluff Face Erosion for Failure | 3 | Phi = 23; c = 570 | 1.01 (for 35' of bluff face erosion) |
| Upper Switch Back – Existing Condition Stability (Circular Failure Search at Bluff Face) | 1 | Phi = 23; c = 570 | 1.4 |
| Upper Switch Back – Existing Condition Stability (Circular Failure Search at Road) | 1 | Phi = 23; c = 570 | 1.3 |
| Upper Switchback – Amount of Bluff Face Erosion for Failure | 1 | Phi = 23; c = 570 | 1.02 (for 40' of bluff face erosion) |
| Tarapaca Landslide – Fill Height at Toe for Approx. 1.25 Safety Factor | 2 | Slide: Phi = 21 deg. Fill Butt.: Phi =28; c=250 | 1.3 (for fill height = 20 feet) |
| Tarapaca Landslide – Fill Height at Toe for Approx. 1.5 Safety Factor | 2 | Slide: Phi = 21 deg. Fill Butt.: Phi =28; c=250 | 1.5 (for fill height = 30 feet) |
| Tarapaca Landslide – Fill Height at Toe for Approx. 1.25 Safety Factor | 3 | Slide: Phi = 24 deg. Fill Butt.: Phi =28; c=250 | 1.2 (for fill height = 10 feet) |
| Tarapaca Landslide – Fill Height at Toe for Approx. 1.5 Safety Factor | 3 | Slide: Phi = 24 deg. Fill Butt.: Phi =28; c=250 | 1.5 (for fill height = 16.5 feet) |

# Sect 2, Static, Back-calculation of Terrapaca Landslide

u:\2010\10-036-00\analyses\slope stability\2_s_b.pl2 Run By: John Smith, XYZ Company 9/28/2010 10:16AM




GSTABL7 v.2 FSmin=1.0

Safety Factors Are Calculated By The Simplified Janbu Method for the case of c=0

***** GSTABL7 *****

** GSTABL7 by Garry H. Gregory, P.E. **
** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **


********************************************************************************

SLOPE STABILITY ANALYSIS SYSTEM
Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.

********************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 10:16AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\2_s_b.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\2_s_b.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\2_s_b.PLT
PROBLEM DESCRIPTION: Sect 2, Static, Back-calculation
of Terrapaca Landslide

BOUNDARY COORDINATES
24 Top Boundaries
36 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 280.00 | 35.00 | 280.00 | 1 |
| 2 | 35.00 | 280.00 | 80.00 | 272.00 | 1 |
| 3 | 80.00 | 272.00 | 108.00 | 254.00 | 1 |
| 4 | 108.00 | 254.00 | 111.00 | 250.00 | 1 |
| 5 | 111.00 | 250.00 | 112.00 | 245.00 | 1 |
| 6 | 112.00 | 245.00 | 118.00 | 237.00 | 1 |
| 7 | 118.00 | 237.00 | 122.00 | 235.00 | 1 |
| 8 | 122.00 | 235.00 | 129.00 | 234.00 | 1 |
| 9 | 129.00 | 234.00 | 131.00 | 235.00 | 1 |
| 10 | 131.00 | 235.00 | 134.00 | 239.00 | 1 |
| 11 | 134.00 | 239.00 | 146.00 | 246.00 | 1 |
| 12 | 146.00 | 246.00 | 165.00 | 265.00 | 1 |
| 13 | 165.00 | 265.00 | 228.00 | 306.00 | 1 |
| 14 | 228.00 | 306.00 | 238.00 | 310.00 | 1 |
| 15 | 238.00 | 310.00 | 253.00 | 322.00 | 1 |
| 16 | 253.00 | 322.00 | 287.00 | 328.00 | 1 |
| 17 | 287.00 | 328.00 | 332.00 | 335.00 | 1 |
| 18 | 332.00 | 335.00 | 361.00 | 334.00 | 1 |
| 19 | 361.00 | 334.00 | 367.00 | 340.00 | 1 |
| 20 | 367.00 | 340.00 | 377.00 | 345.00 | 1 |
| 21 | 377.00 | 345.00 | 383.00 | 355.00 | 1 |
| 22 | 383.00 | 355.00 | 440.00 | 369.00 | 1 |
| 23 | 440.00 | 369.00 | 490.00 | 389.00 | 1 |
| 24 | 490.00 | 389.00 | 521.00 | 399.00 | 1 |
| 25 | 129.00 | 234.00 | 150.00 | 234.00 | 1 |
| 26 | 150.00 | 234.00 | 185.00 | 241.00 | 1 |
| 27 | 185.00 | 241.00 | 191.00 | 243.00 | 1 |
| 28 | 191.00 | 243.00 | 288.00 | 275.00 | 1 |
| 29 | 288.00 | 275.00 | 356.00 | 313.00 | 1 |
| 30 | 356.00 | 313.00 | 368.00 | 325.00 | 1 |
| 31 | 368.00 | 325.00 | 377.00 | 345.00 | 1 |
| 32 | 0.00 | 200.00 | 30.00 | 201.00 | 1 |
| 33 | 30.00 | 201.00 | 137.00 | 207.00 | 1 |
| 34 | 137.00 | 207.00 | 160.00 | 211.00 | 1 |
| 35 | 160.00 | 211.00 | 173.00 | 219.00 | 1 |
| 36 | 173.00 | 219.00 | 185.00 | 241.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)

ISOTROPIC SOIL PARAMETERS
2 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 104.5 | 110.0 | 0.0 | 21.0 | 0.00 | 0.0 | 0 |
| 2 | 125.0 | 130.0 | 1500.0 | 50.0 | 0.00 | 0.0 | 0 |

Janbus Empirical Coef is being used for the case of c=0
A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.
10 Trial Surfaces Have Been Generated.
8 Boxes Specified For Generation Of Central Block Base
Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 10.0

| Box No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Height (ft) |
|---|---|---|---|---|---|
| 1 | 130.00 | 234.00 | 130.00 | 234.00 | 0.10 |
| 2 | 150.00 | 234.00 | 150.00 | 234.00 | 1.00 |
| 3 | 185.00 | 241.00 | 185.00 | 241.00 | 1.00 |
| 4 | 191.00 | 243.00 | 191.00 | 243.00 | 1.00 |
| 5 | 288.00 | 275.00 | 288.00 | 275.00 | 1.00 |
| 6 | 356.00 | 313.00 | 356.00 | 313.00 | 1.00 |
| 7 | 368.00 | 325.00 | 368.00 | 325.00 | 1.00 |
| 8 | 377.00 | 345.00 | 377.00 | 345.00 | 0.00 |

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Evaluated. They Are Ordered - Most Critical First.
* * Safety Factors Are Calculated By The Simplified Janbu Method * *
Total Number of Trial Surfaces Attempted = 10
Number of Trial Surfaces With Valid FS = 10
Statistical Data On All Valid FS Values:
FS Max = 1.011 FS Min = 1.003 FS Ave = 1.007
Standard Deviation = 0.002 Coefficient of Variation = 0.23 %
Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 129.367 | 234.183 |
| 2 | 130.000 | 233.955 |
| 3 | 150.000 | 233.750 |
| 4 | 185.000 | 240.840 |
| 5 | 191.000 | 242.534 |
| 6 | 288.000 | 275.303 |
| 7 | 356.000 | 313.365 |
| 8 | 368.000 | 324.689 |
| 9 | 377.000 | 345.000 |

Factor of Safety
*** 1.003 ***
Individual data on the 23 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.5 | 11.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 0.1 | 6.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 1.0 | 83.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 3.0 | 962.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 12.0 | 10844.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 4.0 | 5947.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 15.0 | 34846.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 19.9 | 67948.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 0.1 | 382.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 6.0 | 24002.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 37.0 | 174673.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 10.0 | 53584.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 11.7 | 66565.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 3.3 | 19732.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 34.0 | 198177.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 16 | 1.0 | 5532.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 17 | 44.0 | 202129.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 18 | 24.0 | 70067.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 19 | 5.0 | 9594.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 20 | 1.5 | 2474.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 21 | 4.5 | 7610.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 22 | 1.0 | 1675.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 23 | 9.0 | 7435.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 129.367 | 234.183 |
| 2 | 130.000 | 233.986 |
| 3 | 150.000 | 233.772 |
| 4 | 185.000 | 241.465 |
| 5 | 191.000 | 243.279 |
| 6 | 288.000 | 275.308 |
| 7 | 356.000 | 313.395 |
| 8 | 368.000 | 325.135 |
| 9 | 377.000 | 345.000 |

Factor of Safety
*** 1.005 ***

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 129.436 | 234.218 |
| 2 | 130.000 | 234.026 |
| 3 | 150.000 | 233.847 |
| 4 | 185.000 | 240.997 |
| 5 | 191.000 | 243.299 |
| 6 | 288.000 | 275.097 |
| 7 | 356.000 | 313.485 |
| 8 | 368.000 | 325.307 |
| 9 | 377.000 | 345.000 |

Factor of Safety
*** 1.006 ***

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 129.613 | 234.306 |
| 2 | 130.000 | 234.007 |
| 3 | 150.000 | 234.263 |
| 4 | 185.000 | 240.667 |
| 5 | 191.000 | 243.129 |
| 6 | 288.000 | 275.244 |
| 7 | 356.000 | 313.355 |
| 8 | 368.000 | 324.556 |
| 9 | 377.000 | 345.000 |

Factor of Safety
*** 1.007 ***

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 129.651 | 234.326 |
| 2 | 130.000 | 233.989 |
| 3 | 150.000 | 233.769 |
| 4 | 185.000 | 241.271 |
| 5 | 191.000 | 243.487 |
| 6 | 288.000 | 275.262 |
| 7 | 356.000 | 313.189 |
| 8 | 368.000 | 324.613 |
| 9 | 377.000 | 345.000 |

Factor of Safety
*** 1.007 ***

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 129.498 | 234.249 |
| 2 | 130.000 | 233.989 |
| 3 | 150.000 | 233.979 |

| | | |
|---|---|---|
| 4 | 185.000 | 240.584 |
| 5 | 191.000 | 243.419 |
| 6 | 288.000 | 274.954 |
| 7 | 356.000 | 313.406 |
| 8 | 368.000 | 324.746 |
| 9 | 377.000 | 345.000 |

Factor of Safety
*** 1.008 ***

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 129.310 | 234.155 |
| 2 | 130.000 | 233.988 |
| 3 | 150.000 | 234.427 |
| 4 | 185.000 | 240.655 |
| 5 | 191.000 | 243.160 |
| 6 | 288.000 | 275.287 |
| 7 | 356.000 | 313.128 |
| 8 | 368.000 | 324.528 |
| 9 | 377.000 | 345.000 |

Factor of Safety
*** 1.008 ***

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 129.359 | 234.180 |
| 2 | 130.000 | 233.981 |
| 3 | 150.000 | 234.357 |
| 4 | 185.000 | 240.630 |
| 5 | 191.000 | 243.102 |
| 6 | 288.000 | 274.992 |
| 7 | 356.000 | 313.269 |
| 8 | 368.000 | 324.652 |
| 9 | 377.000 | 345.000 |

Factor of Safety
*** 1.009 ***

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 129.581 | 234.290 |
| 2 | 130.000 | 234.013 |
| 3 | 150.000 | 233.841 |
| 4 | 185.000 | 241.251 |
| 5 | 191.000 | 242.578 |
| 6 | 288.000 | 274.793 |
| 7 | 356.000 | 312.612 |
| 8 | 368.000 | 324.507 |
| 9 | 377.000 | 345.000 |

Factor of Safety
*** 1.010 ***

Failure Surface Specified By 9 Coordinate Points

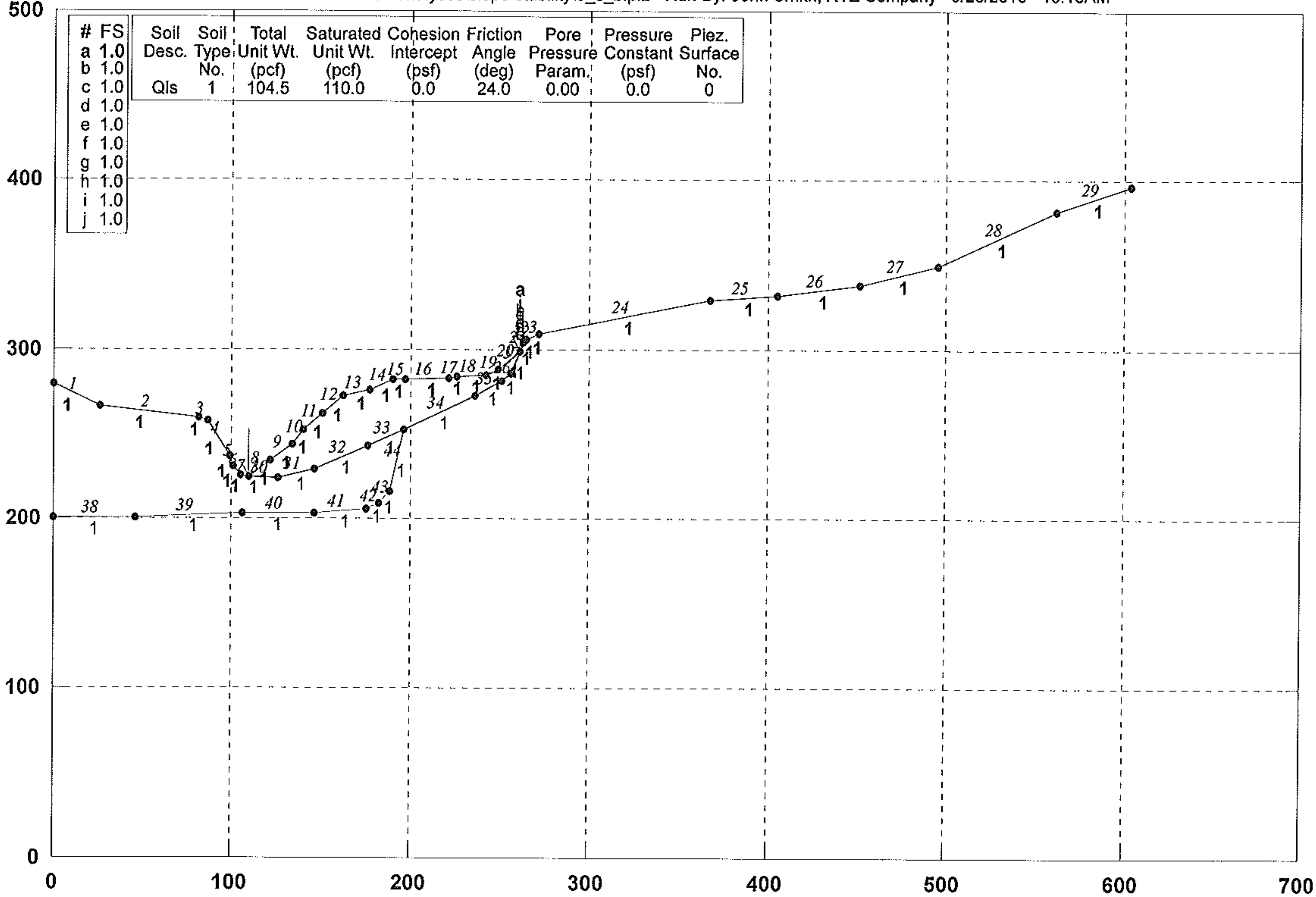
| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 129.273 | 234.137 |
| 2 | 130.000 | 234.005 |
| 3 | 150.000 | 234.399 |
| 4 | 185.000 | 241.164 |
| 5 | 191.000 | 243.316 |
| 6 | 288.000 | 274.573 |
| 7 | 356.000 | 313.405 |
| 8 | 368.000 | 325.029 |
| 9 | 377.000 | 345.000 |

Factor of Safety
*** 1.011 ***

**** END OF GSTABL7 OUTPUT ****

## Sect 3, Static, Back-calculation of Terrapaca Landslide

u:\2010\10-036-00\analyses\slope stability\3_s_b.pl2  Run By: John Smith, XYZ Company  9/28/2010  10:18AM




GSTABL7 v.2 FSmin=1.0

Safety Factors Are Calculated By The Simplified Janbu Method for the case of c=0

***** GSTABL7 *****

** GSTABL7 by Garry H. Gregory, P.E. **
** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **

*******************************************************************************
SLOPE STABILITY ANALYSIS SYSTEM
Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.
*******************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 10:18AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_b.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_b.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_b.PLT
PROBLEM DESCRIPTION: Sect 3, Static, Back-calculation of Terrapaca Landslide

BOUNDARY COORDINATES
29 Top Boundaries
44 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 280.00 | 26.00 | 267.00 | 1 |
| 2 | 26.00 | 267.00 | 82.00 | 260.00 | 1 |
| 3 | 82.00 | 260.00 | 87.00 | 258.00 | 1 |
| 4 | 87.00 | 258.00 | 99.00 | 237.00 | 1 |
| 5 | 99.00 | 237.00 | 101.00 | 231.00 | 1 |
| 6 | 101.00 | 231.00 | 105.00 | 226.00 | 1 |
| 7 | 105.00 | 226.00 | 110.00 | 225.00 | 1 |
| 8 | 110.00 | 225.00 | 122.00 | 234.00 | 1 |
| 9 | 122.00 | 234.00 | 134.00 | 244.00 | 1 |
| 10 | 134.00 | 244.00 | 140.00 | 253.00 | 1 |
| 11 | 140.00 | 253.00 | 151.00 | 262.00 | 1 |
| 12 | 151.00 | 262.00 | 162.00 | 273.00 | 1 |
| 13 | 162.00 | 273.00 | 177.00 | 276.00 | 1 |
| 14 | 177.00 | 276.00 | 190.00 | 282.00 | 1 |
| 15 | 190.00 | 282.00 | 197.00 | 282.00 | 1 |
| 16 | 197.00 | 282.00 | 221.00 | 283.00 | 1 |
| 17 | 221.00 | 283.00 | 226.00 | 284.00 | 1 |
| 18 | 226.00 | 284.00 | 242.00 | 285.00 | 1 |
| 19 | 242.00 | 285.00 | 249.00 | 288.00 | 1 |
| 20 | 249.00 | 288.00 | 261.00 | 299.00 | 1 |
| 21 | 261.00 | 299.00 | 263.00 | 304.00 | 1 |
| 22 | 263.00 | 304.00 | 265.00 | 306.00 | 1 |
| 23 | 265.00 | 306.00 | 272.00 | 309.00 | 1 |
| 24 | 272.00 | 309.00 | 368.00 | 329.00 | 1 |
| 25 | 368.00 | 329.00 | 405.00 | 332.00 | 1 |
| 26 | 405.00 | 332.00 | 451.00 | 338.00 | 1 |
| 27 | 451.00 | 338.00 | 496.00 | 349.00 | 1 |
| 28 | 496.00 | 349.00 | 562.00 | 382.00 | 1 |
| 29 | 562.00 | 382.00 | 604.00 | 396.00 | 1 |
| 30 | 110.00 | 225.00 | 126.00 | 224.00 | 1 |
| 31 | 126.00 | 224.00 | 146.00 | 229.00 | 1 |
| 32 | 146.00 | 229.00 | 176.00 | 243.00 | 1 |
| 33 | 176.00 | 243.00 | 196.00 | 253.00 | 1 |
| 34 | 196.00 | 253.00 | 236.00 | 273.00 | 1 |
| 35 | 236.00 | 273.00 | 251.00 | 281.00 | 1 |
| 36 | 251.00 | 281.00 | 256.00 | 286.00 | 1 |
| 37 | 256.00 | 286.00 | 261.00 | 299.00 | 1 |
| 38 | 0.00 | 200.00 | 46.00 | 200.00 | 1 |
| 39 | 46.00 | 200.00 | 106.00 | 203.00 | 1 |
| 40 | 106.00 | 203.00 | 146.00 | 203.00 | 1 |
| 41 | 146.00 | 203.00 | 175.00 | 206.00 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 42 | 175.00 | 206.00 | 182.00 | 209.00 | 1 |
| 43 | 182.00 | 209.00 | 188.00 | 216.00 | 1 |
| 44 | 188.00 | 216.00 | 196.00 | 253.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)
ISOTROPIC SOIL PARAMETERS
1 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 104.5 | 110.0 | 0.0 | 24.0 | 0.00 | 0.0 | 0 |

Janbus Empirical Coef is being used for the case of c=0
A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.
10 Trial Surfaces Have Been Generated.
9 Boxes Specified For Generation Of Central Block Base
Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 15.0

| Box No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Height (ft) |
|---|---|---|---|---|---|
| 1 | 110.00 | 225.00 | 110.00 | 225.00 | 0.00 |
| 2 | 126.00 | 224.00 | 126.00 | 224.00 | 0.00 |
| 3 | 146.00 | 229.00 | 146.00 | 229.00 | 0.00 |
| 4 | 176.00 | 243.00 | 176.00 | 243.00 | 0.00 |
| 5 | 196.00 | 253.00 | 196.00 | 253.00 | 0.00 |
| 6 | 236.00 | 273.00 | 236.00 | 273.00 | 0.00 |
| 7 | 251.00 | 281.00 | 251.00 | 281.00 | 0.00 |
| 8 | 256.00 | 286.00 | 256.00 | 286.00 | 0.00 |
| 9 | 261.00 | 299.00 | 261.00 | 299.00 | 0.00 |

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Evaluated. They Are Ordered - Most Critical First.
* * Safety Factors Are Calculated By The Simplified Janbu Method * *
Total Number of Trial Surfaces Attempted = 10
Number of Trial Surfaces With Valid FS = 10
Statistical Data On All Valid FS Values:
FS Max = 1.020 FS Min = 1.020 FS Ave = 1.020
Standard Deviation = 0.000 Coefficient of Variation = 0.00 %
Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 110.000 | 225.000 |
| 2 | 126.000 | 224.000 |
| 3 | 146.000 | 229.000 |
| 4 | 176.000 | 243.000 |
| 5 | 196.000 | 253.000 |
| 6 | 236.000 | 273.000 |
| 7 | 251.000 | 281.000 |
| 8 | 256.000 | 286.000 |
| 9 | 261.000 | 299.000 |

Factor of Safety
*** 1.020 ***
Individual data on the 20 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 12.0 | 6113.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 4.0 | 4824.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 8.0 | 13097.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 6.0 | 13637.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 6.0 | 17057.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 5.0 | 15564.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 11.0 | 38623.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 14.0 | 50717.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 1.0 | 3411.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 13.0 | 43811.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 6.0 | 19123.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 1.0 | 3004.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 24.0 | 57684.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 5.0 | 8751.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 10.0 | 14434.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 16 | 6.0 | 6403.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 17 | 7.0 | 6169.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 18 | 2.0 | 1766.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 19 | 5.0 | 4506.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 20 | 5.0 | 2198.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 110.000 | 225.000 |
| 2 | 126.000 | 224.000 |
| 3 | 146.000 | 229.000 |
| 4 | 176.000 | 243.000 |
| 5 | 196.000 | 253.000 |
| 6 | 236.000 | 273.000 |
| 7 | 251.000 | 281.000 |
| 8 | 256.000 | 286.000 |
| 9 | 261.000 | 299.000 |

Factor of Safety
*** 1.020 ***

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 110.000 | 225.000 |
| 2 | 126.000 | 224.000 |
| 3 | 146.000 | 229.000 |
| 4 | 176.000 | 243.000 |
| 5 | 196.000 | 253.000 |
| 6 | 236.000 | 273.000 |
| 7 | 251.000 | 281.000 |
| 8 | 256.000 | 286.000 |
| 9 | 261.000 | 299.000 |

Factor of Safety
*** 1.020 ***

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 110.000 | 225.000 |
| 2 | 126.000 | 224.000 |
| 3 | 146.000 | 229.000 |
| 4 | 176.000 | 243.000 |
| 5 | 196.000 | 253.000 |
| 6 | 236.000 | 273.000 |
| 7 | 251.000 | 281.000 |
| 8 | 256.000 | 286.000 |
| 9 | 261.000 | 299.000 |

Factor of Safety
*** 1.020 ***

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 110.000 | 225.000 |
| 2 | 126.000 | 224.000 |
| 3 | 146.000 | 229.000 |
| 4 | 176.000 | 243.000 |
| 5 | 196.000 | 253.000 |
| 6 | 236.000 | 273.000 |
| 7 | 251.000 | 281.000 |
| 8 | 256.000 | 286.000 |
| 9 | 261.000 | 299.000 |

Factor of Safety
*** 1.020 ***

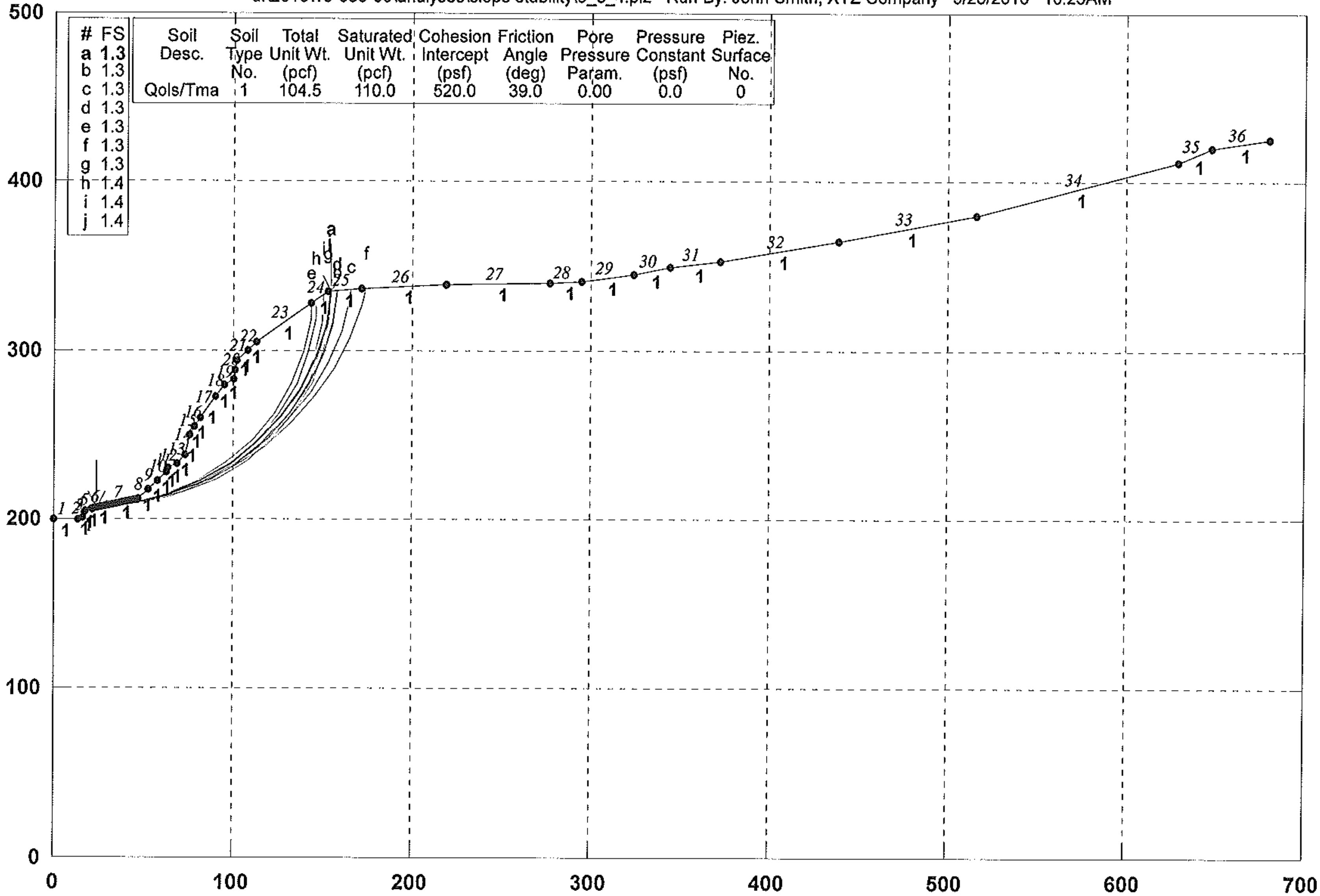
Failure Surface Specified By 9 Coordinate Points

```
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1        110.000     225.000
    2        126.000     224.000
    3        146.000     229.000
    4        176.000     243.000
    5        196.000     253.000
    6        236.000     273.000
    7        251.000     281.000
    8        256.000     286.000
    9        261.000     299.000
       Factor of Safety
      ***    1.020    ***
Failure Surface Specified By  9 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1        110.000     225.000
    2        126.000     224.000
    3        146.000     229.000
    4        176.000     243.000
    5        196.000     253.000
    6        236.000     273.000
    7        251.000     281.000
    8        256.000     286.000
    9        261.000     299.000
       Factor of Safety
      ***    1.020    ***
Failure Surface Specified By  9 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1        110.000     225.000
    2        126.000     224.000
    3        146.000     229.000
    4        176.000     243.000
    5        196.000     253.000
    6        236.000     273.000
    7        251.000     281.000
    8        256.000     286.000
    9        261.000     299.000
       Factor of Safety
      ***    1.020    ***
Failure Surface Specified By  9 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1        110.000     225.000
    2        126.000     224.000
    3        146.000     229.000
    4        176.000     243.000
    5        196.000     253.000
    6        236.000     273.000
    7        251.000     281.000
    8        256.000     286.000
    9        261.000     299.000
       Factor of Safety
      ***    1.020    ***
Failure Surface Specified By  9 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1        110.000     225.000
    2        126.000     224.000
    3        146.000     229.000
    4        176.000     243.000
    5        196.000     253.000
    6        236.000     273.000
    7        251.000     281.000
    8        256.000     286.000
    9        261.000     299.000
       Factor of Safety
```

```
***     1.020    ***
    **** END OF GSTABL7 OUTPUT ****
```

## Sect 6, Back-calculation of the cross- bedding Strength for Bluff Slope

u:\2010\10-036-00\analyses\slope stability\6_s_4.pl2 Run By: John Smith, XYZ Company 9/28/2010 10:25AM



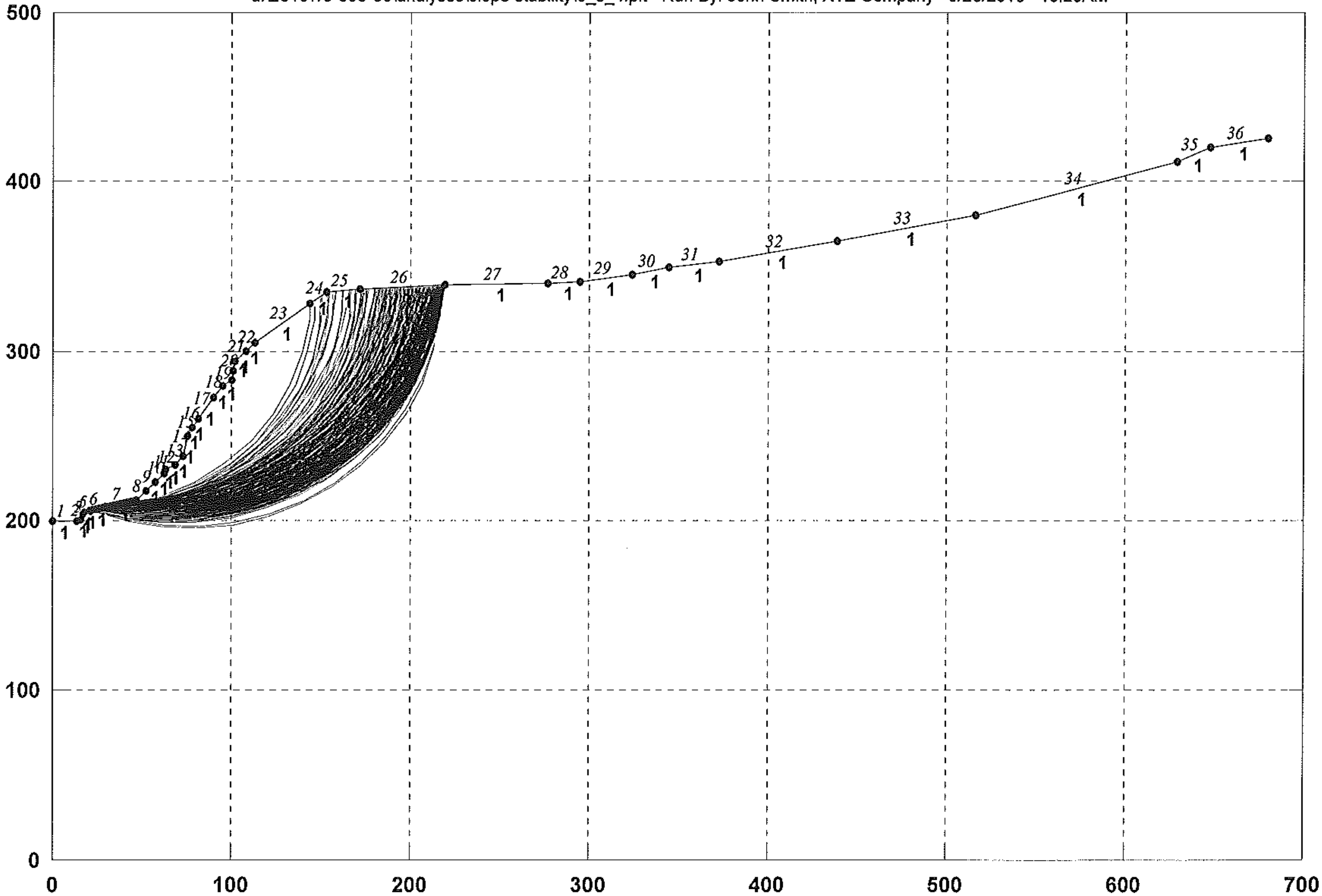

| Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|---|
| Qols/Tma | 1 | 104.5 | 110.0 | 520.0 | 39.0 | 0.00 | 0.0 | 0 |

**GSTABL7 v.2 FSmin=1.3**

**Safety Factors Are Calculated By The Modified Bishop Method**

## Sect 6, Back-calculation of the cross- bedding Strength for Bluff Slope

u:\2010\10-036-00\analyses\slope stability\6_s_4.plt Run By: John Smith, XYZ Company 9/28/2010 10:25AM



*** GSTABL7 ***

** GSTABL7 by Garry H. Gregory, P.E. **

** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **



*********************************************************************************

SLOPE STABILITY ANALYSIS SYSTEM

Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.

*********************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 10:25AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\6_s_4.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\6_s_4.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\6_s_4.PLT
PROBLEM DESCRIPTION: Sect 6, Back-calculation of the cross-
bedding Strength for Bluff Slope

BOUNDARY COORDINATES
36 Top Boundaries
36 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 200.00 | 14.00 | 200.00 | 1 |
| 2 | 14.00 | 200.00 | 16.00 | 201.00 | 1 |
| 3 | 16.00 | 201.00 | 17.00 | 204.00 | 1 |
| 4 | 17.00 | 204.00 | 18.00 | 205.00 | 1 |
| 5 | 18.00 | 205.00 | 21.00 | 206.00 | 1 |
| 6 | 21.00 | 206.00 | 30.00 | 208.00 | 1 |
| 7 | 30.00 | 208.00 | 47.00 | 212.00 | 1 |
| 8 | 47.00 | 212.00 | 53.00 | 218.00 | 1 |
| 9 | 53.00 | 218.00 | 58.00 | 223.00 | 1 |
| 10 | 58.00 | 223.00 | 63.00 | 228.00 | 1 |
| 11 | 63.00 | 228.00 | 64.00 | 230.00 | 1 |
| 12 | 64.00 | 230.00 | 69.00 | 233.00 | 1 |
| 13 | 69.00 | 233.00 | 73.00 | 238.00 | 1 |
| 14 | 73.00 | 238.00 | 76.00 | 250.00 | 1 |
| 15 | 76.00 | 250.00 | 78.00 | 255.00 | 1 |
| 16 | 78.00 | 255.00 | 82.00 | 260.00 | 1 |
| 17 | 82.00 | 260.00 | 90.00 | 273.00 | 1 |
| 18 | 90.00 | 273.00 | 95.00 | 280.00 | 1 |
| 19 | 95.00 | 280.00 | 100.00 | 283.00 | 1 |
| 20 | 100.00 | 283.00 | 102.00 | 294.00 | 1 |
| 21 | 102.00 | 294.00 | 108.00 | 300.00 | 1 |
| 22 | 108.00 | 300.00 | 113.00 | 305.00 | 1 |
| 23 | 113.00 | 305.00 | 144.00 | 328.00 | 1 |
| 24 | 144.00 | 328.00 | 153.00 | 335.00 | 1 |
| 25 | 153.00 | 335.00 | 172.00 | 337.00 | 1 |
| 26 | 172.00 | 337.00 | 219.00 | 339.00 | 1 |
| 27 | 219.00 | 339.00 | 277.00 | 340.00 | 1 |
| 28 | 277.00 | 340.00 | 295.00 | 341.00 | 1 |
| 29 | 295.00 | 341.00 | 324.00 | 345.00 | 1 |
| 30 | 324.00 | 345.00 | 344.00 | 349.00 | 1 |
| 31 | 344.00 | 349.00 | 372.00 | 353.00 | 1 |
| 32 | 372.00 | 353.00 | 439.00 | 365.00 | 1 |
| 33 | 439.00 | 365.00 | 516.00 | 380.00 | 1 |
| 34 | 516.00 | 380.00 | 629.00 | 411.00 | 1 |
| 35 | 629.00 | 411.00 | 648.00 | 420.00 | 1 |
| 36 | 648.00 | 420.00 | 680.00 | 425.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)

ISOTROPIC SOIL PARAMETERS
1 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 104.5 | 110.0 | 520.0 | 39.0 | 0.00 | 0.0 | 0 |

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

500 Trial Surfaces Have Been Generated.

25 Surface(s) Initiate(s) From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 21.00(ft) and X = 47.00(ft)

Each Surface Terminates Between X = 101.00(ft) and X = 219.00(ft)

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00(ft)

20.00(ft) Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Evaluated. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Total Number of Trial Surfaces Attempted = 500

Number of Trial Surfaces With Valid FS = 500

Statistical Data On All Valid FS Values:

FS Max = 2.052 FS Min = 1.334 FS Ave = 1.709

Standard Deviation = 0.160 Coefficient of Variation = 9.37 %

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 23.737 | 206.608 |
| 2 | 43.586 | 209.058 |
| 3 | 62.876 | 214.341 |
| 4 | 81.203 | 222.348 |
| 5 | 98.187 | 232.910 |
| 6 | 113.472 | 245.809 |
| 7 | 126.740 | 260.774 |
| 8 | 137.714 | 277.494 |
| 9 | 146.165 | 295.621 |
| 10 | 151.918 | 314.775 |
| 11 | 154.852 | 334.559 |
| 12 | 154.854 | 335.195 |

Circle Center At X = 16.778 ; Y = 344.846 ; and Radius = 138.413

Factor of Safety

*** 1.334 ***

Individual data on the 30 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.3 | 202.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 13.6 | 1957.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 3.4 | 739.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 6.0 | 2624.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 5.0 | 4273.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 4.9 | 5994.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 0.1 | 176.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 1.0 | 1503.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 5.0 | 8138.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 4.0 | 7360.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 3.0 | 7706.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 2.0 | 6685.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 3.2 | 11834.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 0.8 | 3072.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 8.0 | 34417.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 16 | 5.0 | 24623.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 17 | 3.2 | 16329.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 18 | 1.8 | 9243.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 19 | 2.0 | 11122.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 20 | 6.0 | 36579.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 21 | 5.0 | 30931.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 22 | 0.5 | 2935.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 23 | 13.3 | 79003.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 24 | 11.0 | 57490.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 25 | 6.3 | 27217.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 26 | 2.2 | 8043.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 27 | 5.8 | 16065.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 28 | 1.1 | 1826.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 29 | 1.9 | 1313.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 30 | 0.0 | 0.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 29.211 | 207.825 |
| 2 | 49.060 | 210.271 |
| 3 | 68.335 | 215.610 |
| 4 | 86.614 | 223.726 |
| 5 | 103.500 | 234.443 |
| 6 | 118.627 | 247.527 |
| 7 | 131.664 | 262.693 |
| 8 | 142.328 | 279.613 |
| 9 | 150.388 | 297.917 |
| 10 | 155.668 | 317.207 |
| 11 | 157.867 | 335.512 |

Circle Center At X = 22.597 ; Y = 343.261 ; and Radius = 135.598

Factor of Safety
*** 1.337 ***

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 26.474 | 207.216 |
| 2 | 46.318 | 209.705 |
| 3 | 65.654 | 214.818 |
| 4 | 84.135 | 222.463 |
| 5 | 101.431 | 232.505 |
| 6 | 117.234 | 244.763 |
| 7 | 131.261 | 259.020 |
| 8 | 143.261 | 275.019 |
| 9 | 153.021 | 292.476 |
| 10 | 160.366 | 311.079 |
| 11 | 165.164 | 330.495 |
| 12 | 165.801 | 336.348 |

Circle Center At X = 18.059 ; Y = 356.026 ; and Radius = 149.048

Factor of Safety
*** 1.337 ***

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 26.474 | 207.216 |
| 2 | 46.339 | 209.533 |
| 3 | 65.663 | 214.691 |
| 4 | 84.040 | 222.581 |
| 5 | 101.088 | 233.039 |
| 6 | 116.449 | 245.847 |
| 7 | 129.802 | 260.736 |
| 8 | 140.869 | 277.396 |
| 9 | 149.417 | 295.477 |
| 10 | 155.268 | 314.602 |
| 11 | 158.299 | 334.371 |
| 12 | 158.308 | 335.559 |

Circle Center At X = 20.494 ; Y = 345.241 ; and Radius = 138.154

Factor of Safety
*** 1.338 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 22.368 | 206.304 |
| 2 | 42.239 | 208.573 |
| 3 | 61.502 | 213.954 |

| | | |
|---|---|---|
| 4 | 79.671 | 222.313 |
| 5 | 96.292 | 233.438 |
| 6 | 110.944 | 247.051 |
| 7 | 123.261 | 262.808 |
| 8 | 132.932 | 280.314 |
| 9 | 139.714 | 299.129 |
| 10 | 143.437 | 318.780 |
| 11 | 143.694 | 327.773 |

