APPENDIX G – GEOTECHNICAL ENGINEERING

for

RIO GUAYANILLA, GUAYANILLA, PR

2018 SUPPLEMENTAL APPROPRIATIONS

FLOOD RISK MANAGEMENT STUDY

March 2020

US Army Corps of Engineers®
Chicago District

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1.0 Introduction

The Rio Guayanilla basin is located within the Municipality of Guayanilla on the southwestern coast of Puerto Rico. The Rio Guayanilla originates at a point near the central mountain range and flows in a southerly direction through steep slopes in the upper part of the basin producing fast runoff velocities and allowing minimal infiltration. The total length of the river channel is approximately 13.9 miles. The total drainage area of the Rio Guayanilla basin is approximately 37 square miles.

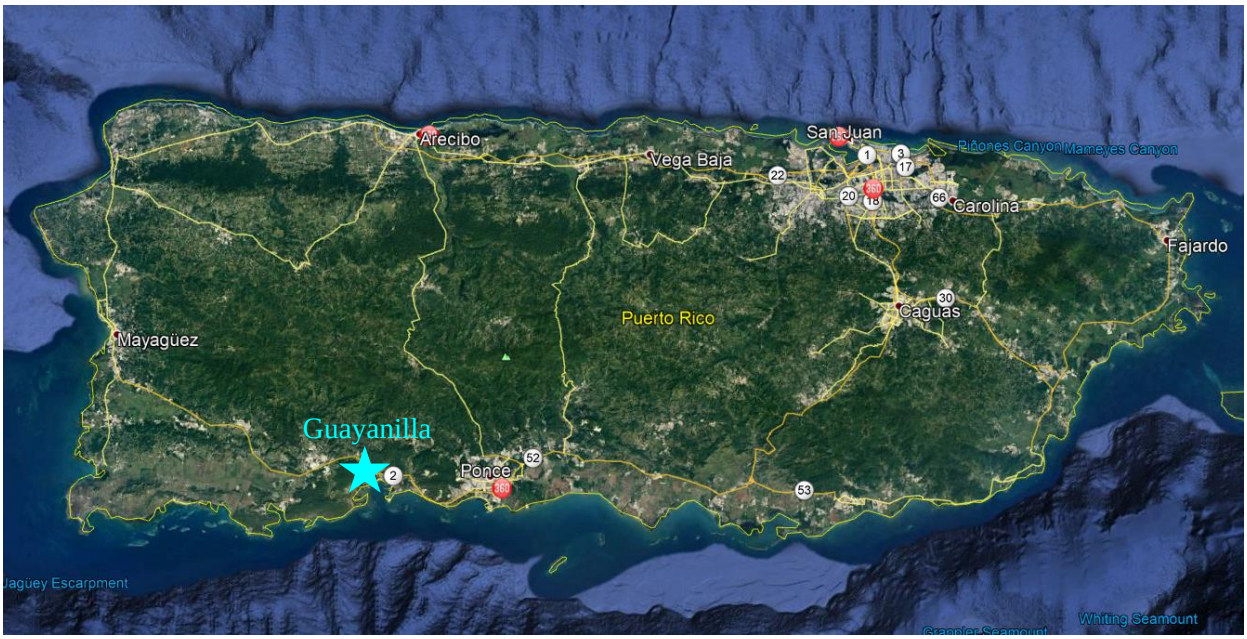

Figure 1: Location of Guayanilla

A Reconnaissance Report was prepared by USACE in 1990 to investigate flooding problems in the Town of Guayanilla and identify measures within the Federal interest. Federal interest was determined but the Non-Federal Sponsor opted out of moving into the Feasibility Phase. The Sponsor constructed a portion of the project recommended in the Reconnaissance Report in 2004. This segment of levee will be referred to as the Phase 1 Levee in this appendix and is located at the coast.

The feasibility team identified six alternatives in the feasibility report, with one alternative as the tentatively selected plan (TSP). The purpose of this appendix is to evaluate subsurface soil information and provide generalized geotechnical design and related construction considerations for each of the proposed flood risk management alternative.

2.0 Geology

2.1 Topography

Guayanilla lies in a coastal plain approximately eleven and a half miles west of the city of Ponce. The topography of Puerto Rico is extremely varied, but most of the island is hilly to mountainous, with very steep slopes and narrow valleys in the interior (Kaye, 1959). The south coast of the island is a low alluvial plain where nearly flat areas slope slightly upward to the foothills and grade into the alluvial plains of the larger rivers (Monroe 1980). The plains consist of combined alluvial fans with deposits from the Quaternary age consisting of sand, clay, and gravel (Monroe 1980).

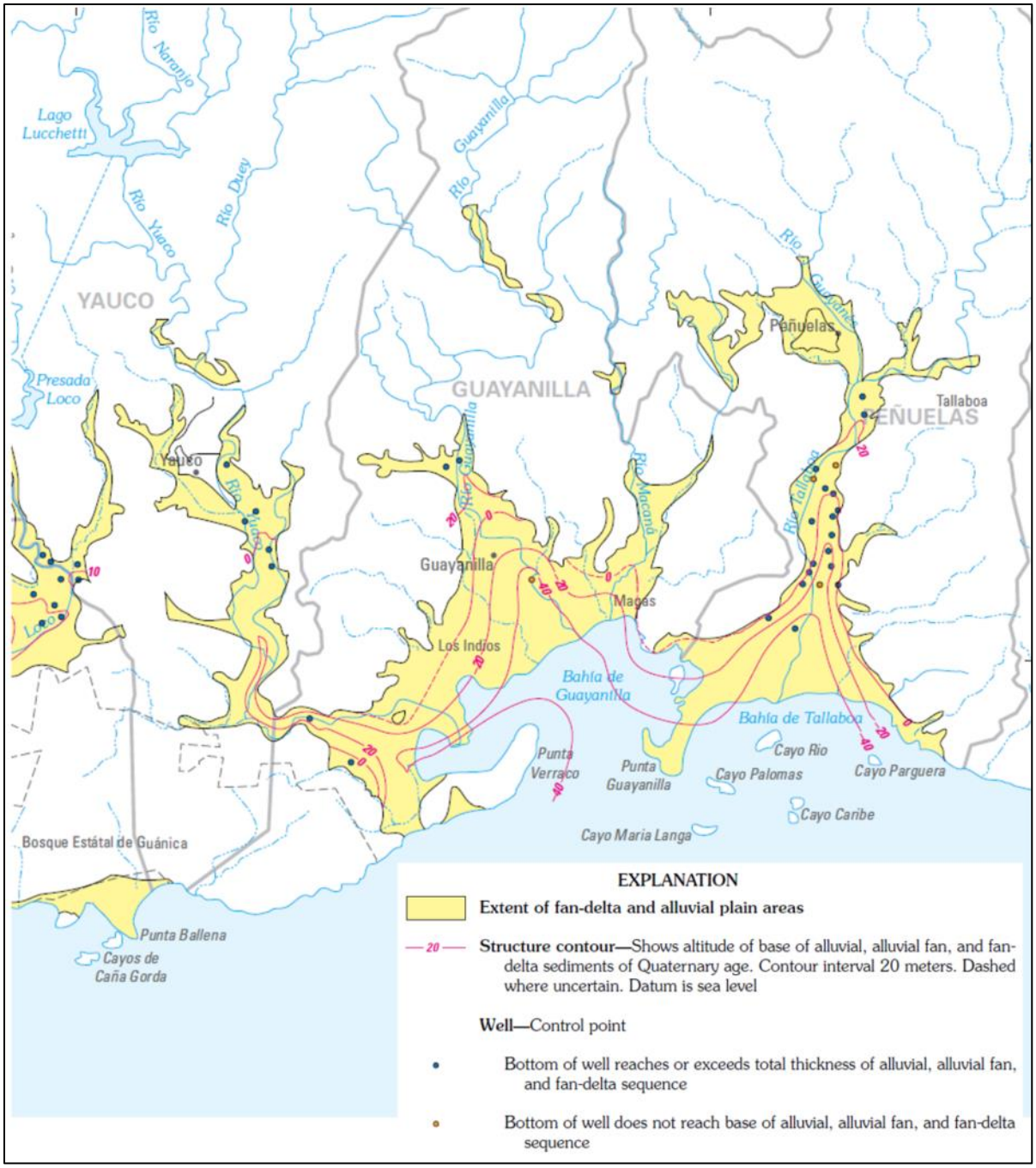

Figure 2: Bedrock Surface Underlying Alluvial-Fan and Fan-Delta Sediments (Renken and others, 2002)

Topographic maps from the USGS were available from 1946 and 1966. Water drains from the mountains to the ocean. Within 20 years, there was rapid expansion of the town footprint and cemetery. Expressway PR-2 was established north of the town within that time period and the establishment of the banana plantation altered the orientation of the contours. A pond was shown west of 335 on the topo maps but no longer appears to exist today based on site inspections. There also appears to be an old river along the proposed diversion channel alignment that was not observed in the present. These features can impact levee construction due to different subsurface conditions and should be considered during design.

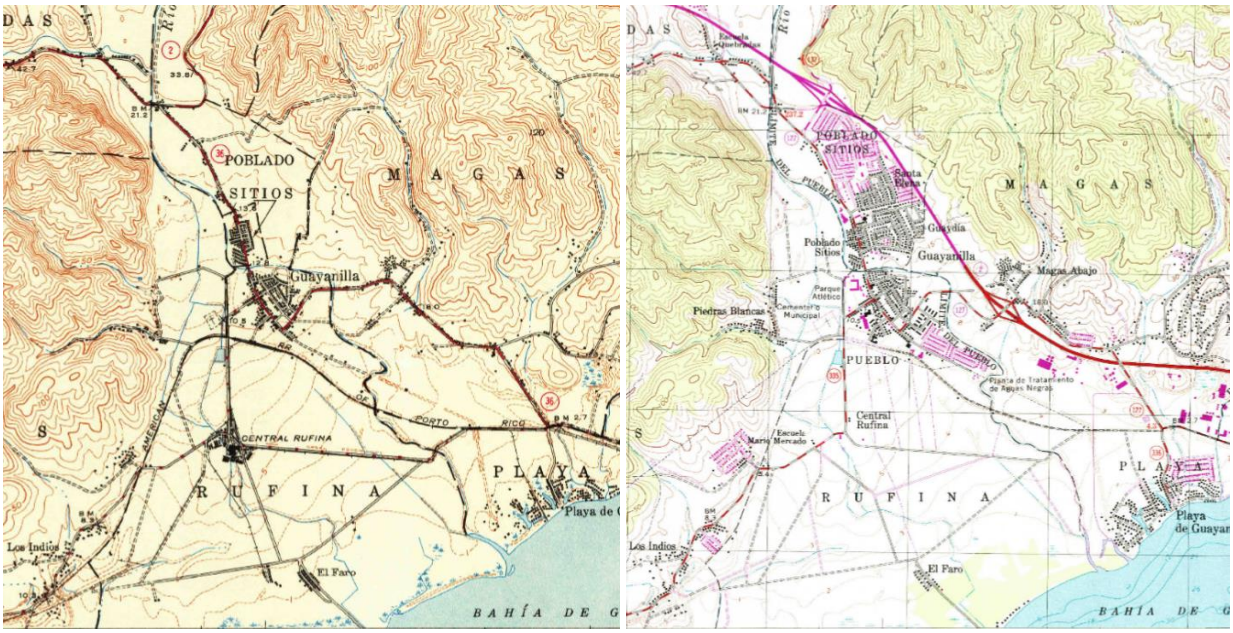

Figure 3: Topographic Maps from 1946 and 1966 (USGS)

2.2 Surficial Geology

The soils in the Rio Guayanilla basin consist of alluvial deposits of sand, clay, and talus in the floodplain, and limestone overlain by strata of clay, slates and sands in the mountain slopes. The soils map from the Natural Resources Conservation Services (NRCS) shows that the proposed project will encounter Constancia silty clay (Ct) and San Anton clay loam (Sa). The Constancia series consists of silty clay. It is somewhat poorly drained with very low to moderately low permeability and found in riverine floodplains. They formed in calcareous fine-textured sediments derived from volcanic and limestone rocks. The San Anton series consists of clay loam, loam, silty clay loam, and silt loam. It is well drained with moderately low to moderately high permeability and found on alluvial fans and flood plains. They formed in stratified alluvial deposits that weathered from volcanic rock and limestone.

The NRCS soils map shows that the mountains west of Guayanilla consist of Aguilita gravelly and stony clay loam (AgF and AhF). The Aguilita series consists of very stony clay loam in the upper foot and stony loam below. It is well drained with a moderately high to high permeability and usually found on ridge tops, summits and side slopes in uplands and limestone hills (NRCS). They formed from colluvium and residuum that weathered from soft limestone bedrock.

The NRCS soils map shows that the Phase 1 Levee was constructed on Constancia silty clay (Ct), Machuelo clay (Ma), Teresa clay (Te), and Hydraquents. The Machuelo soils consist of clay and are found on nearly level flood plains. They are poorly drained with moderately low permeability. The soil formed in clayey sediments washed out from the volcanic and limestone hills. The Teresa series consists of clay, silty clay loam, and sandy loam. They are somewhat poorly drained with very low to moderately low permeability and are found on alluvial flats in valley floors. They formed in clayey marine sediments. The Hydraquents soils occur on tidal flats and are formed in sandy sediments derived from volcanic fragments, sea shells, and corals. They are very poorly drained with moderately low to moderately high permeability and permanently saturated with water.

The NRCS soils map shows that the El Faro Levee will be constructed on Constancia silty clay (Ct), Teresa

clay (Te), Hydraquents, and Meros sand (Mr). Meros soils consist of sand and are found on beaches. They are excessively drained with high to very high permeability.

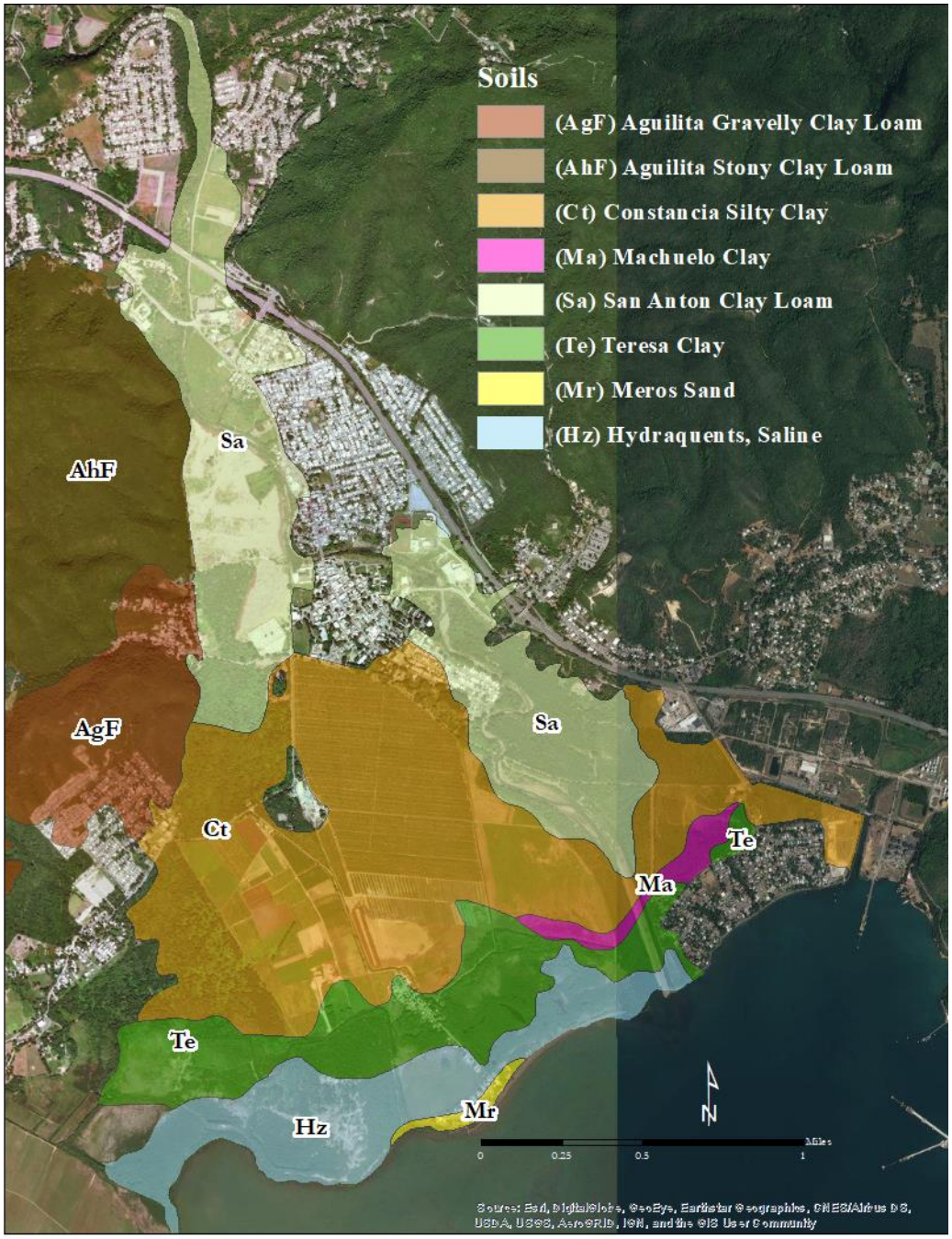

Figure 4: Soils around Guayanilla (NRCS)

2.3 Groundwater

Guayanilla is located in the Guayanilla alluvial valley that is part of the South Coast Groundwater Province. The principal water bearing units within the alluvial and fan-delta deposits in Guayanilla contains boulder to sand size sediments (USGS). Recharge is mostly from stream and irrigation ditch seepage with minor

recharge from infiltration of precipitation. There is a USGS well (USGS 180052066471000 MER 3 WELL) located in the banana plantation south of 3336 and west of the Rio Guayanilla River. Groundwater flows to the southeast towards the coast. Based on NRCS soils data, the Constancia silty clay usually has a depth to water table of 3 to 5 ft and the Machuelo clay has a depth of 1.5 to 3 ft. Water is found lower than 80 inches in the other soil types in the area except for the Hydraquents which are saturated. Borings collected in the project area show the groundwater levels around 25 ft below ground surface.

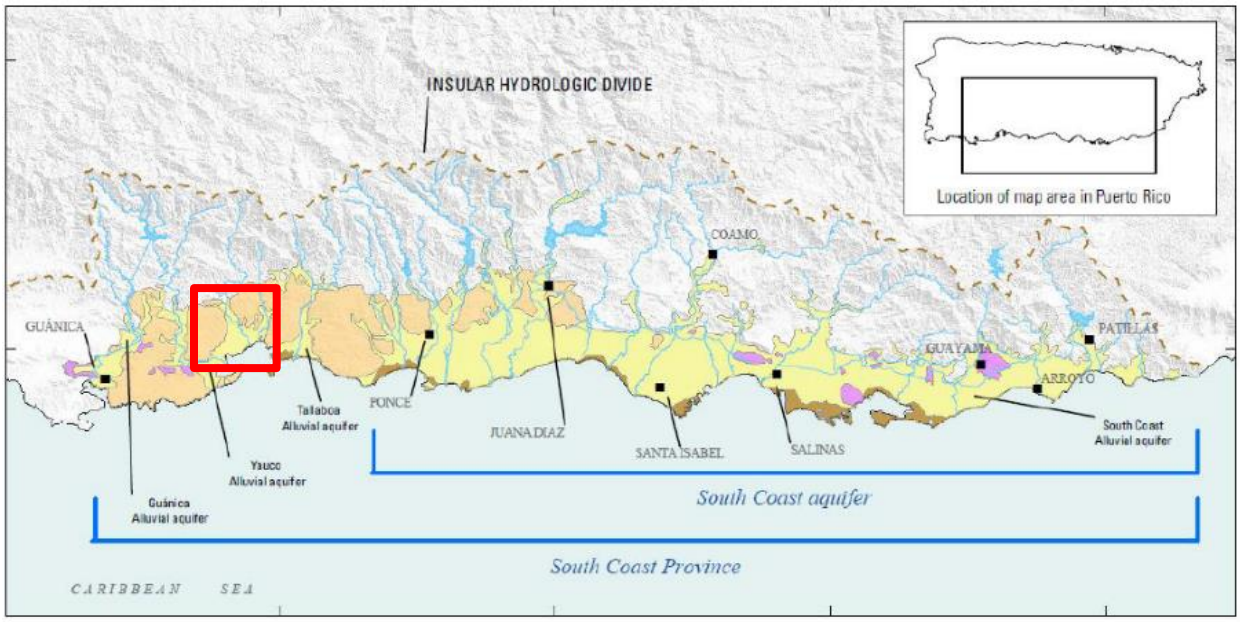

Figure 5: USGS map showing location of the groundwater basin within the study area

2.4 Bedrock Geology

Monroe (1980) described the mountainous area as steep eroded slopes of 30° to 45° in the valley. The rocks in the mountainous core consist predominantly of Lower Cretaceous to middle Eocene volcanic formations and are bordered by sedimentary rocks of Oligocene and Miocene age along the south coast (Monroe 1980). Most of the Lower Cretaceous rocks are submarine, deep-water volcanic-ash deposits interspersed with pillow lava and intruded by masses of granitic rock from the very Late Cretaceous to Eocene time (Monroe, 1980). Paleocene and lower Eocene rocks are volcanic and sedimentary (Monroe, 1980). The Cretaceous and early Tertiary rocks have been folded and intensely faulted into hundreds of fault blocks (Briggs and Akers, 1965). The younger rocks consist of conglomerate, sand, clay, chalk, and limestone of late Oligocene to early Miocene age (Kaye, 1959).

Large faults are common in southern Puerto Rico and older rocks have been folded, faulted, uplifted, and eroded into a rugged landscape before the Juana Diaz Formation of southern Puerto Rico were deposited upon them (Monroe, 1980). The Juana Diaz Formation is middle Tertiary in age and consists of a very thick mass of intertonguing mudstone, conglomerate, limestone, and a small amount of unconsolidated sand and lignite (Monroe, 1980). The Juana Diaz is overlain unconformably by the Ponce Limestone. The Ponce Limestone is an organic reef deposit that probably formed as a fringing reef on the southern coast of Puerto Rico in Miocene time and became thicker as the coastal shelf slowly subsided (Monroe, 1980). The Guanajibo Formation consists of light-yellow to gray limestones and sands, silts, and clays, probably from late Miocene or Pliocene age (Monroe, 1980). Though Guayanilla is officially outside of the known area of southern coastal karst, there are karstic formations near Guayanilla (Monroe, Karst 14).

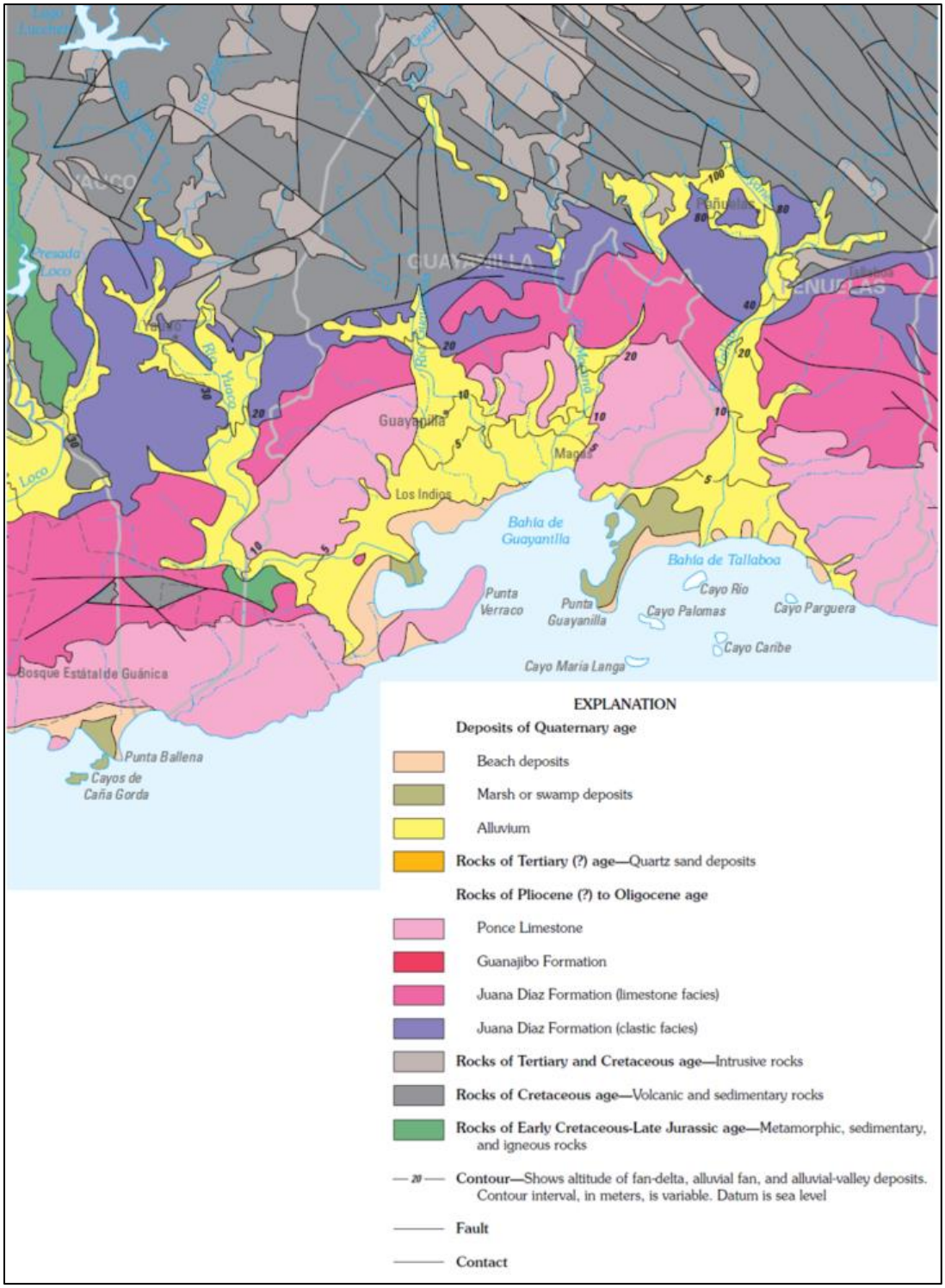

Figure 6: Geologic Map of Tertiary Rocks (Renken and others, 2002)

Puerto Rico is presently bound on the north by the Puerto Rico trench, which is characterized by oblique subduction, and on the south by the Muertos trough, which is characterized by extremely slow subduction (Larue, 1988). The Great Northern Fault Zone and the Great Southern Fault Zone are two through-going fault zones that divide Puerto Rico into northeastern, central and southwestern blocks (Larue, 1988). Puerto

Rico is a broad arch where younger rocks on the south coast dip south away from an outcrop of older rocks that extend as a continuous belt from the west to the east coast in the middle of the island (Kaye, 1959). In southern Puerto Rico, the attitudes are irregular and range from a few degrees to as much as 30° with the direction of dip generally south (Monroe, 1980).

2.5 Earthquakes/Tsunamis

The closest major tectonic fault to Puerto Rico is a transform fault running east-west approximately 125 miles north of Guayanilla. According to the USGS, there have been several very large earthquakes north of Puerto Rico (magnitude 7.3 in 1918; magnitude 7.8 in 1943; magnitude 8.0 in 1946 and four major aftershocks of magnitude 7.6, 7.0, 7.3 and 7.1 between 1946 and 1953). The October 1918 earthquake originated west of the island in an underwater canyon between Puerto Rico and the Dominican Republic and caused significant property damage along the west coast.

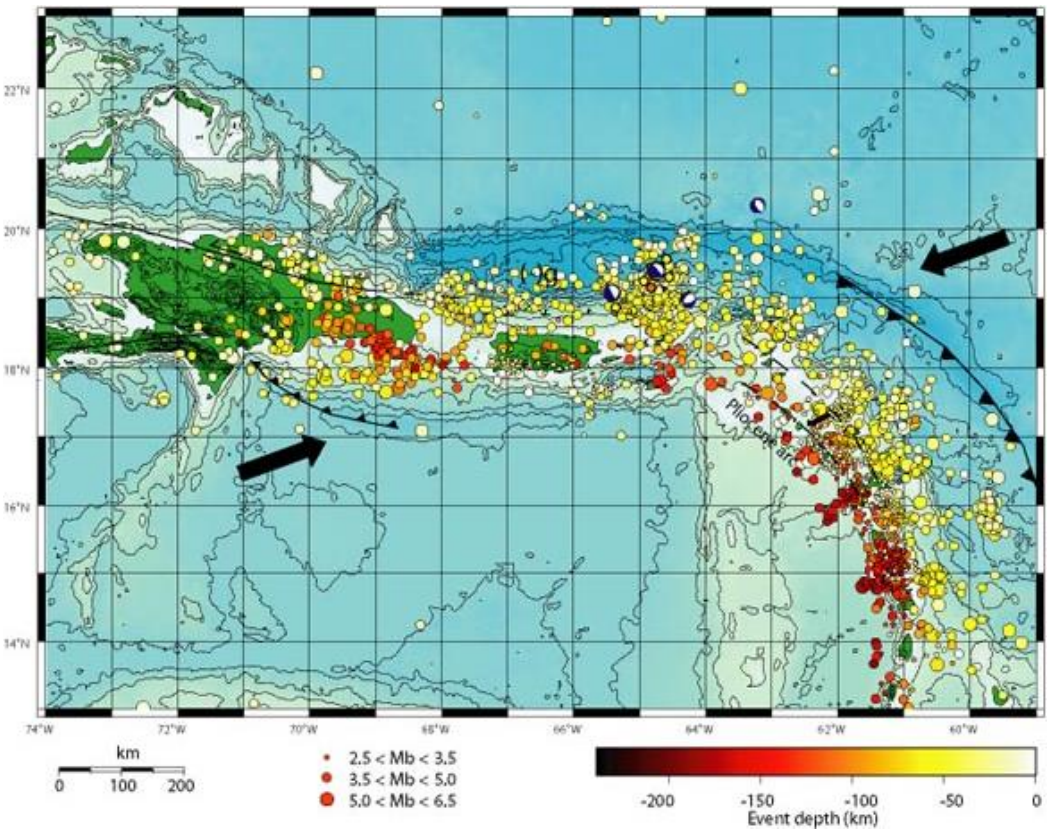

Figure 7: USGS Map of Puerto Rico Trench, Tectonic Plate Direction and Occurrence & Magnitudes of Resulting Earthquakes

Southern Puerto Rico experienced an earthquake sequence starting with a 4.7 magnitude earthquake on December 2019. The USGS has reported more than 300 earthquakes greater than a magnitude of 3, which people can feel, as of 16 January 2020. This included a 5.9 magnitude quake on 6 January 2020 in Guanica, a 6.4 magnitude quake on 7 January 2020 in Ponce, and a 5.0 magnitude quake in Guayanilla on 25 January 2020. These earthquakes occurred offshore of southwest Puerto Rico in a deformation zone bounded by the Punta Montalva Fault on land and the Guayanilla Canyon offshore. The USGS reported that the ground dropped about 6 inches at Playa de Guayanilla. Areas where ground shaking caused liquefaction, lateral spreading, and landslides were also reported. There were also reports that El Faro experienced more than 6 inches of settlement.

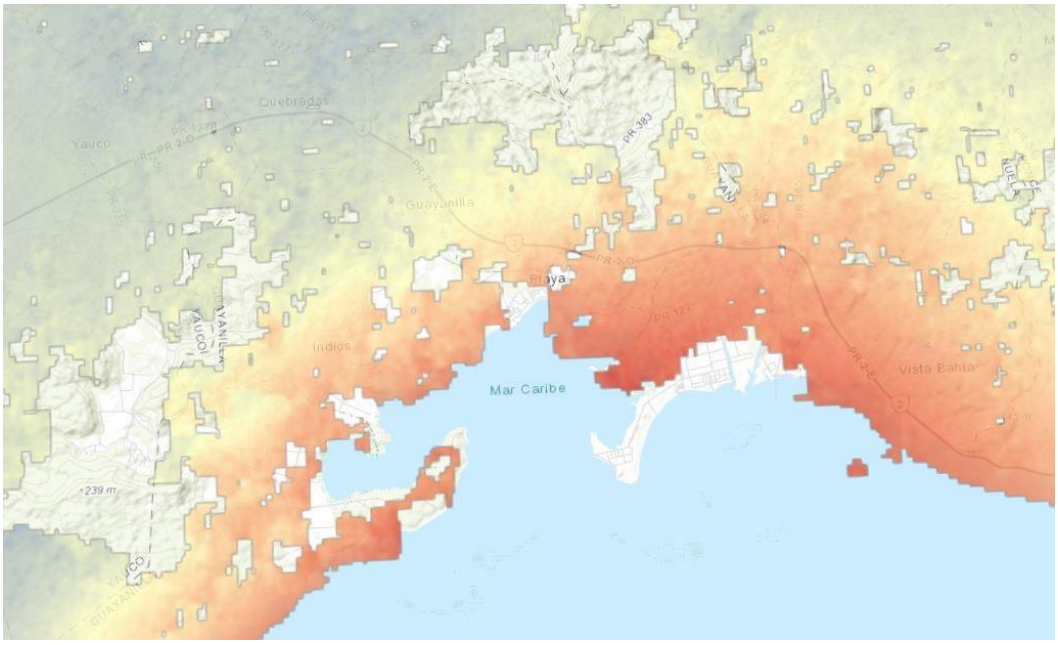

Figure 8: Surface Deformation Map due to the 2020 earthquakes (NASA)

The 1918 earthquake caused a tsunami which then caused major damage to two coastal cities, Aguada and Anasco. Similar tsunamis have accompanied every major earthquake on record, flooding the coast nearest to the epicenter. No tsunamis were reported for the 2020 earthquakes but there were reports of damage to structures in Guayanilla. Guayanilla has evacuation zones identified along the coast in yellow in the figure below.

Figure 9: Tsunami Evacuation Zone

2.6 Landslides

A landslide is defined as the movement of a mass of rock, debris, or earth down a slope under the direct influence of gravity. The term "landslide" encompasses five modes of slope movement: falls, topples, slides, spreads, and flows (USGS). Slope movement occurs when forces acting down-slope (mainly due to gravity) exceed the strength of the earth materials that compose the slope. Causes include factors that increase the effects of down-slope forces and factors that contribute to low or reduced strength. Landslides can be initiated in slopes already on the verge of movement by rainfall, snowmelt, changes in water level, stream erosion, changes in ground water, earthquakes, volcanic activity, disturbance by human activities, or any combination of these factors. Earthquake shaking and other factors can also induce landslides underwater. These landslides are called submarine landslides. Submarine landslides sometimes cause tsunamis that damage coastal areas.

On September 20, 2017, Hurricane Maria hit the U.S. territory of Puerto Rico as a Category 4 storm. Heavy rainfall caused landslides in mountainous regions throughout the territory. It is assumed that the majority of landslides were triggered by rainfall from Hurricane Maria, but rainfall from Hurricane Irma during the first week of September and rainfall from thunderstorms after Hurricane Maria may have also initiated landslides (USGS, 2017). Landslides in the mountains near the project area were mapped by NASA after the January 2020 earthquakes.

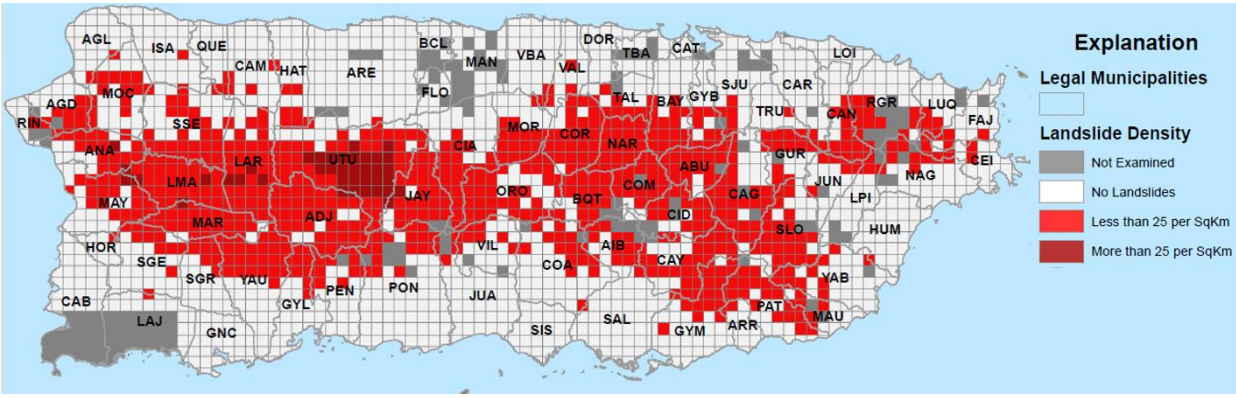

Figure 10: USGS Map of Landslides Caused by Hurricane Maria (2017)

3.0 Subsurface Investigations

3.1 2004 GEO-Engineering, LLC

Three borings were drilled in 2004 as part of a geotechnical evaluation performed by Geo-Engineering, LCC that is based in Puerto Rico. Boring B-1 was located in the Phase 1 Levee and was drilled 100 ft below ground surface. Boring B-2 was located just south of the 3336 bridge and was drilled 100 ft below ground surface. Boring B-3 was located in between the other two borings at the end of the ditch and was drilled 70 ft below ground surface. The holes were sampled at 2.5 foot intervals in the upper 10 feet and then in 5 foot intervals. Blow counts, unconfined compression tests, water content, Atterberg limits, soil classification, consolidation tests, and direct shear tests were performed for this investigation.

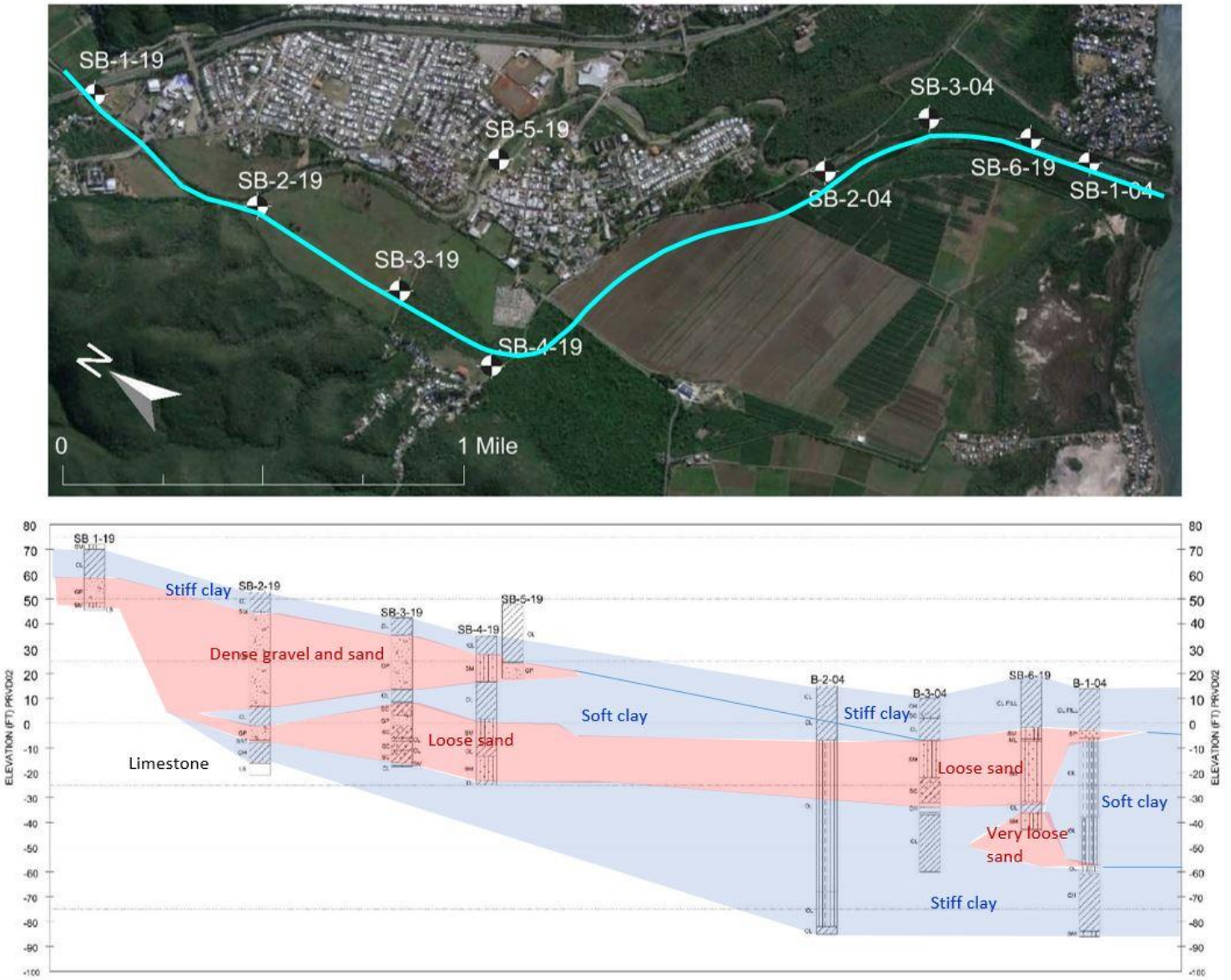

Figure 11: Subsurface Profile

3.2 2019 Challenge Engineering & Testing, Inc

There was no subsurface information in the area of the proposed project other than the three borings around the Phase 1 Levee. The Chicago District issued a task order under Jacksonville District's Geotechnical IDIQ contract with Challenge Engineering & Testing, Inc. The firm is based in Alabama but has offices in Puerto Rico and subcontracted a local drilling crew. The geotechnical field investigation consisted of drilling and sampling six holes of varying depths of 30 ft to 75 ft with laboratory testing. The holes were sampled at 2.5 foot intervals in the upper 10 feet and then in 5 foot intervals. Three of the borings were drilled through existing embankments so a Drilling Program Plan (DPP) was prepared for these borings. Hollow stem augers is the method normally used in the field in Puerto Rico due to limited water availability. Two field permeability tests were performed and all borings were backfilled with bentonite pellets that had to be shipped from the mainland. Blow counts, pocket penetrometer, and pocket torvane readings were also taken in the field. Laboratory tests included sieve analyses, Atterberg limits, organic content, moisture content, specific gravity, unit weight, CU triaxial compression tests, unconfined compression tests, and consolidation tests.

3.3 Subsurface Conditions

The locations of the nine borings that were performed in the project area are shown in the aerial above. The three borings from the 2004 investigation near the coast showed three types of soil: levee fill, highly compressible organic clayey silt/silty clay, and a stiff to very stiff clayey silt/silty clay and silty sand. The 2019 borings showed more silt, sand, and gravel. This information seems to correlate with the NRCS soils data of the area. The 2019 investigation shows softer clays at depths of 40 feet below ground surface. Bedrock was encountered 70 feet below ground surface in boring SB-2. Hard conditions where encountered 30 ft below ground surface in boring SB-1 so another boring was offset and blind drilled but it could not be confirmed whether it was a boulder or bedrock. The Department of Transportation was not contacted to see if there were existing borings for the bridges and PR-2 highway embankment. This will be pursued in PED.

4.0 Alternatives

4.1 Alternative 0 – No action

This alternative involves no federal action taken at the town of Guayanilla, which would remain subject to frequent flooding and associated damages and social effects.

4.2 Alternative 1 – Non-Structural

This alternative combines two non-structural measures and is intended to complement a structural alternative. It includes a flood warning system that can take real time weather data and provide instant reports and alerts. The USGS can set up real time alerts for flood warnings and city points of contact would be responsible for alerting the whole town via emergency signals (sounds/flags), messages and patrols. This alternative also includes maintenance to remove vegetation, sediment, and debris that can accumulate in the channel and interfere with the conveyance of flood flows.

4.3 Alternative 2 – South Diversion Channel with Double Line of Protection

This alternative includes an engineered diversion channel with a diversion structure that would send flood waters to the diversion channel but allow water continue to flow through town via culverts. The alignment for this alternative directs flood water along the confining mountain valley wall to the west of town and though agriculture fields and banana fields to join up with the Phase I project near PR 3336.

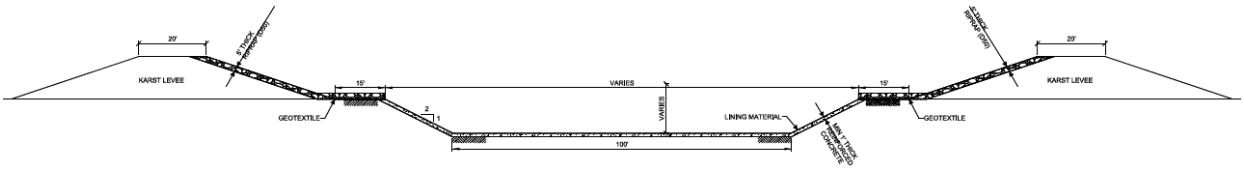

Figure 12: Alternative 2 Cross Section

The diversion channel would be concrete lined and trapezoidal with a bottom width of 100-feet and 2:1 side slopes. This alternative would have levees on both sides of the diversion channel to provide a 100 year plus 2 ft of freeboard level of protection. The riverside slope of the levees would be lined with riprap to prevent erosion. Upstream of the diversion channel, the channel will be widened and a combination of levees and floodwalls would be installed on both sides of the river channel. The levees and floodway would be kept free of trees via clearing or mowing. This alternative also includes rehabilitating the Phase 1 project, bridge and road modifications, vegetation removal, a backflow structure, and utility relocations.

4.4 Alternative 3 – South Diversion Channel with Single Line of Protection

This alternative is the same as Alternative 2 except a levee to the full design height on the west side of the diversion channel may not be needed for the entire length. Certain magnitudes of flood events can overtop the right descending bank of the diversion channel to allow water to spread out to flood non-developed and agricultural lands. A tieback levee protecting the community of El Faro would be constructed in place of continuing the line of protection along the right descending bank of the river.

4.5 Alternative 4 – North Diversion Channel with Double Line of Protection

This alternative includes an engineered diversion channel, a new canal through the town, and channelization of the Rio Guayanilla to the west of town. A new canal would be excavated to the north of town to tie in with Phase 1. The diversion channel would be concrete lined and trapezoidal with a bottom width of 100-feet and 2:1 side slopes. This alternative would have levees on both sides of the diversion channel to provide a 100 year plus 2 ft of freeboard level of protection. The riverside slope of the levees would be lined with riprap to prevent erosion. Upstream of the diversion channel, a combination of levees and floodwalls would be installed on both sides of the river channel. Floodwall would likely be required in town to provide the level of protection since space is limited. The levees and floodway would be kept free of woody vegetation via clearing or mowing. This alternative also includes rehabilitating the Phase 1 project, bridge and road modifications, vegetation removal, and utility relocations. A large woody debris and sediment/rock removal plan would need to be implemented to prevent flood back up issues through town to ensure alternative would successfully convey floodwaters.

4.6 Alternative 5 – South Diversion Channel, Greenway, Double Line of Protection

This alternative includes a terraced greenway diversion channel with a diversion structure that would send flood waters to the diversion channel but allow water continue to flow through town. The alignment for this alternative directs flood water along the confining mountain valley wall to the west of town and though agriculture fields and banana fields to join up with the Phase I project near PR 3336. The diversion channel follows the same alignment as Alternative 2 but is 7 times wider. The diversion channel would be lined with riprap and with concrete in higher velocity areas. Vegetation that can be mowed would be established in the terrace. This alternative would have levees on both sides of the diversion channel to provide a 100 year plus 2 ft of freeboard level of protection. The riverside slope of the levees would be lined with riprap to prevent erosion. Upstream of the diversion channel, a combination of levees and floodwalls would be installed on both sides of the river channel. The levees and floodway would be kept free of woody

vegetation via clearing or mowing. This alternative also includes rehabilitating the Phase 1 project, bridge and road modifications, vegetation removal, backflow structure, and utility relocations.

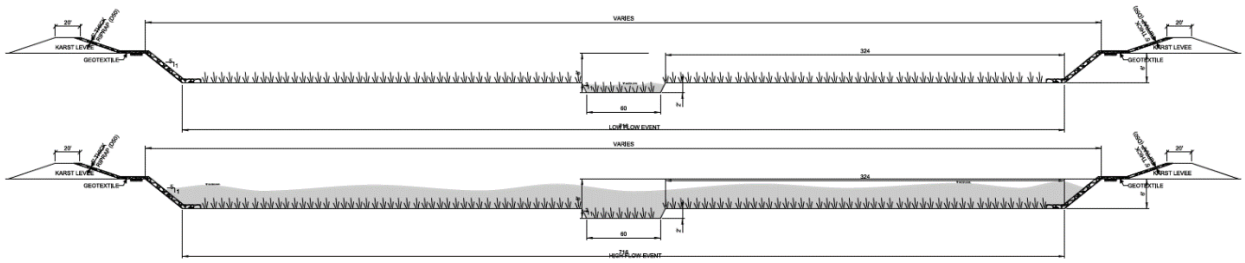

Figure 13: Alternative 5 Cross Section

4.7 Alternative 6 – South Diversion Channel, Greenway, Single Line of Protection

This alternative is the same as Alternative 5 except a levee to the full design height on the right descending bank of the diversion channel may not be needed for the entire length. Parts of the channel would remain at grade and overtop to allow certain magnitudes of flood to spread wider to the west, flooding non-developed and agricultural lands. A tieback levee protecting the community of El Faro would be constructed in place of continuing the line of protection along the right descending bank of the river.

5.0 Design Considerations

5.1 Material Sources

Material encountered in the excavated channel would likely consist of clay and sandy gravel. Gravel is not considered suitable for levee construction in this area due to the high flow velocities and larger footprint required. The amount of space required for levees constructed with this type of material as well as susceptibility to erosion is a concern. These materials can be re-used for other purposes such as a base for the concrete lined channel. Cohesive material such as clay would be ideal for levee construction and has been used in typical levee construction. The Phase 1 levee was constructed with high plasticity clay excavated from the creation of the interior ditch adjacent to the levee. However, the limited quantity of clay available for this project is a concern. Borings indicate a 7 to 8 ft layer of clay overlying a thick sandy gravel layer. Additional stiff clay exists about 50 to 60 ft below ground surface which is not practical to excavate. The levees upstream of the diversion channel near PR-2 would most likely be constructed first. Excavation would be limited to the new diversion channel and river modifications for this project. Clay material is not locally available at existing borrow sites. Borrow pits on the landside of the levee are not recommended since that could create potential seepage paths in the gravel layer. There is potential for borrow sites east of the town that are far enough away from the river and channel with potential clay but there are no borings to confirm the soils in that area. There is a data gap in the available subsurface information around the banana fields creating some uncertainty. Additional borings will be needed during design.

An alternate source considered for levee construction is karst limestone. There are karst hills and forests immediately to the west of the project site that could be a potential borrow source close to the project. However, there are seven federally listed species that would make permitting difficult so using an existing quarry is recommended. The material has been classified as GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SM, SW-SM, SC, SW-SC, SP-SM, and SP-SC. The material is placed in lifts and compacted to 95 percent of its maximum laboratory density at a target moisture content within +/- 2% of that material's ASTM D698 optimum moisture content. The material can be broken down further during compaction and cements together over time which adds some strength and resistance to erosion. A concern about cementation is that

the levee could be more susceptible to cracking during seismic events. Karst has been used for other levee projects on the island such as the Manati Repair project in Barceloneta. This levee has performed well with minor erosion issues due to failure of the gabion baskets used for erosion protection. Riprap will be included on the riverside slope to prevent erosion.

Construction activities were in decline prior to Hurricane Maria and a number of quarries on the island closed. There is currently a shortage of stone sources on the island. The island has always been in short supply of quality riprap and have at times reached out to quarries in the Dominican Republic, Mexico, Haiti, and Georgia. Due to the high velocities, karst would not be an ideal source since it would degrade and require more frequent repair. The mountain belt in the central part of Guayanilla could provide a potential source of stone, however, there would be high costs associated with trucking the material to the project if it was too far.

5.2 Erosion

This area is prone to flash floods due to the terrain. There is almost a 70 foot change in elevation from the north end of town to the coast. The silty and sandy material found along the banks of the river are susceptible to erosion. The 3336 bridge at the downstream end of the river has had to be rebuilt a number of times due to the east bank eroding further east. Large loads of sediment build up within the river channel but are washed away during high flow events. Flow velocities are expected to be around 10 to 20 ft/sec for Alternatives 2 and 3, which requires concrete or heavy armoring to prevent further erosion. Flow velocities are expected to be around 5 to 10 ft/sec for Alternatives 5 and 6, which are still relatively high and requires some type of heavy armoring on the banks to prevent erosion. The flow velocities along El Faro are expected to be around 1-2 ft/sec, which is fairly low and may not need armoring.

Figure 14: Eroded banks upstream of the 3336 bridge

5.3 Phase 1 Levee

The Phase 1 Levee has not been maintained since it was constructed. Trees have grown over the slopes and along the edges of the riprap. The ditch and channel have filled in with sediment. The 2019 survey indicated that the levee elevation is lower than the original design height, by as much as 2.5 ft closer to the jetty. Resources for O&M in the community are low so the design for the project will need to take these issues into account. The height of the Phase 1 levee is still higher than the 100 year plus 2 ft of freeboard that this project is being designed to so the height does not need to be restored to the as-built condition as part of this project.

Figure 15: Phase 1 Levee

5.4 Vegetation

Seeding is not an issue in this area since vegetation grows quickly due to favorable climate conditions. The concern is growth of large trees on the levees which could lead to potential seepage and stability issues, as well as in the channel which could lead to debris blockages. Trees noted on the Phase 1 levee consist of mesquite and pithecellobium, which are tall and have deep roots. The combination of saturated ground and high wind can cause trees to lose their foundation structure (root wad) and overturn. Larger root systems lead to higher likelihood of slope instability if the tree overturns, but on the other hand, can also reduce the likelihood of trees overturning. Mangrove trees were observed along the banks of the channel along the toe of the riprap and locals say those sprout up quickly and cannot easily be contained. Mangroves have shallow roots that spread laterally. It is unlikely that the mangroves would encroach into the levee cross section since there is 5 ft of riprap covering the riverside slope that would make it difficult for the roots to spread.

Figure 16: Mangrove trees along the banks

5.5 Settlement

A geotechnical evaluation was performed for the Phase 1 Levee in 2004 while it was under construction. Seven inches of settlement was reported over several months during construction. An undisturbed sample of the compressible organic clay was collected and an odometer test was performed for an intact sample and another for a remolded sample. A settlement analysis performed by the A-E based on the laboratory data determined that the levee would experience total settlements up to 50 inches. Primary consolidation was estimated to complete within 14 to 18 years for double drainage and within 55 to 74 years for single drainage behavior. A survey was performed in April 2019 that indicated the levee had settled up to an additional 10 inches and over 2 ft by the jetty since construction completion. The amount of settlement experienced appears to be less than originally estimated and seems to exhibit single drainage behavior. Additional testing and survey is needed to verify the original analysis. The height of the Phase 1 levee is still higher than the 100 year plus 2 ft of freeboard that this project is being designed to so the height does not need to be restored to the as-built condition as part of this project. Differential settlement for the Phase 1 levee was also looked at as part of a 2-dimensional Finite Element Method (FEM) analysis and was estimated to be about an inch which is negligible.

Since most of the compressible soils are closer to the ocean, it is not anticipated that the upstream levees for the projects will experience settlement on the same order of magnitude and this was confirmed by the results of the borings performed in 2019. Differential settlement will need to be looked at for seismic events.

There are no borings near the community of El Faro but based on NRCS soils data, the new levee will likely encounter soft soils similar to that of the Phase 1 levee and experience excessive settlement. Overbuild will probably be needed for this stretch of levee. Preloading will also be looked at to prevent lateral spreading.

5.6 Slope Stability

The 2004 geotechnical evaluation looked at the stability of the Phase 1 Levee using StablPro. The short term, long term, and seismic conditions were looked at for the levee. The levee had factors of safety greater than 2 for the short term condition which is higher than the recommended safety factor of 1.5. The levee had a factor of safety of 1.3 for the long term and 1.17 for seismic conditions (max ground acceleration of 0.2g) which was compared to recommended minimums of 1.5 and 1.2 respectively. The Corps uses a recommended factor of safety of 1.3 for the short term and 1.4 for the long term. The A-E Firm that performed the geotechnical evaluation believed that the expected consolidation will improve the strength of the soils and increase the factors of safety. Boring B-6 from the 2019 subsurface investigation showed higher strengths in the foundation materials. Due to the increased number of earthquakes in the area in 2020, a more detailed seismic analyses will be looked at.