Circle Center At X = 18.040 ; Y = 332.360 ; and Radius = 126.131

Factor of Safety

*** 1.346 ***

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 26.474 | 207.216 |
| 2 | 46.303 | 209.822 |
| 3 | 65.661 | 214.849 |
| 4 | 84.252 | 222.223 |
| 5 | 101.794 | 231.829 |
| 6 | 118.019 | 243.523 |
| 7 | 132.680 | 257.126 |
| 8 | 145.555 | 272.431 |
| 9 | 156.447 | 289.206 |
| 10 | 165.190 | 307.193 |
| 11 | 171.651 | 326.121 |
| 12 | 173.936 | 337.082 |

Circle Center At X = 15.587 ; Y = 368.232 ; and Radius = 161.383

Factor of Safety

*** 1.348 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 31.947 | 208.458 |
| 2 | 51.833 | 210.591 |
| 3 | 71.122 | 215.877 |
| 4 | 89.318 | 224.178 |
| 5 | 105.952 | 235.283 |
| 6 | 120.597 | 248.904 |
| 7 | 132.874 | 264.692 |
| 8 | 142.470 | 282.239 |
| 9 | 149.136 | 301.096 |
| 10 | 152.701 | 320.775 |
| 11 | 152.966 | 334.973 |

Circle Center At X = 28.637 ; Y = 333.088 ; and Radius = 124.674

Factor of Safety

*** 1.349 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 25.105 | 206.912 |
| 2 | 45.010 | 208.864 |
| 3 | 64.337 | 214.009 |
| 4 | 82.576 | 222.214 |
| 5 | 99.249 | 233.261 |
| 6 | 113.914 | 246.859 |
| 7 | 126.187 | 262.651 |
| 8 | 135.743 | 280.220 |
| 9 | 142.332 | 299.104 |
| 10 | 145.779 | 318.805 |
| 11 | 145.893 | 329.472 |

Circle Center At X = 23.074 ; Y = 330.121 ; and Radius = 123.226

Factor of Safety

*** 1.350 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 26.474 | 207.216 |
| 2 | 46.412 | 208.792 |

| | | |
|---|---|---|
| 3 | 65.835 | 213.559 |
| 4 | 84.237 | 221.393 |
| 5 | 101.136 | 232.090 |
| 6 | 116.090 | 245.370 |
| 7 | 128.710 | 260.886 |
| 8 | 138.665 | 278.233 |
| 9 | 145.694 | 296.956 |
| 10 | 149.615 | 316.568 |
| 11 | 150.192 | 332.816 |

Circle Center At X = 26.730 ; Y = 330.939 ; and Radius = 123.723

Factor of Safety

*** 1.360 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 33.316 | 208.780 |
| 2 | 53.238 | 210.546 |
| 3 | 72.602 | 215.548 |
| 4 | 90.887 | 223.650 |
| 5 | 107.601 | 234.635 |
| 6 | 122.292 | 248.206 |
| 7 | 134.565 | 263.997 |
| 8 | 144.089 | 281.584 |
| 9 | 150.608 | 300.492 |
| 10 | 153.945 | 320.211 |
| 11 | 153.995 | 335.105 |

Circle Center At X = 32.554 ; Y = 330.614 ; and Radius = 121.837

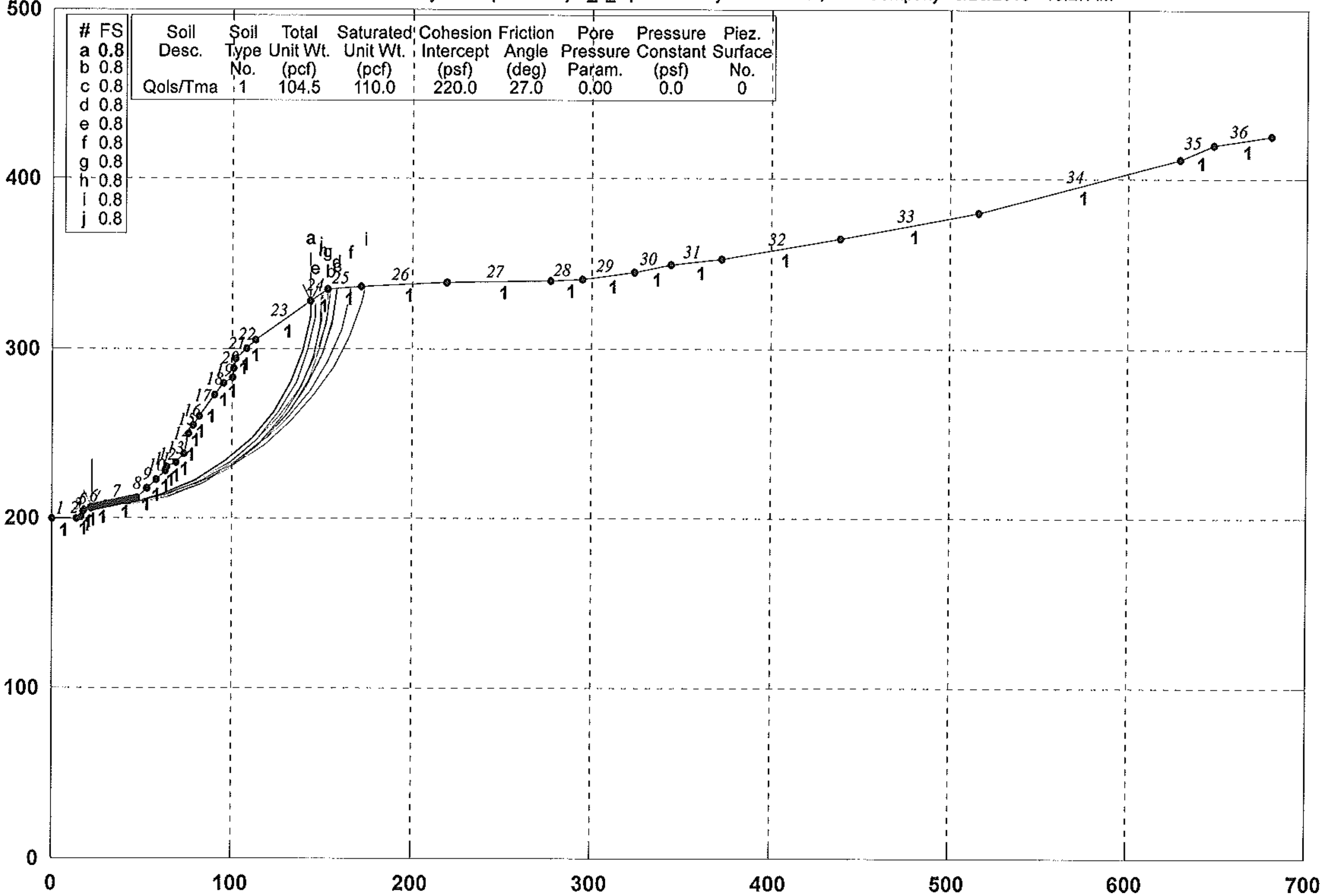
Factor of Safety

*** 1.365 ***

**** END OF GSTABL7 OUTPUT ****

## Sect 6, Back-calculation of the cross- bedding strength for Bluff Slope

u:\2010\10-036-00\analyses\slope stability\6_s_3.pl2 Run By: John Smith, XYZ Company 9/28/2010 10:27AM

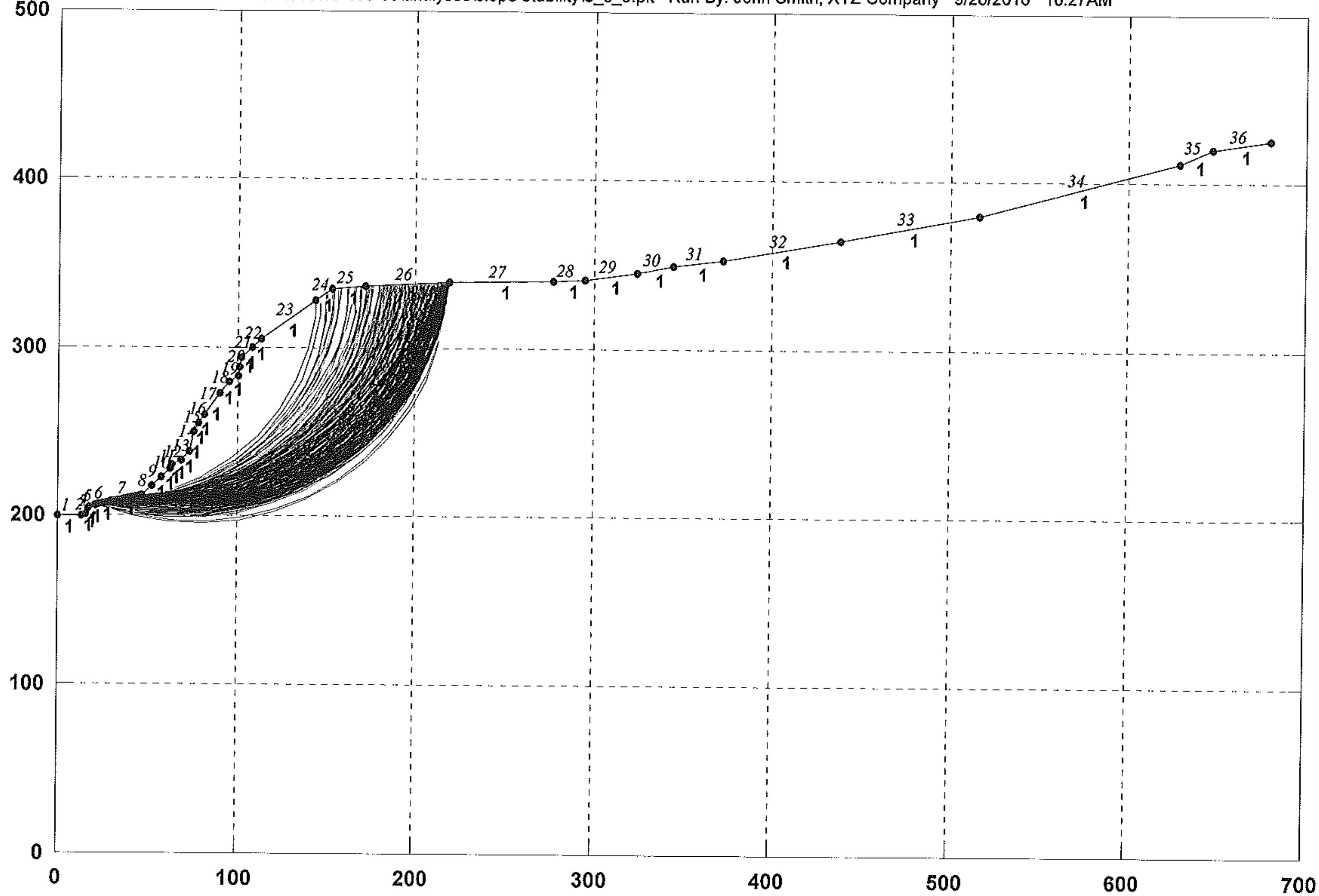



GSTABL7 v.2 FSmin=0.8

**Safety Factors Are Calculated By The Modified Bishop Method**

# Sect 6, Back-calculation of the cross- bedding strength for Bluff Slope

u:\2010\10-036-00\analyses\slope stability\6_s_3.plt Run By: John Smith, XYZ Company 9/28/2010 10:27AM



*** **GSTABL7** ***
** GSTABL7 by Garry H. Gregory, P.E. **
** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **

*****************************************************************************
SLOPE STABILITY ANALYSIS SYSTEM
Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.
*****************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 10:27AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\6_s_3.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\6_s_3.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\6_s_3.PLT
PROBLEM DESCRIPTION: Sect 6, Back-calculation of the cross-bedding strength for Bluff Slope

BOUNDARY COORDINATES
36 Top Boundaries
36 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 200.00 | 14.00 | 200.00 | 1 |
| 2 | 14.00 | 200.00 | 16.00 | 201.00 | 1 |
| 3 | 16.00 | 201.00 | 17.00 | 204.00 | 1 |
| 4 | 17.00 | 204.00 | 18.00 | 205.00 | 1 |
| 5 | 18.00 | 205.00 | 21.00 | 206.00 | 1 |
| 6 | 21.00 | 206.00 | 30.00 | 208.00 | 1 |
| 7 | 30.00 | 208.00 | 47.00 | 212.00 | 1 |
| 8 | 47.00 | 212.00 | 53.00 | 218.00 | 1 |
| 9 | 53.00 | 218.00 | 58.00 | 223.00 | 1 |
| 10 | 58.00 | 223.00 | 63.00 | 228.00 | 1 |
| 11 | 63.00 | 228.00 | 64.00 | 230.00 | 1 |
| 12 | 64.00 | 230.00 | 69.00 | 233.00 | 1 |
| 13 | 69.00 | 233.00 | 73.00 | 238.00 | 1 |
| 14 | 73.00 | 238.00 | 76.00 | 250.00 | 1 |
| 15 | 76.00 | 250.00 | 78.00 | 255.00 | 1 |
| 16 | 78.00 | 255.00 | 82.00 | 260.00 | 1 |
| 17 | 82.00 | 260.00 | 90.00 | 273.00 | 1 |
| 18 | 90.00 | 273.00 | 95.00 | 280.00 | 1 |
| 19 | 95.00 | 280.00 | 100.00 | 283.00 | 1 |
| 20 | 100.00 | 283.00 | 102.00 | 294.00 | 1 |
| 21 | 102.00 | 294.00 | 108.00 | 300.00 | 1 |
| 22 | 108.00 | 300.00 | 113.00 | 305.00 | 1 |
| 23 | 113.00 | 305.00 | 144.00 | 328.00 | 1 |
| 24 | 144.00 | 328.00 | 153.00 | 335.00 | 1 |
| 25 | 153.00 | 335.00 | 172.00 | 337.00 | 1 |
| 26 | 172.00 | 337.00 | 219.00 | 339.00 | 1 |
| 27 | 219.00 | 339.00 | 277.00 | 340.00 | 1 |
| 28 | 277.00 | 340.00 | 295.00 | 341.00 | 1 |
| 29 | 295.00 | 341.00 | 324.00 | 345.00 | 1 |
| 30 | 324.00 | 345.00 | 344.00 | 349.00 | 1 |
| 31 | 344.00 | 349.00 | 372.00 | 353.00 | 1 |
| 32 | 372.00 | 353.00 | 439.00 | 365.00 | 1 |
| 33 | 439.00 | 365.00 | 516.00 | 380.00 | 1 |
| 34 | 516.00 | 380.00 | 629.00 | 411.00 | 1 |
| 35 | 629.00 | 411.00 | 648.00 | 420.00 | 1 |
| 36 | 648.00 | 420.00 | 680.00 | 425.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)
ISOTROPIC SOIL PARAMETERS
1 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 104.5 | 110.0 | 220.0 | 27.0 | 0.00 | 0.0 | 0 |

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

500 Trial Surfaces Have Been Generated.

25 Surface(s) Initiate(s) From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 21.00(ft) and X = 47.00(ft)

Each Surface Terminates Between X = 101.00(ft) and X = 219.00(ft)

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00(ft)

20.00(ft) Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Evaluated. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Total Number of Trial Surfaces Attempted = 500

Number of Trial Surfaces With Valid FS = 500

Statistical Data On All Valid FS Values:

FS Max = 1.249 FS Min = 0.765 FS Ave = 1.030

Standard Deviation = 0.105 Coefficient of Variation = 10.17 %

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 22.368 | 206.304 |
| 2 | 42.239 | 208.573 |
| 3 | 61.502 | 213.954 |
| 4 | 79.671 | 222.313 |
| 5 | 96.292 | 233.438 |
| 6 | 110.944 | 247.051 |
| 7 | 123.261 | 262.808 |
| 8 | 132.932 | 280.314 |
| 9 | 139.714 | 299.129 |
| 10 | 143.437 | 318.780 |
| 11 | 143.694 | 327.773 |

Circle Center At X = 18.040 ; Y = 332.360 ; and Radius = 126.131

Factor of Safety

*** 0.765 ***

Individual data on the 27 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.6 | 328.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 12.2 | 2002.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 4.8 | 1095.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 6.0 | 2670.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 5.0 | 4296.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 3.5 | 4129.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 1.5 | 2027.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 1.0 | 1476.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 5.0 | 7966.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 4.0 | 7179.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 3.0 | 7544.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 2.0 | 6566.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 1.7 | 5958.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 2.3 | 8626.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 8.0 | 33399.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 16 | 5.0 | 23826.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 17 | 1.3 | 6394.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 18 | 3.7 | 18108.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 19 | 2.0 | 10593.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 20 | 6.0 | 34780.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 21 | 2.9 | 17164.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 22 | 2.1 | 11946.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 23 | 10.3 | 56359.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 24 | 9.7 | 45114.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 25 | 6.8 | 23093.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 26 | 3.7 | 6710.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 27 | 0.3 | 118.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 23.737 | 206.608 |
| 2 | 43.586 | 209.058 |
| 3 | 62.876 | 214.341 |
| 4 | 81.203 | 222.348 |
| 5 | 98.187 | 232.910 |
| 6 | 113.472 | 245.809 |
| 7 | 126.740 | 260.774 |
| 8 | 137.714 | 277.494 |
| 9 | 146.165 | 295.621 |
| 10 | 151.918 | 314.775 |
| 11 | 154.852 | 334.559 |
| 12 | 154.854 | 335.195 |

Circle Center At X = 16.778 ; Y = 344.846 ; and Radius = 138.413

Factor of Safety

*** 0.765 ***

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 26.474 | 207.216 |
| 2 | 46.339 | 209.533 |
| 3 | 65.663 | 214.691 |
| 4 | 84.040 | 222.581 |
| 5 | 101.088 | 233.039 |
| 6 | 116.449 | 245.847 |
| 7 | 129.802 | 260.736 |
| 8 | 140.869 | 277.396 |
| 9 | 149.417 | 295.477 |
| 10 | 155.268 | 314.602 |
| 11 | 158.299 | 334.371 |
| 12 | 158.308 | 335.559 |

Circle Center At X = 20.494 ; Y = 345.241 ; and Radius = 138.154

Factor of Safety

*** 0.773 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 29.211 | 207.825 |
| 2 | 49.060 | 210.271 |
| 3 | 68.335 | 215.610 |
| 4 | 86.614 | 223.726 |
| 5 | 103.500 | 234.443 |
| 6 | 118.627 | 247.527 |
| 7 | 131.664 | 262.693 |
| 8 | 142.328 | 279.613 |
| 9 | 150.388 | 297.917 |
| 10 | 155.668 | 317.207 |
| 11 | 157.867 | 335.512 |

Circle Center At X = 22.597 ; Y = 343.261 ; and Radius = 135.598

Factor of Safety

*** 0.774 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 25.105 | 206.912 |
| 2 | 45.010 | 208.864 |
| 3 | 64.337 | 214.009 |
| 4 | 82.576 | 222.214 |
| 5 | 99.249 | 233.261 |
| 6 | 113.914 | 246.859 |
| 7 | 126.187 | 262.651 |

```
    8          135.743      280.220
    9          142.332      299.104
   10          145.779      318.805
   11          145.893      329.472
 Circle Center At X =    23.074 ; Y =   330.121 ; and Radius =   123.226
        Factor of Safety
       ***    0.774   ***
 Failure Surface Specified By 12 Coordinate Points
   Point       X-Surf       Y-Surf
    No.         (ft)         (ft)
    1           26.474      207.216
    2           46.318      209.705
    3           65.654      214.818
    4           84.135      222.463
    5          101.431      232.505
    6          117.234      244.763
    7          131.261      259.020
    8          143.261      275.019
    9          153.021      292.476
   10          160.366      311.079
   11          165.164      330.495
   12          165.801      336.348
 Circle Center At X =    18.059 ; Y =   356.026 ; and Radius =   149.048
        Factor of Safety
       ***    0.778   ***
 Failure Surface Specified By 11 Coordinate Points
   Point       X-Surf       Y-Surf
    No.         (ft)         (ft)
    1           31.947      208.458
    2           51.833      210.591
    3           71.122      215.877
    4           89.318      224.178
    5          105.952      235.283
    6          120.597      248.904
    7          132.874      264.692
    8          142.470      282.239
    9          149.136      301.096
   10          152.701      320.775
   11          152.966      334.973
 Circle Center At X =    28.637 ; Y =   333.088 ; and Radius =   124.674
        Factor of Safety
       ***    0.783   ***
 Failure Surface Specified By 11 Coordinate Points
   Point       X-Surf       Y-Surf
    No.         (ft)         (ft)
    1           26.474      207.216
    2           46.412      208.792
    3           65.835      213.559
    4           84.237      221.393
    5          101.136      232.090
    6          116.090      245.370
    7          128.710      260.886
    8          138.665      278.233
    9          145.694      296.956
   10          149.615      316.568
   11          150.192      332.816
 Circle Center At X =    26.730 ; Y =   330.939 ; and Radius =   123.723
        Factor of Safety
       ***    0.787   ***
 Failure Surface Specified By 12 Coordinate Points
   Point       X-Surf       Y-Surf
    No.         (ft)         (ft)
    1           26.474      207.216
    2           46.303      209.822
    3           65.661      214.849
    4           84.252      222.223
    5          101.794      231.829
    6          118.019      243.523
```

| | | |
|---|---|---|
| 7 | 132.680 | 257.126 |
| 8 | 145.555 | 272.431 |
| 9 | 156.447 | 289.206 |
| 10 | 165.190 | 307.193 |
| 11 | 171.651 | 326.121 |
| 12 | 173.936 | 337.082 |

Circle Center At X = 15.587 ; Y = 368.232 ; and Radius = 161.383

Factor of Safety

*** 0.787 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 25.105 | 206.912 |
| 2 | 45.067 | 208.145 |
| 3 | 64.561 | 212.615 |
| 4 | 83.065 | 220.204 |
| 5 | 100.085 | 230.709 |
| 6 | 115.164 | 243.848 |
| 7 | 127.898 | 259.269 |
| 8 | 137.948 | 276.561 |
| 9 | 145.045 | 295.259 |
| 10 | 148.997 | 314.865 |
| 11 | 149.613 | 332.366 |

Circle Center At X = 27.579 ; Y = 329.142 ; and Radius = 122.255

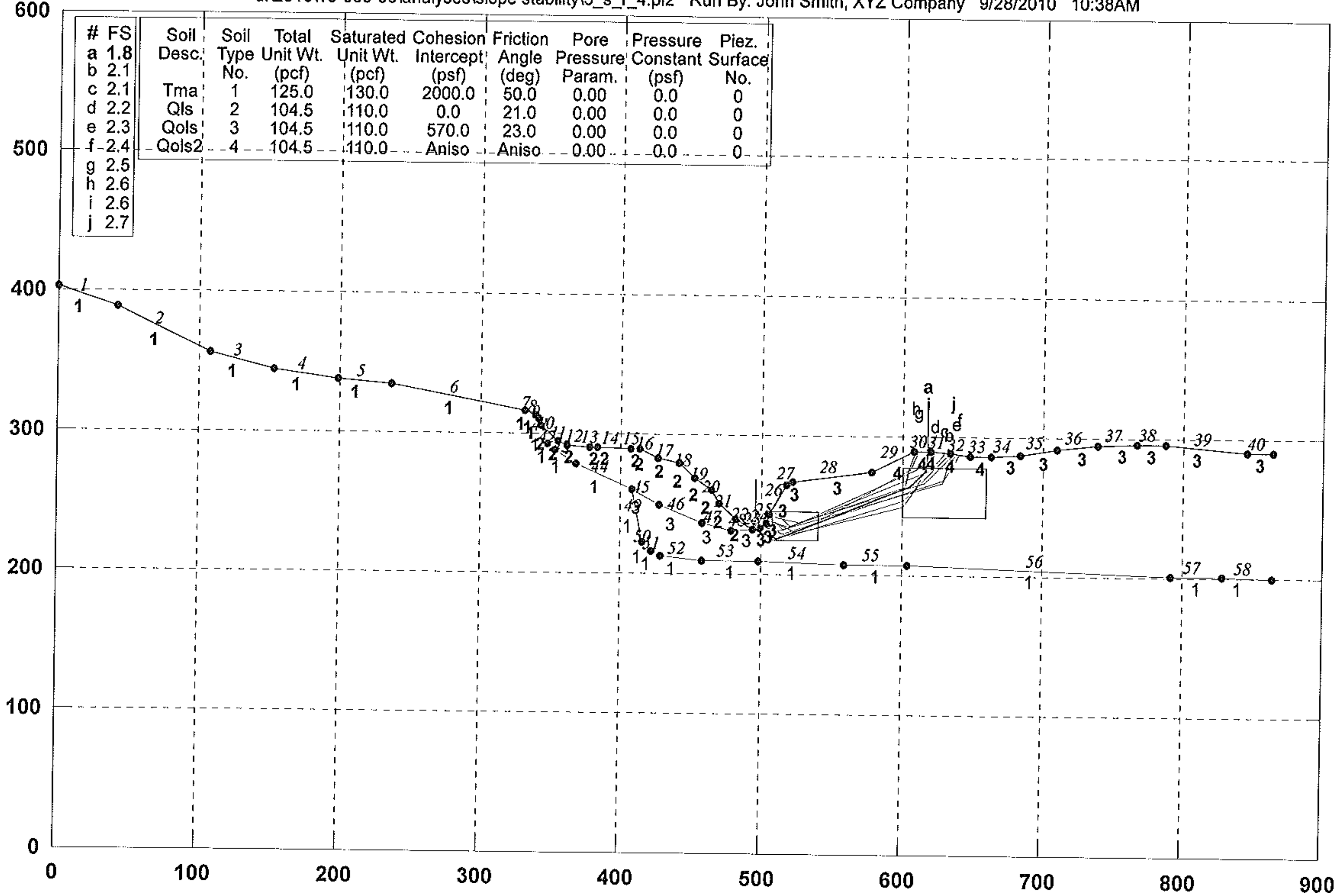
Factor of Safety

*** 0.793 ***

**** END OF GSTABL7 OUTPUT ****

# Sect 3, Lower switch back, Existing condstability, Translation search at road

u:\2010\10-036-00\analyses\slope stability\3_s_r_4.pl2 Run By: John Smith, XYZ Company 9/28/2010 10:38AM

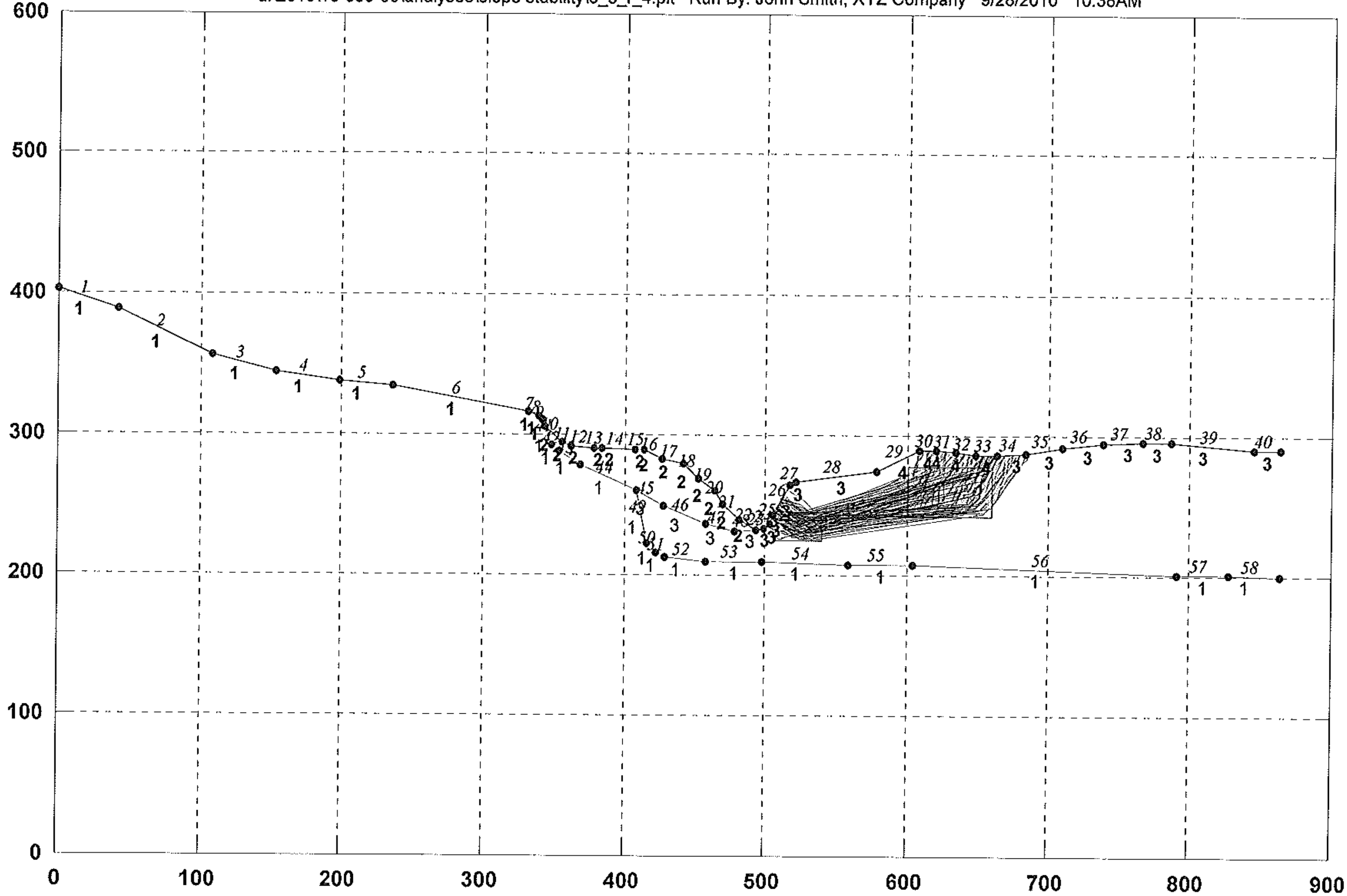



GSTABL7 v.2 FSmin=1.8

Safety Factors Are Calculated By The Simplified Janbu Method for the case of c=0

## Sect 3, Lower switch back, Existing condstability, Translation search at road

u:\2010\10-036-00\analyses\slope stability\3_s_r_4.plt Run By: John Smith, XYZ Company 9/28/2010 10:38AM



*** **GSTABL7** ***

** GSTABL7 by Garry H. Gregory, P.E. **

** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **



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SLOPE STABILITY ANALYSIS SYSTEM

Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.

*********************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 10:38AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_r_4.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_r_4.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_r_4.PLT
PROBLEM DESCRIPTION: Sect 3, Lower switch back, Existing cond stability, Translation search at road

BOUNDARY COORDINATES
40 Top Boundaries
58 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 403.00 | 42.00 | 389.00 | 1 |
| 2 | 42.00 | 389.00 | 108.00 | 356.00 | 1 |
| 3 | 108.00 | 356.00 | 153.00 | 345.00 | 1 |
| 4 | 153.00 | 345.00 | 199.00 | 338.00 | 1 |
| 5 | 199.00 | 338.00 | 236.00 | 335.00 | 1 |
| 6 | 236.00 | 335.00 | 332.00 | 316.00 | 1 |
| 7 | 332.00 | 316.00 | 339.00 | 313.00 | 1 |
| 8 | 339.00 | 313.00 | 341.00 | 311.00 | 1 |
| 9 | 341.00 | 311.00 | 343.00 | 306.00 | 1 |
| 10 | 343.00 | 306.00 | 355.00 | 295.00 | 2 |
| 11 | 355.00 | 295.00 | 362.00 | 292.00 | 2 |
| 12 | 362.00 | 292.00 | 378.00 | 291.00 | 2 |
| 13 | 378.00 | 291.00 | 383.00 | 291.00 | 2 |
| 14 | 383.00 | 291.00 | 407.00 | 289.00 | 2 |
| 15 | 407.00 | 289.00 | 414.00 | 289.00 | 2 |
| 16 | 414.00 | 289.00 | 427.00 | 283.00 | 2 |
| 17 | 427.00 | 283.00 | 442.00 | 280.00 | 2 |
| 18 | 442.00 | 280.00 | 453.00 | 269.00 | 2 |
| 19 | 453.00 | 269.00 | 464.00 | 260.00 | 2 |
| 20 | 464.00 | 260.00 | 470.00 | 251.00 | 2 |
| 21 | 470.00 | 251.00 | 482.00 | 240.00 | 2 |
| 22 | 482.00 | 240.00 | 494.00 | 232.00 | 2 |
| 23 | 494.00 | 232.00 | 499.00 | 233.00 | 3 |
| 24 | 499.00 | 233.00 | 503.00 | 237.00 | 3 |
| 25 | 503.00 | 237.00 | 505.00 | 243.00 | 3 |
| 26 | 505.00 | 243.00 | 517.00 | 265.00 | 3 |
| 27 | 517.00 | 265.00 | 522.00 | 267.00 | 3 |
| 28 | 522.00 | 267.00 | 578.00 | 274.00 | 3 |
| 29 | 578.00 | 274.00 | 608.00 | 289.00 | 4 |
| 30 | 608.00 | 289.00 | 620.00 | 289.00 | 4 |
| 31 | 620.00 | 289.00 | 634.00 | 288.00 | 4 |
| 32 | 634.00 | 288.00 | 648.00 | 286.00 | 4 |
| 33 | 648.00 | 286.00 | 663.00 | 286.00 | 4 |
| 34 | 663.00 | 286.00 | 684.00 | 287.00 | 3 |
| 35 | 684.00 | 287.00 | 710.00 | 292.00 | 3 |
| 36 | 710.00 | 292.00 | 739.00 | 295.00 | 3 |
| 37 | 739.00 | 295.00 | 767.00 | 296.00 | 3 |
| 38 | 767.00 | 296.00 | 787.00 | 296.00 | 3 |
| 39 | 787.00 | 296.00 | 846.00 | 291.00 | 3 |
| 40 | 846.00 | 291.00 | 864.00 | 291.00 | 3 |
| 41 | 343.00 | 306.00 | 348.00 | 293.00 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 42 | 348.00 | 293.00 | 353.00 | 288.00 | 1 |
| 43 | 353.00 | 288.00 | 368.00 | 279.00 | 1 |
| 44 | 368.00 | 279.00 | 408.00 | 260.00 | 1 |
| 45 | 408.00 | 260.00 | 428.00 | 250.00 | 3 |
| 46 | 428.00 | 250.00 | 458.00 | 236.00 | 3 |
| 47 | 458.00 | 236.00 | 478.00 | 231.00 | 3 |
| 48 | 478.00 | 231.00 | 494.00 | 232.00 | 3 |
| 49 | 408.00 | 260.00 | 416.00 | 223.00 | 1 |
| 50 | 416.00 | 223.00 | 422.00 | 216.00 | 1 |
| 51 | 422.00 | 216.00 | 429.00 | 213.00 | 1 |
| 52 | 429.00 | 213.00 | 458.00 | 210.00 | 1 |
| 53 | 458.00 | 210.00 | 498.00 | 210.00 | 1 |
| 54 | 498.00 | 210.00 | 558.00 | 207.00 | 1 |
| 55 | 558.00 | 207.00 | 604.00 | 207.00 | 1 |
| 56 | 604.00 | 207.00 | 792.00 | 201.00 | 1 |
| 57 | 792.00 | 201.00 | 828.00 | 201.00 | 1 |
| 58 | 828.00 | 201.00 | 864.00 | 200.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 125.0 | 130.0 | 2000.0 | 50.0 | 0.00 | 0.0 | 0 |
| 2 | 104.5 | 110.0 | 0.0 | 21.0 | 0.00 | 0.0 | 0 |
| 3 | 104.5 | 110.0 | 570.0 | 23.0 | 0.00 | 0.0 | 0 |
| 4 | 104.5 | 110.0 | 0.0 | 17.0 | 0.00 | 0.0 | 0 |

ANISOTROPIC STRENGTH PARAMETERS

1 soil type(s)

Soil Type 4 Is Anisotropic

Number Of Direction Ranges Specified = 3

| Direction Range No. | Counterclockwise Direction Limit (deg) | Cohesion Intercept (psf) | Friction Angle (deg) |
|---|---|---|---|
| 1 | 22.0 | 570.00 | 23.00 |
| 2 | 28.0 | 0.00 | 17.00 |
| 3 | 90.0 | 570.00 | 23.00 |

ANISOTROPIC SOIL NOTES:

(1) An input value of 0.01 for C and/or Phi will cause Aniso C and/or Phi to be ignored in that range.
(2) An input value of 0.02 for Phi will set both Phi and C equal to zero, with no water weight in the tension crack.
(3) An input value of 0.03 for Phi will set both Phi and C equal to zero, with water weight in the tension crack.

Janbus Empirical Coef is being used for the case of c=0

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

100 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 15.0

| Box No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Height (ft) |
|---|---|---|---|---|---|
| 1 | 508.00 | 235.00 | 540.00 | 235.00 | 20.00 |
| 2 | 600.00 | 260.00 | 660.00 | 260.00 | 36.00 |

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Evaluated. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Simplified Janbu Method * *

Total Number of Trial Surfaces Attempted = 100
Number of Trial Surfaces With Valid FS = 100
Statistical Data On All Valid FS Values:
FS Max = 12.841 FS Min = 1.794 FS Ave = 3.988
Standard Deviation = 1.402 Coefficient of Variation = 35.16 %

Failure Surface Specified By 6 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 495.296 | 232.259 |
| 2 | 496.986 | 230.664 |
| 3 | 510.951 | 225.189 |
| 4 | 605.856 | 264.542 |
| 5 | 616.427 | 275.184 |
| 6 | 617.980 | 289.000 |

Factor of Safety
*** 1.794 ***

Individual data on the 12 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.7 | 170.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 2.0 | 532.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 4.0 | 2470.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 2.0 | 2525.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 6.0 | 13743.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 6.0 | 20866.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 5.0 | 19471.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 56.0 | 170404.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 27.9 | 64615.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 2.1 | 5118.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 8.4 | 15901.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 1.6 | 1121.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 8 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 501.504 | 235.504 |
| 2 | 505.068 | 232.378 |
| 3 | 519.256 | 227.509 |
| 4 | 600.216 | 254.021 |
| 5 | 610.751 | 264.699 |
| 6 | 621.300 | 275.363 |
| 7 | 631.508 | 286.354 |
| 8 | 632.552 | 288.103 |

Factor of Safety
*** 2.117 ***

Failure Surface Specified By 5 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 504.860 | 242.581 |
| 2 | 515.350 | 232.645 |
| 3 | 618.673 | 275.361 |
| 4 | 629.078 | 286.165 |
| 5 | 629.637 | 288.312 |

Factor of Safety
*** 2.137 ***

Failure Surface Specified By 7 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 502.117 | 236.117 |
| 2 | 511.600 | 227.177 |
| 3 | 600.392 | 249.767 |
| 4 | 608.663 | 262.281 |
| 5 | 615.341 | 275.712 |
| 6 | 622.879 | 288.681 |
| 7 | 622.984 | 288.787 |

Factor of Safety
*** 2.232 ***

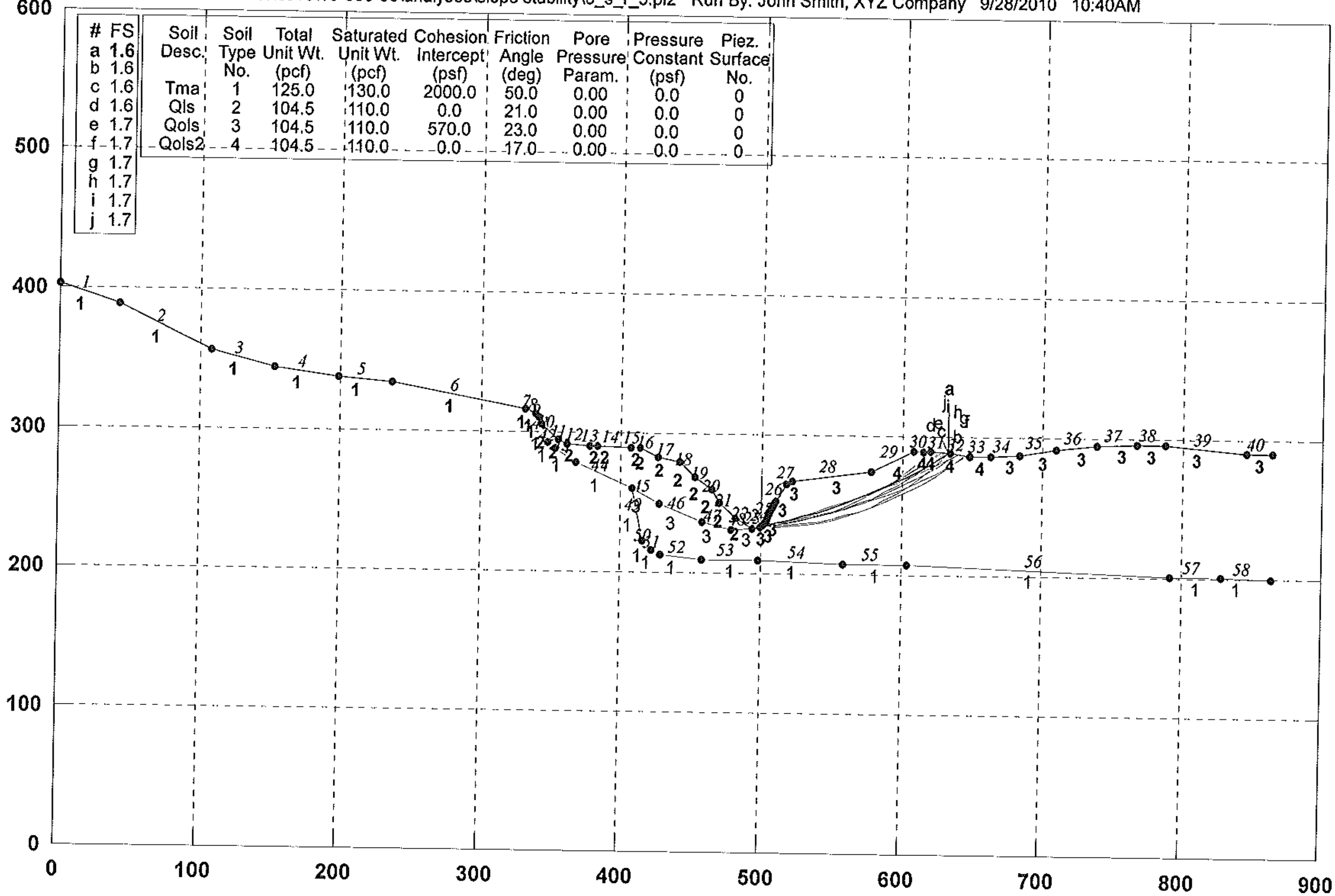
Failure Surface Specified By 5 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.632 | 234.632 |
| 2 | 511.303 | 231.327 |
| 3 | 628.195 | 266.941 |

```
     4        632.663      281.260
     5        638.146      287.408
       Factor of Safety
      ***    2.340   ***
Failure Surface Specified By  5 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        503.438      238.315
    2        514.053      228.671
    3        629.601      268.910
    4        637.668      281.556
    5        640.246      287.108
       Factor of Safety
      ***    2.435   ***
Failure Surface Specified By  5 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        503.795      239.385
    2        511.213      237.016
    3        524.693      230.438
    4        605.724      276.732
    5        611.657      289.000
       Factor of Safety
      ***    2.542   ***
Failure Surface Specified By  6 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        503.645      238.936
    2        504.443      238.145
    3        518.865      234.022
    4        602.062      263.355
    5        605.000      278.065
    6        609.048      289.000
       Factor of Safety
      ***    2.592   ***
Failure Surface Specified By  5 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        506.753      246.213
    2        510.023      244.478
    3        521.100      234.364
    4        610.704      276.205
    5        618.295      289.000
       Factor of Safety
      ***    2.638   ***
Failure Surface Specified By  6 Coordinate Points
  Point       X-Surf       Y-Surf
   No.         (ft)         (ft)
    1        505.820      244.504
    2        511.272      241.248
    3        525.686      237.094
    4        615.436      266.704
    5        626.035      277.318
    6        635.838      287.737
       Factor of Safety
      ***    2.712   ***
          **** END OF GSTABL7 OUTPUT ****
```

## Sect 3, Lower switch back, Existing condstability, Circular search at road

u:\2010\10-036-00\analyses\slope stability\3_s_r_5.pl2 Run By: John Smith, XYZ Company 9/28/2010 10:40AM

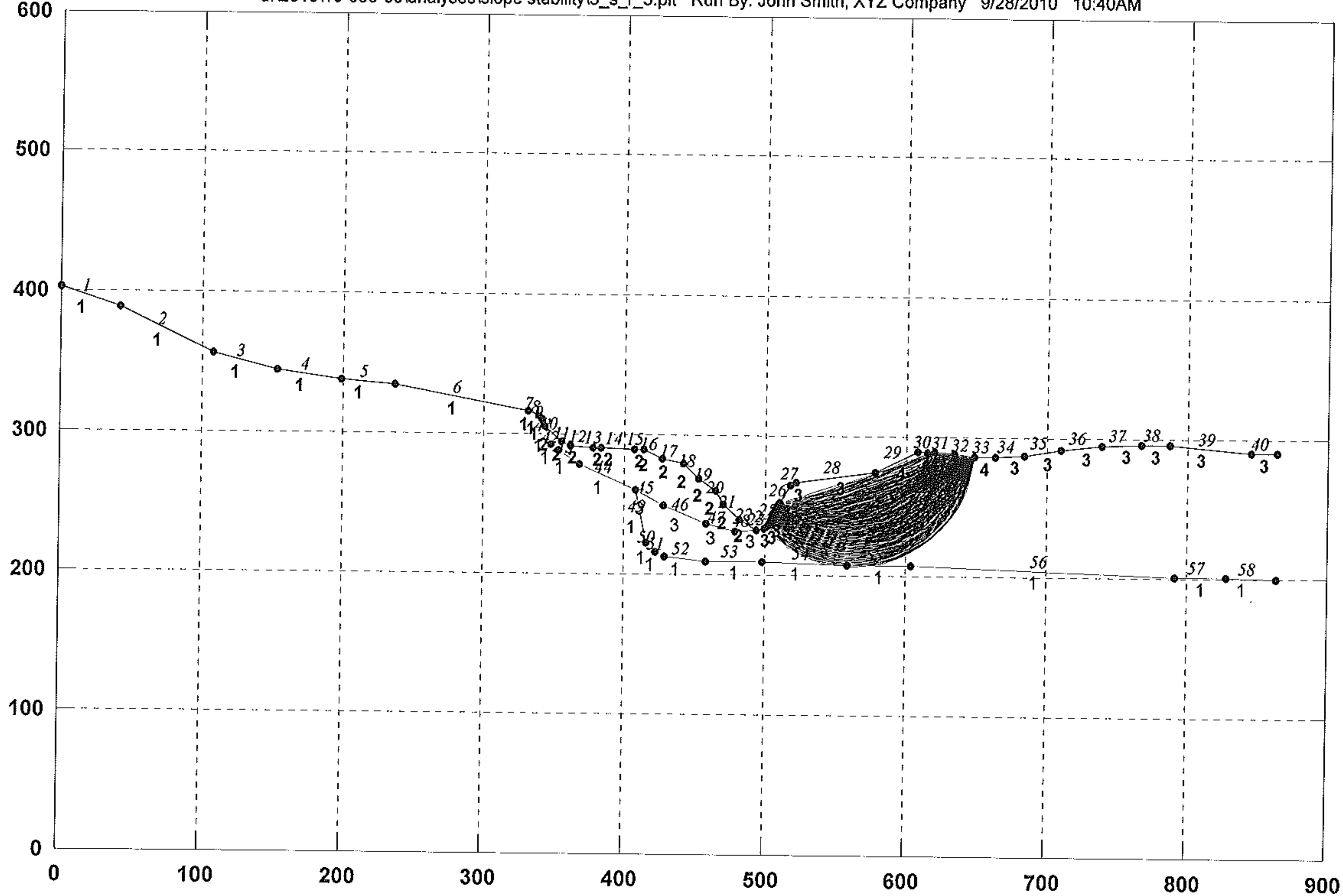



GSTABL7 v.2 FSmin=1.6

Safety Factors Are Calculated By The Modified Bishop Method

## Sect 3, Lower switch back, Existing condstability, Circular search at road

u:\2010\10-036-00\analyses\slope stability\3_s_r_5.plt Run By: John Smith, XYZ Company 9/28/2010 10:40AM



*** **GSTABL7** ***

** GSTABL7 by Garry H. Gregory, P.E. **

** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **



*****************************************************************************

SLOPE STABILITY ANALYSIS SYSTEM

Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.

*****************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 10:40AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_r_5.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_r_5.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_r_5.PLT
PROBLEM DESCRIPTION: Sect 3, Lower switch back, Existing cond
stability, Circular search at road

BOUNDARY COORDINATES
40 Top Boundaries
58 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 403.00 | 42.00 | 389.00 | 1 |
| 2 | 42.00 | 389.00 | 108.00 | 356.00 | 1 |
| 3 | 108.00 | 356.00 | 153.00 | 345.00 | 1 |
| 4 | 153.00 | 345.00 | 199.00 | 338.00 | 1 |
| 5 | 199.00 | 338.00 | 236.00 | 335.00 | 1 |
| 6 | 236.00 | 335.00 | 332.00 | 316.00 | 1 |
| 7 | 332.00 | 316.00 | 339.00 | 313.00 | 1 |
| 8 | 339.00 | 313.00 | 341.00 | 311.00 | 1 |
| 9 | 341.00 | 311.00 | 343.00 | 306.00 | 1 |
| 10 | 343.00 | 306.00 | 355.00 | 295.00 | 2 |
| 11 | 355.00 | 295.00 | 362.00 | 292.00 | 2 |
| 12 | 362.00 | 292.00 | 378.00 | 291.00 | 2 |
| 13 | 378.00 | 291.00 | 383.00 | 291.00 | 2 |
| 14 | 383.00 | 291.00 | 407.00 | 289.00 | 2 |
| 15 | 407.00 | 289.00 | 414.00 | 289.00 | 2 |
| 16 | 414.00 | 289.00 | 427.00 | 283.00 | 2 |
| 17 | 427.00 | 283.00 | 442.00 | 280.00 | 2 |
| 18 | 442.00 | 280.00 | 453.00 | 269.00 | 2 |
| 19 | 453.00 | 269.00 | 464.00 | 260.00 | 2 |
| 20 | 464.00 | 260.00 | 470.00 | 251.00 | 2 |
| 21 | 470.00 | 251.00 | 482.00 | 240.00 | 2 |
| 22 | 482.00 | 240.00 | 494.00 | 232.00 | 2 |
| 23 | 494.00 | 232.00 | 499.00 | 233.00 | 3 |
| 24 | 499.00 | 233.00 | 503.00 | 237.00 | 3 |
| 25 | 503.00 | 237.00 | 505.00 | 243.00 | 3 |
| 26 | 505.00 | 243.00 | 517.00 | 265.00 | 3 |
| 27 | 517.00 | 265.00 | 522.00 | 267.00 | 3 |
| 28 | 522.00 | 267.00 | 578.00 | 274.00 | 3 |
| 29 | 578.00 | 274.00 | 608.00 | 289.00 | 4 |
| 30 | 608.00 | 289.00 | 620.00 | 289.00 | 4 |
| 31 | 620.00 | 289.00 | 634.00 | 288.00 | 4 |
| 32 | 634.00 | 288.00 | 648.00 | 286.00 | 4 |
| 33 | 648.00 | 286.00 | 663.00 | 286.00 | 4 |
| 34 | 663.00 | 286.00 | 684.00 | 287.00 | 3 |
| 35 | 684.00 | 287.00 | 710.00 | 292.00 | 3 |
| 36 | 710.00 | 292.00 | 739.00 | 295.00 | 3 |
| 37 | 739.00 | 295.00 | 767.00 | 296.00 | 3 |
| 38 | 767.00 | 296.00 | 787.00 | 296.00 | 3 |
| 39 | 787.00 | 296.00 | 846.00 | 291.00 | 3 |
| 40 | 846.00 | 291.00 | 864.00 | 291.00 | 3 |
| 41 | 343.00 | 306.00 | 348.00 | 293.00 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 42 | 348.00 | 293.00 | 353.00 | 288.00 | 1 |
| 43 | 353.00 | 288.00 | 368.00 | 279.00 | 1 |
| 44 | 368.00 | 279.00 | 408.00 | 260.00 | 1 |
| 45 | 408.00 | 260.00 | 428.00 | 250.00 | 3 |
| 46 | 428.00 | 250.00 | 458.00 | 236.00 | 3 |
| 47 | 458.00 | 236.00 | 478.00 | 231.00 | 3 |
| 48 | 478.00 | 231.00 | 494.00 | 232.00 | 3 |
| 49 | 408.00 | 260.00 | 416.00 | 223.00 | 1 |
| 50 | 416.00 | 223.00 | 422.00 | 216.00 | 1 |
| 51 | 422.00 | 216.00 | 429.00 | 213.00 | 1 |
| 52 | 429.00 | 213.00 | 458.00 | 210.00 | 1 |
| 53 | 458.00 | 210.00 | 498.00 | 210.00 | 1 |
| 54 | 498.00 | 210.00 | 558.00 | 207.00 | 1 |
| 55 | 558.00 | 207.00 | 604.00 | 207.00 | 1 |
| 56 | 604.00 | 207.00 | 792.00 | 201.00 | 1 |
| 57 | 792.00 | 201.00 | 828.00 | 201.00 | 1 |
| 58 | 828.00 | 201.00 | 864.00 | 200.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 125.0 | 130.0 | 2000.0 | 50.0 | 0.00 | 0.0 | 0 |
| 2 | 104.5 | 110.0 | 0.0 | 21.0 | 0.00 | 0.0 | 0 |
| 3 | 104.5 | 110.0 | 570.0 | 23.0 | 0.00 | 0.0 | 0 |
| 4 | 104.5 | 110.0 | 0.0 | 17.0 | 0.00 | 0.0 | 0 |

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

500 Trial Surfaces Have Been Generated.

25 Surface(s) Initiate(s) From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 500.00(ft) and X = 510.00(ft)

Each Surface Terminates Between X = 615.00(ft) and X = 648.00(ft)

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00(ft)

10.00(ft) Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Evaluated. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Total Number of Trial Surfaces Attempted = 500

Number of Trial Surfaces With Valid FS = 500

Statistical Data On All Valid FS Values:

FS Max = 4.140 FS Min = 1.618 FS Ave = 2.547

Standard Deviation = 0.543 Coefficient of Variation = 21.31 %

Failure Surface Specified By 16 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.000 | 234.000 |
| 2 | 509.744 | 236.248 |
| 3 | 519.432 | 238.728 |
| 4 | 529.058 | 241.438 |
| 5 | 538.616 | 244.376 |
| 6 | 548.102 | 247.542 |
| 7 | 557.509 | 250.933 |
| 8 | 566.833 | 254.548 |
| 9 | 576.068 | 258.383 |
| 10 | 585.209 | 262.438 |
| 11 | 594.251 | 266.710 |
| 12 | 603.188 | 271.196 |
| 13 | 612.016 | 275.894 |
| 14 | 620.729 | 280.801 |
| 15 | 629.323 | 285.915 |
| 16 | 632.783 | 288.087 |

Circle Center At X = 410.896 ; Y = 642.784 ; and Radius = 418.382

Factor of Safety

*** 1.618 ***

Individual data on the 22 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.0 | 361.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 2.0 | 1061.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 4.7 | 5774.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 7.3 | 16053.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 2.4 | 6879.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 2.6 | 7352.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 7.1 | 19910.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 9.6 | 25543.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 9.5 | 23503.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 9.4 | 21247.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 9.3 | 18786.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 9.2 | 16131.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 1.9 | 3041.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 7.2 | 11272.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 9.0 | 14447.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 16 | 8.9 | 14389.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 17 | 4.8 | 7703.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 18 | 4.0 | 5948.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 19 | 8.0 | 9059.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 20 | 0.7 | 638.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 21 | 8.6 | 4744.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 22 | 3.5 | 437.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 16 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.000 | 234.000 |
| 2 | 509.675 | 236.529 |
| 3 | 519.310 | 239.207 |
| 4 | 528.902 | 242.035 |
| 5 | 538.448 | 245.011 |
| 6 | 547.948 | 248.134 |
| 7 | 557.398 | 251.405 |
| 8 | 566.796 | 254.821 |
| 9 | 576.141 | 258.383 |
| 10 | 585.428 | 262.089 |
| 11 | 594.658 | 265.939 |
| 12 | 603.826 | 269.932 |
| 13 | 612.931 | 274.066 |
| 14 | 621.971 | 278.341 |
| 15 | 630.944 | 282.756 |
| 16 | 639.627 | 287.196 |

Circle Center At X = 341.796 ; Y = 859.089 ; and Radius = 644.799

Factor of Safety

*** 1.632 ***

Failure Surface Specified By 15 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.526 | 234.526 |
| 2 | 510.341 | 236.442 |
| 3 | 520.089 | 238.675 |
| 4 | 529.758 | 241.223 |
| 5 | 539.341 | 244.084 |
| 6 | 548.825 | 247.254 |
| 7 | 558.201 | 250.729 |
| 8 | 567.460 | 254.508 |
| 9 | 576.592 | 258.584 |
| 10 | 585.586 | 262.955 |
| 11 | 594.434 | 267.615 |
| 12 | 603.126 | 272.560 |
| 13 | 611.653 | 277.784 |

| | | |
|---|---|---|
| 14 | 620.006 | 283.282 |
| 15 | 627.363 | 288.474 |

Circle Center At X = 446.395 ; Y = 537.954 ; and Radius = 308.219

Factor of Safety

*** 1.633 ***

Failure Surface Specified By 15 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.000 | 234.000 |
| 2 | 509.937 | 235.118 |
| 3 | 519.805 | 236.741 |
| 4 | 529.576 | 238.867 |
| 5 | 539.227 | 241.488 |
| 6 | 548.730 | 244.598 |
| 7 | 558.063 | 248.190 |
| 8 | 567.200 | 252.253 |
| 9 | 576.118 | 256.778 |
| 10 | 584.794 | 261.752 |
| 11 | 593.204 | 267.162 |
| 12 | 601.327 | 272.995 |
| 13 | 609.141 | 279.234 |
| 14 | 616.627 | 285.865 |
| 15 | 619.822 | 289.000 |

Circle Center At X = 483.088 ; Y = 429.090 ; and Radius = 195.821

Factor of Safety

*** 1.649 ***

Failure Surface Specified By 15 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 501.053 | 235.053 |
| 2 | 510.878 | 236.911 |
| 3 | 520.635 | 239.105 |
| 4 | 530.310 | 241.633 |
| 5 | 539.893 | 244.492 |
| 6 | 549.371 | 247.679 |
| 7 | 558.735 | 251.189 |
| 8 | 567.973 | 255.018 |
| 9 | 577.073 | 259.163 |
| 10 | 586.026 | 263.617 |
| 11 | 594.821 | 268.377 |
| 12 | 603.447 | 273.436 |
| 13 | 611.895 | 278.788 |
| 14 | 620.153 | 284.426 |
| 15 | 625.815 | 288.585 |

Circle Center At X = 451.880 ; Y = 522.003 ; and Radius = 291.133

Factor of Safety

*** 1.650 ***

Failure Surface Specified By 17 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.526 | 234.526 |
| 2 | 510.427 | 235.933 |
| 3 | 520.284 | 237.616 |
| 4 | 530.091 | 239.572 |
| 5 | 539.840 | 241.801 |
| 6 | 549.522 | 244.300 |
| 7 | 559.131 | 247.068 |
| 8 | 568.660 | 250.103 |
| 9 | 578.100 | 253.402 |
| 10 | 587.445 | 256.962 |
| 11 | 596.687 | 260.782 |
| 12 | 605.818 | 264.857 |
| 13 | 614.833 | 269.185 |
| 14 | 623.724 | 273.762 |
| 15 | 632.484 | 278.586 |
| 16 | 641.106 | 283.651 |
| 17 | 645.444 | 286.365 |

Circle Center At X = 454.965 ; Y = 590.617 ; and Radius = 358.993

Factor of Safety
*** 1.657 ***
Failure Surface Specified By 17 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.000 | 234.000 |
| 2 | 509.993 | 234.387 |
| 3 | 519.959 | 235.201 |
| 4 | 529.882 | 236.442 |
| 5 | 539.742 | 238.107 |
| 6 | 549.523 | 240.192 |
| 7 | 559.204 | 242.694 |
| 8 | 568.770 | 245.609 |
| 9 | 578.202 | 248.931 |
| 10 | 587.484 | 252.654 |
| 11 | 596.597 | 256.771 |
| 12 | 605.525 | 261.274 |
| 13 | 614.253 | 266.156 |
| 14 | 622.763 | 271.407 |
| 15 | 631.040 | 277.018 |
| 16 | 639.070 | 282.979 |
| 17 | 643.575 | 286.632 |

Circle Center At X = 495.969 ; Y = 467.371 ; and Radius = 233.406
Factor of Safety
*** 1.661 ***
Failure Surface Specified By 16 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 501.579 | 235.579 |
| 2 | 511.482 | 236.966 |
| 3 | 521.337 | 238.667 |
| 4 | 531.132 | 240.678 |
| 5 | 540.859 | 242.999 |
| 6 | 550.508 | 245.627 |
| 7 | 560.068 | 248.559 |
| 8 | 569.531 | 251.793 |
| 9 | 578.886 | 255.325 |
| 10 | 588.125 | 259.151 |
| 11 | 597.239 | 263.268 |
| 12 | 606.217 | 267.672 |
| 13 | 615.051 | 272.357 |
| 14 | 623.733 | 277.320 |
| 15 | 632.252 | 282.556 |
| 16 | 639.352 | 287.235 |

Circle Center At X = 462.822 ; Y = 548.505 ; and Radius = 315.317
Factor of Safety
*** 1.663 ***
Failure Surface Specified By 16 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.000 | 234.000 |
| 2 | 509.998 | 233.809 |
| 3 | 519.990 | 234.213 |
| 4 | 529.940 | 235.209 |
| 5 | 539.814 | 236.795 |
| 6 | 549.576 | 238.964 |
| 7 | 559.192 | 241.709 |
| 8 | 568.627 | 245.021 |
| 9 | 577.850 | 248.886 |
| 10 | 586.827 | 253.293 |
| 11 | 595.526 | 258.226 |
| 12 | 603.916 | 263.666 |
| 13 | 611.969 | 269.595 |
| 14 | 619.656 | 275.991 |
| 15 | 626.949 | 282.833 |
| 16 | 631.976 | 288.145 |

Circle Center At X = 508.252 ; Y = 401.801 ; and Radius = 168.003
Factor of Safety

*** 1.664 ***

Failure Surface Specified By 16 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 501.579 | 235.579 |
| 2 | 511.537 | 236.492 |
| 3 | 521.443 | 237.858 |
| 4 | 531.277 | 239.675 |
| 5 | 541.017 | 241.939 |
| 6 | 550.644 | 244.645 |
| 7 | 560.138 | 247.788 |
| 8 | 569.478 | 251.361 |
| 9 | 578.645 | 255.356 |
| 10 | 587.620 | 259.765 |
| 11 | 596.385 | 264.580 |
| 12 | 604.921 | 269.789 |
| 13 | 613.210 | 275.383 |
| 14 | 621.235 | 281.349 |
| 15 | 628.980 | 287.675 |
| 16 | 629.686 | 288.308 |

Circle Center At X = 486.612 ; Y = 453.928 ; and Radius = 218.861

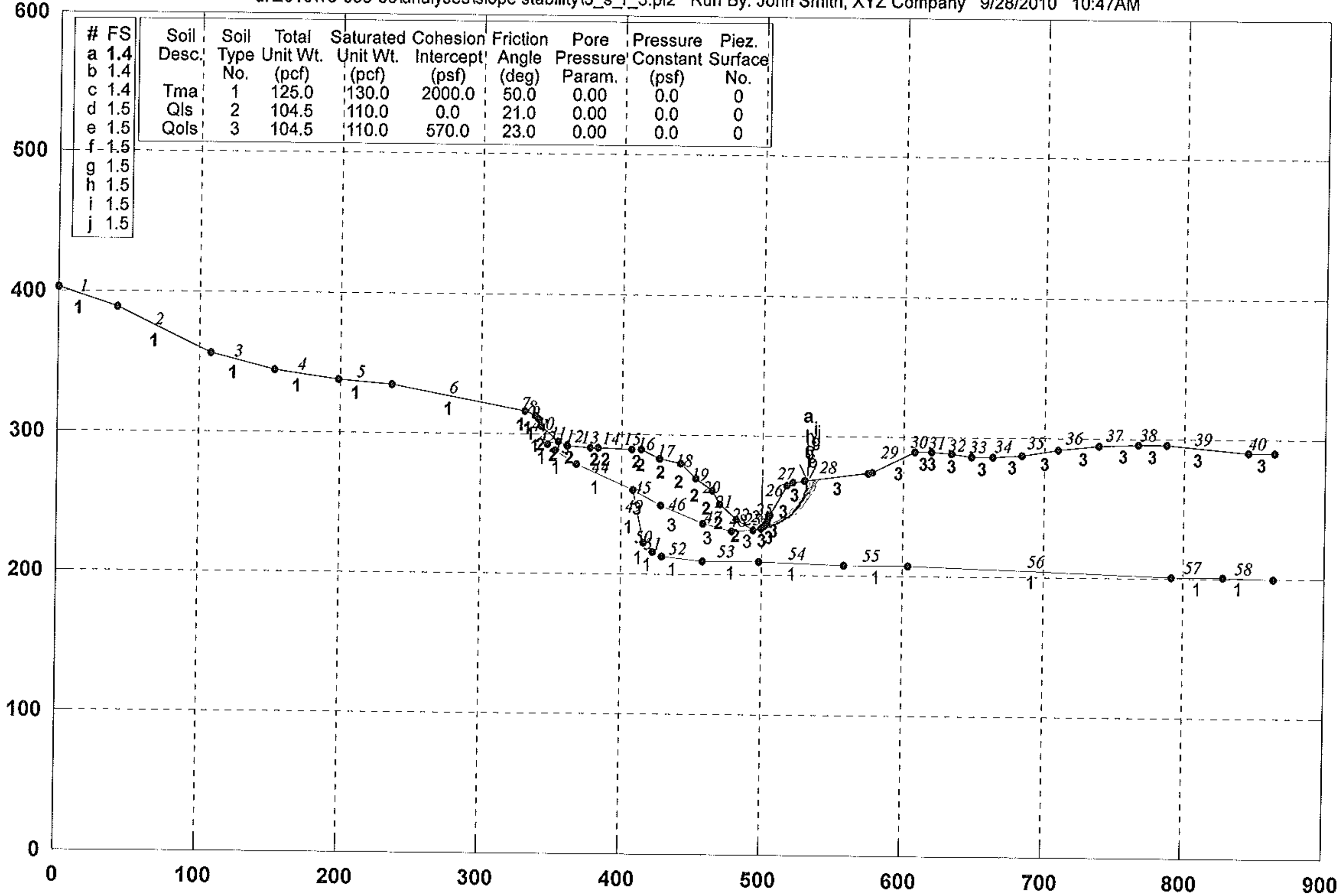
Factor of Safety

*** 1.665 ***

**** END OF GSTABL7 OUTPUT ****

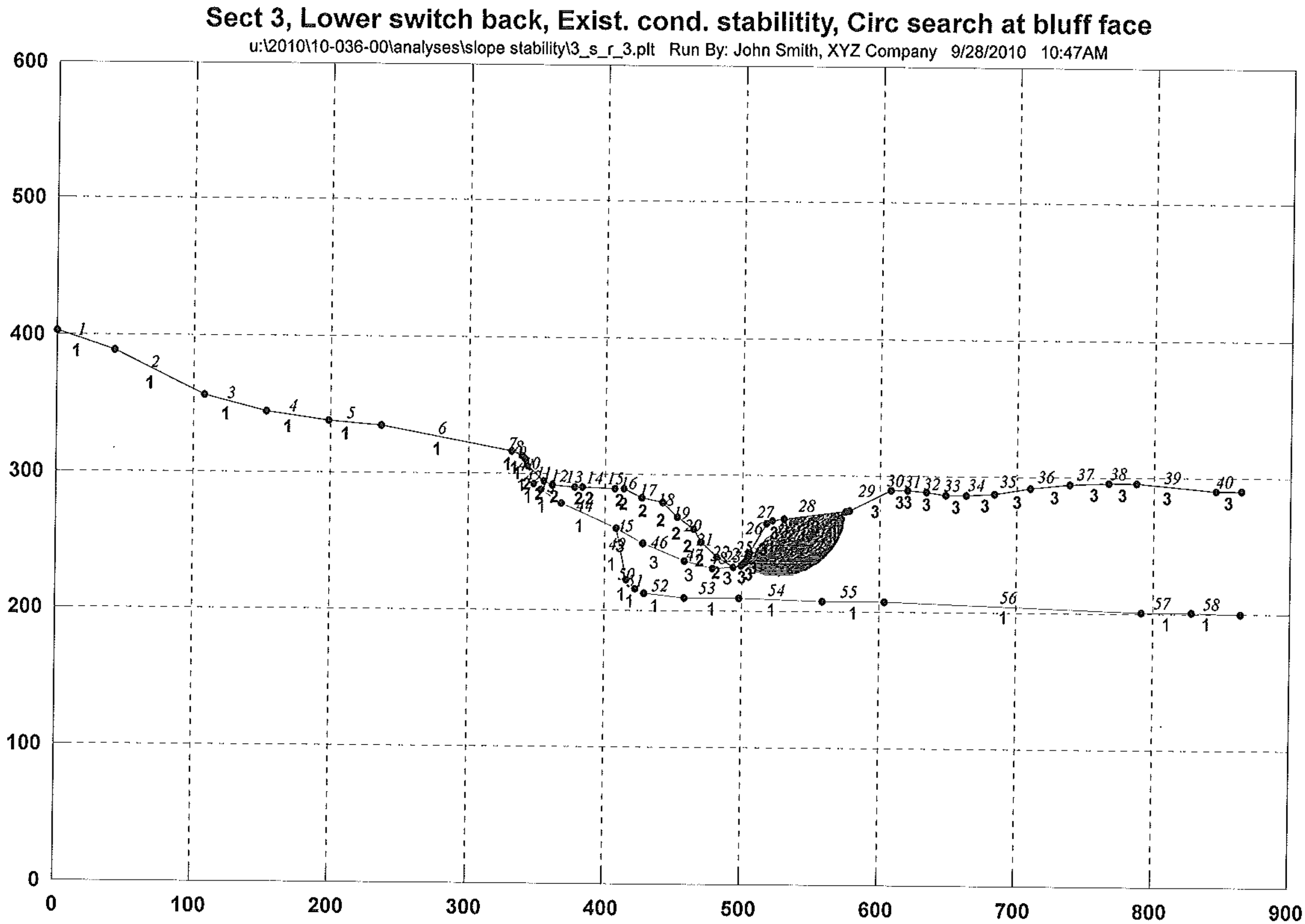
## Sect 3, Lower switch back, Exist. cond. stabilitity, Circ search at bluff face

u:\2010\10-036-00\analyses\slope stability\3_s_r_3.pl2 Run By: John Smith, XYZ Company 9/28/2010 10:47AM




**GSTABL7 v.2 FSmin=1.4**

**Safety Factors Are Calculated By The Modified Bishop Method**


Sect 3, Lower switch back, Exist. cond. stabilitity, Circ search at bluff face
u:\2010\10-036-00\analyses\slope stability\3_s_r_3.plt Run By: John Smith, XYZ Company 9/28/2010 10:47AM
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
900

***** GSTABL7 *****

** GSTABL7 by Garry H. Gregory, P.E. **
** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **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SLOPE STABILITY ANALYSIS SYSTEM
Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.

*********************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 10:47AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_r_3.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_r_3.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_r_3.PLT
PROBLEM DESCRIPTION: Sect 3, Lower switch back, Exist. cond.
stabilitity, Circ search at bluff face

BOUNDARY COORDINATES
40 Top Boundaries
58 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 403.00 | 42.00 | 389.00 | 1 |
| 2 | 42.00 | 389.00 | 108.00 | 356.00 | 1 |
| 3 | 108.00 | 356.00 | 153.00 | 345.00 | 1 |
| 4 | 153.00 | 345.00 | 199.00 | 338.00 | 1 |
| 5 | 199.00 | 338.00 | 236.00 | 335.00 | 1 |
| 6 | 236.00 | 335.00 | 332.00 | 316.00 | 1 |
| 7 | 332.00 | 316.00 | 339.00 | 313.00 | 1 |
| 8 | 339.00 | 313.00 | 341.00 | 311.00 | 1 |
| 9 | 341.00 | 311.00 | 343.00 | 306.00 | 1 |
| 10 | 343.00 | 306.00 | 355.00 | 295.00 | 2 |
| 11 | 355.00 | 295.00 | 362.00 | 292.00 | 2 |
| 12 | 362.00 | 292.00 | 378.00 | 291.00 | 2 |
| 13 | 378.00 | 291.00 | 383.00 | 291.00 | 2 |
| 14 | 383.00 | 291.00 | 407.00 | 289.00 | 2 |
| 15 | 407.00 | 289.00 | 414.00 | 289.00 | 2 |
| 16 | 414.00 | 289.00 | 427.00 | 283.00 | 2 |
| 17 | 427.00 | 283.00 | 442.00 | 280.00 | 2 |
| 18 | 442.00 | 280.00 | 453.00 | 269.00 | 2 |
| 19 | 453.00 | 269.00 | 464.00 | 260.00 | 2 |
| 20 | 464.00 | 260.00 | 470.00 | 251.00 | 2 |
| 21 | 470.00 | 251.00 | 482.00 | 240.00 | 2 |
| 22 | 482.00 | 240.00 | 494.00 | 232.00 | 2 |
| 23 | 494.00 | 232.00 | 499.00 | 233.00 | 3 |
| 24 | 499.00 | 233.00 | 503.00 | 237.00 | 3 |
| 25 | 503.00 | 237.00 | 505.00 | 243.00 | 3 |
| 26 | 505.00 | 243.00 | 517.00 | 265.00 | 3 |
| 27 | 517.00 | 265.00 | 522.00 | 267.00 | 3 |
| 28 | 522.00 | 267.00 | 578.00 | 274.00 | 3 |
| 29 | 578.00 | 274.00 | 608.00 | 289.00 | 3 |
| 30 | 608.00 | 289.00 | 620.00 | 289.00 | 3 |
| 31 | 620.00 | 289.00 | 634.00 | 288.00 | 3 |
| 32 | 634.00 | 288.00 | 648.00 | 286.00 | 3 |
| 33 | 648.00 | 286.00 | 663.00 | 286.00 | 3 |
| 34 | 663.00 | 286.00 | 684.00 | 287.00 | 3 |
| 35 | 684.00 | 287.00 | 710.00 | 292.00 | 3 |
| 36 | 710.00 | 292.00 | 739.00 | 295.00 | 3 |
| 37 | 739.00 | 295.00 | 767.00 | 296.00 | 3 |
| 38 | 767.00 | 296.00 | 787.00 | 296.00 | 3 |
| 39 | 787.00 | 296.00 | 846.00 | 291.00 | 3 |
| 40 | 846.00 | 291.00 | 864.00 | 291.00 | 3 |
| 41 | 343.00 | 306.00 | 348.00 | 293.00 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 42 | 348.00 | 293.00 | 353.00 | 288.00 | 1 |
| 43 | 353.00 | 288.00 | 368.00 | 279.00 | 1 |
| 44 | 368.00 | 279.00 | 408.00 | 260.00 | 1 |
| 45 | 408.00 | 260.00 | 428.00 | 250.00 | 3 |
| 46 | 428.00 | 250.00 | 458.00 | 236.00 | 3 |
| 47 | 458.00 | 236.00 | 478.00 | 231.00 | 3 |
| 48 | 478.00 | 231.00 | 494.00 | 232.00 | 3 |
| 49 | 408.00 | 260.00 | 416.00 | 223.00 | 1 |
| 50 | 416.00 | 223.00 | 422.00 | 216.00 | 1 |
| 51 | 422.00 | 216.00 | 429.00 | 213.00 | 1 |
| 52 | 429.00 | 213.00 | 458.00 | 210.00 | 1 |
| 53 | 458.00 | 210.00 | 498.00 | 210.00 | 1 |
| 54 | 498.00 | 210.00 | 558.00 | 207.00 | 1 |
| 55 | 558.00 | 207.00 | 604.00 | 207.00 | 1 |
| 56 | 604.00 | 207.00 | 792.00 | 201.00 | 1 |
| 57 | 792.00 | 201.00 | 828.00 | 201.00 | 1 |
| 58 | 828.00 | 201.00 | 864.00 | 200.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)
ISOTROPIC SOIL PARAMETERS
3 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 125.0 | 130.0 | 2000.0 | 50.0 | 0.00 | 0.0 | 0 |
| 2 | 104.5 | 110.0 | 0.0 | 21.0 | 0.00 | 0.0 | 0 |
| 3 | 104.5 | 110.0 | 570.0 | 23.0 | 0.00 | 0.0 | 0 |

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.
400 Trial Surfaces Have Been Generated.
40 Surface(s) Initiate(s) From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 500.00(ft)
and X = 505.00(ft)
Each Surface Terminates Between X = 530.00(ft)
and X = 575.00(ft)
Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00(ft)
2.00(ft) Line Segments Define Each Trial Failure Surface.
Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Evaluated. They Are
Ordered - Most Critical First.
* * Safety Factors Are Calculated By The Modified Bishop Method * *
Total Number of Trial Surfaces Attempted = 400
Number of Trial Surfaces With Valid FS = 400
Statistical Data On All Valid FS Values:
FS Max = 4.046 FS Min = 1.438 FS Ave = 2.292
Standard Deviation = 0.599 Coefficient of Variation = 26.14 %
Failure Surface Specified By 27 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.000 | 234.000 |
| 2 | 501.971 | 234.342 |
| 3 | 503.920 | 234.788 |
| 4 | 505.844 | 235.336 |
| 5 | 507.735 | 235.986 |
| 6 | 509.590 | 236.735 |
| 7 | 511.402 | 237.581 |
| 8 | 513.166 | 238.522 |
| 9 | 514.879 | 239.556 |
| 10 | 516.534 | 240.678 |
| 11 | 518.127 | 241.887 |
| 12 | 519.654 | 243.179 |
| 13 | 521.111 | 244.549 |
| 14 | 522.493 | 245.995 |
| 15 | 523.796 | 247.512 |
| 16 | 525.017 | 249.096 |
| 17 | 526.152 | 250.743 |

| | | |
|---|---|---|
| 18 | 527.199 | 252.447 |
| 19 | 528.154 | 254.204 |
| 20 | 529.014 | 256.010 |
| 21 | 529.777 | 257.859 |
| 22 | 530.442 | 259.745 |
| 23 | 531.005 | 261.664 |
| 24 | 531.466 | 263.610 |
| 25 | 531.823 | 265.578 |
| 26 | 532.075 | 267.562 |
| 27 | 532.127 | 268.266 |

Circle Center At X = 494.538 ; Y = 271.328 ; and Radius = 37.726

Factor of Safety

*** 1.438 ***

Individual data on the 30 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.0 | 167.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 1.0 | 217.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 0.9 | 355.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 1.1 | 726.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 0.8 | 754.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 1.9 | 2099.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 1.9 | 2587.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 1.8 | 3014.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 1.8 | 3375.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 1.7 | 3668.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 1.7 | 3893.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 0.5 | 1155.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 1.1 | 2799.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 1.5 | 3706.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 1.5 | 3422.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 16 | 0.9 | 2026.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 17 | 0.5 | 1096.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 18 | 1.3 | 2776.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 19 | 1.2 | 2423.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 20 | 1.1 | 2079.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 21 | 1.0 | 1748.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 22 | 1.0 | 1435.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 23 | 0.9 | 1143.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 24 | 0.8 | 876.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 25 | 0.7 | 639.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 26 | 0.6 | 434.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 27 | 0.5 | 265.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 28 | 0.4 | 134.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 29 | 0.3 | 44.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 30 | 0.1 | 1.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 28 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.000 | 234.000 |
| 2 | 501.953 | 234.430 |
| 3 | 503.886 | 234.943 |
| 4 | 505.795 | 235.540 |
| 5 | 507.677 | 236.218 |
| 6 | 509.527 | 236.976 |
| 7 | 511.344 | 237.814 |
| 8 | 513.122 | 238.729 |
| 9 | 514.859 | 239.719 |
| 10 | 516.553 | 240.784 |
| 11 | 518.198 | 241.921 |
| 12 | 519.793 | 243.127 |
| 13 | 521.335 | 244.401 |
| 14 | 522.821 | 245.740 |
| 15 | 524.247 | 247.142 |
| 16 | 525.612 | 248.604 |
| 17 | 526.912 | 250.124 |

| | | |
|---|---|---|
| 18 | 528.146 | 251.698 |
| 19 | 529.310 | 253.324 |
| 20 | 530.404 | 254.998 |
| 21 | 531.425 | 256.718 |
| 22 | 532.370 | 258.481 |
| 23 | 533.239 | 260.282 |
| 24 | 534.029 | 262.119 |
| 25 | 534.739 | 263.989 |
| 26 | 535.369 | 265.887 |
| 27 | 535.915 | 267.811 |
| 28 | 536.143 | 268.768 |

Circle Center At X = 491.019 ; Y = 279.507 ; and Radius = 46.385

Factor of Safety

*** 1.447 ***

Failure Surface Specified By 27 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.556 | 234.556 |
| 2 | 502.506 | 234.996 |
| 3 | 504.435 | 235.526 |
| 4 | 506.337 | 236.145 |
| 5 | 508.208 | 236.852 |
| 6 | 510.044 | 237.645 |
| 7 | 511.841 | 238.522 |
| 8 | 513.596 | 239.481 |
| 9 | 515.305 | 240.521 |
| 10 | 516.963 | 241.638 |
| 11 | 518.568 | 242.832 |
| 12 | 520.116 | 244.098 |
| 13 | 521.604 | 245.435 |
| 14 | 523.028 | 246.839 |
| 15 | 524.385 | 248.308 |
| 16 | 525.673 | 249.839 |
| 17 | 526.888 | 251.427 |
| 18 | 528.029 | 253.070 |
| 19 | 529.092 | 254.764 |
| 20 | 530.075 | 256.505 |
| 21 | 530.977 | 258.291 |
| 22 | 531.794 | 260.116 |
| 23 | 532.527 | 261.977 |
| 24 | 533.172 | 263.870 |
| 25 | 533.729 | 265.791 |
| 26 | 534.196 | 267.736 |
| 27 | 534.351 | 268.544 |