The 2004 geotechnical evaluation also looked at the short term, long term, and seismic stability for the jetty. The jetty had a factor of safety of 1.2 for both the short term and long term conditions which is lower than the recommended factors of safety. The factor of safety for seismic condition was 1.1 and it was recommended to increase the shear strength of the jetty by building the jetty over a concrete mat or gabion structure. The jetty was constructed over a filter material that contained 20% to 30% sand which could erode and lead to deformation. It is anticipated that not much can be done to the jetty as part of the project but this can also be looked at closer during design. A similar feature may be needed at the downstream end of the El Faro Levee.

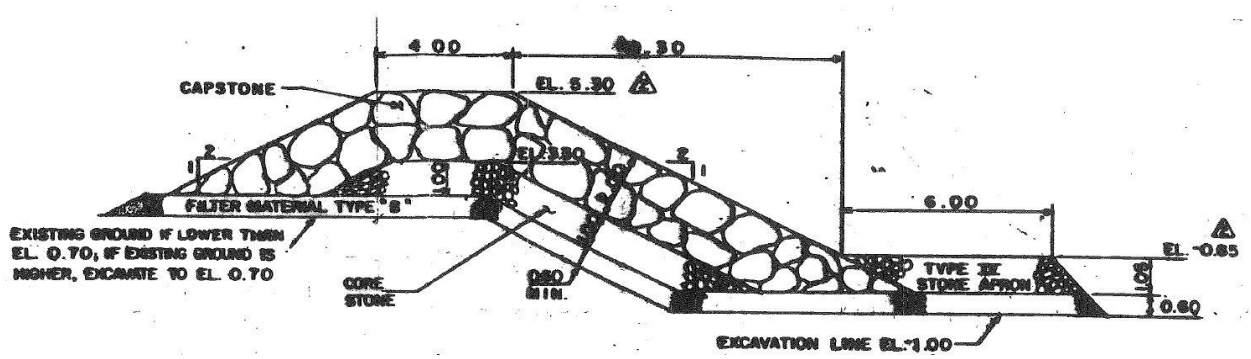

Figure 17: Jetty cross section

5.7 Utilities

There are a number of pipes and overhead power lines that would need to be relocated as part of this project. There are at least three critical crossings where the proposed alignment cuts directly across the utilities. These contain major utility poles that provide power to the town and to the mountains, as well as buried water and sewer lines. There is a small pump station that outlets to the river that would cross the line of protection at the floodwall as well. Utilities that cross under the line of protection can provide a possible seepage path. Most utilities will be relocated or installed over the line of protection. A gate closure will be included if gravity drained but no pipes have been identified yet. The exterior of the pipe can be backfilled with clay or flowable fill where it crosses the alignment under the levee or floodwall as another alternative.

Figure 18: Utility lines and pipes connected to the bridge at Hwy 127

Figure 19: Utility lines along Cll Vertedero

Figure 20: Utility lines, water line, sewer line along 3336

5.8 Structures

Floodwalls will be necessary along the river upstream of the diversion channel where space is limited due to existing structures. A control structure is needed where the river diverges to prevent floodwaters from entering the town. It is assumed that the structure will consist of a large concrete box across the river channel with a rectangular opening to allow normal flow to continue into town but prevent higher events from passing. This will be looked at in more detail during design. This structure will act like a dam with an opening since it is intended to hold water back. ACT 133 and 207 provides guidance about dam safety in Puerto Rico. ACT 133 was enacted on July 15, 1986 and created the Dam and Reservoirs State Inspection and Regulation Program. It defines a dam as an artificial barrier that exceeds an elevation of 25 ft from the natural level of the ground and holds back water exceeding a volume of 50 acre-feet. ACT 207 was enacted on August 28, 2002 and amended Articles 4 and 8 of ACT 133. The structure is currently designed to be 21 ft tall, which does not meet the definition of a dam. Therefore, no permits will be required from the Puerto Rico Electric Power Authority. Debris blockages may be a continued maintenance issue that could prevent water from flowing through town as intended.

A backflow structure is being considered at the downstream end where the channel merges with the river since the line of protection will cross the river. The river will flow within bank during high water events through town and merge with the diversion channel. There may be potential for the river to back up if pool levels go up at the confluence. Debris blockages may be a continued maintenance issue that could also cause the river levels to rise and flow around the levee to La Playa. This area will be need to be looked at closer to see if there is an alternative alignment that could avoid the need for a structure. There is a boring near the bank in that area but a boring should be drilled at the structure.

6.0 Design Analysis

The cross section of the levee is similar for all of the alternatives. The levee consists of 3H:1V side slopes and a 15 ft width with additional 5 ft width for riprap along the riverside slope. The diversion channel will be lined with 1 ft thick reinforced concrete and the upstream channel slopes will have additional riprap. Analyses were performed based on the conceptual design and available subsurface information. The cross section at Station 52+00 was selected to represent the typical section along the diversion channel. The subsurface profile at Station 52+00 was based on boring SB-03-19.

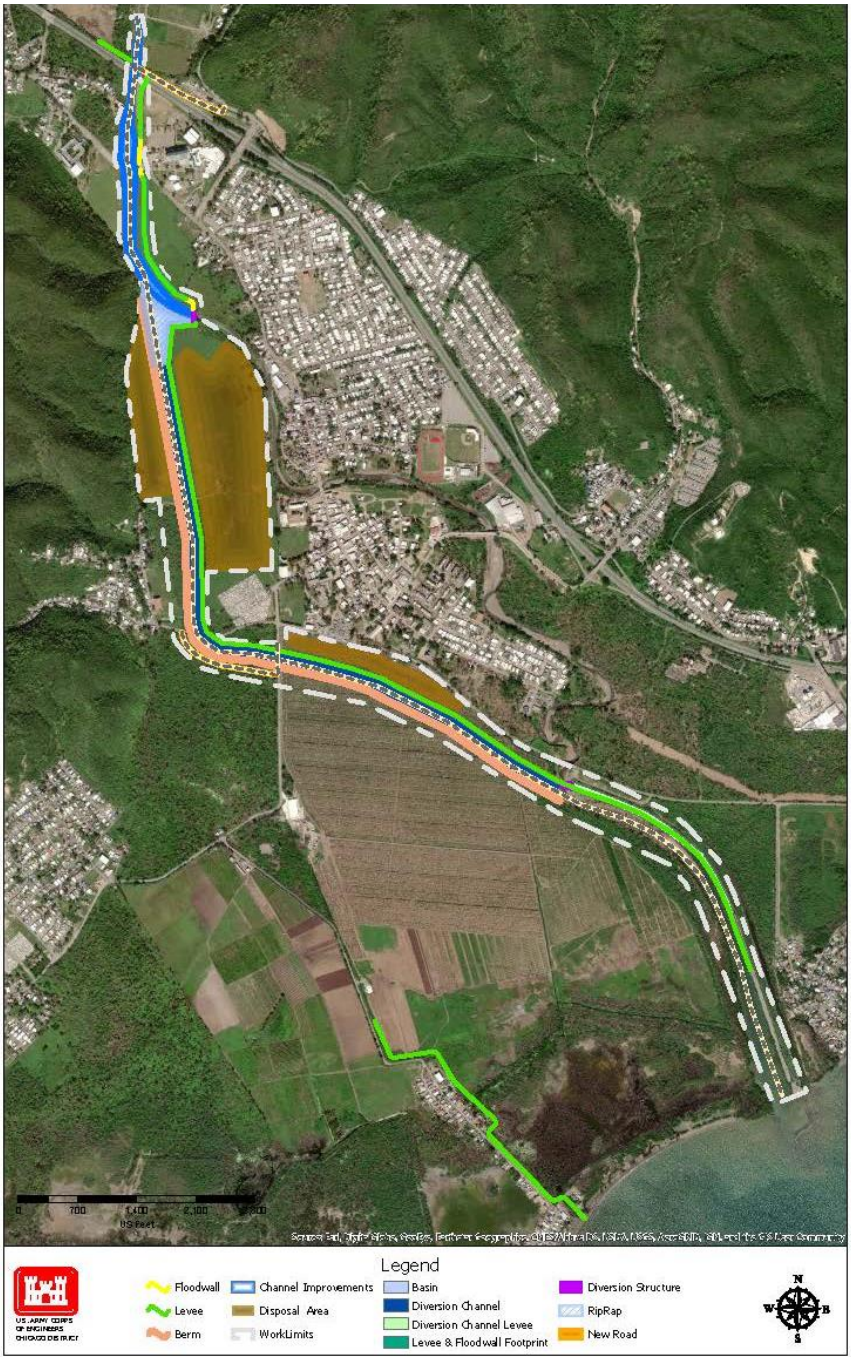

Figure 21: Alternative 3 Alignment

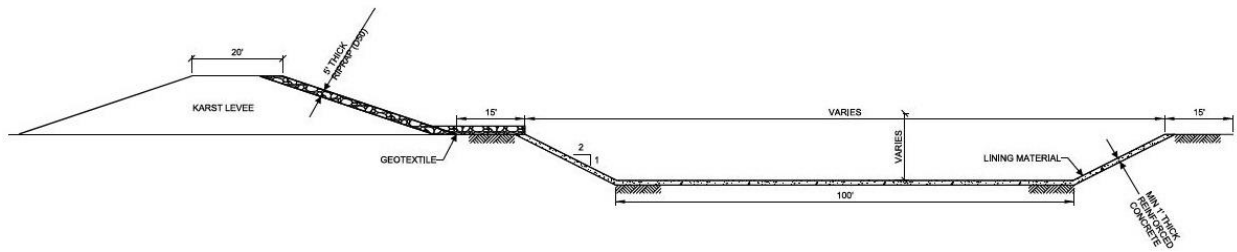

Figure 22: Typical Levee Cross section

6.1 Soil Parameters

Soil parameters were developed for each of the borings. Laboratory test data, pocket penetrometer readings, and field torvane readings were used where available. Where no test data was available, Table 3-4 from EM 1110-2-2504 was used to develop the cohesion values for cohesive material such as CL and OL based on the blow counts provided in the boring logs. Table 3-1 from EM 1110-2-2504 was used to find the relative density of granular soils including gravels, sands, and silts based on the compactness description and blow counts provided in the boring logs. Using the relative densities found from Table 3-1, Figure 3-1 from EM 1110-2-2504 was used to determine the angle of internal friction. Soil parameters were provided to the Structural Engineer for structural evaluation of the floodwall and control structure. Riprap was assumed to be about 150 pcf with a friction angle of 40°. A summary of the soil parameters are included in Attachment G-2.

6.2 Seepage

SEEPW was used to perform a seepage analysis of the proposed levee and slopes. Due to the flashy nature of flood events, the loading duration was expected to be less than a day. The initial analyses was performed for a duration of 5 days for conservatism but will need to be updated. The permeability values were selected based on Figure 2-5 from EM 1110-2-1901 and a table from Freeze and Cherry (1979). The units were converted from cm/sec to ft/sec. The input parameter for conductivity in Geostudio is k_h. The k-ratio used in the analysis was assumed to be greater horizontally than vertically in finer grained soils. Water flow, c_v, was determined from a reference table based on permeability and used to determine soil compressibility: $m_v = \frac{k_v}{c_v \gamma_w}$. The input parameter for compressibility in Geostudio is m_v.

Table 1: Permeability Parameters

Material	Permeability k cm/sec	Permeability k_h ft/sec	K-ratio	Permeability k_v ft/sec	Water flow c_v ft^2/day	Compressibility m_v /psf
Riprap	1e+3	3.28e+1	1	3.28e+1	1e+12	4.5e-8
GP	1e+1	3.28e-1	0.5	1.64e-1	1e+9	2.3e-7
SM	1e-3	3.28e-5	0.3	9.84e-6	1e+4	1.4e-6
ML/SC	1e-4	3.28e-6	0.3	9.84e-7	8e+2	1.7e-6
OL/OH/CL	1e-6	3.28e-8	0.1	3.28e-9	5e-1	9.1e-6
Concrete	1e-7	3.28e-9	1	3.28e-9	5e-1	9.1e-6

The exit gradient is the total head loss divided by the elevation difference. The equation used to find the factor of safety against piping is $FS = \frac{i_c}{i_e}$ where $i_c = \frac{\gamma_{sat} - \gamma_w}{\gamma_w}$. The minimum required factor of safety against piping is 1.5. The standard section with the concrete lined channel did not meet the required factor of safety although seepage was minimal so different options were looked at. The clay layer at the surface is acting as a confining layer over a thick pervious gravel layer which increases the exit gradient and lowers

the factor of safety. This analysis indicates a potential seepage concern that may require enhanced protective measures. The approach presented here is to provide information to develop a rough order cost estimate. Additional investigations and more detailed site specific analyses will be required for final design.

An option with a 2 ft thick landside blanket that extended about 15 ft was analyzed but the exit gradient was still high. There is excess material from the excavated channel that could be used for this feature but the amount of real estate available may be limited. An option with a ditch offset 2 ft from the levee toe was added on the landside with 3H:1V slopes and a 5 ft wide bottom. In order for the exit gradients to be low enough, the bottom of the ditch needed to reach the gravel layer. The seepage was higher but still considered to be a minimal amount. There is concern about the amount of space required for the ditch. Another option that was looked at was a 3 ft wide gravel filled trench offset about 5 ft from the levee toe that reached down to the gravel layer. The factor of safety for piping was much higher and the seepage was considered to be minimal. The results are summarized in the table below and the outputs are included in Attachment G-3.

Table 2: Permeability Results

Station	Seepage ($ft^3/sec/ft^2$)	Total Head Loss	Elevation Difference	Exit Gradient	Critical Gradient	Factor of Safety
52+00	1.5e-7	3.18	4.42	0.72	0.84	1.17
52+00 with 2'x15' blanket	1.3e-7	3.32	4.28	0.77	0.84	1.09
52+00 with ditch	6.9e-6	1.6	4.5	0.36	0.84	2.33
52+00 with trench	2.9e-6	0.08	4.44	0.02	0.84	42.0

6.3 Stability

A slope stability analysis was performed for the levee using SLOPEW and the Spencer Method with the trench option. The pore water pressures from the SEEP/W analysis and drained strengths were used for the Long Term Flood condition with the Entry and Exit option. Undrained strengths and a piezometric line for the normal water level was used for the End of Construction (EOC) condition. The Grid and Radius option was used to obtain the factor of safety. According to Appendix C in ER 1110-2-1806, Puerto Rico is classified as having a High seismic hazard potential. Projects in a High Seismic Hazard Region require an analysis looking at potential deformations. A seismic slope stability analysis was performed using undrained strengths and a horizontal seismic coefficient of 0.3 based the USGS map for peak ground acceleration, 10% in 50 years. Due to the stretch of strong earthquakes in early 2020, the seismic analysis should be revisited. A sensitivity analyses for higher peak ground acceleration values should be performed to determine if there are any impacts from stronger events.

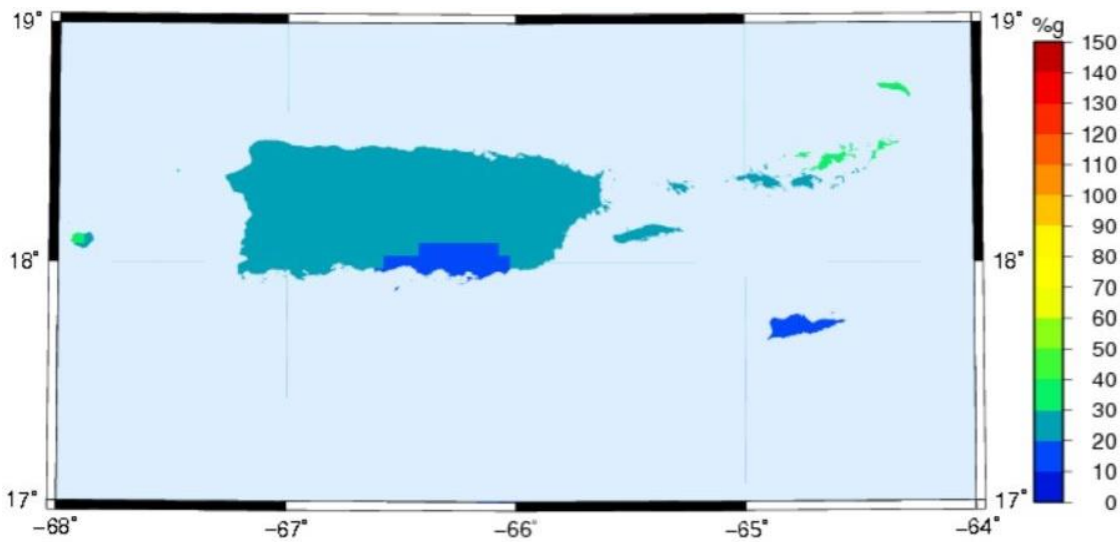

Figure 23: Peak Ground Acceleration, 10% in 50 years

The minimum recommended factors of safety according to EM 1110-2-1913 are summarized with the factor of safety results in the table below. All of the Factors of Safety exceeded the required Factors of Safety except the Long Term condition for a shallow slide. A deep seated failure that extended to the river had higher factors of safety close to 3.0. Since the levee is unlikely to reach the fully drained condition due to the short loading duration, a small amount of cohesion was included in the analysis and the Factor of Safety exceeded 1.4. The graphical results are included in Attachment G-4.

Table 3: Stability Results

Station	End of Construction (Upstream)	End of Construction (Downstream)	Long Term	Long Term c=50 psf	Rapid Drawdown	Seismic
52+00 trench	3.589	11.370	1.263*	1.696	2.051	2.726
Required F.S.	1.3	1.3	1.4	1.4	1.0	1.2

* shallow slide

6.4 Settlement

The stratigraphy of the subsurface was based on the results from boring SB-4-19. A consolidation test was performed on a soft clay sample at elevation 15.2 from this boring. The soil was assumed to be incompressible for cohesionless soil. It was assumed that the unit weight of the clay fill to be used for the levee was 114 pcf. The water level was based on the water level data collected after 24-hrs which was at elevation 17.5 ft.

The Boussinesq chart for an embankment load of infinite length was used to find the influence factors under vertical stress. The influence factors were doubled for the calculations since the chart was for only half of the embankment. The chart is attached with the calculations. The clay layers were subdivided into smaller layers to calculate settlement for a depth of 50 ft.

The consolidation data was graphed to plot void ratio versus vertical stress. The Schmertmann procedure was used to develop the field virgin compression curve. The slopes were derived graphically to determine the compression index.

Table 4: Settlement Parameters

	σ_p' (psf)	e_o	C_c	C_r
Clay	4000	1.15	0.44	0.046

There are two equations to determine the settlement of the foundation but only the first applied since the pre-consolidation pressure was higher than the effective vertical stress and load.

$\sigma_{vo}' + \Delta\sigma_v \leq \sigma_p'$: $S_c = C_r \frac{H_0}{1+e_0} \log \frac{\sigma_{v0}' + \Delta\sigma_v}{\sigma_{v0}'}$

$\sigma_{vo}' + \Delta\sigma_v \geq \sigma_p'$: $S_c = C_r \frac{H_0}{1+e_0} \log \frac{\sigma_p'}{\sigma_{v0}'} + C_c \frac{H_0}{1+e_0} \log \frac{\sigma_{v0}' + \Delta\sigma_v}{\sigma_p'}$

The total settlement is estimated to be about 1 inch for a 5 ft tall levee along the diversion channel, upstream of the confluence near station 121+00. The soils in this area are assumed to consist of granular soils and stiff clays based on borings.

The Phase 1 levee was constructed over a soft organic clay where prior settlement analyses indicated anticipated settlement of 50 inches. The levee has already experienced settlement ranging from 17 inches to 2 ft. It is expected that the El Faro Levee would experience similar settlement and would need to include additional overbuild.

6.5 Bearing Capacity

A diversion structure is proposed in the existing channel to control flow into town. There is no subsurface information available in the river channel at the location of the proposed structure. Based on visual observations and the nearest boring, there is about 40 ft of gravel overlying about 20 ft of alternating layers of clay and gravel before reaching bedrock. The structure is anticipated to require 735 CY of concrete, which would weigh about 1,490 tons. Structural recommendations include steel H-piles spaced at 10 ft centers and 50 ft long since the structure would not be founded on rock. Additional subsurface information and more detailed analysis is needed and should be performed during the next phase of plans and specifications. EM 1110-1-1905 will be used to evaluate bearing capacity.

An alternative diversion structure being considered is a concrete U-wall channel structure. The diversion opening will be formed by opposing 21 foot tall concrete walls 24 feet apart with a single or double constricting wall running down the from the top of the structure to 8 feet above the structural apron slab. A footing will run behind the walls and the structure will be backfilled with impervious fill. This foundation slab for this structure will spread the structure load out over the site and will not require steel H-Piles for support. This option will be looked at closer during the design phase.

6.6 Fragility Curve

A fragility curve, as defined in EM 1110-2-1619, 'Risk-Based Analysis for Flood Damage Reduction Studies', is a statistical distribution of levee failure which is used to develop the stage-damage function and description of the overall uncertainty of that function. The fragility curve is used by Economics to assist with their economic evaluation of the consequences. The fragility curve is defined by determining two points on a graph; the probable failure point (PFP) and probable non-failure point (PNP). The PFP is defined as the water elevation above which the levee is highly likely to fail, set at 85% failure rate in the EM. The PNP is defined as the water elevation below which the levee has a low likelihood of failure, set at 15%

failure rate in the EM. Figure 7-4 is extracted from EM 1110-2-1619 to illustrate the fragility curve, as shown below.

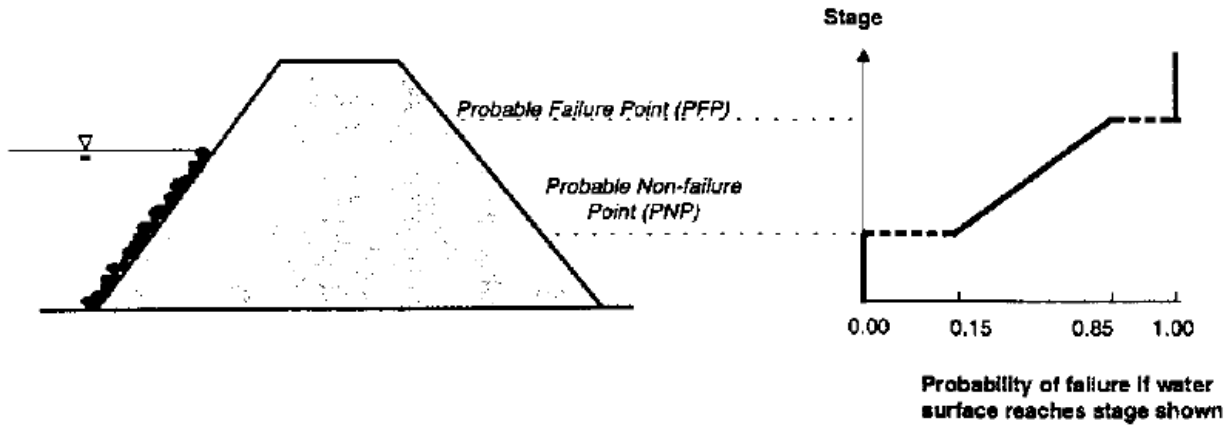

Figure 24: Levee failure probability function from EM 1110-2-1619, Figure 7-4

A fragility curve was developed for the existing levee through town and for the Phase 1 Levee. A global stability analysis using SLOPE/W determined that the Factor of Safety was much higher than the recommended minimum for steady-state seepage per EM 1110-2-1913, so the driver for the PFP and PNP would be the likelihood of failure.

6.6.1 Overtopping Locations

Portions of the berm that was built by the residents in town have been overtopped. The Phase 1 Levee has not been overtopped but section was chosen for analysis that had a relatively low elevation and narrow crest compared to the other surveyed sections. The approximate locations are shown below.

Figure 25: Overtopping location for Existing Levee and Phase 1 Levee

6.6.2 Existing Levee

<u>SLOPE/W Analysis</u>

SLOPE/W software was used to model the global stability of the existing berm for the steady state seepage condition since the berms have been in place for years and have experienced previous loading. A cross

section through the low area based on LiDAR data was used. Boring SB-5 was used to develop the stratigraphy. The soil parameters are based on typical values for the materials and are shown in the figure below. A SEEP/W analysis was used to develop the water level. The Spencer method was used in the program to calculate the Factor of Safety which resulted in a factor of safety of 1.79 under fully loaded conditions. This is higher than the factor of safety of 1.4 recommended for the steady state condition in EM 1110-2-1913. Therefore, it does not appear that slope instability would occur on the landside slope when the levee is loaded to the top.

PFP and PNP Determination

Based on the field inspection, animal burrows have been noted in the banks in other locations along the river channel and large trees were growing on the berm. Tree roots and animal burrows create seepage paths through the berm. As trees mature and die, they are more likely to fall over during storm events, increasing the incidence of significant root ball upheaval from the levee leading to decay of the levee section.

The Probable Failure Point (PFP) (85% chance of failure) is at the top of the lowest point of the berm at elevation 33.6 for the most likely failure scenario. At this elevation, the berm would be overtopped and susceptible to erosion of the crest and landside slope, which could lead to failure. The berm has experienced overtopping at this location in the past.

Based on LiDAR data, the crest width is approximately 21 feet wide at the low spot. EM 1110-2-1905 recommends a minimum crest width of 10 feet. Since the actual crest is about twice the recommended width and there is good grass cover on the slopes and ground, the berm has some resiliency.

To determine the Probable No Failure Point (PNP) (15% chance of failure) elevation, the trees and animal burrows were determined to be the controlling factor. While the levee is wider than necessary, issues could arise such as seepage due to large animal burrows or fallen/dead trees on the slope which could lead to a breach and would extend to the levee toe. The levee toe is about elevation 25.7 ft and was chosen as the PNP because this elevation is when flood-fighting activities would start should a breach occur.

These points for the Fragility Curve are based on existing knowledge and field observations. Each subsequent flood event will continue to degrade the levee and lead to more issues with seepage, erosion, and eventually instability and failure.

There is some uncertainty that may not produce accurate PFP and PNP elevations.

1. There are no borings at the low spot so actual subsurface conditions may not be captured.
2. Permeability test results were not available at the time this memo was prepared.
3. The model cannot take into account features such as the trees or burrows. Trees provide seepage paths along their root systems, particularly after a tree dies and the roots rot away. Burrows allow connections between the riverside and landside.

Table 5: Summary of Fragility Curve Points for Existing Levee

Failure Node	Probability of Failure by Node	Elevation Assignment for M. Likely P(f)
Levee Crest	1.00	33.6
Probable Failure Point (PFP)	0.85	33.6
Probable Non-Failure Point (PNP)	0.15	25.7
Levee Toe	0.00	25.7

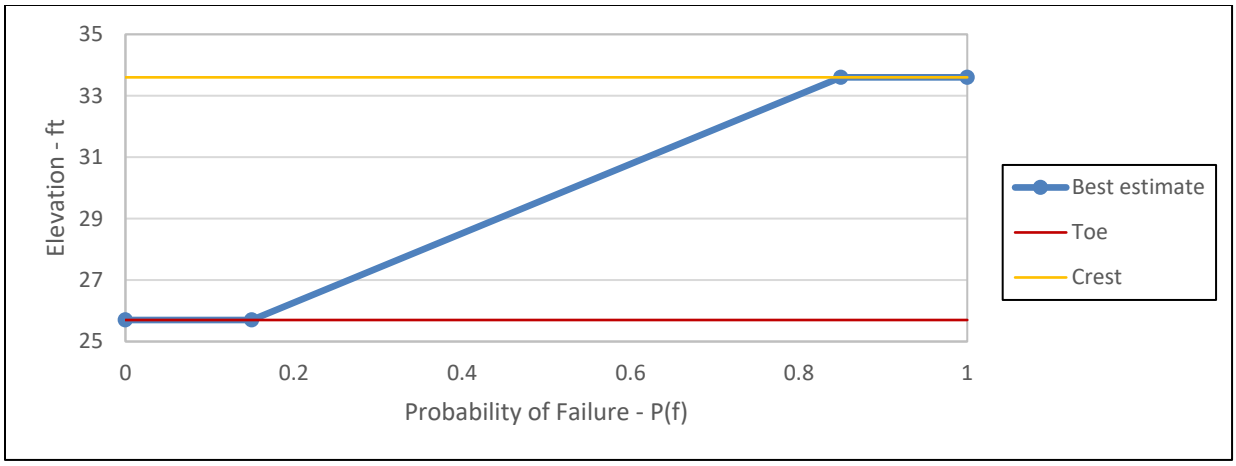

Figure 26: Existing Levee Fragility Curve

6.6.3 Phase 1 Levee

A portion of the recommended levee was built starting at the coast. A survey of the Phase 1 levee was performed and the section chosen for analysis was relatively low elevation and had a narrow crest compared to the other surveyed sections. The Phase 1 levee has riprap on the river side. This was not included in the model because it would not have a significant effect on the slope stability of the land slide. The nearest soil boring is SB-6 which is further inland (north) on the alignment of the Phase 1 levee. The subsurface profile was also checked for boring B-1 and it appeared to be similar so the profile of SB-6 was used for the model.

<u>SLOPE/W Analysis</u>

SLOPE/W software was used to model the global stability of the Phase 1 berm for the steady state seepage condition since the berm has been in place for years and have experienced previous loading. A cross section from the survey was used, shown below. XS-61 was chosen after reviewing all the survey cross sections due to the relatively narrow crest width and low height compared to other surveyed cross sections. Note that metric units are used for the survey and the seepage and stability analyses.

Boring SB-6 was used to develop the stratigraphy. The soil parameters are based on typical values for the materials and are shown in the figure below. Laboratory testing was performed on the soil and parameters were derived from that, but the CU triaxial lab result values for the top clay layer seemed overly high so more conservative numbers were used. The test results gave values for effective friction angle and cohesion of 34.7° and 114 psf, respectively. In reviewing the test results it appeared the friction angle was estimated incorrectly and was higher than reasonable. A lower friction angle was estimated based on the plot of test results. For the first analysis, effective cohesion was assumed to be zero. A SEEP/W analysis was used to develop the piezometric water level.

The Spencer method was used in the program to calculate the Factor of Safety under fully loaded conditions. The factor of safety for the first analysis assuming zero effective cohesion was 1.04 which is less than the factor of safety of 1.4 recommended for the steady state condition in EM 1110-2-1913 and very close to failure. The levee has not exhibited any stability issues during past performance. It is likely that the levee would not be fully drained due to the short duration of the loading.

Since the levee is unlikely to reach the steady state condition, a small amount of cohesion was included in the analysis. The second analysis was performed with the top layer of clay fill redefined using half of the

value of effective cohesion from the test results. The reported cohesion was divided by 20.89 to convert to metric and then divided by two for the analysis. The analysis was re-run with all other parameters the same as the first analysis. This resulted in a factor of safety of 1.80 which meets the recommended criteria in the EM. Therefore, it does not appear that slope instability would occur on the landside slope when the levee is loaded to the top.

PFP and PNP Determination

The Probable Failure Point (PFP) (85% chance of failure) is at the top of the lowest point of the berm at elevation 4.55 meters for the most likely failure scenario. At this elevation, the berm would be overtopped and susceptible to erosion of the crest and landside slope, which could lead to failure.

Based on survey data, the crest width is approximately 5.36 meters or 17.59 feet wide at the cross section modeled. EM 1110-2-1905 recommends a minimum crest width of 10 feet. Since the actual crest is nearly twice the recommended width and there is riprap and grass cover on the slopes and ground, the berm has some resiliency.

To determine the Probable No Failure Point (PNP) (15% chance of failure) elevation, the uncertainty about the exact soil properties and possible roots and animal burrows were determined to be the controlling factor. While the levee is wider than necessary, issues could arise such as seepage due to large animal burrows which could lead to a breach and would extend to the levee toe. The levee toe is at elevation -0.06 meters and was chosen as the PNP.

These points for the Fragility Curve are based on existing knowledge and field observations. Each subsequent flood event will continue to degrade the levee and lead to more issues with seepage, erosion, and eventually instability and failure.

Table 6: Summary of Fragility Curve Points for Phase 1

Failure Node	Probability of Failure by Node	Elevation Assignment for M. Likely P(f)
Levee Crest	1.00	13.65
Probable Failure Point (PFP)	0.85	13.65
Probable Non-Failure Point (PNP)	0.15	-0.18
Levee Toe	0.00	-0.18

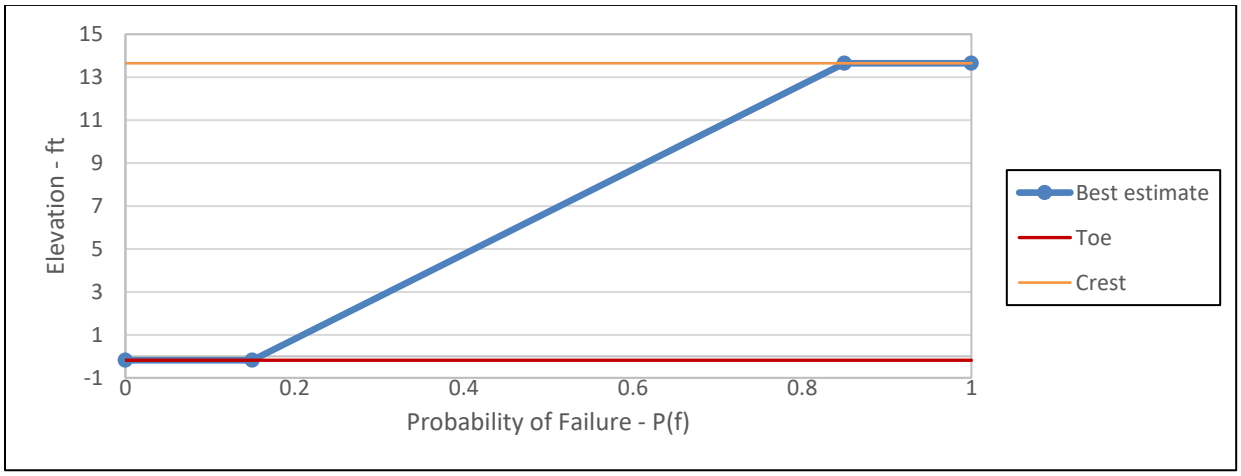

Figure 27: Phase 1 Fragility Curve

7.0 Recommendations

7.1 Future Field Exploration and Laboratory Testing

Borings were collected along the general alignment of the channel but additional subsurface information and laboratory testing is required for design to fill in data gaps. Areas for further investigation include the locations for the floodwalls, the control structure, backflow structure, bridge abutments, upstream channel banks, and the El Faro levee. Borings should be collected at potential borrow sites for clay. Additional borings should be performed within the PR-2 embankment to reduce the uncertainty about the material and inform risk assessment assumptions. Additional laboratory testing should include consolidation testing of the soft soils in El Faro, compaction testing of surface clays, and permeability testing of the gravel layer.

Borings should be spaced a maximum of 1,000 feet apart in accordance with EM 1110-2-1913. Three borings should be collected at each location on the riverside toe, crest, and landside toe in accordance with ETL 1110-2-569. Cost may be a limiting factor in the number of borings. A minimum of 13 additional borings for the levee are needed. Depths would vary from 50 ft along the levee to 80 ft. Bentonite chips are not readily available on the island and would need to be shipped from the mainland. Consider associated shipping costs or grouting when determining the backfill method.

7.2 Survey

Post-earthquake surveys are needed along the project features and the Phase 1 Levee to determine the extent of settlement due to the 2020 earthquakes. A field inspection of the condition of the Phase 1 Levee is needed to verify that the earthquakes did not cause differential settlement or cracking that would impact the integrity of the levee.

7.3 Further Analyses

Subsurface conditions vary and additional seepage, stability, seismic, settlement, and bearing capacity analyses should be performed as needed. A sensitivity analyses for higher peak ground acceleration values should be performed to help address concerns from recent strong earthquakes. Areas that will require further analyses include the floodwall sections, the diversion structure, backflow structure, PR-2 embankment, and El Faro levee once subsurface information is available at those locations. It is believed that the El Faro levee near the coast will be located on similar soils as the Phase 1 Levee and would experience similar settlement issues.

7.4 Dewatering

A portion of the existing channel is dry during the summer. Groundwater depths appear to be lower than the bottom of the diversion channel. For areas where the groundwater is below or near the bottom of the proposed excavations, control of groundwater can likely be accomplished by pumping from sumps within the excavation. It is generally recommended that the water levels be lowered to 5 feet below the bottom of the excavation.

In areas where the groundwater will be near or above the excavation bottom, the bottom of the excavations are anticipated to be relatively soft and wet. Remedial measures will be needed to stabilize the bottom to support various construction work and equipment traffic. Such measures can include the placement of geo-fabric at the bottom of the excavation along with a layer of ¾-inch crushed rock, or alternatively, using geo-grid with rock. Depending on the type of construction equipment used and actual

conditions of exposed excavation bottom, the thickness of the crushed rock may vary. Temporary shoring may be required for the channel slopes to prevent sloughing of granular soils. Sumps and pumps could also be used to control groundwater. Any concrete placement must be done on a dry foundation that has not been softened due to lack of groundwater control.

It should be noted that the design of the dewatering system should assess the influence zone and the potential impact on adjacent structures due to settlement. Based on the data available, loose or soft soils are also common throughout the project area that are susceptible to settlement and surface deformation due to dewatering. Localized subsidence or sinkholes related to settlement of shallow, loose or soft, saturated soils during dewatering or structural loading is possible.

7.5 Excavated Material

There will be excess material from excavation of the diversion channel. Gravel material would not be used for the levee. The tentative plan is to spread the material in open areas or provide fill to interested residents for reuse. It is estimated that the fill would take up 2 ft in designated areas. There is opportunity for the surficial clay material in the foundation to be used for the levee provided a proctor test verified that the material would be suitable for levee construction. The design can be optimized once more subsurface information is available. Clay would be ideal for construction since there would be less concern for cracking and erosion.

7.6 Borrow Material

About 11,000 cubic yards of material would be required to construct the levees and berms. Borings indicate a 7 to 8 ft layer of clay overlying a thick sandy gravel layer. Clay material excavated from the channel that could be reused would probably only account for less than a third of the required amount. Clay material is not locally available at existing borrow sites so new ones would be needed. There is potential for borrow sites east of the town that are far enough away from the river and channel with potential clay but there are no borings to confirm the soils in that area. Borings should be collected at potential borrow sites for clay. Borrow pits on the landside of the levee are not recommended since that could create potential seepage paths in the gravel layer. An alternate source considered for levee construction is karst limestone. There are karst hills and forests immediately to the west of the project site that could be a potential borrow source close to the project.

Granite is needed for riprap along the levees and at the ocean. Stone can be obtained from existing quarries or other islands such as the Dominican Republic, Mexico, Haiti, and Georgia. Sources can be limited so costs will need to be considered at during PED.

7.7 Seepage Trench

A seepage trench (with or without a permeable seepage berm to keep it in place) or series of relief wells would be needed on the landside in areas where there is a clay layer over a thick permeable layer such as gravel or sand in order to prevent uplift and piping issues. The depth would vary depending on subsurface conditions but would need to connect to the pervious stratum. Additional subsurface information and seepage analyses along different sections will be needed during design to verify the depth. Excavated gravel could be reused to fill in the trench but would need to be clear of vegetation and topsoil from covering it. This will be looked at closer during the design phase.

Attachment G-1
Boring Logs

Boring Designation SB-1-19

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Chicago District	SHEET 1 OF 3 SHEETS

1. PROJECT	RIO GUAYANILLA FEASIBILITY STUDY Base Slope - South Bridge Abutment - Hwy 2
2. BORING DESIGNATION	SB-1-19
LOCATION COORDINATES	X = 529,331 Y = 729,212
3. DRILLING AGENCY	Challenge Engineering & Testing, Inc.
CONTRACTOR FILE NO.	2019D03
4. NAME OF DRILLER	Nicolas Andino - SUELOS, Inc.
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	N/A
7. DEPTH DRILLED INTO ROCK	N/A
8. TOTAL DEPTH OF BORING	26.6 Ft.
9. SIZE AND TYPE OF BIT	See Remarks
10. COORDINATE SYSTEM/DATUM	State Plane, PR/VI (U.S. Ft.)
HORIZONTAL	NAD83
VERTICAL	PRVD02
11. MANUFACTURER'S DESIGNATION OF DRILL	CME-55 (land-based)
	☐ AUTO HAMMER ☒ MANUAL HAMMER
12. TOTAL SAMPLES	DISTURBED 7 / UNDISTURBED (UD) 0
13. TOTAL NUMBER CORE BOXES	0
14. ELEVATION GROUND WATER	Not Encountered
15. DATE BORING	STARTED 03-18-19 / COMPLETED 03-26-19
16. ELEVATION TOP OF BORING	72.0 Ft.
17. TOTAL RECOVERY FOR BORING	78 %
18. SIGNATURE AND TITLE OF INSPECTOR	V.J. Thompson III, P.E., Civil Engineer

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
72.0	0.0						72.0		
			SAND, silty, mostly fine to medium-grained sand-sized sand, some subangular to rounded coarse gravel-sized gravel up to 2", little clay, dry, Bridge Abutment Fill, 5Y 7/2 light gray (SM)	73	1		SPT Sampler	6 13 22	35
70.0	2.0						70.5		
			CLAY, lean, low plasticity, mostly clay, little fine to medium-grained sand-sized sand, few subangular to rounded gravel up to 2", dry, 2.5Y 4/2 dark grayish brown (CL)				Advanced Boring		
							68.5		
				67	2		SPT Sampler	9 9 6	15
							67.0		
							Advanced Boring		
							63.5		
			At El. 63.5 Ft., little subangular to rounded gravel up to 2", 2.5Y 4/3 olive brown	80	3		SPT Sampler	16 32 23	55
							62.0		
							Advanced Boring		
58.5	13.5						58.5		
			GRAVEL, poorly-graded, hard, mostly subangular to rounded coarse gravel-sized gravel up to 2-1/2", few fine to medium-grained sand-sized sand, dry, 2.5Y 7/1 light gray (GP)	80	4		SPT Sampler	25 18 20	38
							57.0		

0 5 10 15

(Continued)

Boring Designation SB-1-19

DRILLING LOG (Cont. Sheet)	INSTALLATION: Chicago District	SHEET 2 OF 3 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,331 Y = 729,212	72.0 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
							Advanced Boring		
			At El. 53.5 Ft., 2.5Y 5/2 grayish brown				53.5		
				87	5		SPT Sampler	15, 16, 15	31
							52.0		
							Advanced Boring		
48.5	23.5						48.5		
			SAND, silty, firm, mostly fine to medium-grained sand-sized sand, little clay, few subangular to rounded sand to gravel-sized gravel up to 1/2", dry, 2.5Y 3/3 dark olive brown (SM)	87	6		SPT Sampler	7, 15, 20	35
							47.0		
46.5	25.5								
		Mod. Wea.	LIMESTONE, sparsely fossiliferous, hard, moderately weathered, solid				Advanced Boring		
45.4	26.6						45.5		
			BORING TERMINATED IN REFUSAL	0	7		SPT Sampler 140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.).	50/0.1'	50
			SAMPLE SAMPLE LABORATORY						

NOTES:

1. USACE Jacksonville is the custodian for these original files.

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Attempted To Advance Boring Below 26.5 Ft. With 4 1/4 Hollow Stem Auger. Breaking Bits, Would Not Penetrate.

4. Drilled Companion Boring 10 Ft. South in Attempt To Penetrate Refusal Rock. Boring Terminated at 25.0 Ft. After Repeated Attempts and Breaking Auger Bits.

5. PP = Pocket Penetrometer
TV= Field Torvane

6. Sealed With Bentonite Chips

7. Laboratory Testing Results

(Continued)

Boring Designation SB-1-19

DRILLING LOG (Cont. Sheet)	INSTALLATION: Chicago District	SHEET 3 OF 3 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,331 Y = 729,212	72.0 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE

ID	DEPTH	CLASSIFICATION
1	0.0/1.5	SM*
4	13.5/15.0	GP*
5	18.5/20.0	GP*

*Lab visual classification based on gradation curve

SAMPLE DEPTH	LABORATORY SOIL TESTING	RESULT	UNIT
0.0	Water Content	4	%
0.0	Unit Weight	/	pcf
3.5	Atterberg (PI)	24	
3.5	Water Content	4	%
3.5	Unit Weight	/	pcf
8.5	Specific Gravity	2.85	
8.5	Water Content	2	%
8.5	Unit Weight	/	pcf
13.5	Water Content	1	%
13.5	Unit Weight	/	pcf
18.5	Specific Gravity	2.82	
18.5	Water Content	6	%
18.5	Unit Weight	/	pcf
23.5	Water Content	8	%
23.5	Unit Weight	/	pcf

35
40
45
50
55

Boring Designation SB-2-19

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Chicago District	SHEET 1 OF 6 SHEETS

1. PROJECT	RIO GUAYANILLA FEASIBILITY STUDY North End of Field - South of Concrete Structure Wall
2. BORING DESIGNATION	SB-2-19
LOCATION COORDINATES	X = 529,458 Y = 726,580
3. DRILLING AGENCY	Challenge Engineering & Testing, Inc.
CONTRACTOR FILE NO.	2019D03
4. NAME OF DRILLER	Nicolas Andino - SUELOS, Inc.
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	N/A
7. DEPTH DRILLED INTO ROCK	N/A
8. TOTAL DEPTH OF BORING	73.8 Ft.
9. SIZE AND TYPE OF BIT	See Remarks
10. COORDINATE SYSTEM/DATUM	State Plane, PR/VI (U.S. Ft.)
HORIZONTAL	NAD83
VERTICAL	PRVD02
11. MANUFACTURER'S DESIGNATION OF DRILL	CME-55 (land-based)
	☐ AUTO HAMMER ☒ MANUAL HAMMER
12. TOTAL SAMPLES	DISTURBED 19 / UNDISTURBED (UD) 2
13. TOTAL NUMBER CORE BOXES	0
14. ELEVATION GROUND WATER	23.5 Ft. measured after 24 hrs.
15. DATE BORING	STARTED 03-20-19 / COMPLETED 03-20-19
16. ELEVATION TOP OF BORING	52.9 Ft.
17. TOTAL RECOVERY FOR BORING	78 %
18. SIGNATURE AND TITLE OF INSPECTOR	V.J. Thompson III, P.E., Civil Engineer

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
52.9	0.0						52.9		
			CLAY, lean, low plasticity, firm, mostly clay, some fine-grained sand-sized sand, little silt, dry, 10YR 3/4 dark yellowish brown (CL)	100	1		SPT Sampler	5, 5, 7	12
							51.4 Advanced Boring 50.4		
			At El. 49.4 Ft., PP= 1.75 tsf TV=2.0 tsf in U-1	93	2		SPT Sampler	4, 4, 3	7
						U-1	48.9 Advanced Boring 47.9		
			At El. 46.6 Ft., little coarse gravel-sized gravel up to 2-1/4"	93	3		SPT Sampler	5, 5, 11	16
							46.4 Advanced Boring 45.4		
44.9	8.0								
44.4	8.5		SAND, silty, firm, mostly fine to medium-grained sand-sized sand, trace clay, dry, 5Y 4/4 olive (SM)	80	4		SPT Sampler	8, 18, 18	36
			GRAVEL, poorly-graded, hard, mostly subangular to rounded sand to gravel-sized gravel up to 2", some fine-grained sand-sized sand, few silt, dry, 5Y 7/1 light gray (GP)				43.9 Advanced Boring 43.4		
				80	5		SPT Sampler	11, 15, 20	35
							41.9 Advanced Boring 39.4		
			At El. 38.4 Ft., moist, 5Y 4/4 olive	60	6		SPT Sampler	20, 27, 9	36
							37.9		

0 5 10 15

(Continued)

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Boring Designation SB-2-19

DRILLING LOG (Cont. Sheet)	INSTALLATION: Chicago District	SHEET 2 OF 6 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,458 Y = 726,580	52.9 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
							Advanced Boring		
							34.4		
			At El. 34.4 Ft., trace clay, 2.5Y 3/3 dark olive brown	73	7		SPT Sampler	11, 14, 29	43
							32.9		
							Advanced Boring		
							29.4		
			At El. 29.4 Ft., mostly subangular to subrounded gravel up to 1-3/4", some clay, few fine to medium-grained sand-sized sand, trace silt, moist, 2.5Y 3/3 dark olive brown	87	8		SPT Sampler	9, 13, 11	24
							27.9		
							Advanced Boring		
							24.4		
			At El. 24.4 Ft., wet, 10YR 3/4 dark yellowish brown	87	9		SPT Sampler	11, 15, 11	26
							22.9		
							Advanced Boring		
							19.4		
			At El. 19.4 Ft., some fine to medium-grained sand-sized sand, few clay, trace silt, wet, 10YR 3/3 dark brown	73	10		SPT Sampler	14, 8, 8	16
			At El. 18.4 Ft., 10YR 4/4 dark yellowish				17.9		

15 20 25 30 35

(Continued)

Boring Designation SB-2-19

DRILLING LOG (Cont. Sheet)	INSTALLATION Chicago District	SHEET 3 OF 6 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,458 Y = 726,580	52.9 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			brown				Advanced Boring		
							14.4		
			At El. 14.4 Ft., mostly subangular to rounded sand to gravel-sized gravel up to 2", some fine to medium-grained sand-sized sand, few clay, trace silt, wet, (Possibly Boulder), 10YR 4/4 dark yellowish brown	100	11		13.9 SPT Sampler	99	99
							Advanced Boring		
							9.4		
			At El. 9.4 Ft., 10YR 4/3 brown	67	12		SPT Sampler	16 16 15	31
							7.9		
6.9	46.0		CLAY, lean, low plasticity, firm, mostly clay, few fine to medium-grained sand-sized sand, trace gravel up to 1/2", wet, 10YR 4/6 dark yellowish brown (CL)				Advanced Boring		
							4.4		
			At El. 4.4 Ft., PP= 1.0 tsf TV= 3.25 tsf	60	13		SPT Sampler	12 15 16	31
							2.9		
-0.6	53.5						Advanced Boring		
							-0.6		
			GRAVEL, poorly-graded, hard, mostly subangular to rounded sand to gravel-sized gravel up to 2", some clay, few fine to medium-grained sand-sized sand, moist, Highly Weathered, 10YR 5/4 yellowish brown	87	14		SPT Sampler	16 23 26	49
							-2.1		

35 40 45 50 55

(Continued)

Boring Designation SB-2-19

DRILLING LOG (Cont. Sheet)	INSTALLATION: Chicago District	SHEET 4 OF 6 SHEETS
PROJECT: RIO GUAYANILLA FEASIBILITY STUDY	COORDINATE SYSTEM/DATUM: State Plane, PR/VI (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: PRVD02
LOCATION COORDINATES: X = 529,458 Y = 726,580	ELEVATION TOP OF BORING: 52.9 Ft.	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			(GP)				Advanced Boring		
			At El. -5.6 Ft., wet, 10YR 5/4 yellowish brown	100	15A		-5.6 SPT Sampler	26 / 25	25
-6.9	59.8	HW	SANDSTONE, non-fossiliferous, moderately hard, highly weathered, broken due to drill action, Volcanic, 5Y 5/2 olive gray	20	15B		-6.6 SPT Sampler	16	16
-7.9	60.8		CLAY, fat, low plasticity, hard, mostly clay, some fine to medium-grained sand-sized sand, few subangular to rounded gravel up to 2", moist, 10YR 5/6 yellowish brown (CH)				-7.1 Advanced Boring		
			At El. -10.6 Ft., PP=1.0 tsf TV= 1.5 tsf	93	16		-10.6 SPT Sampler	10 / 5 / 5	10
							-12.1 Advanced Boring		
				50		U-2	-13.1 Shelby Tube HP = 800 psi		
							-15.1 Advanced Boring		
-16.1	69.0		LIMESTONE, sparsely fossiliferous, hard, highly weathered, broken due to drill action, 2.5Y 7/6 yellow	67	17		-15.6 SPT Sampler	2 / 2 / 4	6
		Highly Weathered					-17.1 Advanced Boring		
-20.9	73.8		At El. -20.6 Ft., 2.5Y 7/1 light gray	100	18		-20.6 -20.9 SPT Sampler	50/0.3'	50
			BORING TERMINATED IN REFUSAL				140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.).		
			NOTES:						

55 60 65 70 75

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JUN 02

(Continued)

DRILLING LOG (Cont. Sheet)	INSTALLATION	SHEET 5 OF 6 SHEETS
	Chicago District	

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,458 Y = 726,580	52.9 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			1. USACE Jacksonville is the custodian for these original files.				Abbreviations:		

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Companion Boring Drilled 10 ft. South. U-1 Pushed From 3.5 to 5.5 Ft.

4. Installed 2 Piezometer With 5 Ft. of 0.010 Slotted Screen At 14.5 Ft. Following Completion of the Permeability Test, Pipe Was Pulled and Boring Backfilled With Bentonite Chips.