Circle Center At X = 492.037 ; Y = 276.837 ; and Radius = 43.131

Factor of Safety

*** 1.449 ***

Failure Surface Specified By 26 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.556 | 234.556 |
| 2 | 502.459 | 235.169 |
| 3 | 504.336 | 235.861 |
| 4 | 506.181 | 236.632 |
| 5 | 507.993 | 237.479 |
| 6 | 509.768 | 238.401 |
| 7 | 511.502 | 239.396 |
| 8 | 513.194 | 240.464 |
| 9 | 514.839 | 241.601 |
| 10 | 516.435 | 242.806 |
| 11 | 517.979 | 244.077 |
| 12 | 519.469 | 245.411 |
| 13 | 520.901 | 246.807 |
| 14 | 522.274 | 248.261 |
| 15 | 523.585 | 249.772 |
| 16 | 524.831 | 251.336 |
| 17 | 526.011 | 252.951 |
| 18 | 527.122 | 254.614 |

| | | |
|---|---|---|
| 19 | 528.163 | 256.322 |
| 20 | 529.131 | 258.072 |
| 21 | 530.025 | 259.862 |
| 22 | 530.843 | 261.687 |
| 23 | 531.584 | 263.544 |
| 24 | 532.247 | 265.431 |
| 25 | 532.830 | 267.344 |
| 26 | 533.100 | 268.388 |

Circle Center At X = 486.889 ; Y = 280.272 ; and Radius = 47.715

Factor of Safety

*** 1.451 ***

Failure Surface Specified By 27 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.556 | 234.556 |
| 2 | 502.537 | 234.826 |
| 3 | 504.502 | 235.201 |
| 4 | 506.444 | 235.680 |
| 5 | 508.357 | 236.261 |
| 6 | 510.238 | 236.942 |
| 7 | 512.079 | 237.722 |
| 8 | 513.877 | 238.599 |
| 9 | 515.625 | 239.570 |
| 10 | 517.320 | 240.632 |
| 11 | 518.956 | 241.783 |
| 12 | 520.528 | 243.018 |
| 13 | 522.033 | 244.336 |
| 14 | 523.466 | 245.731 |
| 15 | 524.823 | 247.200 |
| 16 | 526.101 | 248.739 |
| 17 | 527.294 | 250.344 |
| 18 | 528.401 | 252.010 |
| 19 | 529.419 | 253.732 |
| 20 | 530.343 | 255.505 |
| 21 | 531.172 | 257.325 |
| 22 | 531.904 | 259.186 |
| 23 | 532.536 | 261.084 |
| 24 | 533.066 | 263.012 |
| 25 | 533.493 | 264.966 |
| 26 | 533.817 | 266.940 |
| 27 | 533.988 | 268.498 |

Circle Center At X = 496.450 ; Y = 272.046 ; and Radius = 37.714

Factor of Safety

*** 1.461 ***

Failure Surface Specified By 28 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.556 | 234.556 |
| 2 | 502.521 | 234.928 |
| 3 | 504.467 | 235.388 |
| 4 | 506.391 | 235.935 |
| 5 | 508.288 | 236.568 |
| 6 | 510.155 | 237.285 |
| 7 | 511.988 | 238.085 |
| 8 | 513.783 | 238.966 |
| 9 | 515.537 | 239.927 |
| 10 | 517.246 | 240.966 |
| 11 | 518.907 | 242.080 |
| 12 | 520.516 | 243.268 |
| 13 | 522.071 | 244.527 |
| 14 | 523.567 | 245.854 |
| 15 | 525.002 | 247.246 |
| 16 | 526.374 | 248.702 |
| 17 | 527.678 | 250.218 |
| 18 | 528.914 | 251.791 |
| 19 | 530.078 | 253.417 |
| 20 | 531.167 | 255.094 |
| 21 | 532.181 | 256.819 |

| | | |
|---|---|---|
| 22 | 533.116 | 258.587 |
| 23 | 533.970 | 260.395 |
| 24 | 534.743 | 262.240 |
| 25 | 535.432 | 264.117 |
| 26 | 536.037 | 266.023 |
| 27 | 536.555 | 267.955 |
| 28 | 536.752 | 268.844 |

Circle Center At X = 493.252 ; Y = 278.514 ; and Radius = 44.561

Factor of Safety

*** 1.463 ***

Failure Surface Specified By 28 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.556 | 234.556 |
| 2 | 502.499 | 235.030 |
| 3 | 504.422 | 235.579 |
| 4 | 506.322 | 236.202 |
| 5 | 508.197 | 236.899 |
| 6 | 510.043 | 237.668 |
| 7 | 511.858 | 238.508 |
| 8 | 513.639 | 239.418 |
| 9 | 515.383 | 240.397 |
| 10 | 517.088 | 241.443 |
| 11 | 518.751 | 242.554 |
| 12 | 520.370 | 243.728 |
| 13 | 521.941 | 244.965 |
| 14 | 523.464 | 246.262 |
| 15 | 524.935 | 247.617 |
| 16 | 526.352 | 249.028 |
| 17 | 527.714 | 250.493 |
| 18 | 529.017 | 252.010 |
| 19 | 530.261 | 253.576 |
| 20 | 531.443 | 255.190 |
| 21 | 532.561 | 256.848 |
| 22 | 533.614 | 258.548 |
| 23 | 534.600 | 260.288 |
| 24 | 535.518 | 262.065 |
| 25 | 536.366 | 263.877 |
| 26 | 537.143 | 265.719 |
| 27 | 537.848 | 267.591 |
| 28 | 538.331 | 269.041 |

Circle Center At X = 489.337 ; Y = 284.777 ; and Radius = 51.459

Factor of Safety

*** 1.465 ***

Failure Surface Specified By 27 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 501.111 | 235.111 |
| 2 | 503.089 | 235.405 |
| 3 | 505.049 | 235.804 |
| 4 | 506.984 | 236.309 |
| 5 | 508.890 | 236.917 |
| 6 | 510.760 | 237.626 |
| 7 | 512.589 | 238.435 |
| 8 | 514.371 | 239.342 |
| 9 | 516.103 | 240.343 |
| 10 | 517.778 | 241.436 |
| 11 | 519.392 | 242.617 |
| 12 | 520.939 | 243.884 |
| 13 | 522.417 | 245.232 |
| 14 | 523.820 | 246.658 |
| 15 | 525.144 | 248.157 |
| 16 | 526.385 | 249.725 |
| 17 | 527.540 | 251.357 |
| 18 | 528.606 | 253.050 |
| 19 | 529.579 | 254.797 |
| 20 | 530.456 | 256.594 |
| 21 | 531.236 | 258.436 |

| | | |
|---|---|---|
| 22 | 531.915 | 260.317 |
| 23 | 532.492 | 262.232 |
| 24 | 532.965 | 264.176 |
| 25 | 533.333 | 266.141 |
| 26 | 533.594 | 268.124 |
| 27 | 533.620 | 268.452 |

Circle Center At X = 496.650 ; Y = 271.988 ; and Radius = 37.146

Factor of Safety

*** 1.467 ***

Failure Surface Specified By 29 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 500.000 | 234.000 |
| 2 | 501.966 | 234.365 |
| 3 | 503.916 | 234.809 |
| 4 | 505.847 | 235.332 |
| 5 | 507.755 | 235.932 |
| 6 | 509.637 | 236.608 |
| 7 | 511.490 | 237.360 |
| 8 | 513.312 | 238.186 |
| 9 | 515.099 | 239.085 |
| 10 | 516.848 | 240.055 |
| 11 | 518.556 | 241.095 |
| 12 | 520.221 | 242.203 |
| 13 | 521.840 | 243.377 |
| 14 | 523.410 | 244.616 |
| 15 | 524.929 | 245.917 |
| 16 | 526.394 | 247.278 |
| 17 | 527.804 | 248.697 |
| 18 | 529.154 | 250.172 |
| 19 | 530.445 | 251.700 |
| 20 | 531.672 | 253.279 |
| 21 | 532.835 | 254.907 |
| 22 | 533.931 | 256.579 |
| 23 | 534.959 | 258.295 |
| 24 | 535.916 | 260.051 |
| 25 | 536.802 | 261.844 |
| 26 | 537.615 | 263.671 |
| 27 | 538.354 | 265.530 |
| 28 | 539.017 | 267.417 |
| 29 | 539.562 | 269.195 |

Circle Center At X = 491.938 ; Y = 282.900 ; and Radius = 49.560

Factor of Safety

*** 1.470 ***

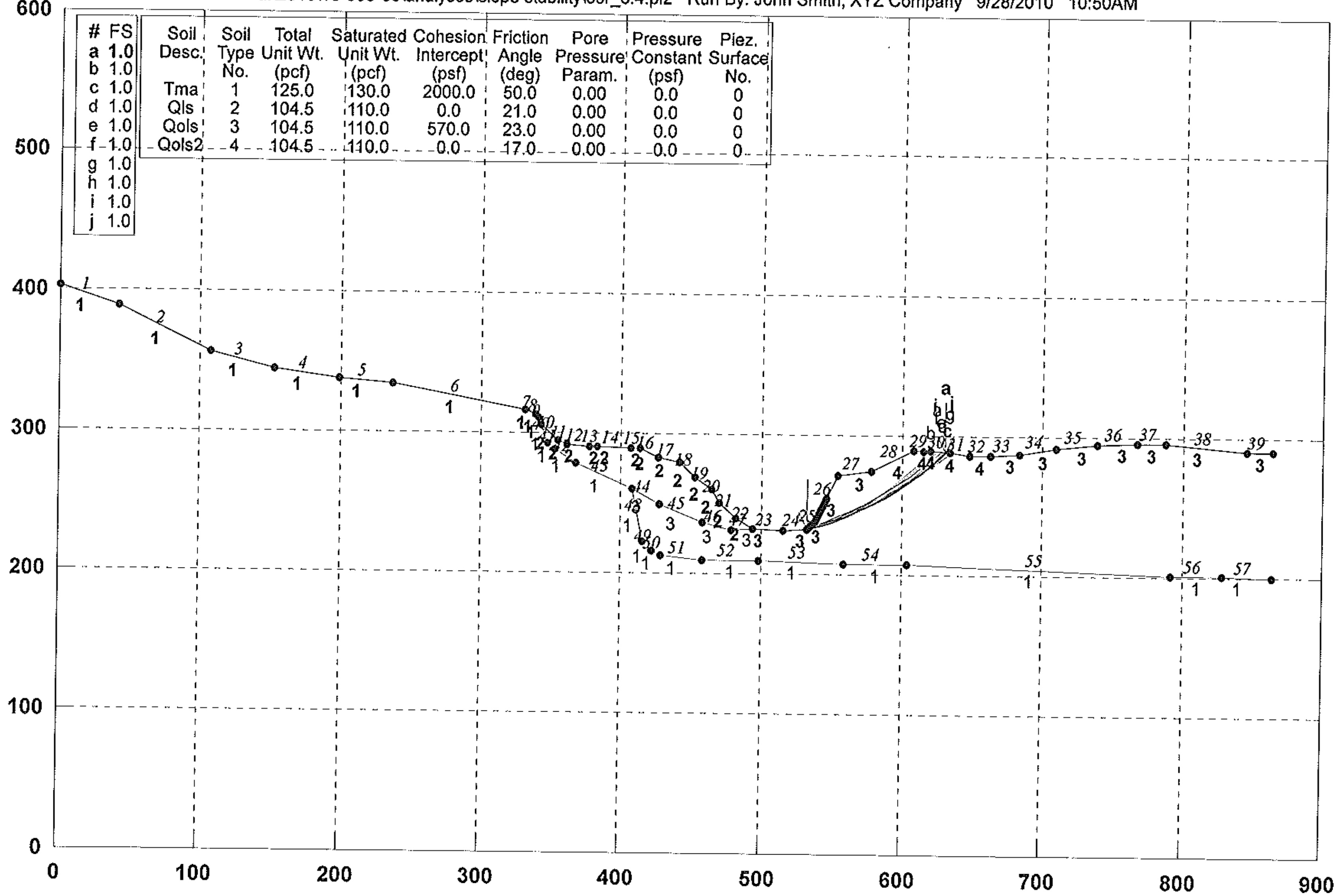
Failure Surface Specified By 27 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 501.111 | 235.111 |
| 2 | 503.019 | 235.712 |
| 3 | 504.903 | 236.381 |
| 4 | 506.763 | 237.118 |
| 5 | 508.595 | 237.920 |
| 6 | 510.396 | 238.788 |
| 7 | 512.166 | 239.721 |
| 8 | 513.901 | 240.716 |
| 9 | 515.599 | 241.773 |
| 10 | 517.257 | 242.890 |
| 11 | 518.875 | 244.066 |
| 12 | 520.449 | 245.300 |
| 13 | 521.978 | 246.589 |
| 14 | 523.460 | 247.933 |
| 15 | 524.892 | 249.328 |
| 16 | 526.274 | 250.775 |
| 17 | 527.602 | 252.270 |
| 18 | 528.876 | 253.812 |
| 19 | 530.094 | 255.398 |
| 20 | 531.253 | 257.028 |
| 21 | 532.354 | 258.698 |

```
   22        533.394      260.406
   23        534.371      262.151
   24        535.286      263.929
   25        536.136      265.740
   26        536.920      267.580
   27        537.439      268.930
Circle Center At X =   485.346 ; Y =   288.479 ; and Radius =    55.647
       Factor of Safety
      ***    1.471   ***
          **** END OF GSTABL7 OUTPUT ****
```

# Sect 3, Lower switch back, Amount of bluff face erosion for failure

u:\2010\10-036-00\analyses\slope stability\3sr_6.4.pl2 Run By: John Smith, XYZ Company 9/28/2010 10:50AM

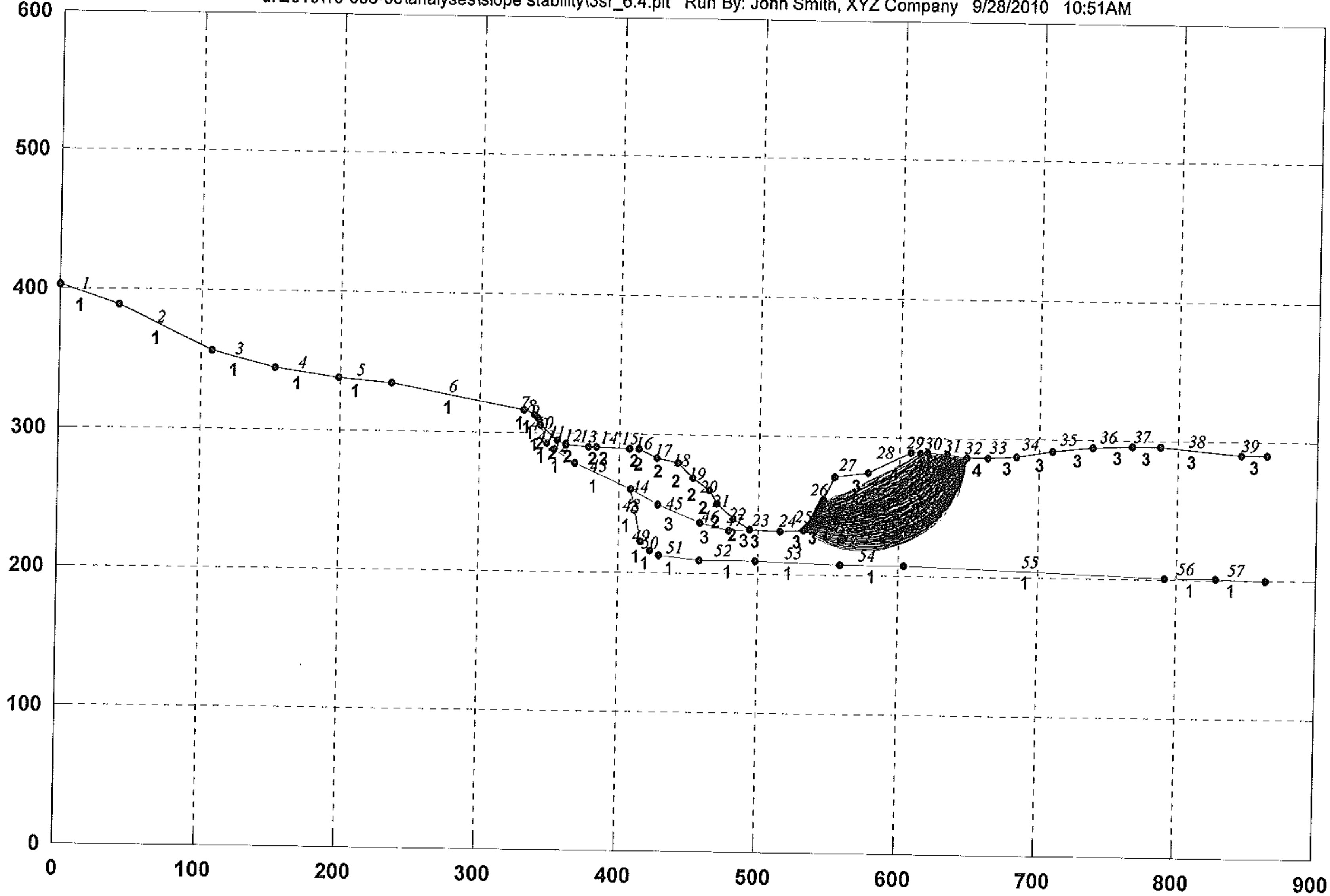



GSTABL7 v.2 FSmin=1.0

Safety Factors Are Calculated By The Modified Bishop Method

# Sect 3, Lower switch back, Amount of bluff face erosion for failure

u:\2010\10-036-00\analyses\slope stability\3sr_6.4.plt Run By: John Smith, XYZ Company 9/28/2010 10:51AM



*** **GSTABL7** ***

** GSTABL7 by Garry H. Gregory, P.E. **

** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **



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SLOPE STABILITY ANALYSIS SYSTEM

Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.

*********************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 10:50AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\3sr_6.4.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3sr_6.4.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3sr_6.4.PLT
PROBLEM DESCRIPTION: Sect 3, Lower switch back, Amount of
bluff face erosion for failure

BOUNDARY COORDINATES
39 Top Boundaries
57 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 403.00 | 42.00 | 389.00 | 1 |
| 2 | 42.00 | 389.00 | 108.00 | 356.00 | 1 |
| 3 | 108.00 | 356.00 | 153.00 | 345.00 | 1 |
| 4 | 153.00 | 345.00 | 199.00 | 338.00 | 1 |
| 5 | 199.00 | 338.00 | 236.00 | 335.00 | 1 |
| 6 | 236.00 | 335.00 | 332.00 | 316.00 | 1 |
| 7 | 332.00 | 316.00 | 339.00 | 313.00 | 1 |
| 8 | 339.00 | 313.00 | 341.00 | 311.00 | 1 |
| 9 | 341.00 | 311.00 | 343.00 | 306.00 | 1 |
| 10 | 343.00 | 306.00 | 355.00 | 295.00 | 2 |
| 11 | 355.00 | 295.00 | 362.00 | 292.00 | 2 |
| 12 | 362.00 | 292.00 | 378.00 | 291.00 | 2 |
| 13 | 378.00 | 291.00 | 383.00 | 291.00 | 2 |
| 14 | 383.00 | 291.00 | 407.00 | 289.00 | 2 |
| 15 | 407.00 | 289.00 | 414.00 | 289.00 | 2 |
| 16 | 414.00 | 289.00 | 427.00 | 283.00 | 2 |
| 17 | 427.00 | 283.00 | 442.00 | 280.00 | 2 |
| 18 | 442.00 | 280.00 | 453.00 | 269.00 | 2 |
| 19 | 453.00 | 269.00 | 464.00 | 260.00 | 2 |
| 20 | 464.00 | 260.00 | 470.00 | 251.00 | 2 |
| 21 | 470.00 | 251.00 | 482.00 | 240.00 | 2 |
| 22 | 482.00 | 240.00 | 494.00 | 232.00 | 2 |
| 23 | 494.00 | 232.00 | 515.00 | 231.00 | 3 |
| 24 | 515.00 | 231.00 | 532.00 | 232.00 | 3 |
| 25 | 532.00 | 232.00 | 538.00 | 238.00 | 3 |
| 26 | 538.00 | 238.00 | 554.00 | 271.00 | 3 |
| 27 | 554.00 | 271.00 | 578.00 | 274.00 | 3 |
| 28 | 578.00 | 274.00 | 608.00 | 289.00 | 4 |
| 29 | 608.00 | 289.00 | 620.00 | 289.00 | 4 |
| 30 | 620.00 | 289.00 | 634.00 | 288.00 | 4 |
| 31 | 634.00 | 288.00 | 648.00 | 286.00 | 4 |
| 32 | 648.00 | 286.00 | 663.00 | 286.00 | 4 |
| 33 | 663.00 | 286.00 | 684.00 | 287.00 | 3 |
| 34 | 684.00 | 287.00 | 710.00 | 292.00 | 3 |
| 35 | 710.00 | 292.00 | 739.00 | 295.00 | 3 |
| 36 | 739.00 | 295.00 | 767.00 | 296.00 | 3 |
| 37 | 767.00 | 296.00 | 787.00 | 296.00 | 3 |
| 38 | 787.00 | 296.00 | 846.00 | 291.00 | 3 |
| 39 | 846.00 | 291.00 | 864.00 | 291.00 | 3 |
| 40 | 343.00 | 306.00 | 348.00 | 293.00 | 1 |
| 41 | 348.00 | 293.00 | 353.00 | 288.00 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 42 | 353.00 | 288.00 | 368.00 | 279.00 | 1 |
| 43 | 368.00 | 279.00 | 408.00 | 260.00 | 1 |
| 44 | 408.00 | 260.00 | 428.00 | 250.00 | 3 |
| 45 | 428.00 | 250.00 | 458.00 | 236.00 | 3 |
| 46 | 458.00 | 236.00 | 478.00 | 231.00 | 3 |
| 47 | 478.00 | 231.00 | 494.00 | 232.00 | 3 |
| 48 | 408.00 | 260.00 | 416.00 | 223.00 | 1 |
| 49 | 416.00 | 223.00 | 422.00 | 216.00 | 1 |
| 50 | 422.00 | 216.00 | 429.00 | 213.00 | 1 |
| 51 | 429.00 | 213.00 | 458.00 | 210.00 | 1 |
| 52 | 458.00 | 210.00 | 498.00 | 210.00 | 1 |
| 53 | 498.00 | 210.00 | 558.00 | 207.00 | 1 |
| 54 | 558.00 | 207.00 | 604.00 | 207.00 | 1 |
| 55 | 604.00 | 207.00 | 792.00 | 201.00 | 1 |
| 56 | 792.00 | 201.00 | 828.00 | 201.00 | 1 |
| 57 | 828.00 | 201.00 | 864.00 | 200.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 125.0 | 130.0 | 2000.0 | 50.0 | 0.00 | 0.0 | 0 |
| 2 | 104.5 | 110.0 | 0.0 | 21.0 | 0.00 | 0.0 | 0 |
| 3 | 104.5 | 110.0 | 570.0 | 23.0 | 0.00 | 0.0 | 0 |
| 4 | 104.5 | 110.0 | 0.0 | 17.0 | 0.00 | 0.0 | 0 |

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.
500 Trial Surfaces Have Been Generated.
25 Surface(s) Initiate(s) From Each Of 20 Points Equally Spaced
Along The Ground Surface Between X = 532.00(ft)
and X = 546.00(ft)
Each Surface Terminates Between X = 615.00(ft)
and X = 648.00(ft)
Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00(ft)
10.00(ft) Line Segments Define Each Trial Failure Surface.
Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Evaluated. They Are
Ordered - Most Critical First.
* * Safety Factors Are Calculated By The Modified Bishop Method * *
Total Number of Trial Surfaces Attempted = 500
Number of Trial Surfaces With Valid FS = 500
Statistical Data On All Valid FS Values:
FS Max = 3.026 FS Min = 1.013 FS Ave = 1.633
Standard Deviation = 0.460 Coefficient of Variation = 28.15 %
Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 532.000 | 232.000 |
| 2 | 541.593 | 234.825 |
| 3 | 551.052 | 238.068 |
| 4 | 560.360 | 241.723 |
| 5 | 569.500 | 245.782 |
| 6 | 578.452 | 250.238 |
| 7 | 587.201 | 255.081 |
| 8 | 595.729 | 260.304 |
| 9 | 604.019 | 265.895 |
| 10 | 612.057 | 271.844 |
| 11 | 619.826 | 278.140 |
| 12 | 627.312 | 284.771 |
| 13 | 630.882 | 288.223 |

Circle Center At X = 472.362 ; Y = 452.177 ; and Radius = 228.111
Factor of Safety
*** 1.013 ***
Individual data on the 17 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.0 | 1327.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 3.6 | 2781.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 9.5 | 18502.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 2.9 | 9030.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 6.4 | 20553.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 9.1 | 27327.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 8.5 | 22715.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 0.5 | 1133.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 8.7 | 21716.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 8.5 | 20532.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 8.3 | 18919.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 4.0 | 8584.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 4.1 | 7910.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 7.8 | 11372.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 0.2 | 195.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 16 | 7.3 | 5506.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 17 | 3.6 | 691.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 532.000 | 232.000 |
| 2 | 541.459 | 235.243 |
| 3 | 550.739 | 238.970 |
| 4 | 559.815 | 243.169 |
| 5 | 568.661 | 247.831 |
| 6 | 577.256 | 252.943 |
| 7 | 585.576 | 258.491 |
| 8 | 593.599 | 264.460 |
| 9 | 601.304 | 270.835 |
| 10 | 608.670 | 277.598 |
| 11 | 615.678 | 284.732 |
| 12 | 619.458 | 289.000 |

Circle Center At X = 474.187 ; Y = 416.301 ; and Radius = 193.156

Factor of Safety

*** 1.014 ***

Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 532.000 | 232.000 |
| 2 | 541.510 | 235.090 |
| 3 | 550.900 | 238.530 |
| 4 | 560.156 | 242.316 |
| 5 | 569.266 | 246.441 |
| 6 | 578.216 | 250.900 |
| 7 | 586.996 | 255.687 |
| 8 | 595.592 | 260.796 |
| 9 | 603.994 | 266.220 |
| 10 | 612.189 | 271.951 |
| 11 | 620.166 | 277.981 |
| 12 | 627.915 | 284.302 |
| 13 | 632.262 | 288.124 |

Circle Center At X = 453.263 ; Y = 490.494 ; and Radius = 270.220

Factor of Safety

*** 1.016 ***

Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 533.474 | 233.474 |
| 2 | 543.055 | 236.335 |
| 3 | 552.497 | 239.631 |
| 4 | 561.778 | 243.354 |
| 5 | 570.879 | 247.497 |
| 6 | 579.782 | 252.051 |
| 7 | 588.468 | 257.007 |

| | | |
|---|---|---|
| 8 | 596.918 | 262.353 |
| 9 | 605.116 | 268.080 |
| 10 | 613.044 | 274.175 |
| 11 | 620.685 | 280.626 |
| 12 | 628.025 | 287.418 |
| 13 | 628.953 | 288.360 |

Circle Center At X = 475.597 ; Y = 444.750 ; and Radius = 219.060
Factor of Safety
*** 1.021 ***

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 533.474 | 233.474 |
| 2 | 542.868 | 236.901 |
| 3 | 552.131 | 240.668 |
| 4 | 561.250 | 244.772 |
| 5 | 570.214 | 249.206 |
| 6 | 579.009 | 253.964 |
| 7 | 587.625 | 259.040 |
| 8 | 596.050 | 264.427 |
| 9 | 604.273 | 270.118 |
| 10 | 612.282 | 276.106 |
| 11 | 620.067 | 282.382 |
| 12 | 627.105 | 288.493 |

Circle Center At X = 444.454 ; Y = 492.147 ; and Radius = 273.563
Factor of Safety
*** 1.022 ***

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 533.474 | 233.474 |
| 2 | 543.256 | 235.550 |
| 3 | 552.873 | 238.289 |
| 4 | 562.281 | 241.679 |
| 5 | 571.435 | 245.704 |
| 6 | 580.294 | 250.344 |
| 7 | 588.814 | 255.579 |
| 8 | 596.957 | 261.383 |
| 9 | 604.685 | 267.730 |
| 10 | 611.961 | 274.590 |
| 11 | 618.752 | 281.931 |
| 12 | 624.205 | 288.700 |

Circle Center At X = 508.090 ; Y = 377.322 ; and Radius = 146.070
Factor of Safety
*** 1.027 ***

Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 532.737 | 232.737 |
| 2 | 542.125 | 236.180 |
| 3 | 551.415 | 239.882 |
| 4 | 560.599 | 243.839 |
| 5 | 569.670 | 248.047 |
| 6 | 578.621 | 252.505 |
| 7 | 587.446 | 257.209 |
| 8 | 596.138 | 262.154 |
| 9 | 604.690 | 267.337 |
| 10 | 613.095 | 272.755 |
| 11 | 621.347 | 278.403 |
| 12 | 629.441 | 284.276 |
| 13 | 634.240 | 287.966 |

Circle Center At X = 412.779 ; Y = 574.307 ; and Radius = 362.022
Factor of Safety
*** 1.028 ***

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 534.947 | 234.947 |

| | | |
|---|---|---|
| 2 | 544.492 | 237.931 |
| 3 | 553.875 | 241.390 |
| 4 | 563.073 | 245.313 |
| 5 | 572.063 | 249.693 |
| 6 | 580.822 | 254.517 |
| 7 | 589.329 | 259.773 |
| 8 | 597.562 | 265.449 |
| 9 | 605.501 | 271.531 |
| 10 | 613.125 | 278.002 |
| 11 | 620.415 | 284.846 |
| 12 | 624.133 | 288.705 |

Circle Center At X = 480.499 ; Y = 426.140 ; and Radius = 198.794
Factor of Safety
*** 1.030 ***

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 534.947 | 234.947 |
| 2 | 544.492 | 237.931 |
| 3 | 553.871 | 241.400 |
| 4 | 563.060 | 245.345 |
| 5 | 572.035 | 249.755 |
| 6 | 580.772 | 254.619 |
| 7 | 589.249 | 259.925 |
| 8 | 597.442 | 265.658 |
| 9 | 605.331 | 271.803 |
| 10 | 612.895 | 278.344 |
| 11 | 620.114 | 285.264 |
| 12 | 623.403 | 288.757 |

Circle Center At X = 481.854 ; Y = 421.833 ; and Radius = 194.281
Factor of Safety
*** 1.030 ***

Failure Surface Specified By 13 Coordinate Points

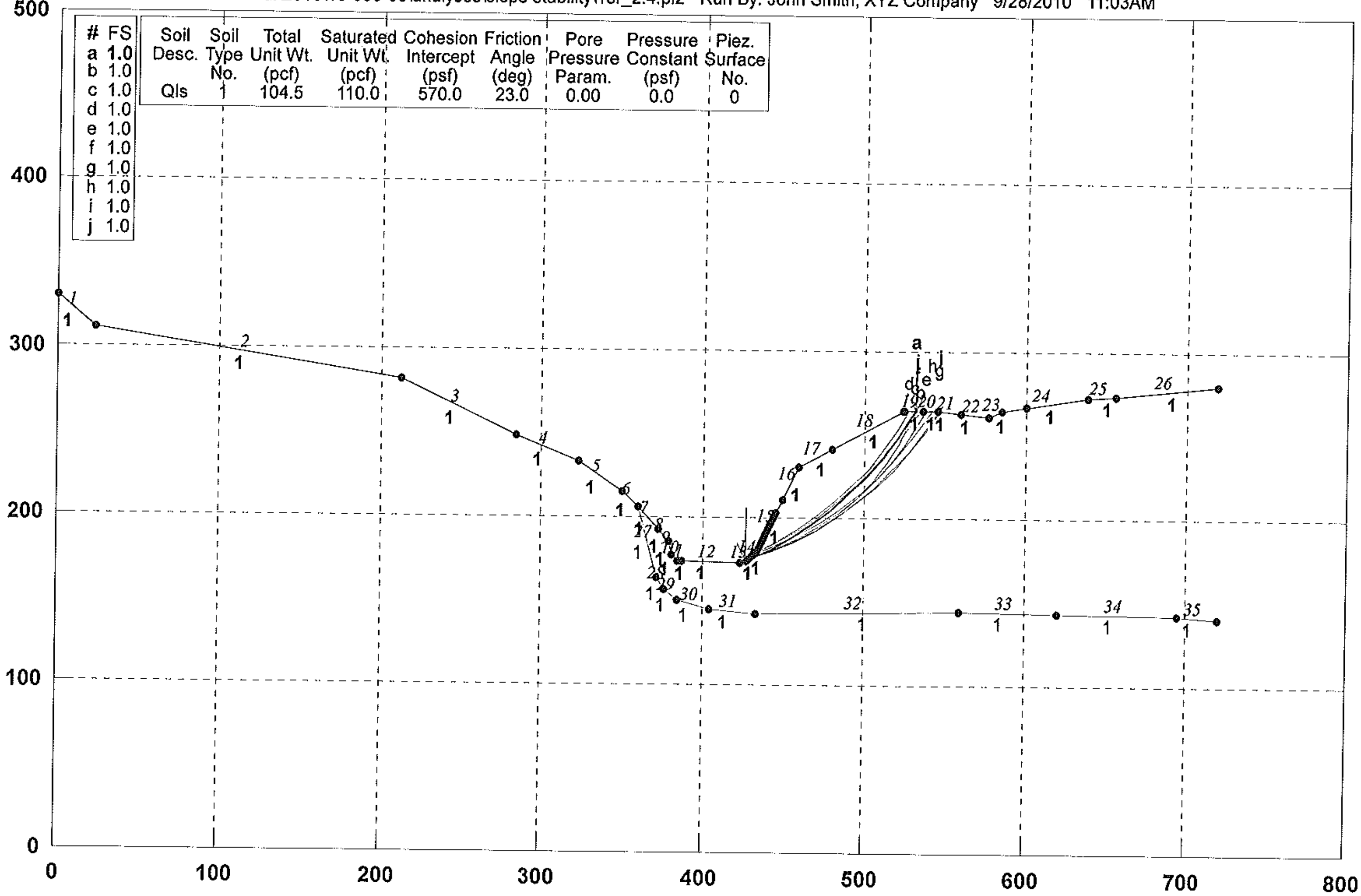
| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 532.737 | 232.737 |
| 2 | 542.147 | 236.120 |
| 3 | 551.461 | 239.760 |
| 4 | 560.671 | 243.655 |
| 5 | 569.771 | 247.802 |
| 6 | 578.754 | 252.197 |
| 7 | 587.612 | 256.836 |
| 8 | 596.340 | 261.718 |
| 9 | 604.930 | 266.837 |
| 10 | 613.376 | 272.191 |
| 11 | 621.673 | 277.774 |
| 12 | 629.812 | 283.583 |
| 13 | 635.392 | 287.801 |

Circle Center At X = 414.295 ; Y = 576.958 ; and Radius = 364.028
Factor of Safety
*** 1.031 ***

**** END OF GSTABL7 OUTPUT ****

**Sect 1, Upper switch back, Amount of bluff face erosion for failure**

u:\2010\10-036-00\analyses\slope stability\1sr_2.4.pl2 Run By: John Smith, XYZ Company 9/28/2010 11:03AM

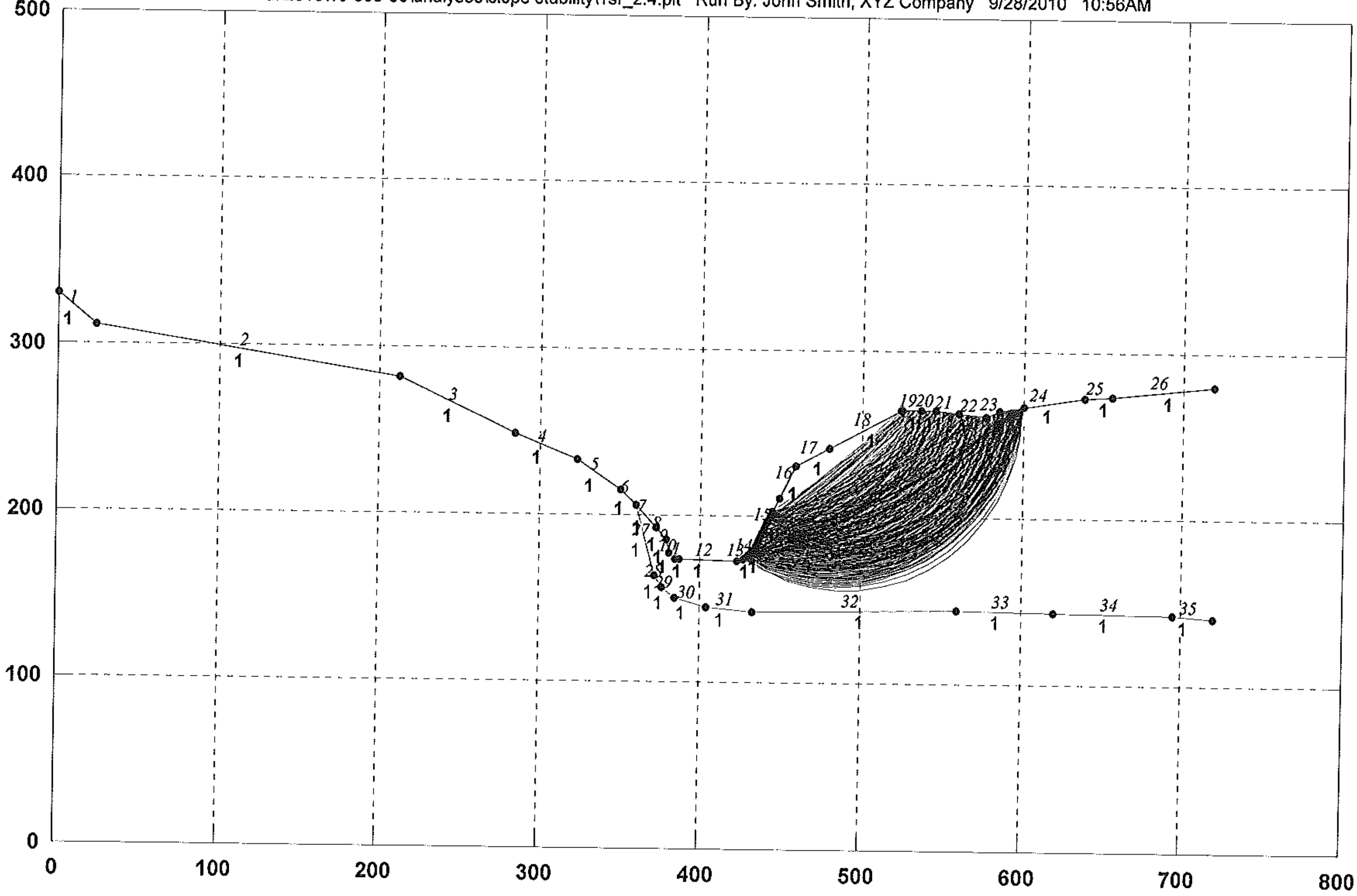



GSTABL7 v.2 FSmin=1.0

Safety Factors Are Calculated By The Modified Bishop Method

# Sect 1, Upper switch back, Amount of bluff face erosion for failure

u:\2010\10-036-00\analyses\slope stability\1sr_2.4.plt Run By: John Smith, XYZ Company 9/28/2010 10:56AM



*** GSTABL7 ***

** GSTABL7 by Garry H. Gregory, P.E. **

** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **



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SLOPE STABILITY ANALYSIS SYSTEM

Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.

*********************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 10:56AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\1sr_2.4.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\1sr_2.4.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\1sr_2.4.PLT
PROBLEM DESCRIPTION: Sect 1, Upper switch back, Amount of bluff face erosion for failure

BOUNDARY COORDINATES
26 Top Boundaries
35 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 330.00 | 23.00 | 311.00 | 1 |
| 2 | 23.00 | 311.00 | 212.00 | 282.00 | 1 |
| 3 | 212.00 | 282.00 | 284.00 | 248.00 | 1 |
| 4 | 284.00 | 248.00 | 323.00 | 233.00 | 1 |
| 5 | 323.00 | 233.00 | 350.00 | 215.00 | 1 |
| 6 | 350.00 | 215.00 | 360.00 | 206.00 | 1 |
| 7 | 360.00 | 206.00 | 373.00 | 193.00 | 1 |
| 8 | 373.00 | 193.00 | 379.00 | 185.00 | 1 |
| 9 | 379.00 | 185.00 | 381.00 | 177.00 | 1 |
| 10 | 381.00 | 177.00 | 384.00 | 174.00 | 1 |
| 11 | 384.00 | 174.00 | 387.00 | 174.00 | 1 |
| 12 | 387.00 | 174.00 | 423.00 | 173.00 | 1 |
| 13 | 423.00 | 173.00 | 427.00 | 174.00 | 1 |
| 14 | 427.00 | 174.00 | 433.00 | 179.00 | 1 |
| 15 | 433.00 | 179.00 | 449.00 | 211.00 | 1 |
| 16 | 449.00 | 211.00 | 459.00 | 230.00 | 1 |
| 17 | 459.00 | 230.00 | 480.00 | 241.00 | 1 |
| 18 | 480.00 | 241.00 | 525.00 | 265.00 | 1 |
| 19 | 525.00 | 265.00 | 536.00 | 265.00 | 1 |
| 20 | 536.00 | 265.00 | 545.00 | 265.00 | 1 |
| 21 | 545.00 | 265.00 | 560.00 | 263.00 | 1 |
| 22 | 560.00 | 263.00 | 577.00 | 261.00 | 1 |
| 23 | 577.00 | 261.00 | 585.00 | 265.00 | 1 |
| 24 | 585.00 | 265.00 | 638.00 | 273.00 | 1 |
| 25 | 638.00 | 273.00 | 655.00 | 274.00 | 1 |
| 26 | 655.00 | 274.00 | 719.00 | 280.00 | 1 |
| 27 | 360.00 | 206.00 | 372.00 | 164.00 | 1 |
| 28 | 372.00 | 164.00 | 376.00 | 157.00 | 1 |
| 29 | 376.00 | 157.00 | 384.00 | 150.00 | 1 |
| 30 | 384.00 | 150.00 | 404.00 | 145.00 | 1 |
| 31 | 404.00 | 145.00 | 433.00 | 142.00 | 1 |
| 32 | 433.00 | 142.00 | 560.00 | 144.00 | 1 |
| 33 | 560.00 | 144.00 | 620.00 | 143.00 | 1 |
| 34 | 620.00 | 143.00 | 695.00 | 142.00 | 1 |
| 35 | 695.00 | 142.00 | 720.00 | 140.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)

ISOTROPIC SOIL PARAMETERS
1 Type(s) of Soil

Soil Total Saturated Cohesion Friction Pore Pressure Piez.

| Type No. | Unit Wt. (pcf) | Unit Wt. (pcf) | Intercept (psf) | Angle (deg) | Pressure Param. | Constant (psf) | Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 104.5 | 110.0 | 570.0 | 23.0 | 0.00 | 0.0 | 0 |

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.
500 Trial Surfaces Have Been Generated.
25 Surface(s) Initiate(s) From Each Of 20 Points Equally Spaced
Along The Ground Surface Between X = 427.00(ft)
and X = 445.00(ft)
Each Surface Terminates Between X = 524.00(ft)
and X = 600.00(ft)
Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00(ft)
15.00(ft) Line Segments Define Each Trial Failure Surface.
Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Evaluated. They Are
Ordered - Most Critical First.
* * Safety Factors Are Calculated By The Modified Bishop Method * *
Total Number of Trial Surfaces Attempted = 500
Number of Trial Surfaces With Valid FS = 500
Statistical Data On All Valid FS Values:
FS Max = 3.265 FS Min = 1.023 FS Ave = 1.684
Standard Deviation = 0.465 Coefficient of Variation = 27.64 %
Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 427.000 | 174.000 |
| 2 | 440.633 | 180.255 |
| 3 | 453.813 | 187.417 |
| 4 | 466.480 | 195.452 |
| 5 | 478.575 | 204.324 |
| 6 | 490.043 | 213.993 |
| 7 | 500.832 | 224.414 |
| 8 | 510.893 | 235.539 |
| 9 | 520.179 | 247.319 |
| 10 | 528.649 | 259.699 |
| 11 | 531.773 | 265.000 |

Circle Center At X = 341.283 ; Y = 378.804 ; and Radius = 222.019
Factor of Safety
*** 1.023 ***
Individual data on the 15 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.0 | 704.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 7.6 | 6484.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 8.4 | 17577.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 4.8 | 14820.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 5.2 | 19517.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 7.5 | 30389.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 12.1 | 47014.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 1.4 | 5318.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 10.0 | 35596.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 10.8 | 33857.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 10.1 | 26091.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 9.3 | 17976.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 4.8 | 6484.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 3.6 | 3038.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 3.1 | 865.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 427.947 | 174.789 |
| 2 | 441.583 | 181.041 |
| 3 | 454.784 | 188.162 |
| 4 | 467.497 | 196.123 |
| 5 | 479.668 | 204.891 |

| | | |
|---|---|---|
| 6 | 491.246 | 214.428 |
| 7 | 502.182 | 224.694 |
| 8 | 512.430 | 235.648 |
| 9 | 521.948 | 247.241 |
| 10 | 530.695 | 259.427 |
| 11 | 534.172 | 265.000 |

Circle Center At X = 338.308 ; Y = 388.295 ; and Radius = 231.559

Factor of Safety

*** 1.025 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 428.895 | 175.579 |
| 2 | 443.290 | 179.794 |
| 3 | 457.174 | 185.473 |
| 4 | 470.398 | 192.553 |
| 5 | 482.821 | 200.960 |
| 6 | 494.310 | 210.603 |
| 7 | 504.743 | 221.381 |
| 8 | 514.008 | 233.177 |
| 9 | 522.007 | 245.866 |
| 10 | 528.654 | 259.313 |
| 11 | 530.767 | 265.000 |

Circle Center At X = 395.343 ; Y = 316.844 ; and Radius = 145.195

Factor of Safety

*** 1.026 ***

Failure Surface Specified By 10 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 429.842 | 176.368 |
| 2 | 443.447 | 182.687 |
| 3 | 456.527 | 190.028 |
| 4 | 469.007 | 198.350 |
| 5 | 480.813 | 207.603 |
| 6 | 491.876 | 217.733 |
| 7 | 502.130 | 228.680 |
| 8 | 511.516 | 240.380 |
| 9 | 519.979 | 252.765 |
| 10 | 527.029 | 265.000 |

Circle Center At X = 354.396 ; Y = 356.696 ; and Radius = 195.475

Factor of Safety

*** 1.029 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 429.842 | 176.368 |
| 2 | 444.021 | 181.263 |
| 3 | 457.748 | 187.310 |
| 4 | 470.929 | 194.470 |
| 5 | 483.474 | 202.693 |
| 6 | 495.298 | 211.923 |
| 7 | 506.321 | 222.097 |
| 8 | 516.466 | 233.146 |
| 9 | 525.665 | 244.994 |
| 10 | 533.854 | 257.561 |
| 11 | 537.870 | 265.000 |

Circle Center At X = 377.716 ; Y = 350.364 ; and Radius = 181.636

Factor of Safety

*** 1.030 ***

Failure Surface Specified By 10 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 432.684 | 178.737 |
| 2 | 446.162 | 185.320 |
| 3 | 459.188 | 192.759 |
| 4 | 471.706 | 201.023 |
| 5 | 483.665 | 210.078 |
| 6 | 495.014 | 219.885 |

| | | |
|---|---|---|
| 7 | 505.708 | 230.404 |
| 8 | 515.700 | 241.591 |
| 9 | 524.950 | 253.400 |
| 10 | 532.884 | 265.000 |

Circle Center At X = 337.667 ; Y = 390.430 ; and Radius = 232.039

Factor of Safety

*** 1.036 ***

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 427.947 | 174.789 |
| 2 | 442.130 | 179.673 |
| 3 | 455.936 | 185.538 |
| 4 | 469.297 | 192.356 |
| 5 | 482.148 | 200.092 |
| 6 | 494.425 | 208.711 |
| 7 | 506.068 | 218.168 |
| 8 | 517.020 | 228.417 |
| 9 | 527.227 | 239.409 |
| 10 | 536.640 | 251.088 |
| 11 | 545.211 | 263.398 |
| 12 | 546.081 | 264.856 |

Circle Center At X = 365.607 ; Y = 379.063 ; and Radius = 213.574

Factor of Safety

*** 1.040 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 431.737 | 177.947 |
| 2 | 445.721 | 183.373 |
| 3 | 459.292 | 189.764 |
| 4 | 472.382 | 197.087 |
| 5 | 484.929 | 205.309 |
| 6 | 496.869 | 214.387 |
| 7 | 508.146 | 224.278 |
| 8 | 518.703 | 234.934 |
| 9 | 528.490 | 246.302 |
| 10 | 537.457 | 258.326 |
| 11 | 541.742 | 265.000 |

Circle Center At X = 361.235 ; Y = 380.391 ; and Radius = 214.369

Factor of Safety

*** 1.042 ***

Failure Surface Specified By 10 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 432.684 | 178.737 |
| 2 | 445.936 | 185.764 |
| 3 | 458.771 | 193.528 |
| 4 | 471.146 | 202.004 |
| 5 | 483.023 | 211.165 |
| 6 | 494.364 | 220.983 |
| 7 | 505.133 | 231.425 |
| 8 | 515.295 | 242.458 |
| 9 | 524.817 | 254.048 |
| 10 | 532.825 | 265.000 |

Circle Center At X = 315.244 ; Y = 416.326 ; and Radius = 265.030

Factor of Safety

*** 1.043 ***

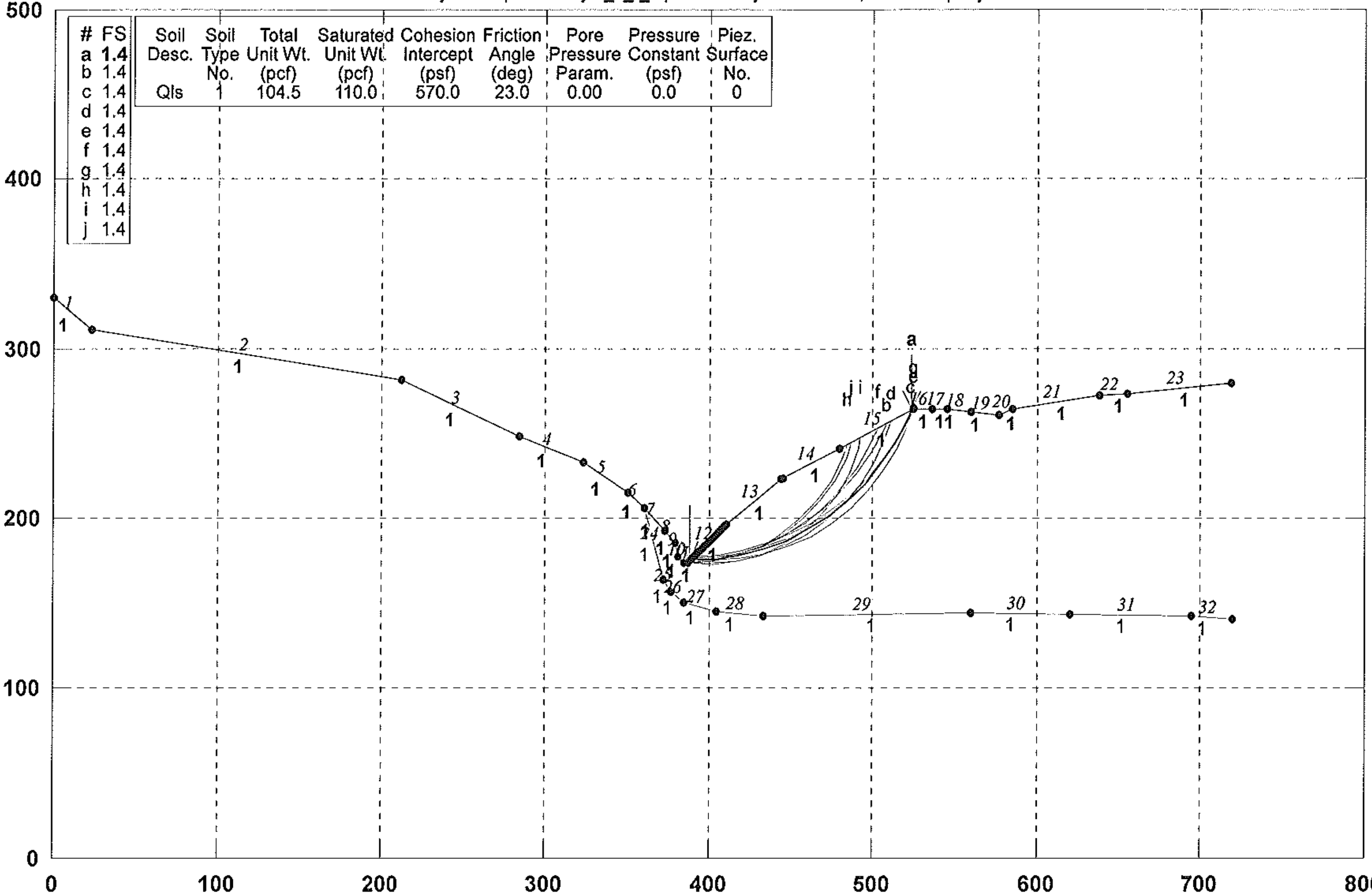
Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 428.895 | 175.579 |
| 2 | 443.097 | 180.405 |
| 3 | 456.925 | 186.218 |
| 4 | 470.309 | 192.990 |
| 5 | 483.184 | 200.687 |
| 6 | 495.485 | 209.271 |
| 7 | 507.152 | 218.699 |

```
     8        518.126      228.925
     9        528.353      239.898
    10        537.784      251.563
    11        546.370      263.862
    12        546.899      264.747
Circle Center At X =   367.619 ; Y =   379.338 ; and Radius =   212.773
       Factor of Safety
      ***    1.046   ***
          **** END OF GSTABL7 OUTPUT ****
```

**Sect 1, Static, Upper swich back, Existing Cond, circ. search @ bluff face**

u:\2010\10-036-00\analyses\slope stability\1_s_r_2.pl2 Run By: John Smith, XYZ Company 9/28/2010 10:12AM

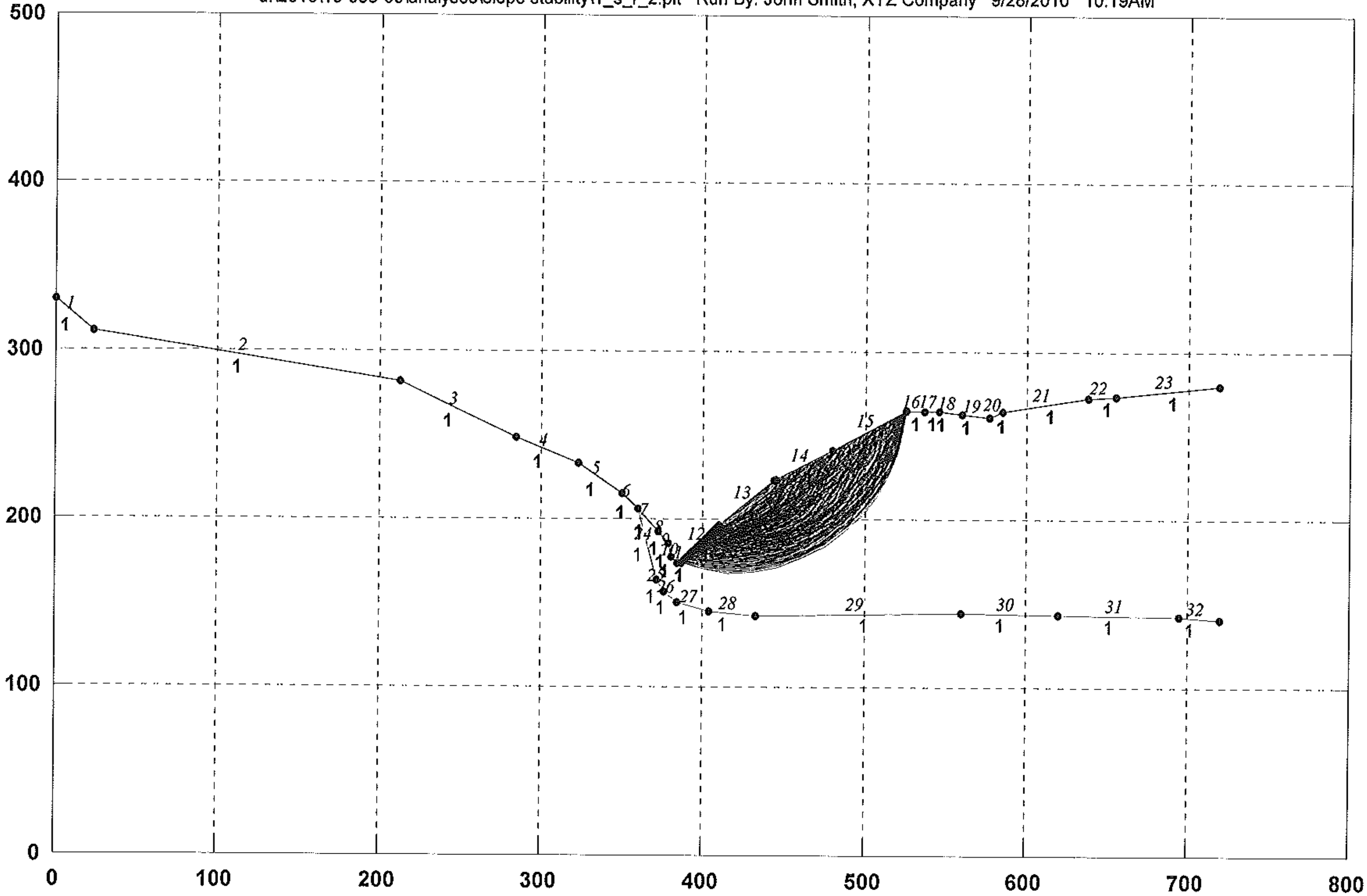



**GSTABL7 v.2 FSmin=1.4**

**Safety Factors Are Calculated By The Modified Bishop Method**

# Sect 1, Static, Upper swich back, Existing Cond, circ. search @ bluff face

u:\2010\10-036-00\analyses\slope stability\1_s_r_2.plt   Run By: John Smith, XYZ Company   9/28/2010   10:19AM



*** **GSTABL7** ***
** GSTABL7 by Garry H. Gregory, P.E. **
** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **

*****************************************************************************
SLOPE STABILITY ANALYSIS SYSTEM
Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.
*****************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 10:12AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\1_s_r_2.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\1_s_r_2.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\1_s_r_2.PLT
PROBLEM DESCRIPTION: Sect 1, Static, Upper swich back,
Existing Cond, circ. search @ bluff face

BOUNDARY COORDINATES
23 Top Boundaries
32 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 330.00 | 23.00 | 311.00 | 1 |
| 2 | 23.00 | 311.00 | 212.00 | 282.00 | 1 |
| 3 | 212.00 | 282.00 | 284.00 | 248.00 | 1 |
| 4 | 284.00 | 248.00 | 323.00 | 233.00 | 1 |
| 5 | 323.00 | 233.00 | 350.00 | 215.00 | 1 |
| 6 | 350.00 | 215.00 | 360.00 | 206.00 | 1 |
| 7 | 360.00 | 206.00 | 373.00 | 193.00 | 1 |
| 8 | 373.00 | 193.00 | 379.00 | 185.00 | 1 |
| 9 | 379.00 | 185.00 | 381.00 | 177.00 | 1 |
| 10 | 381.00 | 177.00 | 384.00 | 174.00 | 1 |
| 11 | 384.00 | 174.00 | 387.00 | 174.00 | 1 |
| 12 | 387.00 | 174.00 | 410.00 | 196.00 | 1 |
| 13 | 410.00 | 196.00 | 444.00 | 223.00 | 1 |
| 14 | 444.00 | 223.00 | 480.00 | 241.00 | 1 |
| 15 | 480.00 | 241.00 | 525.00 | 265.00 | 1 |
| 16 | 525.00 | 265.00 | 536.00 | 265.00 | 1 |
| 17 | 536.00 | 265.00 | 545.00 | 265.00 | 1 |
| 18 | 545.00 | 265.00 | 560.00 | 263.00 | 1 |
| 19 | 560.00 | 263.00 | 577.00 | 261.00 | 1 |
| 20 | 577.00 | 261.00 | 585.00 | 265.00 | 1 |
| 21 | 585.00 | 265.00 | 638.00 | 273.00 | 1 |
| 22 | 638.00 | 273.00 | 655.00 | 274.00 | 1 |
| 23 | 655.00 | 274.00 | 719.00 | 280.00 | 1 |
| 24 | 360.00 | 206.00 | 372.00 | 164.00 | 1 |
| 25 | 372.00 | 164.00 | 376.00 | 157.00 | 1 |
| 26 | 376.00 | 157.00 | 384.00 | 150.00 | 1 |
| 27 | 384.00 | 150.00 | 404.00 | 145.00 | 1 |
| 28 | 404.00 | 145.00 | 433.00 | 142.00 | 1 |
| 29 | 433.00 | 142.00 | 560.00 | 144.00 | 1 |
| 30 | 560.00 | 144.00 | 620.00 | 143.00 | 1 |
| 31 | 620.00 | 143.00 | 695.00 | 142.00 | 1 |
| 32 | 695.00 | 142.00 | 720.00 | 140.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)

ISOTROPIC SOIL PARAMETERS
1 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 104.5 | 110.0 | 570.0 | 23.0 | 0.00 | 0.0 | 0 |

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.
500 Trial Surfaces Have Been Generated.
25 Surface(s) Initiate(s) From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 387.00(ft) and X = 410.00(ft)
Each Surface Terminates Between X = 445.00(ft) and X = 525.00(ft)
Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00(ft)
15.00(ft) Line Segments Define Each Trial Failure Surface.
Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Evaluated. They Are Ordered - Most Critical First.
* * Safety Factors Are Calculated By The Modified Bishop Method * *
Total Number of Trial Surfaces Attempted = 500
Number of Trial Surfaces With Valid FS = 500
Statistical Data On All Valid FS Values:
FS Max = 17.699 FS Min = 1.377 FS Ave = 2.042
Standard Deviation = 1.452 Coefficient of Variation = 71.13 %
Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 388.211 | 175.158 |
| 2 | 403.200 | 175.723 |
| 3 | 418.050 | 177.837 |
| 4 | 432.602 | 181.478 |
| 5 | 446.698 | 186.606 |
| 6 | 460.187 | 193.167 |
| 7 | 472.924 | 201.089 |
| 8 | 484.773 | 210.287 |
| 9 | 495.605 | 220.663 |
| 10 | 505.305 | 232.105 |
| 11 | 513.767 | 244.490 |
| 12 | 520.902 | 257.685 |
| 13 | 523.622 | 264.265 |

Circle Center At X = 390.262 ; Y = 319.796 ; and Radius = 144.653
Factor of Safety
*** 1.377 ***
Individual data on the 15 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.0 | 10786.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 6.8 | 11753.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 8.1 | 18450.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 14.6 | 43357.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 11.4 | 41597.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 2.7 | 10588.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 13.5 | 53332.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 12.7 | 49449.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 7.1 | 26171.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 4.8 | 16877.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 10.8 | 35044.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 9.7 | 25872.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 8.5 | 16320.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 7.1 | 7324.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 2.7 | 728.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 387.000 | 174.000 |
| 2 | 401.930 | 175.451 |
| 3 | 416.618 | 178.495 |
| 4 | 430.894 | 183.096 |
| 5 | 444.595 | 189.202 |
| 6 | 457.563 | 196.742 |

| | | |
|---|---|---|
| 7 | 469.647 | 205.629 |
| 8 | 480.708 | 215.760 |
| 9 | 490.619 | 227.020 |
| 10 | 499.266 | 239.277 |
| 11 | 506.548 | 252.390 |
| 12 | 508.057 | 255.964 |

Circle Center At X = 381.132 ; Y = 313.047 ; and Radius = 139.171

Factor of Safety

*** 1.389 ***

Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 389.421 | 176.316 |
| 2 | 404.402 | 177.072 |
| 3 | 419.226 | 179.362 |
| 4 | 433.738 | 183.159 |
| 5 | 447.783 | 188.425 |
| 6 | 461.214 | 195.104 |
| 7 | 473.889 | 203.125 |
| 8 | 485.675 | 212.404 |
| 9 | 496.447 | 222.843 |
| 10 | 506.091 | 234.331 |
| 11 | 514.506 | 246.748 |
| 12 | 521.603 | 259.963 |
| 13 | 523.302 | 264.094 |

Circle Center At X = 389.554 ; Y = 322.368 ; and Radius = 146.052

Factor of Safety

*** 1.390 ***

Failure Surface Specified By 12 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 387.000 | 174.000 |
| 2 | 401.990 | 173.455 |
| 3 | 416.927 | 174.829 |
| 4 | 431.566 | 178.100 |
| 5 | 445.668 | 183.213 |
| 6 | 459.001 | 190.084 |
| 7 | 471.348 | 198.603 |
| 8 | 482.506 | 208.628 |
| 9 | 492.292 | 219.996 |
| 10 | 500.546 | 232.521 |
| 11 | 507.133 | 245.997 |
| 12 | 511.050 | 257.560 |

Circle Center At X = 398.811 ; Y = 290.326 ; and Radius = 116.924

Factor of Safety

*** 1.400 ***

Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 390.632 | 177.474 |
| 2 | 405.592 | 178.566 |
| 3 | 420.372 | 181.123 |
| 4 | 434.830 | 185.120 |
| 5 | 448.825 | 190.518 |
| 6 | 462.222 | 197.266 |
| 7 | 474.891 | 205.297 |
| 8 | 486.709 | 214.534 |
| 9 | 497.563 | 224.888 |
| 10 | 507.346 | 236.258 |
| 11 | 515.966 | 248.534 |
| 12 | 523.337 | 261.598 |
| 13 | 524.787 | 264.886 |

Circle Center At X = 387.022 ; Y = 329.900 ; and Radius = 152.469

Factor of Safety

*** 1.401 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|

```
    1         388.211      175.158
    2         403.177      176.156
    3         417.916      178.942
    4         432.214      183.478
    5         445.864      189.698
    6         458.669      197.510
    7         470.443      206.803
    8         481.017      217.443
    9         490.237      229.274
   10         497.971      242.127
   11         502.951      253.241
Circle Center At X =   387.413 ; Y =   299.896 ; and Radius =   124.741
       Factor of Safety
      ***    1.410   ***
Failure Surface Specified By 13 Coordinate Points
  Point       X-Surf      Y-Surf
   No.         (ft)        (ft)
    1         389.421      176.316
    2         404.391      175.362
    3         419.367      176.209
    4         434.133      178.845
    5         448.478      183.231
    6         462.193      189.304
    7         475.082      196.977
    8         486.959      206.140
    9         497.652      216.659
   10         507.007      228.385
   11         514.890      241.146
   12         521.186      254.761
   13         524.397      264.678
Circle Center At X =   404.836 ; Y =   300.310 ; and Radius =   124.949
       Factor of Safety
      ***    1.412   ***
Failure Surface Specified By 10 Coordinate Points
  Point       X-Surf      Y-Surf
   No.         (ft)        (ft)
    1         387.000      174.000
    2         401.975      174.869
    3         416.657      177.938
    4         430.726      183.141
    5         443.873      190.363
    6         455.810      199.447
    7         466.276      210.192
    8         475.041      222.365
    9         481.914      235.697
   10         484.541      243.422
Circle Center At X =   388.826 ; Y =   274.670 ; and Radius =   100.687
       Factor of Safety
      ***    1.430   ***
Failure Surface Specified By 11 Coordinate Points
  Point       X-Surf      Y-Surf
   No.         (ft)        (ft)
    1         387.000      174.000
    2         401.974      173.121
    3         416.901      174.604
    4         431.409      178.414
    5         445.139      184.455
    6         457.749      192.578
    7         468.927      202.580
    8         478.396      214.214
    9         485.919      227.191
   10         491.312      241.188
   11         492.717      247.782
Circle Center At X =   400.050 ; Y =   268.307 ; and Radius =    95.206
       Factor of Safety
      ***    1.440   ***
Failure Surface Specified By 10 Coordinate Points
  Point       X-Surf      Y-Surf
```

| No. | (ft) | (ft) |
|---|---|---|
| 1 | 388.211 | 175.158 |
| 2 | 403.193 | 175.885 |
| 3 | 417.905 | 178.808 |
| 4 | 432.028 | 183.862 |
| 5 | 445.254 | 190.939 |
| 6 | 457.295 | 199.883 |
| 7 | 467.890 | 210.502 |
| 8 | 476.809 | 222.562 |
| 9 | 483.856 | 235.804 |
| 10 | 487.037 | 244.753 |

Circle Center At X = 390.955 ; Y = 276.227 ; and Radius = 101.106

Factor of Safety

*** 1.441 ***

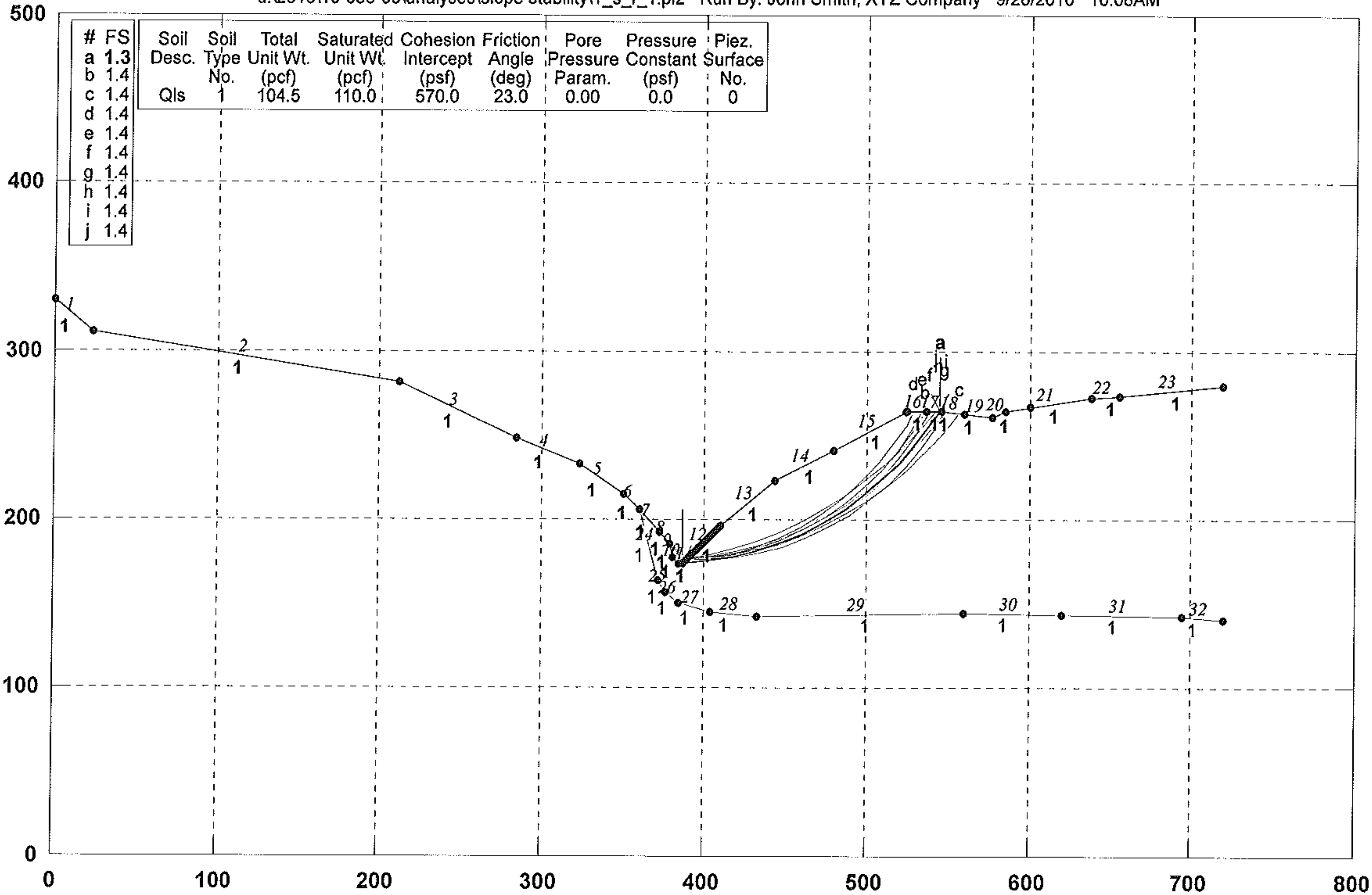
**** END OF GSTABL7 OUTPUT ****

## Sect 1, Static, Upper swich back, Existing Cond, circular search at road

u:\2010\10-036-00\analyses\slope stability\1_s_r_1.pl2   Run By: John Smith, XYZ Company   9/28/2010   10:08AM

| # | FS |
|---|---|
| a | 1.3 |
| b | 1.4 |
| c | 1.4 |
| d | 1.4 |
| e | 1.4 |
| f | 1.4 |
| g | 1.4 |
| h | 1.4 |
| i | 1.4 |
| j | 1.4 |

| Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|---|
| Qls | 1 | 104.5 | 110.0 | 570.0 | 23.0 | 0.00 | 0.0 | 0 |

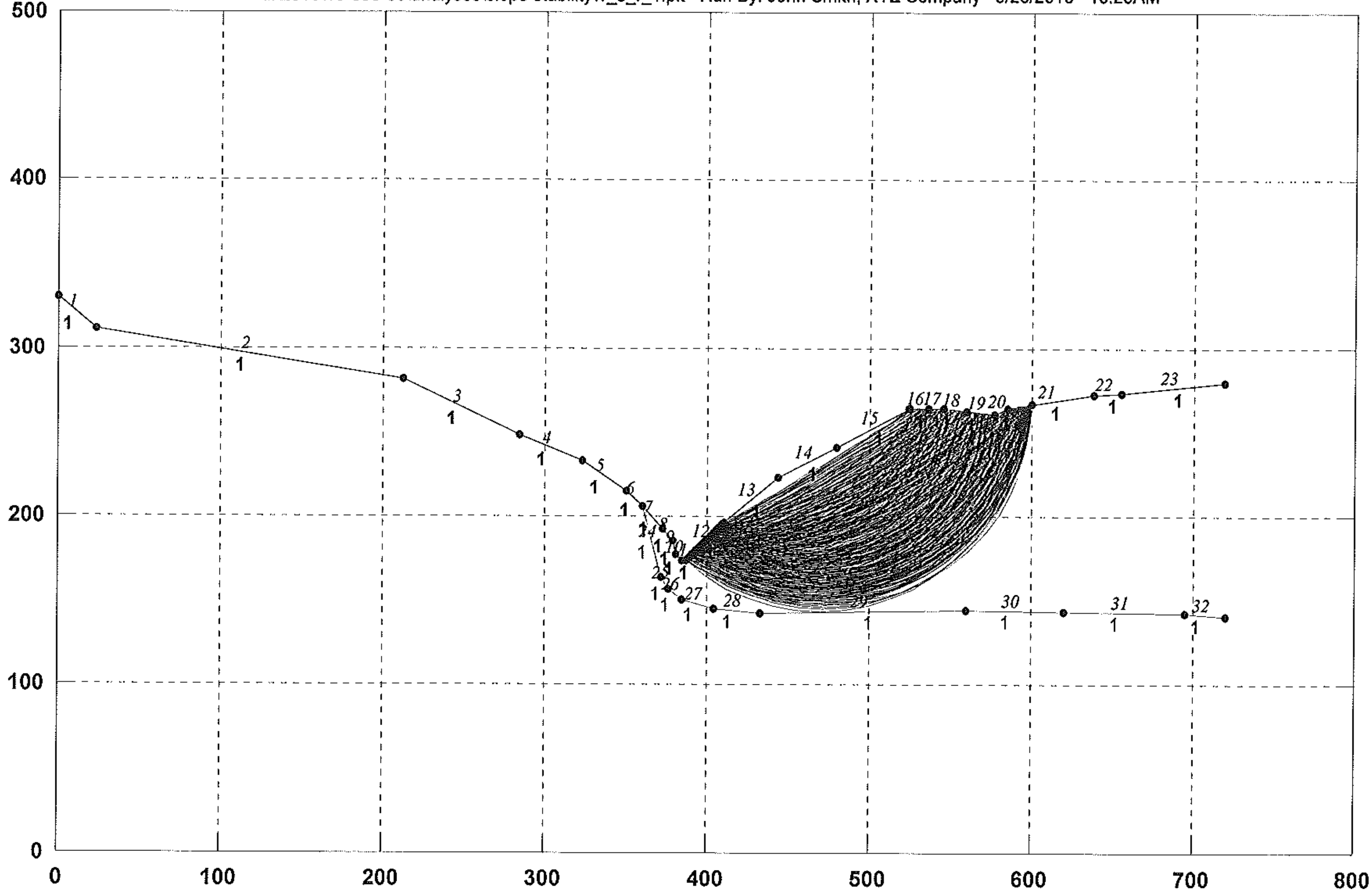


GSTABL7 v.2  FSmin=1.3

**Safety Factors Are Calculated By The Modified Bishop Method**

## Sect 1, Static, Upper swich back, Existing Cond, circular search at road

u:\2010\10-036-00\analyses\slope stability\1_s_r_1.plt Run By: John Smith, XYZ Company 9/28/2010 10:20AM



```
                         ***  GSTABL7  ***
               ** GSTABL7 by Garry H. Gregory, P.E. **
   ** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **
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*********************************************************************************
                    SLOPE STABILITY ANALYSIS SYSTEM
       Modified Bishop, Simplified Janbu, or GLE Method of Slices.
       (Includes Spencer & Morgenstern-Price Type Analysis)
       Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
       Nonlinear Undrained Shear Strength, Curved Phi Envelope,
       Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
       Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.
*********************************************************************************
Analysis Run Date:         9/28/2010
Time of Run:               10:08AM
Run By:                    John Smith, XYZ Company
Input Data Filename:       U:\2010\10-036-00\Analyses\Slope Stability\1_s_r_1.in
Output Filename:           U:\2010\10-036-00\Analyses\Slope Stability\1_s_r_1.OUT
Unit System:               English
Plotted Output Filename:   U:\2010\10-036-00\Analyses\Slope Stability\1_s_r_1.PLT
PROBLEM DESCRIPTION:  Sect 1, Static, Upper swich back,
                      Existing Cond, circular search at road
BOUNDARY COORDINATES
   23 Top   Boundaries
   32 Total Boundaries
Boundary     X-Left     Y-Left    X-Right    Y-Right    Soil Type
   No.        (ft)       (ft)       (ft)       (ft)     Below Bnd
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| | | | | | |
|---|---|---|---|---|---|
| 1 | 0.00 | 330.00 | 23.00 | 311.00 | 1 |
| 2 | 23.00 | 311.00 | 212.00 | 282.00 | 1 |
| 3 | 212.00 | 282.00 | 284.00 | 248.00 | 1 |
| 4 | 284.00 | 248.00 | 323.00 | 233.00 | 1 |
| 5 | 323.00 | 233.00 | 350.00 | 215.00 | 1 |
| 6 | 350.00 | 215.00 | 360.00 | 206.00 | 1 |
| 7 | 360.00 | 206.00 | 373.00 | 193.00 | 1 |
| 8 | 373.00 | 193.00 | 379.00 | 185.00 | 1 |
| 9 | 379.00 | 185.00 | 381.00 | 177.00 | 1 |
| 10 | 381.00 | 177.00 | 384.00 | 174.00 | 1 |
| 11 | 384.00 | 174.00 | 387.00 | 174.00 | 1 |
| 12 | 387.00 | 174.00 | 410.00 | 196.00 | 1 |
| 13 | 410.00 | 196.00 | 444.00 | 223.00 | 1 |
| 14 | 444.00 | 223.00 | 480.00 | 241.00 | 1 |
| 15 | 480.00 | 241.00 | 525.00 | 265.00 | 1 |
| 16 | 525.00 | 265.00 | 536.00 | 265.00 | 1 |
| 17 | 536.00 | 265.00 | 545.00 | 265.00 | 1 |
| 18 | 545.00 | 265.00 | 560.00 | 263.00 | 1 |
| 19 | 560.00 | 263.00 | 577.00 | 261.00 | 1 |
| 20 | 577.00 | 261.00 | 585.00 | 265.00 | 1 |
| 21 | 585.00 | 265.00 | 638.00 | 273.00 | 1 |
| 22 | 638.00 | 273.00 | 655.00 | 274.00 | 1 |
| 23 | 655.00 | 274.00 | 719.00 | 280.00 | 1 |
| 24 | 360.00 | 206.00 | 372.00 | 164.00 | 1 |
| 25 | 372.00 | 164.00 | 376.00 | 157.00 | 1 |
| 26 | 376.00 | 157.00 | 384.00 | 150.00 | 1 |
| 27 | 384.00 | 150.00 | 404.00 | 145.00 | 1 |
| 28 | 404.00 | 145.00 | 433.00 | 142.00 | 1 |
| 29 | 433.00 | 142.00 | 560.00 | 144.00 | 1 |
| 30 | 560.00 | 144.00 | 620.00 | 143.00 | 1 |
| 31 | 620.00 | 143.00 | 695.00 | 142.00 | 1 |
| 32 | 695.00 | 142.00 | 720.00 | 140.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)
ISOTROPIC SOIL PARAMETERS
1 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 104.5 | 110.0 | 570.0 | 23.0 | 0.00 | 0.0 | 0 |

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.
500 Trial Surfaces Have Been Generated.
25 Surface(s) Initiate(s) From Each Of 20 Points Equally Spaced
Along The Ground Surface Between X = 387.00(ft)
and X = 410.00(ft)
Each Surface Terminates Between X = 524.00(ft)
and X = 600.00(ft)
Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00(ft)
15.00(ft) Line Segments Define Each Trial Failure Surface.
Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Evaluated. They Are
Ordered - Most Critical First.
* * Safety Factors Are Calculated By The Modified Bishop Method * *
Total Number of Trial Surfaces Attempted = 500
Number of Trial Surfaces With Valid FS = 500
Statistical Data On All Valid FS Values:
FS Max = 3.482 FS Min = 1.342 FS Ave = 1.952
Standard Deviation = 0.392 Coefficient of Variation = 20.07 %
Failure Surface Specified By 14 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 387.000 | 174.000 |
| 2 | 401.954 | 175.170 |
| 3 | 416.775 | 177.483 |
| 4 | 431.375 | 180.925 |

| | | |
|---|---|---|
| 5 | 445.668 | 185.475 |
| 6 | 459.570 | 191.107 |
| 7 | 473.001 | 197.787 |
| 8 | 485.879 | 205.477 |
| 9 | 498.131 | 214.132 |
| 10 | 509.684 | 223.699 |
| 11 | 520.469 | 234.124 |
| 12 | 530.424 | 245.344 |
| 13 | 539.490 | 257.294 |
| 14 | 544.455 | 265.000 |

Circle Center At X = 379.380 ; Y = 368.904 ; and Radius = 195.053

Factor of Safety

*** 1.342 ***

Individual data on the 18 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.0 | 10262.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 8.0 | 13750.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 6.8 | 15388.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 14.6 | 42678.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 12.6 | 46246.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 1.7 | 6659.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 13.9 | 56687.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 13.4 | 55711.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 7.0 | 28798.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 5.9 | 23867.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 12.3 | 48137.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 11.6 | 42054.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 10.8 | 34709.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 4.5 | 12837.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 5.4 | 12874.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 16 | 5.6 | 9311.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 17 | 3.5 | 3649.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 18 | 5.0 | 1998.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 389.421 | 176.316 |
| 2 | 404.382 | 177.393 |
| 3 | 419.195 | 179.757 |
| 4 | 433.748 | 183.392 |
| 5 | 447.933 | 188.269 |
| 6 | 461.643 | 194.353 |
| 7 | 474.778 | 201.598 |
| 8 | 487.237 | 209.950 |
| 9 | 498.930 | 219.347 |
| 10 | 509.767 | 229.718 |
| 11 | 519.668 | 240.986 |
| 12 | 528.559 | 253.066 |
| 13 | 535.844 | 265.000 |

Circle Center At X = 384.452 ; Y = 349.818 ; and Radius = 173.573

Factor of Safety

*** 1.363 ***

Failure Surface Specified By 15 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 387.000 | 174.000 |
| 2 | 401.942 | 175.318 |
| 3 | 416.766 | 177.609 |
| 4 | 431.408 | 180.865 |
| 5 | 445.807 | 185.070 |
| 6 | 459.899 | 190.208 |
| 7 | 473.626 | 196.257 |
| 8 | 486.928 | 203.189 |
| 9 | 499.748 | 210.977 |
| 10 | 512.032 | 219.585 |

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     11          523.726       228.979
     12          534.782       239.116
     13          545.151       249.955
     14          554.790       261.449
     15          556.289       263.495
 Circle Center At X =   374.338 ; Y =   402.991 ; and Radius =   229.341
        Factor of Safety
       ***     1.364    ***
 Failure Surface Specified By 13 Coordinate Points
   Point        X-Surf        Y-Surf
    No.          (ft)          (ft)
     1          388.211       175.158
     2          403.135       176.661
     3          417.869       179.471
     4          432.300       183.566
     5          446.314       188.914
     6          459.804       195.473
     7          472.665       203.193
     8          484.797       212.014
     9          496.106       221.868
    10          506.506       232.678
    11          515.914       244.360
    12          524.259       256.825
    13          528.745       265.000
 Circle Center At X =   378.608 ; Y =   345.309 ; and Radius =   170.422
        Factor of Safety
       ***     1.364    ***
 Failure Surface Specified By 13 Coordinate Points
   Point        X-Surf        Y-Surf
    No.          (ft)          (ft)
     1          389.421       176.316
     2          404.394       177.213
     3          419.226       179.454
     4          433.795       183.022
     5          447.984       187.887
     6          461.678       194.010
     7          474.764       201.341
     8          487.137       209.821
     9          498.697       219.380
    10          509.348       229.941
    11          519.006       241.419
    12          527.591       253.720
    13          534.037       265.000
 Circle Center At X =   386.968 ; Y =   342.716 ; and Radius =   166.418
        Factor of Safety
       ***     1.365    ***
 Failure Surface Specified By 14 Coordinate Points
   Point        X-Surf        Y-Surf
    No.          (ft)          (ft)
     1          389.421       176.316
     2          404.418       176.639
     3          419.320       178.343
     4          434.003       181.413
     5          448.340       185.824
     6          462.209       191.537
     7          475.493       198.504
     8          488.078       206.666
     9          499.857       215.954
    10          510.730       226.287
    11          520.604       237.578
    12          529.396       249.732
    13          537.030       262.644
    14          538.144       265.000
 Circle Center At X =   393.503 ; Y =   338.515 ; and Radius =   162.250
        Factor of Safety
       ***     1.367    ***
 Failure Surface Specified By 14 Coordinate Points
   Point        X-Surf        Y-Surf
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| No. | (ft) | (ft) |
|---|---|---|
| 1 | 389.421 | 176.316 |
| 2 | 404.332 | 177.950 |
| 3 | 419.091 | 180.626 |
| 4 | 433.626 | 184.331 |
| 5 | 447.866 | 189.046 |
| 6 | 461.740 | 194.749 |
| 7 | 475.179 | 201.411 |
| 8 | 488.118 | 208.999 |
| 9 | 500.493 | 217.476 |
| 10 | 512.243 | 226.800 |
| 11 | 523.310 | 236.925 |
| 12 | 533.639 | 247.802 |
| 13 | 543.180 | 259.377 |
| 14 | 546.998 | 264.734 |

Circle Center At X = 373.799 ; Y = 388.781 ; and Radius = 213.039
Factor of Safety
*** 1.368 ***
Failure Surface Specified By 14 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 390.632 | 177.474 |
| 2 | 405.621 | 178.047 |
| 3 | 420.507 | 179.888 |
| 4 | 435.184 | 182.984 |
| 5 | 449.546 | 187.313 |
| 6 | 463.489 | 192.844 |
| 7 | 476.913 | 199.536 |
| 8 | 489.722 | 207.342 |
| 9 | 501.823 | 216.206 |
| 10 | 513.130 | 226.063 |
| 11 | 523.560 | 236.843 |
| 12 | 533.039 | 248.468 |
| 13 | 541.499 | 260.855 |
| 14 | 543.842 | 265.000 |

Circle Center At X = 391.506 ; Y = 353.799 ; and Radius = 176.328
Factor of Safety
*** 1.378 ***
Failure Surface Specified By 14 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 389.421 | 176.316 |
| 2 | 404.421 | 176.253 |
| 3 | 419.369 | 177.499 |
| 4 | 434.152 | 180.045 |
| 5 | 448.656 | 183.870 |
| 6 | 462.770 | 188.946 |
| 7 | 476.389 | 195.235 |
| 8 | 489.406 | 202.688 |
| 9 | 501.724 | 211.248 |
| 10 | 513.248 | 220.850 |
| 11 | 523.890 | 231.421 |
| 12 | 533.569 | 242.880 |
| 13 | 542.212 | 255.140 |
| 14 | 547.734 | 264.636 |

Circle Center At X = 397.729 ; Y = 347.470 ; and Radius = 171.356
Factor of Safety
*** 1.379 ***
Failure Surface Specified By 14 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 389.421 | 176.316 |
| 2 | 404.154 | 179.133 |
| 3 | 418.687 | 182.846 |
| 4 | 432.966 | 187.441 |
| 5 | 446.938 | 192.900 |
| 6 | 460.549 | 199.204 |
| 7 | 473.749 | 206.328 |