5. PP = Pocket Penetrometer
TV= Field Torvane

6. Sealed With Bentonite Chips

7. Laboratory Testing Results

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
2	2.5/4.0	CL*
6	13.5/15.0	GP*
8	23.5/25.0	GP*
14	53.5/55.0	GP*

*Lab visual classification based on gradation curve

SAMPLE DEPTH	LABORATORY SOIL TESTING	RESULT	UNIT
0.0	Water Content	10	%
0.0	Unit Weight	/	pcf
2.5	Water Content	11	%
2.5	Unit Weight	/	pcf
5.0	Specific Gravity	2.83	
5.0	Water Content	8	%
5.0	Unit Weight	/	pcf
7.5	Water Content	4	%
7.5	Unit Weight	/	pcf
9.5	Water Content	3	%
9.5	Unit Weight	/	pcf
13.5	Water Content	3	%
13.5	Unit Weight	/	pcf
18.5	Specific Gravity	2.83	
18.5	Water Content	6	%
18.5	Unit Weight	/	pcf
23.5	Water Content	6	%
23.5	Unit Weight	/	pcf
28.5	Water Content	10	%
28.5	Unit Weight	/	pcf
33.5	Water Content	13	%
33.5	Unit Weight	/	pcf
38.5	Water Content	17	%
38.5	Unit Weight	/	pcf
43.5	Water Content	12	%
43.5	Unit Weight	/	pcf
48.5	Atterberg (PI)	27	
48.5	Water Content	30	%
48.5	Unit Weight	/	pcf

75
80
85
90
95

(Continued)

Boring Designation SB-2-19

DRILLING LOG (Cont. Sheet)	INSTALLATION Chicago District	SHEET 6 OF 6 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,458 Y = 726,580	52.9 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			53.5 Specific Gravity 2.78						
			53.5 Water Content 20 %						
			53.5 Unit Weight / pcf						
			58.5 Water Content 14 %						
			58.5 Unit Weight / pcf						
			59.8 Water Content 8 %						
			59.8 Unit Weight / pcf						
			63.5 Atterberg (PI) 30						
			63.5 Water Content 31 %						
			63.5 Unit Weight / pcf						

95
100
105
110
115

SAJ FORM 1836-A
JUN 02

Boring Designation SB-3-19

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Chicago District	SHEET 1 OF 5 SHEETS

1. PROJECT	RIO GUAYANILLA FEASIBILITY STUDY South End of Field
2. BORING DESIGNATION	SB-3-19
LOCATION COORDINATES	X = 529,743 Y = 724,379
3. DRILLING AGENCY	Challenge Engineering & Testing, Inc.
CONTRACTOR FILE NO.	2019D03
4. NAME OF DRILLER	Nicolas Andino - SUELOS, Inc.
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	N/A
7. DEPTH DRILLED INTO ROCK	N/A
8. TOTAL DEPTH OF BORING	60.0 Ft.
9. SIZE AND TYPE OF BIT	See Remarks
10. COORDINATE SYSTEM/DATUM	State Plane, PR/VI (U.S. Ft.)
HORIZONTAL	NAD83
VERTICAL	PRVD02
11. MANUFACTURER'S DESIGNATION OF DRILL	CME-55 (land-based)
	☐ AUTO HAMMER ☒ MANUAL HAMMER
12. TOTAL SAMPLES	DISTURBED 16 / UNDISTURBED (UD) 1
13. TOTAL NUMBER CORE BOXES	0
14. ELEVATION GROUND WATER	21.0 Ft. measured after 24 hrs.
15. DATE BORING	STARTED 03-21-19 / COMPLETED 03-21-19
16. ELEVATION TOP OF BORING	42.5 Ft.
17. TOTAL RECOVERY FOR BORING	89 %
18. SIGNATURE AND TITLE OF INSPECTOR	V.J. Thompson III, P.E., Civil Engineer

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
42.5	0.0						42.5		
			CLAY, lean, low plasticity, firm, mostly clay, some fine-grained sand-sized sand, little silt, trace organic matter, dry, 10YR 4/4 dark yellowish brown (CL)	80	1		SPT Sampler	4 5 6	11
							41.0 Advanced Boring		
			At El. 39.0 Ft., 10YR 5/3 brown	73	2		39.0 SPT Sampler	6 6 5	11
							37.5 Advanced Boring		
35.5	7.0		GRAVEL, poorly-graded, very hard, mostly subangular to rounded sand to gravel-sized gravel up to 2-1/2", some fine to medium-grained sand-sized sand, dry, (Possibly Boulders), 5Y 6/2 light olive gray (GP)				34.0		
				83	3		33.7 SPT Sampler	50/0.3'	50
							Advanced Boring		
			At El. 29.0 Ft., mostly gravel up to 2-1/4"	100	4		29.0 SPT Sampler	50	50
							28.5 Advanced Boring		

0 5 10 15

(Continued)

SAJ FORM 1836
JUN 02

Boring Designation SB-3-19

DRILLING LOG (Cont. Sheet)	INSTALLATION Chicago District	SHEET 2 OF 5 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,743 Y = 724,379	42.5 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
							Advanced Boring		
							24.0		
			At El. 24.0 Ft., dry, 5Y 6/1 gray	33	5		23.7 SPT Sampler	50/0.3'	50
							Advanced Boring		
							19.0		
			At El. 19.0 Ft., dry, 5Y 7/1 light gray					42	
			At El. 18.5 Ft., some fine to medium-grained sand-sized sand, few clay, moist, 5Y 4/4 olive	80	6		SPT Sampler	20	33
							17.5	13	
							Advanced Boring		
							14.0		
13.5	29.0							2	
			CLAY, lean, medium plasticity, firm, mostly clay, few fine to medium-grained sand-sized sand, wet, PP=0.0 tsf TV=0.1 tsf, 5Y 5/4 olive (CL)	93	7		SPT Sampler	2	4
							12.5	2	
			At El. 13.0 Ft., PP=0.25 tsf TV=2.0 tsf, 5Y 3/2 dark olive gray						
			At El. 12.5 Ft., Shelby Tube PP=0.25 tsf TV=2.0 tsf	100		U-1	Shelby Tube HP = 750 psi		
							10.5		
							Advanced Boring		
							9.0		
8.5	34.0		At El. 9.0 Ft., low plasticity, soft, 5Y 3/1 very dark gray	100	8A		8.5 SPT Sampler	2	2
			SAND, silty, firm, mostly fine to medium-grained sand-sized sand, some gravel up to 3/4", trace clay, wet,	100	8B		SPT Sampler	4	4
							7.5	4	

15 20 25 30 35

(Continued)

Boring Designation SB-3-19

DRILLING LOG (Cont. Sheet)	INSTALLATION: Chicago District	SHEET 3 OF 5 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,743 Y = 724,379	42.5 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			10YR 4/3 brown (SM)				Advanced Boring		
			At El. 4.0 Ft., 5Y 3/2 dark olive gray	100	9A		4.0 / 3.5 SPT Sampler	10	10
3.2	39.3		GRAVEL, poorly-graded, hard, mostly subangular to rounded sand to gravel-sized gravel up to 2", some fine to medium-grained sand-sized sand, trace clay, wet, 5Y 5/4 olive (GP)	90	9B		SPT Sampler	11 / 22	22
							2.5 Advanced Boring		
-1.0	43.5		SAND, clayey, low plasticity, firm, mostly fine to medium-grained sand-sized sand, wet, PP=0.5 tsf TV=1.25 tsf, 5Y 3/1 very dark gray (SC)	100	10		-1.0 SPT Sampler	3 / 3 / 7	10
							-2.5 Advanced Boring		
-6.0	48.5		CLAY, lean, medium plasticity, firm, mostly clay, some silt, few fine to medium-grained sand-sized sand, moist, PP=0.5 tsf TV=3.75 tsf, 5Y 4/1 dark gray (CL)	100	11		-6.0 SPT Sampler	4 / 6 / 6	12
-7.3	49.8		SAND, clayey, low plasticity, firm, mostly fine to medium-grained sand-sized sand, little clay, moist, 10YR 4/4 dark yellowish brown (SC)				-7.5 Advanced Boring		
-11.0	53.5						-11.0		
-11.5	54.0		CLAY, lean, medium plasticity, firm, mostly clay, some fine to medium-grained sand-sized sand, wet, PP=0.25 tsf TV=1.25 tsf, 5Y 4/3 olive (CL)	100	12a		-11.5 SPT Sampler	4	4
			SAND, clayey, low plasticity, firm, mostly fine	80	12b		-12.5 SPT Sampler	5 / 6	6

35 40 45 50 55

(Continued)

DRILLING LOG (Cont. Sheet)	INSTALLATION Chicago District	SHEET 4 OF 5 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,743 Y = 724,379	42.5 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			to medium-grained sand-sized sand, some clay, few gravel up to 1/4", wet, 10YR 3/3 dark brown (SC)				Advanced Boring		
-16.0	58.5						-16.0		
-17.0	59.5		SAND, silty, firm, mostly subrounded to rounded fine to coarse-grained sand-sized sand, some gravel up to 1/2", wet, 5Y 5/3 olive (SM)	80	13		SPT Sampler	6 7 8	15
-17.5	60.0		CLAY, lean, medium plasticity, firm, mostly clay, few angular elongated gravel up to 1-1/2", wet, 10YR 3/3 dark brown (CL)				-17.5		

140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.).

Abbreviations:

NOTES:

1. USACE Jacksonville is the custodian for these original files.

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Companion Boring Drilled 10 ft.

4. Installed 2 Piezometer With 5 Ft. of 0.010 Slotted Screen At 6.5 Ft. Following Completion of the Permeability Test, Pipe Was Pulled and Boring Backfilled With Bentonite Chips.

5. PP = Pocket Penetrometer
TV= Field Torvane

6. Sealed With Bentonite Chips

7. Laboratory Testing Results

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
2	3.5/5.0	CL*
4	13.5/15.0	GP*
8b	34.0/35.0	SM*
10	43.5/45.0	SC*

*Lab visual classification based on gradation curve

SAMPLE DEPTH	LABORATORY SOIL TESTING	RESULT	UNIT
0.0	Atterberg (PI)	16	
0.0	Water Content	15	%
0.0	Unit Weight	/	pcf
3.5	Water Content	14	%
3.5	Unit Weight	/	pcf
8.5	Water Content	3	%
8.5	Unit Weight	/	pcf
13.5	Water Content	1	%
13.5	Unit Weight	/	pcf

(Continued)

Boring Designation SB-3-19

DRILLING LOG (Cont. Sheet)	INSTALLATION: Chicago District	SHEET 5 OF 5 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,743 Y = 724,379	42.5 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS				% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			23.5	Water Content	5	%						
			23.5	Unit Weight	/	pcf						
			28.5	Atterberg (PI)	22							
			28.5	Water Content	34	%						
			28.5	Unit Weight	/	pcf						
			30.0	Water Content	30	%						
			30.0	Unit Weight	117/90	pcf						
			33.5	Atterberg (PI)	9							
			33.5	Water Content	34	%						
			33.5	Unit Weight	/	pcf						
			34.0	Water Content	23	%						
			34.0	Unit Weight	/	pcf						
			38.5	Water Content	21	%						
			38.5	Unit Weight	/	pcf						
			39.3	Water Content	11	%						
			39.3	Unit Weight	/	pcf						
			43.5	Water Content	33	%						
			43.5	Unit Weight	/	pcf						
			48.5	Atterberg (PI)	20							
			48.5	Water Content	31	%						
			48.5	Unit Weight	/	pcf						
			53.5	Water Content	32	%						
			53.5	Unit Weight	/	pcf						
			54.3	Water Content	21	%						
			54.3	Unit Weight	/	pcf						
			59.5	Atterberg (PI)	17							
			59.5	Water Content	22	%						
			59.5	Unit Weight	/	pcf						

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Boring Designation SB-4-19

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Chicago District	SHEET 1 OF 5 SHEETS

1. PROJECT	RIO GUAYANILLA FEASIBILITY STUDY North of Roadway On East Edge of Clearing
2. BORING DESIGNATION	SB-4-19
LOCATION COORDINATES	X = 529,758 Y = 722,877
3. DRILLING AGENCY	Challenge Engineering & Testing, Inc.
CONTRACTOR FILE NO.	2019D03
4. NAME OF DRILLER	Nicolas Andino - SUELOS, Inc.
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	N/A
7. DEPTH DRILLED INTO ROCK	N/A
8. TOTAL DEPTH OF BORING	60.0 Ft.
9. SIZE AND TYPE OF BIT	See Remarks
10. COORDINATE SYSTEM/DATUM	State Plane, PR/VI (U.S. Ft.)
HORIZONTAL	NAD83
VERTICAL	PRVD02
11. MANUFACTURER'S DESIGNATION OF DRILL	CME-55 (land-based)
	☐ AUTO HAMMER ☒ MANUAL HAMMER
12. TOTAL SAMPLES	DISTURBED: 16 UNDISTURBED (UD): 1
13. TOTAL NUMBER CORE BOXES	0
14. ELEVATION GROUND WATER	17.7 Ft. measured after 24 hrs.
15. DATE BORING	STARTED: 03-22-19 COMPLETED: 03-23-19
16. ELEVATION TOP OF BORING	35.2 Ft.
17. TOTAL RECOVERY FOR BORING	89 %
18. SIGNATURE AND TITLE OF INSPECTOR	V.J. Thompson III, P.E., Civil Engineer

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
35.2	0.0						35.2		
			CLAY, lean, medium plasticity, soft, mostly clay, some fine to medium-grained sand-sized sand, few silt, trace organic matter, dry, 10YR 4/6 dark yellowish brown (CL)	80	1		SPT Sampler 33.7	4 6 7	13
							Advanced Boring 32.7		
				73	2		SPT Sampler 31.2	5 5 4	9
							Advanced Boring 30.2		
				80	3		SPT Sampler 28.7	6 5 6	11
27.7	7.5						Advanced Boring 27.7		
			SAND, silty, firm, mostly fine to medium-grained sand-sized sand, some subangular to rounded sand to gravel-sized gravel up to 1-1/2', few silt, trace clay, dry, 5Y 5/4 olive (SM)	87	4		SPT Sampler 26.2	4 5 6	11
							25.7 Advanced Boring		
				80	5		SPT Sampler 24.2	5 7 8	15
							Advanced Boring 21.7		
			At El. 20.9 Ft., mostly medium to coarse-grained sand-sized sand	80	6		SPT Sampler 20.2	7 8 8	16

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(Continued)

Boring Designation SB-4-19

DRILLING LOG (Cont. Sheet)	INSTALLATION: Chicago District	SHEET 2 OF 5 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,758 Y = 722,877	35.2 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
16.7	18.5						Advanced Boring 16.7		
			CLAY, lean, medium plasticity, soft, mostly clay, few fine-grained sand-sized sand, moist, PP=0.5 tsf TV=2.0 tsf, 10YR 4/6 dark yellowish brown (CL)	93	7		SPT Sampler 15.2	2 3 2	5
			At El. 15.2 Ft., Shelby Tube U-1 PP=0.25 tsf TV=1.0 tsf T/Ft2	100		U-1	Shelby Tube HP = 700 psi 13.2		
							Advanced Boring 11.7		
			At El. 11.7 Ft., PP=0.25 tsf TV=1.0 tsf, 5Y 5/3 olive	100	8		SPT Sampler 10.2	2 2 2	4
							Advanced Boring 6.7		
			At El. 6.7 Ft., low plasticity, soft, mostly clay, trace fine to medium-grained sand-sized sand, moist, PP=0.0 tsf TV=0.5 tsf, 5Y 4/2 olive gray	100	9		SPT Sampler 5.2	1 1 1	2
1.7	33.5						Advanced Boring 1.7		
			SAND, silty, firm, mostly fine to medium-grained sand-sized sand, few clay, wet, 5Y 3/1 very dark gray (SM)	100	10		SPT Sampler 0.2	1 2 3	5

15 20 25 30 35

(Continued)

Boring Designation SB-4-19

DRILLING LOG (Cont. Sheet)	INSTALLATION Chicago District	SHEET 3 OF 5 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,758 Y = 722,877	35.2 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
							Advanced Boring		
							-3.3		
			At El. -3.3 Ft., little subangular to rounded sand to gravel-sized gravel up to 1", few clay, few shell up to 1/8", wet, 5Y 3/1 very dark gray	100	11		SPT Sampler	2 3 3	6
			At El. -4.6 Ft., 3" lense of wood				-4.8		
							Advanced Boring		
							-8.3		
-9.3	44.5			100	12A		SPT Sampler -9.3	1 2	2
			CLAY, lean, low plasticity, soft, mostly clay, trace fine to medium-grained sand-sized sand, wet, PP=0.25 tsf TV=1.0 tsf, 5Y 3/1 very dark gray (CL)	60	12B		-9.8 SPT Sampler	3	3
							Advanced Boring		
-13.3	48.5						-13.3		
			SAND, silty, firm, mostly fine to medium-grained sand-sized sand, some angular to subrounded gravel up to 1", few shell up to 1/4", wet, 5Y 3/1 very dark gray (SM)	80	13		SPT Sampler	5 5 5	10
							-14.8		
							Advanced Boring		
							-18.3		
			At El. -19.3 Ft., few shell up to 1/4", few	100	14		SPT Sampler -19.8	2 3 5	8

35 40 45 50 55

(Continued)

DRILLING LOG (Cont. Sheet)	INSTALLATION: Chicago District	SHEET 4 OF 5 SHEETS
PROJECT: RIO GUAYANILLA FEASIBILITY STUDY	COORDINATE SYSTEM/DATUM: State Plane, PR/VI (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: PRVD02
LOCATION COORDINATES: X = 529,758 Y = 722,877	ELEVATION TOP OF BORING: 35.2 Ft.	

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
-23.3	58.5		gravel up to 1/4", few peat, moist, 5Y 3/1 very dark gray				Advanced Boring -23.3		
-24.8	60.0		CLAY, lean, medium plasticity, firm, mostly clay, some subangular to rounded sand to gravel-sized gravel up to 1-1/2", few shell up to 1", trace fine to medium-grained sand-sized sand, wet, PP=0.25 tsf TV=1.25 tsf, 5Y 6/2 light olive gray (CL)	87	15		SPT Sampler -24.8	5 8 6	14

140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.).

Abbreviations:

NOTES:

1. USACE Jacksonville is the custodian for these original files.

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. PP = Pocket Penetrometer
TV= Field Torvane

4. Boring Originally Set Up To Be Sampled On East Side Of Highway Near Banana Plantation. Relocated Due To Utility Concerns.

5. Sealed With Bentonite Chips

6. Laboratory Testing Results

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
2	2.5/4.0	CL*
4	7.5/9.0	SM*
6	13.5/15.0	SM*
10	33.5/35.0	SM*

*Lab visual classification based on gradation curve

SAMPLE DEPTH	LABORATORY SOIL TESTING	RESULT	UNIT
0.0	Water Content	14	%
0.0	Unit Weight	/	pcf
5.0	Water Content	11	%
5.0	Unit Weight	/	pcf
7.5	Water Content	5	%
7.5	Unit Weight	/	pcf
9.5	Specific Gravity	2.81	
9.5	Water Content	5	%
9.5	Unit Weight	/	pcf
13.5	Water Content	5	%
13.5	Unit Weight	/	pcf
18.5	Water Content	28	%
18.5	Unit Weight	/	pcf

(Continued)

Boring Designation SB-4-19

DRILLING LOG (Cont. Sheet)	INSTALLATION: Chicago District	SHEET 5 OF 5 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 529,758 Y = 722,877	35.2 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS				% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			20.0	Water Content	28	%						
			20.0	Unit Weight	125/98	pcf						
			23.5	Atterberg (PI)	13							
			23.5	Specific Gravity	2.77							
			23.5	Water Content	36	%						
			23.5	Unit Weight	/	pcf						
			28.5	Atterberg (PI)	17							
			28.5	Specific Gravity	2.74							
			28.5	Water Content	34	%						
			28.5	Unit Weight	/	pcf						
			33.5	Water Content	32	%						
			33.5	Unit Weight	/	pcf						
			38.5	Specific Gravity	2.83							
			38.5	Water Content	20	%						
			38.5	Unit Weight	/	pcf						
			43.5	Water Content	21	%						
			43.5	Unit Weight	/	pcf						
			44.5	Water Content	25	%						
			44.5	Unit Weight	/	pcf						
			48.5	Water Content	19	%						
			48.5	Unit Weight	/	pcf						
			53.5	Specific Gravity	2.68							
			53.5	Water Content	42	%						
			53.5	Unit Weight	/	pcf						
			58.5	Atterberg (PI)	22							
			58.5	Water Content	27	%						
			58.5	Unit Weight	/	pcf						

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Boring Designation SB-5-19

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Chicago District	SHEET 1 OF 3 SHEETS

1. PROJECT	RIO GUAYANILLA FEASIBILITY STUDY Top Of Levee
2. BORING DESIGNATION	SB-5-19
LOCATION COORDINATES	X = 531,952 Y = 724,491
3. DRILLING AGENCY	Challenge Engineering & Testing, Inc.
CONTRACTOR FILE NO.	2019D03
4. NAME OF DRILLER	Nicolas Andino - SUELOS, Inc.
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	N/A
7. DEPTH DRILLED INTO ROCK	N/A
8. TOTAL DEPTH OF BORING	30.0 Ft.
9. SIZE AND TYPE OF BIT	See Remarks
10. COORDINATE SYSTEM/DATUM	State Plane, PR/VI (U.S. Ft.)
HORIZONTAL	NAD83
VERTICAL	PRVD02
11. MANUFACTURER'S DESIGNATION OF DRILL	CME-55 (land-based)
	☐ AUTO HAMMER ☒ MANUAL HAMMER
12. TOTAL SAMPLES	DISTURBED: 8 UNDISTURBED (UD): 0
13. TOTAL NUMBER CORE BOXES	0
14. ELEVATION GROUND WATER	18.5 Ft. measured after 24 hrs.
15. DATE BORING	STARTED: 03-19-19 COMPLETED: 03-19-19
16. ELEVATION TOP OF BORING	48.0 Ft.
17. TOTAL RECOVERY FOR BORING	67 %
18. SIGNATURE AND TITLE OF INSPECTOR	V.J. Thompson III, P.E., Civil Engineer

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
48.0	0.0						48.0		
			CLAY, lean, low plasticity, firm, mostly clay, some silt, little fine-grained sand-sized sand, few subangular to rounded fine to coarse gravel-sized gravel up to 1", dry, Levee Fill, 5Y 5/3 olive (CL)	67	1		SPT Sampler	4 4 4	8
							46.5 Advanced Boring 45.5		
			At El. 45.5 Ft., some gravel up to 2"	73	2		SPT Sampler	8 10 7	17
							44.0 Advanced Boring 43.0		
				67	3		SPT Sampler	10 11 11	22
							41.5 Advanced Boring 39.5		
			At El. 39.5 Ft., few gravel up to 1", dry, 2.5Y 5/3 light olive brown	67	4		SPT Sampler	4 8 14	22
							38.0 Advanced Boring 34.5		
			At El. 34.5 Ft., 10YR 5/4 yellowish brown	73	5		SPT Sampler	5 4 4	8
							33.0		

0 5 10 15

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation SB-5-19

DRILLING LOG (Cont. Sheet)	INSTALLATION Chicago District		SHEET 2 OF 3 SHEETS
PROJECT RIO GUAYANILLA FEASIBILITY STUDY	COORDINATE SYSTEM/DATUM State Plane, PR/VI (U.S. Ft.)	HORIZONTAL NAD83	VERTICAL PRVD02
LOCATION COORDINATES X = 531,952 Y = 724,491	ELEVATION TOP OF BORING 48.0 Ft.		

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
							Advanced Boring		
							29.5		
			At El. 29.5 Ft., some gravel up to 2", 2.5Y 5/4 light olive brown	80	6		SPT Sampler	10, 24, 26	50
							28.0		
							Advanced Boring		
24.5	23.5						24.5		
			GRAVEL, poorly-graded, hard, mostly angular to subrounded sand to gravel-sized gravel up to 2-1/2", few fine to medium-grained sand-sized sand, dry, 2.5Y 6/3 light yellowish brown (GP)	73	7		SPT Sampler	19, 19, 18	37
							23.0		
							Advanced Boring		
							19.5		
			At El. 19.5 Ft., little subangular to rounded sand to gravel-sized gravel up to 3/4", wet, 2.5Y 6/3 light yellowish brown ▼	33	8		SPT Sampler	10, 8, 11	19
18.0	30.0						18.0		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Sealed With Bentonite Chips 4. Laboratory Testing Results SAMPLE ID / SAMPLE DEPTH / LABORATORY CLASSIFICATION				140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.).		

15 20 25 30 35

(Continued)

Boring Designation SB-5-19

DRILLING LOG (Cont. Sheet)	INSTALLATION Chicago District	SHEET 3 OF 3 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 531,952 Y = 724,491	48.0 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			3 5.0/6.5 CL not on atterberg limits.						

SAMPLE DEPTH	LABORATORY SOIL TESTING	RESULT	UNIT
0.0	Water Content	6	%
0.0	Unit Weight	/	pcf
2.5	Water Content	6	%
2.5	Unit Weight	/	pcf
5.0	Atterberg (PI)	22	
8.5	Specific Gravity	2.81	
8.5	Water Content	6	%
8.5	Unit Weight	/	pcf
13.5	Atterberg (PI)	17	
13.5	Water Content	12	%
13.5	Unit Weight	/	pcf
18.5	Water Content	5	%
18.5	Unit Weight	/	pcf
23.5	Water Content	3	%
23.5	Unit Weight	/	pcf
28.5	Water Content	15	%
28.5	Unit Weight	/	pcf

35 40 45 50 55

Boring Designation SB-6-19

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Chicago District	SHEET 1 OF 5 SHEETS

1. PROJECT: RIO GUAYANILLA FEASIBILITY STUDY Center Of Levee	9. SIZE AND TYPE OF BIT: See Remarks
	10. COORDINATE SYSTEM/DATUM: State Plane, PR/VI (U.S. Ft.) HORIZONTAL: NAD83 VERTICAL: PRVD02
2. BORING DESIGNATION: SB-6-19 LOCATION COORDINATES: X = 536,425 Y = 719,157	11. MANUFACTURER'S DESIGNATION OF DRILL: CME-55 (land-based) ☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Challenge Engineering & Testing, Inc. CONTRACTOR FILE NO.: 2019D03	12. TOTAL SAMPLES: DISTURBED 15 UNDISTURBED (UD) 2
4. NAME OF DRILLER: Nicolas Andino - SUELOS, Inc.	13. TOTAL NUMBER CORE BOXES: 0
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL: ; BEARING:	14. ELEVATION GROUND WATER: 0.7 Ft. measured after 24 hrs.
	15. DATE BORING: STARTED 03-19-19 COMPLETED 03-19-19
6. THICKNESS OF OVERBURDEN: N/A	16. ELEVATION TOP OF BORING: 17.2 Ft.
7. DEPTH DRILLED INTO ROCK: N/A	17. TOTAL RECOVERY FOR BORING: 89 %
8. TOTAL DEPTH OF BORING: 60.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: V.J. Thompson III, P.E., Civil Engineer

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
17.2	0.0						17.2		
			CLAY, lean, low plasticity, firm, mostly clay, some fine to medium-grained sand-sized sand, few subangular to rounded gravel up to 2", few silt, dry, 10YR 4/3 brown (CL)	67	1		SPT Sampler 15.7	5 7 11	18
							Advanced Boring 13.7		
			At El. 13.7 Ft., few fine to medium-grained sand-sized sand, dry, PP= 2.0 tsf TV= 3.0 tsf, 5Y 5/4 olive	93	2		SPT Sampler 12.2	8 6 6	12
							Advanced Boring 10.7		
			At El. 10.7 Ft., Bent Shelby Tube U-1 in Attempt to Push	100		U-1	10.4 Shelby Tube		
							Advanced Boring 8.7		
			At El. 8.7 Ft., trace subangular to rounded gravel up to 1/2", dry, PP= 2.0 tsf TV=3.25 tsf, 10YR 4/4 dark yellowish brown	80	3		SPT Sampler 7.2	4 7 7	14
							Advanced Boring 5.7		
			At El. 5.7 Ft., PP=4.25 tsf TV= 10.0 tsf	100		U-2	Shelby Tube HP = 600 psi 3.7		
			At El. 3.7 Ft., moist, PP= 2.5 tsf TV= 4.5 tsf	73	4		SPT Sampler 2.2	6 6 5	11

0 5 10 15

(Continued)

Boring Designation SB-6-19

DRILLING LOG (Cont. Sheet)	INSTALLATION Chicago District		SHEET 2 OF 5 SHEETS
PROJECT RIO GUAYANILLA FEASIBILITY STUDY	COORDINATE SYSTEM/DATUM State Plane, PR/VI (U.S. Ft.)	HORIZONTAL NAD83	VERTICAL PRVD02
LOCATION COORDINATES X = 536,425 Y = 719,157	ELEVATION TOP OF BORING 17.2 Ft.		

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
							Advanced Boring		
							-1.3		
-1.8	19.0			100	5A		-1.8 SPT Sampler	2	2
			SAND, silty, firm, mostly fine to medium-grained sand-sized sand, few gravel up to 1/4", trace shell up to 1/4", trace peat, wet, 2.5Y 3/1 very dark gray (SM)	50	5B		SPT Sampler	3 5	5
							-2.8		
							Advanced Boring		
-6.3	23.5						-6.3		
			SILT, inorganic-L, medium plasticity, firm, mostly clay, few fine-grained sand-sized sand, wet, PP= 1.0 tsf TV= 1.5 tsf, 2.5Y 3/1 very dark gray (ML)	100	6a		SPT Sampler	3 4	4
-7.3	24.5						-7.3		
			SAND, silty, firm, mostly fine to medium-grained sand-sized sand, few clay, trace subangular to rounded gravel up to 1/4", wet, 2.5Y 2.5/1 black (SM)	80	6b		-7.8 SPT Sampler	5	5
							Advanced Boring		
							-11.3		
			At El. -11.8 Ft., some subangular to rounded shell up to 1/4", wet, 2.5Y 5/1 gray	100	7		SPT Sampler	2 3 3	6
							-12.8		
							Advanced Boring		
							-16.3		
			At El. -16.3 Ft., trace shell up to 1/4", 2.5Y 2.5/1 black	87	8		SPT Sampler	2 3 2	5
							-17.8		

15 20 25 30 35

SAJ FORM 1836-A
JUN 02

(Continued)

Boring Designation SB-6-19

DRILLING LOG (Cont. Sheet)	INSTALLATION: Chicago District	SHEET 3 OF 5 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 536,425 Y = 719,157	17.2 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
							Advanced Boring		
							-21.3		
			At El. -21.3 Ft., 5Y 2.5/1 black	87	9		SPT Sampler	2, 2, 2	4
							-22.8		
							Advanced Boring		
							-26.3		
			At El. -26.3 Ft., few shell up to 1/4", trace clay, 5Y 4/1 dark gray	100	10		SPT Sampler	1, 1, 2	3
							-27.8		
							Advanced Boring		
							-31.3		
-31.8	49.0		CLAY, lean, medium plasticity, firm, mostly clay, few fine-grained sand-sized sand, moist, PP= 1.0 tsf TV= 2.0 tsf, 10YR 4/6 dark yellowish brown (CL)	100	11		SPT Sampler	3, 4, 5	9
							-32.8		
							Advanced Boring		
-36.3	53.5						-36.3		
			SAND, silty, firm, mostly fine to medium-grained sand-sized sand, few subrounded to rounded gravel up to 1/8", wet, 10YR 3/6 dark yellowish brown (SM)	100	12		SPT Sampler	4, 5, 7	12
							-37.8		

35 40 45 50 55

(Continued)

DRILLING LOG (Cont. Sheet)	INSTALLATION: Chicago District	SHEET 4 OF 5 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 536,425 Y = 719,157	17.2 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
							Advanced Boring		
							-41.3		
-42.8	60.0		At El. -42.1 Ft., trace gravel up to 1/4", trace clay, 10YR 4/6 dark yellowish brown	100	13		SPT Sampler -42.8	7 / 11 / 11	22

NOTES:

1. USACE Jacksonville is the custodian for these original files.

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. U-1 Was Pushed To Refusal. Tube Bent

4. PP = Pocket Penetrometer
TV= Field Torvane

5. Sealed With Bentonite Chips

6. Laboratory Testing Results

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
2	3.5/5.0	CL*
7	28.5/30.0	SM*

*Lab visual classification based on gradation curve

SAMPLE DEPTH	LABORATORY SOIL TESTING	RESULT	UNIT
0.0	Specific Gravity	2.80	
0.0	Water Content	8	%
0.0	Unit Weight	/	pcf
2.5	Water Content	13	%
2.5	Unit Weight	/	pcf
6.5	Water Content	17	%
6.5	Unit Weight	/	pcf
11.5	Water Content	25	%
11.5	Unit Weight	114/92	pcf
13.5	Water Content	25	%
13.5	Unit Weight	/	pcf
18.5	Water Content	18	%
18.5	Unit Weight	/	pcf
19.0	Water Content	20	%
19.0	Unit Weight	/	pcf
23.5	Atterberg (PI)	17	
23.5	Water Content	30	%
23.5	Unit Weight	/	pcf
24.5	Water Content	19	%

140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.).

Abbreviations:

55 60 65 70 75

(Continued)

Boring Designation SB-6-19

DRILLING LOG (Cont. Sheet)	INSTALLATION Chicago District	SHEET 5 OF 5 SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
RIO GUAYANILLA FEASIBILITY STUDY	State Plane, PR/VI (U.S. Ft.)	NAD83	PRVD02

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 536,425 Y = 719,157	17.2 Ft.

ELEV. (ft)	DEPTH (ft)	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			24.5 Unit Weight / pcf						
			28.5 Specific Gravity 2.88						
			28.5 Water Content 28 %						
			28.5 Unit Weight / pcf						
			33.5 Water Content 30 %						
			33.5 Unit Weight / pcf						
			38.5 Water Content 32 %						
			38.5 Unit Weight / pcf						
			43.5 Water Content 32 %						
			43.5 Unit Weight / pcf						
			49.3 Atterberg (PI) 15						
			49.3 Water Content 31 %						
			49.3 Unit Weight / pcf						
			53.5 Water Content 21 %						
			53.5 Unit Weight / pcf						
			58.5 Water Content 25 %						
			58.5 Unit Weight / pcf						

75
80
85
90
95

Geo-ENGINEERING		**LOG OF BORING NO.**	1 (Approx. Sta. 13+00)		
Project:	Channeling of Guayanilla River	**Sheet No.**	1 of 3	**Date:**	7/2/04 7/13/04
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	100'		
Ground Surf.		**Water Depth:**		**When finishing**	
Elev.:		**During Drilling**	20'	**the boring:**	

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
2'	15	Fill recovered as brown clay with tiny roots and traces of fine sand	2-4-3-5	7	[1.5]	22				
4'	12		3-9-15-14	24		19				
6'	16		4-6-10-15	16	[4.5]	23				
8'	18		7-13-16-17	29		19				
10'	20	(wet and rock fragments)	3-2-5-9	7	1.7	31				
15'	24	(rock fragments)	4-9-9-12	18	[1.5]	22				
20'	24	Gray medium to coarse sand with rock fragments, lumps of clay and organic	1-2-3-5	5		39				
25'	24	Gray clayey silt/silty clay with some medium to coarse sand, rock fragments, shell fragments and decayed wood, organic	1-1-1-6	2		50				
30'	24	Gray sandy silty clay/clayey silty sand, organic	2-2-6-4	8		49	28	27	OL	
35'	7		1/12"-2-2	3		36				
40'	24	Gray clayey silt/silty clay with shell fragments, organic	1/12"-4-3	5	[0.5]	38	45	23	OL	

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.**	1 (Approx. Sta. 13+00)
Project:	Channeling of Guayanilla River	**Sheet No.**	2 of 3
Date:	7/2/04 7/13/04		
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	100'
Ground Surf. Elev.:		**Water Depth: During Drilling**	20'
When finishing the boring:			

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
45'	24		2-3-2-3	5	[0.5]	44				
50'	24	Gray sandy silty clay/clayey silty sand with shell fragments, organic	push 24"	0		30	32	20	OL	
55'	24		2-4-4-4	8		29				
60'	24		push 24"	0		35				
65'	24	(w/ coral fragments)	push 18" -2	0		37				
70'	24	Light gray clayey silt/silty clay with pieces of coral, organic	2-4-4-7	8		27				
75'	24	Tannish brown clayey silt/silty clay with pebbles, gray mottled (old alluvial)	4-4-8-8	12	[2.0]	24				
80'	24		2-5-6-6	11	[0.5]	34				

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.**	1 (Approx. Sta. 13+00)
Project:	Channeling of Guayanilla River	**Sheet No.**	3 of 3
Date:	7/2/04 7/13/04		
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	100'
Ground Surf. Elev.:		**Water Depth: During Drilling**	20'
When finishing the boring:			

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
85'	24		7-10-12-15	22		21	65	26	CH	
90'	0	No Recovery	8-13-16-17	29						
95'	24		6-10-12-17	22		34				
100'	20	Tannish brown silty sand	15-18-13-18	31		26				
		End of Boring 100'								
105'										
110'										
115'										
120'										

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.**	2 (Approx. Sta. 25+00)
Project:	Channeling of Guayanilla River	**Sheet No.**	1 of 3
Date:	7/13/04 7/15/04		
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	100'
Ground Surf. Elev.:		**Water Depth: During Drilling**	25'
When finishing the boring:			

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
2'	18	Fill- recovered as brown clay with tiny roots & few fine sand	7-10-12-12	22		14				
4'	20		8-11-13-14	24		14	38	22	CL	
6'	21		6-8-7-7	15	[>4.5]	19				
8'	19		3-7-6-6	13		16	35	22	CL	
10'		Brownish clay w/ little fine sand & tiny roots (alluvial)	4-5-8-9	13		27				
15'	20	Gray & brown clayey silt/silty clay	2-4-4-6	8	[1.0]	32				
20'	18	(w/ fine silty sand)	3-4-4-4	8		26				
25'	21	Grayish clayey silt/silty clay, organic	4-4-3-3	7	0.45	29				
30'	20	(w/ rock frags)	3-4-5-6	9		33				
35'	24	(w/ decayed root)	3-4-4-4	8	[1.0]	33	47	18	OL	
40'	24	Gray clayey silty sand/sandy silty clay, organic	3-3-4-4	7	[0.5]	29				

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.**	2 (Approx. Sta. 25+00)
Project:	Channeling of Guayanilla River	**Sheet No.**	2 of 3
Date:	7/13/04 7/15/04		
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	100'
Ground Surf. Elev.:		**Water Depth: During Drilling**	25'
When finishing the boring:			

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
45'	24		2-4-4-5	8	[0.25]	31				
50'	24		push 12"-2-3	2	[0.5]	28	30	18	OL	
55'	24	Gray clayey silt/silty clay w/ shell frags & decayed roots, organic	push 12"-5-5	5	[0.5]	41				
60'	24		3-3-4-5	7		42				
65'	24	Gray clayey silty sand/ sandy silty clay, organic	3-5-5-8	10		34				
70'	24	(w/ traces of cemented sand)	3-5-5-7	10	[0.5]	27				
75'	24	(w/ traces of cemented sand)	4-3-5-7	8		30				
80'	24	Gray clayey silt/silty clay w/ decayed wood, organic	4-5-7-8	12	[1.25]	31	52	23	OH	

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.**	2 (Approx. Sta. 25+00)
Project:	Channeling of Guayanilla River	**Sheet No.**	3 of 3
Date:	7/13/04 7/15/04		
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	100'
Ground Surf. Elev.:		**Water Depth: During Drilling**	25'
When finishing the boring:			

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
85'	24	Gray cemented sand, clayey silt & silty clay, organic	10-14-16-23	30		21				
90'	22		12-27-32-50/5"	59		18				
95'	24	Tannish brown clayey silt/silty clay w/ traces of fine sand (Old Alluvial)	13-19-18-24	37	[2.5]	27				
100'	24		14-20-27-38	47	5.2	28	36	16	CL	
		End of Boring 100'								
105'										
110'										
115'										
120'										

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		LOG OF BORING NO.	3		
Project:	Channeling of Guayanilla River	**Sheet No.**	1 of 2	**Date:**	7/15/04 7/16/04
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	70'		
Ground Surf.		**Water Depth:**		**When finishing**	
Elev.:		**During Drilling**	20'	**the boring:**	

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
2'	19	Fill - recovered as brown clay with few fine sand and rock fragments	10-17-21-23	38		11				
4'	20		10-8-11-13	19	[3.25]	28				
6'	21	(clayey)	7-9-10-11	18	[2.5]	29	56	25	CH	
8'	18	Brownish sandy silty clay/clayey silty sand with rock fragments (alluvial)	7-8-9-12	17	[1.25]	29				
10'	19	Brown clayey silt/silty clay with rock fragments and tiny roots, organic	6-9-8-7	17	[0.5]	30				
15'	15	(gray and brown)	1-2-4-4	6	[0.5]	43				
20'	24	Gray fine silty sand with rock fragments, organic	3-14-18-17	32		27				
25'	24	(silty, soft and wet)	3-7-11-10	18		32				
30'	24	Gray sandy silty clay/clayey silty sand with shell fragments	2-2-3-4	5	[1.0]	33				
35'	24	(sandy decayed wood)	4-5-5-9	10		23				
40'	24	Gray clayey silt/silty clay with decayed wood, organic	3-4-5-6	9	[0.5]	50	64	41	OH	

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.** 3	
Project:	Channeling of Guayanilla River	**Sheet No.** 2 of 2	**Date:** 7/15/04 7/16/04
Site Location:	Guayanilla, Puerto Rico	**Boring End At:** 70'	
Ground Surf.		**Water Depth:**	**When finishing**
Elev.:		**During Drilling** 20'	**the boring:**

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
45'	24	Gray sandy silty clay/ clayey silty sand, organic	4-5-7-16	12		27				
50'	24	Tannish brown sandy silty clay/clay silty sand (old alluvial)	5-18-29-37	47		26				
55'	24	Tannish brown clayey silt/silty clay	10-27-49-50/5"	76	[>4.5]	31	47	30	CL	
60'	18	(traces of fine sand and limestone fragments)	18-50-50/3"	100/9"		18				
65'	24		8-14-15-18	29	[3.25]	28				
70'	12	Tannish brown sandy clay/clayey sand with few pebbles	35-28-33-46	61		22				
		End of Boring 70'								
75'										
80'										

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Attachment G-2
Soil Parameters

SB-1-19

Material	Sat unit weight (pcf)	Short Φ (deg)	Short c (psf)	Long Φ (deg)	Long c (psf)	Top elevation	Bottom elevation
Dense silty sand, some gravel (SM)	106	34.5	0	34.5	0	72	70
Very stiff clay (CL)	120	0	2500	29	0	70	58.5
Dense gravel, poorly graded (GP)	130	37.5	0	37.5	0	58.5	48.5
Dense silt sand (SM)	110	34.5	0	34.5	0	48.5	46.5
limestone	140	45	0	45	0	46.5	

* no goundwater encountered

SB-2-19

Material	Sat unit weight (pcf)	Short Φ (deg)	Short c (psf)	Long Φ (deg)	Long c (psf)	Top elevation	Bottom elevation
Stiff clay, some sand (CL)	115	0	1750	27	0	52.9	44.9
Dense silty sand (SM)	106	34.5	0	34.5	0	44.9	44.4
Medium dense gravel, poorly graded, some sand (GP)	137	37	0	37	0	44.4	6.9
Very stiff clay (CL)	120	0	2500	29	0	6.9	-0.6
Dense gravel, poorly graded, some clay (GP)	148	39	0	39	0	-0.6	-6.9
sandstone	120	35	0	35	0	-6.9	-7.9
Stiff clay, fat, some sand (CH)	115	0	1000	26	0	-7.9	-16.1
limestone	140	45	0	45	0	-16.1	

* groundwater at elevation 29.4 after 24 hours

SB-3-19

Material	Sat unit weight (pcf)	Short Φ (deg)	Short c (psf)	Long Φ (deg)	Long c (psf)	Top elevation	Bottom elevation
Stiff clay, some sand (CL)	115	0	1000	26	0	42.5	35.5
Dense gravel, some sand (GP)	134	35	0	35	0	35.5	13.5
Soft clay (CL)	117	0	250	24	0	13.5	8.5
Loose silty sand, some gravel (SM)	112	29	0	29	0	8.5	3.2
Medium dense gravel, poorly graded, some sand (GP)	134	35	0	35	0	3.2	-1
Loose clayey sand (SC)	120	30	0	30	0	-1	-6
Soft clay, some silt (CL)	115	0	250	24	0	-6	-11
Medium dense clayey sand (SC)	109	30	0	30	0	-11	-16
Medium dense silty sand, some gravel (SM)	96	30	0	30	0	-16	-17
Stiff clay (CL)	115	0	1500	27	0	-17	

* groundwater at elevation 21.5 after 24 hours

SB-4-19

Material	Sat unit weight (pcf)	Short Φ (deg)	Short c (psf)	Long Φ (deg)	Long c (psf)	Top elevation	Bottom elevation
Stiff clay, some sand (CL)	115	0	1000	26	0	35.2	27.7
Medium dense silty sand (SM)	100	31	0	31	0	27.7	16.7
Soft clay (CL)	125	0	250	24	0	16.7	1.7
Loose silty sand (SM)	112	28.5	0	28.5	0	1.7	-9.3
Soft clay (CL)	125	0	250	24	0	-9.3	-13.3
Loose silty sand (SM)	122	30	0	30	0	-13.3	-23.3
Stiff clay, some sand (CL)	115	0	1500	27	0	-23.3	

* groundwater at elevation 17.5 after 24 hours

SB-5-19

Material	Sat unit weight (pcf)	Short Φ (deg)	Short c (psf)	Long Φ (deg)	Long c (psf)	Top elevation	Bottom elevation
Stiff clay, some silt (CL)	115	0	1000	26	0	48	24.5
Medium dense gravel, poorly graded (GP)	141	36.5	0	36.5	0	24.5	18

* groundwater at elevation 29.5 after 24 hours

SB-6-19

Material	Sat unit weight (pcf)	Short Φ (deg)	Short c (psf)	Long Φ (deg)	Long c (psf)	Top elevation	Bottom elevation
Stiff clay, some sand (CL)	114	0	2000	28	0	17.2	-1.8
Loose silty sand (SM)	112	29.5	0	29.5	0	-1.8	-6.3
Medium stiff clayey silt (ML)	110	0	1000	26	0	-6.3	-7.3
Very loose silty sand (SM)	107	28	0	28	0	-7.3	-31.8
Medium stiff clay (CL)	110	0	1000	26	0	-31.8	-36.3
Medium dense silty sand (SM)	119	32	0	32	0	-36.3	

* groundwater at elevation 16.5 after 24 hours

B-1-04

Material	Sat unit weight (pcf)	Short Φ (deg)	Short c (psf)	Long Φ (deg)	Long c (psf)	Top elevation	Bottom elevation
Stiff clay fill (CL)	120	0	1500	27	0	10	-7
Loose sand (SP)	135	28	0	28	0	-7	-10
Soft sandy silty clay (OL)	100	0	500	24	0	-10	-37
Very soft sandy silty clay (OL)	90	0	100	22	0	-37	-57
Medium stiff clayey silt (OL)	110	0	500	25	0	-57	-62
Medium stiff silty clay (CH)	120	0	1000	26	0	-62	-87
Dense silty sand (SM)	129	34	0	32	0	-87	

* groundwater at elevation -10 during drilling

B-2-04

Material	Sat unit weight (pcf)	Short Φ (deg)	Short c (psf)	Long Φ (deg)	Long c (psf)	Top elevation	Bottom elevation
Hard clay (CL)	135	0	4500	30	0	15	7
Medium stiff clay (CL)	120	0	1000	26	0	7	-7
Medium stiff silty clay (OL)	110	0	500	24	0	-7	-68
Very stiff clayey silt (OL)	125	0	2500	28	0	-68	-77
Very stiff (CL)	125	0	2500	28	0	-77	

* groundwater at elevation -10 during drilling

B-3-04

Material	Sat unit weight (pcf)	Short Φ (deg)	Short c (psf)	Long Φ (deg)	Long c (psf)	Top elevation	Bottom elevation
Very stiff clay fill (CH)	125	0	2500	28	0	14	8
Stiff sandy silty clay (SC)	120	0	1250	27	0	8	6
Medium stiff clayey silt (CL)	110	0	500	25	0	6	-3
Medium dense silty sand (SM)	110	33	0	33	0	-3	-13
Medium stiff sandy silty clay (SC)	120	0	1000	26	0	-13	-23
Medium stiff clayey silt (OH)	110	0	500	24	0	-23	-28
Very stiff sandy silty clay(CL)	130	0	3250	30	0	-28	

* groundwater at elevation -6 during drilling

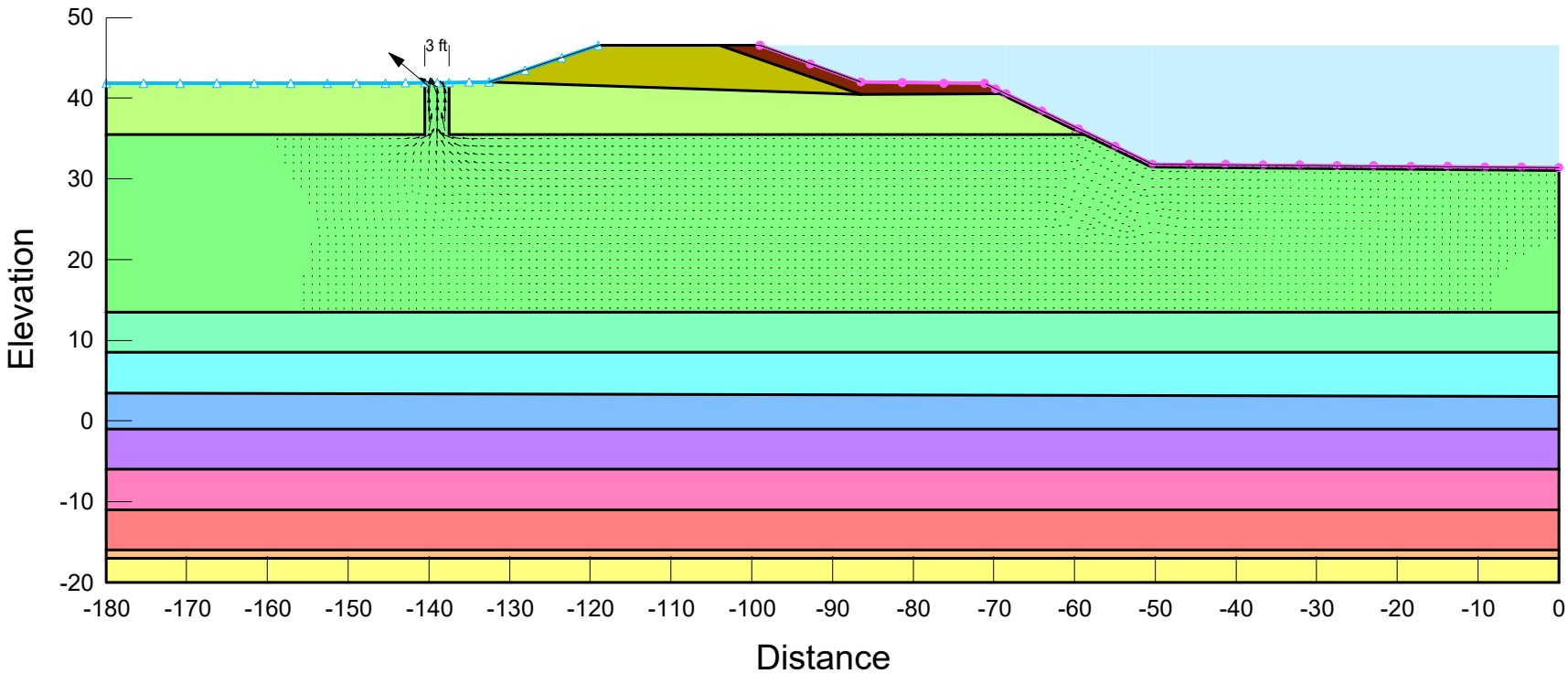
Material	Sat unit weight (pcf)	Φ (deg)	c (psf)
Riprap	150	40	0
Concrete	150	0	2500

Attachment G-3
Geostudio SEEP/W Outputs

Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel
Trench

Flow

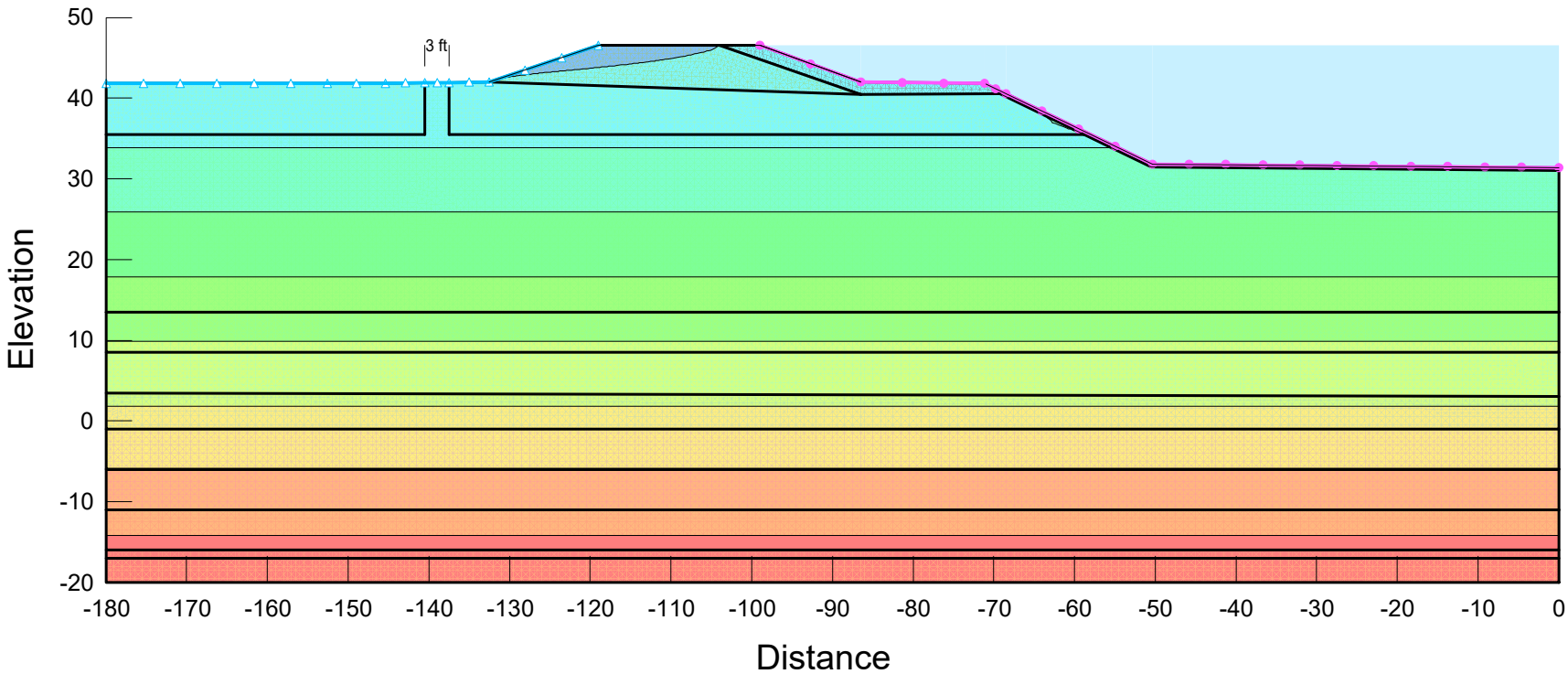
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel
Trench

Pore-Water Pressure

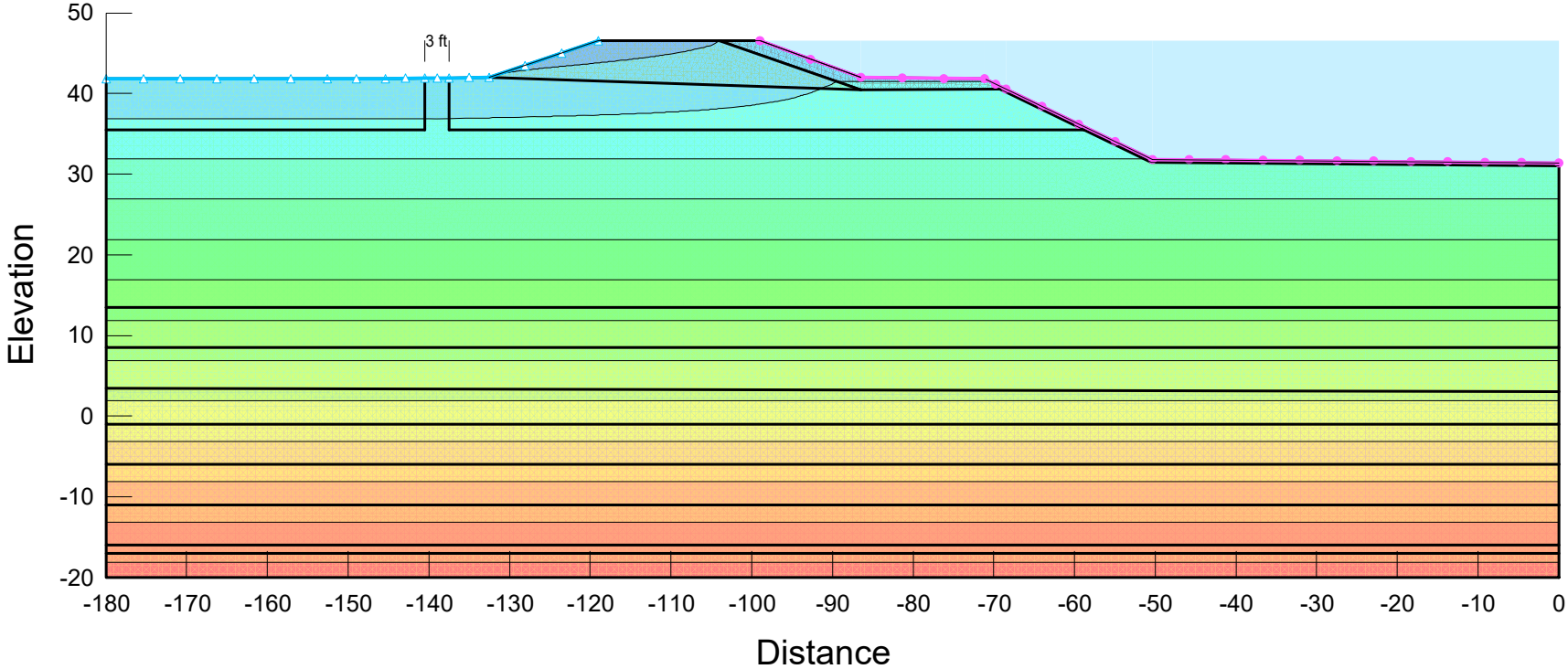
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel
Trench