```
   8        486.488       214.246
   9        498.720       222.929
  10        510.398       232.344
  11        521.478       242.455
  12        531.919       253.225
  13        541.681       264.613
  14        541.974       265.000
Circle Center At X =   350.806 ; Y =   418.292 ; and Radius =   245.038
       Factor of Safety
      ***    1.384   ***
          **** END OF GSTABL7 OUTPUT ****
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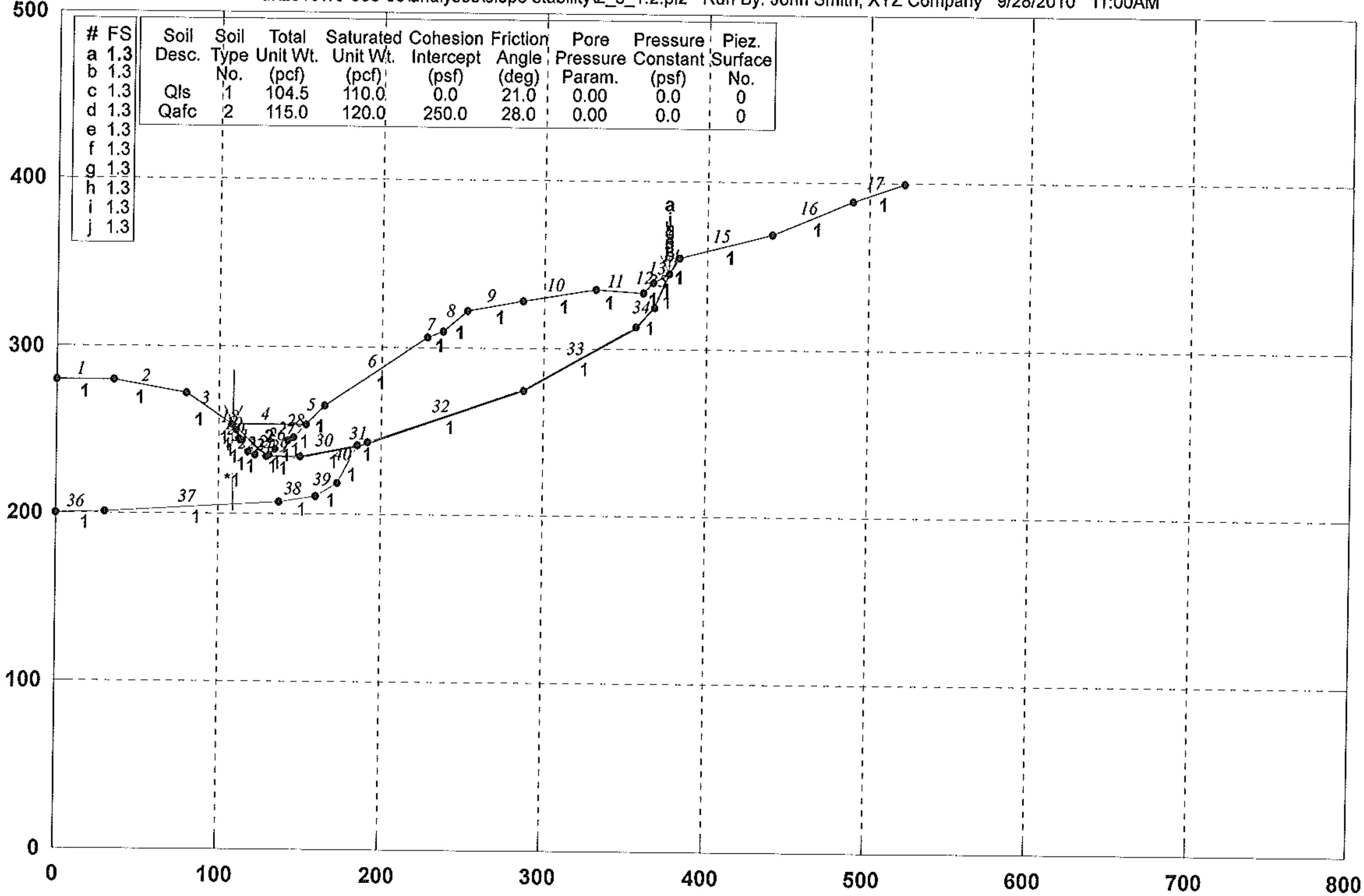
## Sect 2, Terrapaca Landslide, Fill height at toe for approx. 1.25 FS

u:\2010\10-036-00\analyses\slope stability\2_s_1.2.pl2 Run By: John Smith, XYZ Company 9/28/2010 11:00AM




GSTABL7 v.2 FSmin=1.3

Safety Factors Are Calculated By The Simplified Janbu Method for the case of c=0

*** **GSTABL7** ***

** GSTABL7 by Garry H. Gregory, P.E. **
** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **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SLOPE STABILITY ANALYSIS SYSTEM

Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.

*********************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 11:00AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\2_s_1.2.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\2_s_1.2.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\2_s_1.2.PLT
PROBLEM DESCRIPTION: Sect 2, Terrapaca Landslide, Fill
height at toe for approx. 1.25 FS

BOUNDARY COORDINATES
17 Top Boundaries
40 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 280.00 | 35.00 | 280.00 | 1 |
| 2 | 35.00 | 280.00 | 80.00 | 272.00 | 1 |
| 3 | 80.00 | 272.00 | 108.00 | 254.00 | 1 |
| 4 | 108.00 | 254.00 | 154.00 | 254.00 | 2 |
| 5 | 154.00 | 254.00 | 165.00 | 265.00 | 1 |
| 6 | 165.00 | 265.00 | 228.00 | 306.00 | 1 |
| 7 | 228.00 | 306.00 | 238.00 | 310.00 | 1 |
| 8 | 238.00 | 310.00 | 253.00 | 322.00 | 1 |
| 9 | 253.00 | 322.00 | 287.00 | 328.00 | 1 |
| 10 | 287.00 | 328.00 | 332.00 | 335.00 | 1 |
| 11 | 332.00 | 335.00 | 361.00 | 334.00 | 1 |
| 12 | 361.00 | 334.00 | 367.00 | 340.00 | 1 |
| 13 | 367.00 | 340.00 | 377.00 | 345.00 | 1 |
| 14 | 377.00 | 345.00 | 383.00 | 355.00 | 1 |
| 15 | 383.00 | 355.00 | 440.00 | 369.00 | 1 |
| 16 | 440.00 | 369.00 | 490.00 | 389.00 | 1 |
| 17 | 490.00 | 389.00 | 521.00 | 399.00 | 1 |
| 18 | 108.00 | 254.00 | 111.00 | 250.00 | 1 |
| 19 | 111.00 | 250.00 | 112.00 | 245.00 | 1 |
| 20 | 112.00 | 245.00 | 113.00 | 244.00 | 1 |
| 21 | 113.00 | 244.00 | 118.00 | 237.00 | 1 |
| 22 | 118.00 | 237.00 | 122.00 | 235.00 | 1 |
| 23 | 122.00 | 235.00 | 129.00 | 234.00 | 1 |
| 24 | 129.00 | 234.00 | 131.00 | 235.00 | 1 |
| 25 | 131.00 | 235.00 | 134.00 | 239.00 | 1 |
| 26 | 134.00 | 239.00 | 142.00 | 244.00 | 1 |
| 27 | 142.00 | 244.00 | 146.00 | 246.00 | 1 |
| 28 | 146.00 | 246.00 | 154.00 | 254.00 | 1 |
| 29 | 129.00 | 234.00 | 150.00 | 234.00 | 1 |
| 30 | 150.00 | 234.00 | 185.00 | 241.00 | 1 |
| 31 | 185.00 | 241.00 | 191.00 | 243.00 | 1 |
| 32 | 191.00 | 243.00 | 288.00 | 275.00 | 1 |
| 33 | 288.00 | 275.00 | 356.00 | 313.00 | 1 |
| 34 | 356.00 | 313.00 | 368.00 | 325.00 | 1 |
| 35 | 368.00 | 325.00 | 377.00 | 345.00 | 1 |
| 36 | 0.00 | 200.00 | 30.00 | 201.00 | 1 |
| 37 | 30.00 | 201.00 | 137.00 | 207.00 | 1 |
| 38 | 137.00 | 207.00 | 160.00 | 211.00 | 1 |
| 39 | 160.00 | 211.00 | 173.00 | 219.00 | 1 |
| 40 | 173.00 | 219.00 | 185.00 | 241.00 | 1 |

Default Y-Origin = 0.00(ft)

Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)
ISOTROPIC SOIL PARAMETERS
2 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 104.5 | 110.0 | 0.0 | 21.0 | 0.00 | 0.0 | 0 |
| 2 | 115.0 | 120.0 | 250.0 | 28.0 | 0.00 | 0.0 | 0 |

Searching Routine Will Be Limited To An Area Defined By 1 Boundaries
Of Which The First 1 Boundaries Will Deflect Surfaces Upward

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) |
|---|---|---|---|---|
| 1 | 108.00 | 254.00 | 109.00 | 200.00 |

Janbus Empirical Coef is being used for the case of c=0
A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.
10 Trial Surfaces Have Been Generated.
8 Boxes Specified For Generation Of Central Block Base
Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 10.0

| Box No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Height (ft) |
|---|---|---|---|---|---|
| 1 | 130.00 | 234.00 | 130.00 | 234.00 | 0.10 |
| 2 | 150.00 | 234.00 | 150.00 | 234.00 | 1.00 |
| 3 | 185.00 | 241.00 | 185.00 | 241.00 | 1.00 |
| 4 | 191.00 | 243.00 | 191.00 | 243.00 | 1.00 |
| 5 | 288.00 | 275.00 | 288.00 | 275.00 | 1.00 |
| 6 | 356.00 | 313.00 | 356.00 | 313.00 | 1.00 |
| 7 | 368.00 | 325.00 | 368.00 | 325.00 | 1.00 |
| 8 | 377.00 | 345.00 | 377.00 | 345.00 | 0.00 |

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Evaluated. They Are Ordered - Most Critical First.
* * Safety Factors Are Calculated By The Simplified Janbu Method * *
Total Number of Trial Surfaces Attempted = 10
Number of Trial Surfaces With Valid FS = 10
Statistical Data On All Valid FS Values:
FS Max = 1.307 FS Min = 1.298 FS Ave = 1.302
Standard Deviation = 0.003 Coefficient of Variation = 0.20 %
Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 108.467 | 254.000 |
| 2 | 115.170 | 247.420 |
| 3 | 122.311 | 240.420 |
| 4 | 130.000 | 234.026 |
| 5 | 150.000 | 234.189 |
| 6 | 185.000 | 240.613 |
| 7 | 191.000 | 242.626 |
| 8 | 288.000 | 275.073 |
| 9 | 356.000 | 312.547 |
| 10 | 368.000 | 325.392 |
| 11 | 377.000 | 345.000 |

Factor of Safety
*** 1.298 ***
Individual data on the 29 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.7 | 2536.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 7.1 | 8277.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 7.3 | 14023.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 0.4 | 810.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 1.0 | 2289.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 3.0 | 6790.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 8.0 | 17693.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 4.0 | 8679.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 4.0 | 8539.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 4.0 | 8211.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 7.5 | 17337.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 3.5 | 9752.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 19.8 | 67490.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 0.2 | 916.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 6.0 | 24044.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 16 | 37.0 | 174557.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 17 | 10.0 | 53634.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 18 | 15.0 | 86437.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 19 | 19.2 | 114703.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 20 | 14.8 | 84081.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 21 | 1.0 | 5556.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 22 | 9.4 | 50315.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 23 | 34.6 | 153748.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 24 | 24.0 | 71860.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 25 | 5.0 | 9856.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 26 | 1.4 | 2405.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 27 | 4.6 | 7557.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 28 | 1.0 | 1608.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 29 | 9.0 | 7104.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 108.852 | 254.000 |
| 2 | 115.360 | 247.560 |
| 3 | 122.432 | 240.491 |
| 4 | 130.000 | 233.954 |
| 5 | 150.000 | 234.124 |
| 6 | 185.000 | 241.498 |
| 7 | 191.000 | 242.634 |
| 8 | 288.000 | 275.251 |
| 9 | 356.000 | 312.817 |
| 10 | 368.000 | 324.551 |
| 11 | 377.000 | 345.000 |

Factor of Safety
*** 1.301 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 108.893 | 254.000 |
| 2 | 115.334 | 247.571 |
| 3 | 122.831 | 240.954 |
| 4 | 130.000 | 233.982 |
| 5 | 150.000 | 234.461 |
| 6 | 185.000 | 241.488 |
| 7 | 191.000 | 242.620 |
| 8 | 288.000 | 275.327 |
| 9 | 356.000 | 312.826 |
| 10 | 368.000 | 325.088 |
| 11 | 377.000 | 345.000 |

Factor of Safety
*** 1.301 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 109.028 | 254.000 |
| 2 | 115.392 | 247.686 |
| 3 | 122.602 | 240.757 |
| 4 | 130.000 | 234.028 |
| 5 | 150.000 | 234.218 |
| 6 | 185.000 | 241.461 |
| 7 | 191.000 | 242.607 |
| 8 | 288.000 | 274.999 |
| 9 | 356.000 | 312.731 |
| 10 | 368.000 | 324.647 |

| | | |
|---|---|---|
| 11 | 377.000 | 345.000 |

Factor of Safety
*** 1.301 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 108.423 | 254.000 |
| 2 | 115.240 | 247.472 |
| 3 | 122.759 | 240.878 |
| 4 | 130.000 | 233.982 |
| 5 | 150.000 | 234.387 |
| 6 | 185.000 | 241.076 |
| 7 | 191.000 | 242.979 |
| 8 | 288.000 | 274.942 |
| 9 | 356.000 | 312.557 |
| 10 | 368.000 | 325.167 |
| 11 | 377.000 | 345.000 |

Factor of Safety
*** 1.302 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 109.758 | 254.000 |
| 2 | 115.778 | 248.095 |
| 3 | 122.851 | 241.026 |
| 4 | 130.000 | 234.033 |
| 5 | 150.000 | 234.169 |
| 6 | 185.000 | 240.704 |
| 7 | 191.000 | 243.156 |
| 8 | 288.000 | 275.496 |
| 9 | 356.000 | 313.441 |
| 10 | 368.000 | 325.460 |
| 11 | 377.000 | 345.000 |

Factor of Safety
*** 1.303 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 109.697 | 254.000 |
| 2 | 115.749 | 248.066 |
| 3 | 122.871 | 241.046 |
| 4 | 130.000 | 234.034 |
| 5 | 150.000 | 233.602 |
| 6 | 185.000 | 241.254 |
| 7 | 191.000 | 243.011 |
| 8 | 288.000 | 275.342 |
| 9 | 356.000 | 313.467 |
| 10 | 368.000 | 325.353 |
| 11 | 377.000 | 345.000 |

Factor of Safety
*** 1.303 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 109.279 | 254.000 |
| 2 | 115.755 | 248.035 |
| 3 | 122.828 | 240.965 |
| 4 | 130.000 | 233.997 |
| 5 | 150.000 | 233.928 |
| 6 | 185.000 | 240.632 |
| 7 | 191.000 | 243.177 |
| 8 | 288.000 | 275.405 |
| 9 | 356.000 | 312.910 |
| 10 | 368.000 | 325.037 |
| 11 | 377.000 | 345.000 |

Factor of Safety
*** 1.304 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 109.731 | 254.000 |
| 2 | 115.785 | 248.038 |
| 3 | 122.897 | 241.008 |
| 4 | 130.000 | 233.969 |
| 5 | 150.000 | 233.680 |
| 6 | 185.000 | 240.576 |
| 7 | 191.000 | 242.718 |
| 8 | 288.000 | 275.200 |
| 9 | 356.000 | 312.866 |
| 10 | 368.000 | 325.309 |
| 11 | 377.000 | 345.000 |

Factor of Safety
*** 1.304 ***

Failure Surface Specified By 11 Coordinate Points

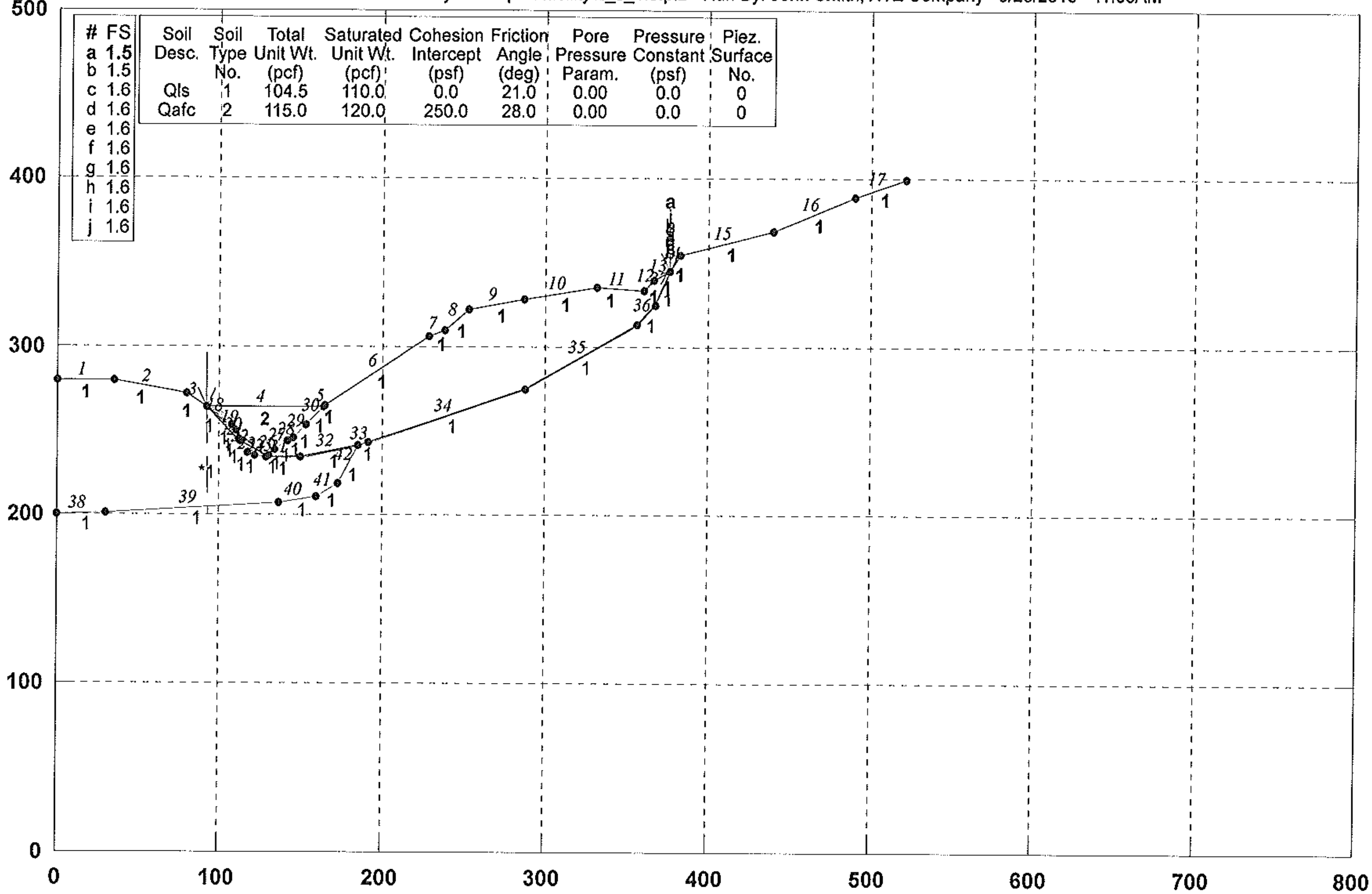
| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 108.705 | 254.000 |
| 2 | 115.771 | 248.075 |
| 3 | 122.842 | 241.004 |
| 4 | 130.000 | 234.021 |
| 5 | 150.000 | 234.208 |
| 6 | 185.000 | 240.925 |
| 7 | 191.000 | 243.200 |
| 8 | 288.000 | 274.627 |
| 9 | 356.000 | 312.550 |
| 10 | 368.000 | 325.063 |
| 11 | 377.000 | 345.000 |

Factor of Safety
*** 1.307 ***

**** END OF GSTABL7 OUTPUT ****

## Sect 2, Terrapaca Landslide, Fill height at toe for approx. 1.5 FS

u:\2010\10-036-00\analyses\slope stability\2_s_1.3.pl2 Run By: John Smith, XYZ Company 9/28/2010 11:05AM




GSTABL7 v.2 FSmin=1.5

Safety Factors Are Calculated By The Simplified Janbu Method for the case of c=0

*** GSTABL7 ***

** GSTABL7 by Garry H. Gregory, P.E. **

** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **



*********************************************************************************

SLOPE STABILITY ANALYSIS SYSTEM

Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.

*********************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 11:05AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\2_s_1.3.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\2_s_1.3.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\2_s_1.3.PLT
PROBLEM DESCRIPTION: Sect 2, Terrapaca Landslide, Fill
height at toe for approx. 1.5 FS

BOUNDARY COORDINATES
17 Top Boundaries
42 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 280.00 | 35.00 | 280.00 | 1 |
| 2 | 35.00 | 280.00 | 80.00 | 272.00 | 1 |
| 3 | 80.00 | 272.00 | 92.00 | 264.00 | 1 |
| 4 | 92.00 | 264.00 | 164.00 | 264.00 | 2 |
| 5 | 164.00 | 264.00 | 165.00 | 265.00 | 1 |
| 6 | 165.00 | 265.00 | 228.00 | 306.00 | 1 |
| 7 | 228.00 | 306.00 | 238.00 | 310.00 | 1 |
| 8 | 238.00 | 310.00 | 253.00 | 322.00 | 1 |
| 9 | 253.00 | 322.00 | 287.00 | 328.00 | 1 |
| 10 | 287.00 | 328.00 | 332.00 | 335.00 | 1 |
| 11 | 332.00 | 335.00 | 361.00 | 334.00 | 1 |
| 12 | 361.00 | 334.00 | 367.00 | 340.00 | 1 |
| 13 | 367.00 | 340.00 | 377.00 | 345.00 | 1 |
| 14 | 377.00 | 345.00 | 383.00 | 355.00 | 1 |
| 15 | 383.00 | 355.00 | 440.00 | 369.00 | 1 |
| 16 | 440.00 | 369.00 | 490.00 | 389.00 | 1 |
| 17 | 490.00 | 389.00 | 521.00 | 399.00 | 1 |
| 18 | 92.00 | 264.00 | 108.00 | 254.00 | 1 |
| 19 | 108.00 | 254.00 | 111.00 | 250.00 | 1 |
| 20 | 111.00 | 250.00 | 112.00 | 245.00 | 1 |
| 21 | 112.00 | 245.00 | 113.00 | 244.00 | 1 |
| 22 | 113.00 | 244.00 | 118.00 | 237.00 | 1 |
| 23 | 118.00 | 237.00 | 122.00 | 235.00 | 1 |
| 24 | 122.00 | 235.00 | 129.00 | 234.00 | 1 |
| 25 | 129.00 | 234.00 | 131.00 | 235.00 | 1 |
| 26 | 131.00 | 235.00 | 134.00 | 239.00 | 1 |
| 27 | 134.00 | 239.00 | 142.00 | 244.00 | 1 |
| 28 | 142.00 | 244.00 | 146.00 | 246.00 | 1 |
| 29 | 146.00 | 246.00 | 154.00 | 254.00 | 1 |
| 30 | 154.00 | 254.00 | 164.00 | 264.00 | 1 |
| 31 | 129.00 | 234.00 | 150.00 | 234.00 | 1 |
| 32 | 150.00 | 234.00 | 185.00 | 241.00 | 1 |
| 33 | 185.00 | 241.00 | 191.00 | 243.00 | 1 |
| 34 | 191.00 | 243.00 | 288.00 | 275.00 | 1 |
| 35 | 288.00 | 275.00 | 356.00 | 313.00 | 1 |
| 36 | 356.00 | 313.00 | 368.00 | 325.00 | 1 |
| 37 | 368.00 | 325.00 | 377.00 | 345.00 | 1 |
| 38 | 0.00 | 200.00 | 30.00 | 201.00 | 1 |
| 39 | 30.00 | 201.00 | 137.00 | 207.00 | 1 |
| 40 | 137.00 | 207.00 | 160.00 | 211.00 | 1 |
| 41 | 160.00 | 211.00 | 173.00 | 219.00 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 42 | 173.00 | 219.00 | 185.00 | 241.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)
ISOTROPIC SOIL PARAMETERS
2 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 104.5 | 110.0 | 0.0 | 21.0 | 0.00 | 0.0 | 0 |
| 2 | 115.0 | 120.0 | 250.0 | 28.0 | 0.00 | 0.0 | 0 |

Searching Routine Will Be Limited To An Area Defined By 1 Boundaries
Of Which The First 1 Boundaries Will Deflect Surfaces Upward

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) |
|---|---|---|---|---|
| 1 | 92.00 | 264.00 | 93.00 | 200.00 |

Janbus Empirical Coef is being used for the case of c=0
A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Sliding Block Surfaces, Has Been
Specified.
10 Trial Surfaces Have Been Generated.
8 Boxes Specified For Generation Of Central Block Base
Length Of Line Segments For Active And Passive Portions Of
Sliding Block Is 10.0

| Box No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Height (ft) |
|---|---|---|---|---|---|
| 1 | 130.00 | 234.00 | 130.00 | 234.00 | 0.10 |
| 2 | 150.00 | 234.00 | 150.00 | 234.00 | 1.00 |
| 3 | 185.00 | 241.00 | 185.00 | 241.00 | 1.00 |
| 4 | 191.00 | 243.00 | 191.00 | 243.00 | 1.00 |
| 5 | 288.00 | 275.00 | 288.00 | 275.00 | 1.00 |
| 6 | 356.00 | 313.00 | 356.00 | 313.00 | 1.00 |
| 7 | 368.00 | 325.00 | 368.00 | 325.00 | 1.00 |
| 8 | 377.00 | 345.00 | 377.00 | 345.00 | 0.00 |

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Evaluated. They Are
Ordered - Most Critical First.
* * Safety Factors Are Calculated By The Simplified Janbu Method * *
Total Number of Trial Surfaces Attempted = 10
Number of Trial Surfaces With Valid FS = 10
Statistical Data On All Valid FS Values:
FS Max = 1.621 FS Min = 1.521 FS Ave = 1.567
Standard Deviation = 0.027 Coefficient of Variation = 1.73 %
Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 92.373 | 264.000 |
| 2 | 98.401 | 257.975 |
| 3 | 105.551 | 250.983 |
| 4 | 112.728 | 244.020 |
| 5 | 121.526 | 239.266 |
| 6 | 130.000 | 233.956 |
| 7 | 150.000 | 234.107 |
| 8 | 185.000 | 241.380 |
| 9 | 191.000 | 242.852 |
| 10 | 288.000 | 274.742 |
| 11 | 356.000 | 313.019 |
| 12 | 368.000 | 325.402 |
| 13 | 377.000 | 345.000 |

Factor of Safety
*** 1.521 ***
Individual data on the 37 slices

| Slice No. | Width (ft) | Weight (lbs) | Water Force Top (lbs) | Water Force Bot (lbs) | Tie Force Norm (lbs) | Tie Force Tan (lbs) | Earthquake Force Hor (lbs) | Earthquake Force Ver (lbs) | Surcharge Load (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.6 | 22.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 5.4 | 2008.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 7.1 | 7581.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 2.4 | 3873.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 3.0 | 5660.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 1.0 | 2136.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 0.7 | 1641.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 0.3 | 626.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 0.1 | 342.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 8.4 | 21650.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 8.0 | 25032.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 0.4 | 1417.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 0.1 | 239.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 1.0 | 3446.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 3.0 | 10263.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 16 | 1.8 | 6036.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 17 | 6.2 | 20919.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 18 | 4.0 | 13312.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 19 | 4.0 | 13173.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 20 | 4.0 | 12825.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 21 | 10.0 | 29808.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 22 | 1.0 | 2861.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 23 | 20.0 | 67310.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 24 | 4.3 | 16935.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 25 | 1.7 | 6797.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 26 | 37.0 | 174092.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 27 | 10.0 | 53649.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 28 | 15.0 | 86573.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 29 | 34.0 | 199591.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 30 | 1.0 | 5590.7 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 31 | 44.0 | 204389.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 32 | 19.3 | 59896.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 33 | 4.7 | 11134.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 34 | 5.0 | 9659.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 35 | 6.0 | 9860.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 36 | 1.0 | 1605.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 37 | 9.0 | 7100.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 93.283 | 264.000 |
| 2 | 98.663 | 258.622 |
| 3 | 105.835 | 251.654 |
| 4 | 113.655 | 245.421 |
| 5 | 122.351 | 240.482 |
| 6 | 130.000 | 234.041 |
| 7 | 150.000 | 233.969 |
| 8 | 185.000 | 240.928 |
| 9 | 191.000 | 242.632 |
| 10 | 288.000 | 275.177 |
| 11 | 356.000 | 313.405 |
| 12 | 368.000 | 324.910 |
| 13 | 377.000 | 345.000 |

Factor of Safety

*** 1.539 ***

Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 93.423 | 264.000 |
| 2 | 98.752 | 258.733 |
| 3 | 106.374 | 252.259 |
| 4 | 113.756 | 245.514 |
| 5 | 121.276 | 238.922 |
| 6 | 130.000 | 234.034 |
| 7 | 150.000 | 233.945 |
| 8 | 185.000 | 240.870 |
| 9 | 191.000 | 243.338 |
| 10 | 288.000 | 275.318 |
| 11 | 356.000 | 312.529 |
| 12 | 368.000 | 325.438 |

```
   13        377.000      345.000
        Factor of Safety
       ***    1.555    ***
Failure Surface Specified By 13 Coordinate Points
  Point        X-Surf       Y-Surf
   No.          (ft)         (ft)
    1          93.030      264.000
    2          98.593      258.554
    3         107.225      253.504
    4         114.617      246.770
    5         122.331      240.406
    6         130.000      233.988
    7         150.000      234.069
    8         185.000      240.517
    9         191.000      242.946
   10         288.000      274.825
   11         356.000      313.371
   12         368.000      324.554
   13         377.000      345.000
        Factor of Safety
       ***    1.560    ***
Failure Surface Specified By 13 Coordinate Points
  Point        X-Surf       Y-Surf
   No.          (ft)         (ft)
    1          93.313      264.000
    2          98.747      258.795
    3         106.882      252.981
    4         114.718      246.768
    5         121.810      239.717
    6         130.000      233.980
    7         150.000      234.478
    8         185.000      240.606
    9         191.000      243.403
   10         288.000      274.836
   11         356.000      312.624
   12         368.000      325.237
   13         377.000      345.000
        Factor of Safety
       ***    1.567    ***
Failure Surface Specified By 13 Coordinate Points
  Point        X-Surf       Y-Surf
   No.          (ft)         (ft)
    1          93.133      264.000
    2          99.181      259.053
    3         106.492      252.230
    4         115.366      247.620
    5         122.636      240.753
    6         130.000      233.988
    7         150.000      234.427
    8         185.000      240.655
    9         191.000      243.160
   10         288.000      275.287
   11         356.000      313.128
   12         368.000      324.528
   13         377.000      345.000
        Factor of Safety
       ***    1.569    ***
Failure Surface Specified By 13 Coordinate Points
  Point        X-Surf       Y-Surf
   No.          (ft)         (ft)
    1          94.343      264.000
    2          99.507      259.790
    3         106.782      252.929
    4         114.627      246.728
    5         121.946      239.913
    6         130.000      233.986
    7         150.000      233.846
    8         185.000      240.877
```

| | | |
|---|---|---|
| 9 | 191.000 | 242.920 |
| 10 | 288.000 | 274.693 |
| 11 | 356.000 | 312.665 |
| 12 | 368.000 | 325.055 |
| 13 | 377.000 | 345.000 |

Factor of Safety
*** 1.571 ***

Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 94.404 | 264.000 |
| 2 | 100.087 | 260.425 |
| 3 | 107.239 | 253.435 |
| 4 | 114.321 | 246.376 |
| 5 | 122.165 | 240.173 |
| 6 | 130.000 | 233.959 |
| 7 | 150.000 | 233.687 |
| 8 | 185.000 | 241.158 |
| 9 | 191.000 | 243.093 |
| 10 | 288.000 | 275.336 |
| 11 | 356.000 | 313.482 |
| 12 | 368.000 | 324.874 |
| 13 | 377.000 | 345.000 |

Factor of Safety
*** 1.579 ***

Failure Surface Specified By 13 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 92.099 | 264.000 |
| 2 | 99.961 | 260.342 |
| 3 | 107.455 | 253.721 |
| 4 | 114.544 | 246.667 |
| 5 | 121.932 | 239.929 |
| 6 | 130.000 | 234.020 |
| 7 | 150.000 | 234.015 |
| 8 | 185.000 | 241.133 |
| 9 | 191.000 | 243.154 |
| 10 | 288.000 | 275.421 |
| 11 | 356.000 | 313.028 |
| 12 | 368.000 | 324.819 |
| 13 | 377.000 | 345.000 |

Factor of Safety
*** 1.589 ***

Failure Surface Specified By 13 Coordinate Points

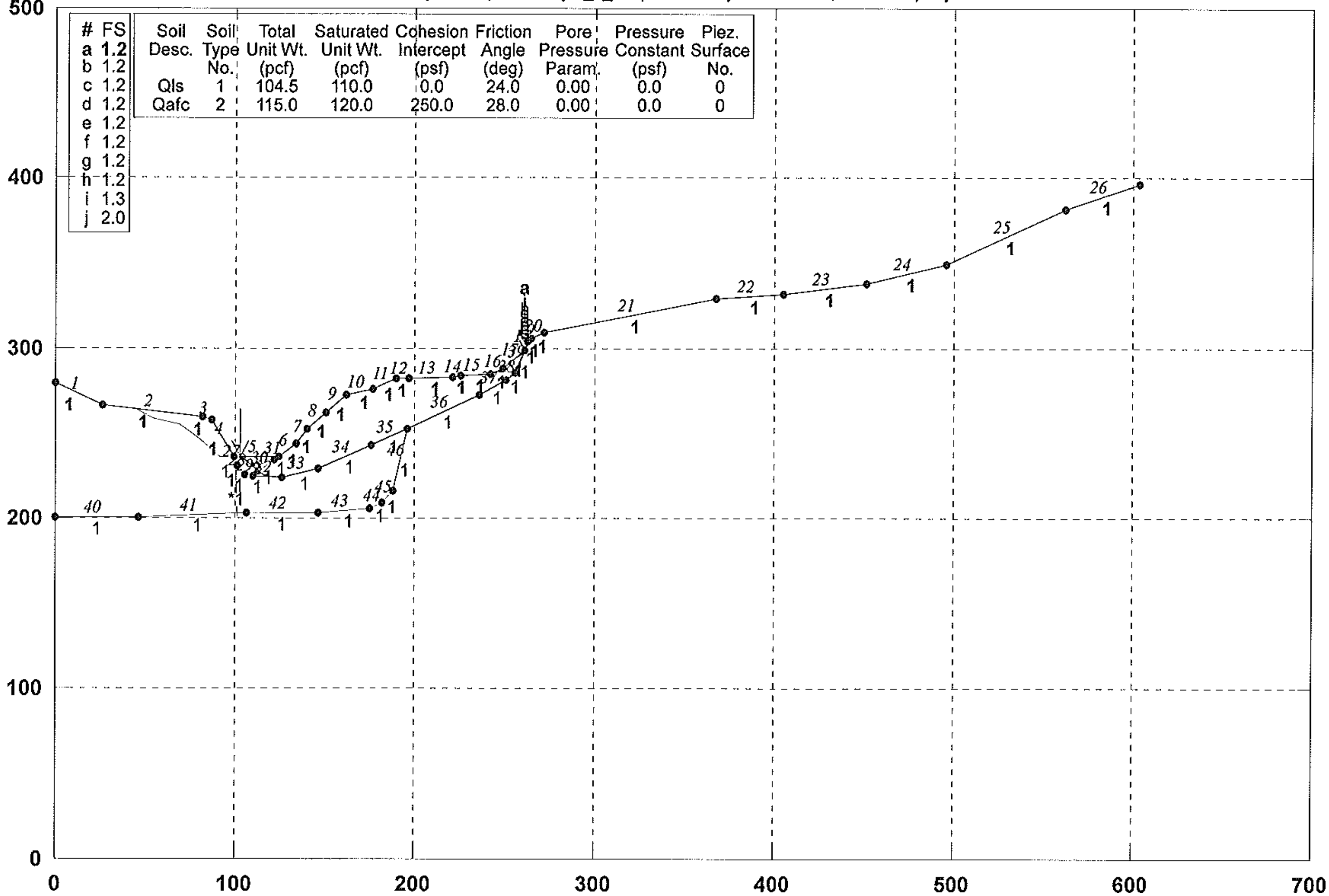
| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 97.743 | 264.000 |
| 2 | 101.191 | 261.721 |
| 3 | 108.467 | 254.861 |
| 4 | 115.792 | 248.053 |
| 5 | 122.863 | 240.982 |
| 6 | 130.000 | 233.977 |
| 7 | 150.000 | 234.465 |
| 8 | 185.000 | 241.279 |
| 9 | 191.000 | 243.308 |
| 10 | 288.000 | 275.395 |
| 11 | 356.000 | 313.135 |
| 12 | 368.000 | 324.871 |
| 13 | 377.000 | 345.000 |