Pressure Head

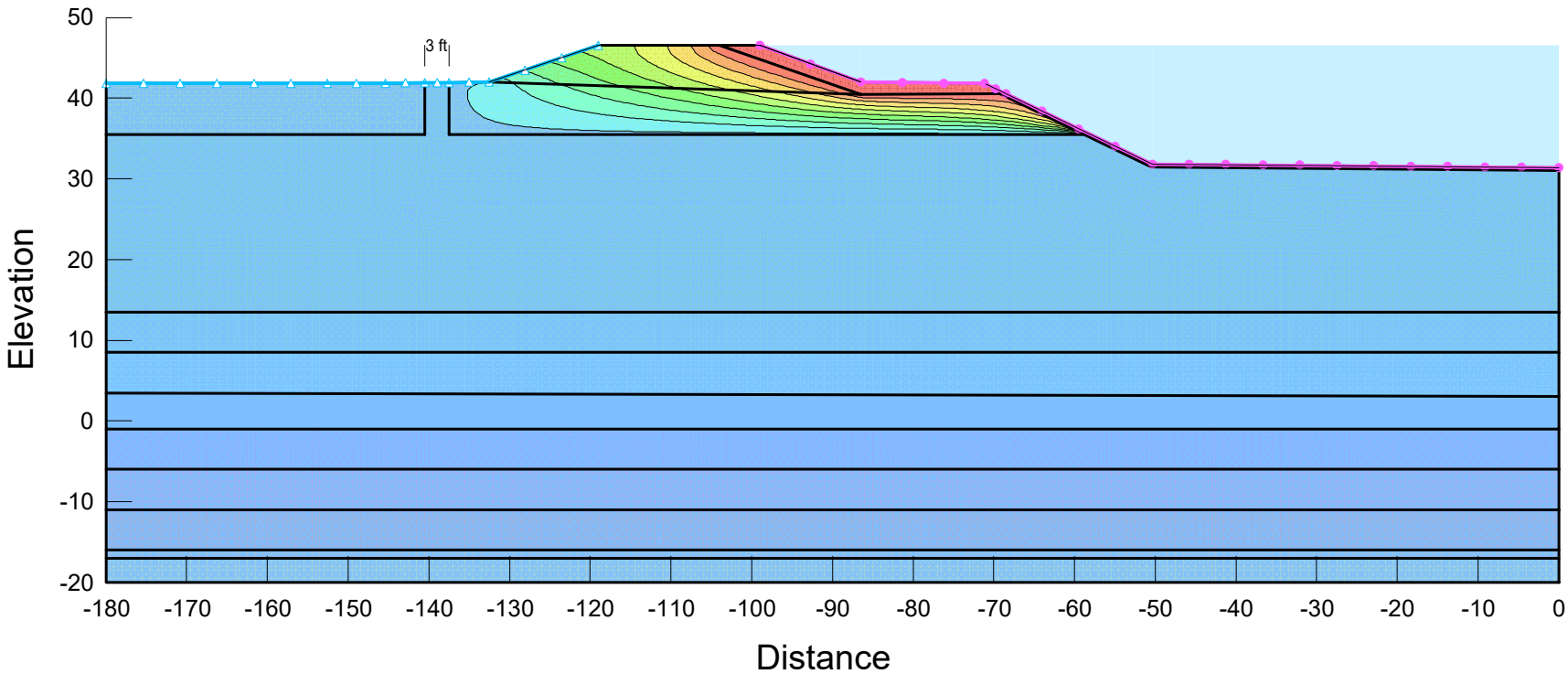
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel
Trench

Total Head

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



SEEP/W - Flood

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File Information

File Version: 9.01
Created By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Last Edited By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Revision Number: 105
Date: 08/15/2019
Time: 12:53:22 PM
Tool Version: 9.1.1.16749
File Name: 52+00 trench LT concrete.gsz
Directory: C:\Users\h6ts9yjs\Desktop\draft\
Last Solved Date: 08/15/2019
Last Solved Time: 12:53:30 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SEEP/W - Flood

Description: Station 52+00 SEEP/W - Flood Concrete Channel Trench
Kind: SEEP/W
Method: Steady-State
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Maximum Number of Iterations: 500
- Maximum Difference: 0.005
- Significant Digits: 2
- Max # of Reviews: 10
- Under-Relaxation Criteria
  - Initial Rate: 1
  - Minimum Rate: 0.1
  - Rate Reduction Factor: 0.65
  - Reduction Frequency (iterations): 10
- Unit Weight of Water: 62.430189 pcf

Bulk Modulus of Pore-Fluid: 43,511,321 psf

Settings

Dimension: 2D

Time

Starting Time: 0 d

Duration: 5 d

Ending Time: 5 d

Materials

01 Levee

Hydraulic

Model: Saturated Only

Sat Kx: 3.28e-08 ft/sec

Ky'/Kx' Ratio: 0.1

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 9.1e-06 /psf

02 Stiff clay CL

Hydraulic

Model: Saturated Only

Sat Kx: 3.28e-08 ft/sec

Ky'/Kx' Ratio: 0.1

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 9.1e-06 /psf

03 Dense gravel GP

Hydraulic

Model: Saturated Only

Sat Kx: 0.328 ft/sec

Ky'/Kx' Ratio: 0.5

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 2.3e-07 /psf

04 Soft clay CL

Hydraulic

Model: Saturated Only

Sat Kx: 3.28e-08 ft/sec

Ky'/Kx' Ratio: 0.1

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 9.1e-06 /psf

05 Loose stilty sand SM

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-05 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.4e-06 /psf

06 Medium dense gravel GP

Hydraulic

Model: Saturated Only
Sat Kx: 0.328 ft/sec
Ky'/Kx' Ratio: 0.5
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 2.3e-07 /psf

07 Loose clayey sand SC

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-06 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.7e-06 /psf

08 Soft clay CL

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-08 ft/sec
Ky'/Kx' Ratio: 0.1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 9.1e-06 /psf

09 Medium dense clayey sand SC

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-06 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.7e-06 /psf

10 Medium dense silty sand SM

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-05 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.4e-06 /psf

11 Stiff clay CL

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-08 ft/sec
Ky'/Kx' Ratio: 0.1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 9.1e-06 /psf

12 Riprap

Hydraulic

Model: Saturated Only
Sat Kx: 32.8 ft/sec
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 4.5e-08 /psf

13 Concrete

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-09 ft/sec
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 9.1e-06 /psf

Boundary Conditions

Seepage face

Category: Hydraulic
Kind: Water Rate 0 ft^3/sec
Review: Yes

Channel

Category: Hydraulic
Kind: Water Total Head 46.5 ft
Review: No

Points

	X	Y
Point 1	-180 ft	41.818182 ft
Point 2	-152.57919 ft	41.818182 ft
Point 3	-145.33937 ft	41.818182 ft
Point 4	-132.5 ft	42 ft
Point 5	-119 ft	46.5 ft
Point 6	-99 ft	46.5 ft
Point 7	-86.5 ft	42 ft
Point 8	-71.13122 ft	41.818182 ft
Point 9	-50.31674 ft	31.818182 ft
Point 10	0 ft	31.4 ft
Point 11	-180 ft	35.5 ft
Point 12	-180 ft	13.5 ft
Point 13	-180 ft	8.5 ft
Point 14	-180 ft	3.5 ft
Point 15	-180 ft	-1 ft
Point 16	-180 ft	-6 ft
Point 17	-180 ft	-11 ft
Point 18	-180 ft	-16 ft
Point 19	-180 ft	-17 ft
Point 20	-180 ft	-20 ft
Point 21	0 ft	-20 ft
Point 22	0 ft	-17 ft
Point 23	0 ft	-16 ft
Point 24	0 ft	-11 ft
Point 25	0 ft	13.5 ft
Point 26	0 ft	8.5 ft
Point 27	0 ft	3 ft
Point 28	0 ft	-1 ft
Point 29	0 ft	-6 ft
Point 30	-104 ft	46.5 ft
Point 31	-86.50667 ft	40.495158 ft
Point 32	-58.83323 ft	35.5 ft
Point 33	-50.5 ft	31.5 ft

Point 34	0 ft	31 ft
Point 35	-68.5 ft	40.5 ft
Point 36	-69.25156 ft	40.5 ft
Point 37	-137.5 ft	41.929195 ft
Point 38	-137.5 ft	35.5 ft
Point 39	-140.5 ft	35.5 ft
Point 40	-140.5 ft	41.886712 ft

Lines

	Start Point	End Point	Length	Angle	Hydraulic Boundary
Line 1	25	12	180 ft	0 °	
Line 2	25	26	5 ft	90 °	
Line 3	26	13	180 ft	0 °	
Line 4	13	12	5 ft	90 °	
Line 5	26	27	5.5 ft	90 °	
Line 6	27	14	180 ft	-0.159 °	
Line 7	14	13	5 ft	90 °	
Line 8	27	28	4 ft	90 °	
Line 9	28	15	180 ft	0 °	
Line 10	15	14	4.5 ft	90 °	
Line 11	29	28	5 ft	90 °	
Line 12	15	16	5 ft	90 °	
Line 13	16	29	180 ft	0 °	
Line 14	21	22	3 ft	90 °	
Line 15	22	19	180 ft	0 °	
Line 16	19	20	3 ft	90 °	
Line 17	20	21	180 ft	0 °	
Line 18	24	17	180 ft	0 °	
Line 19	24	23	5 ft	90 °	
Line 20	23	18	180 ft	0 °	
Line 21	18	17	5 ft	90 °	
Line 22	23	22	1 ft	90 °	
Line 23	19	18	1 ft	90 °	
Line 24	29	24	5 ft	90 °	
Line 25	17	16	5 ft	90 °	

Line 26	30	31	18.495 ft	-18.9 °	
Line 27	34	10	0.4 ft	90 °	
Line 28	35	36	0.75156 ft	0 °	
Line 29	36	32	11.556 ft	-25.6 °	
Line 30	33	34	50.502 ft	-0.567 °	
Line 31	35	8	2.9429 ft	-26.6 °	Channel
Line 32	8	7	15.37 ft	-0.678 °	Channel
Line 33	7	6	13.285 ft	-19.8 °	Channel
Line 34	6	30	5 ft	0 °	
Line 35	31	36	17.255 ft	0.0161 °	
Line 36	31	4	46.018 ft	-1.87 °	
Line 37	4	5	14.23 ft	18.4 °	Seepage face
Line 38	5	30	15 ft	0 °	
Line 39	3	2	7.2398 ft	0 °	Seepage face
Line 40	2	1	27.421 ft	0 °	Seepage face
Line 41	1	11	6.3182 ft	90 °	
Line 42	33	32	9.2435 ft	-25.6 °	
Line 43	35	9	20.15 ft	-25.5 °	Channel
Line 44	9	10	50.318 ft	-0.476 °	Channel
Line 45	25	34	17.5 ft	90 °	
Line 46	11	12	22 ft	90 °	
Line 47	4	37	5.0005 ft	0.811 °	Seepage face
Line 48	38	32	78.667 ft	0 °	
Line 49	37	38	6.4292 ft	90 °	
Line 50	11	39	39.5 ft	0 °	
Line 51	39	38	3 ft	0 °	
Line 52	37	40	3.0003 ft	0.811 °	Seepage face
Line 53	40	3	4.8399 ft	0.811 °	Seepage face
Line 54	39	40	6.3867 ft	90 °	

Regions

	Material	Points	Area
Region 1	04 Soft clay CL	25,26,13,12	900 ft²
Region 2	05 Loose stilty sand SM	26,27,14,13	945 ft²
Region 3	06 Medium dense gravel GP	27,28,15,14	765 ft²

Region 4	07 Loose clayey sand SC	29,28,15,16	900 ft²
Region 5	11 Stiff clay CL	21,22,19,20	540 ft²
Region 6	09 Medium dense clayey sand SC	24,23,18,17	900 ft²
Region 7	10 Medium dense silty sand SM	23,22,19,18	180 ft²
Region 8	08 Soft clay CL	29,24,17,16	900 ft²
Region 9	12 Riprap	35,8,7,6,30,31,36	47.869 ft²
Region 10	01 Levee	31,4,5,30	158.68 ft²
Region 11	02 Stiff clay CL	4,37,38,32,36,31	408.95 ft²
Region 12	13 Concrete	33,32,36,35,9,10,34	25.21 ft²
Region 13	03 Dense gravel GP	25,34,33,32,38,39,11,12	3,728.7 ft²
Region 14	02 Stiff clay CL	3,2,1,11,39,40	249.73 ft²
Region 15	03 Dense gravel GP	38,37,40,39	19.224 ft²

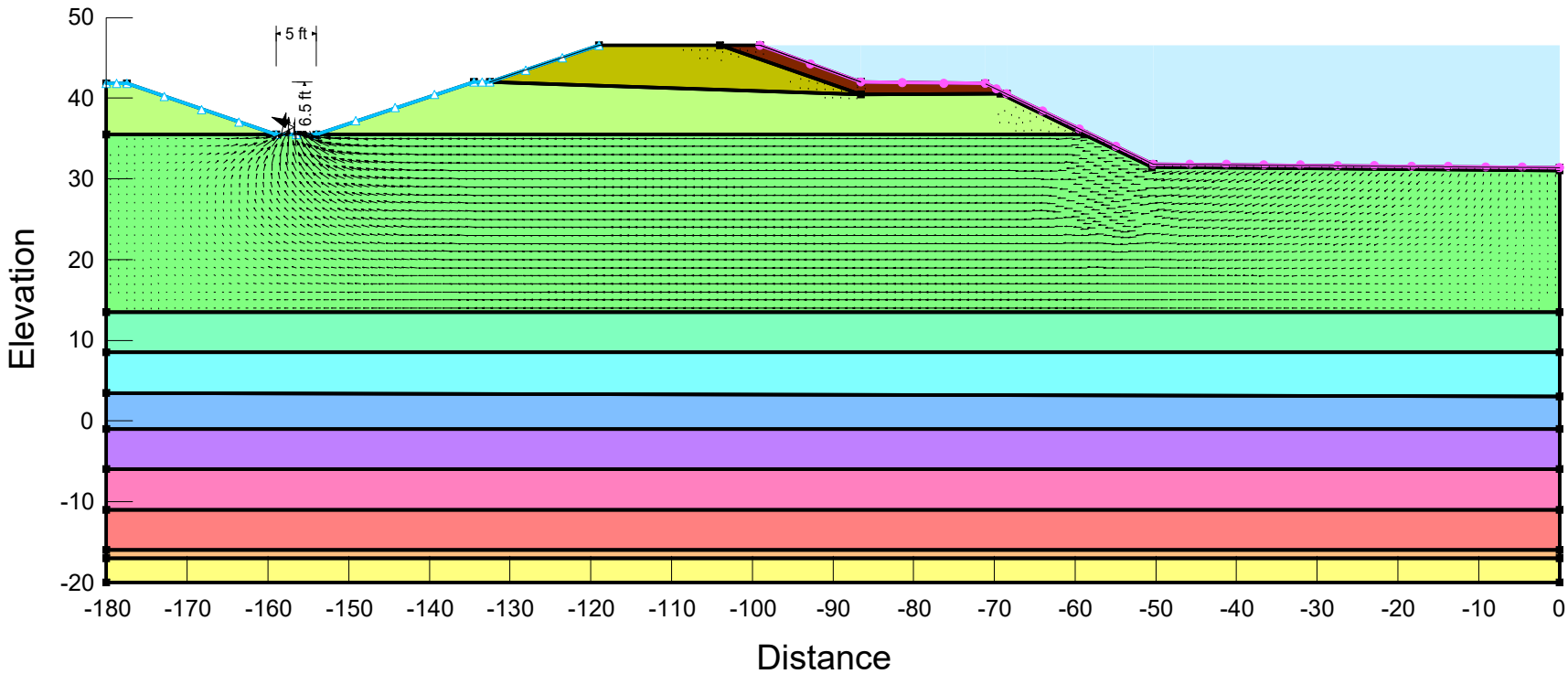
Mesh Properties

View: 2D
Element Thickness: 1 ft

Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel
Landside Ditch

Flow

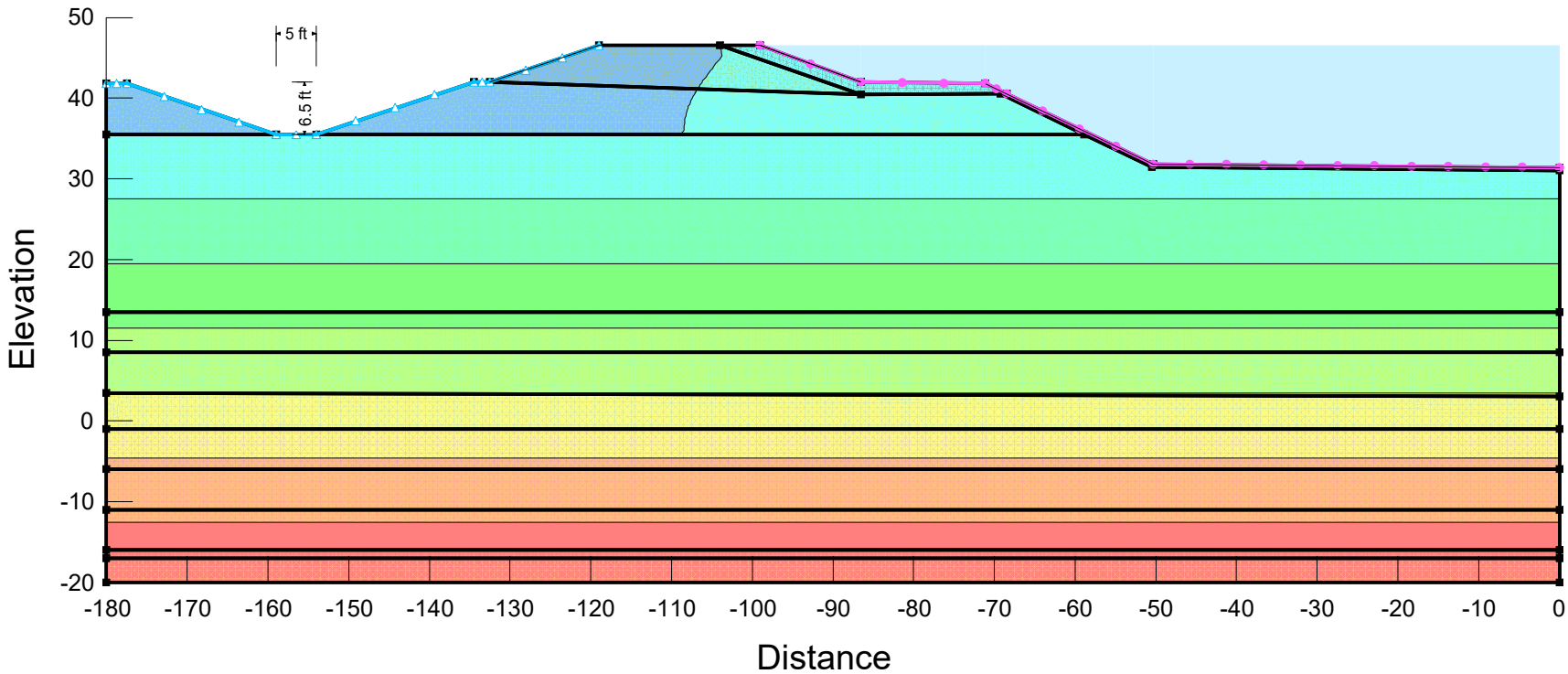
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel
Landside Ditch

Pore-Water Pressure

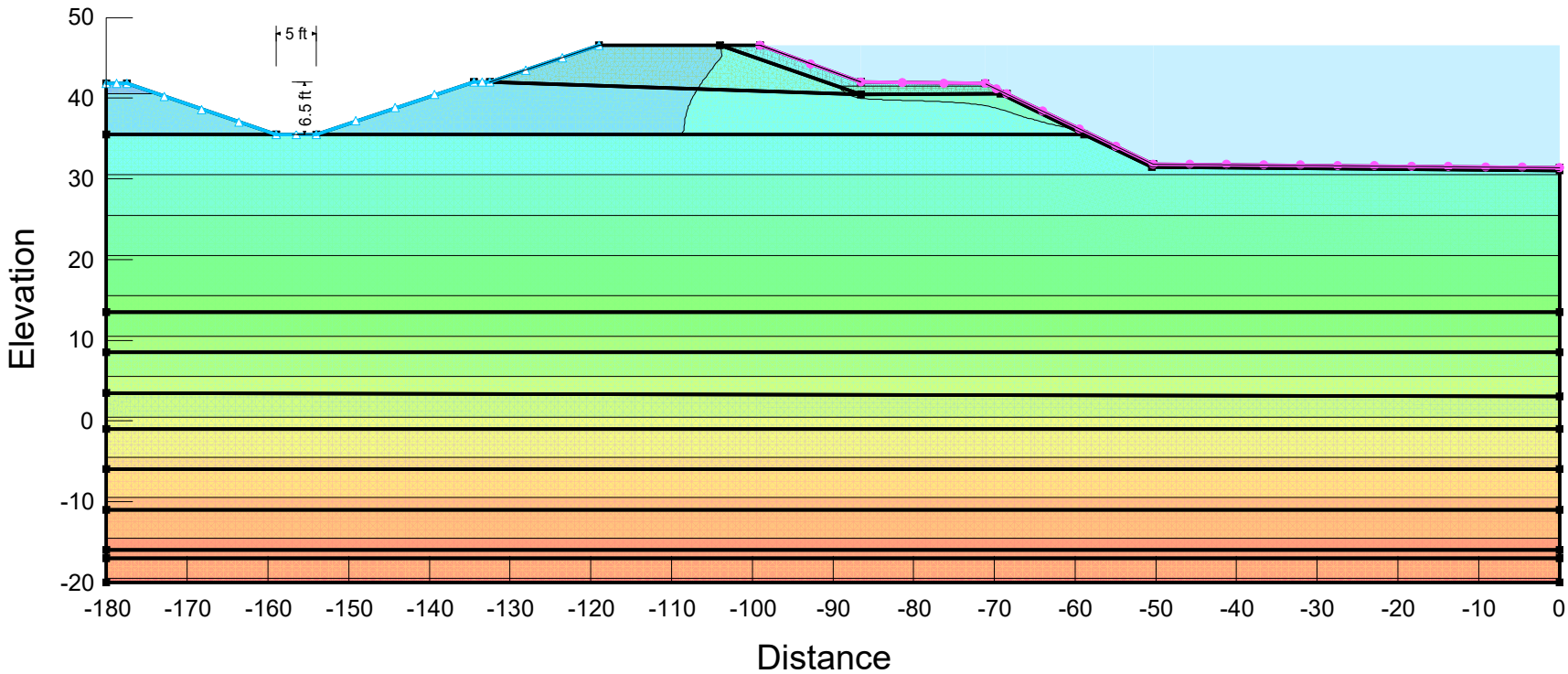
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel
Landside Ditch

Pressure Head

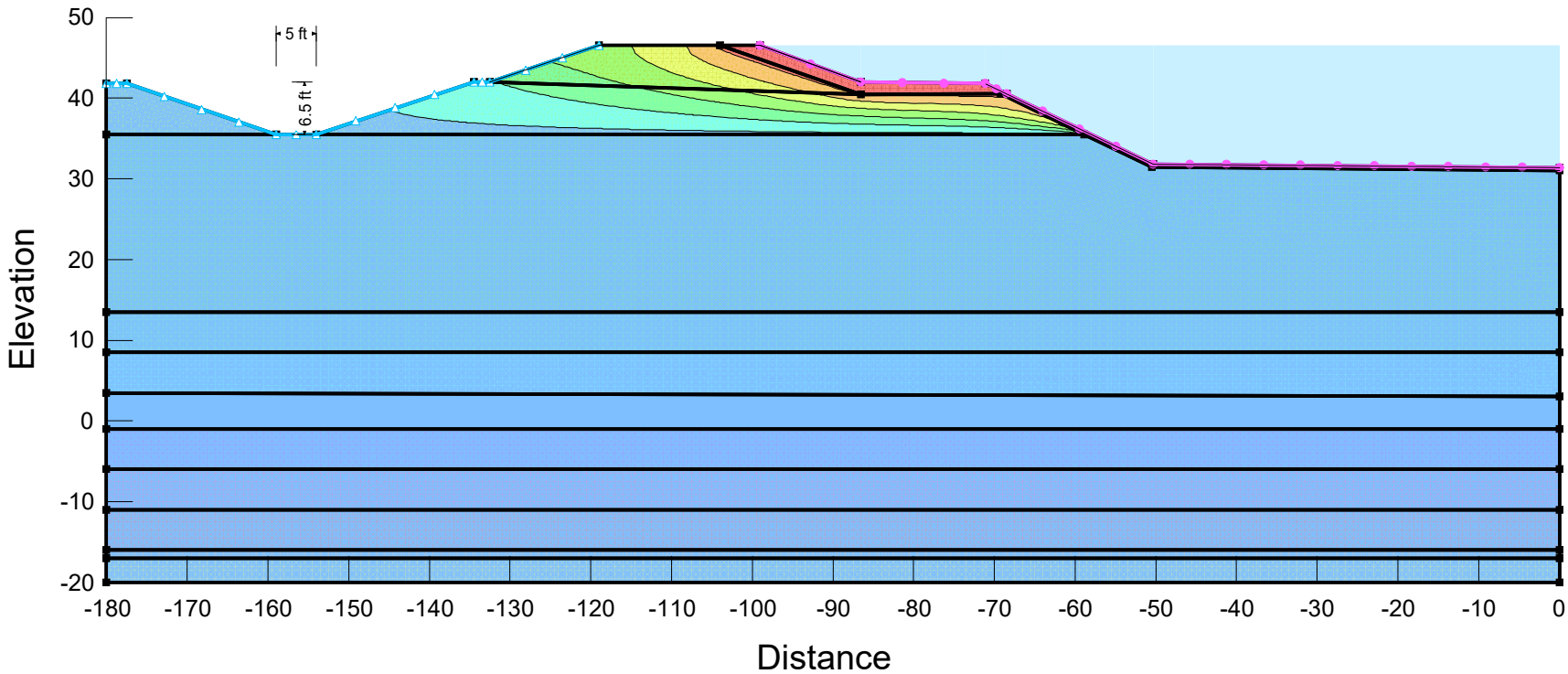
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel
Landside Ditch

Total Head

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



SEEP/W - Flood

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File Information

File Version: 9.01
Created By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Last Edited By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Revision Number: 113
Date: 08/15/2019
Time: 11:44:58 AM
Tool Version: 9.1.1.16749
File Name: 52+00 ditch LT concrete.gsz
Directory: C:\Users\h6ts9yjs\Desktop\draft\
Last Solved Date: 08/15/2019
Last Solved Time: 11:45:06 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SEEP/W - Flood

Description: Station 52+00 SEEP/W - Flood Concrete Channel Landside Ditch
Kind: SEEP/W
Method: Steady-State
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Maximum Number of Iterations: 500
- Maximum Difference: 0.005
- Significant Digits: 2
- Max # of Reviews: 10
- Under-Relaxation Criteria
  - Initial Rate: 1
  - Minimum Rate: 0.1
  - Rate Reduction Factor: 0.65
  - Reduction Frequency (iterations): 10
- Unit Weight of Water: 62.430189 pcf

Bulk Modulus of Pore-Fluid: 43,511,321 psf

Settings

Dimension: 2D

Time

Starting Time: 0 d

Duration: 5 d

Ending Time: 5 d

Materials

01 Levee

Hydraulic

Model: Saturated Only

Sat Kx: 3.28e-08 ft/sec

Ky'/Kx' Ratio: 0.1

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 9.1e-06 /psf

02 Stiff clay CL

Hydraulic

Model: Saturated Only

Sat Kx: 3.28e-08 ft/sec

Ky'/Kx' Ratio: 0.1

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 9.1e-06 /psf

03 Dense gravel GP

Hydraulic

Model: Saturated Only

Sat Kx: 0.328 ft/sec

Ky'/Kx' Ratio: 0.5

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 2.3e-07 /psf

04 Soft clay CL

Hydraulic

Model: Saturated Only

Sat Kx: 3.28e-08 ft/sec

Ky'/Kx' Ratio: 0.1

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 9.1e-06 /psf

05 Loose stilty sand SM

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-05 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.4e-06 /psf

06 Medium dense gravel GP

Hydraulic

Model: Saturated Only
Sat Kx: 0.328 ft/sec
Ky'/Kx' Ratio: 0.5
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 2.3e-07 /psf

07 Loose clayey sand SC

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-06 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.7e-06 /psf

08 Soft clay CL

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-08 ft/sec
Ky'/Kx' Ratio: 0.1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 9.1e-06 /psf

09 Medium dense clayey sand SC

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-06 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.7e-06 /psf

10 Medium dense silty sand SM

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-05 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.4e-06 /psf

11 Stiff clay CL

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-08 ft/sec
Ky'/Kx' Ratio: 0.1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 9.1e-06 /psf

12 Riprap

Hydraulic

Model: Saturated Only
Sat Kx: 32.8 ft/sec
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 4.5e-08 /psf

13 Concrete

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-09 ft/sec
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 9.1e-06 /psf

Boundary Conditions

Seepage face

Category: Hydraulic
Kind: Water Rate 0 ft^3/sec
Review: Yes

Channel

Category: Hydraulic
Kind: Water Total Head 46.5 ft
Review: No

Points

	X	Y
Point 1	-180 ft	41.818182 ft
Point 2	-132.5 ft	42 ft
Point 3	-119 ft	46.5 ft
Point 4	-99 ft	46.5 ft
Point 5	-86.5 ft	42 ft
Point 6	-71.13122 ft	41.818182 ft
Point 7	-50.31674 ft	31.818182 ft
Point 8	0 ft	31.4 ft
Point 9	-180 ft	35.5 ft
Point 10	-180 ft	13.5 ft
Point 11	-180 ft	8.5 ft
Point 12	-180 ft	3.5 ft
Point 13	-180 ft	-1 ft
Point 14	-180 ft	-6 ft
Point 15	-180 ft	-11 ft
Point 16	-180 ft	-16 ft
Point 17	-180 ft	-17 ft
Point 18	-180 ft	-20 ft
Point 19	0 ft	-20 ft
Point 20	0 ft	-17 ft
Point 21	0 ft	-16 ft
Point 22	0 ft	-11 ft
Point 23	0 ft	13.5 ft
Point 24	0 ft	8.5 ft
Point 25	0 ft	3 ft
Point 26	0 ft	-1 ft
Point 27	0 ft	-6 ft
Point 28	-104 ft	46.5 ft
Point 29	-86.50667 ft	40.495158 ft
Point 30	-58.83323 ft	35.5 ft
Point 31	-50.5 ft	31.5 ft
Point 32	0 ft	31 ft
Point 33	-68.5 ft	40.5 ft

Point 34	-69.25156 ft	40.5 ft
Point 35	-134.5 ft	41.957517 ft
Point 36	-153.99352 ft	35.5 ft
Point 37	-159 ft	35.5 ft
Point 38	-177.5 ft	41.8 ft

Lines

	Start Point	End Point	Length	Angle	Hydraulic Boundary
Line 1	23	10	180 ft	0 °	
Line 2	23	24	5 ft	90 °	
Line 3	24	11	180 ft	0 °	
Line 4	11	10	5 ft	90 °	
Line 5	24	25	5.5 ft	90 °	
Line 6	25	12	180 ft	-0.159 °	
Line 7	12	11	5 ft	90 °	
Line 8	25	26	4 ft	90 °	
Line 9	26	13	180 ft	0 °	
Line 10	13	12	4.5 ft	90 °	
Line 11	27	26	5 ft	90 °	
Line 12	13	14	5 ft	90 °	
Line 13	14	27	180 ft	0 °	
Line 14	19	20	3 ft	90 °	
Line 15	20	17	180 ft	0 °	
Line 16	17	18	3 ft	90 °	
Line 17	18	19	180 ft	0 °	
Line 18	22	15	180 ft	0 °	
Line 19	22	21	5 ft	90 °	
Line 20	21	16	180 ft	0 °	
Line 21	16	15	5 ft	90 °	
Line 22	21	20	1 ft	90 °	
Line 23	17	16	1 ft	90 °	
Line 24	27	22	5 ft	90 °	
Line 25	15	14	5 ft	90 °	
Line 26	28	29	18.495 ft	-18.9 °	
Line 27	32	8	0.4 ft	90 °	

Line 28	33	34	0.75156 ft	0 °	
Line 29	34	30	11.556 ft	-25.6 °	
Line 30	31	32	50.502 ft	-0.567 °	
Line 31	33	6	2.9429 ft	-26.6 °	Channel
Line 32	6	5	15.37 ft	-0.678 °	Channel
Line 33	5	4	13.285 ft	-19.8 °	Channel
Line 34	4	28	5 ft	0 °	
Line 35	29	34	17.255 ft	0.0161 °	
Line 36	29	2	46.018 ft	-1.87 °	
Line 37	2	3	14.23 ft	18.4 °	Seepage face
Line 38	3	28	15 ft	0 °	
Line 39	31	30	9.2435 ft	-25.6 °	
Line 40	33	7	20.15 ft	-25.5 °	Channel
Line 41	7	8	50.318 ft	-0.476 °	Channel
Line 42	23	32	17.5 ft	90 °	
Line 43	9	10	22 ft	90 °	
Line 44	2	35	2.0005 ft	1.22 °	Seepage face
Line 45	36	30	95.16 ft	0 °	
Line 46	35	36	20.535 ft	18.3 °	Seepage face
Line 47	9	37	21 ft	0 °	
Line 48	37	36	5.0065 ft	0 °	Seepage face
Line 49	37	38	19.543 ft	-18.8 °	Seepage face
Line 50	1	38	2.5001 ft	-0.417 °	Seepage face
Line 51	9	1	6.3182 ft	90 °	

Regions

	Material	Points	Area
Region 1	04 Soft clay CL	23,24,11,10	900 ft²
Region 2	05 Loose stilty sand SM	24,25,12,11	945 ft²
Region 3	06 Medium dense gravel GP	25,26,13,12	765 ft²
Region 4	07 Loose clayey sand SC	27,26,13,14	900 ft²
Region 5	11 Stiff clay CL	19,20,17,18	540 ft²
Region 6	09 Medium dense clayey sand SC	22,21,16,15	900 ft²
Region 7	10 Medium dense silty sand SM	21,20,17,16	180 ft²
Region 8	08 Soft clay CL	27,22,15,14	900 ft²

Region 9	12 Riprap	33,6,5,4,28,29,34	47.869 ft²
Region 10	01 Levee	29,2,3,28	158.68 ft²
Region 11	02 Stiff clay CL	2,35,36,30,34,29	452.53 ft²
Region 12	13 Concrete	31,30,34,33,7,8,32	25.21 ft²
Region 13	03 Dense gravel GP	23,32,31,30,36,37,9,10	3,728.7 ft²
Region 14	02 Stiff clay CL	1,38,37,9	74.048 ft²

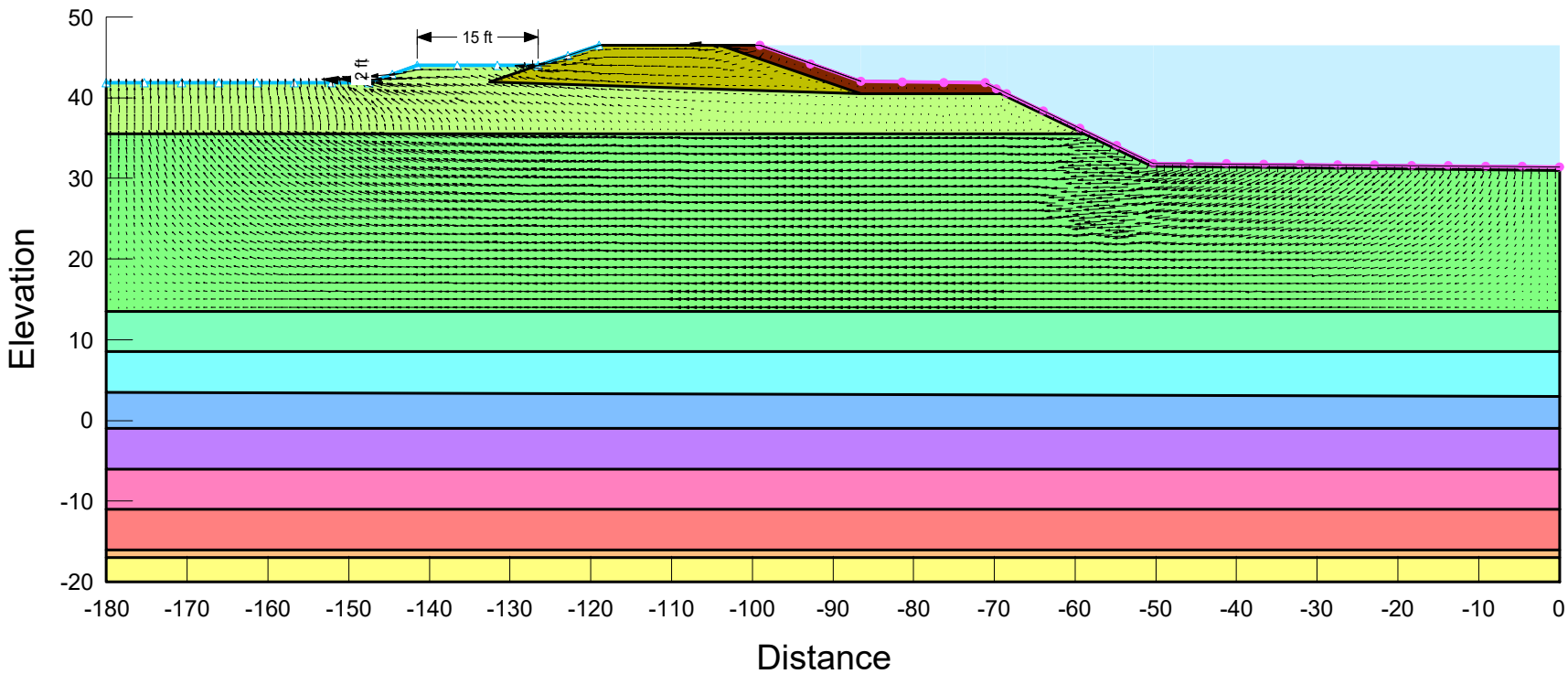
Mesh Properties

View: 2D
Element Thickness: 1 ft

Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel
Landside Blanket

Flow

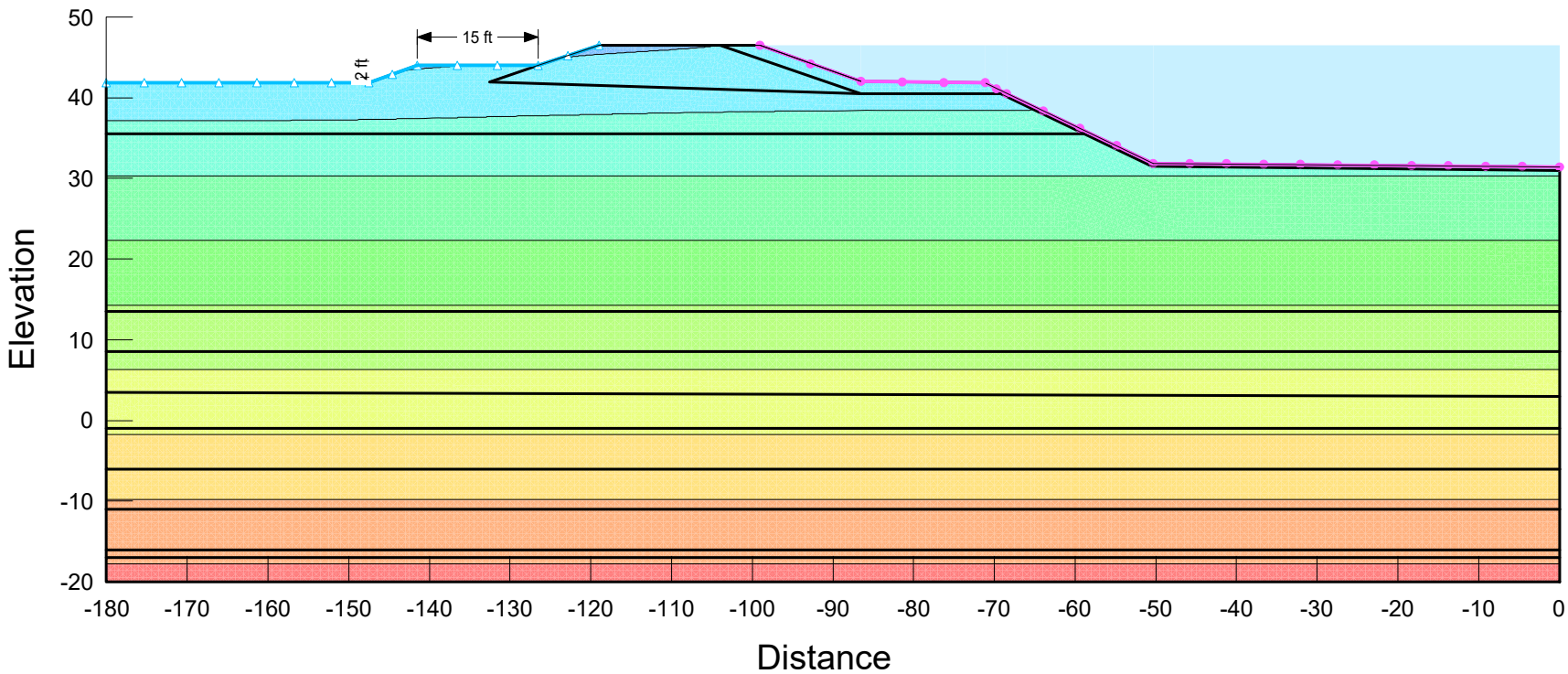
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel
Landside Blanket

Pore-Water Pressure

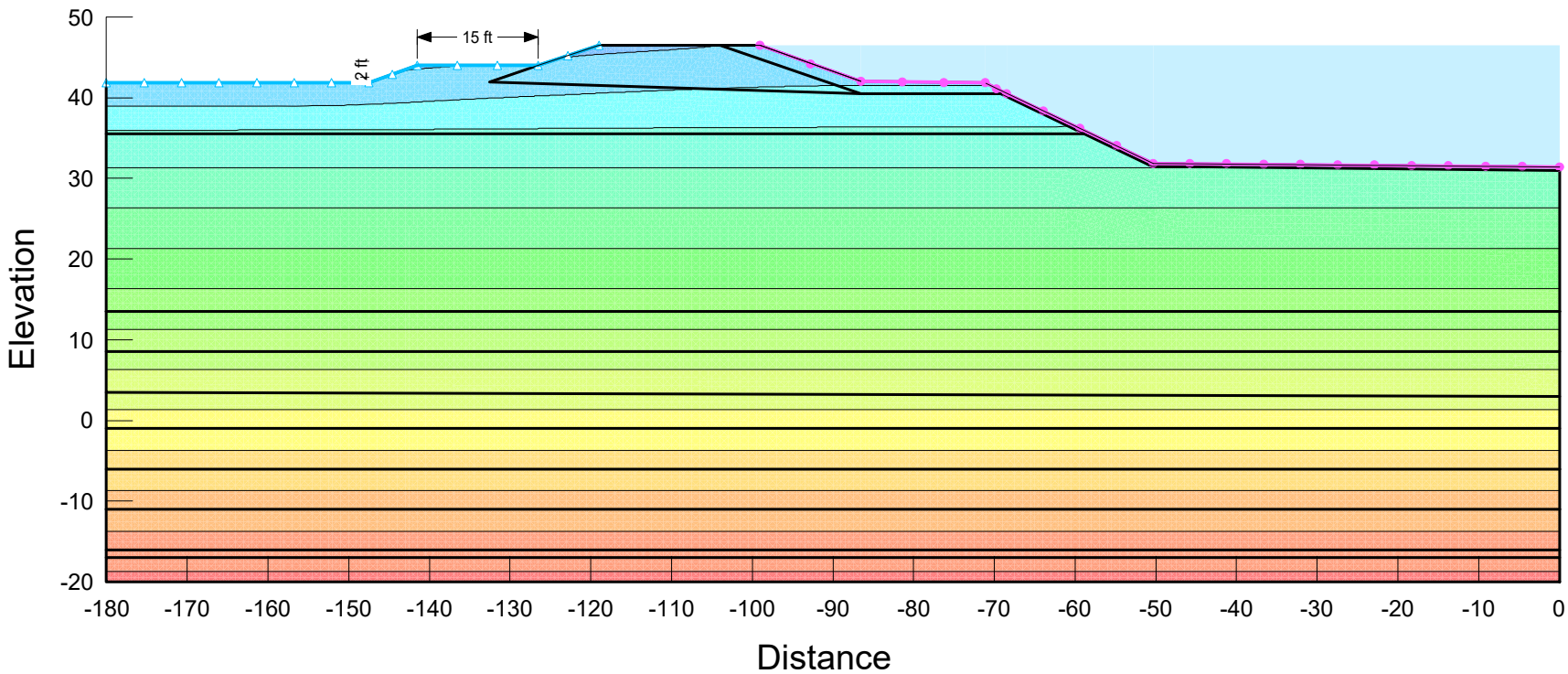
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel
Landside Blanket

Pressure Head

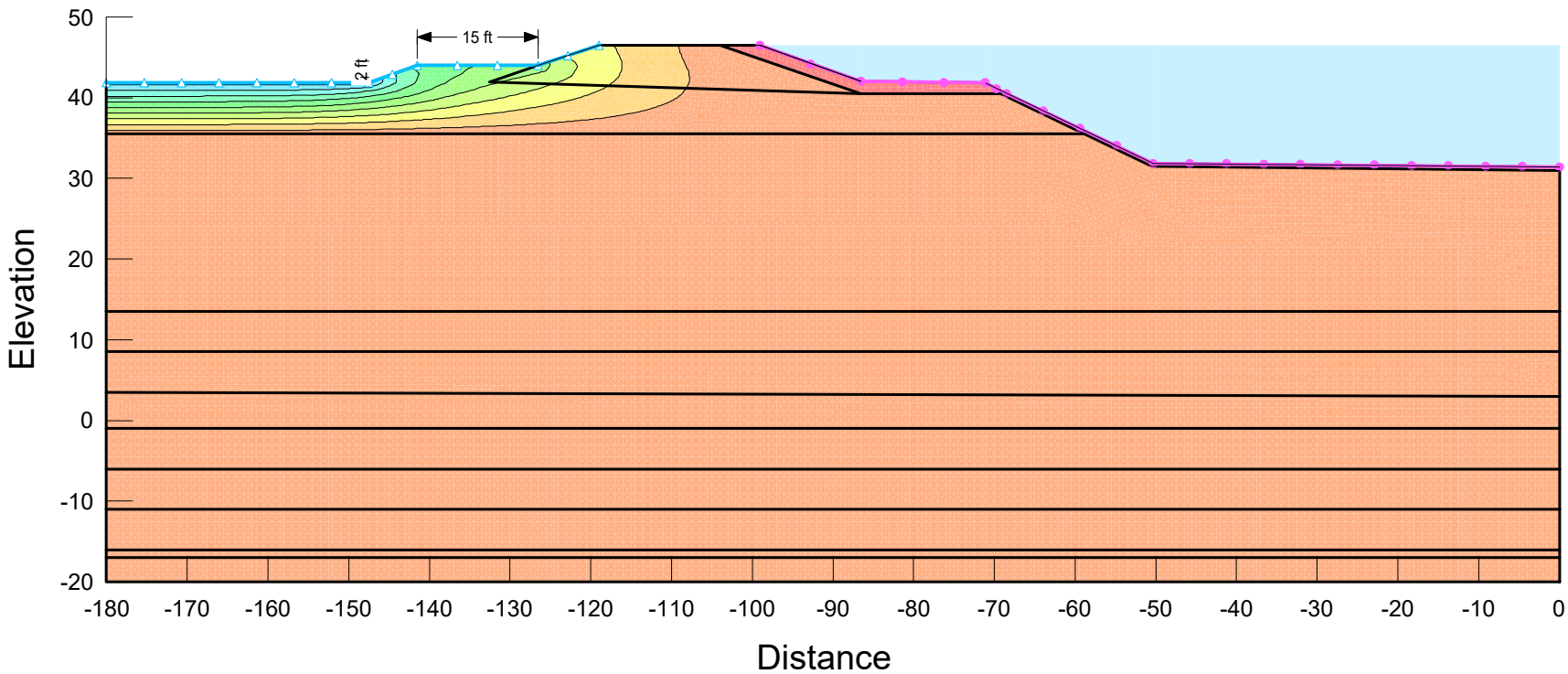
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel
Landside Blanket

Total Head

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



SEEP/W - Flood

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File Information

File Version: 9.01
Created By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Last Edited By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Revision Number: 113
Date: 08/15/2019
Time: 11:05:05 AM
Tool Version: 9.1.1.16749
File Name: 52+00 blanket LT concrete.gsz
Directory: C:\Users\h6ts9yjs\Desktop\draft\
Last Solved Date: 08/15/2019
Last Solved Time: 11:05:14 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SEEP/W - Flood

Description: Station 52+00 SEEP/W - Flood Concrete Channel Landside Blanket
Kind: SEEP/W
Method: Steady-State
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Maximum Number of Iterations: 500
- Maximum Difference: 0.005
- Significant Digits: 2
- Max # of Reviews: 10
- Under-Relaxation Criteria
  - Initial Rate: 1
  - Minimum Rate: 0.1
  - Rate Reduction Factor: 0.65
  - Reduction Frequency (iterations): 10
- Unit Weight of Water: 62.430189 pcf

Bulk Modulus of Pore-Fluid: 43,511,321 psf

Settings

Dimension: 2D

Time

Starting Time: 0 d

Duration: 5 d

Ending Time: 5 d

Materials

01 Levee

Hydraulic

Model: Saturated Only

Sat Kx: 3.28e-08 ft/sec

Ky'/Kx' Ratio: 0.1

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 9.1e-06 /psf

02 Stiff clay CL

Hydraulic

Model: Saturated Only

Sat Kx: 3.28e-08 ft/sec

Ky'/Kx' Ratio: 0.1

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 9.1e-06 /psf

03 Dense gravel GP

Hydraulic

Model: Saturated Only

Sat Kx: 0.328 ft/sec

Ky'/Kx' Ratio: 0.5

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 2.3e-07 /psf

04 Soft clay CL

Hydraulic

Model: Saturated Only

Sat Kx: 3.28e-08 ft/sec

Ky'/Kx' Ratio: 0.1

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 9.1e-06 /psf

05 Loose stilty sand SM

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-05 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.4e-06 /psf

06 Medium dense gravel GP

Hydraulic

Model: Saturated Only
Sat Kx: 0.328 ft/sec
Ky'/Kx' Ratio: 0.5
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 2.3e-07 /psf

07 Loose clayey sand SC

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-06 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.7e-06 /psf

08 Soft clay CL

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-08 ft/sec
Ky'/Kx' Ratio: 0.1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 9.1e-06 /psf

09 Medium dense clayey sand SC

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-06 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.7e-06 /psf

10 Medium dense silty sand SM

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-05 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.4e-06 /psf

11 Stiff clay CL

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-08 ft/sec
Ky'/Kx' Ratio: 0.1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 9.1e-06 /psf

12 Riprap

Hydraulic

Model: Saturated Only
Sat Kx: 32.8 ft/sec
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 4.5e-08 /psf

13 Concrete

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-09 ft/sec
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 9.1e-06 /psf

Boundary Conditions

Seepage face

Category: Hydraulic
Kind: Water Rate 0 ft^3/sec
Review: Yes

Channel

Category: Hydraulic
Kind: Water Total Head 46.5 ft
Review: No

Points

	X	Y
Point 1	-180 ft	41.818182 ft
Point 2	-147.5 ft	41.818151 ft
Point 3	-145.33937 ft	41.818151 ft
Point 4	-132.5 ft	41.94273 ft
Point 5	-119 ft	46.5 ft
Point 6	-99 ft	46.5 ft
Point 7	-86.5 ft	42 ft
Point 8	-71.13122 ft	41.818182 ft
Point 9	-50.31674 ft	31.818182 ft
Point 10	0 ft	31.4 ft
Point 11	-180 ft	35.5 ft
Point 12	-180 ft	13.5 ft
Point 13	-180 ft	8.5 ft
Point 14	-180 ft	3.5 ft
Point 15	-180 ft	-1 ft
Point 16	-180 ft	-6 ft
Point 17	-180 ft	-11 ft
Point 18	-180 ft	-16 ft
Point 19	-180 ft	-17 ft
Point 20	-180 ft	-20 ft
Point 21	0 ft	-20 ft
Point 22	0 ft	-17 ft
Point 23	0 ft	-16 ft
Point 24	0 ft	-11 ft
Point 25	0 ft	13.5 ft
Point 26	0 ft	8.5 ft
Point 27	0 ft	3 ft
Point 28	0 ft	-1 ft
Point 29	0 ft	-6 ft
Point 30	-104 ft	46.5 ft
Point 31	-86.50667 ft	40.495158 ft
Point 32	-58.83323 ft	35.5 ft
Point 33	-50.5 ft	31.5 ft

Point 34	0 ft	31 ft
Point 35	-68.5 ft	40.5 ft
Point 36	-69.25156 ft	40.5 ft
Point 37	-126.5 ft	43.998285 ft
Point 38	-141.5 ft	43.998285 ft

Lines

	Start Point	End Point	Length	Angle	Hydraulic Boundary
Line 1	25	12	180 ft	0 °	
Line 2	25	26	5 ft	90 °	
Line 3	26	13	180 ft	0 °	
Line 4	13	12	5 ft	90 °	
Line 5	26	27	5.5 ft	90 °	
Line 6	27	14	180 ft	-0.159 °	
Line 7	14	13	5 ft	90 °	
Line 8	27	28	4 ft	90 °	
Line 9	28	15	180 ft	0 °	
Line 10	15	14	4.5 ft	90 °	
Line 11	29	28	5 ft	90 °	
Line 12	15	16	5 ft	90 °	
Line 13	16	29	180 ft	0 °	
Line 14	21	22	3 ft	90 °	
Line 15	22	19	180 ft	0 °	
Line 16	19	20	3 ft	90 °	
Line 17	20	21	180 ft	0 °	
Line 18	24	17	180 ft	0 °	
Line 19	24	23	5 ft	90 °	
Line 20	23	18	180 ft	0 °	
Line 21	18	17	5 ft	90 °	
Line 22	23	22	1 ft	90 °	
Line 23	19	18	1 ft	90 °	
Line 24	29	24	5 ft	90 °	
Line 25	17	16	5 ft	90 °	
Line 26	30	31	18.495 ft	-18.9 °	
Line 27	34	10	0.4 ft	90 °	

Line 28	35	36	0.75156 ft	0 °	
Line 29	36	32	11.556 ft	-25.6 °	
Line 30	33	34	50.502 ft	-0.567 °	
Line 31	35	8	2.9429 ft	-26.6 °	Channel
Line 32	8	7	15.37 ft	-0.678 °	Channel
Line 33	7	6	13.285 ft	-19.8 °	Channel
Line 34	6	30	5 ft	0 °	
Line 35	31	36	17.255 ft	0.0161 °	
Line 36	31	4	46.016 ft	-1.8 °	
Line 37	5	30	15 ft	0 °	
Line 38	2	1	32.5 ft	-5.47e-05 °	Seepage face
Line 39	1	11	6.3182 ft	90 °	
Line 40	11	32	121.17 ft	0 °	
Line 41	33	32	9.2435 ft	-25.6 °	
Line 42	35	9	20.15 ft	-25.5 °	Channel
Line 43	9	10	50.318 ft	-0.476 °	Channel
Line 44	25	34	17.5 ft	90 °	
Line 45	11	12	22 ft	90 °	
Line 46	4	37	6.3423 ft	18.9 °	
Line 47	37	5	7.9062 ft	18.4 °	Seepage face
Line 48	4	3	12.84 ft	0.556 °	
Line 49	38	37	15 ft	0 °	Seepage face
Line 50	2	38	6.3838 ft	20 °	Seepage face
Line 51	3	2	2.1606 ft	0 °	

Regions

	Material	Points	Area
Region 1	04 Soft clay CL	25,26,13,12	900 ft²
Region 2	05 Loose stilty sand SM	26,27,14,13	945 ft²
Region 3	06 Medium dense gravel GP	27,28,15,14	765 ft²
Region 4	07 Loose clayey sand SC	29,28,15,16	900 ft²
Region 5	11 Stiff clay CL	21,22,19,20	540 ft²
Region 6	09 Medium dense clayey sand SC	24,23,18,17	900 ft²
Region 7	10 Medium dense silty sand SM	23,22,19,18	180 ft²
Region 8	08 Soft clay CL	29,24,17,16	900 ft²

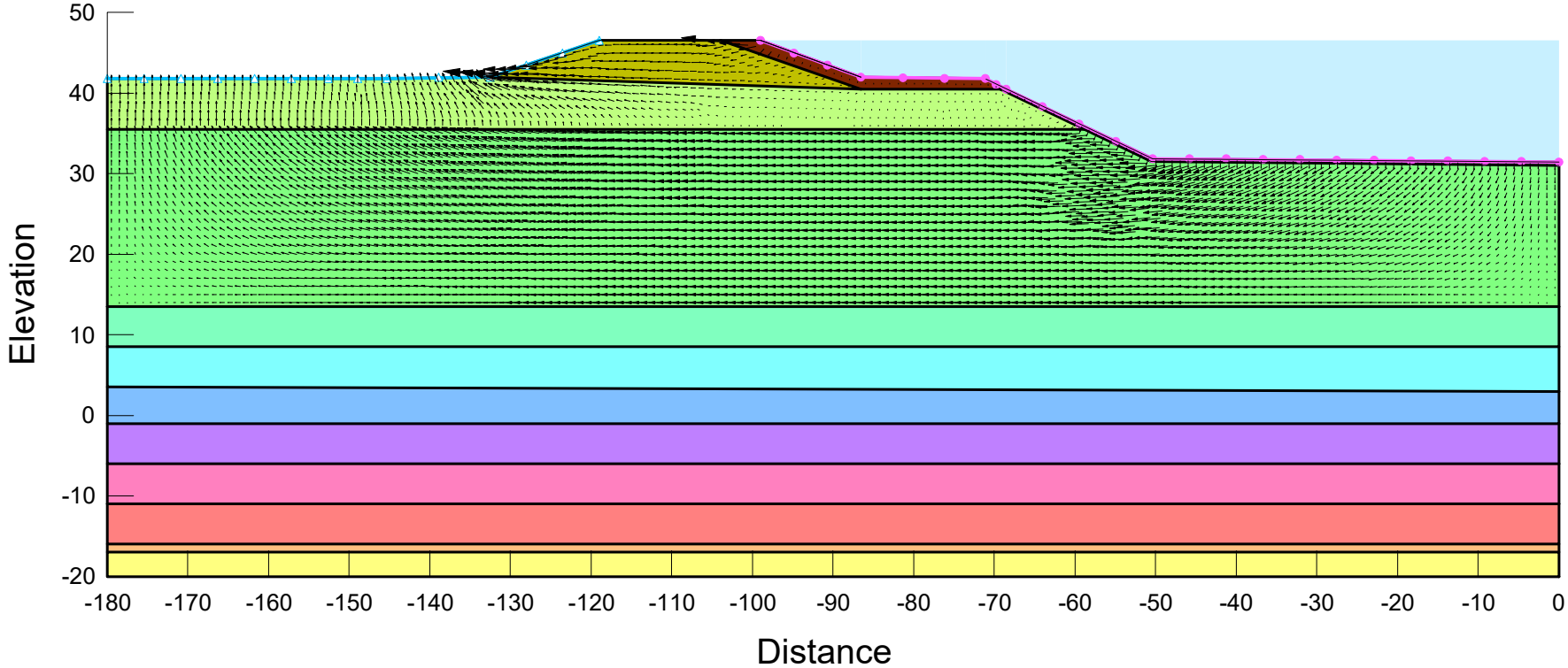
Region 9	12 Riprap	35,8,7,6,30,31,36	47.869 ft²
Region 10	01 Levee	31,4,37,5,30	159.81 ft²
Region 11	02 Stiff clay CL	4,3,2,1,11,32,36,31	676.23 ft²
Region 12	13 Concrete	33,32,36,35,9,10,34	25.21 ft²
Region 13	03 Dense gravel GP	25,34,33,32,11,12	3,728.7 ft²
Region 14	02 Stiff clay CL	37,38,2,3,4	31.529 ft²

Mesh Properties

View: 2D
Element Thickness: 1 ft

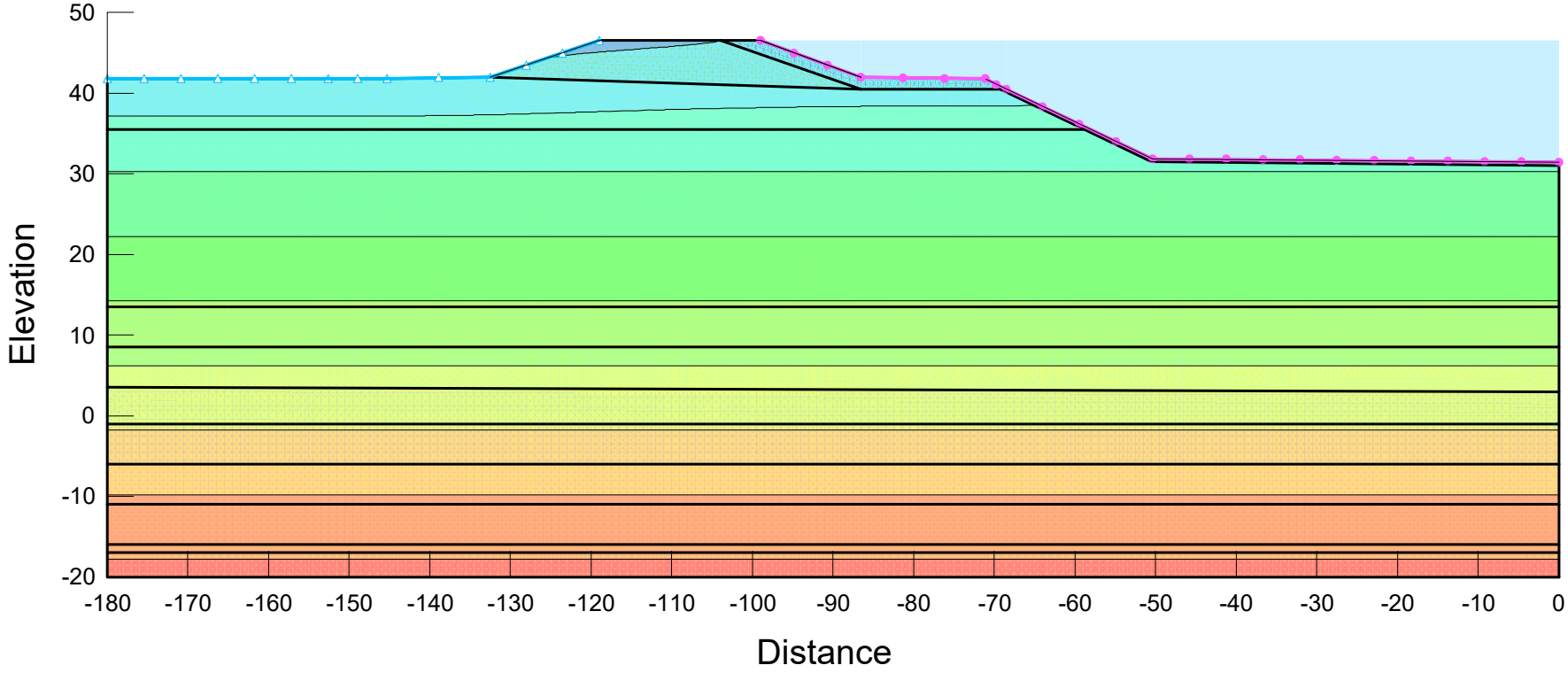
Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



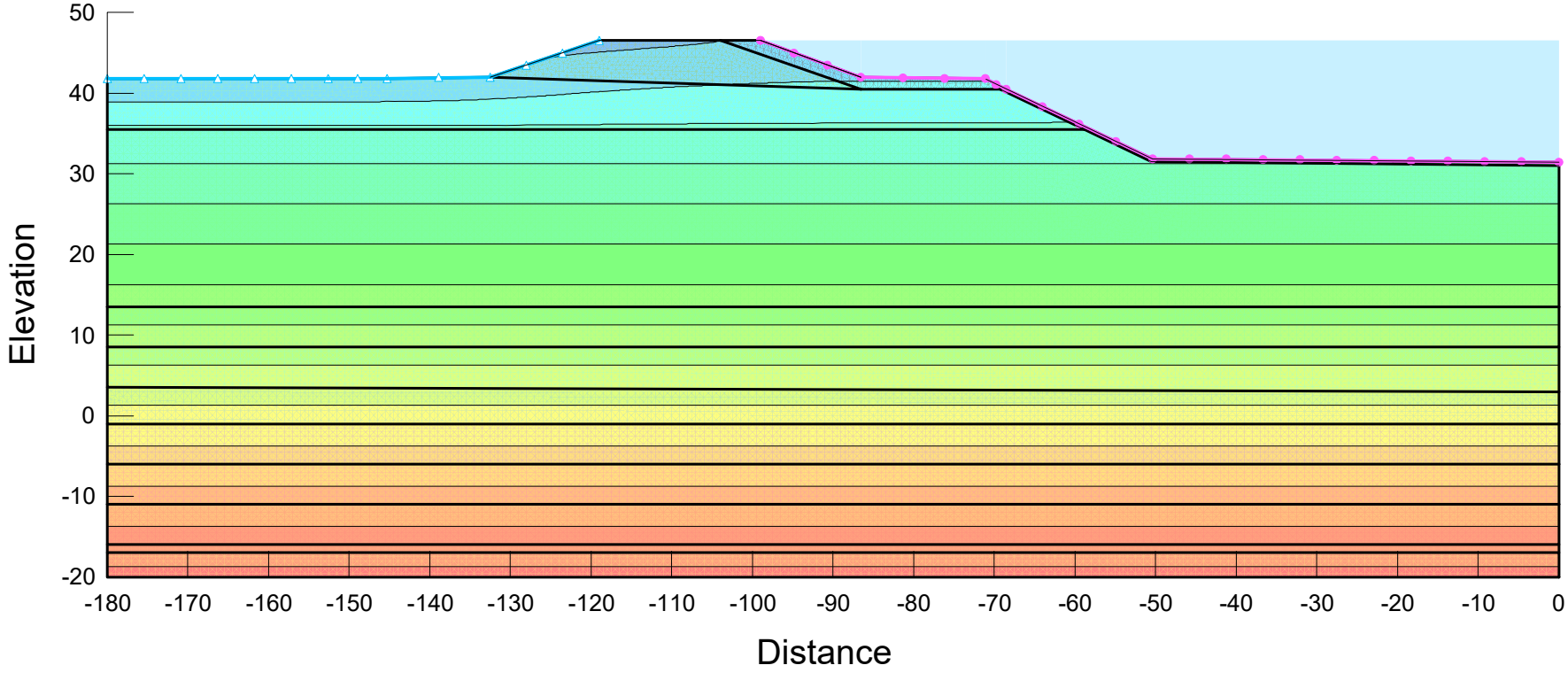
Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



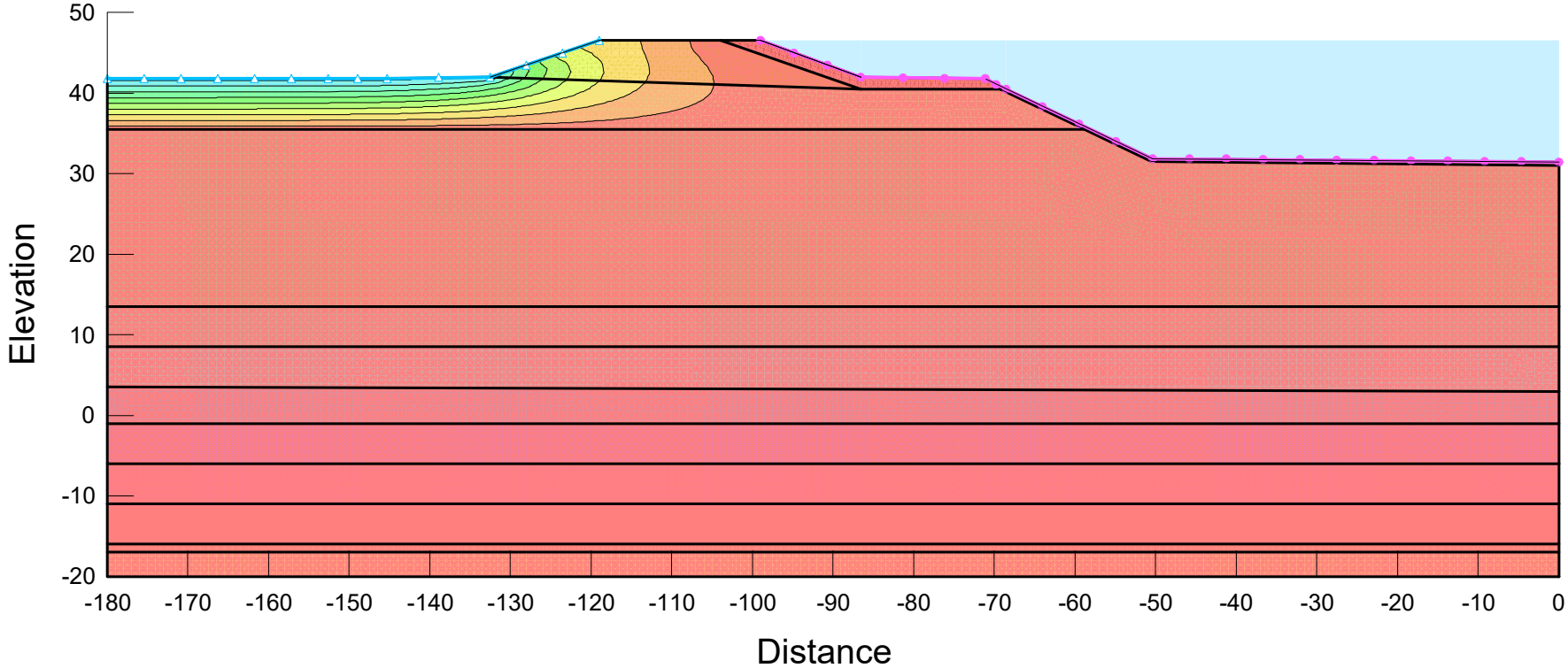
Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel

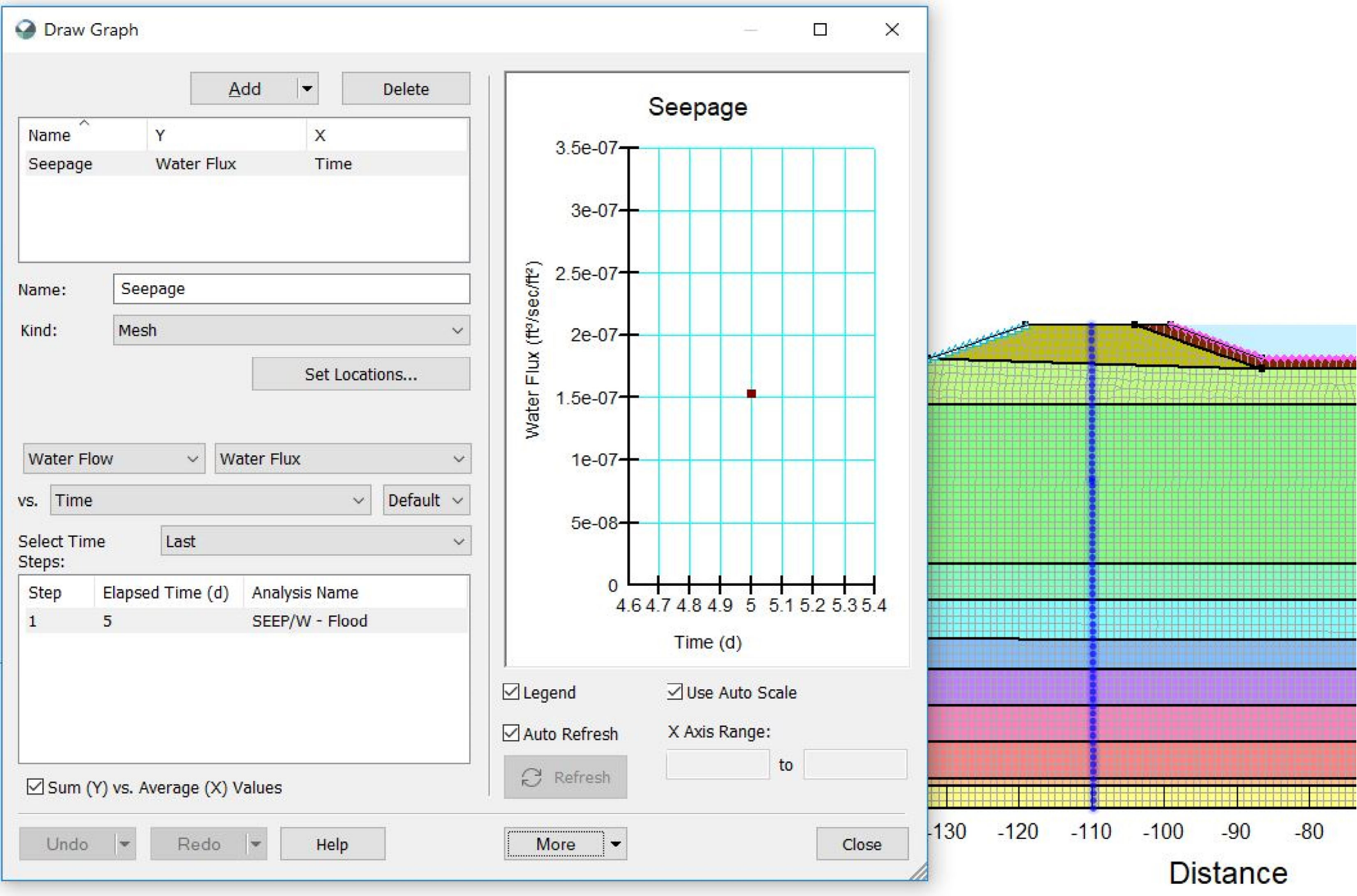
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06



Rio Guayanilla
Station 52+00
SEEP/W - Flood
Concrete Channel

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	01 Levee	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	02 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	03 Dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	04 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	05 Loose stilty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	06 Medium dense gravel GP	Saturated Only	0.328	0.5	0	0	2.3e-07
	07 Loose clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	08 Soft clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	09 Medium dense clayey sand SC	Saturated Only	3.28e-06	0.3	0	0	1.7e-06
	10 Medium dense silty sand SM	Saturated Only	3.28e-05	0.3	0	0	1.4e-06
	11 Stiff clay CL	Saturated Only	3.28e-08	0.1	0	0	9.1e-06
	12 Riprap	Saturated Only	32.8	1	0	0	4.5e-08
	13 Concrete	Saturated Only	3.28e-09	1	0	0	9.1e-06




Draw Graph
Add
Delete
Name
Y
X
Seepage
Water Flux
Time
Name:
Seepage
Kind:
Mesh
Set Locations...
Water Flow
Water Flux
vs.
Time
Default
Select Time Steps:
Last
Step
Elapsed Time (d)
Analysis Name
1
5
SEEP/W - Flood
Sum (Y) vs. Average (X) Values
Seepage
3.5e-07
3e-07
2.5e-07
2e-07
1.5e-07
1e-07
5e-08
0
Water Flux (ft³/sec/ft²)
4.6 4.7 4.8 4.9 5 5.1 5.2 5.3 5.4
Time (d)
Legend
Use Auto Scale
Auto Refresh
X Axis Range:
Refresh
to
Undo
Redo
Help
More
Close
-130 -120 -110 -100 -90 -80
Distance

SEEP/W - Flood

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File Information

File Version: 9.01
Created By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Last Edited By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Revision Number: 99
Date: 08/12/2019
Time: 07:57:43 AM
Tool Version: 9.1.1.16749
File Name: 52+00 LT concrete.gsz
Directory: C:\Users\h6ts9yjs\Desktop\draft\
Last Solved Date: 08/12/2019
Last Solved Time: 07:57:52 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SEEP/W - Flood

Description: Station 52+00 SEEP/W - Flood Concrete Channel
Kind: SEEP/W
Method: Steady-State
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Maximum Number of Iterations: 500
- Maximum Difference: 0.005
- Significant Digits: 2
- Max # of Reviews: 10
- Under-Relaxation Criteria
  - Initial Rate: 1
  - Minimum Rate: 0.1
  - Rate Reduction Factor: 0.65
  - Reduction Frequency (iterations): 10
- Unit Weight of Water: 62.430189 pcf

Bulk Modulus of Pore-Fluid: 43,511,321 psf

Settings

Dimension: 2D

Time

Starting Time: 0 d

Duration: 5 d

Ending Time: 5 d

Materials

01 Levee

Hydraulic

Model: Saturated Only

Sat Kx: 3.28e-08 ft/sec

Ky'/Kx' Ratio: 0.1

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 9.1e-06 /psf

02 Stiff clay CL

Hydraulic

Model: Saturated Only

Sat Kx: 3.28e-08 ft/sec

Ky'/Kx' Ratio: 0.1

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 9.1e-06 /psf

03 Dense gravel GP

Hydraulic

Model: Saturated Only

Sat Kx: 0.328 ft/sec

Ky'/Kx' Ratio: 0.5

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 2.3e-07 /psf

04 Soft clay CL

Hydraulic

Model: Saturated Only

Sat Kx: 3.28e-08 ft/sec

Ky'/Kx' Ratio: 0.1

Rotation: 0 °

Volumetric Water Content: 0

Compressibility: 9.1e-06 /psf

05 Loose stilty sand SM

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-05 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.4e-06 /psf

06 Medium dense gravel GP

Hydraulic

Model: Saturated Only
Sat Kx: 0.328 ft/sec
Ky'/Kx' Ratio: 0.5
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 2.3e-07 /psf

07 Loose clayey sand SC

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-06 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.7e-06 /psf

08 Soft clay CL

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-08 ft/sec
Ky'/Kx' Ratio: 0.1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 9.1e-06 /psf

09 Medium dense clayey sand SC

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-06 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.7e-06 /psf

10 Medium dense silty sand SM

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-05 ft/sec
Ky'/Kx' Ratio: 0.3
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 1.4e-06 /psf

11 Stiff clay CL

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-08 ft/sec
Ky'/Kx' Ratio: 0.1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 9.1e-06 /psf

12 Riprap

Hydraulic

Model: Saturated Only
Sat Kx: 32.8 ft/sec
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 4.5e-08 /psf

13 Concrete

Hydraulic

Model: Saturated Only
Sat Kx: 3.28e-09 ft/sec
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0
Compressibility: 9.1e-06 /psf

Boundary Conditions

Seepage face

Category: Hydraulic
Kind: Water Rate 0 ft^3/sec
Review: Yes

Channel

Category: Hydraulic
Kind: Water Total Head 46.5 ft
Review: No

Points

	X	Y
Point 1	-180 ft	41.818182 ft
Point 2	-152.57919 ft	41.818182 ft
Point 3	-145.33937 ft	41.818182 ft
Point 4	-132.5 ft	42 ft
Point 5	-119 ft	46.5 ft
Point 6	-99 ft	46.5 ft
Point 7	-86.5 ft	42 ft
Point 8	-71.13122 ft	41.818182 ft
Point 9	-50.31674 ft	31.818182 ft
Point 10	0 ft	31.4 ft
Point 11	-180 ft	35.5 ft
Point 12	-180 ft	13.5 ft
Point 13	-180 ft	8.5 ft
Point 14	-180 ft	3.5 ft
Point 15	-180 ft	-1 ft
Point 16	-180 ft	-6 ft
Point 17	-180 ft	-11 ft
Point 18	-180 ft	-16 ft
Point 19	-180 ft	-17 ft
Point 20	-180 ft	-20 ft
Point 21	0 ft	-20 ft
Point 22	0 ft	-17 ft
Point 23	0 ft	-16 ft
Point 24	0 ft	-11 ft
Point 25	0 ft	13.5 ft
Point 26	0 ft	8.5 ft
Point 27	0 ft	3 ft
Point 28	0 ft	-1 ft
Point 29	0 ft	-6 ft
Point 30	-104 ft	46.5 ft
Point 31	-86.50667 ft	40.495158 ft
Point 32	-58.83323 ft	35.5 ft
Point 33	-50.5 ft	31.5 ft

Point 34	0 ft	31 ft
Point 35	-68.5 ft	40.5 ft
Point 36	-69.25156 ft	40.5 ft

Lines

	Start Point	End Point	Length	Angle	Hydraulic Boundary
Line 1	25	12	180 ft	0 °	
Line 2	25	26	5 ft	90 °	
Line 3	26	13	180 ft	0 °	
Line 4	13	12	5 ft	90 °	
Line 5	26	27	5.5 ft	90 °	
Line 6	27	14	180 ft	-0.159 °	
Line 7	14	13	5 ft	90 °	
Line 8	27	28	4 ft	90 °	
Line 9	28	15	180 ft	0 °	
Line 10	15	14	4.5 ft	90 °	
Line 11	29	28	5 ft	90 °	
Line 12	15	16	5 ft	90 °	
Line 13	16	29	180 ft	0 °	
Line 14	21	22	3 ft	90 °	
Line 15	22	19	180 ft	0 °	
Line 16	19	20	3 ft	90 °	
Line 17	20	21	180 ft	0 °	
Line 18	24	17	180 ft	0 °	
Line 19	24	23	5 ft	90 °	
Line 20	23	18	180 ft	0 °	
Line 21	18	17	5 ft	90 °	
Line 22	23	22	1 ft	90 °	
Line 23	19	18	1 ft	90 °	
Line 24	29	24	5 ft	90 °	
Line 25	17	16	5 ft	90 °	
Line 26	30	31	18.495 ft	-18.9 °	
Line 27	34	10	0.4 ft	90 °	
Line 28	35	36	0.75156 ft	0 °	
Line 29	36	32	11.556 ft	-25.6 °	

Line 30	33	34	50.502 ft	-0.567 °	
Line 31	35	8	2.9429 ft	-26.6 °	Channel
Line 32	8	7	15.37 ft	-0.678 °	Channel
Line 33	7	6	13.285 ft	-19.8 °	Channel
Line 34	6	30	5 ft	0 °	
Line 35	31	36	17.255 ft	0.0161 °	
Line 36	31	4	46.018 ft	-1.87 °	
Line 37	4	5	14.23 ft	18.4 °	Seepage face
Line 38	5	30	15 ft	0 °	
Line 39	4	3	12.841 ft	0.811 °	Seepage face
Line 40	3	2	7.2398 ft	0 °	Seepage face
Line 41	2	1	27.421 ft	0 °	Seepage face
Line 42	1	11	6.3182 ft	90 °	
Line 43	11	32	121.17 ft	0 °	
Line 44	33	32	9.2435 ft	-25.6 °	
Line 45	35	9	20.15 ft	-25.5 °	Channel
Line 46	9	10	50.318 ft	-0.476 °	Channel
Line 47	25	34	17.5 ft	90 °	
Line 48	11	12	22 ft	90 °	

Regions

	Material	Points	Area
Region 1	04 Soft clay CL	25,26,13,12	900 ft²
Region 2	05 Loose stilty sand SM	26,27,14,13	945 ft²
Region 3	06 Medium dense gravel GP	27,28,15,14	765 ft²
Region 4	07 Loose clayey sand SC	29,28,15,16	900 ft²
Region 5	11 Stiff clay CL	21,22,19,20	540 ft²
Region 6	09 Medium dense clayey sand SC	24,23,18,17	900 ft²
Region 7	10 Medium dense silty sand SM	23,22,19,18	180 ft²
Region 8	08 Soft clay CL	29,24,17,16	900 ft²
Region 9	12 Riprap	35,8,7,6,30,31,36	47.869 ft²
Region 10	01 Levee	31,4,5,30	158.68 ft²
Region 11	02 Stiff clay CL	4,3,2,1,11,32,36,31	677.91 ft²
Region 12	13 Concrete	33,32,36,35,9,10,34	25.21 ft²
Region 13	03 Dense gravel GP	25,34,33,32,11,12	3,728.7 ft²

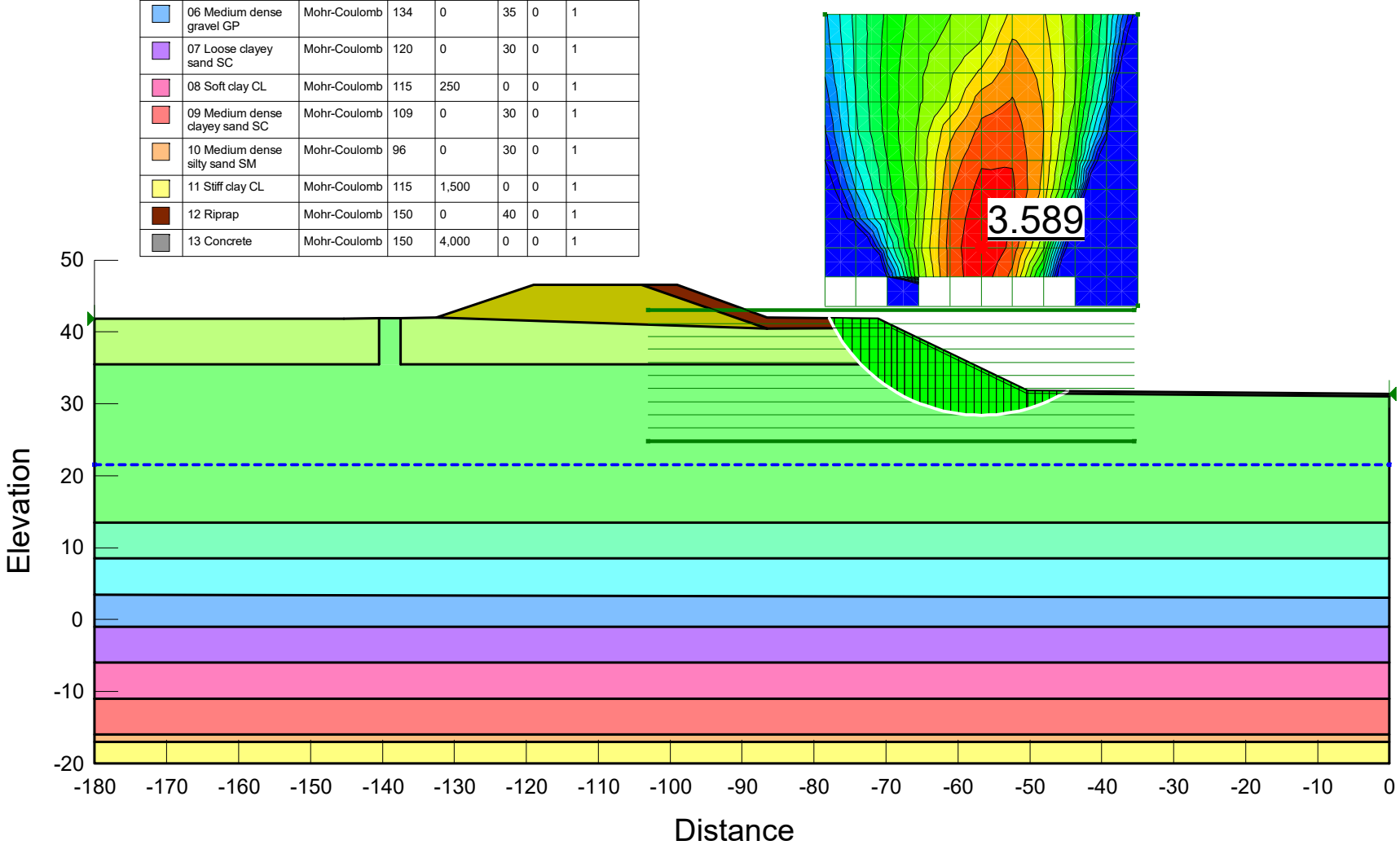
Mesh Properties

View: 2D
Element Thickness: 1 ft

Attachment G-4
Geostudio SLOPE/W Outputs

Rio Guayanilla
Station 52+00
End of Construction - R/S
Concrete Channel
Normal Water Level
Trench

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	01 Levee	Mohr-Coulomb	114	2,000	0	0	1
	02 Stiff clay CL	Mohr-Coulomb	115	1,000	0	0	1
	03 Dense gravel GP	Mohr-Coulomb	134	0	35	0	1
	04 Soft clay CL	Mohr-Coulomb	117	250	0	0	1
	05 Loose stilty sand SM	Mohr-Coulomb	112	0	29	0	1
	06 Medium dense gravel GP	Mohr-Coulomb	134	0	35	0	1
	07 Loose clayey sand SC	Mohr-Coulomb	120	0	30	0	1
	08 Soft clay CL	Mohr-Coulomb	115	250	0	0	1
	09 Medium dense clayey sand SC	Mohr-Coulomb	109	0	30	0	1
	10 Medium dense silty sand SM	Mohr-Coulomb	96	0	30	0	1
	11 Stiff clay CL	Mohr-Coulomb	115	1,500	0	0	1
	12 Riprap	Mohr-Coulomb	150	0	40	0	1
	13 Concrete	Mohr-Coulomb	150	4,000	0	0	1



SLOPE/W - EOC RS Normal

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File Information

File Version: 9.01
Created By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Last Edited By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Revision Number: 147
Date: 08/16/2019
Time: 09:02:33 AM
Tool Version: 9.1.1.16749
File Name: 52+00 trench EOC concrete.gsz
Directory: C:\Users\h6ts9yjs\Desktop\draft\
Last Solved Date: 08/16/2019
Last Solved Time: 09:02:40 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W - EOC RS Normal

Description: Station 52+00 End of Construction - R/S Concrete Channel Normal Water Level Trench
Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

01 Levee

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

02 Stiff clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 1,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

03 Dense gravel GP

Model: Mohr-Coulomb
Unit Weight: 134 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

04 Soft clay CL

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion': 250 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

05 Loose stilty sand SM

Model: Mohr-Coulomb
Unit Weight: 112 pcf
Cohesion': 0 psf
Phi': 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

06 Medium dense gravel GP

Model: Mohr-Coulomb
Unit Weight: 134 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

07 Loose clayey sand SC

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

08 Soft clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

09 Medium dense clayey sand SC

Model: Mohr-Coulomb
Unit Weight: 109 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

10 Medium dense silty sand SM

Model: Mohr-Coulomb
Unit Weight: 96 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

11 Stiff clay CL

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

12 Riprap

Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 0 psf
Phi': 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

13 Concrete

Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 4,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (-78.51575, 84.133444) ft
Lower Left: (-35.01575, 84.133444) ft
Lower Right: (-35.01575, 43.633444) ft
Grid Horizontal Increment: 10
Grid Vertical Increment: 10

Slip Surface Radius

Upper Left Coordinate: (-103.02155, 43.04823) ft

Upper Right Coordinate: (-35.48101, 43.04823) ft
Lower Left Coordinate: (-103.02155, 24.752297) ft
Lower Right Coordinate: (-35.48101, 24.752297) ft
Number of Increments: 10
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-180, 41.818182) ft
Right Coordinate: (0, 31.4) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-180 ft	21.5 ft
Coordinate 2	0 ft	21.5 ft

Points

	X	Y
Point 1	-180 ft	41.818182 ft
Point 2	-152.57919 ft	41.818182 ft
Point 3	-145.33937 ft	41.818182 ft
Point 4	-132.5 ft	42 ft
Point 5	-119 ft	46.5 ft
Point 6	-99 ft	46.5 ft
Point 7	-86.5 ft	42 ft
Point 8	-71.13122 ft	41.818182 ft
Point 9	-50.31674 ft	31.818182 ft
Point 10	0 ft	31.4 ft
Point 11	-180 ft	35.5 ft
Point 12	-180 ft	13.5 ft
Point 13	-180 ft	8.5 ft

Point 14	-180 ft	3.5 ft
Point 15	-180 ft	-1 ft
Point 16	-180 ft	-6 ft
Point 17	-180 ft	-11 ft
Point 18	-180 ft	-16 ft
Point 19	-180 ft	-17 ft
Point 20	-180 ft	-20 ft
Point 21	0 ft	-20 ft
Point 22	0 ft	-17 ft
Point 23	0 ft	-16 ft
Point 24	0 ft	-11 ft
Point 25	0 ft	13.5 ft
Point 26	0 ft	8.5 ft
Point 27	0 ft	3 ft
Point 28	0 ft	-1 ft
Point 29	0 ft	-6 ft
Point 30	-104 ft	46.5 ft
Point 31	-86.50667 ft	40.495158 ft
Point 32	-58.83323 ft	35.5 ft
Point 33	-50.5 ft	31.5 ft
Point 34	0 ft	31 ft
Point 35	-68.5 ft	40.5 ft
Point 36	-69.25156 ft	40.5 ft
Point 37	-137.5 ft	41.929195 ft
Point 38	-137.5 ft	35.5 ft
Point 39	-140.5 ft	35.5 ft
Point 40	-140.5 ft	41.886712 ft

Regions

	Material	Points	Area
Region 1	04 Soft clay CL	25,26,13,12	900 ft²
Region 2	05 Loose stilty sand SM	26,27,14,13	945 ft²
Region 3	06 Medium dense gravel GP	27,28,15,14	765 ft²
Region 4	07 Loose clayey sand SC	29,28,15,16	900 ft²
Region 5	11 Stiff clay CL	21,22,19,20	540 ft²

Region 6	09 Medium dense clayey sand SC	24,23,18,17	900 ft²
Region 7	10 Medium dense silty sand SM	23,22,19,18	180 ft²
Region 8	08 Soft clay CL	29,24,17,16	900 ft²
Region 9	12 Riprap	35,8,7,6,30,31,36	47.869 ft²
Region 10	01 Levee	31,4,5,30	158.68 ft²
Region 11	02 Stiff clay CL	4,37,38,32,36,31	408.95 ft²
Region 12	13 Concrete	33,32,36,35,9,10,34	25.21 ft²
Region 13	03 Dense gravel GP	25,34,33,32,38,39,11,12	3,728.7 ft²
Region 14	02 Stiff clay CL	3,2,1,11,39,40	249.73 ft²
Region 15	03 Dense gravel GP	38,37,40,39	19.224 ft²

Slip Results

Slip Surfaces Analysed: 704 of 1331 converged

Current Slip Surface

Slip Surface: 702
Factor of Safety: 3.589
Volume: 190.83951 ft³
Weight: 24,791.779 lbf
Resisting Moment: 589,189.02 lbf·ft
Activating Moment: 164,201.91 lbf·ft
Resisting Force: 21,069.263 lbf
Activating Force: 5,870.3929 lbf
Slip Rank: 1 of 1,331 slip surfaces
Exit: (-44.706037, 31.771551) ft
Entry: (-77.91252, 41.898407) ft
Radius: 23.32196 ft
Center: (-56.76575, 51.733444) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Materi
Slice 1	-77.557665 ft	41.198088 ft	-1,229.7553 psf	63.569627 psf	53.34125 psf	0 psf	0 psf	12 Riprap
Slice 2	-76.587438 ft	39.500637 ft	-1,123.7831 psf	-85.686132 psf	-0 psf	1,000 psf	0 psf	02 St clay CL

Slice 3	-75.356692 ft	37.688926 ft	-1,010.6777 psf	165.82683 psf	0 psf	1,000 psf	0 psf	02 St clay CL
Slice 4	-74.125947 ft	36.187174 ft	-916.92304 psf	373.46349 psf	0 psf	1,000 psf	0 psf	02 St clay CL
Slice 5	-72.915736 ft	34.92835 ft	-838.33442 psf	672.73849 psf	471.05656 psf	0 psf	0 psf	03 Dense gravel GP
Slice 6	-71.726059 ft	33.858844 ft	-771.56498 psf	807.81618 psf	565.63898 psf	0 psf	0 psf	03 Dense gravel GP
Slice 7	-70.661305 ft	33.012202 ft	-718.70892 psf	890.99882 psf	623.88409 psf	0 psf	0 psf	03 Dense gravel GP
Slice 8	-69.721475 ft	32.349338 ft	-677.32622 psf	923.11133 psf	646.36951 psf	0 psf	0 psf	03 Dense gravel GP
Slice 9	-68.87578 ft	31.806888 ft	-643.46094 psf	950.82716 psf	665.77635 psf	0 psf	0 psf	03 Dense gravel GP
Slice 10	-67.962957 ft	31.284447 ft	-610.84484 psf	982.09546 psf	687.67065 psf	0 psf	0 psf	03 Dense gravel GP
Slice 11	-66.888872 ft	30.73152 ft	-576.32552 psf	1,012.7684 psf	709.14806 psf	0 psf	0 psf	03 Dense gravel GP
Slice 12	-65.814786 ft	30.246489 ft	-546.04499 psf	1,034.977 psf	724.69872 psf	0 psf	0 psf	03 Dense gravel GP

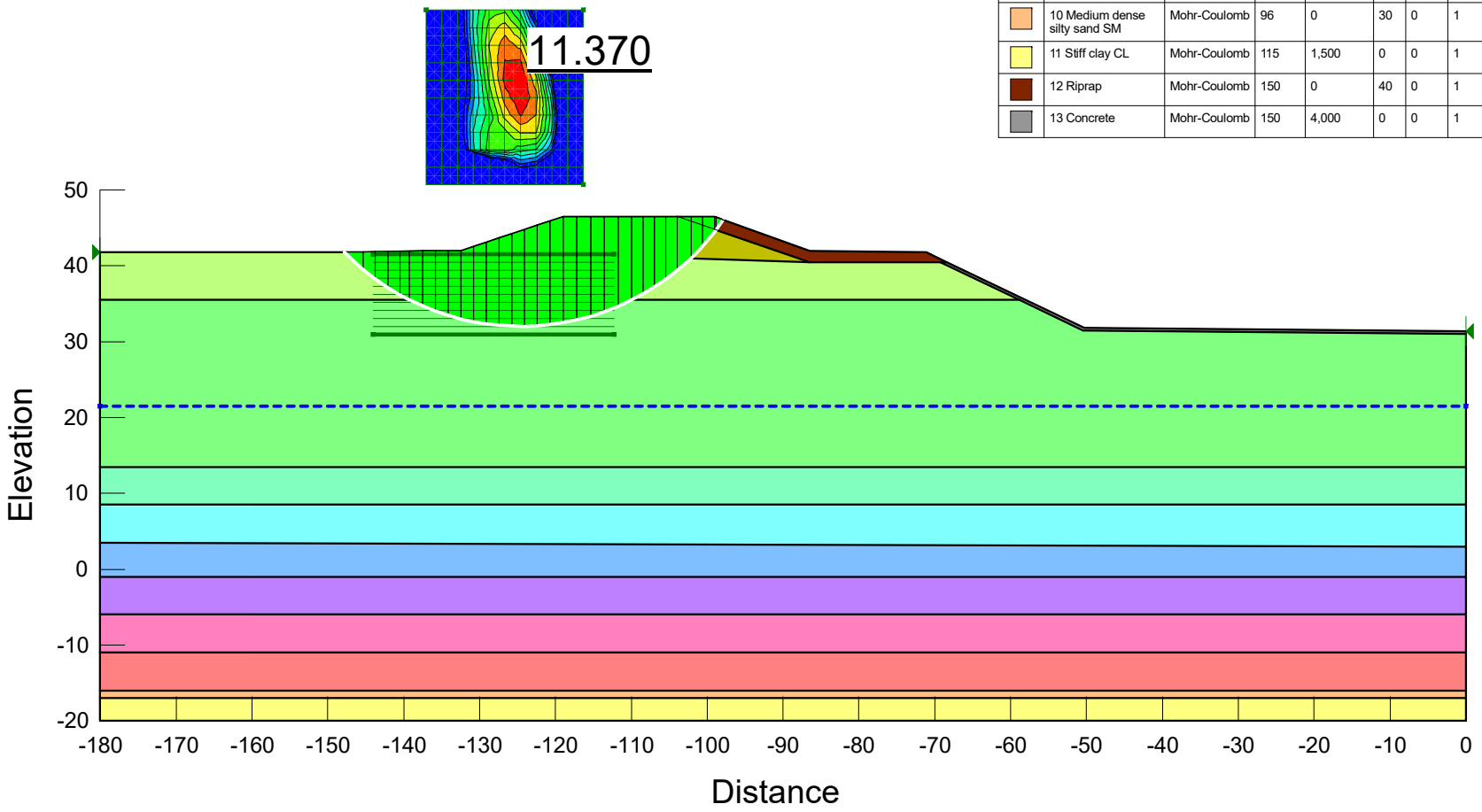
Slice 13	-64.740701 ft	29.82483 ft	-519.7207 psf	1,049.0424 psf	734.5474 psf	0 psf	0 psf	03 Dense gravel GP
Slice 14	-63.666615 ft	29.46293 ft	-497.12722 psf	1,055.2032 psf	738.86121 psf	0 psf	0 psf	03 Dense gravel GP
Slice 15	-62.592529 ft	29.157907 ft	-478.08461 psf	1,053.6265 psf	737.75723 psf	0 psf	0 psf	03 Dense gravel GP
Slice 16	-61.518444 ft	28.907476 ft	-462.45012 psf	1,044.4156 psf	731.30769 psf	0 psf	0 psf	03 Dense gravel GP
Slice 17	-60.444358 ft	28.70985 ft	-450.11227 psf	1,027.614 psf	719.54304 psf	0 psf	0 psf	03 Dense gravel GP
Slice 18	-59.370273 ft	28.563674 ft	-440.9865 psf	1,003.2075 psf	702.45347 psf	0 psf	0 psf	03 Dense gravel GP
Slice 19	-58.312403 ft	28.46868 ft	-435.05601 psf	966.96619 psf	677.07702 psf	0 psf	0 psf	03 Dense gravel GP
Slice 20	-57.270749 ft	28.422772 ft	-432.18997 psf	918.81704 psf	643.36262 psf	0 psf	0 psf	03 Dense gravel GP
Slice 21	-56.229096 ft	28.42348 ft	-432.23414 psf	862.88444 psf	604.19819 psf	0 psf	0 psf	03 Dense gravel GP
Slice 22	-55.187442 ft	28.470807 ft	-435.18881 psf	798.91611 psf	559.40708 psf	0 psf	0 psf	03 Dense gravel GP

Slice 23	-54.145788 ft	28.565041 ft	-441.07183 psf	726.58401 psf	508.7596 psf	0 psf	0 psf	03 Dense gravel GP
Slice 24	-53.104134 ft	28.706758 ft	-449.91923 psf	645.47134 psf	451.9639 psf	0 psf	0 psf	03 Dense gravel GP
Slice 25	-52.062481 ft	28.896843 ft	-461.78633 psf	555.05487 psf	388.65361 psf	0 psf	0 psf	03 Dense gravel GP
Slice 26	-51.020827 ft	29.136522 ft	-476.74948 psf	454.68052 psf	318.37073 psf	0 psf	0 psf	03 Dense gravel GP
Slice 27	-50.40837 ft	29.294895 ft	-486.63676 psf	390.86061 psf	273.68354 psf	0 psf	0 psf	03 Dense gravel GP
Slice 28	-49.810907 ft	29.478936 ft	-498.12645 psf	358.87404 psf	251.28631 psf	0 psf	0 psf	03 Dense gravel GP
Slice 29	-48.799242 ft	29.820916 ft	-519.47632 psf	311.28613 psf	217.9649 psf	0 psf	0 psf	03 Dense gravel GP
Slice 30	-47.787577 ft	30.215874 ft	-544.13363 psf	253.93714 psf	177.8087 psf	0 psf	0 psf	03 Dense gravel GP
Slice 31	-46.775912 ft	30.666798 ft	-572.28494 psf	185.6666 psf	130.00515 psf	0 psf	0 psf	03 Dense gravel GP
Slice 32	-45.764247 ft	31.177384 ft	-604.16091 psf	104.97517 psf	73.504402 psf	0 psf	0 psf	03 Dense gravel GP

Slice 33	-44.982225 ft	31.609827 ft	-631.15842 psf	844.80164 psf	0 psf	4,000 psf	0 psf	13 Concre

Rio Guayanilla
Station 52+00
End of Construction - L/S
Concrete Channel
Normal Water Level
Trench

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	01 Levee	Mohr-Coulomb	114	2,000	0	0	1
	02 Stiff clay CL	Mohr-Coulomb	115	1,000	0	0	1
	03 Dense gravel GP	Mohr-Coulomb	134	0	35	0	1
	04 Soft clay CL	Mohr-Coulomb	117	250	0	0	1
	05 Loose stilty sand SM	Mohr-Coulomb	112	0	29	0	1
	06 Medium dense gravel GP	Mohr-Coulomb	134	0	35	0	1
	07 Loose clayey sand SC	Mohr-Coulomb	120	0	30	0	1
	08 Soft clay CL	Mohr-Coulomb	115	250	0	0	1
	09 Medium dense clayey sand SC	Mohr-Coulomb	109	0	30	0	1
	10 Medium dense silty sand SM	Mohr-Coulomb	96	0	30	0	1
	11 Stiff clay CL	Mohr-Coulomb	115	1,500	0	0	1
	12 Riprap	Mohr-Coulomb	150	0	40	0	1
	13 Concrete	Mohr-Coulomb	150	4,000	0	0	1



SLOPE/W - EOC LS Normal

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File Information

File Version: 9.01
Created By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Last Edited By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Revision Number: 138
Date: 08/16/2019
Time: 08:47:55 AM
Tool Version: 9.1.1.16749
File Name: 52+00 trench EOC concrete.gsz
Directory: C:\Users\h6ts9yjs\Desktop\draft\
Last Solved Date: 08/16/2019
Last Solved Time: 08:48:04 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W - EOC LS Normal

Description: Station 52+00 End of Construction - L/S Concrete Channel Normal Water Level Trench
Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

01 Levee

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

02 Stiff clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 1,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

03 Dense gravel GP

Model: Mohr-Coulomb
Unit Weight: 134 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

04 Soft clay CL

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion': 250 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

05 Loose stilty sand SM

Model: Mohr-Coulomb
Unit Weight: 112 pcf
Cohesion': 0 psf
Phi': 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

06 Medium dense gravel GP

Model: Mohr-Coulomb
Unit Weight: 134 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

07 Loose clayey sand SC

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

08 Soft clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

09 Medium dense clayey sand SC

Model: Mohr-Coulomb
Unit Weight: 109 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

10 Medium dense silty sand SM

Model: Mohr-Coulomb
Unit Weight: 96 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

11 Stiff clay CL

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

12 Riprap

Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 0 psf
Phi': 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

13 Concrete

Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 4,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (-137.02214, 73.703229) ft
Lower Left: (-116.28796, 73.703229) ft
Lower Right: (-116.28796, 50.702321) ft
Grid Horizontal Increment: 10
Grid Vertical Increment: 10

Slip Surface Radius

Upper Left Coordinate: (-144.01565, 41.508307) ft

Upper Right Coordinate: (-112.28691, 41.508307) ft
Lower Left Coordinate: (-144.01565, 30.96229) ft
Lower Right Coordinate: (-112.28691, 30.96229) ft
Number of Increments: 10
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-180, 41.818182) ft
Right Coordinate: (0, 31.4) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-180 ft	21.5 ft
Coordinate 2	0 ft	21.5 ft

Points

	X	Y
Point 1	-180 ft	41.818182 ft
Point 2	-152.57919 ft	41.818182 ft
Point 3	-145.33937 ft	41.818182 ft
Point 4	-132.5 ft	42 ft
Point 5	-119 ft	46.5 ft
Point 6	-99 ft	46.5 ft
Point 7	-86.5 ft	42 ft
Point 8	-71.13122 ft	41.818182 ft
Point 9	-50.31674 ft	31.818182 ft
Point 10	0 ft	31.4 ft
Point 11	-180 ft	35.5 ft
Point 12	-180 ft	13.5 ft
Point 13	-180 ft	8.5 ft

Point 14	-180 ft	3.5 ft
Point 15	-180 ft	-1 ft
Point 16	-180 ft	-6 ft
Point 17	-180 ft	-11 ft
Point 18	-180 ft	-16 ft
Point 19	-180 ft	-17 ft
Point 20	-180 ft	-20 ft
Point 21	0 ft	-20 ft
Point 22	0 ft	-17 ft
Point 23	0 ft	-16 ft
Point 24	0 ft	-11 ft
Point 25	0 ft	13.5 ft
Point 26	0 ft	8.5 ft
Point 27	0 ft	3 ft
Point 28	0 ft	-1 ft
Point 29	0 ft	-6 ft
Point 30	-104 ft	46.5 ft
Point 31	-86.50667 ft	40.495158 ft
Point 32	-58.83323 ft	35.5 ft
Point 33	-50.5 ft	31.5 ft
Point 34	0 ft	31 ft
Point 35	-68.5 ft	40.5 ft
Point 36	-69.25156 ft	40.5 ft
Point 37	-137.5 ft	41.929195 ft
Point 38	-137.5 ft	35.5 ft
Point 39	-140.5 ft	35.5 ft
Point 40	-140.5 ft	41.886712 ft

Regions

	Material	Points	Area
Region 1	04 Soft clay CL	25,26,13,12	900 ft²
Region 2	05 Loose stilty sand SM	26,27,14,13	945 ft²
Region 3	06 Medium dense gravel GP	27,28,15,14	765 ft²
Region 4	07 Loose clayey sand SC	29,28,15,16	900 ft²
Region 5	11 Stiff clay CL	21,22,19,20	540 ft²

Region 6	09 Medium dense clayey sand SC	24,23,18,17	900 ft²
Region 7	10 Medium dense silty sand SM	23,22,19,18	180 ft²
Region 8	08 Soft clay CL	29,24,17,16	900 ft²
Region 9	12 Riprap	35,8,7,6,30,31,36	47.869 ft²
Region 10	01 Levee	31,4,5,30	158.68 ft²
Region 11	02 Stiff clay CL	4,37,38,32,36,31	408.95 ft²
Region 12	13 Concrete	33,32,36,35,9,10,34	25.21 ft²
Region 13	03 Dense gravel GP	25,34,33,32,38,39,11,12	3,728.7 ft²
Region 14	02 Stiff clay CL	3,2,1,11,39,40	249.73 ft²
Region 15	02 Stiff clay CL	38,37,40,39	19.224 ft²

Slip Results

Slip Surfaces Analysed: 1195 of 1331 converged

Current Slip Surface

Slip Surface: 702
Factor of Safety: 11.811
Volume: 303.36616 ft³
Weight: 35,421.9 lbf
Resisting Moment: 1,088,902.7 lbf·ft
Activating Moment: 92,194.06 lbf·ft
Resisting Force: 37,998.547 lbf
Activating Force: 3,217.2615 lbf
Slip Rank: 54 of 1,331 slip surfaces
Exit: (-144.34042, 41.832328) ft
Entry: (-106.24099, 46.5) ft
Radius: 22.231009 ft
Center: (-126.65505, 55.302503) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Materia
Slice 1	-143.70035 ft	41.065977 ft	-1,221.5077 psf	186.5492 psf	0 psf	1,000 psf	0 psf	02 Stif clay CL
Slice 2	-142.42021 ft	39.654755 ft	-1,133.4048 psf	333.39606 psf	0 psf	1,000 psf	0 psf	02 Stif clay CL