Factor of Safety
*** 1.621 ***

**** END OF GSTABL7 OUTPUT ****

## Sect 3, Terrapaca Landslide, Fill height at toe for approx. 1.25 FS

u:\2010\10-036-00\analyses\slope stability\3_s_1.1.pl2 Run By: John Smith, XYZ Company 9/28/2010 11:06AM




GSTABL7 v.2 FSmin=1.2

**Safety Factors Are Calculated By The Simplified Janbu Method for the case of c=0**

***** GSTABL7 *****

** GSTABL7 by Garry H. Gregory, P.E. **
** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **

*******************************************************************************
SLOPE STABILITY ANALYSIS SYSTEM
Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.
*******************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 11:06AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_1.1.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_1.1.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_1.1.PLT
PROBLEM DESCRIPTION: Sect 3, Terrapaca Landslide, Fill
height at toe for approx. 1.25 FS

BOUNDARY COORDINATES
26 Top Boundaries
46 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 280.00 | 26.00 | 267.00 | 1 |
| 2 | 26.00 | 267.00 | 82.00 | 260.00 | 1 |
| 3 | 82.00 | 260.00 | 87.00 | 258.00 | 1 |
| 4 | 87.00 | 258.00 | 99.50 | 236.00 | 1 |
| 5 | 99.50 | 236.00 | 125.00 | 236.00 | 2 |
| 6 | 125.00 | 236.00 | 134.00 | 244.00 | 1 |
| 7 | 134.00 | 244.00 | 140.00 | 253.00 | 1 |
| 8 | 140.00 | 253.00 | 151.00 | 262.00 | 1 |
| 9 | 151.00 | 262.00 | 162.00 | 273.00 | 1 |
| 10 | 162.00 | 273.00 | 177.00 | 276.00 | 1 |
| 11 | 177.00 | 276.00 | 190.00 | 282.00 | 1 |
| 12 | 190.00 | 282.00 | 197.00 | 282.00 | 1 |
| 13 | 197.00 | 282.00 | 221.00 | 283.00 | 1 |
| 14 | 221.00 | 283.00 | 226.00 | 284.00 | 1 |
| 15 | 226.00 | 284.00 | 242.00 | 285.00 | 1 |
| 16 | 242.00 | 285.00 | 249.00 | 288.00 | 1 |
| 17 | 249.00 | 288.00 | 261.00 | 299.00 | 1 |
| 18 | 261.00 | 299.00 | 263.00 | 304.00 | 1 |
| 19 | 263.00 | 304.00 | 265.00 | 306.00 | 1 |
| 20 | 265.00 | 306.00 | 272.00 | 309.00 | 1 |
| 21 | 272.00 | 309.00 | 368.00 | 329.00 | 1 |
| 22 | 368.00 | 329.00 | 405.00 | 332.00 | 1 |
| 23 | 405.00 | 332.00 | 451.00 | 338.00 | 1 |
| 24 | 451.00 | 338.00 | 496.00 | 349.00 | 1 |
| 25 | 496.00 | 349.00 | 562.00 | 382.00 | 1 |
| 26 | 562.00 | 382.00 | 604.00 | 396.00 | 1 |
| 27 | 99.50 | 236.00 | 101.00 | 231.00 | 1 |
| 28 | 101.00 | 231.00 | 105.00 | 226.00 | 1 |
| 29 | 105.00 | 226.00 | 110.00 | 225.00 | 1 |
| 30 | 110.00 | 225.00 | 122.00 | 234.00 | 1 |
| 31 | 122.00 | 234.00 | 125.00 | 236.00 | 1 |
| 32 | 110.00 | 225.00 | 126.00 | 224.00 | 1 |
| 33 | 126.00 | 224.00 | 146.00 | 229.00 | 1 |
| 34 | 146.00 | 229.00 | 176.00 | 243.00 | 1 |
| 35 | 176.00 | 243.00 | 196.00 | 253.00 | 1 |
| 36 | 196.00 | 253.00 | 236.00 | 273.00 | 1 |
| 37 | 236.00 | 273.00 | 251.00 | 281.00 | 1 |
| 38 | 251.00 | 281.00 | 256.00 | 286.00 | 1 |
| 39 | 256.00 | 286.00 | 261.00 | 299.00 | 1 |
| 40 | 0.00 | 200.00 | 46.00 | 200.00 | 1 |
| 41 | 46.00 | 200.00 | 106.00 | 203.00 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 42 | 106.00 | 203.00 | 146.00 | 203.00 | 1 |
| 43 | 146.00 | 203.00 | 175.00 | 206.00 | 1 |
| 44 | 175.00 | 206.00 | 182.00 | 209.00 | 1 |
| 45 | 182.00 | 209.00 | 188.00 | 216.00 | 1 |
| 46 | 188.00 | 216.00 | 196.00 | 253.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 104.5 | 110.0 | 0.0 | 24.0 | 0.00 | 0.0 | 0 |
| 2 | 115.0 | 120.0 | 250.0 | 28.0 | 0.00 | 0.0 | 0 |

Searching Routine Will Be Limited To An Area Defined By 1 Boundaries
Of Which The First 1 Boundaries Will Deflect Surfaces Upward

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) |
|---|---|---|---|---|
| 1 | 100.00 | 235.00 | 101.00 | 200.00 |

Janbus Empirical Coef is being used for the case of c=0
A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.
10 Trial Surfaces Have Been Generated.
9 Boxes Specified For Generation Of Central Block Base
Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 15.0

| Box No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Height (ft) |
|---|---|---|---|---|---|
| 1 | 117.00 | 225.00 | 117.00 | 225.00 | 0.00 |
| 2 | 126.00 | 224.00 | 126.00 | 224.00 | 0.00 |
| 3 | 146.00 | 229.00 | 146.00 | 229.00 | 0.00 |
| 4 | 176.00 | 243.00 | 176.00 | 243.00 | 0.00 |
| 5 | 196.00 | 253.00 | 196.00 | 253.00 | 0.00 |
| 6 | 236.00 | 273.00 | 236.00 | 273.00 | 0.00 |
| 7 | 251.00 | 281.00 | 251.00 | 281.00 | 0.00 |
| 8 | 256.00 | 286.00 | 256.00 | 286.00 | 0.00 |
| 9 | 261.00 | 299.00 | 261.00 | 299.00 | 0.00 |

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Evaluated. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Simplified Janbu Method * *

Total Number of Trial Surfaces Attempted = 10
Number of Trial Surfaces With Valid FS = 10
Statistical Data On All Valid FS Values:
FS Max = 2.044 FS Min = 1.241 FS Ave = 1.325
Standard Deviation = 0.253 Coefficient of Variation = 19.10 %

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 103.069 | 236.000 |
| 2 | 105.210 | 234.273 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.241 ***

Individual data on the 24 slices

| Slice | Width | Weight | Water Force Top | Water Force Bot | Tie Force Norm | Tie Force Tan | Earthquake Force Hor | Earthquake Force Ver | Surcharge Load |
|---|---|---|---|---|---|---|---|---|---|

| No. | (ft) | (lbs) | (lbs) | (lbs) | (lbs) | (lbs) | (lbs) | (lbs) | (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.1 | 212.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 8.4 | 4833.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 3.4 | 3700.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 5.0 | 6096.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 3.0 | 3706.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 1.0 | 1294.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 8.0 | 12911.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 6.0 | 13637.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 6.0 | 17057.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 5.0 | 15564.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 11.0 | 38623.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 14.0 | 50717.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 1.0 | 3411.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 13.0 | 43811.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 6.0 | 19123.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 16 | 1.0 | 3004.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 17 | 24.0 | 57684.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 18 | 5.0 | 8751.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 19 | 10.0 | 14434.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 20 | 6.0 | 6403.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 21 | 7.0 | 6169.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 22 | 2.0 | 1766.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 23 | 5.0 | 4506.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 24 | 5.0 | 2198.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 103.329 | 236.000 |
| 2 | 105.231 | 234.300 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.241 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 102.921 | 236.000 |
| 2 | 105.441 | 234.560 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.242 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 103.642 | 236.000 |
| 2 | 105.324 | 234.417 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |

| | | |
|---|---|---|
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.242 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 102.620 | 236.000 |
| 2 | 104.841 | 233.783 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.242 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 100.203 | 236.000 |
| 2 | 105.313 | 234.403 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.245 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 103.595 | 236.000 |
| 2 | 105.959 | 235.153 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.248 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 105.313 | 236.000 |
| 2 | 106.059 | 235.261 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety

*** 1.248 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 105.536 | 236.000 |
| 2 | 106.343 | 235.556 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety

*** 1.252 ***

Failure Surface Specified By 15 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 43.728 | 264.784 |
| 2 | 53.941 | 258.576 |
| 3 | 68.593 | 255.362 |
| 4 | 80.468 | 246.199 |
| 5 | 91.371 | 235.896 |
| 6 | 106.368 | 235.581 |
| 7 | 117.000 | 225.000 |
| 8 | 126.000 | 224.000 |
| 9 | 146.000 | 229.000 |
| 10 | 176.000 | 243.000 |
| 11 | 196.000 | 253.000 |
| 12 | 236.000 | 273.000 |
| 13 | 251.000 | 281.000 |
| 14 | 256.000 | 286.000 |
| 15 | 261.000 | 299.000 |

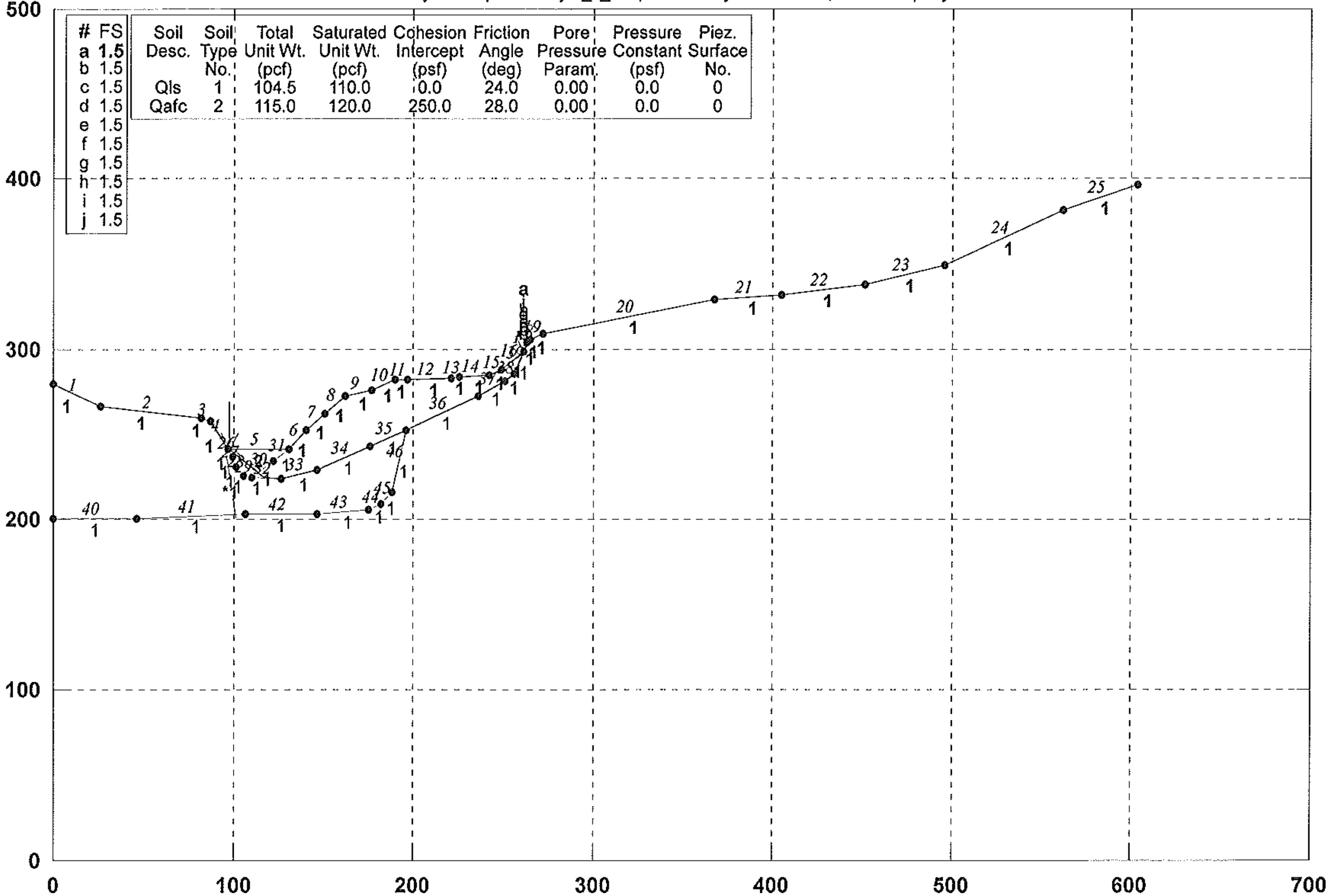
Factor of Safety

*** 2.044 ***

**** END OF GSTABL7 OUTPUT ****

## Sect 3, Terrapaca Landslide, Fill height at toe for approx. 1.5 FS

u:\2010\10-036-00\analyses\slope stability\3_s_1.2.pl2 Run By: John Smith, XYZ Company 9/28/2010 11:08AM




GSTABL7 v.2 FSmin=1.5

Safety Factors Are Calculated By The Simplified Janbu Method for the case of c=0

***** GSTABL7 *****

** GSTABL7 by Garry H. Gregory, P.E. **
** Original Version 1.0, January 1996; Current Version 2.005, Sept. 2006 **

********************************************************************************
SLOPE STABILITY ANALYSIS SYSTEM
Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.
********************************************************************************

Analysis Run Date: 9/28/2010
Time of Run: 11:08AM
Run By: John Smith, XYZ Company
Input Data Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_1.2.in
Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_1.2.OUT
Unit System: English
Plotted Output Filename: U:\2010\10-036-00\Analyses\Slope Stability\3_s_1.2.PLT
PROBLEM DESCRIPTION: Sect 3, Terrapaca Landslide, Fill
height at toe for approx. 1.5 FS

BOUNDARY COORDINATES
25 Top Boundaries
46 Total Boundaries

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Soil Type Below Bnd |
|---|---|---|---|---|---|
| 1 | 0.00 | 280.00 | 26.00 | 267.00 | 1 |
| 2 | 26.00 | 267.00 | 82.00 | 260.00 | 1 |
| 3 | 82.00 | 260.00 | 87.00 | 258.00 | 1 |
| 4 | 87.00 | 258.00 | 96.50 | 241.50 | 1 |
| 5 | 96.50 | 241.50 | 131.00 | 241.50 | 2 |
| 6 | 131.00 | 241.50 | 140.00 | 253.00 | 1 |
| 7 | 140.00 | 253.00 | 151.00 | 262.00 | 1 |
| 8 | 151.00 | 262.00 | 162.00 | 273.00 | 1 |
| 9 | 162.00 | 273.00 | 177.00 | 276.00 | 1 |
| 10 | 177.00 | 276.00 | 190.00 | 282.00 | 1 |
| 11 | 190.00 | 282.00 | 197.00 | 282.00 | 1 |
| 12 | 197.00 | 282.00 | 221.00 | 283.00 | 1 |
| 13 | 221.00 | 283.00 | 226.00 | 284.00 | 1 |
| 14 | 226.00 | 284.00 | 242.00 | 285.00 | 1 |
| 15 | 242.00 | 285.00 | 249.00 | 288.00 | 1 |
| 16 | 249.00 | 288.00 | 261.00 | 299.00 | 1 |
| 17 | 261.00 | 299.00 | 263.00 | 304.00 | 1 |
| 18 | 263.00 | 304.00 | 265.00 | 306.00 | 1 |
| 19 | 265.00 | 306.00 | 272.00 | 309.00 | 1 |
| 20 | 272.00 | 309.00 | 368.00 | 329.00 | 1 |
| 21 | 368.00 | 329.00 | 405.00 | 332.00 | 1 |
| 22 | 405.00 | 332.00 | 451.00 | 338.00 | 1 |
| 23 | 451.00 | 338.00 | 496.00 | 349.00 | 1 |
| 24 | 496.00 | 349.00 | 562.00 | 382.00 | 1 |
| 25 | 562.00 | 382.00 | 604.00 | 396.00 | 1 |
| 26 | 96.50 | 241.50 | 99.00 | 237.00 | 1 |
| 27 | 99.00 | 237.00 | 101.00 | 231.00 | 1 |
| 28 | 101.00 | 231.00 | 105.00 | 226.00 | 1 |
| 29 | 105.00 | 226.00 | 110.00 | 225.00 | 1 |
| 30 | 110.00 | 225.00 | 122.00 | 234.00 | 1 |
| 31 | 122.00 | 234.00 | 131.00 | 241.50 | 1 |
| 32 | 110.00 | 225.00 | 126.00 | 224.00 | 1 |
| 33 | 126.00 | 224.00 | 146.00 | 229.00 | 1 |
| 34 | 146.00 | 229.00 | 176.00 | 243.00 | 1 |
| 35 | 176.00 | 243.00 | 196.00 | 253.00 | 1 |
| 36 | 196.00 | 253.00 | 236.00 | 273.00 | 1 |
| 37 | 236.00 | 273.00 | 251.00 | 281.00 | 1 |
| 38 | 251.00 | 281.00 | 256.00 | 286.00 | 1 |
| 39 | 256.00 | 286.00 | 261.00 | 299.00 | 1 |
| 40 | 0.00 | 200.00 | 46.00 | 200.00 | 1 |
| 41 | 46.00 | 200.00 | 106.00 | 203.00 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 42 | 106.00 | 203.00 | 146.00 | 203.00 | 1 |
| 43 | 146.00 | 203.00 | 175.00 | 206.00 | 1 |
| 44 | 175.00 | 206.00 | 182.00 | 209.00 | 1 |
| 45 | 182.00 | 209.00 | 188.00 | 216.00 | 1 |
| 46 | 188.00 | 216.00 | 196.00 | 253.00 | 1 |

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

| Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Pore Pressure Param. | Pressure Constant (psf) | Piez. Surface No. |
|---|---|---|---|---|---|---|---|
| 1 | 104.5 | 110.0 | 0.0 | 24.0 | 0.00 | 0.0 | 0 |
| 2 | 115.0 | 120.0 | 250.0 | 28.0 | 0.00 | 0.0 | 0 |

Searching Routine Will Be Limited To An Area Defined By 1 Boundaries
Of Which The First 1 Boundaries Will Deflect Surfaces Upward

| Boundary No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) |
|---|---|---|---|---|
| 1 | 95.00 | 245.00 | 101.00 | 200.00 |

Janbus Empirical Coef is being used for the case of c=0
A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

10 Trial Surfaces Have Been Generated.

9 Boxes Specified For Generation Of Central Block Base
Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 15.0

| Box No. | X-Left (ft) | Y-Left (ft) | X-Right (ft) | Y-Right (ft) | Height (ft) |
|---|---|---|---|---|---|
| 1 | 117.00 | 225.00 | 117.00 | 225.00 | 0.00 |
| 2 | 126.00 | 224.00 | 126.00 | 224.00 | 0.00 |
| 3 | 146.00 | 229.00 | 146.00 | 229.00 | 0.00 |
| 4 | 176.00 | 243.00 | 176.00 | 243.00 | 0.00 |
| 5 | 196.00 | 253.00 | 196.00 | 253.00 | 0.00 |
| 6 | 236.00 | 273.00 | 236.00 | 273.00 | 0.00 |
| 7 | 251.00 | 281.00 | 251.00 | 281.00 | 0.00 |
| 8 | 256.00 | 286.00 | 256.00 | 286.00 | 0.00 |
| 9 | 261.00 | 299.00 | 261.00 | 299.00 | 0.00 |

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Evaluated. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Simplified Janbu Method * *

Total Number of Trial Surfaces Attempted = 10
Number of Trial Surfaces With Valid FS = 10
Statistical Data On All Valid FS Values:
FS Max = 1.517 FS Min = 1.507 FS Ave = 1.512
Standard Deviation = 0.004 Coefficient of Variation = 0.27 %

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 97.179 | 241.500 |
| 2 | 105.231 | 234.300 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.507 ***

Individual data on the 23 slices

| Slice | Width | Weight | Water Force Top | Water Force Bot | Tie Force Norm | Tie Force Tan | Earthquake Force Hor | Earthquake Force Ver | Surcharge Load |
|---|---|---|---|---|---|---|---|---|---|

| No. | (ft) | (lbs) | (lbs) | (lbs) | (lbs) | (lbs) | (lbs) | (lbs) | (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 8.1 | 3333.8 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 2 | 8.4 | 10098.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 3 | 3.4 | 5846.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 4 | 5.0 | 9258.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 5 | 4.0 | 7467.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 6 | 5.0 | 8926.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 7 | 9.0 | 19632.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 8 | 6.0 | 17057.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 9 | 5.0 | 15564.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 10 | 11.0 | 38623.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 11 | 14.0 | 50717.3 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 12 | 1.0 | 3411.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 13 | 13.0 | 43811.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 14 | 6.0 | 19123.5 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 15 | 1.0 | 3004.4 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 16 | 24.0 | 57684.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 17 | 5.0 | 8751.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 18 | 10.0 | 14434.1 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 19 | 6.0 | 6403.2 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 20 | 7.0 | 6169.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 21 | 2.0 | 1766.0 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 22 | 5.0 | 4506.6 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |
| 23 | 5.0 | 2198.9 | 0.0 | 0.0 | 0. | 0. | 0.0 | 0.0 | 0.0 |

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 97.380 | 241.500 |
| 2 | 105.323 | 234.415 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.507 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 97.426 | 241.500 |
| 2 | 105.689 | 234.852 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.508 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 97.731 | 241.500 |
| 2 | 105.704 | 234.870 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |

| | | |
|---|---|---|
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.508 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 98.268 | 241.500 |
| 2 | 106.127 | 235.334 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.513 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 99.265 | 241.500 |
| 2 | 106.078 | 235.282 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.514 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 99.324 | 241.500 |
| 2 | 106.035 | 235.236 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.514 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 99.567 | 241.500 |
| 2 | 106.100 | 235.304 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.516 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 99.133 | 241.500 |
| 2 | 106.349 | 235.562 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.517 ***

Failure Surface Specified By 11 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |
|---|---|---|
| 1 | 99.844 | 241.500 |
| 2 | 106.091 | 235.295 |
| 3 | 117.000 | 225.000 |
| 4 | 126.000 | 224.000 |
| 5 | 146.000 | 229.000 |
| 6 | 176.000 | 243.000 |
| 7 | 196.000 | 253.000 |
| 8 | 236.000 | 273.000 |
| 9 | 251.000 | 281.000 |
| 10 | 256.000 | 286.000 |
| 11 | 261.000 | 299.000 |

Factor of Safety
*** 1.517 ***

**** END OF GSTABL7 OUTPUT ****

# APPENDIX D

## Geophysical Testing Results

GMU
GEOTECHNICAL, INC.

July 22, 2010

Ms Lisa Bates
Engineering Geologist
GMU Geotechnical, Inc.
23241 Arroyo Vista
Rancho Santa Margarita, CA 92688

RE: BOREHOLE GEOPHYSICAL LOGGING REPORT
PALOS VERDE DRIVE
RANCHO PALOS VERDE, CALIFORNIA

NORCAL JOB No. 10-703.02B

Dear Ms Bates,

This report presents the findings of a borehole geophysical logging survey performed by NORCAL Geophysical Consultants for the subject project. The survey was part of a geotechnical site characterization concerning a proposed drainage tunnel. The survey was conducted by NORCAL Professional Geophysicist William J. Henrich on June 28, 2010. Logistical support was provided by Ms Wendy Drummond of GMU Geotechnical, Inc.

## 1.0 PURPOSE

The purpose of the geophysical logging was to quantitatively map orientations of the borehole discontinuities such as bedding, fractures, geologic contacts etc. in two core borings. One borehole was located along Palos Verde Drive; the other was located approximately 1/4 mile up slope on a line parallel to the tunnel alignment. Additionally, we were tasked to measure compressional (P-) and shear (S-) wave velocities as an aid in the determination of shear strength of the underlying bedrock.

## 2.0 SCOPE OF WORK

Our scope of work consisted of geophysical logging in two boreholes labeled as CH-1 and CH-2. The geophysical logging suite consisted of caliper, optical televiewer and Suspension P- and S-wave velocity tools. We were also tasked to analyze and interpret these field data and present the results in a written report.

## 3.0 BOREHOLE CONDITIONS

Boreholes were drilled with HQ diamond core methods. The boreholes penetrated shales and siltstone units of the Monterey Formation. This area of Palos Verde is prone to landsliding. It was reported by the on site geologist that both boreholes intercepted "multiple" slide planes. Both boreholes were drilled vertically. Borehole CH-1 had been completed to 150 below ground surface and allowed to equilibrate for three days prior to geophysical logging. The static water level encountered during geophysical logging was 103 feet below ground surface. Borehole CH-2 was dry down to 93 feet below ground surface.

## 4.0 BOREHOLE LOGGING METHODOLOGY

Geophysical logging consists of lowering various probes down the test bores and conducting various physical property measurements of the geologic formations. Our geophysical logging instruments (console, PC computer, downhole tools and DC powered four conductor winch) consisted of a digital ***Robertson Geologging, Ltd.*** Model ***Micrologger2 System***. The following discusses the three logging methods used in this survey.

### a.) Caliper

Borehole diameter was measured by a mechanical spring loaded 3-armed device and calibrated to read diameters in units of inches. Caliper logs are used to indicate formation washouts associated with either fracture zones or voids. The caliper log results are often used to correct the response of other logs (see section OPTV data reduction).

### b.) Image Logs

The presence and orientation of borehole discontinuities (fractures, bedding, geologic contacts, etc.) can be measured with image logging tools consisting of either optical (OPTV) or acoustic televiewer (BHTV). Our tool of choice for this survey was the OPTV televiewer. The OPTV tool consists of a charged coupled device (CCD) video camera that can operate in either dry or water-filled portions of the borehole providing that the water-filled portion is optically clear. A light source composed of a circular series of LEDs located at the bottom of the tool illuminates the borehole via a transparent viewing glass. Light reflected from the borehole wall is gathered by a hyperbolic mirror inside the transparent viewing window and reflected vertically up to the CCD camera. This results in a radial image strip that is referenced to magnetic north by an on board magnetic compass. The acquisition system then converts the analog data to oriented, digitized radial images with a maximum resolution of 0.004 feet. Built-in computer software also unwraps and composites the radial images into a real-time, two-dimensional plot of the borehole wall on the computer screen. During acquisition the inclination (tilt from vertical) of the borehole is recorded by an omni-directional three-axis accelerometer. The bearing (azimuth) of the tool was measured by a three-axis magnetometer.

### c.) Suspension P- and S-wave Logger

We used an OYO-Robertson Model 3403 digital suspension logging system to measure downhole compressional (P-) and shear (S-) velocities. The probe is equipped with a dipole seismic energy source located near the base of the probe and a pair of geophones (detectors) located towards the upper end of the probe. A schematic showing the probe configuration and equipment attachments is shown in Appendix A. In this survey the distance from the energy source to the first geophone was 7.02 feet (2.13 meters). The in-line distance between the geophone pair is 3.28 feet (1.0 meter). Each geophone contains one horizontal and one vertical oriented element. The horizontal geophone elements preferentially record the shear wave, the vertical geophone elements record first arriving P-wave energy.

Suspension seismic data is collected at discrete depths in a fluid-filled boring. At each measurement depth, the energy source is activated via commands from the surface control console. This activation causes a metal solenoid to strike a plate (anvil) mounted inside the probe housing. This energy transmits through the fluid to the borehole wall which produces a seismic wave ("flexure") in the adjacent formation. As this wave propagates radially in the formation away from the source, a seismic interaction between the seismic wave and the borehole wall creates tube waves together with a refracted compressional P-wave that travels up the borehole to the two recording geophones. P-wave arrival times are identified as the first break on the vertical geophone seismic records. Tube wave arrivals are later arriving seismic events and are recorded on the horizontal geophones. The identification of the tube wave arrival times are facilitated by recording seismic records from two opposite directions (horizontally left and right) of solenoid impacts. By superimposing these two seismic records, the onset of the tube wave/S-wave arrival time is usually identified as a higher amplitude and phase reversal event. The velocity of the tube wave is very close (90 percent) to that of the S-wave. Hence, we report tube wave velocities as seismic S-wave velocities.

When assembled, the suspension logging tool measures approximately 19 feet in length. The measuring point of the tool is taken at the center of the pair of geophones. This measuring point is approximately 11 feet from the bottom of the probe. Therefore, the maximum depth of our survey will always be reported 11 feet from the total depth of the borehole assuming the borehole is free of obstructions.

## 5.0 DATA ACQUISITION

### a.) Caliper

Prior to the survey, the caliper log response was calibrated to read in units of inches. The caliper logs were acquired in the up going direction at speeds ranging from 10 to12-feet-per-minute. The digital data sampling rate was every 0.05 feet.

### b.) OPTV Logs

The OPTV logging was recorded initially in an downhole direction at a logging speed of 4 feet-per-minute. After a review of this initial log, lighting parameters were adjusted and a second up going log was recorded. The purpose of the second log was to improve image quality and to create a repeat log to demonstrate the stability of the magnetic north reference measured by the instrumentation. The north compass direction was checked with a Brunton Compass prior to geophysical logging.

**c.) Suspension Logging**

We measured seismic suspension velocities ranging from one to two-foot intervals beginning approximately 11 feet from the bottom of each borehole. At each measurement station, we cycled the energy source to fire 3 times in succession into each geophone element. This cycling stacks seismic records to achieve better signal to noise ratios. We also recorded S-wave data using a 2.4 KHz low pass filter. This filtering reduces high frequency interference from the onset of earlier arriving P-wave modes.

Only borehole CH-,1 under ambient conditions, had a standing water column beginning at 103 feet below ground surface (bgs). The survey target interval in this borehole ranged from 90 to 70 feet bgs. Borehole CH-2 was dry down to total depth or approximately 93 feet bgs. The operation of the suspension logging requires a fluid-filled borehole column. Therefore, water was gravity fed into the boreholes from a water truck to raise the water level in each of the boreholes. Despite the constant influx of imported water, the water level in CH-1 did not rise above 103 feet. As a result, Suspension measurements were regulated to depths below 103 feet bgs.

## 6.0 DATA REDUCTION

**a.) OPTV Image Logs**

We used the computer program WELLCAD (Version 4.0, ALT, Luxemburg) to produce merged borehole optical televiewer images and caliper log plots and to calculate orientations of interpreted discontinuities (e.g. bedding and fractures) from the televiewer imagery. Corrections for the magnetic declination in the survey area required adding 13.5 degrees to the magnetic compass bearings in order to orient the borehole images to true north (NOAA, 2004, Magnetic Declination for The U.S.). Since borehole diameter is a major input parameter in determining dip magnitude, we input caliper log data into the program calculation of dips. Discontinuities analysis was performed interactively on sections of the unwrapped OPTV image as viewed on a computer monitor. An interpretable discontinuity on a two-dimensional unwrapped borehole televiewer log appears as a recognizable sinusoidal shaped trace that usually extends across the width of the borehole image. The sinusoidal shape is a visual manifestation of a planar discontinuity intercepting a three-dimensional cylindrical borehole. Planar discontinuities can be geologic features that include discrete fractures, bedding planes or other such planar contacts. Identified discontinuity traces on the image logs were fitted with a bendable sinusoid that best overlies the trend of the trace. WELLCAD then calculates a plane that represents the orientation of the discontinuity in terms of dip direction and dip magnitude based on the sinusoid overlay. The process is repeated for every significant discontinuity until the entire open section of the borehole is interpreted. At this stage, apparent dip direction and dip magnitude of the discontinuities are converted to true geographic dip direction and magnitude by factoring a correction for borehole deviation (azimuth and tilt).

Most discontinuities were observed to be continuous (360 degrees) across the "unwrapped" image plot, however, in complex fracture zones or in occurrences of high angle discontinuities (greater than 60 degree dip) the discontinuity trace is shown either in segments or in one partial irregular segment (much less than 360 degrees across). In either case only portions of the discontinuity are presented. Nonetheless, a best fit sinusoid was superimposed over these incomplete traces. These sinusoids and resulting calculations represent an approximate dip direction and magnitude for these noncontinuous features.

**b.) Suspension Logs**

Seismic P- and S-wave velocities were calculated with the interpretation computer software Glog SUS, Version 1.12 published by Oyo Corporation (2000). A typical interpreted seismic record is presented in Appendix B. This record shows six geophone traces. Traces H1 and H2 are horizontal geophone elements which are preferentially aligned to record S-waves. H1 is the geophone nearest to the source, H2 is the farthest from the source. V1 and V2 are the vertical geophone elements which are preferentially aligned to record P-waves. The horizontal geophone elements (H1 and H2) show a total of four S-wave arrival times; two arrival times identified at each geophone are referenced as "up" and "down" breaks. The"up" and "down" breaks are the result of two separate and oppositely directed (180 degrees) solenoid impacts by the energy source. As the example record illustrates, these opposing impacts produce amplitude phase reversals which identifies the on set of the S-wave energy. All seismic records were analyzed for P- and S- arrival times in this manner. Seismic velocities are calculated by dividing the geophone spacing interval (1 meter) by the interpreted interval travel times in microseconds to yield seismic velocities in meters per second. Two S-wave velocities are calculated at each depth measurement station. We averaged the results of two S-wave interval velocities and presented a single S-wave value at each measurement station.

The interval velocity calculation method is the preferred reduction technique. However, we have noticed that depending on borehole conditions the waveform record can show more than one S-wave phase reversal. To help eliminate this equivalence we calculate direct velocities from the arrival times. That is, we divide the travel distance from the source to the detectors by the arrival times (see graphic regarding the probe geometry). These direct arrival time velocities are compared to the interval velocities. When we see velocity discrepancies we reinterpret arrival times in the Glog-SUS program so that the interval velocities approximately correspond to the direct velocity calculation. It should be noted that the direct velocity calculation though useful as a velocity constraint can not substitute for an interval velocity because the delay times due to instrumental and probe standoff are not known precisely.

## 7.0 PRESENTATION AND RESULTS

Summary plots of all log data and interpretative illustrations can be found in Appendix C at a vertical scale of one inch equals two feet. The plots present the caliper log trace (green) superimposed on the initial Down going OPTV image plot in the far left track. Additional plots left to right are as follows: Up going OPTV log with sinusoid overlays, Tadpole, Suspension P- and S-wave Velocities (bar graph) and borehole deviation (see Azimuth and Tilt).

The tadpole symbol depicts discontinuity dip magnitude by its position on the depth versus degrees (0° to 90°) plot where 0° represents horizontal and 90° represents vertical. Dip direction is indicated by the position of the symbols tail as if it were positioned on a 360°compass face where north is the tail pointing vertically up the page, east is the tail pointing 90° to the right of vertical, south is pointing vertically down the page and west is 90° from vertical to the left of the page. The color of the sinusoid and tadpole have classification meaning. Black refers to fractures; green to bedding and blue to contacts.

Due either to the complexity or incompleteness of discontinuity traces in some fracture intervals, not all possible fractures were subject to tabulation and interpretation. This is to say that the number of interpreted fractures in our analysis will not always correlate to the fracture frequency as determined from rock core analysis for reasons of significance, silica mineralization within fractures and undetected mechanical breakage of core samples at the surface.

**a.) Discontinuity analysis**

Interpreted discontinuities were classified as bedding, fractures and contacts. We identified discontinuities as bedding because these features appeared closely spaced, had very thin traces with no open aperture and followed a near constant dip direction and angle across limited depth intervals. A contact classification was given to a discontinuity that visually appeared to separate distinctly different rock units. A discontinuity was classified as a fracture because we observed evidence of an open or partially open aperture. This open or partially aperture characteristic can be inferred by caliper log breakouts or the appearance of an open aperture of the discontinuity on an optical televiewer. A complete listing of interpreted discontinuity depth, dip direction (Azimuth), dip angle from horizontal, WELLCAD code and classification ("class") has been summarized in a series of tables. These discontinuity tables are presented in Appendix D.

**b.) Suspension P- and S- wave velocities**

Suspension S- and P-wave Interval velocities presented in bar graph form on the Log Summary Plots (see Appendix C) are presented as numerical tables in Appendix E. In general, Borehole CH-1 ranged from 1100 to 2600 feet per second (fps). S-wave velocities in Borehole CH-2 ranged from 760 to 1649 fps. The lower S-wave velocities in CH-2 versus CH-1 are probably the result of the rock mass in the former having been subjected to greater amounts of weathering and possibly greater slide movement. Landslide movement mechanically deforms the rock which reduces shear strength and S-wave velocity. P-wave velocities were measured below 5000 fps in Boreholes CH-1 above 120 feet and all of CH-2. It is our experience that in unsaturated bedrock where we are adding water to the borehole to create an artificially high fluid column, the P-wave arrivals on the waveform records are not conclusive because the signal level is relatively weak compared to the S-wave. We therefore state that our P-wave results are at best estimates.

## STANDARD CARE AND WARRANTY

The scope of NORCAL's services for this project consisted of using the downhole geophysical techniques to measure the orientation of bedrock discontinuities and measure Suspension seismic velocities. The accuracy of our findings is subject to specific site conditions and limitations inherent to the techniques used. We performed our services in a manner consistent with the standard of care ordinarily exercised by members of the profession currently employing similar methods. No warranty, with respect to the performance of services or products delivered under this agreement, expressed or implied, is made by NORCAL.

Thank you for the opportunity to participate in this investigation. Should you have questions please call me at your earliest convenience.

Yours very truly,

NORCAL Geophysical Consultants, Inc.