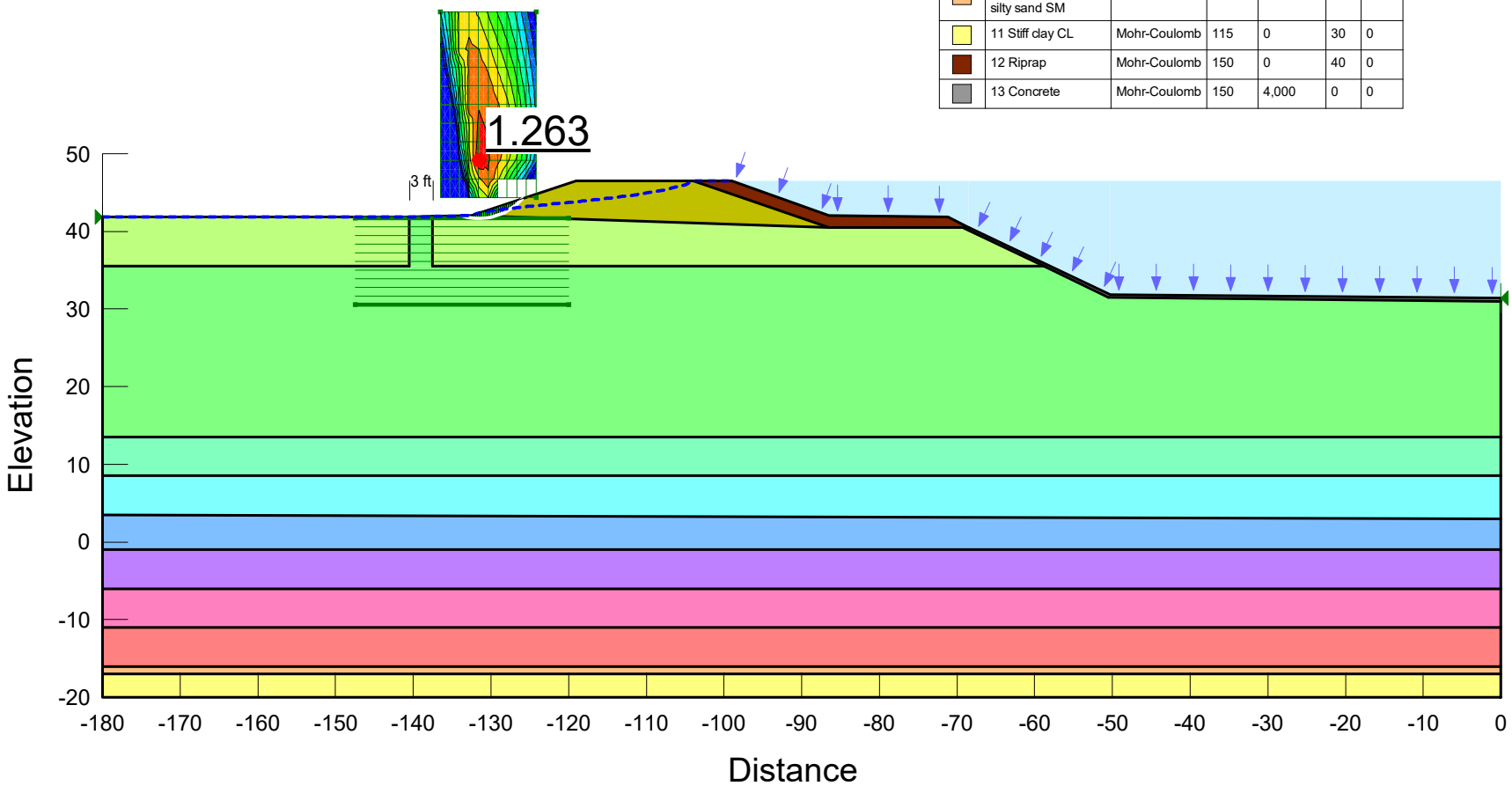
Slice 3	-141.14007 ft	38.459424 ft	-1,058.78 psf	459.68426 psf	0 psf	1,000 psf	0 psf	02 Stif clay CL
Slice 4	-139.75 ft	37.361547 ft	-990.23937 psf	576.85466 psf	0 psf	1,000 psf	0 psf	02 Stif clay CL
Slice 5	-138.25 ft	36.355161 ft	-927.4105 psf	685.07009 psf	0 psf	1,000 psf	0 psf	02 Stif clay CL
Slice 6	-137.12922 ft	35.698097 ft	-886.38986 psf	756.07889 psf	0 psf	1,000 psf	0 psf	02 Stif clay CL
Slice 7	-136.04871 ft	35.168859 ft	-853.34947 psf	802.82497 psf	562.14409 psf	0 psf	0 psf	03 Dense gravel GP
Slice 8	-134.62922 ft	34.564805 ft	-815.63824 psf	884.41983 psf	619.27743 psf	0 psf	0 psf	03 Dense gravel GP
Slice 9	-133.20974 ft	34.072758 ft	-784.91968 psf	950.45532 psf	665.51598 psf	0 psf	0 psf	03 Dense gravel GP
Slice 10	-131.88636 ft	33.704991 ft	-761.95992 psf	1,022.0089 psf	715.61836 psf	0 psf	0 psf	03 Dense gravel GP
Slice 11	-130.65909 ft	33.443952 ft	-745.66316 psf	1,101.4024 psf	771.21026 psf	0 psf	0 psf	03 Dense gravel GP
Slice 12	-129.43182 ft	33.254264 ft	-733.82094 psf	1,170.8485 psf	819.83696 psf	0 psf	0 psf	03 Dense gravel GP
Slice 13	-128.20455 ft	33.134092 ft	-726.31853 psf	1,230.6563 psf	861.71484 psf	0 psf	0 psf	03 Dense gravel GP

Slice 14	-126.97727 ft	33.082302 ft	-723.0853 psf	1,281.03 psf	896.98686 psf	0 psf	0 psf	03 Dense gravel GP
Slice 15	-125.75 ft	33.098416 ft	-724.09127 psf	1,322.0792 psf	925.72979 psf	0 psf	0 psf	03 Dense gravel GP
Slice 16	-124.52273 ft	33.182581 ft	-729.34575 psf	1,353.8242 psf	947.95788 psf	0 psf	0 psf	03 Dense gravel GP
Slice 17	-123.29545 ft	33.335584 ft	-738.89771 psf	1,376.1971 psf	963.62358 psf	0 psf	0 psf	03 Dense gravel GP
Slice 18	-122.06818 ft	33.55888 ft	-752.83818 psf	1,389.0384 psf	972.61518 psf	0 psf	0 psf	03 Dense gravel GP
Slice 19	-120.84091 ft	33.854675 ft	-771.30468 psf	1,392.0891 psf	974.75127 psf	0 psf	0 psf	03 Dense gravel GP
Slice 20	-119.61364 ft	34.22603 ft	-794.48847 psf	1,384.9769 psf	969.77124 psf	0 psf	0 psf	03 Dense gravel GP
Slice 21	-118.38791 ft	34.676369 ft	-822.60322 psf	1,344.4139 psf	941.36872 psf	0 psf	0 psf	03 Dense gravel GP
Slice 22	-117.16374 ft	35.21085 ft	-855.97093 psf	1,269.9814 psf	889.25053 psf	0 psf	0 psf	03 Dense gravel GP
Slice 23	-115.9584 ft	35.825816 ft	-894.36337 psf	1,183.3209 psf	0 psf	1,000 psf	0 psf	02 Stif clay CL

Slice 24	-114.7719 ft	36.527107 ft	-938.14513 psf	1,096.115 psf	0 psf	1,000 psf	0 psf	02 Stif clay CL
Slice 25	-113.58539 ft	37.334096 ft	-988.52559 psf	995.67027 psf	0 psf	1,000 psf	0 psf	02 Stif clay CL
Slice 26	-112.39889 ft	38.261924 ft	-1,046.4501 psf	879.83657 psf	0 psf	1,000 psf	0 psf	02 Stif clay CL
Slice 27	-111.21238 ft	39.33188 ft	-1,113.2476 psf	745.52017 psf	0 psf	1,000 psf	0 psf	02 Stif clay CL
Slice 28	-110.02588 ft	40.575393 ft	-1,190.8804 psf	588.0051 psf	0 psf	1,000 psf	0 psf	02 Stif clay CL
Slice 29	-108.90069 ft	41.95271 ft	-1,276.8665 psf	296.0989 psf	0 psf	2,000 psf	0 psf	01 Levee
Slice 30	-107.83681 ft	43.508935 ft	-1,374.022 psf	70.039401 psf	0 psf	2,000 psf	0 psf	01 Levee
Slice 31	-106.77293 ft	45.428858 ft	-1,493.8831 psf	-226.99396 psf	-0 psf	2,000 psf	0 psf	01 Levee

Rio Guayanilla
Station 52+00
Long Term
Concrete Channel
Trench

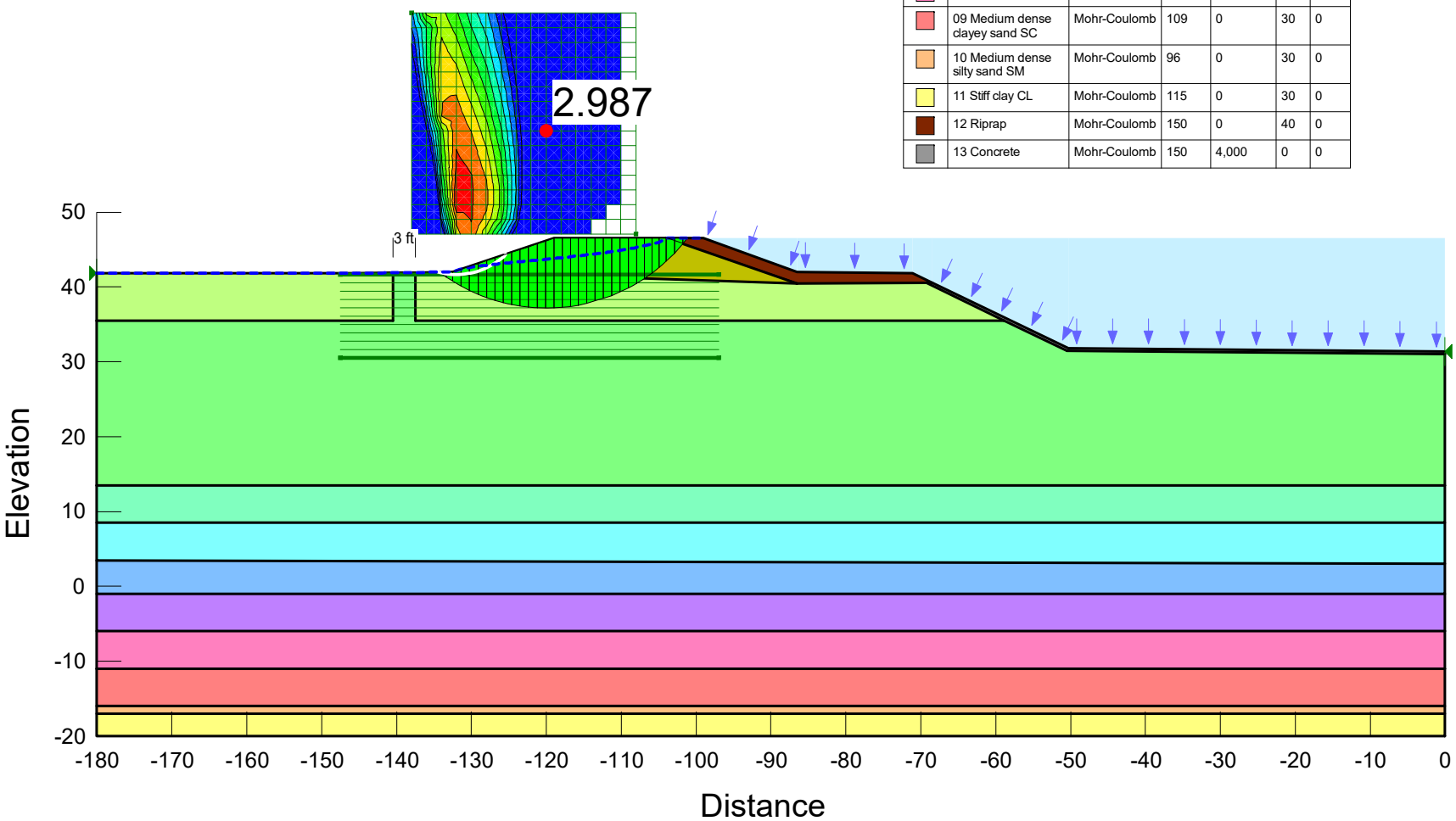
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01 Levee	Mohr-Coulomb	114	0	28	0
	02 Stiff clay CL	Mohr-Coulomb	115	0	26	0
	03 Dense gravel GP	Mohr-Coulomb	134	0	35	0
	04 Soft clay CL	Mohr-Coulomb	117	0	24	0
	05 Loose stilty sand SM	Mohr-Coulomb	112	0	29	0
	06 Medium dense gravel GP	Mohr-Coulomb	134	0	35	0
	07 Loose clayey sand SC	Mohr-Coulomb	120	0	30	0
	08 Soft clay CL	Mohr-Coulomb	115	0	24	0
	09 Medium dense clayey sand SC	Mohr-Coulomb	109	0	30	0
	10 Medium dense silty sand SM	Mohr-Coulomb	96	0	30	0
	11 Stiff clay CL	Mohr-Coulomb	115	0	30	0
	12 Riprap	Mohr-Coulomb	150	0	40	0
	13 Concrete	Mohr-Coulomb	150	4,000	0	0



Rio Guayanilla
Station 52+00
Long Term
Concrete Channel
Trench

Deep slide

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01 Levee	Mohr-Coulomb	114	0	28	0
	02 Stiff clay CL	Mohr-Coulomb	115	0	26	0
	03 Dense gravel GP	Mohr-Coulomb	134	0	35	0
	04 Soft clay CL	Mohr-Coulomb	117	0	24	0
	05 Loose stilty sand SM	Mohr-Coulomb	112	0	29	0
	06 Medium dense gravel GP	Mohr-Coulomb	134	0	35	0
	07 Loose clayey sand SC	Mohr-Coulomb	120	0	30	0
	08 Soft clay CL	Mohr-Coulomb	115	0	24	0
	09 Medium dense clayey sand SC	Mohr-Coulomb	109	0	30	0
	10 Medium dense silty sand SM	Mohr-Coulomb	96	0	30	0
	11 Stiff clay CL	Mohr-Coulomb	115	0	30	0
	12 Riprap	Mohr-Coulomb	150	0	40	0
	13 Concrete	Mohr-Coulomb	150	4,000	0	0



SLOPE/W - LT

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File Information

File Version: 9.01
Created By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Last Edited By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Revision Number: 119
Date: 08/16/2019
Time: 08:23:03 AM
Tool Version: 9.1.1.16749
File Name: 52+00 trench LT concrete.gsz
Directory: C:\Users\h6ts9yjs\Desktop\draft\
Last Solved Date: 08/16/2019
Last Solved Time: 08:23:12 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W - LT

Description: Station 52+00 Long Term Concrete Channel Trench
Kind: SLOPE/W
Parent: SEEP/W - Flood
Method: Spencer
Settings
- PWP Conditions from: Parent Analysis
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

01 Levee

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

02 Stiff clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 26 °
Phi-B: 0 °

03 Dense gravel GP

Model: Mohr-Coulomb
Unit Weight: 134 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °

04 Soft clay CL

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion': 0 psf
Phi': 24 °
Phi-B: 0 °

05 Loose stilty sand SM

Model: Mohr-Coulomb
Unit Weight: 112 pcf
Cohesion': 0 psf
Phi': 29 °
Phi-B: 0 °

06 Medium dense gravel GP

Model: Mohr-Coulomb
Unit Weight: 134 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °

07 Loose clayey sand SC

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

08 Soft clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 24 °
Phi-B: 0 °

09 Medium dense clayey sand SC

Model: Mohr-Coulomb
Unit Weight: 109 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

10 Medium dense silty sand SM

Model: Mohr-Coulomb
Unit Weight: 96 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

11 Stiff clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

12 Riprap

Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 0 psf
Phi': 40 °

Phi-B: 0 °

13 Concrete

Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 4,000 psf
Phi': 0 °
Phi-B: 0 °

Slip Surface Grid

Upper Left: (-136.49729, 68.183857) ft
Lower Left: (-124.18439, 68.183857) ft
Lower Right: (-124.18439, 44.318067) ft
Grid Horizontal Increment: 10
Grid Vertical Increment: 10

Slip Surface Radius

Upper Left Coordinate: (-147.5, 41.641848) ft
Upper Right Coordinate: (-120, 41.641848) ft
Lower Left Coordinate: (-147.5, 30.505484) ft
Lower Right Coordinate: (-120, 30.505484) ft
Number of Increments: 10
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-180, 41.818182) ft
Right Coordinate: (0, 31.4) ft

Points

	X	Y
Point 1	-180 ft	41.818182 ft
Point 2	-152.57919 ft	41.818182 ft
Point 3	-145.33937 ft	41.818182 ft
Point 4	-132.5 ft	42 ft
Point 5	-119 ft	46.5 ft
Point 6	-99 ft	46.5 ft

Point 7	-86.5 ft	42 ft
Point 8	-71.13122 ft	41.818182 ft
Point 9	-50.31674 ft	31.818182 ft
Point 10	0 ft	31.4 ft
Point 11	-180 ft	35.5 ft
Point 12	-180 ft	13.5 ft
Point 13	-180 ft	8.5 ft
Point 14	-180 ft	3.5 ft
Point 15	-180 ft	-1 ft
Point 16	-180 ft	-6 ft
Point 17	-180 ft	-11 ft
Point 18	-180 ft	-16 ft
Point 19	-180 ft	-17 ft
Point 20	-180 ft	-20 ft
Point 21	0 ft	-20 ft
Point 22	0 ft	-17 ft
Point 23	0 ft	-16 ft
Point 24	0 ft	-11 ft
Point 25	0 ft	13.5 ft
Point 26	0 ft	8.5 ft
Point 27	0 ft	3 ft
Point 28	0 ft	-1 ft
Point 29	0 ft	-6 ft
Point 30	-104 ft	46.5 ft
Point 31	-86.50667 ft	40.495158 ft
Point 32	-58.83323 ft	35.5 ft
Point 33	-50.5 ft	31.5 ft
Point 34	0 ft	31 ft
Point 35	-68.5 ft	40.5 ft
Point 36	-69.25156 ft	40.5 ft
Point 37	-137.5 ft	41.929195 ft
Point 38	-137.5 ft	35.5 ft
Point 39	-140.5 ft	35.5 ft
Point 40	-140.5 ft	41.886712 ft

Regions

	Material	Points	Area
Region 1	04 Soft clay CL	25,26,13,12	900 ft²
Region 2	05 Loose stilty sand SM	26,27,14,13	945 ft²
Region 3	06 Medium dense gravel GP	27,28,15,14	765 ft²
Region 4	07 Loose clayey sand SC	29,28,15,16	900 ft²
Region 5	11 Stiff clay CL	21,22,19,20	540 ft²
Region 6	09 Medium dense clayey sand SC	24,23,18,17	900 ft²
Region 7	10 Medium dense silty sand SM	23,22,19,18	180 ft²
Region 8	08 Soft clay CL	29,24,17,16	900 ft²
Region 9	12 Riprap	35,8,7,6,30,31,36	47.869 ft²
Region 10	01 Levee	31,4,5,30	158.68 ft²
Region 11	02 Stiff clay CL	4,37,38,32,36,31	408.95 ft²
Region 12	13 Concrete	33,32,36,35,9,10,34	25.21 ft²
Region 13	03 Dense gravel GP	25,34,33,32,38,39,11,12	3,728.7 ft²
Region 14	02 Stiff clay CL	3,2,1,11,39,40	249.73 ft²
Region 15	03 Dense gravel GP	38,37,40,39	19.224 ft²

Slip Results

Slip Surfaces Analysed: 1190 of 1331 converged

Current Slip Surface

Slip Surface: 564
Factor of Safety: 1.516
Volume: 53.814635 ft³
Weight: 6,159.1941 lbf
Resisting Moment: 25,332.345 lbf·ft
Activating Moment: 16,706.898 lbf·ft
Resisting Force: 1,854.8704 lbf
Activating Force: 1,222.9741 lbf
Slip Rank: 49 of 1,331 slip surfaces
Exit: (-136.4998, 41.943359) ft
Entry: (-118.12124, 46.5) ft
Radius: 12.063229 ft
Center: (-129.10955, 51.477804) ft

Slip Slices

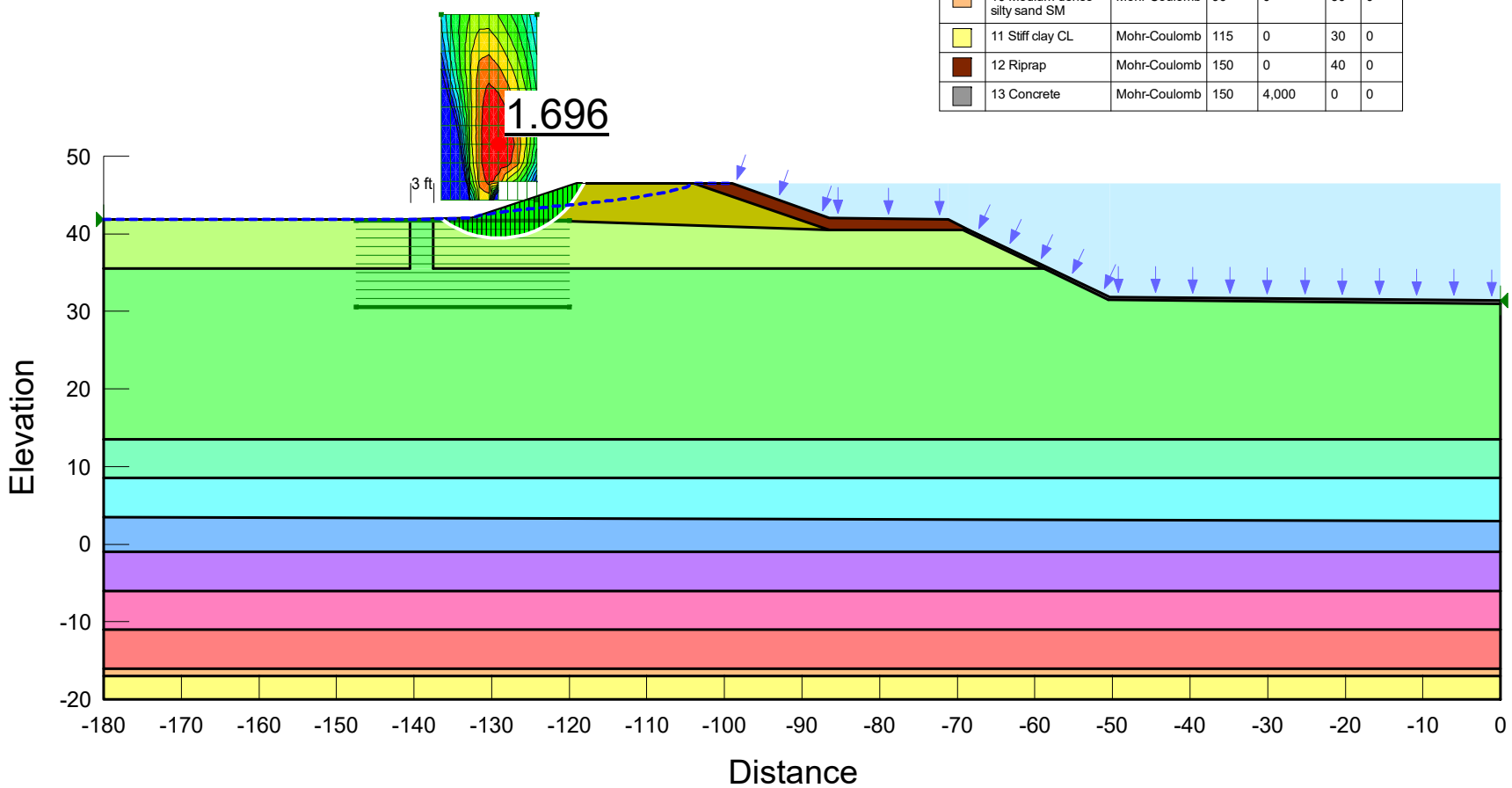
	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	E Ma
Slice 1	-136.2141 ft	41.735023 ft	12.512498 psf	37.983192 psf	12.422888 psf	0 psf	0 psf	0 cla
Slice 2	-135.6427 ft	41.342526 ft	38.844086 psf	101.64417 psf	30.629646 psf	0 psf	0 psf	0 cla
Slice 3	-135.0713 ft	40.995869 ft	62.83529 psf	151.94353 psf	43.460994 psf	0 psf	0 psf	0 cla
Slice 4	-134.4999 ft	40.690608 ft	84.018181 psf	192.51 psf	52.914995 psf	0 psf	0 psf	0 cla
Slice 5	-133.9285 ft	40.4233 ft	102.75271 psf	225.31964 psf	59.779889 psf	0 psf	0 psf	0 cla
Slice 6	-133.3571 ft	40.191236 ft	119.1591 psf	251.74851 psf	64.668174 psf	0 psf	0 psf	0 cla
Slice 7	-132.7857 ft	39.992273 ft	133.32632 psf	272.75438 psf	68.00361 psf	0 psf	0 psf	0 cla
Slice 8	-132.19413 ft	39.819899 ft	145.7259 psf	303.49556 psf	76.949403 psf	0 psf	0 psf	0 cla
Slice 9	-131.58239 ft	39.674886 ft	156.4691 psf	342.64819 psf	90.80561 psf	0 psf	0 psf	0 cla
Slice 10	-130.97066 ft	39.563026 ft	164.9943 psf	375.66703 psf	102.75196 psf	0 psf	0 psf	0 cla
Slice 11	-130.35892 ft	39.483389 ft	171.55709 psf	403.11071 psf	112.93625 psf	0 psf	0 psf	0 cla
Slice 12	-129.74718 ft	39.435334 ft	176.28282 psf	425.42283 psf	121.5137 psf	0 psf	0 psf	0 cla
Slice 13	-129.13545 ft	39.418481 ft	179.22561 psf	442.94913 psf	128.62656 psf	0 psf	0 psf	0 cla
Slice 14	-128.52371 ft	39.432701 ft	180.43758 psf	455.95184 psf	134.37729 psf	0 psf	0 psf	0 cla

Slice 15	-127.91197 ft	39.478103 ft	179.95407 psf	464.62799 psf	138.84475 psf	0 psf	0 psf	0 cla
Slice 16	-127.30024 ft	39.555046 ft	177.80271 psf	469.12007 psf	142.08497 psf	0 psf	0 psf	0 cla
Slice 17	-126.6885 ft	39.664146 ft	174.00579 psf	469.52398 psf	144.13385 psf	0 psf	0 psf	0 cla
Slice 18	-126.07676 ft	39.806308 ft	168.55772 psf	465.89399 psf	145.02059 psf	0 psf	0 psf	0 cla
Slice 19	-125.46503 ft	39.982762 ft	161.51567 psf	458.24676 psf	144.72542 psf	0 psf	0 psf	0 cla
Slice 20	-124.85329 ft	40.195124 ft	152.75634 psf	446.55663 psf	143.29598 psf	0 psf	0 psf	0 cla
Slice 21	-124.24155 ft	40.445473 ft	142.23059 psf	430.75696 psf	140.72371 psf	0 psf	0 psf	0 cla
Slice 22	-123.62982 ft	40.736477 ft	129.86493 psf	410.73619 psf	136.99007 psf	0 psf	0 psf	0 cla
Slice 23	-123.01808 ft	41.071562 ft	115.67689 psf	386.34271 psf	132.01254 psf	0 psf	0 psf	0 cla
Slice 24	-122.40634 ft	41.455174 ft	99.261535 psf	357.32696 psf	125.86692 psf	0 psf	0 psf	0 cla
Slice 25	-121.79043 ft	41.896587 ft	80.285351 psf	320.41786 psf	127.68072 psf	0 psf	0 psf	Lev
Slice 26	-121.17033 ft	42.404735 ft	58.273425 psf	280.65589 psf	118.24285 psf	0 psf	0 psf	Lev
Slice 27	-120.55024 ft	42.988646 ft	32.572971 psf	234.78171 psf	107.51629 psf	0 psf	0 psf	Lev

Slice 28	-119.93014 ft	43.665562 ft	2.2724944 psf	181.87447 psf	95.496062 psf	0 psf	0 psf	Lev
Slice 29	-119.31005 ft	44.462997 ft	-35.275463 psf	128.81762 psf	68.493542 psf	0 psf	0 psf	Lev
Slice 30	-118.56062 ft	45.698063 ft	-97.299124 psf	46.845244 psf	24.908058 psf	0 psf	0 psf	Lev

Rio Guayanilla
Station 52+00
Long Term with c=50 psf
Concrete Channel
Trench

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	01 Levee	Mohr-Coulomb	114	50	28	0
	02 Stiff clay CL	Mohr-Coulomb	115	0	26	0
	03 Dense gravel GP	Mohr-Coulomb	134	0	35	0
	04 Soft clay CL	Mohr-Coulomb	117	0	24	0
	05 Loose stilty sand SM	Mohr-Coulomb	112	0	29	0
	06 Medium dense gravel GP	Mohr-Coulomb	134	0	35	0
	07 Loose clayey sand SC	Mohr-Coulomb	120	0	30	0
	08 Soft clay CL	Mohr-Coulomb	115	0	24	0
	09 Medium dense clayey sand SC	Mohr-Coulomb	109	0	30	0
	10 Medium dense silty sand SM	Mohr-Coulomb	96	0	30	0
	11 Stiff clay CL	Mohr-Coulomb	115	0	30	0
	12 Riprap	Mohr-Coulomb	150	0	40	0
	13 Concrete	Mohr-Coulomb	150	4,000	0	0



SLOPE/W - LT c=50

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File Information

File Version: 9.01
Created By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Last Edited By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Revision Number: 120
Date: 08/16/2019
Time: 08:29:53 AM
Tool Version: 9.1.1.16749
File Name: 52+00 trench LT concrete.gsz
Directory: C:\Users\h6ts9yjs\Desktop\draft\
Last Solved Date: 08/16/2019
Last Solved Time: 08:30:02 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W - LT c=50

Description: Station 52+00 Long Term with c=50 psf Concrete Channel Trench
Kind: SLOPE/W
Parent: SEEP/W - Flood
Method: Spencer
Settings
- PWP Conditions from: Parent Analysis
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

01 Levee

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 50 psf
Phi': 28 °
Phi-B: 0 °

02 Stiff clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 26 °
Phi-B: 0 °

03 Dense gravel GP

Model: Mohr-Coulomb
Unit Weight: 134 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °

04 Soft clay CL

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion': 0 psf
Phi': 24 °
Phi-B: 0 °

05 Loose stilty sand SM

Model: Mohr-Coulomb
Unit Weight: 112 pcf
Cohesion': 0 psf
Phi': 29 °
Phi-B: 0 °

06 Medium dense gravel GP

Model: Mohr-Coulomb
Unit Weight: 134 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °

07 Loose clayey sand SC

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

08 Soft clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 24 °
Phi-B: 0 °

09 Medium dense clayey sand SC

Model: Mohr-Coulomb
Unit Weight: 109 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

10 Medium dense silty sand SM

Model: Mohr-Coulomb
Unit Weight: 96 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

11 Stiff clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

12 Riprap

Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 0 psf
Phi': 40 °

Phi-B: 0 °

13 Concrete

Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 4,000 psf
Phi': 0 °
Phi-B: 0 °

Slip Surface Grid

Upper Left: (-136.49729, 68.183857) ft
Lower Left: (-124.18439, 68.183857) ft
Lower Right: (-124.18439, 44.318067) ft
Grid Horizontal Increment: 10
Grid Vertical Increment: 10

Slip Surface Radius

Upper Left Coordinate: (-147.5, 41.641848) ft
Upper Right Coordinate: (-120, 41.641848) ft
Lower Left Coordinate: (-147.5, 30.505484) ft
Lower Right Coordinate: (-120, 30.505484) ft
Number of Increments: 10
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-180, 41.818182) ft
Right Coordinate: (0, 31.4) ft

Points

	X	Y
Point 1	-180 ft	41.818182 ft
Point 2	-152.57919 ft	41.818182 ft
Point 3	-145.33937 ft	41.818182 ft
Point 4	-132.5 ft	42 ft
Point 5	-119 ft	46.5 ft
Point 6	-99 ft	46.5 ft

Point 7	-86.5 ft	42 ft
Point 8	-71.13122 ft	41.818182 ft
Point 9	-50.31674 ft	31.818182 ft
Point 10	0 ft	31.4 ft
Point 11	-180 ft	35.5 ft
Point 12	-180 ft	13.5 ft
Point 13	-180 ft	8.5 ft
Point 14	-180 ft	3.5 ft
Point 15	-180 ft	-1 ft
Point 16	-180 ft	-6 ft
Point 17	-180 ft	-11 ft
Point 18	-180 ft	-16 ft
Point 19	-180 ft	-17 ft
Point 20	-180 ft	-20 ft
Point 21	0 ft	-20 ft
Point 22	0 ft	-17 ft
Point 23	0 ft	-16 ft
Point 24	0 ft	-11 ft
Point 25	0 ft	13.5 ft
Point 26	0 ft	8.5 ft
Point 27	0 ft	3 ft
Point 28	0 ft	-1 ft
Point 29	0 ft	-6 ft
Point 30	-104 ft	46.5 ft
Point 31	-86.50667 ft	40.495158 ft
Point 32	-58.83323 ft	35.5 ft
Point 33	-50.5 ft	31.5 ft
Point 34	0 ft	31 ft
Point 35	-68.5 ft	40.5 ft
Point 36	-69.25156 ft	40.5 ft
Point 37	-137.5 ft	41.929195 ft
Point 38	-137.5 ft	35.5 ft
Point 39	-140.5 ft	35.5 ft
Point 40	-140.5 ft	41.886712 ft

Regions

	Material	Points	Area
Region 1	04 Soft clay CL	25,26,13,12	900 ft²
Region 2	05 Loose stilty sand SM	26,27,14,13	945 ft²
Region 3	06 Medium dense gravel GP	27,28,15,14	765 ft²
Region 4	07 Loose clayey sand SC	29,28,15,16	900 ft²
Region 5	11 Stiff clay CL	21,22,19,20	540 ft²
Region 6	09 Medium dense clayey sand SC	24,23,18,17	900 ft²
Region 7	10 Medium dense silty sand SM	23,22,19,18	180 ft²
Region 8	08 Soft clay CL	29,24,17,16	900 ft²
Region 9	12 Riprap	35,8,7,6,30,31,36	47.869 ft²
Region 10	01 Levee	31,4,5,30	158.68 ft²
Region 11	02 Stiff clay CL	4,37,38,32,36,31	408.95 ft²
Region 12	13 Concrete	33,32,36,35,9,10,34	25.21 ft²
Region 13	03 Dense gravel GP	25,34,33,32,38,39,11,12	3,728.7 ft²
Region 14	02 Stiff clay CL	3,2,1,11,39,40	249.73 ft²
Region 15	03 Dense gravel GP	38,37,40,39	19.224 ft²

Slip Results

Slip Surfaces Analysed: 1192 of 1331 converged

Current Slip Surface

Slip Surface: 564
Factor of Safety: 1.696
Volume: 53.814635 ft³
Weight: 6,159.1941 lbf
Resisting Moment: 28,334.019 lbf·ft
Activating Moment: 16,706.898 lbf·ft
Resisting Force: 2,006.6091 lbf
Activating Force: 1,183.0641 lbf
Slip Rank: 1 of 1,331 slip surfaces
Exit: (-136.4998, 41.943359) ft
Entry: (-118.12124, 46.5) ft
Radius: 12.063229 ft
Center: (-129.10955, 51.477804) ft

Slip Slices

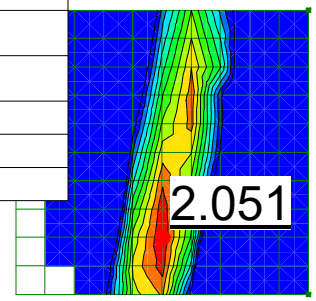
	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	E Ma
Slice 1	-136.2141 ft	41.735023 ft	12.512498 psf	34.582211 psf	10.764118 psf	0 psf	0 psf	0 cla
Slice 2	-135.6427 ft	41.342526 ft	38.844086 psf	94.172251 psf	26.985349 psf	0 psf	0 psf	0 cla
Slice 3	-135.0713 ft	40.995869 ft	62.83529 psf	142.55062 psf	38.879763 psf	0 psf	0 psf	0 cla
Slice 4	-134.4999 ft	40.690608 ft	84.018181 psf	182.38706 psf	47.977706 psf	0 psf	0 psf	0 cla
Slice 5	-133.9285 ft	40.4233 ft	102.75271 psf	215.1964 psf	54.842455 psf	0 psf	0 psf	0 cla
Slice 6	-133.3571 ft	40.191236 ft	119.1591 psf	242.0742 psf	59.9497 psf	0 psf	0 psf	0 cla
Slice 7	-132.7857 ft	39.992273 ft	133.32632 psf	263.80644 psf	63.639408 psf	0 psf	0 psf	0 cla
Slice 8	-132.19413 ft	39.819899 ft	145.7259 psf	294.86134 psf	72.738213 psf	0 psf	0 psf	0 cla
Slice 9	-131.58239 ft	39.674886 ft	156.4691 psf	334.15814 psf	86.664734 psf	0 psf	0 psf	0 cla
Slice 10	-130.97066 ft	39.563026 ft	164.9943 psf	367.70628 psf	98.869241 psf	0 psf	0 psf	0 cla
Slice 11	-130.35892 ft	39.483389 ft	171.55709 psf	395.96338 psf	109.45026 psf	0 psf	0 psf	0 cla
Slice 12	-129.74718 ft	39.435334 ft	176.28282 psf	419.29532 psf	118.52511 psf	0 psf	0 psf	0 cla
Slice 13	-129.13545 ft	39.418481 ft	179.22561 psf	437.98765 psf	126.20668 psf	0 psf	0 psf	0 cla
Slice 14	-128.52371 ft	39.432701 ft	180.43758 psf	452.25604 psf	132.57472 psf	0 psf	0 psf	0 cla

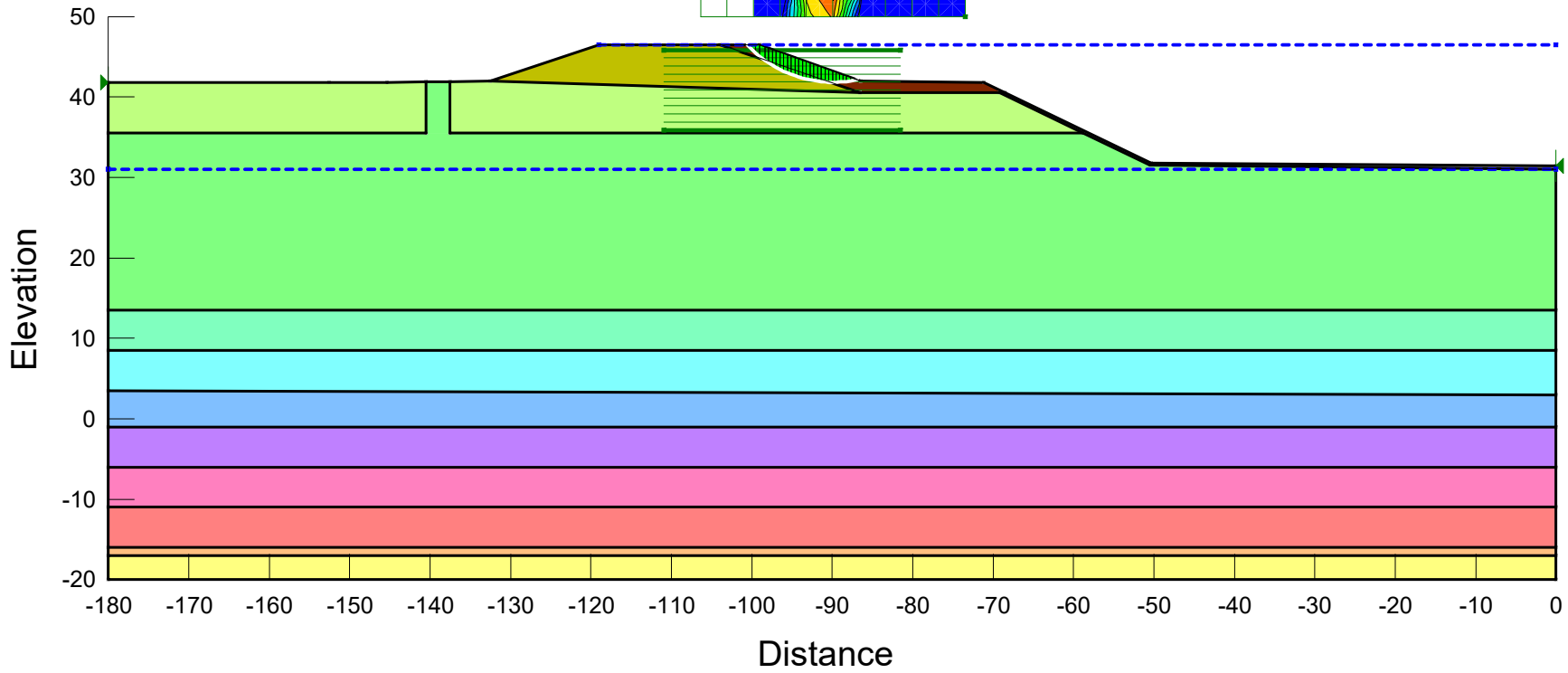
Slice 15	-127.91197 ft	39.478103 ft	179.95407 psf	462.25997 psf	137.68979 psf	0 psf	0 psf	0 cla
Slice 16	-127.30024 ft	39.555046 ft	177.80271 psf	468.11073 psf	141.59268 psf	0 psf	0 psf	0 cla
Slice 17	-126.6885 ft	39.664146 ft	174.00579 psf	469.87729 psf	144.30617 psf	0 psf	0 psf	0 cla
Slice 18	-126.07676 ft	39.806308 ft	168.55772 psf	467.58947 psf	145.84753 psf	0 psf	0 psf	0 cla
Slice 19	-125.46503 ft	39.982762 ft	161.51567 psf	461.2414 psf	146.18601 psf	0 psf	0 psf	0 cla
Slice 20	-124.85329 ft	40.195124 ft	152.75634 psf	450.78396 psf	145.35778 psf	0 psf	0 psf	0 cla
Slice 21	-124.24155 ft	40.445473 ft	142.23059 psf	436.12719 psf	143.34295 psf	0 psf	0 psf	0 cla
Slice 22	-123.62982 ft	40.736477 ft	129.86493 psf	417.13435 psf	140.11066 psf	0 psf	0 psf	0 cla
Slice 23	-123.01808 ft	41.071562 ft	115.67689 psf	393.62529 psf	135.56449 psf	0 psf	0 psf	0 cla
Slice 24	-122.40634 ft	41.455174 ft	99.261535 psf	365.31676 psf	129.7638 psf	0 psf	0 psf	0 cla
Slice 25	-121.79043 ft	41.896587 ft	80.285351 psf	315.7092 psf	125.17708 psf	50 psf	0 psf	Lev
Slice 26	-121.17033 ft	42.404735 ft	58.273425 psf	274.31667 psf	114.87223 psf	50 psf	0 psf	Lev
Slice 27	-120.55024 ft	42.988646 ft	32.572971 psf	226.27871 psf	102.99517 psf	50 psf	0 psf	Lev

Slice 28	-119.93014 ft	43.665562 ft	2.2724944 psf	170.49363 psf	89.444767 psf	50 psf	0 psf	Lev
Slice 29	-119.31005 ft	44.462997 ft	-35.275463 psf	113.2996 psf	60.242465 psf	50 psf	0 psf	Lev
Slice 30	-118.56062 ft	45.698063 ft	-97.299124 psf	23.289001 psf	12.382981 psf	50 psf	0 psf	Lev

Rio Guayanilla
Station 52+00
Rapid Drawdown
Concrete Channel
Trench, Shallow failure

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	01 Levee	Mohr-Coulomb	114	0	28	0	2,000	0	1	2
	02 Stiff clay CL	Mohr-Coulomb	115	0	26	0	1,000	0	1	2
	03 Dense gravel GP	Mohr-Coulomb	134	0	35	0	0	0	1	2
	04 Soft clay CL	Mohr-Coulomb	117	0	24	0	250	0	1	2
	05 Loose stilty sand SM	Mohr-Coulomb	112	0	29	0	0	0	1	2
	06 Medium dense gravel GP	Mohr-Coulomb	134	0	35	0	0	0	1	2
	07 Loose clayey sand SC	Mohr-Coulomb	120	0	30	0	0	0	1	2
	08 Soft clay CL	Mohr-Coulomb	115	0	24	0	250	0	1	2
	09 Medium dense clayey sand SC	Mohr-Coulomb	109	0	30	0	0	0	1	2
	10 Medium dense silty sand SM	Mohr-Coulomb	96	0	30	0	0	0	1	2
	11 Stiff clay CL	Mohr-Coulomb	115	0	30	0	1,500	0	1	2
	12 Riprap	Mohr-Coulomb	150	0	40	0	0	0	1	2
	13 Concrete	Mohr-Coulomb	150	4,000	0	0	0	0	1	2





SLOPE/W - RD shallow

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File Information

File Version: 9.01
Created By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Last Edited By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Revision Number: 115
Date: 08/16/2019
Time: 09:19:41 AM
Tool Version: 9.1.1.16749
File Name: 52+00 trench RD concrete.gsz
Directory: C:\Users\h6ts9yjs\Desktop\draft\
Last Solved Date: 08/16/2019
Last Solved Time: 09:19:48 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W - RD shallow

Description: Station 52+00 Rapid Drawdown Concrete Channel Trench, Shallow failure
Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: Yes
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

01 Levee

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Cohesion R: 2,000 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

02 Stiff clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 26 °
Phi-B: 0 °
Cohesion R: 1,000 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

03 Dense gravel GP

Model: Mohr-Coulomb
Unit Weight: 134 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1

Piezometric Line After Drawdown: 2

04 Soft clay CL

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion': 0 psf
Phi': 24 °
Phi-B: 0 °
Cohesion R: 250 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

05 Loose stilty sand SM

Model: Mohr-Coulomb
Unit Weight: 112 pcf
Cohesion': 0 psf
Phi': 29 °
Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

06 Medium dense gravel GP

Model: Mohr-Coulomb
Unit Weight: 134 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

07 Loose clayey sand SC

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1

Piezometric Line After Drawdown: 2

08 Soft clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 24 °
Phi-B: 0 °
Cohesion R: 250 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

09 Medium dense clayey sand SC

Model: Mohr-Coulomb
Unit Weight: 109 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

10 Medium dense silty sand SM

Model: Mohr-Coulomb
Unit Weight: 96 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

11 Stiff clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Cohesion R: 1,500 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1

Piezometric Line After Drawdown: 2

12 Riprap

Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 0 psf
Phi': 40 °
Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

13 Concrete

Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 4,000 psf
Phi': 0 °
Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (-106.31776, 81.948893) ft
Lower Left: (-73.45342, 81.948893) ft
Lower Right: (-73.45342, 49.944441) ft
Grid Horizontal Increment: 10
Grid Vertical Increment: 10

Slip Surface Radius

Upper Left Coordinate: (-110.93862, 45.832036) ft
Upper Right Coordinate: (-81.51086, 45.832036) ft
Lower Left Coordinate: (-110.93862, 35.824083) ft
Lower Right Coordinate: (-81.51086, 35.824083) ft
Number of Increments: 10
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-180, 41.818182) ft
Right Coordinate: (0, 31.4) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-119 ft	46.5 ft
Coordinate 2	0 ft	46.5 ft

Piezometric Line 2

Coordinates

	X	Y
Coordinate 1	-180 ft	31 ft
Coordinate 2	0 ft	31 ft

Points

	X	Y
Point 1	-180 ft	41.818182 ft
Point 2	-152.57919 ft	41.818182 ft
Point 3	-145.33937 ft	41.818182 ft
Point 4	-132.5 ft	42 ft
Point 5	-119 ft	46.5 ft
Point 6	-99 ft	46.5 ft
Point 7	-86.5 ft	42 ft
Point 8	-71.13122 ft	41.818182 ft
Point 9	-50.31674 ft	31.818182 ft
Point 10	0 ft	31.4 ft
Point 11	-180 ft	35.5 ft
Point 12	-180 ft	13.5 ft
Point 13	-180 ft	8.5 ft
Point 14	-180 ft	3.5 ft

Point 15	-180 ft	-1 ft
Point 16	-180 ft	-6 ft
Point 17	-180 ft	-11 ft
Point 18	-180 ft	-16 ft
Point 19	-180 ft	-17 ft
Point 20	-180 ft	-20 ft
Point 21	0 ft	-20 ft
Point 22	0 ft	-17 ft
Point 23	0 ft	-16 ft
Point 24	0 ft	-11 ft
Point 25	0 ft	13.5 ft
Point 26	0 ft	8.5 ft
Point 27	0 ft	3 ft
Point 28	0 ft	-1 ft
Point 29	0 ft	-6 ft
Point 30	-104 ft	46.5 ft
Point 31	-86.50667 ft	40.495158 ft
Point 32	-58.83323 ft	35.5 ft
Point 33	-50.5 ft	31.5 ft
Point 34	0 ft	31 ft
Point 35	-68.5 ft	40.5 ft
Point 36	-69.25156 ft	40.5 ft
Point 37	-137.5 ft	41.929195 ft
Point 38	-137.5 ft	35.5 ft
Point 39	-140.5 ft	35.5 ft
Point 40	-140.5 ft	41.886712 ft

Regions

	Material	Points	Area
Region 1	04 Soft clay CL	25,26,13,12	900 ft²
Region 2	05 Loose stilty sand SM	26,27,14,13	945 ft²
Region 3	06 Medium dense gravel GP	27,28,15,14	765 ft²
Region 4	07 Loose clayey sand SC	29,28,15,16	900 ft²
Region 5	11 Stiff clay CL	21,22,19,20	540 ft²
Region 6	09 Medium dense clayey sand SC	24,23,18,17	900 ft²

Region 7	10 Medium dense silty sand SM	23,22,19,18	180 ft²
Region 8	08 Soft clay CL	29,24,17,16	900 ft²
Region 9	12 Riprap	35,8,7,6,30,31,36	47.869 ft²
Region 10	01 Levee	31,4,5,30	158.68 ft²
Region 11	02 Stiff clay CL	4,37,38,32,36,31	408.95 ft²
Region 12	13 Concrete	33,32,36,35,9,10,34	25.21 ft²
Region 13	03 Dense gravel GP	25,34,33,32,38,39,11,12	3,728.7 ft²
Region 14	02 Stiff clay CL	3,2,1,11,39,40	249.73 ft²
Region 15	03 Dense gravel GP	38,37,40,39	19.224 ft²

Slip Results

Slip Surfaces Analysed: 825 of 1331 converged

Current Slip Surface

Slip Surface: 579
Factor of Safety: 2.611
Volume: 45.767045 ft³
Weight: 6,291.6423 lbf
Resisting Moment: 59,193.782 lbf·ft
Activating Moment: 22,674.496 lbf·ft
Resisting Force: 3,284.1023 lbf
Activating Force: 1,257.9328 lbf
Slip Rank: 45 of 1,331 slip surfaces
Exit: (-78.576694, 41.906265) ft
Entry: (-99.862489, 46.5) ft
Radius: 16.518067 ft
Center: (-86.599156, 56.345331) ft

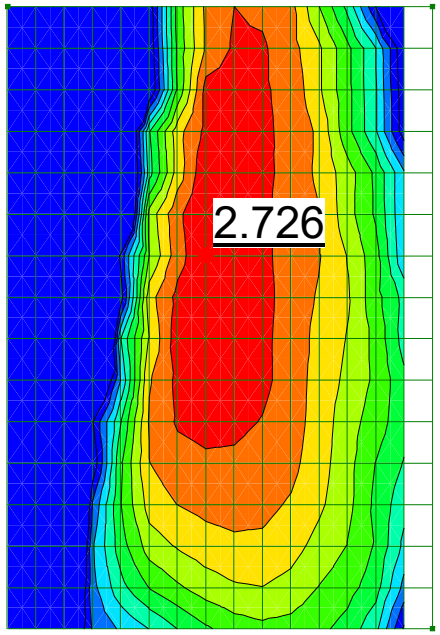
Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Materia
Slice 1	-99.431244 ft	45.966806 ft	-934.38053 psf	50.982514 psf	42.779409 psf	0 psf	0 psf	12 Riprap
Slice 2	-98.538742 ft	44.950311 ft	-870.92054 psf	140.91554 psf	118.24218 psf	0 psf	0 psf	12 Riprap

Slice 3	-97.728913 ft	44.148923 ft	-820.88973 psf	209.97335 psf	111.64481 psf	0 psf	0 psf	01 Levee
Slice 4	-97.03177 ft	43.546703 ft	-783.29304 psf	247.15787 psf	131.41617 psf	0 psf	0 psf	01 Levee
Slice 5	-96.334627 ft	43.008131 ft	-749.66988 psf	279.70699 psf	148.72285 psf	0 psf	0 psf	01 Levee
Slice 6	-95.637484 ft	42.525718 ft	-719.55277 psf	307.85062 psf	163.68708 psf	0 psf	0 psf	01 Levee
Slice 7	-94.940341 ft	42.093733 ft	-692.58383 psf	331.7771 psf	176.40901 psf	0 psf	0 psf	01 Levee
Slice 8	-94.243198 ft	41.70769 ft	-668.48313 psf	351.63782 psf	186.96915 psf	0 psf	0 psf	01 Levee
Slice 9	-93.546055 ft	41.364026 ft	-647.02809 psf	367.55142 psf	195.43056 psf	0 psf	0 psf	01 Levee
Slice 10	-92.848912 ft	41.059871 ft	-628.03967 psf	379.60723 psf	201.84075 psf	0 psf	0 psf	01 Levee
Slice 11	-92.151769 ft	40.792902 ft	-611.37274 psf	387.86796 psf	206.23305 psf	0 psf	0 psf	01 Levee
Slice 12	-91.424874 ft	40.552849 ft	-596.38616 psf	393.21951 psf	191.78597 psf	0 psf	0 psf	02 Stif clay CL
Slice 13	-90.668227 ft	40.341056 ft	-583.1639 psf	393.57202 psf	191.9579 psf	0 psf	0 psf	02 Stif clay CL
Slice 14	-89.91158 ft	40.167406 ft	-572.3229 psf	389.46857 psf	189.95651 psf	0 psf	0 psf	02 Stif clay CL
Slice 15	-89.154934 ft	40.030678 ft	-563.78695 psf	380.87072 psf	185.76306 psf	0 psf	0 psf	02 Stif clay CL

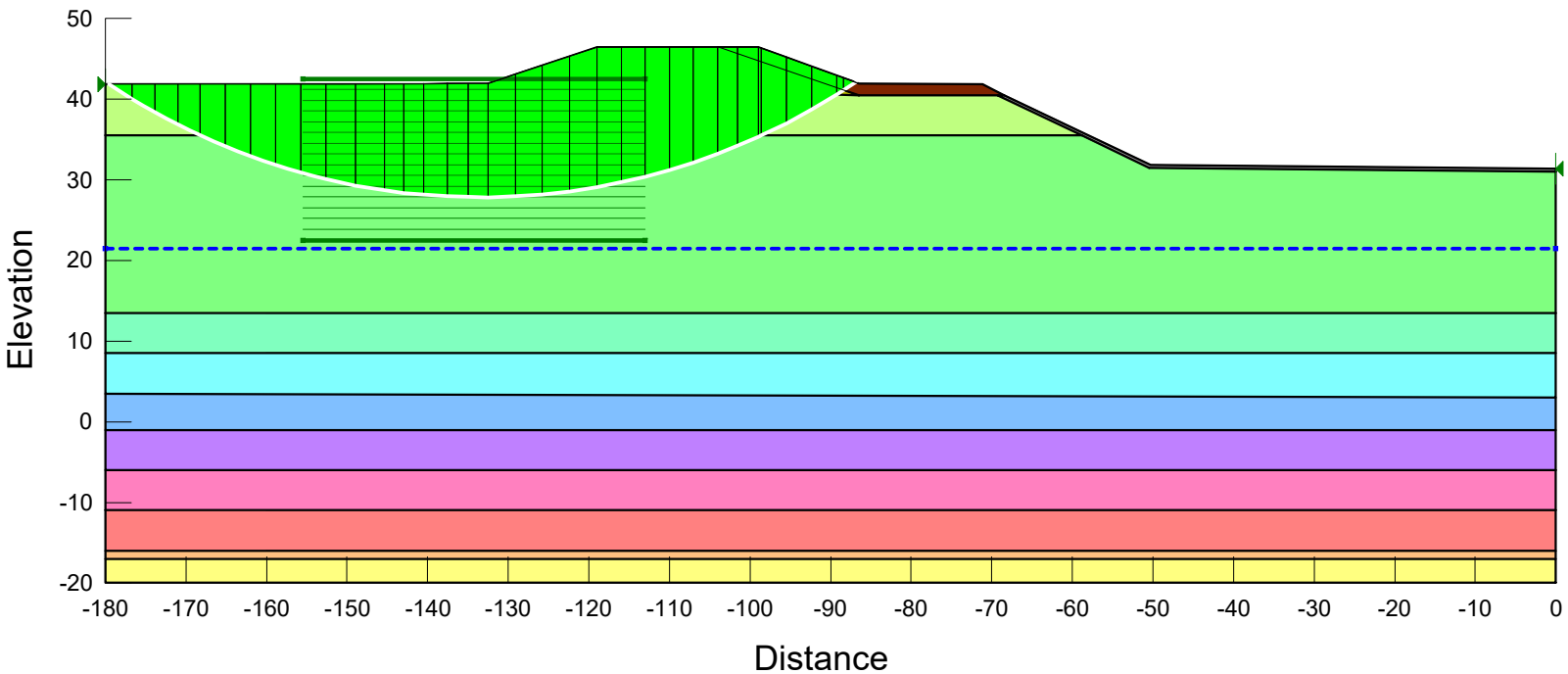
Slice 16	-88.398287 ft	39.929948 ft	-557.49831 psf	367.7065 psf	179.34245 psf	0 psf	0 psf	02 Stif clay CL
Slice 17	-87.64164 ft	39.864553 ft	-553.41569 psf	349.86813 psf	170.64209 psf	0 psf	0 psf	02 Stif clay CL
Slice 18	-86.881658 ft	39.834092 ft	-551.51402 psf	327.04612 psf	159.51105 psf	0 psf	0 psf	02 Stif clay CL
Slice 19	-86.120435 ft	39.83857 ft	-551.79358 psf	314.99751 psf	153.63455 psf	0 psf	0 psf	02 Stif clay CL
Slice 20	-85.361305 ft	39.87811 ft	-554.26207 psf	314.50665 psf	153.39514 psf	0 psf	0 psf	02 Stif clay CL
Slice 21	-84.602175 ft	39.952882 ft	-558.9301 psf	309.65242 psf	151.02758 psf	0 psf	0 psf	02 Stif clay CL
Slice 22	-83.843045 ft	40.063372 ft	-565.82803 psf	300.15564 psf	146.39569 psf	0 psf	0 psf	02 Stif clay CL
Slice 23	-83.083915 ft	40.210316 ft	-575.00178 psf	285.67237 psf	139.33173 psf	0 psf	0 psf	02 Stif clay CL
Slice 24	-82.324785 ft	40.394724 ft	-586.51438 psf	265.77629 psf	129.62776 psf	0 psf	0 psf	02 Stif clay CL
Slice 25	-81.608367 ft	40.603232 ft	-599.53158 psf	257.97874 psf	216.46987 psf	0 psf	0 psf	12 Riprap
Slice 26	-80.934662 ft	40.833031 ft	-613.878 psf	219.05445 psf	183.80851 psf	0 psf	0 psf	12 Riprap
Slice 27	-80.260957 ft	41.096046 ft	-630.29805 psf	170.96756 psf	143.45881 psf	0 psf	0 psf	12 Riprap
Slice 28	-79.587252 ft	41.394033 ft	-648.90145 psf	112.13239 psf	94.09025 psf	0 psf	0 psf	12 Riprap