William J. Henrich, CEG, GP
Professional Geophysicist-893

Enclosures

WJH/KGB/tt

ENCLOSURES

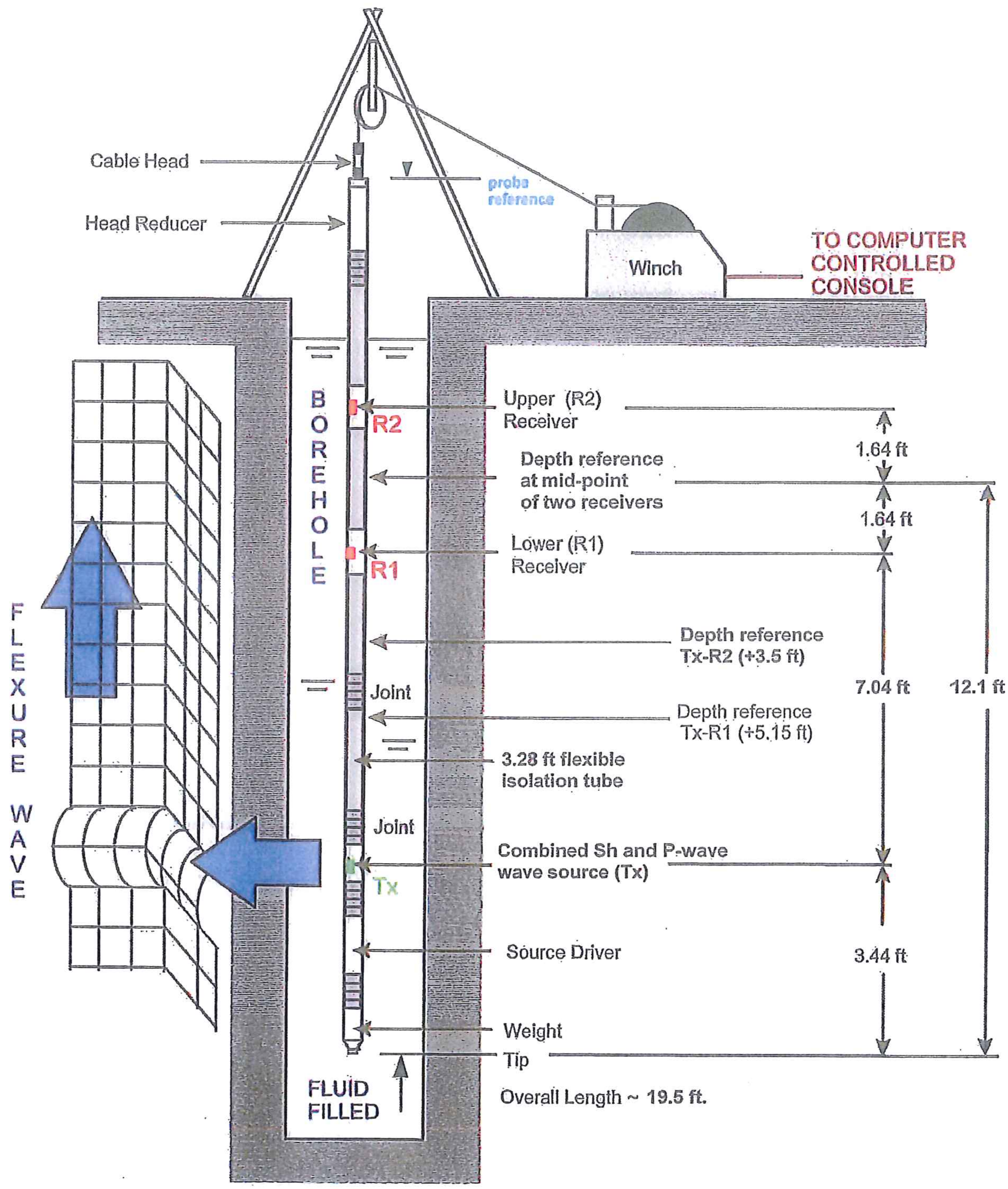
APPENDIX A: Suspension Logging Probe and System Schematic
APPENDIX B: Example Survey Suspension Waveform Records with Interpreted Arrival Times
APPENDIX C: Summary Log Plots, CH-1 and CH-2
APPENDIX D: Discontinuity Tables, CH-1 and CH-2
APPENDIX E: P-and S-wave Suspension Velocity Table, CH-1 and CH-2

NORCAL

# APPENDIX A

## Suspension Logging Probe and System Schematic

## SUSPENSION LOGGING PROBE AND EQUIPMENT CONFIGURATION




**Constructed with 1 meter (3.28 ft) isolation tube**

Drawing not to scale

NORCAL

# APPENDIX B

Example Suspension Waveform Record with Interpreted Arrival Times

# Example Interpreted Waveform Record via GLOG-SUS Program CH-2

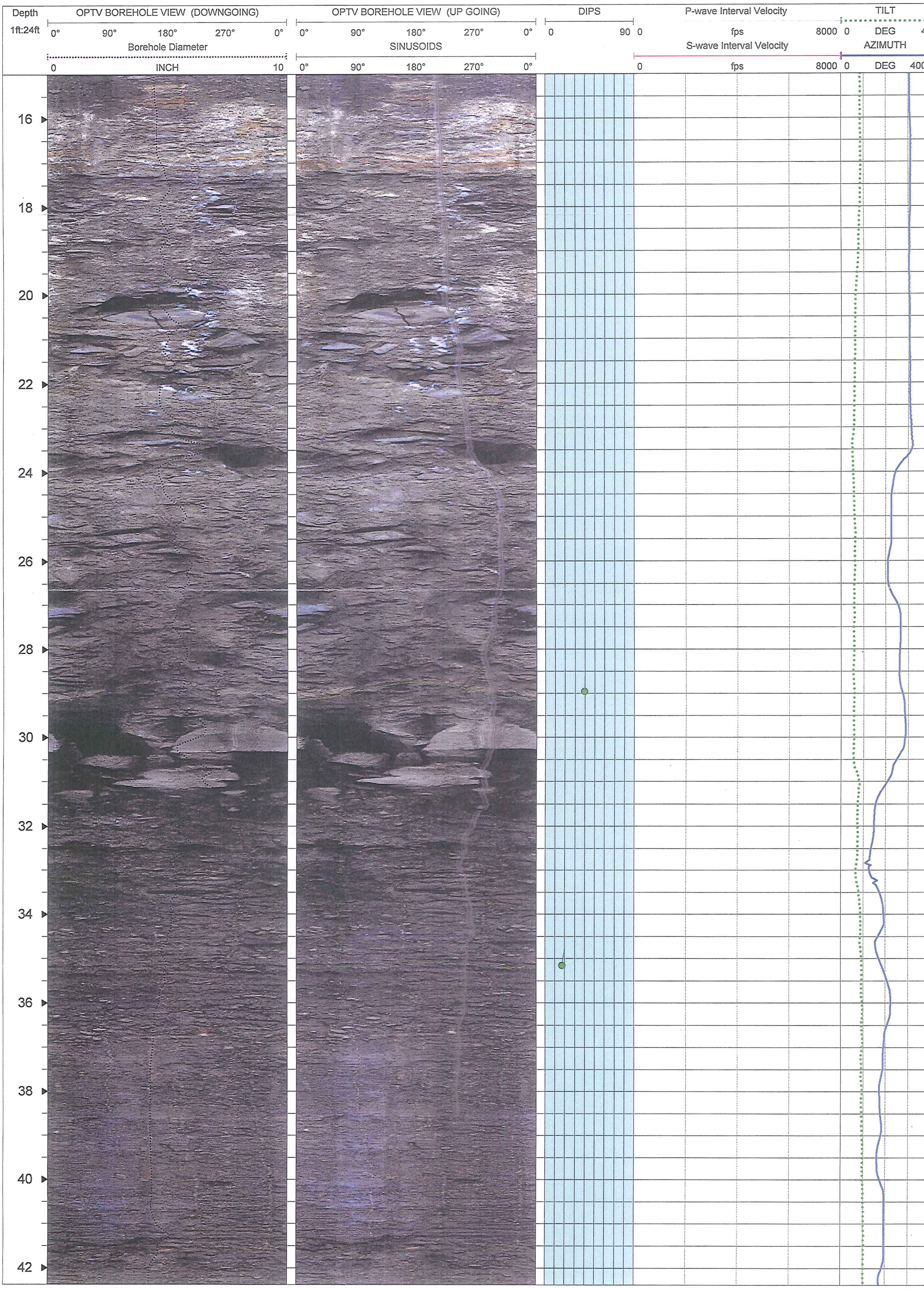

Example Waveform Record CH-1

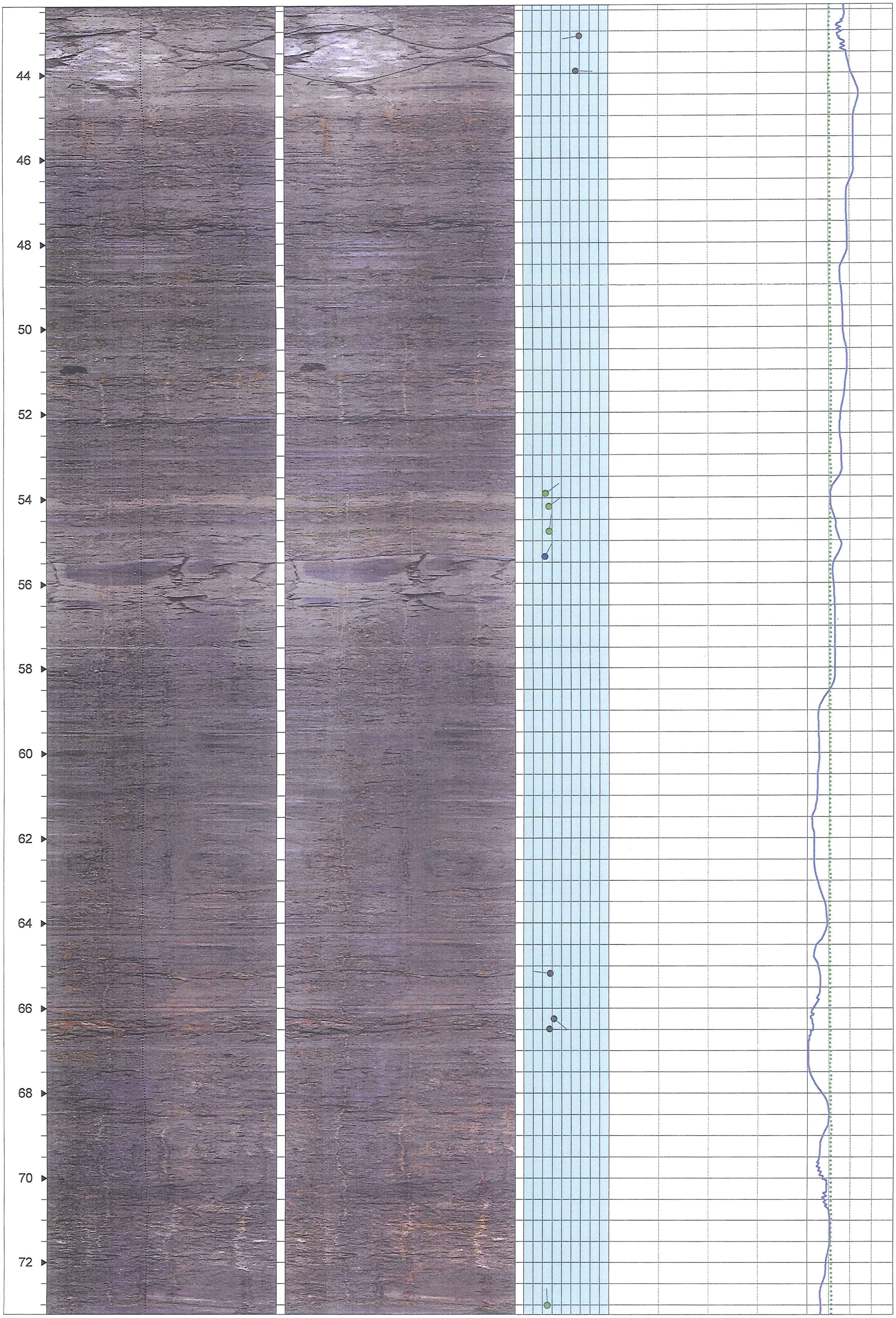
APPENDIX C

Summary Log Plots, CH-1 and CH-2

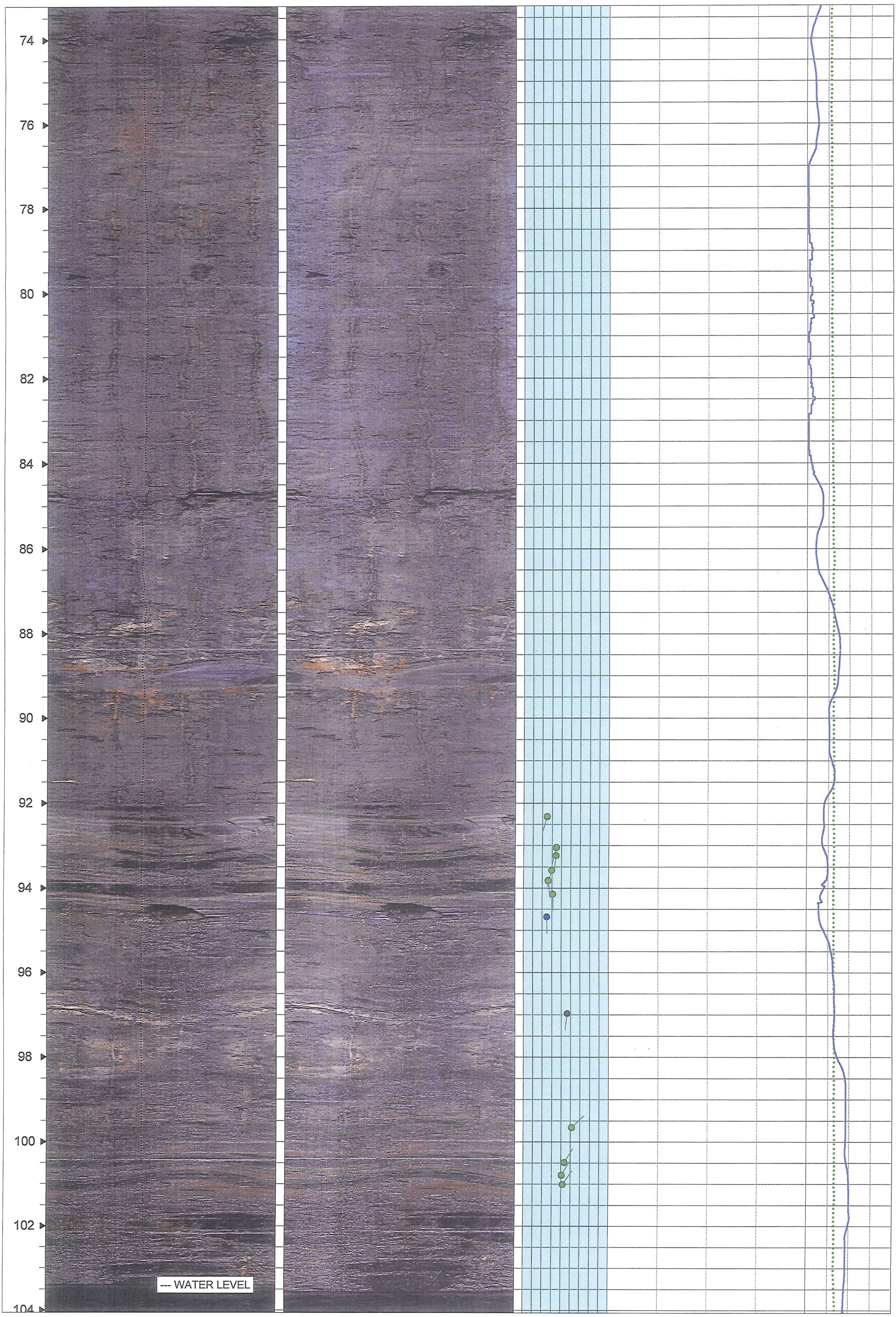
| NORCAL GEOPHYSICAL CONSULTANTS, INC. | OPTV, CALIPER, SUSPENSION LOG SUMMARY PLOT | COMPANY: GMU Geotechnical<br>WELL ID: CH-1<br>FIELD: PALOS VERDE<br>COUNTY: LOS ANGELES | DATE: JUNE 28, 2010<br>Borehole Dia. 4 in.<br>JOB NO. 10-703.02B<br>STATE: CA |
|---|---|---|---|

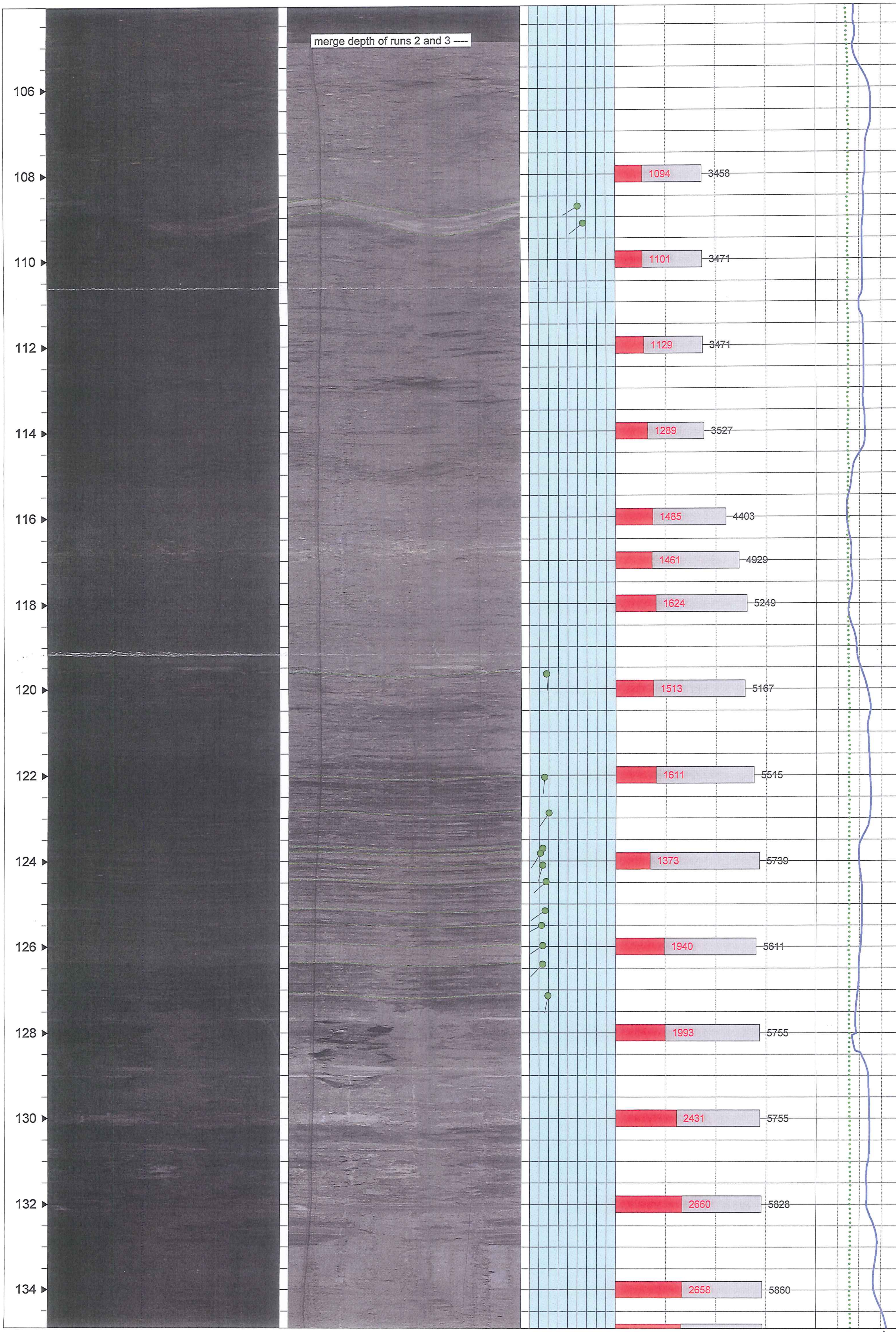
NOTES: Water added to borehole during Suspension logging. Unable to maintain water level above 103 feet. Therefore, velocity data acquisition restricted to lower borehole depths.

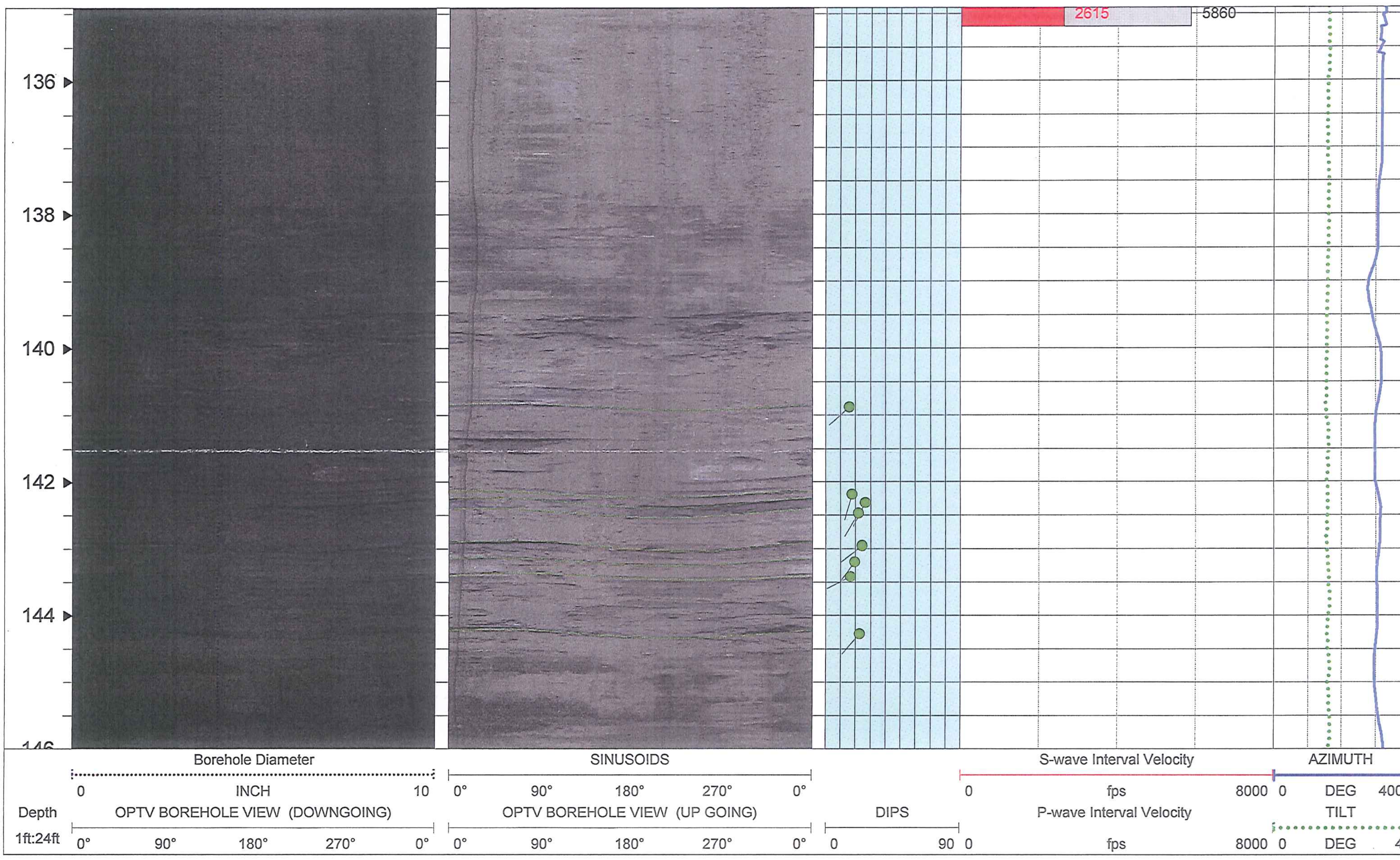




44
46
48
50
52
54
56
58
60
62
64
66
68
70
72


74
76
78
80
82
84
86
88
90
92
94
96
98
100
102
104
--- WATER LEVEL


106
108
110
112
114
116
118
120
122
124
126
128
130
132
134
merge depth of runs 2 and 3 ----
1094
3458
1101
3471
1129
3471
1289
3527
1485
4403
1461
4929
1624
5249
1513
5167
1611
5515
1373
5739
1940
5611
1993
5755
2431
5755
2660
5828
2658
5860


136
138
140
142
144
146
2615
5860
Borehole Diameter
0
INCH
10
OPTV BOREHOLE VIEW (DOWNGOING)
0° 90° 180° 270° 0°
SINUSOIDS
0° 90° 180° 270° 0°
OPTV BOREHOLE VIEW (UP GOING)
0° 90° 180° 270° 0°
DIPS
0 90
S-wave Interval Velocity
0 fps 8000
P-wave Interval Velocity
0 fps 8000
AZIMUTH
0 DEG 400
TILT
0 DEG 4
Depth
1ft:24ft

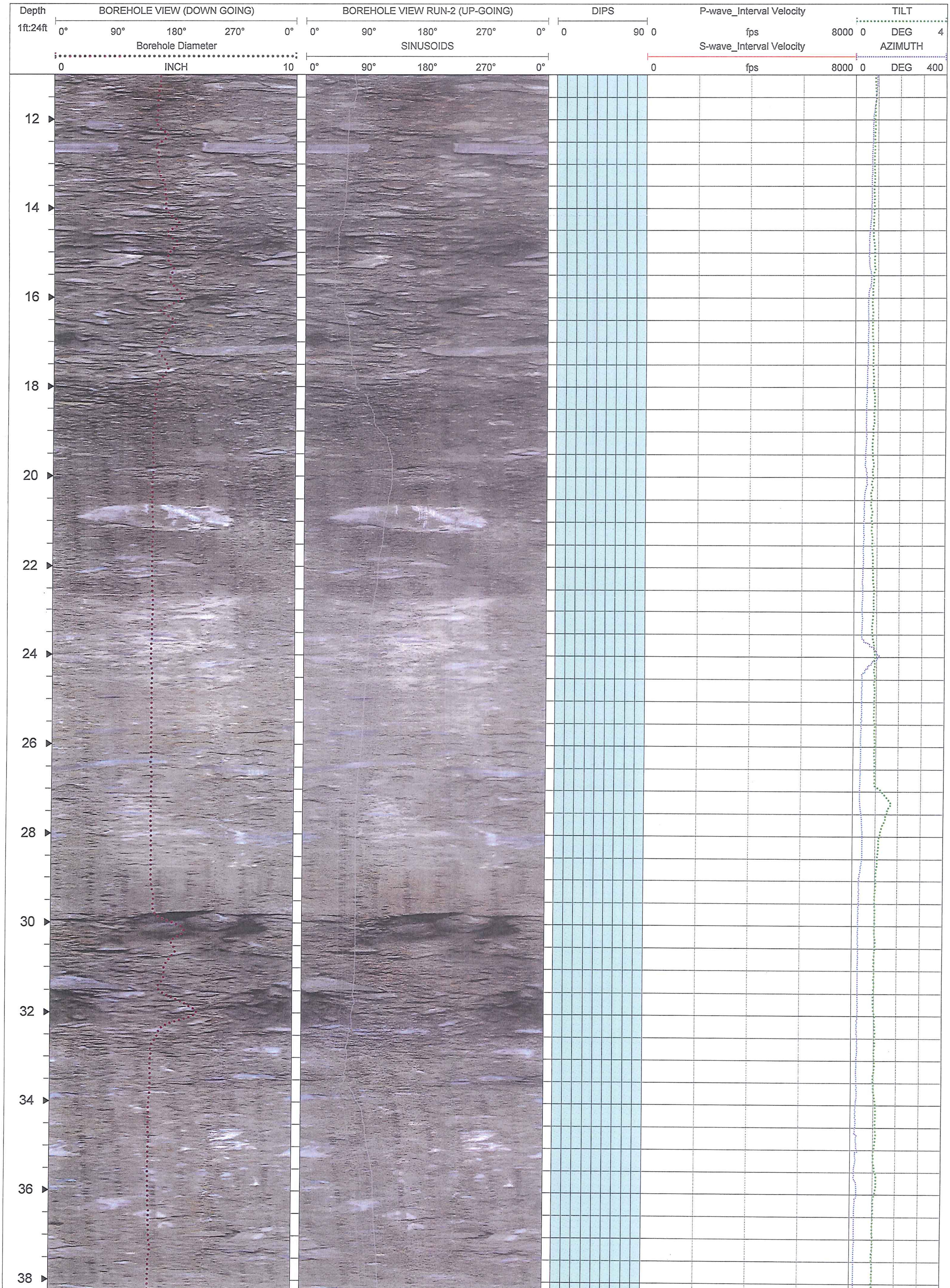
**NORCAL** NORCAL GEOPHYSICAL CONSULTANTS, INC.

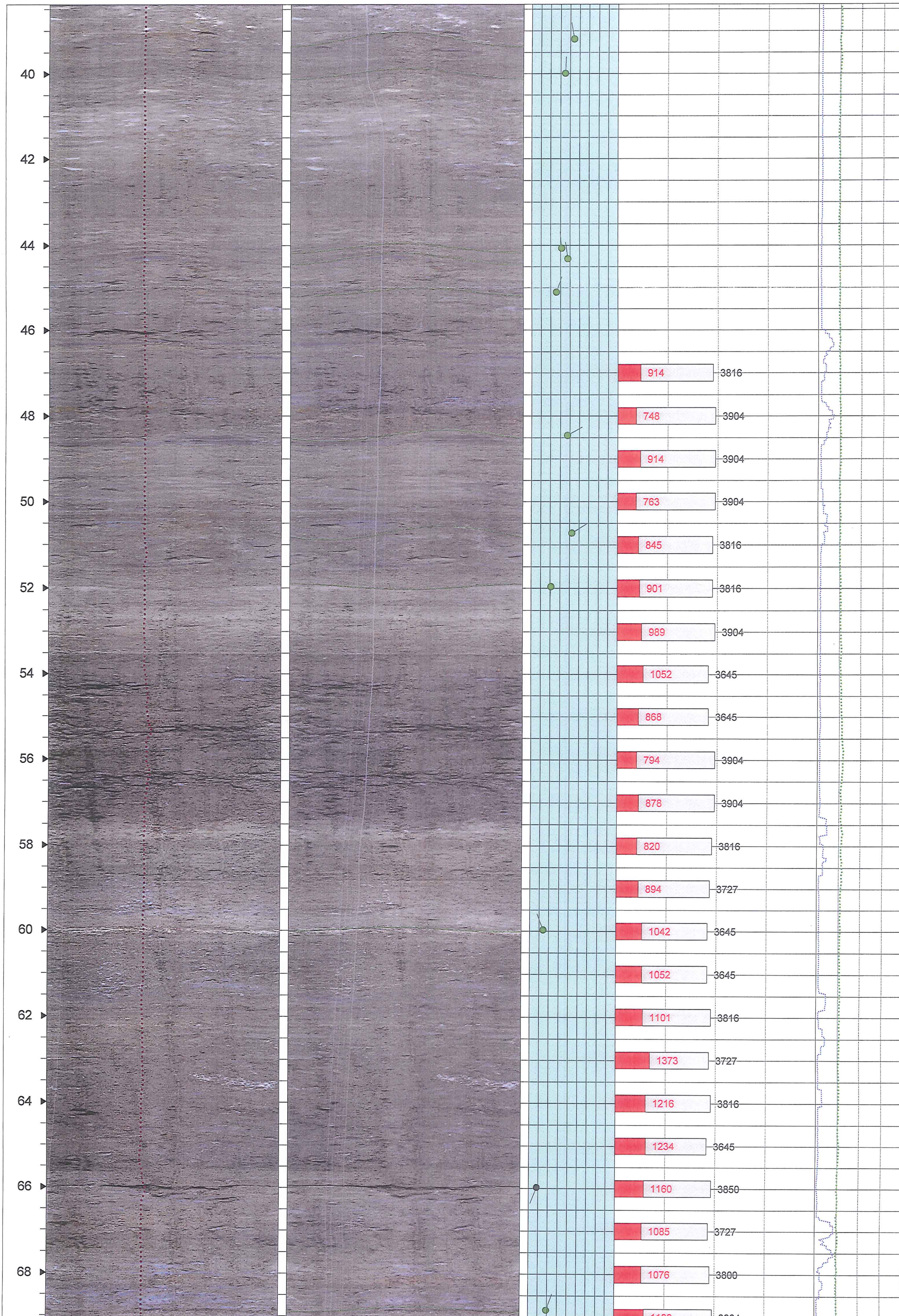
**OPTV, CALIPER, SUSPENSION LOG SUMMARY PLOT**

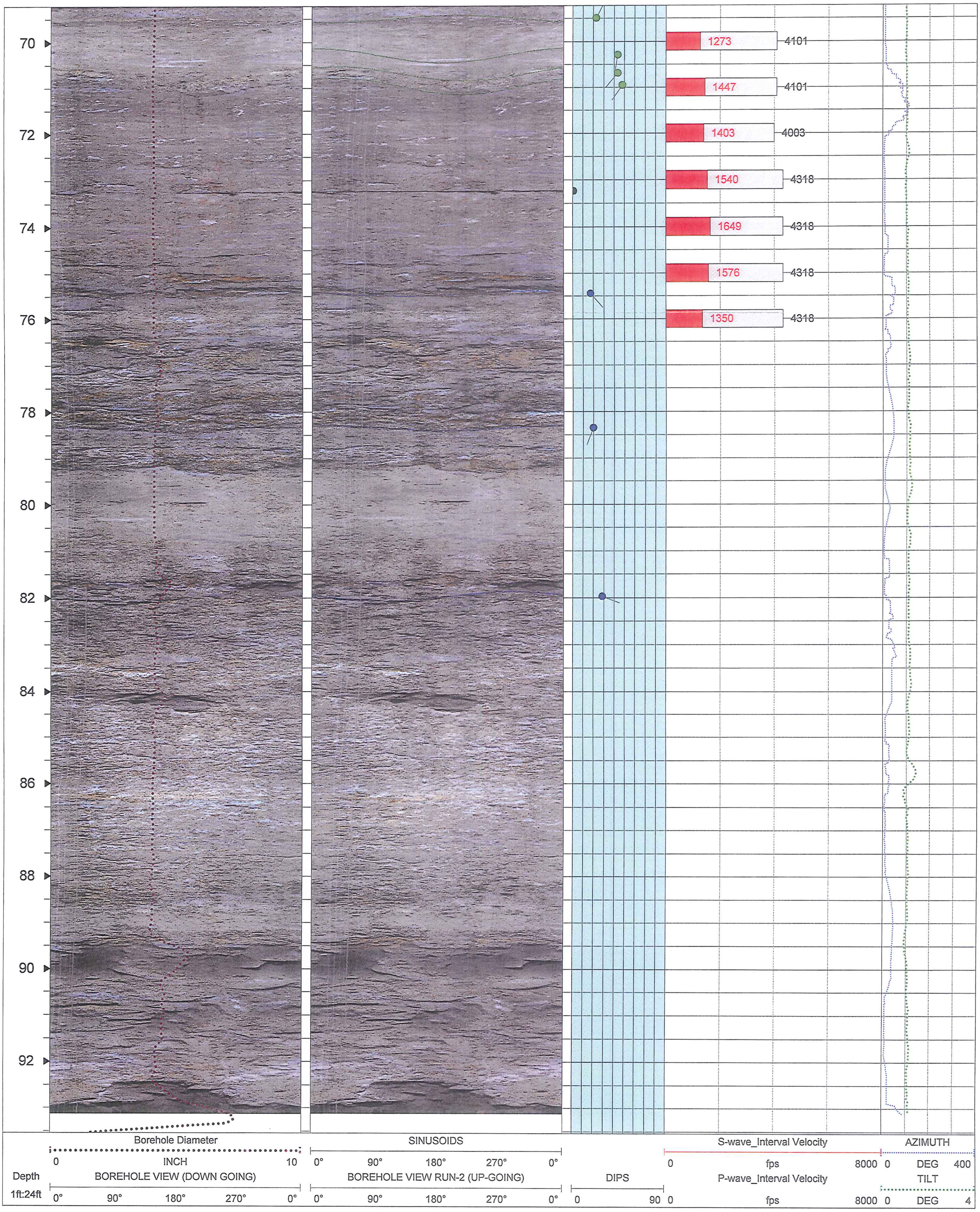
COMPANY: GMU Geotechnical
WELL ID: CH-2
FIELD: PALOS VERDE
COUNTY: LOS ANGELES

DATE: JUNE 28, 2010
Borehole Dia. 4 in.
JOB NO. 10-703.02B
STATE: CA

NOTES: Borehole dry to total depth. Added water to borehole during Suspension logging survey




40
42
44
46
48
50
52
54
56
58
60
62
64
66
68
914 3816
748 3904
914 3904
763 3904
845 3816
901 3816
989 3904
1052 3645
868 3645
794 3904
878 3904
820 3816
894 3727
1042 3645
1052 3645
1101 3816
1373 3727
1216 3816
1234 3645
1160 3850
1085 3727
1076 3800
1189 3904



70
72
74
76
78
80
82
84
86
88
90
92
1273
4101
1447
4101
1403
4003
1540
4318
1649
4318
1576
4318
1350
4318
Depth
1ft:24ft
Borehole Diameter
0 INCH 10
BOREHOLE VIEW (DOWN GOING)
0° 90° 180° 270° 0°
SINUSOIDS
0° 90° 180° 270° 0°
BOREHOLE VIEW RUN-2 (UP-GOING)
0° 90° 180° 270° 0°
DIPS
0 90
S-wave_Interval Velocity
0 fps 8000
P-wave_Interval Velocity
0 fps 8000
AZIMUTH
0 DEG 400
TILT
0 DEG 4

APPENDIX D

Discontinuity Tables, CH-1 and CH-2

| Boring CH-1 DISCONTINUITY TABLE<br>PALOS VERDE DRIVE<br>RANCHO PALOS VERDE, CA | | | | |
|---|---|---|---|---|
| Depth | Azimuth | Dip | Class | Comment |
| ft. (bgs) | deg | deg | code-color | class |
| 28.95 | 0.98 | 39.88 | 106-green | bedding |
| 35.16 | 7.77 | 17.52 | 106-green | bedding |
| 43.11 | 259.76 | 59.59 | 100-black | fracture |
| 43.93 | 90.99 | 56.29 | 100-black | fracture |
| 53.9 | 53.21 | 23.69 | 106-green | bedding |
| 54.2 | 53.5 | 27.13 | 106-green | bedding |
| 54.78 | 6.39 | 27.52 | 106-green | bedding |
| 55.37 | 27.73 | 22.68 | 107-blue | contact |
| 65.18 | 277.32 | 28.41 | 100-black | fracture |
| 66.25 | 129.22 | 32.51 | 100-black | fracture |
| 66.49 | 92.97 | 27.95 | 100-black | fracture |
| 73.01 | 357.79 | 25.36 | 106-green | bedding |
| 92.31 | 196.12 | 25.15 | 106-green | bedding |
| 93.04 | 193.68 | 34.97 | 106-green | bedding |
| 93.24 | 186.26 | 34.49 | 106-green | bedding |
| 93.58 | 193.2 | 29.97 | 106-green | bedding |
| 93.83 | 173.41 | 26.52 | 106-green | bedding |
| 94.14 | 179.9 | 31.3 | 106-green | bedding |
| 94.68 | 178.97 | 24.96 | 107-blue | contact |
| 96.97 | 186.73 | 46.42 | 100-black | fracture |
| 99.66 | 45.47 | 51.54 | 106-green | bedding |
| 100.49 | 31.83 | 43.73 | 106-green | bedding |
| 100.78 | 29.59 | 41.01 | 106-green | bedding |
| 101.01 | 34.7 | 41.97 | 106-green | bedding |
| 108.75 | 238.01 | 51.33 | 106-green | bedding |
| 109.15 | 231.68 | 56.81 | 106-green | bedding |
| 119.65 | 176.06 | 17.81 | 106-green | bedding |
| 122.05 | 184.64 | 15.92 | 106-green | bedding |
| 122.88 | 214.63 | 20.22 | 106-green | bedding |
| 123.7 | 207.81 | 13.87 | 106-green | bedding |
| 123.82 | 212.18 | 11.44 | 106-green | bedding |
| 124.09 | 195.59 | 13.94 | 106-green | bedding |
| 124.48 | 227.53 | 17.52 | 106-green | bedding |
| 125.17 | 235.91 | 16.59 | 106-green | bedding |
| 125.5 | 242.22 | 12.98 | 106-green | bedding |
| 125.97 | 236.18 | 13.99 | 106-green | bedding |
| 126.41 | 224.03 | 14.03 | 106-green | bedding |
| 127.14 | 190.57 | 19.71 | 106-green | bedding |
| 140.88 | 228.5 | 16.25 | 106-green | bedding |
| 142.19 | 195.53 | 17.86 | 106-green | bedding |
| 142.31 | 207.04 | 26.8 | 106-green | bedding |
| 142.47 | 210.37 | 22.23 | 106-green | bedding |
| 142.95 | 231.66 | 24.55 | 106-green | bedding |
| 143.2 | 215.7 | 19.57 | 106-green | bedding |
| 143.42 | 243.62 | 16.71 | 106-green | bedding |
| 144.28 | 221 | 22.87 | 106-green | bedding |

| Boring CH-2 DISCONTINUITY TABLE<br>PALOS VERDE DRIVE<br>RANCHO PALOS VERDE, CA | | | | |
|---|---|---|---|---|
| Depth | Azimuth | Dip | Class | Comment |
| ft | deg | deg | code-color | class |
| 39.19 | 350.49 | 44.46 | 106-green | bedding |
| 39.99 | 1.85 | 35.24 | 106-green | bedding |
| 44.06 | 354.44 | 31.73 | 106-green | bedding |
| 44.31 | 352.47 | 38.01 | 106-green | bedding |
| 45.11 | 19.26 | 25.89 | 106-green | bedding |
| 48.45 | 59.42 | 37.58 | 106-green | bedding |
| 50.73 | 59.07 | 42.67 | 106-green | bedding |
| 51.96 | 182.76 | 21.15 | 106-green | bedding |
| 59.97 | 339.86 | 14.33 | 106-green | bedding |
| 65.98 | 202.32 | 8.72 | 100-black | fracture |
| 68.83 | 19.43 | 19.19 | 106-green | bedding |
| 69.13 | 6.09 | 19.15 | 106-green | bedding |
| 69.49 | 27.41 | 22.77 | 106-green | bedding |
| 70.28 | 188.29 | 43.75 | 106-green | bedding |
| 70.67 | 218.37 | 43.93 | 106-green | bedding |
| 70.94 | 214.39 | 48.48 | 106-green | bedding |
| 73.23 | 194.7 | 1.08 | 100-black | fracture |
| 75.44 | 138.07 | 17.61 | 107-contact | contact |
| 78.34 | 200.41 | 19.97 | 107-contact | contact |
| 81.97 | 109.96 | 28.99 | 107-contact | contact |

# APPENDIX E

P-and S-wave Suspension Velocity Table, CH-1 and CH-2

SUSPENSION LOGGING VELOCITY TABLES
BOREHOLE CH-1
INTERVAL VELOCITIES

| Depth | S-wave Velocity | P-wave Velocity |
|---|---|---|
| feet | fps | fps |
| 108 | 1094 | 3458 |
| 110 | 1101 | 3471 |
| 112 | 1129 | 3471 |
| 114 | 1289 | 3527 |
| 116 | 1485 | 4403 |
| 117 | 1461 | 4929 |
| 118 | 1624 | 5249 |
| 120 | 1513 | 5167 |
| 122 | 1611 | 5515 |
| 124 | 1373 | 5739 |
| 126 | 1941 | 5755 |
| 126 | 1940 | 5611 |
| 128 | 1993 | 5755 |
| 130 | 2431 | 5755 |
| 132 | 2660 | 5828 |
| 134 | 2658 | 5860 |
| 135 | 2615 | 5860 |

BOREHOLE CH-2
INTERVAL VELOCITIES

| Depth | S-wave Velocity | P-wave Velocity |
|---|---|---|
| feet | fps | fps |
| 47 | 914 | 3816 |
| 48 | 748 | 3904 |
| 49 | 914 | 3904 |
| 50 | 763 | 3904 |
| 51 | 845 | 3816 |
| 52 | 901 | 3816 |
| 53 | 989 | 3904 |
| 54 | 1052 | 3645 |
| 55 | 868 | 3645 |
| 56 | 794 | 3904 |
| 57 | 878 | 3904 |
| 58 | 820 | 3816 |
| 59 | 894 | 3727 |
| 60 | 1042 | 3645 |
| 61 | 1052 | 3645 |
| 62 | 1101 | 3816 |
| 63 | 1373 | 3727 |
| 64 | 1216 | 3816 |
| 65 | 1234 | 3645 |
| 66 | 1160 | 3850 |
| 67 | 1085 | 3727 |
| 68 | 1076 | 3800 |
| 69 | 1189 | 3904 |
| 70 | 1273 | 4101 |
| 71 | 1447 | 4101 |
| 72 | 1403 | 4003 |
| 73 | 1540 | 4318 |
| 74 | 1649 | 4318 |
| 75 | 1576 | 4318 |
| 76 | 1350 | 4318 |