Slice 29	-78.913547 ft	41.729138 ft	-669.8221 psf	40.408202 psf	33.906508 psf	0 psf	0 psf	12 Riprap



Rio Guayanilla
Station 52+00
Seismic Undrained
Concrete Channel
Normal Water Level
Trench

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	01 Levee	Mohr-Coulomb	114	2,000	0	0	1
	02 Stiff clay CL	Mohr-Coulomb	115	1,000	0	0	1
	03 Dense gravel GP	Mohr-Coulomb	134	0	35	0	1
	04 Soft clay CL	Mohr-Coulomb	117	250	0	0	1
	05 Loose stilty sand SM	Mohr-Coulomb	112	0	29	0	1
	06 Medium dense gravel GP	Mohr-Coulomb	134	0	35	0	1
	07 Loose clayey sand SC	Mohr-Coulomb	120	0	30	0	1
	08 Soft clay CL	Mohr-Coulomb	115	250	0	0	1
	09 Medium dense clayey sand SC	Mohr-Coulomb	109	0	30	0	1
	10 Medium dense silty sand SM	Mohr-Coulomb	96	0	30	0	1
	11 Stiff clay CL	Mohr-Coulomb	115	1,500	0	0	1
	12 Riprap	Mohr-Coulomb	150	0	40	0	1
	13 Concrete	Mohr-Coulomb	150	4,000	0	0	1



SLOPE/W - EOC LS Normal

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File Information

File Version: 9.01
Created By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Last Edited By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Revision Number: 147
Date: 08/16/2019
Time: 09:15:25 AM
Tool Version: 9.1.1.16749
File Name: 52+00 trench Seismic concrete.gsz
Directory: C:\Users\h6ts9yjs\Desktop\draft\
Last Solved Date: 08/16/2019
Last Solved Time: 09:22:10 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W - EOC LS Normal

Description: Station 52+00 Seismic Undrained Concrete Channel Normal Water Level Trench
Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

01 Levee

Model: Mohr-Coulomb
Unit Weight: 114 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

02 Stiff clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 1,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

03 Dense gravel GP

Model: Mohr-Coulomb
Unit Weight: 134 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

04 Soft clay CL

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion': 250 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

05 Loose stilty sand SM

Model: Mohr-Coulomb
Unit Weight: 112 pcf
Cohesion': 0 psf
Phi': 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

06 Medium dense gravel GP

Model: Mohr-Coulomb
Unit Weight: 134 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

07 Loose clayey sand SC

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

08 Soft clay CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 250 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

09 Medium dense clayey sand SC

Model: Mohr-Coulomb
Unit Weight: 109 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

10 Medium dense silty sand SM

Model: Mohr-Coulomb
Unit Weight: 96 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

11 Stiff clay CL

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

12 Riprap

Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 0 psf
Phi': 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

13 Concrete

Model: Mohr-Coulomb
Unit Weight: 150 pcf
Cohesion': 4,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (-157.49403, 141.06825) ft
Lower Left: (-105.86474, 141.06825) ft
Lower Right: (-105.86474, 65.493177) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15

Slip Surface Radius

Upper Left Coordinate: (-155.5, 42.49796) ft

Upper Right Coordinate: (-113, 42.49796) ft
Lower Left Coordinate: (-155.5, 22.519794) ft
Lower Right Coordinate: (-113, 22.519794) ft
Number of Increments: 15
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-180, 41.818182) ft
Right Coordinate: (0, 31.4) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-180 ft	21.5 ft
Coordinate 2	0 ft	21.5 ft

Seismic Coefficients

Horz Seismic Coef.: 0.3

Points

	X	Y
Point 1	-180 ft	41.818182 ft
Point 2	-152.57919 ft	41.818182 ft
Point 3	-145.33937 ft	41.818182 ft
Point 4	-132.5 ft	42 ft
Point 5	-119 ft	46.5 ft
Point 6	-99 ft	46.5 ft
Point 7	-86.5 ft	42 ft
Point 8	-71.13122 ft	41.818182 ft
Point 9	-50.31674 ft	31.818182 ft
Point 10	0 ft	31.4 ft

Point 11	-180 ft	35.5 ft
Point 12	-180 ft	13.5 ft
Point 13	-180 ft	8.5 ft
Point 14	-180 ft	3.5 ft
Point 15	-180 ft	-1 ft
Point 16	-180 ft	-6 ft
Point 17	-180 ft	-11 ft
Point 18	-180 ft	-16 ft
Point 19	-180 ft	-17 ft
Point 20	-180 ft	-20 ft
Point 21	0 ft	-20 ft
Point 22	0 ft	-17 ft
Point 23	0 ft	-16 ft
Point 24	0 ft	-11 ft
Point 25	0 ft	13.5 ft
Point 26	0 ft	8.5 ft
Point 27	0 ft	3 ft
Point 28	0 ft	-1 ft
Point 29	0 ft	-6 ft
Point 30	-104 ft	46.5 ft
Point 31	-86.50667 ft	40.495158 ft
Point 32	-58.83323 ft	35.5 ft
Point 33	-50.5 ft	31.5 ft
Point 34	0 ft	31 ft
Point 35	-68.5 ft	40.5 ft
Point 36	-69.25156 ft	40.5 ft
Point 37	-140.5 ft	35.5 ft
Point 38	-140.5 ft	41.886712 ft
Point 39	-137.5 ft	41.929195 ft
Point 40	-137.5 ft	35.5 ft

Regions

	Material	Points	Area
Region 1	04 Soft clay CL	25,26,13,12	900 ft^2
Region 2	05 Loose stilty sand SM	26,27,14,13	945 ft^2

Region 3	06 Medium dense gravel GP	27,28,15,14	765 ft²
Region 4	07 Loose clayey sand SC	29,28,15,16	900 ft²
Region 5	11 Stiff clay CL	21,22,19,20	540 ft²
Region 6	09 Medium dense clayey sand SC	24,23,18,17	900 ft²
Region 7	10 Medium dense silty sand SM	23,22,19,18	180 ft²
Region 8	08 Soft clay CL	29,24,17,16	900 ft²
Region 9	12 Riprap	35,8,7,6,30,31,36	47.869 ft²
Region 10	01 Levee	31,4,5,30	158.68 ft²
Region 11	02 Stiff clay CL	4,39,40,32,36,31	408.95 ft²
Region 12	13 Concrete	33,32,36,35,9,10,34	25.21 ft²
Region 13	03 Dense gravel GP	25,34,33,32,40,37,11,12	3,728.7 ft²
Region 14	02 Stiff clay CL	3,2,1,11,37,38	249.73 ft²
Region 15	03 Dense gravel GP	38,37,40,39	19.224 ft²

Slip Results

Slip Surfaces Analysed: 2288 of 4096 converged

Current Slip Surface

Slip Surface: 2,156
Factor of Safety: 2.726
Volume: 1,030.8952 ft³
Weight: 126,356.35 lbf
Resisting Moment: 8,845,651.1 lbf·ft
Activating Moment: 3,244,941.4 lbf·ft
Resisting Force: 101,155.93 lbf
Activating Force: 37,106.755 lbf
Slip Rank: 1 of 4,096 slip surfaces
Exit: (-179.48427, 41.818182) ft
Entry: (-86.855704, 42.128054) ft
Radius: 82.990918 ft
Center: (-133.40036, 110.83822) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Materi
Slice 1	-178.07487 ft	40.917669 ft	-1,212.2487 psf	473.6563 psf	0 psf	1,000 psf	0 psf	02 Sti clay CL

Slice 2	-175.25606 ft	39.193764 ft	-1,104.625 psf	656.37175 psf	0 psf	1,000 psf	0 psf	02 Sti clay CL
Slice 3	-172.43725 ft	37.618947 ft	-1,006.3089 psf	818.43653 psf	0 psf	1,000 psf	0 psf	02 Sti clay CL
Slice 4	-169.61845 ft	36.183762 ft	-916.71002 psf	961.77595 psf	0 psf	1,000 psf	0 psf	02 Sti clay CL
Slice 5	-166.64606 ft	34.816478 ft	-831.35022 psf	1,034.9765 psf	724.69835 psf	0 psf	0 psf	03 Dense gravel GP
Slice 6	-163.52009 ft	33.524054 ft	-750.66396 psf	1,217.2041 psf	852.29545 psf	0 psf	0 psf	03 Dense gravel GP
Slice 7	-160.39412 ft	32.377421 ft	-679.07944 psf	1,367.5265 psf	957.55237 psf	0 psf	0 psf	03 Dense gravel GP
Slice 8	-157.26815 ft	31.370255 ft	-616.20186 psf	1,489.7341 psf	1,043.123 psf	0 psf	0 psf	03 Dense gravel GP
Slice 9	-154.14218 ft	30.4973 ft	-561.70315 psf	1,586.8274 psf	1,111.1085 psf	0 psf	0 psf	03 Dense gravel GP
Slice 10	-150.76924 ft	29.706302 ft	-512.32097 psf	1,665.4053 psf	1,166.1294 psf	0 psf	0 psf	03 Dense gravel GP
Slice 11	-147.14933 ft	29.014693 ft	-469.14371 psf	1,723.9878 psf	1,207.1492 psf	0 psf	0 psf	03 Dense gravel GP
Slice 12	-144.12953 ft	28.552812 ft	-440.30838 psf	1,757.1536 psf	1,230.3722 psf	0 psf	0 psf	03 Dense

								gravel GP
Slice 13	-141.70984 ft	28.2733 ft	-422.85842 psf	1,772.9819 psf	1,241.4553 psf	0 psf	0 psf	03 Dense gravel GP
Slice 14	-139 ft	28.050082 ft	-408.92288 psf	1,902.8484 psf	1,332.3888 psf	0 psf	0 psf	03 Dense gravel GP
Slice 15	-136.25 ft	27.905674 ft	-399.90743 psf	1,772.2044 psf	1,240.9108 psf	0 psf	0 psf	03 Dense gravel GP
Slice 16	-133.75 ft	27.857456 ft	-396.89717 psf	1,756.071 psf	1,229.6141 psf	0 psf	0 psf	03 Dense gravel GP
Slice 17	-130.8125 ft	27.904846 ft	-399.85574 psf	1,783.9308 psf	1,249.1218 psf	0 psf	0 psf	03 Dense gravel GP
Slice 18	-127.4375 ft	28.079089 ft	-410.73374 psf	1,849.1874 psf	1,294.8149 psf	0 psf	0 psf	03 Dense gravel GP
Slice 19	-124.0625 ft	28.3918 ft	-430.25638 psf	1,894.2153 psf	1,326.3439 psf	0 psf	0 psf	03 Dense gravel GP
Slice 20	-120.6875 ft	28.844568 ft	-458.52274 psf	1,919.7586 psf	1,344.2294 psf	0 psf	0 psf	03 Dense gravel GP
Slice 21	-117.5 ft	29.399073 ft	-493.14059 psf	1,875.5449 psf	1,313.2707 psf	0 psf	0 psf	03 Dense gravel GP

Slice 22	-114.5 ft	30.042829 ft	-533.33042 psf	1,766.6422 psf	1,237.0162 psf	0 psf	0 psf	03 Dense gravel GP
Slice 23	-111.5 ft	30.804179 ft	-580.86166 psf	1,646.9437 psf	1,153.2024 psf	0 psf	0 psf	03 Dense gravel GP
Slice 24	-108.5 ft	31.686522 ft	-635.94647 psf	1,516.6263 psf	1,061.9532 psf	0 psf	0 psf	03 Dense gravel GP
Slice 25	-105.5 ft	32.693962 ft	-698.84117 psf	1,375.8367 psf	963.3712 psf	0 psf	0 psf	03 Dense gravel GP
Slice 26	-102.75 ft	33.726366 ft	-763.29434 psf	1,251.0455 psf	875.99149 psf	0 psf	0 psf	03 Dense gravel GP
Slice 27	-100.25 ft	34.767948 ft	-828.32048 psf	1,142.938 psf	800.29383 psf	0 psf	0 psf	03 Dense gravel GP
Slice 28	-98.795838 ft	35.40634 ft	-868.17543 psf	1,068.8885 psf	748.44377 psf	0 psf	0 psf	03 Dense gravel GP
Slice 29	-97.029867 ft	36.261684 ft	-921.57469 psf	885.34183 psf	0 psf	1,000 psf	0 psf	02 Sti clay CL
Slice 30	-93.906251 ft	37.868682 ft	-1,021.8999 psf	594.21906 psf	0 psf	1,000 psf	0 psf	02 Sti clay CL
Slice 31	-90.782635 ft	39.648979 ft	-1,133.0442 psf	290.94477 psf	0 psf	1,000 psf	0 psf	02 Sti clay CL
Slice 32	-88.791106 ft	40.857889 ft	-1,208.5167 psf	-43.807106 psf	-0 psf	2,000 psf	0 psf	01 Levee

Slice 33	-87.608545 ft	41.629935 ft	-1,256.7156 psf	84.458914 psf	70.869444 psf	0 psf	0 psf	12 Riprap

Attachment G-5
Settlement Calculations

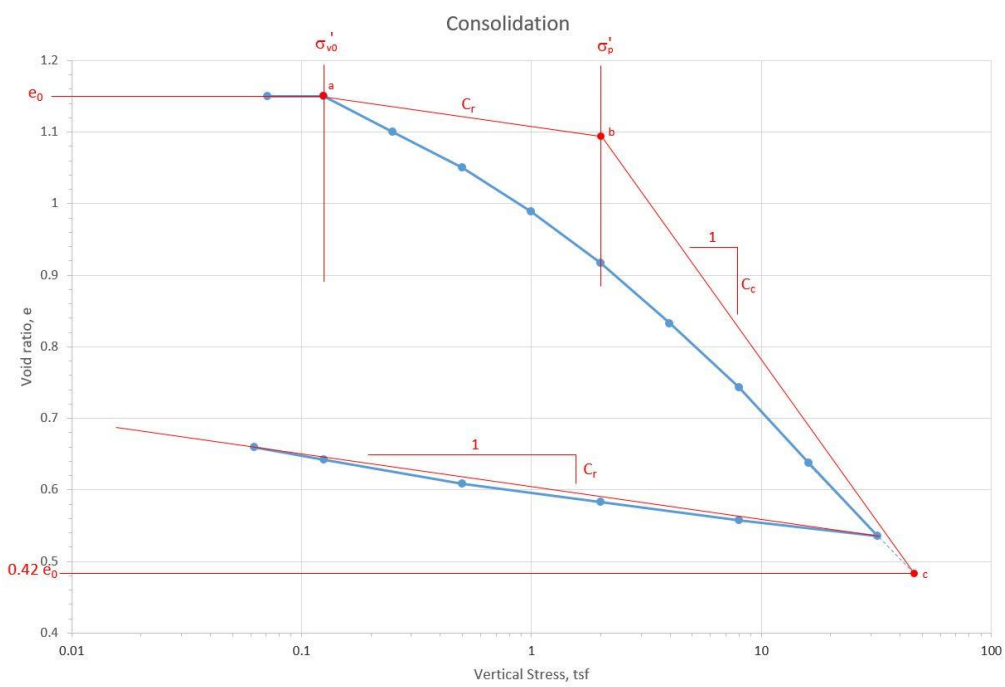
US Army Corps of Engineers® Chicago District	PROJECT TITLE: Rio Guayanilla	COMPUTED BY: YJG	DATE: 8/15/19	SHEET: 1 of 2
	COMPUTATION TITLE: Settlement	CHECKED BY: JH	DATE: 8/15/19	

The stratigraphy of the subsurface was based on the results from boring SB-4-19. A consolidation test was performed on a soft clay sample at elevation 15.2 from this boring. The soil was assumed to be incompressible for clay 50 ft below ground surface and for cohesionless soil. It was assumed that the unit weight of the clay fill to be used for the levee was 114 pcf. The water level was based on the water level data collected after 24-hrs which was at elevation 17.5 ft.

Material	Sat unit weight (pcf)	Top elevation	Bottom elevation
Layer 1 - Stiff clay, some sand (CL)	115	35.2	27.7
Medium dense silty sand (SM)	100	27.7	16.7
Layer 2 - Soft clay (CL)	125	16.7	1.7
Loose silty sand (SM)	112	1.7	-9.3
Layer 3 - Soft clay (CL)	125	-9.3	-13.3
Loose silty sand (SM)	122	-13.3	-23.3
Stiff clay, some sand (CL)	115	-23.3	

The Boussinesq chart for an embankment load of infinite length was used to find the influence factors under vertical stress. The influence factors were doubled for the calculations since the chart was for only half of the embankment. The chart is attached with the calculations. The clay layers were subdivided into smaller layers to calculate settlement.

The consolidation data was graphed to plot void ratio versus vertical stress. The Schmertmann procedure was used to develop the field virgin compression curve. Point a (σ_{v0}') and point b (σ_p') were determined from the inflection points on the curve and connected by the slope from C_r. Point c was the intersection of the extended compression curve and $0.42e_0$. Cc was determined by connecting point b and c. The slopes were derived graphically.



$$C_c = \frac{e_1 - e_2}{\log\frac{\sigma_2'}{\sigma_1'}} = \frac{1.09-0.78}{\log\frac{10}{2}} = \frac{0.31}{0.699} = 0.44$$

$$C_r = \frac{e_1 - e_2}{\log\frac{\sigma_2'}{\sigma_1'}} = \frac{0.66-0.535}{\log\frac{32}{0.0625}} = \frac{0.125}{2.71} = 0.046$$

Based on the test data, the following parameters were used:

	σ_p' (psf)	e_o	C_c	C_r
Clay	4000	1.15	0.44	0.046

There are two equations to determine the settlement of the foundation but only the first applied since the preconsolidation pressure was higher than the effective vertical stress and load.

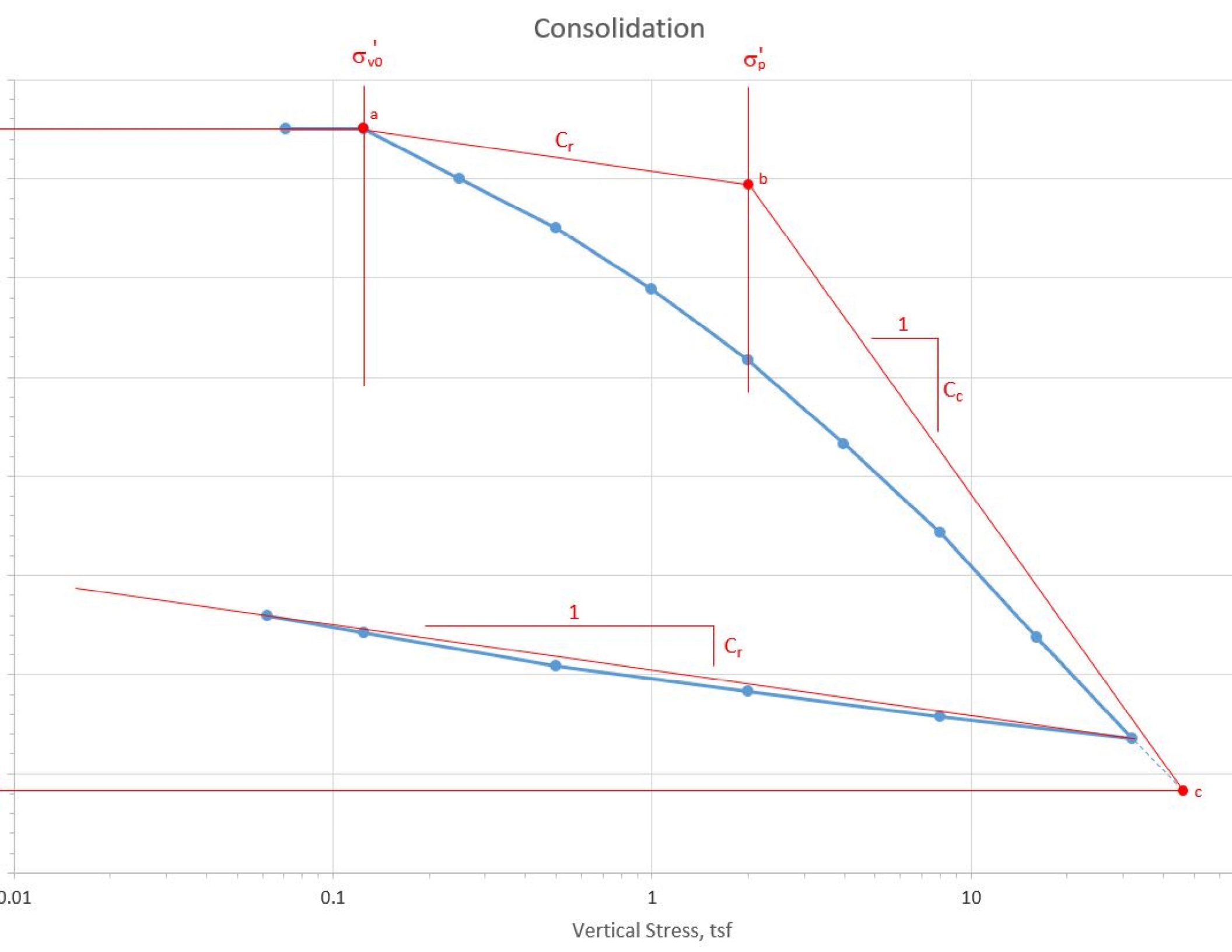
$$\sigma_{vo}' + \Delta\sigma_v \leq \sigma_p' : S_c = C_r \frac{H_0}{1+e_0} \log \frac{\sigma_{v0}' + \Delta\sigma_v}{\sigma_{v0}'}$$

$$\sigma_{vo}' + \Delta\sigma_v \geq \sigma_p' : S_c = C_r \frac{H_0}{1+e_0} \log \frac{\sigma_p'}{\sigma_{v0}'} + C_c \frac{H_0}{1+e_0} \log \frac{\sigma_{v0}' + \Delta\sigma_v}{\sigma_p'}$$

Layer	H	z	a/z	b/z	I	σ_{vo}'	$\Delta\sigma_v$	C_r	C_c	s (ft)	s (in)
1 - 1	3.5	1.75	8.57	4.29	1	201.25	570.0	0.046	0.44	0.04	0.5
1 - 2	4	5.5	2.73	1.36	0.97	632.5	552.9	0.046	0.44	0.02	0.3
2 - 1	5	21	0.71	0.36	0.66	2069.08	376.2	0.046	0.44	0.01	0.1
2 - 2	5	26	0.58	0.29	0.59	2382.08	336.3	0.046	0.44	0.01	0.1
2 - 3	5	31	0.48	0.24	0.52	2695.08	296.4	0.046	0.44	0.00	0.1
3 - 1	4	46.5	0.32	0.16	0.36	3522.38	205.2	0.046	0.44	0.00	0.0
										TOTAL =	1.1

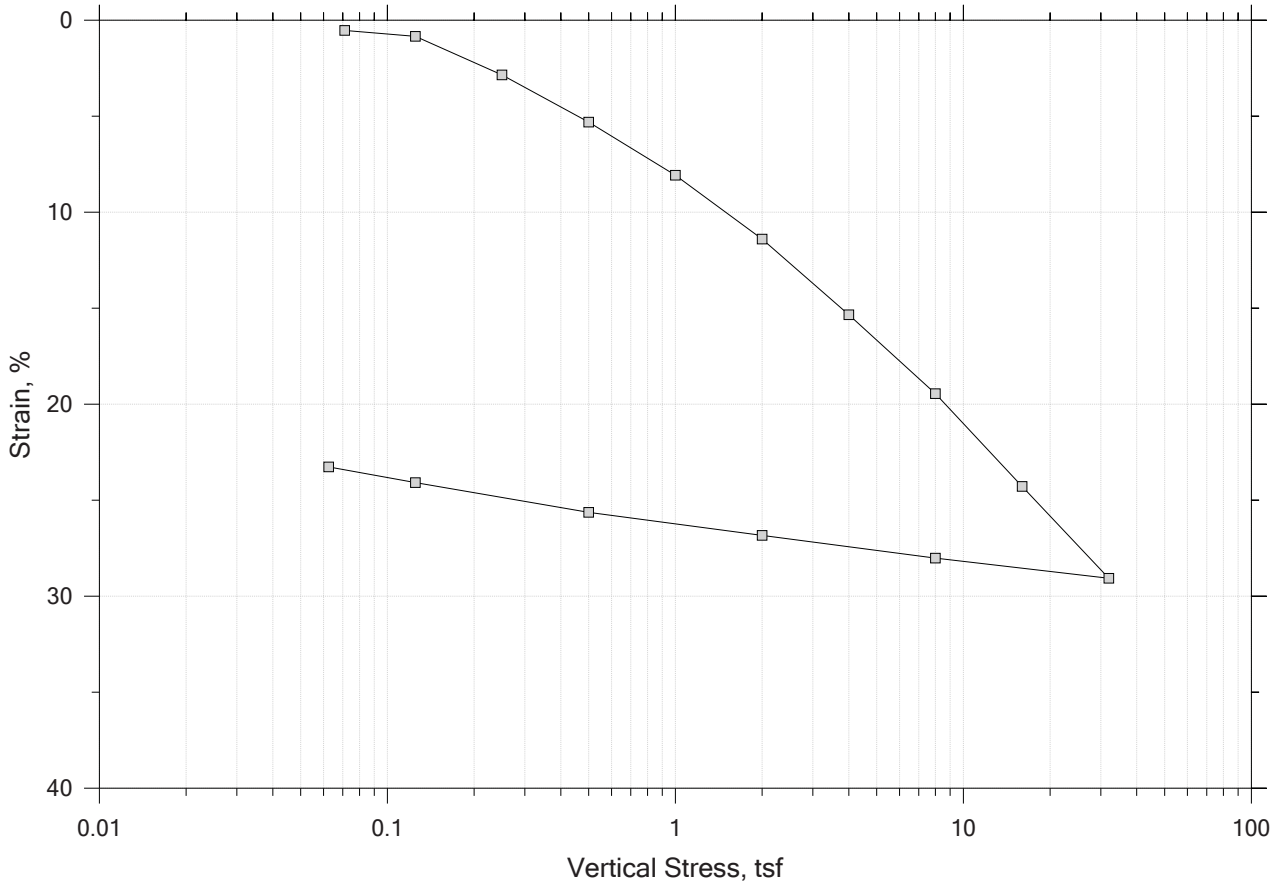
The total settlement is estimated to be about 1 inch for a 5 ft tall levee along this area.

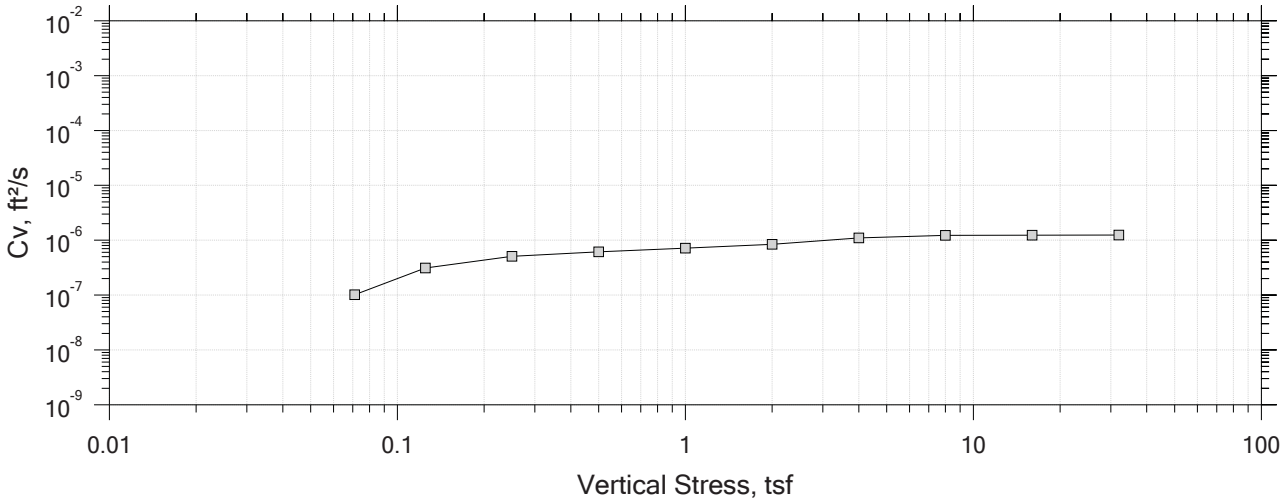
The Phase 1 levee was constructed over softer clays where prior settlement analyses indicated anticipated settlement of 50 inches over 14 to 18 years. It is expected that any levees constructed near this area would experience similar amounts of settlement and would need to include overbuild.


Consolidation
σ'v0
σ'p
a
b
c
Cr
1
Cc
1
Cr
0.01
0.1
1
10
Vertical Stress, tsf

One-Dimensional Consolidation by ASTM D2435 - Method B

Summary Report





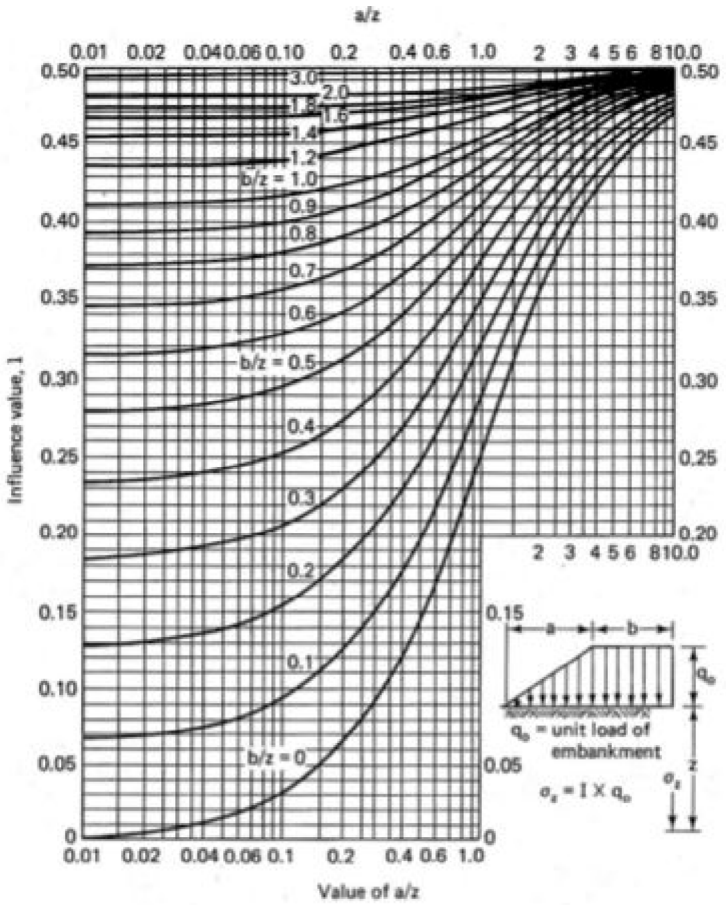
GeoTesting EXPRESS	Project: Guayanilla Feasibility Study	Location: Guayanilla , PR	Project No.: GTX-309756
	Boring No.: SB-4-19	Tested By: trm	Checked By: njh
	Sample No.: T-1	Test Date: 4/8/19	Depth: ---
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, brownish gray sandy clay		
	Remarks: System LTIII-B, Swell Pressure = 0.071 tsf		
	Displacement at End of Increment		

One-Dimensional Consolidation by ASTM D2435 - Method B

Log of Time Coefficients

Step	Applied Stress tsf	Final Displacement in	Void Ratio	Strain at End %	Log T50 min	Cv ft²/s	Mv 1/tsf	k ft/day	Ca %
1	0.0710	0.005302	1.15	0.530	0.000	0.00e+00	7.46e-02	0.00e+00	0.00e+00
2	0.125	0.008386	1.15	0.839	18.098	3.11e-07	5.71e-02	4.79e-05	0.00e+00
3	0.250	0.02851	1.10	2.85	11.346	4.84e-07	1.61e-01	2.10e-04	0.00e+00
4	0.500	0.05304	1.05	5.30	0.000	0.00e+00	9.81e-02	0.00e+00	0.00e+00
5	1.00	0.08075	0.989	8.07	7.026	7.06e-07	5.54e-02	1.06e-04	0.00e+00
6	2.00	0.1140	0.917	11.4	4.817	9.64e-07	3.33e-02	8.65e-05	0.00e+00
7	4.00	0.1534	0.832	15.3	3.240	1.32e-06	1.97e-02	7.02e-05	0.00e+00
8	8.00	0.1945	0.743	19.4	2.918	1.33e-06	1.03e-02	3.69e-05	0.00e+00
9	16.0	0.2429	0.638	24.3	2.556	1.36e-06	6.05e-03	2.22e-05	0.00e+00
10	32.0	0.2907	0.535	29.1	2.451	1.25e-06	2.99e-03	1.01e-05	0.00e+00
11	8.00	0.2801	0.557	28.0	0.000	0.00e+00	4.41e-04	0.00e+00	0.00e+00
12	2.00	0.2683	0.583	26.8	0.000	0.00e+00	1.97e-03	0.00e+00	0.00e+00
13	0.500	0.2563	0.609	25.6	16.466	1.88e-07	8.01e-03	4.07e-06	0.00e+00
14	0.125	0.2408	0.642	24.1	0.000	0.00e+00	4.13e-02	0.00e+00	0.00e+00
15	0.0625	0.2327	0.660	23.3	0.000	0.00e+00	1.30e-01	0.00e+00	0.00e+00

GeoTesting EXPRESS	Project: Guayanilla Feasibility Study	Location: Guayanilla , PR	Project No.: GTX-309756
	Boring No.: SB-4-19	Tested By: trm	Checked By: njh
	Sample No.: T-1	Test Date: 4/8/19	Depth: ---
	Test No.: IP-1	Sample Type: intact	Elevation: ---
	Description: Moist, brownish gray sandy clay		
	Remarks: System LTIII-B, Swell Pressure = 0.071 tsf		
	Displacement at End of Increment		



Influence Factors for Vertical Stress Under a Very Long Embankment
(After NAVFAC, 1971 as Reported in Holtz and Kovacs, 1981)
Figure 9-2

Attachment G-6
Fragility Curve Memos

CELRC-TS-DG 25 March 2019

MEMORANDUM FOR PM-PL

SUBJECT: Fragility Curve Determination for Existing Rio Guayanilla Berms

Introduction

1. This memorandum discusses the fragility curve of the existing berm along the Rio Guayanilla. A fragility curve, as defined in EM 1110-2-1619, 'Risk-Based Analysis for Flood Damage Reduction Studies', is a statistical distribution of levee failure which is used to develop the stage-damage function and description of the overall uncertainty of that function.

2. The fragility curve is defined by determining two points on a graph; the probable failure point (PFP) and probable non-failure point (PNP). The PFP is defined as the water elevation above which the levee is highly likely to fail, set at 85% failure rate in the EM. The PNP is defined as the water elevation below which the levee has a low likelihood of failure, set at 15% failure rate in the EM. Figure 7-4 is extracted from EM 1110-2-1619 to illustrate the fragility curve, as shown below.

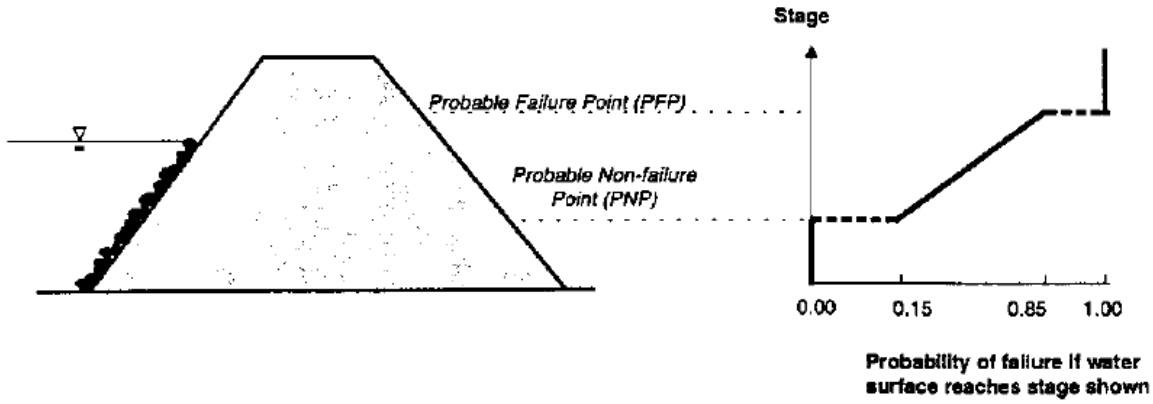


Figure 1. Levee failure probability function from EM 1110-2-1619, Figure 7-4

3. A fragility curve was developed for the existing levee through town. A global stability analysis using SLOPE/W determined that the Factor of Safety was much higher than the recommended minimum for steady-state seepage per EM 1110-2-1913, so the driver for the PFP and PNP would be the likelihood of failure.

Levee Background

4. The Town of Guayanilla is located on the southern part of Puerto Rico and experiences frequent floods from the Rio Guayanilla which runs through the middle of the town. The residents built up berms along the banks to help protect against flooding. Based on information from the locals, portions of the berm have been overtopped. The location that was overtopped is shown below.

Figure 2. Overtopping location

5. A field visit was completed on March 20, 2019. As shown in the photo below, the overtopping location is at a low spot where the crest dips. The slopes of the levee are covered with grass and shrubs and there are some mature trees on the crest to the west. No culverts or encroachments were identified. There are no soil borings at that location but SB-5 is about 2,000 ft to the northwest and B-2 is about 2,000 ft to the southeast. No other issues were noted at that location but animal borrows were observed in the banks further upstream.

Figure 3. Photo of overtopping location

SLOPE/W Analysis

6. SLOPE/W software was used to model the global stability of the existing berm for the steady state seepage condition since the berms have been in place for years and have experienced previous loading. A cross section through the low area based on LiDAR data was used. Boring SB-5 was used to develop the stratigraphy. The soil parameters are based on typical values for the materials and are shown in the figure below. Laboratory testing is still being performed so all of the data is not yet available to develop parameters based on site conditions. A SEEP/W analysis was used to develop the water level. The Spencer method was used in the program to calculate the Factor of Safety which resulted in a factor of safety of 1.79 under fully loaded conditions. This is higher than the factor of safety of 1.4 recommended for the steady state condition in EM 1110-2-1913. Therefore, it does not appear that slope instability would occur on the landside slope when the levee is loaded to the top.

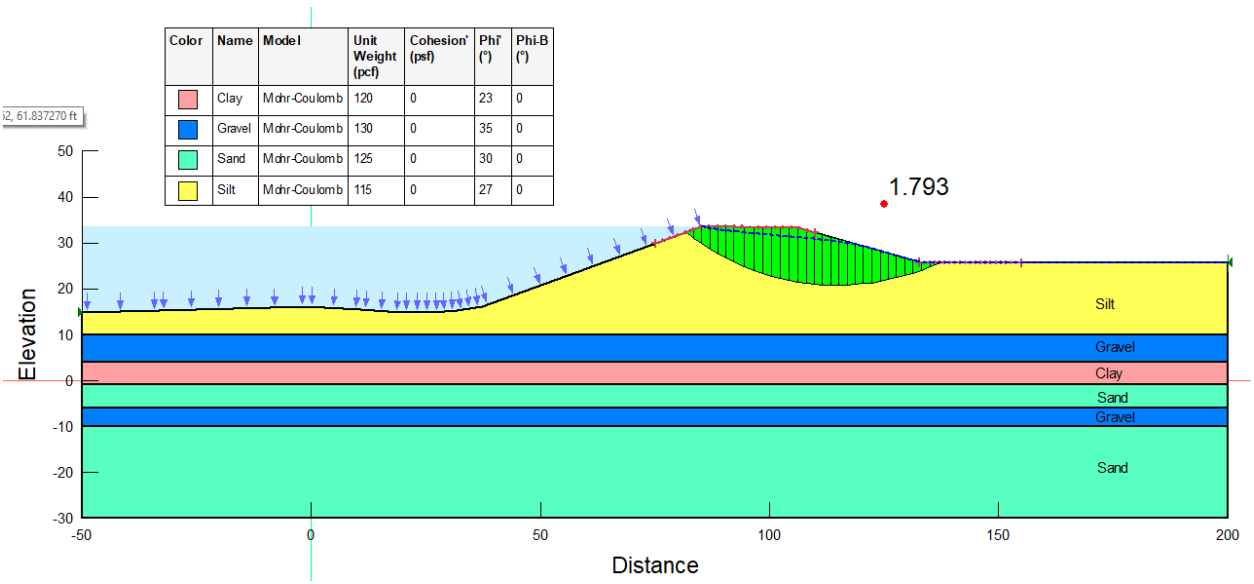


Figure 4. SLOPE/W results

PFP and PNP Determination

7. Based on the field inspection, animal burrows have been noted in the banks in other locations along the river channel and large trees were growing on the berm. Tree roots and animal burrows create seepage paths through the berm. As trees mature and die, they are more likely to fall over during storm events, increasing the incidence of significant root ball upheaval from the levee leading to decay of the levee section.

8. The Probable Failure Point (PFP) (85% chance of failure) is at the top of the lowest point of the berm at elevation 33.6 for the most likely failure scenario. At this elevation, the berm would be overtopped and susceptible to erosion of the crest and landside slope, which could lead to failure. The berm has experienced overtopping at this location in the past.

9. Based on LiDAR data, the crest width is approximately 21 feet wide at the low spot. EM 1110-2-1905 recommends a minimum crest width of 10 feet. Since the actual crest is about twice the recommended width and there is good grass cover on the slopes and ground, the berm has some resiliency.

10. To determine the Probable No Failure Point (PNP) (15% chance of failure) elevation, the trees and animal burrows were determined to be the controlling factor. While the levee is wider than necessary, issues could arise such as seepage due to large animal burrows or fallen/dead trees on the slope which could lead to a breach and would extend to the levee toe. The levee toe is about elevation 25.7 ft and was chosen as the PNP because this elevation is when flood-fighting activities would start should a breach occur.

Summary

11. These points for the Fragility Curve are based on existing knowledge and field observations. Each subsequent flood event will continue to degrade the levee and lead to more issues with seepage, erosion, and eventually instability and failure.

Failure Node	Probability of Failure by Node	Elevation Assignment for M. Likely P(f)
Levee Crest	1.00	33.6
Probable Failure Point (PFP)	0.85	33.6
Probable Non-Failure Point (PNP)	0.15	25.7
Levee Toe	0.00	25.7

Table 1. Summary of Fragility Curve Points

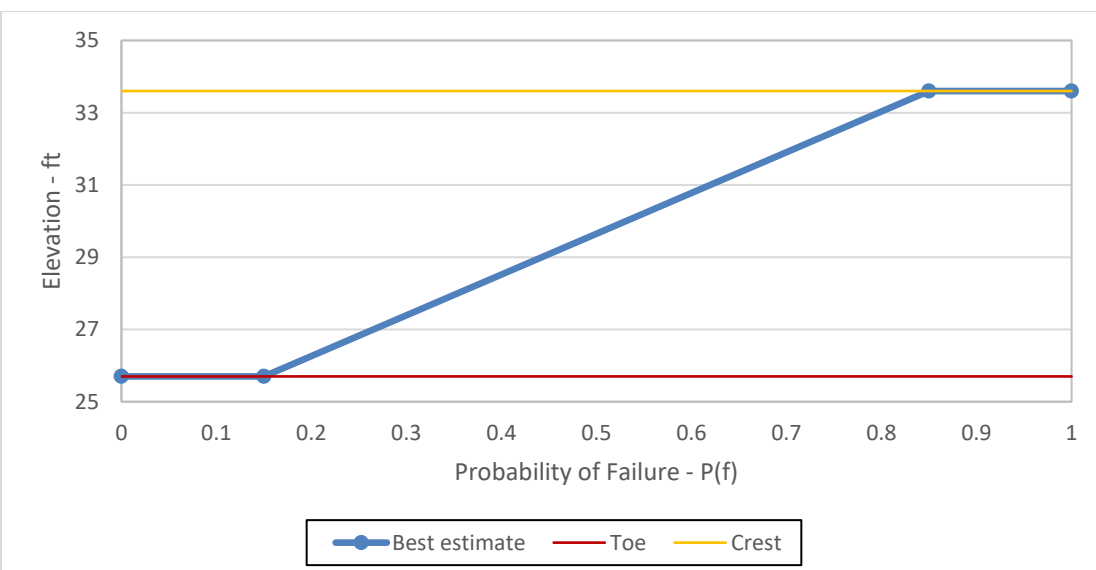


Figure 5. Fragility Curve

12. There is some uncertainty that may not produce accurate PFP and PNP elevations.

    a. There are no borings at the low spot so actual subsurface conditions may not be captured.
    b. Permeability test results were not available at the time this memo was prepared.
    c. The model cannot take into account features such as the trees or burrows. Trees provide seepage paths along their root systems, particularly after a tree dies and the roots rot away. Burrows allow connections between the riverside and landside.

SLOPE/W

Report generated using GeoStudio 2018 R2. Copyright © 1991-2018 GEOSLOPE International Ltd.

File Information

File Version: 9.01
Created By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Last Edited By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Revision Number: 46
Date: 04/25/2019
Time: 10:06:01 AM
Tool Version: 9.1.1.16749
File Name: Existing.gsz
Directory: C:\Users\h6ts9yjs\Desktop\temp\Rio Guayanilla\Fragility curve\
Last Solved Date: 04/25/2019
Last Solved Time: 10:06:14 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W

Kind: SLOPE/W
Parent: Steady State
Method: Spencer
Settings
    PWP Conditions from: Parent Analysis
    Unit Weight of Water: 62.430189 pcf
Slip Surface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 1
    Optimize Critical Slip Surface Location: No
    Tension Crack Option: (none)
Distribution
    F of S Calculation Option: Constant
Advanced
    Geometry Settings
        Minimum Slip Surface Depth: 1 ft
        Number of Slices: 30
    Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Silt

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 27 °
Phi-B: 0 °

Sand

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

Gravel

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °

Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 23 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (75, 29.925816) ft
Left-Zone Right Coordinate: (109.96735, 32.241333) ft
Left-Zone Increment: 20
Right Type: Range
Right-Zone Left Coordinate: (132.69896, 25.808441) ft

Right-Zone Right Coordinate: (154.95914, 25.714286) ft
Right-Zone Increment: 20
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-50, 14.920635) ft
Right Coordinate: (200, 25.714286) ft

Points

	X	Y
Point 1	-50 ft	14.920635 ft
Point 2	-33.25792 ft	15.238095 ft
Point 3	-0.95023 ft	16.190476 ft
Point 4	10.76923 ft	15.555556 ft
Point 5	19.63801 ft	14.920635 ft
Point 6	26.28959 ft	14.920635 ft
Point 7	31.67421 ft	15.238095 ft
Point 8	37.37557 ft	16.190476 ft
Point 9	85.20362 ft	33.650794 ft
Point 10	92.17195 ft	33.650794 ft
Point 11	96.60633 ft	33.333333 ft
Point 12	106.1086 ft	33.333333 ft
Point 13	133.03167 ft	25.714286 ft
Point 14	200 ft	25.714286 ft
Point 15	200 ft	10 ft
Point 16	-50 ft	10 ft
Point 17	-50 ft	4 ft
Point 18	200 ft	4 ft
Point 19	200 ft	-1 ft
Point 20	-50 ft	-1 ft
Point 21	-50 ft	-6 ft
Point 22	200 ft	-6 ft
Point 23	-50 ft	-10 ft
Point 24	200 ft	-10 ft
Point 25	200 ft	-30 ft
Point 26	-50 ft	-30 ft

Regions

	Material	Points	Area
Region 1	Silt	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	3,259.9 ft²
Region 2	Gravel	16,17,18,15	1,500 ft²
Region 3	Clay	17,18,19,20	1,250 ft²
Region 4	Sand	20,21,22,19	1,250 ft²
Region 5	Gravel	21,23,24,22	1,000 ft²
Region 6	Sand	23,24,25,26	5,000 ft²

Slip Results

Slip Surfaces Analysed: 4380 of 4851 converged

Current Slip Surface

Slip Surface: 972
Factor of Safety: 1.793
Volume: 404.52515 ft³
Weight: 46,520.392 lbf
Resisting Moment: 614,203.36 lbf·ft
Activating Moment: 342,433.85 lbf·ft
Resisting Force: 11,140.118 lbf
Activating Force: 6,212.1815 lbf
Slip Rank: 2,568 of 4,851 slip surfaces
Exit: (137.14054, 25.714286) ft
Entry: (81.723747, 32.380416) ft
Radius: 53.126653 ft
Center: (114.83108, 73.929731) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength
Slice 1	82.593715 ft	31.716047 ft	109.77677 psf	146.26092 psf	18.589603 psf	0 psf	0 psf
Slice 2	84.333652 ft	30.441585 ft	169.49259 psf	299.71697 psf	66.352635 psf	0 psf	0 psf
Slice 3	86.074661 ft	29.27062 ft	226.0822 psf	433.29403 psf	105.5797 psf	0 psf	0 psf
Slice 4	87.816744 ft	28.195244 ft	279.35138 psf	546.15271 psf	135.94207 psf	0 psf	0 psf

Slice 5	89.558826 ft	27.209569 ft	328.75854 psf	652.43929 psf	164.92358 psf	0 psf	0 psf
Slice 6	91.300909 ft	26.308011 ft	374.24028 psf	752.29462 psf	192.62831 psf	0 psf	0 psf
Slice 7	93.280545 ft	25.385479 ft	420.74706 psf	849.56893 psf	218.49565 psf	0 psf	0 psf
Slice 8	95.497735 ft	24.460082 ft	467.25713 psf	942.32495 psf	242.05915 psf	0 psf	0 psf
Slice 9	97.556557 ft	23.700036 ft	505.03653 psf	1,026.5913 psf	265.74544 psf	0 psf	0 psf
Slice 10	99.457011 ft	23.085915 ft	534.94404 psf	1,104.1154 psf	290.00728 psf	0 psf	0 psf
Slice 11	101.35746 ft	22.549406 ft	560.25381 psf	1,174.6536 psf	313.05231 psf	0 psf	0 psf
Slice 12	103.25792 ft	22.088096 ft	581.01611 psf	1,238.2648 psf	334.88495 psf	0 psf	0 psf
Slice 13	105.15837 ft	21.699989 ft	597.23716 psf	1,294.9842 psf	355.51987 psf	0 psf	0 psf
Slice 14	107.00604 ft	21.39035 ft	608.54477 psf	1,315.0716 psf	359.99342 psf	0 psf	0 psf
Slice 15	108.80091 ft	21.154147 ft	615.16007 psf	1,297.5906 psf	347.71572 psf	0 psf	0 psf
Slice 16	110.59578 ft	20.979822 ft	617.44787 psf	1,272.2129 psf	333.61943 psf	0 psf	0 psf
Slice 17	112.39065 ft	20.866765 ft	615.35839 psf	1,238.8422 psf	317.68089 psf	0 psf	0 psf
Slice 18	114.18552 ft	20.814583 ft	608.64889 psf	1,197.3557 psf	299.96109 psf	0 psf	0 psf
Slice 19	115.98039 ft	20.823098 ft	597.13321 psf	1,147.5975 psf	280.47558 psf	0 psf	0 psf
Slice 20	117.77526 ft	20.892337 ft	580.68221 psf	1,089.3727 psf	259.19076 psf	0 psf	0 psf
Slice 21	119.57013 ft	21.022541 ft	558.87372 psf	1,022.4639 psf	236.21101 psf	0 psf	0 psf
Slice 22	121.36501 ft	21.214162 ft	531.60863 psf	946.59019 psf	211.44366 psf	0 psf	0 psf
Slice 23	123.15988 ft	21.467872 ft	498.44959 psf	861.44438 psf	184.95508 psf	0 psf	0 psf

Slice 24	124.95475 ft	21.78458 ft	459.00413 psf	766.66235 psf	156.75969 psf	0 psf	0 psf
Slice 25	126.74962 ft	22.165443 ft	412.59451 psf	661.84988 psf	127.00195 psf	0 psf	0 psf
Slice 26	128.54449 ft	22.611891 ft	358.77533 psf	546.51649 psf	95.658897 psf	0 psf	0 psf
Slice 27	130.33936 ft	23.125657 ft	296.5677 psf	420.15977 psf	62.973302 psf	0 psf	0 psf
Slice 28	132.13423 ft	23.708808 ft	225.90406 psf	282.03673 psf	28.601025 psf	0 psf	0 psf
Slice 29	134.05889 ft	24.416921 ft	138.77115 psf	162.02964 psf	11.850795 psf	0 psf	0 psf
Slice 30	136.11332 ft	25.265059 ft	44.963814 psf	57.440619 psf	6.3572495 psf	0 psf	0 psf

Steady State

Report generated using GeoStudio 2018 R2. Copyright © 1991-2018 GEOSLOPE International Ltd.

File Information

File Version: 9.01
Created By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Last Edited By: Galisanao, Yuki J CIV USARMY CELRC (USA)
Revision Number: 46
Date: 04/25/2019
Time: 10:06:01 AM
Tool Version: 9.1.1.16749
File Name: Existing.gsz
Directory: C:\Users\h6ts9yjs\Desktop\temp\Rio Guayanilla\Fragility curve\
Last Solved Date: 04/25/2019
Last Solved Time: 10:06:10 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Steady State

Kind: SEEP/W
Method: Steady-State
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Maximum Number of Iterations: 500
- Maximum Difference: 0.005
- Significant Digits: 2
- Max # of Reviews: 10
- Under-Relaxation Criteria
  - Initial Rate: 1
  - Minimum Rate: 0.1
  - Rate Reduction Factor: 0.65
  - Reduction Frequency (iterations): 10
- Unit Weight of Water: 62.430189 pcf
- Bulk Modulus of Pore-Fluid: 43,511,321 psf

Settings
- Dimension: 2D

Time
- Starting Time: 0 d
- Duration: 5 d
- Ending Time: 5 d

Materials

Silt

Hydraulic
- Model: Saturated / Unsaturated
- Vol. WC. Function: Silt
- K-Function: Permeability fn
- Ky'/Kx' Ratio: 0.3
- Rotation: 0 °

Sand

Hydraulic
- Model: Saturated Only
- Sat Kx: 3.28e-05 ft/sec
- Ky'/Kx' Ratio: 0.5
- Rotation: 0 °
- Volumetric Water Content: 0
- Compressibility: 5e-06 /psf

Gravel

Hydraulic
- Model: Saturated Only
- Sat Kx: 0.00328 ft/sec
- Ky'/Kx' Ratio: 1
- Rotation: 0 °
- Volumetric Water Content: 0
- Compressibility: 2.5e-07 /psf

Clay

Hydraulic
- Model: Saturated Only
- Sat Kx: 3.28e-09 ft/sec
- Ky'/Kx' Ratio: 0.1
- Rotation: 0 °
- Volumetric Water Content: 0
- Compressibility: 0.0001 /psf

Boundary Conditions

Seepage face

Category: Hydraulic
Kind: Water Rate 0 ft^3/sec
Review: Yes

Upstream

Category: Hydraulic
Kind: Water Total Head 33.65 ft
Review: No

Downstream

Category: Hydraulic
Kind: Water Total Head 25.714286 ft
Review: No

Water K Functions

Permeability fn

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 3.2794994e-07 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)
Data Point: (0.20885434, 3.2794994e-07)
Data Point: (0.38282598, 3.2788872e-07)
Data Point: (0.70171264, 3.2775203e-07)
Data Point: (1.2862257, 3.2744797e-07)
Data Point: (2.357627, 3.2677144e-07)
Data Point: (4.3214847, 3.252656e-07)
Data Point: (7.9211981, 3.2191963e-07)
Data Point: (14.519403, 3.1450717e-07)
Data Point: (26.613786, 2.9823976e-07)
Data Point: (48.782557, 2.63602e-07)
Data Point: (89.417486, 1.9624675e-07)
Data Point: (163.90053, 9.6803324e-08)
Data Point: (300.42651, 2.1393684e-08)
Data Point: (550.67599, 1.8829161e-09)
Data Point: (1,009.3785, 9.7291072e-11)
Data Point: (1,850.1713, 4.185607e-12)
Data Point: (3,391.3282, 1.7137277e-13)
Data Point: (6,216.2392, 6.9295004e-15)
Data Point: (11,394.247, 2.7933525e-16)
Data Point: (20,885.434, 1.1251796e-17)

Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Silt
Saturated Kx: 3.28e-07 ft/sec
Residual Water Content: 0.1
Maximum: 20,885.434
Minimum: 0.20885434
Num. Points: 20

Vol. Water Content Functions

Silt

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 1e-05 /psf
Saturated Water Content: 0.30000132
Residual Water Content: 0.030000132
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.30000132
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0.20885434, 0.299999)
Data Point: (0.38282598, 0.29999749)
Data Point: (0.70171264, 0.29999356)
Data Point: (1.2862257, 0.2999833)
Data Point: (2.357627, 0.29995631)
Data Point: (4.3214847, 0.29988506)
Data Point: (7.9211981, 0.29969647)
Data Point: (14.519403, 0.2991971)
Data Point: (26.613786, 0.29787936)
Data Point: (48.782557, 0.29444321)
Data Point: (89.417486, 0.28577206)
Data Point: (163.90053, 0.26560983)
Data Point: (300.42651, 0.22645249)
Data Point: (550.67599, 0.17101613)
Data Point: (1,009.3785, 0.11800084)
Data Point: (1,850.1713, 0.080740817)
Data Point: (3,391.3282, 0.057711328)
Data Point: (6,216.2392, 0.043406793)
Data Point: (11,394.247, 0.033978031)
Data Point: (20,885.434, 0.027298541)
Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.3
Sample Material: Silt
Liquid Limit: 0 %

Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 20,885.434
Minimum: 0.20885434
Num. Points: 20

Points

	X	Y
Point 1	-50 ft	14.920635 ft
Point 2	-33.25792 ft	15.238095 ft
Point 3	-0.95023 ft	16.190476 ft
Point 4	10.76923 ft	15.555556 ft
Point 5	19.63801 ft	14.920635 ft
Point 6	26.28959 ft	14.920635 ft
Point 7	31.67421 ft	15.238095 ft
Point 8	37.37557 ft	16.190476 ft
Point 9	85.20362 ft	33.650794 ft
Point 10	92.17195 ft	33.650794 ft
Point 11	96.60633 ft	33.333333 ft
Point 12	106.1086 ft	33.333333 ft
Point 13	133.03167 ft	25.714286 ft
Point 14	200 ft	25.714286 ft
Point 15	200 ft	10 ft
Point 16	-50 ft	10 ft
Point 17	-50 ft	4 ft
Point 18	200 ft	4 ft
Point 19	200 ft	-1 ft
Point 20	-50 ft	-1 ft
Point 21	-50 ft	-6 ft
Point 22	200 ft	-6 ft
Point 23	-50 ft	-10 ft
Point 24	200 ft	-10 ft
Point 25	200 ft	-30 ft
Point 26	-50 ft	-30 ft

Lines

	Start Point	End Point	Hydraulic Boundary	Length	Angle
Line 1	1	2	Upstream	16.745 ft	1.09 °
Line 2	2	3	Upstream	32.322 ft	1.69 °
Line 3	3	4	Upstream	11.737 ft	-3.1 °
Line 4	4	5	Upstream	8.8915 ft	-4.09 °
Line 5	5	6	Upstream	6.6516 ft	0 °
Line 6	6	7	Upstream	5.394 ft	3.37 °
Line 7	7	8	Upstream	5.7804 ft	9.48 °
Line 8	8	9	Upstream	50.915 ft	20.1 °
Line 9	9	10		6.9683 ft	0 °
Line 10	10	11		4.4457 ft	-4.09 °
Line 11	11	12		9.5023 ft	0 °
Line 12	12	13	Seepage face	27.98 ft	-15.8 °
Line 13	14	15		15.714 ft	90 °
Line 14	15	16		250 ft	0 °
Line 15	16	1		4.9206 ft	90 °
Line 16	16	17		6 ft	90 °
Line 17	17	18		250 ft	0 °
Line 18	18	15		6 ft	90 °
Line 19	18	19		5 ft	90 °
Line 20	19	20		250 ft	0 °
Line 21	20	17		5 ft	90 °
Line 22	20	21		5 ft	90 °
Line 23	21	22		250 ft	0 °
Line 24	22	19		5 ft	90 °
Line 25	21	23		4 ft	90 °
Line 26	23	24		250 ft	0 °
Line 27	24	22		4 ft	90 °
Line 28	24	25		20 ft	90 °
Line 29	25	26		250 ft	0 °
Line 30	26	23		20 ft	90 °
Line 31	13	14	Downstream	66.968 ft	0 °

Regions

	Material	Points	Area
Region 1	Silt	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	3,259.9 ft^2
Region 2	Gravel	16,17,18,15	1,500 ft^2
Region 3	Clay	17,18,19,20	1,250 ft^2
Region 4	Sand	20,21,22,19	1,250 ft^2
Region 5	Gravel	21,23,24,22	1,000 ft^2
Region 6	Sand	23,24,25,26	5,000 ft^2

Mesh Properties

View: 2D
Element Thickness: 1 ft

CELRC-TSD-DG 22 July 2019

MEMORANDUM FOR PM-PL

SUBJECT: Fragility Curve Determination for Rio Guayanilla Phase I Berm

Introduction

1. This memorandum discusses the fragility curve of the existing berm known as Phase I along the Rio Guayanilla. A fragility curve, as defined in EM 1110-2-1619, 'Risk-Based Analysis for Flood Damage Reduction Studies', is a statistical distribution of levee failure which is used to develop the stage-damage function and description of the overall uncertainty of that function.

2. The fragility curve is defined by determining two points on a graph; the probable failure point (PFP) and probable non-failure point (PNP). The PFP is defined as the water elevation above which the levee is highly likely to fail, set at 85% failure rate in the EM. The PNP is defined as the water elevation below which the levee has a low likelihood of failure, set at 15% failure rate in the EM. Figure 7-4 is extracted from EM 1110-2-1619 to illustrate the fragility curve, as shown below.

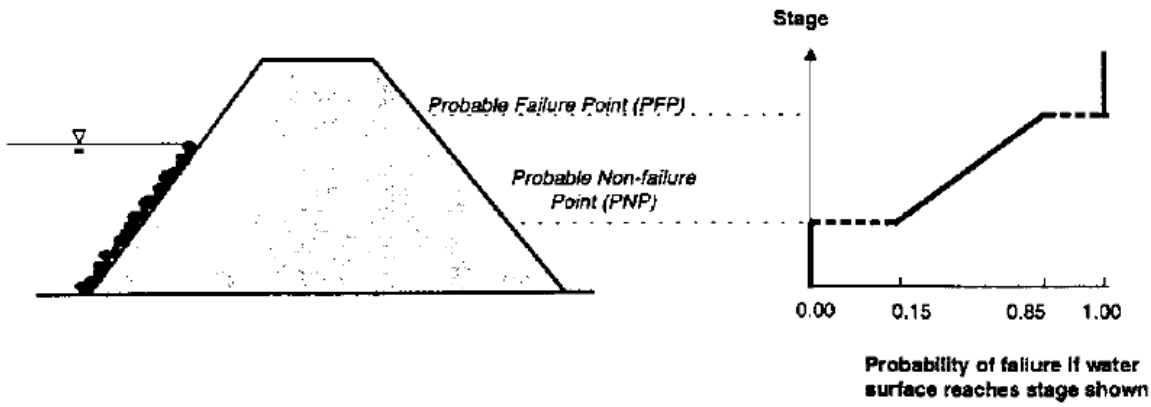


Figure 1. Levee failure probability function from EM 1110-2-1619, Figure 7-4

3. A fragility curve was developed for the existing Phase 1 levee near the coast. A global stability analysis using SLOPE/W determined that the Factor of Safety was much higher than the recommended minimum for steady-state seepage per EM 1110-2-1913, so the driver for the PFP and PNP would be the likelihood of failure.

Levee Background

4. The Town of Guayanilla is located on the southern part of Puerto Rico and experiences frequent floods from the Rio Guayanilla which runs through the middle of the town. The US Army Corps of Engineers recommended building a levee starting at the coast in a report released in the 1990s. A portion of the recommended levee was built starting at the coast. A survey of the Phase 1 levee was performed and the section chosen for analysis was relatively low elevation and had a narrow crest compared to the other surveyed sections. The approximate location is shown below.

Figure 2. Cross section modeled

5. The Phase 1 levee has riprap on the river side. This was not included in the model because it would not have a significant effect on the slope stability of the land slide. The nearest soil boring is SB-6 which is further inland (north) on the alignment of the Phase 1 levee. The subsurface profile was also checked for boring B-1 and it appeared to be similar so the profile of SB-6 was used for the model.

SLOPE/W Analysis

6. SLOPE/W software was used to model the global stability of the Phase 1 berm for the steady state seepage condition since the berm has been in place for years and have experienced previous loading. A cross section from the survey was used, shown below. XS-61 was chosen after reviewing all the survey cross sections due to the relatively narrow crest width and low height compared to other surveyed cross sections. Note that metric units are used for the survey and the seepage and stability analyses.

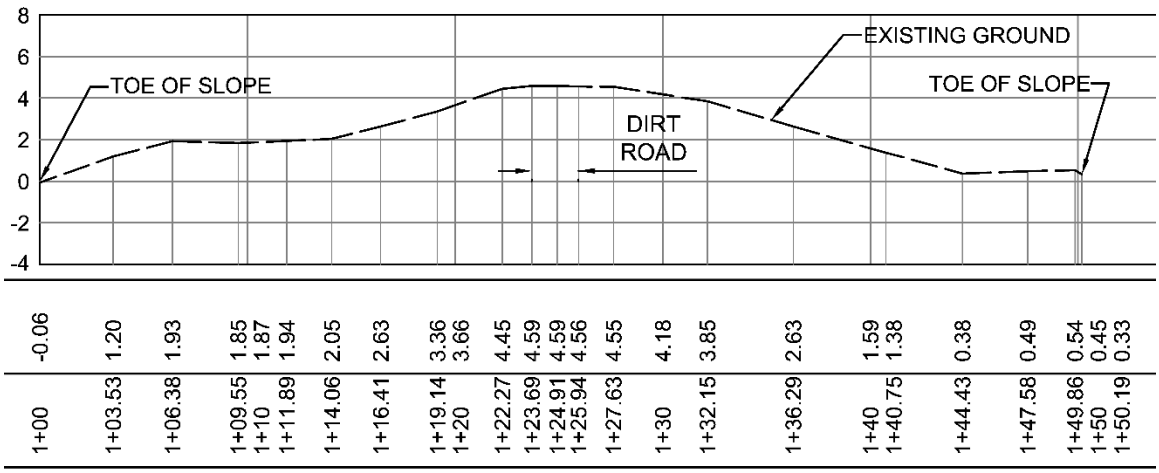


Figure 3. Phase 1 Levee Survey XS61

7. Boring SB-6 was used to develop the stratigraphy. The soil parameters are based on typical values for the materials and are shown in the figure below. Laboratory testing was performed on the soil and parameters were derived from that, but the CU triaxial lab result values for the top clay layer seemed overly high so more conservative numbers were used. The test results gave values for effective friction angle and cohesion of 34.7° and 114 psf, respectively. In reviewing the test results it appeared the friction angle was estimated incorrectly and was higher than reasonable. A lower friction angle was estimated based on the plot of test results. For the first analysis, effective cohesion was assumed to be zero. A SEEP/W analysis was used to develop the piezometric water level.

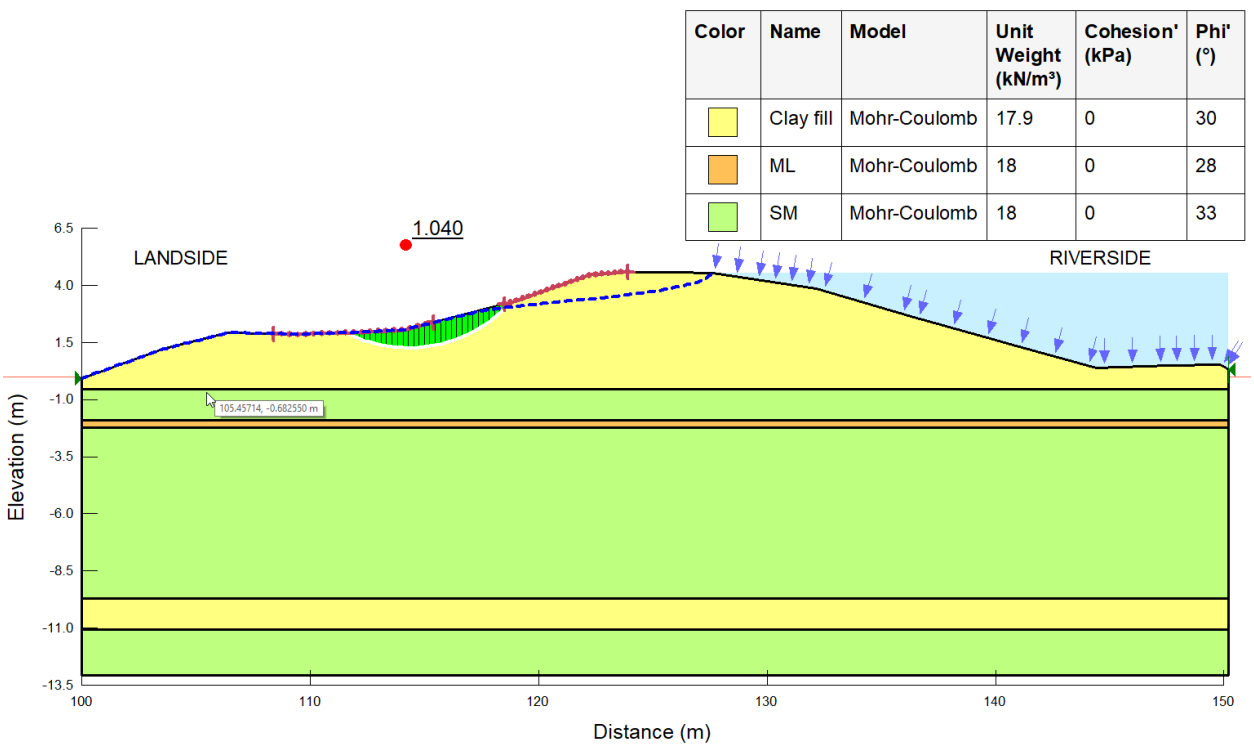


Figure 4. SLOPE/W results, 1st analysis

8. The Spencer method was used in the program to calculate the Factor of Safety under fully loaded conditions. The factor of safety for the first analysis assuming zero effective cohesion was 1.04 which is less than the factor of safety of 1.4 recommended for the steady state condition in EM 1110-2-1913 and very close to failure. The levee has not exhibited any stability issues during past performance. It is likely that the levee would not be fully drained due to the short duration of the loading.

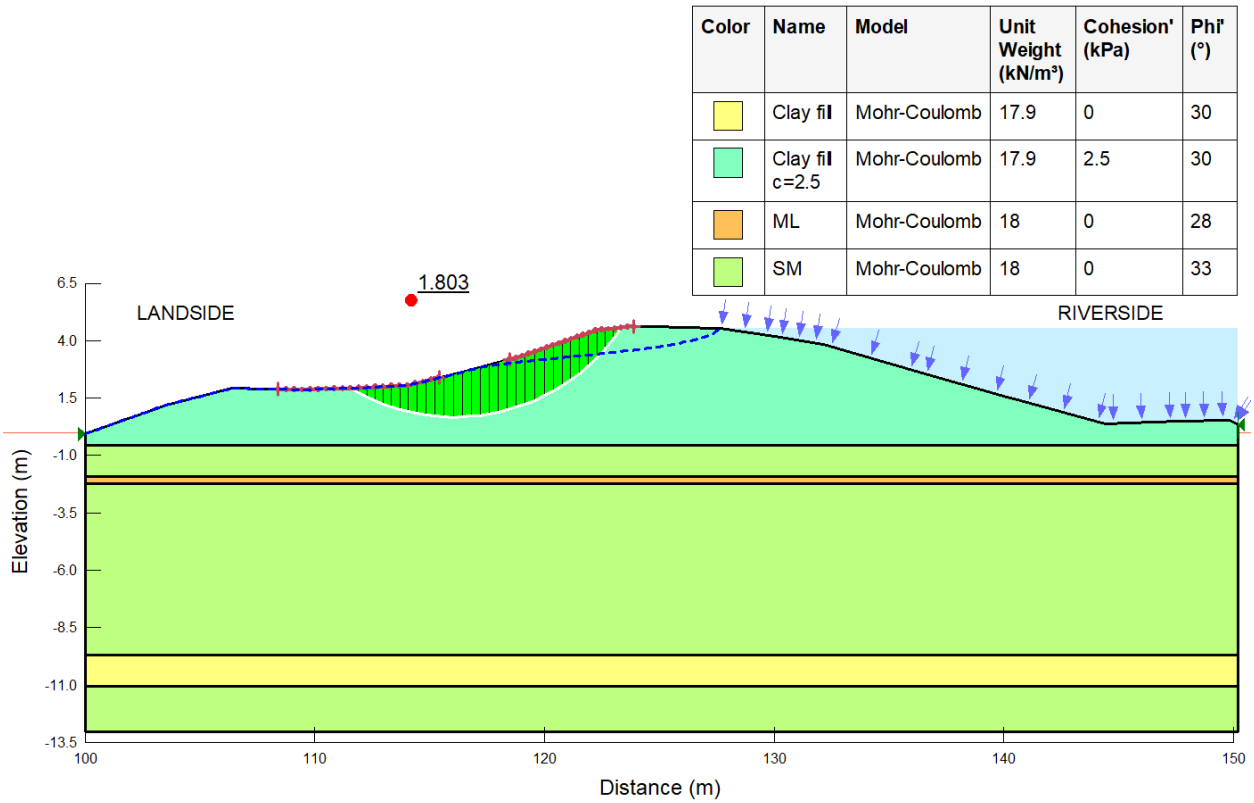


Figure 5. SLOPE/W results, 2nd analysis, with cohesion

9. Since the levee is unlikely to reach the steady state condition, a small amount of cohesion was included in the analysis. The second analysis was performed with the top layer of clay fill redefined using half of the value of effective cohesion from the test results. The reported cohesion was divided by 20.89 to convert to metric and then divided by two for the analysis. The analysis was re-run with all other parameters the same as the first analysis. This resulted in a factor of safety of 1.80 which meets the recommended criteria in the EM. Therefore, it does not appear that slope instability would occur on the landside slope when the levee is loaded to the top.

PFP and PNP Determination

10. The Probable Failure Point (PFP) (85% chance of failure) is at the top of the lowest point of the berm at elevation 4.55 meters for the most likely failure scenario. At this elevation, the berm would be overtopped and susceptible to erosion of the crest and landside slope, which could lead to failure.

11. Based on survey data, the crest width is approximately 5.36 meters or 17.59 feet wide at the cross section modeled. EM 1110-2-1905 recommends a minimum crest width of 10 feet. Since the actual crest is nearly twice the recommended width and there is riprap and grass cover on the slopes and ground, the berm has some resiliency.

12. To determine the Probable No Failure Point (PNP) (15% chance of failure) elevation, the uncertainty about the exact soil properties and possible roots and animal burrows were determined to be the controlling factor. While the levee is wider than necessary, issues could arise such as seepage due to large animal burrows which could lead to a breach and would extend to the levee toe. The levee toe is at elevation -0.06 meters and was chosen as the PNP.

Summary

13. These points for the Fragility Curve are based on existing knowledge and field observations. Each subsequent flood event will continue to degrade the levee and lead to more issues with seepage, erosion, and eventually instability and failure.

Failure Node	Probability of Failure by Node	Elevation Assignment for M. Likely P(f)
Levee Crest	1.00	4.55
Probable Failure Point (PFP)	0.85	4.55
Probable Non-Failure Point (PNP)	0.15	-0.06
Levee Toe	0.00	-0.06

Table 1. Summary of Fragility Curve Points

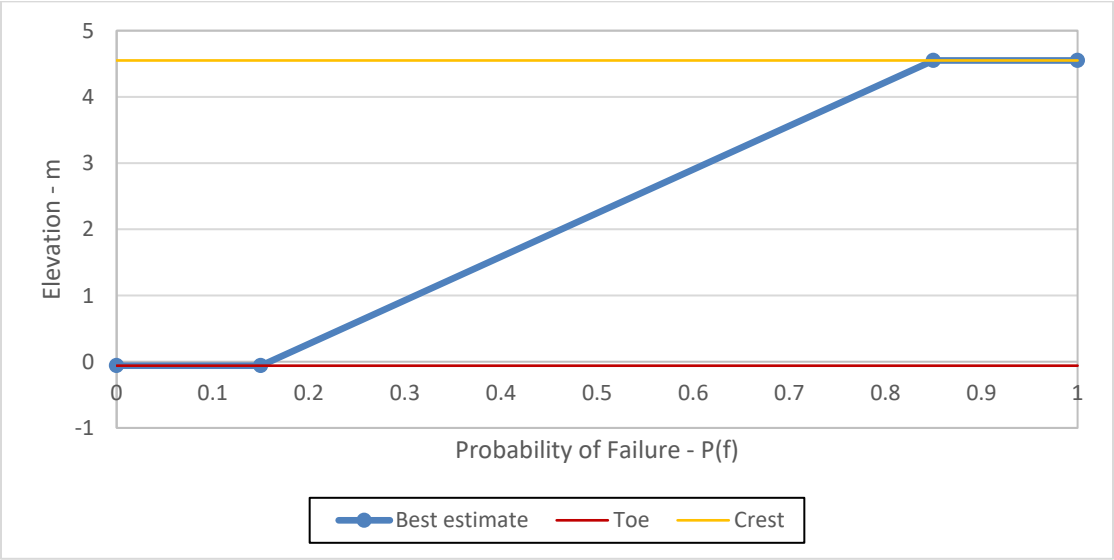


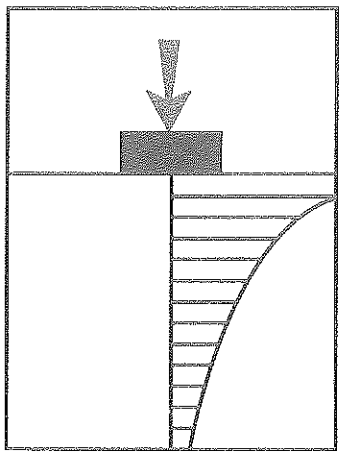
Figure 6. Fragility Curve

14. There is some uncertainty that may not produce accurate PFP and PNP elevations.

a. The actual subsurface conditions at the cross section modeled may be different than what exists at boring SB-6.
b. The soil parameters used are a conservative estimate based on lab results and common values for the type of materials encountered in SB-6.
c. The model cannot take into account features such as animal burrows. Burrows allow connections between the riverside and landside.

Attachment G-7
2004 Stability Report and 2005 Addendum

STABILITY STUDIES OF LEVEE
CANALIZATION OF GUAYANILLA RIVER
GUAYANILLA, PUERTO RICO



Geo
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Fax (787) 706-0183

ESTADO LIBRE ASOCIADO DE PUERTO RICO
DEPARTAMENTO DE RECURSOS NATURALES Y AMBIENTALES
AREA RECURSOS DE AGUA Y MINERALES

12/ Agosto/04 MLMS

Fecha: 11 de Ago de 2004

ING. JOSÉ M. LEBRÓN LASTRA
ADMINISTRADOR AUXILIAR
AREA RECURSOS DE AGUA Y MINERALES

____ Sra. Amparo Urbina Correa	____ Ing. Raymond Acevedo Pimentel	C Ing. Jaime Caballero Álvarez
____ Ing. Mabel C. Rivera Sanabria	____ Sr. Heriberto Sosa Cruz	C Ing. Ramona París Guerra 13/Ago/0
____ Sra. Glisette Estrella Rodríguez	____ Sr. Rafael Figueroa Torres	____ Sr. Carlos A. Paniagua Valverde
____ Sr. Angel M. Bonilla Cruz	____ Sr. José M. Córdova Albino	____ Sr. Félix Santiago Rivera
____ Sra. Magali Alvarado Torres	____ Sr. José A. Dávila Adorno	
____ Sra. Lydia Morales Vélez	____ Geól. Ramón M. Alonso Harris	
____ Sa. Lourdes Bernier Castrello	____ Geól. Verónica Santa Rosa	
____ Sr. Guillermo Infanzón García	A: Ing. Gisela Molinaris Gelpí 12-agosto-2004	
____ Srta. Marianela Torres Rodríguez	____ Ing. Javier Ruiz Bunker	

17-Ago-2004
El Ing. H. González, Inspector en reunión, solicita copia del documento.

____ CONTESTAR PARA MI FIRMA	____ DISCUTIR CONMIGO
____ INVESTIGAR INFORME CON RECOMENDACIONES	____ PARA EL EXPEDIENTE
____ CONTESTAR PARA FIRMA DEL SECRETARIO	____ PARA SU INFORMACIÓN
____ CONTESTAR PARA FIRMA DEL ADM.	____ PREPARAR BORRADOR
____ EVALUAR Y RECOMENDAR	____ SE DEVUELVE EXPEDIENTE
C ACCION CORRESPONDIENTE	____ FAVOR VERME
____ TRAMITAR CON URGENCIA	____ ARCHIVAR

OBSERVACIONES:
Gisela: Favor de revisar estos documentos y luego los discutimos.

Geo ENGINEERING
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Calle 7 Número 1223 Bajos, Extensión San Agustín
Río Piedras, Puerto Rico 00926
Tel. (787) 764-6340
Fax (787) 764-6325

HOJA DE TRAMITE

ATENCION: Ing. José M. Sebión

COMPAÑIA: Recursos naturales

FECHA: 8/10/04

ASUNTO: Proyecto Canalización Río Guayanilla Fase I

LE INCLUIMOS:

☐ PROPUESTA ☐ FACTURA ☒ INFORME ☐ ESPECIFICACIONES ☐ PLANOS

☐ INFORME DE INSPECCION ☐ DIAGRAMAS ☐ Planos y copia de contrato

MENSAJE

Le estamos enviando el informe del proyecto en referencia más los planos y copia contrato del proyecto dados por usted a nosotros

Saludos

AREA RECURSOS DE AGUA
AGO -9 P1:59
'04

SOMETIDO PARA:

☐ INFORMACION ☐ REVISION ☐ ARCHIVO ☐ COMO REQUERIDO

☐ USO PERTINENTE ☐ COMENTARIOS

ENVIADO POR: Dr. Carlos Rodríguez

RECIBIDO POR: Lydia E. Hernández

FECHA: 10-Agosto-04

STABILITY STUDIES OF LEVEE
CANALIZATION OF GUAYANILLA RIVER
GUAYANILLA, PUERTO RICO

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Fax (787) 706-0183

August 5, 2004

Eng. José M. Lebrón Lastra
Assistant Administrator
"Área de Recursos de Agua y Minerales"
DRNA
P.O. Box 9066600 Pta. de Tierra Station
San Juan, P.R., 00906

Re: **"Proyecto de Canalización del Río Guayanilla Etapa I Fase I"**
Guayanilla, Puerto Rico
(GEO-2004-532)

Dear Eng. Lebrón:

Per your request, our office has conducted a geotechnical evaluation on the project of reference. Our evaluation included three borings, drilled at predetermined locations using the information submitted to this office, as well as several engineering analyses that attempted to assess the various problems presented to this office at the time of our hiring. The analyses conducted included the following: 1) settlement and stability analyses, including an FEM deformation analysis, of the levee presently under construction, 2) a stability analysis for the proposed jetty, 3) an additional stability analysis to assess the feasibility of dredging the canal area at the vicinity of the jetty's location, and 4) a negative skin friction analysis to study the effects of the compressible organic layer on the sides of proposed inclinometers to be installed at predetermined locations. All analyses were performed on what have been shown to be the worst area in the field based on data obtained from the three borings. Thus, all other levee areas under study should exhibit lessened effects of the conditions described herein (settlement, instability, etc.).

The necessary subsurface information was obtained by means of three borings drilled at the project site. Boring 1 (see attached figures for boring logs and locations) reached a depth of one hundred feet and was located close to Sta. 13+00, boring 2 was drilled at Sta. 25+00 and to a depth of one hundred feet as well, and boring 3 was drilled in between Stations 20+00 and 21+00 and reached a depth of seventy feet. Three main soil types were found at all three boring locations. Detailed soil descriptions and engineering properties can be found in the attached boring logs. The three types of soil encountered were: 1) fill used for the construction of the levee, 2) a thick, highly compressible, organic clayey silt/silty clay, which underlies the levee and reaches a thickness of approximately 55 ft at boring 1, and 3) a stiff to very stiff clayey silt/silty clay and silty sand that underlies the compressible soils. All of these soils conform to the typical soil profile commonly found in a riverbank and river floodplain.

Nature of Problem

The Department of Natural and Environmental Resources of Puerto Rico is presently undergoing the construction of Phase I of the canalization of the Guayanilla River in Guayanilla, PR (Fig. 1). The project includes the construction of earth levees and other structures in a span of approximately 1.7 kilometers. The levee section under study has a near trapezoidal shape close to 10 m wide at the top, 3:1 (Horizontal:Vertical, H:V) slopes, and a height of approximately 6 m (Fig. 2). Quiñones, Diez, Silva and Assoc. (QDSA) from San Juan, PR designed the project. The original geotechnical evaluation of this project was performed by others in 1989.

By the time this office was contacted, a section of the levee was being built over highly compressible organic soils, whose thickness was not accounted for in the original geotechnical evaluation. Settlements of seven inches (seventeen centimeters) or more were measured at various locations over the course of several months of construction. These settlements were caused by the load imposed by the levee under construction. The settlement problem became a concern for the project owner not only because it would affect the final elevation of the levees (and thus the freeboard), but also because the weak strength characteristic of such soils poses a threat to the structural integrity of the levee.

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Stemming from the instability problem posed by the weak compressible soils, other areas, such as the jetty, were also included in the evaluation. In addition, the efficacy of installing inclinometers to monitor any lateral movements has also been questioned as a result of the known detrimental effects that negative skin friction has on instrumentation installed in consolidating ground.

Analysis of Problem

Settlement

Settlement analyses were conducted using laboratory data from an undisturbed sample of the compressible organic clay collected at the depth interval of forty to forty-two feet in boring 1 (Sta. 13+00). Two laboratory odometer tests were performed on this sample. The first test involved an intact sample of the compressible layer, while the second was remolded prior to testing. The data obtained from both tests would provide a range of results for which the compressible soil could behave in the field. The results from the odometer tests have been included in the appendices.

The compressible layer was found to be normally consolidated and to have a compression index (C_c) range of 0.27-0.37. Using these results, calculations following consolidation theory predicted total settlements of up to 50 inches and completion of the primary consolidation phase within the following two time ranges: 14 to 18 years, if the layer exhibits double drainage behavior, or 55 to 74 years, if the layer exhibits single drainage behavior. Should the compressible layer be homogeneous throughout, and lack any sand pockets, it will most likely exhibit single drainage behavior. However, the current rate of settlement (measured in the field by the project inspector during the construction of the levee) and the presence of cemented sand and silty sand lenses in all three borings indicate that the compressible layer will most likely exhibit double drainage behavior. As a result, it is more probable that the total settlements would be completed in 14 to 18 years. The predicted rates of consolidation and settlement vs. time graphs are included in the appendices. Periodic field measurements should be taken and logged to compare actual field rates with those predicted.

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A two-dimensional FEM (Finite Element Method) deformation analysis was also performed on the same levee section as the consolidation analysis. The FEM model and results are included in the appendices. The goal of the FEM analysis was to determine the pattern of deformation that the levee and the surrounding areas would undergo during and after construction. Three stages of construction were modeled: 1) an initial levee section 7 ft high, 2) a levee section 14 ft high, and 3) the levee design height of 20 ft. The deformations obtained were mainly associated to the elastic-plastic behavior of the compressible organic soils. However, the analysis showed what the pattern of deformation would be as consolidation takes place with time (although not the settlement magnitude due to consolidation). The deformation pattern obtained with the FEM analysis was also used in the slope stability analysis of the levee section.

The ground deformation pattern obtained by the FEM analysis was consistent in all three construction stages analyzed. Maximum settlements developed along the center part of the levee section and heave or bulging occurred at the toe (reportedly, bulging was observed developing at this area during construction). The weight of the levee caused downward and lateral deformations within the compressible soils below most of the levee, and lateral and upward deformation within the compressible soils located in the vicinity of the toe. In other words, the levee is squeezing the compressible soils in a near circular pattern of deformation. Maximum settlement and heave of approximately 15 inches and 6 inches, respectively, were obtained for the completed levee section. The ground deformations were negligible at depths of approximately 40-45 ft below the base of the levee.

Even though the maximum settlement was close to 15 inches, the differential settlement between the levee center and edge was in the order of 1 inch. Furthermore, the difference in vertical deformation between the top and base of the levee was negligible. These results indicate that the levee is practically maintaining its shape at its thickest section, and acting like a near rigid body. This behavior explains the results obtained from the slope stability analysis (described below).

The deformations obtained with the FEM analysis have occurred during construction. Therefore, the deformations have already been accounted for with the elevations taken during the placement of the lifts of fill. As a result, the only settlements predicted to occur with time are the ones resulting from consolidation (up to 50 inches). The magnitude of these settlements

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should be used when calculating the volume of fill needed to reestablish the design freeboard for the levee. In addition, necessary measures should be taken to ensure that fill is available for placement, whenever a significant amount of freeboard is lost due to consolidation.

Slope Stability

A slope stability analysis of the levee section was conducted using the limit-equilibrium method on the simplified two-dimensional section mentioned before. The computer program StablPro was used to conduct the analyses. The stability of the ground was evaluated by determining the Factor of Safety (FS) of the slope section in question. The FS is defined as the ratio between the available resisting forces that can be mobilized along a potential sliding surface to the driving forces acting on this surface. An FS equal to one means that the slope in question is on the verge of undergoing complete failure. An FS larger than one indicates some degree of stability. The degree of stability is proportional to the FS. The larger the FS the more stable the ground and smaller the possibilities of undergoing perceptible deformations. In cases where the FS values are close to one, the ground will deform and crack without failing completely. The current state of practice considers FS-values of 1.5 or larger to be sufficient to prevent a problem of slope instability.

The analyses conducted were performed for three conditions: 1) short-term, 2) long-term, and 3) seismic. The short-term condition was analyzed to determine the stability at the end of construction. The analysis was performed using the undrained shear strength of the clayey soils. On the other hand, the long-term condition was analyzed to determine the stability of the section once consolidation has reached completion, and it was analyzed using the drained shear strength of the clayey soils. The seismic condition was conducted using a maximum ground acceleration (a_{max}) of 0.20g, and it was analyzed using the undrained shear strength of the clayey soil. The current state of practice considers a FS of 1.2 as an acceptable value for the seismic condition.

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The shear strength (drained and undrained) of compressible clayey soils such as those found on this site is commonly expressed in terms of one or two of the following parameters: (1) cohesion (c), and (2) the angle of internal friction (ϕ). These strength parameters are determined by means of shear tests performed on undisturbed soil samples. The undrained shear strength parameters for this project were obtained using the unconfined compressive test. The drained parameters were obtained by performing a direct shear test. Due to the soft nature of the soil, the sample in the direct shear test had to be slightly remoulded to be fit into the shearing box. As a result, the obtained value of ϕ (12°) is slightly smaller than the one expected in the field (assumed to be between 14°-16°). The laboratory shear test results and those from the stability analyses are included in the appendices.

The results obtained for the short-term condition indicate that the levee section is stable with a FS range of 2.1-2.6. Even though the underlying organic soils are soft, the compacted soil levee acts, in agreement with the results from the FEM analyses, as a continuous mat with enough shear strength to prevent failure under this condition. The levee section was also analyzed for a stage of construction when the levee was at a height of 7 ft, and the FS was found to be even higher than the range reported herein.

For the long-term condition, a FS of 1.3 (1.5) was obtained. This value is lower than the 1.5 value commonly accepted to avoid problems of slope instability. As such, the ground will have some degree of stability, but it may undergo large deformations. However, these deformations will be masked by the expected large deformations resulting from the consolidation of the compressible organic soils.

Two time periods were studied under a seismic event. At the end of construction, a FS of 1.17 was obtained. This value is slightly lower than the recommended minimum of 1.2. As such, if a large seismic event occurs in the near future, the levee may undergo large deformations without completely failing. On the other hand, as consolidation takes place, the undrained shear strength of the soft soils will improve and the FS will increase. A FS of 1.43 was obtained when

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an analysis was performed for a condition where approximately 55 percent of consolidation had occurred. Thus, the resistance of the levee against a large seismic event will improve with time.

In conclusion, the levee will maintain marginal stability under a long-term condition and during a large seismic event occurring in the near future. However, the levee will undergo large deformations when these conditions develop.

Stability Analysis of Proposed Jetty

A section of the proposed jetty was also analyzed. Figure 3 shows the section used for all analyses, and the results are included in the appendices. The same three conditions studied for the levee were also evaluated for the jetty.

The jetty, as designed by QDSA, will mainly consist of large rock blocks placed to reach the desired section elevation. It will be shorter than the levee but it will maintain steeper slopes (2:1, H:V). Unlike the levee, the jetty will not behave as a near rigid mat due to its composition. Rather, it will behave as independent block units that can accommodate individually as deformations of the compressible soils occur. As such, the cooperation of the jetty to the overall ground stability will be less than that given by the levee. The shear strength of the jetty will be defined by an angle of internal friction (ϕ), and it will behave under drained conditions.

Under short- and long-term conditions, the jetty will maintain marginal stability (FS of approximately 1.2), but it may undergo large deformations. As in the levee, these deformations will be masked by the large deformations resulting from the consolidation of the compressible organic soils.

The jetty will fail if a large seismic event occurs in the near future, and its stability at the end of consolidation will be critical (FS of 1.1). As a result, it will be necessary to increase the shear strength of the jetty against the effects of a large seismic event. Although some improvement can be reached by adding cementation to the rock blocks by means of grout, the cementation will break as the ground deformations develop. One way to obtain a better response is to build

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PLASTICO O METAL PARA AUMENTAR LA ESTABILIDAD EN EL JETTY

a mat of compacted reinforced soil or of gabion over which the jetty will rest. (If this alternative is feasible from an economic point of view, please contact this office for further recommendations).

SE TOMO EN CONSIDERACIÓN LA EROSIÓN

The design of the jetty includes the installation of a Type B filter material below the rock blocks. According to the specifications given by the designers, this material may contain up to 20 to 35 percent of sand. The sand will be likely eroded by flowing water. As a result, additional settlements of several inches will occur within the rock blocks. However, these settlements will be less than those caused by consolidation of the underlying compressible soils. Periodic maintenance of the jetty will be required, and probably additional block units will have to be placed in the future to maintain the design elevation of the jetty.

Dredging near the Jetty Location

The canalization project requires that the bottom of the new canal be dredged near the location of the jetty. The dredging will reach a maximum of about 1.2 m (4 ft).

A stability analysis of the dredged canal was also performed. The dredging will not have a significant impact on the behavior of the levee. However, it will increase the aforementioned problem of instability for the jetty under a seismic event (if the shear strength of the jetty is not improved).

Reportedly, dredging was performed in this area in the past and the dredged elevation was maintained for a period of time of about a month. The dredged area was soon filled with fine silty sand. A same situation may occur if the area is dredged again. Furthermore, the filling material will be rapidly scoured by the river due to its sandy nature. The efficacy of dredging the area is questioned as a result. The project designers should evaluate this situation, and the hydraulic impact of not conducting this dredging or of having a dredged area only for a short period of time.

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Inclinometer Installation

The canalization project requires the installation of three inclinometers at predetermined locations. The consolidation of the soft compressible organic soils will cause a downdrag force on the inclinometer casing in excess of approximately 30 kips. The casing will buckle and break as a result of the applied force. Therefore, it is not recommended to proceed with the installation of the inclinometers at this point in time.

If you have any questions on this evaluation, please do not hesitate to contact us.

Cordially,
Geo ENGINEERING

Carlos F. Rodríguez Jiménez, E.I.T. José L. Encarnación García, E.I.T.

Carlos E. Rodríguez Pérez, Ph.D., P.E.
Geotechnical Engineer

Enclosures

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FIGURES

Geo ENGINEERING

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LOCATION MAP

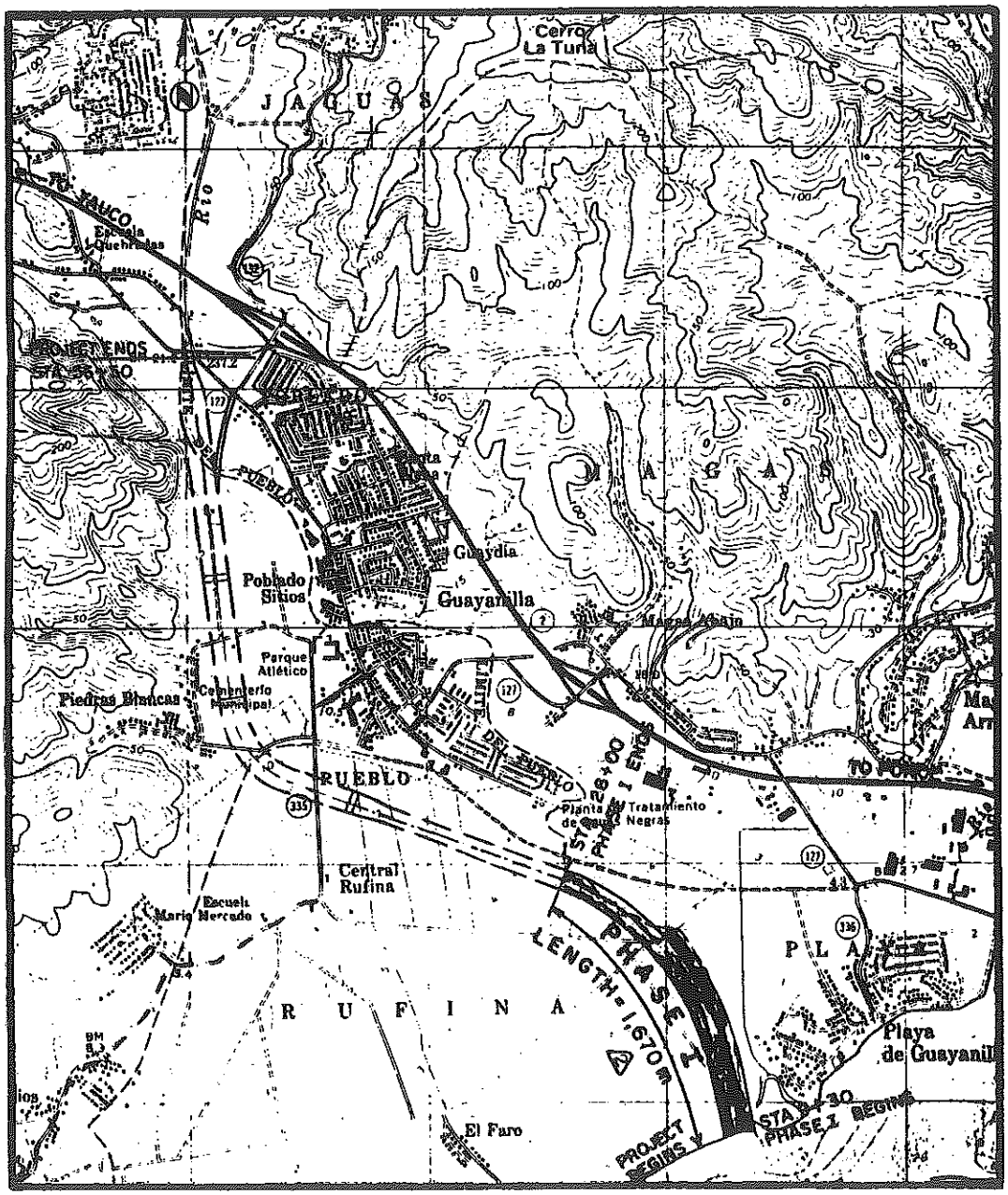


FIGURE 1

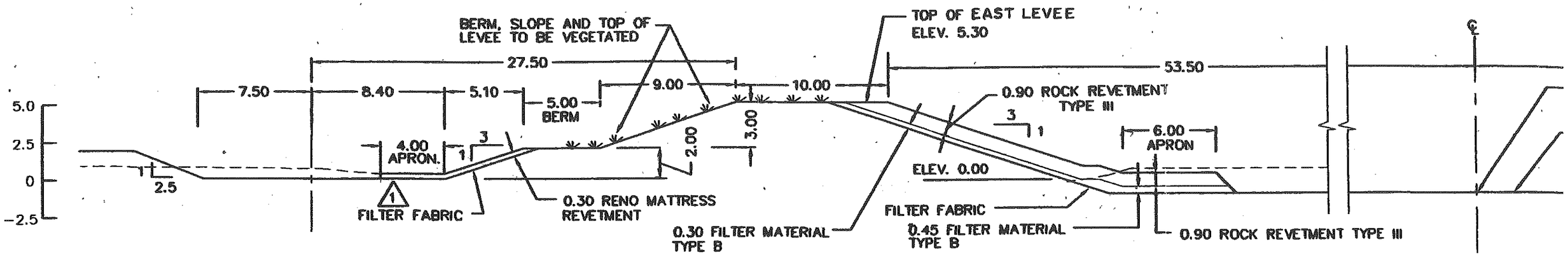
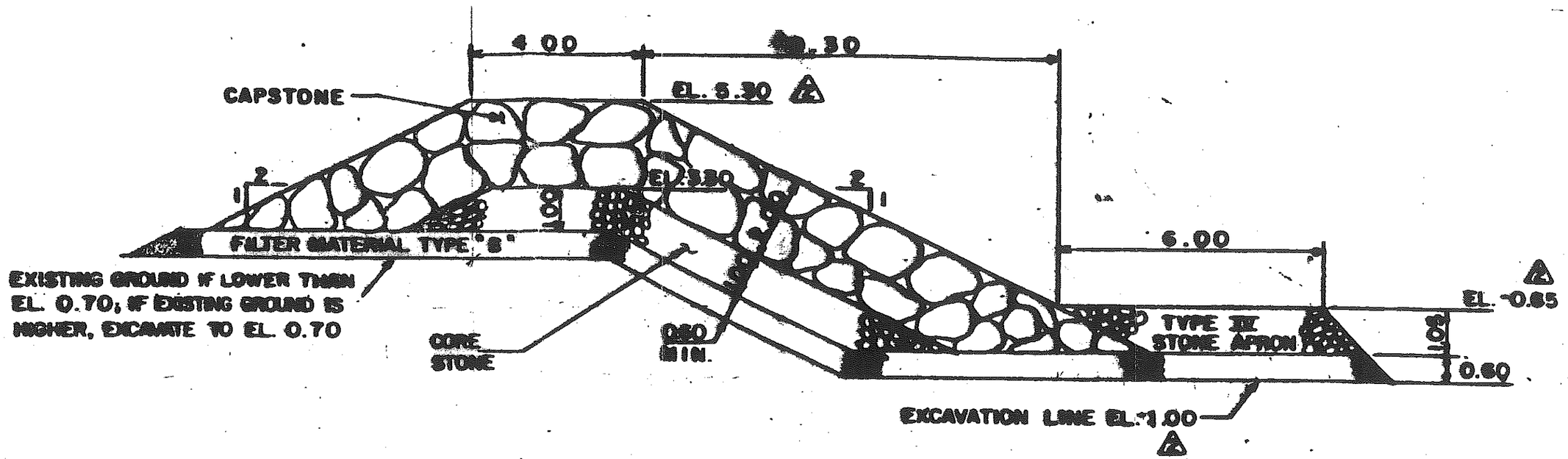

BERM, SLOPE AND TOP OF LEVEE TO BE VEGETATED
TOP OF EAST LEVEE ELEV. 5.30
27.50
53.50
7.50
8.40
5.10
5.00 BERM
9.00
10.00
5.0
2.5
0
-2.5
2.5
4.00 APRON.
3
1
2.00
3.00
0.90 ROCK REVETMENT TYPE III
6.00 APRON
ELEV. 0.00
FILTER FABRIC
0.30 RENO MATTRESS REVETMENT
0.30 FILTER MATERIAL TYPE B
0.45 FILTER MATERIAL TYPE B
0.90 ROCK REVETMENT TYPE III

FIGURE 2



SECTION 1/A-102

SCALE 1:100

FIGURE 3

JL	REV. ROCK JETTY REVISED	DATE JULY, 1990	QUIÑONES, DIEZ, SILVA Y ASOCIADOS	FILE 87-2-4-12 / DATE JULY, 1990	DEL CHANNELIZ

APPENDICES

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BORING LOGS AND TEST RESULTS

Geo ENGINEERING

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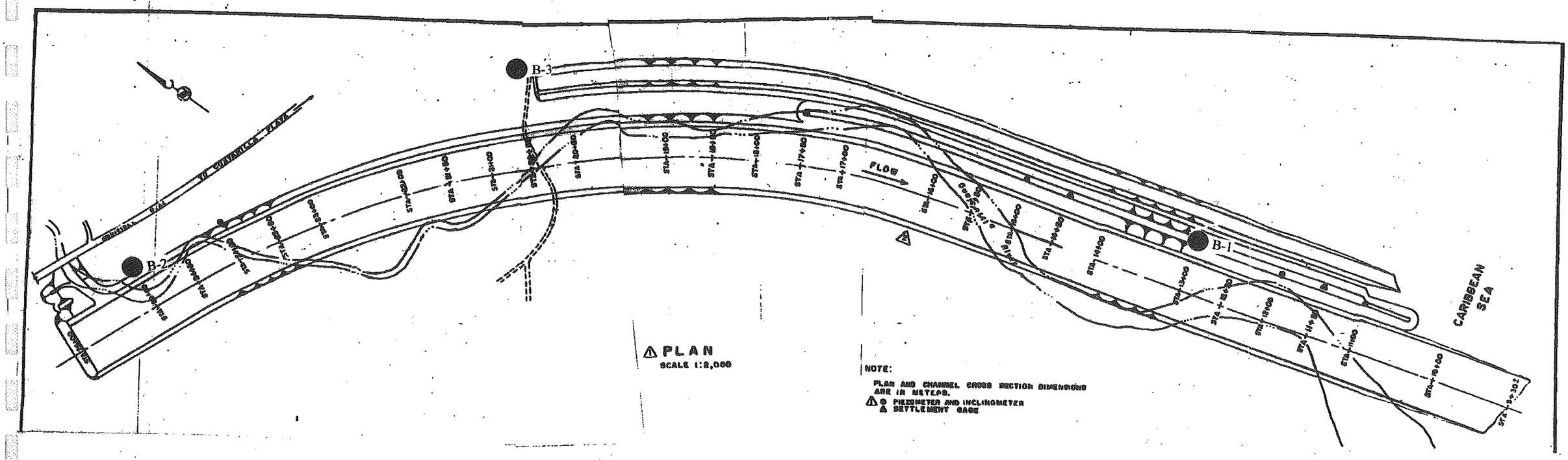


APPROX. BORING LOCATION

Geo-ENGINEERING		**LOG OF BORING NO.**	1 (Approx. Sta. 13+00)		
Project:	Channeling of Guayanilla River	**Sheet No.**	1 of 3	**Date:**	7/2/04 7/13/04
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	100'		
Ground Surf.		**Water Depth:**		**When finishing**	
Elev.:		**During Drilling**	20'	**the boring:**	

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
2'	15	Fill recovered as brown clay with tiny roots and traces of fine sand	2-4-3-5	7	[1.5]	22				
4'	12		3-9-15-14	24		19				
6'	16		4-6-10-15	16	[4.5]	23				
8'	18		7-13-16-17	29		19				
10'	20	(wet and rock fragments)	3-2-5-9	7	1.7	31				
15'	24	(rock fragments)	4-9-9-12	18	[1.5]	22				
20'	24	Gray medium to coarse sand with rock fragments, lumps of clay and organic	1-2-3-5	5		39				
25'	24	Gray clayey silt/silty clay with some medium to coarse sand, rock fragments, shell fragments and decayed wood, organic	1-1-1-6	2		50				
30'	24	Gray sandy silty clay/clayey silty sand, organic	2-2-6-4	8		49	28	27	OL	
35'	7		1/12"-2-2	3		36				
40'	24	Gray clayey silt/silty clay with shell fragments, organic	1/12"-4-3	5	[0.5]	38	45	23	OL	

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.**	1 (Approx. Sta. 13+00)
Project:	Channeling of Guayanilla River	**Sheet No.**	2 of 3
Date:	7/2/04 7/13/04		
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	100'
Ground Surf. Elev.:		**Water Depth: During Drilling**	20'
When finishing the boring:			

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
45'	24		2-3-2-3	5	[0.5]	44				
50'	24	Gray sandy silty clay/clayey silty sand with shell fragments, organic	push 24"	0		30	32	20	OL	
55'	24		2-4-4-4	8		29				
60'	24		push 24"	0		35				
65'	24	(w/ coral fragments)	push 18" -2	0		37				
70'	24	Light gray clayey silt/silty clay with pieces of coral, organic	2-4-4-7	8		27				
75'	24	Tannish brown clayey silt/silty clay with pebbles, gray mottled (old alluvial)	4-4-8-8	12	[2.0]	24				
80'	24		2-5-6-6	11	[0.5]	34				

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.**	1 (Approx. Sta. 13+00)
Project:	Channeling of Guayanilla River	**Sheet No.**	3 of 3
Date:	7/2/04 7/13/04		
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	100'
Ground Surf. Elev.:		**Water Depth: During Drilling**	20'
When finishing the boring:			

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
85'	24		7-10-12-15	22		21	65	26	CH	
90'	0	No Recovery	8-13-16-17	29						
95'	24		6-10-12-17	22		34				
100'	20	Tannish brown silty sand	15-18-13-18	31		26				
		End of Boring 100'								
105'										
110'										
115'										
120'										

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.**	2 (Approx. Sta. 25+00)
Project:	Channeling of Guayanilla River	**Sheet No.**	1 of 3
Date:	7/13/04 7/15/04		
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	100'
Ground Surf. Elev.:		**Water Depth: During Drilling**	25'
When finishing the boring:			

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
2'	18	Fill- recovered as brown clay with tiny roots & few fine sand	7-10-12-12	22		14				
4'	20		8-11-13-14	24		14	38	22	CL	
6'	21		6-8-7-7	15	[>4.5]	19				
8'	19		3-7-6-6	13		16	35	22	CL	
10'		Brownish clay w/ little fine sand & tiny roots (alluvial)	4-5-8-9	13		27				
15'	20	Gray & brown clayey silt/silty clay	2-4-4-6	8	[1.0]	32				
20'	18	(w/ fine silty sand)	3-4-4-4	8		26				
25'	21	Grayish clayey silt/silty clay, organic	4-4-3-3	7	0.45	29				
30'	20	(w/ rock frags)	3-4-5-6	9		33				
35'	24	(w/ decayed root)	3-4-4-4	8	[1.0]	33	47	18	OL	
40'	24	Gray clayey silty sand/sandy silty clay, organic	3-3-4-4	7	[0.5]	29				

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.**	2 (Approx. Sta. 25+00)
Project:	Channeling of Guayanilla River	**Sheet No.**	2 of 3
Date:	7/13/04 7/15/04		
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	100'
Ground Surf. Elev.:		**Water Depth: During Drilling**	25'
When finishing the boring:			

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
45'	24		2-4-4-5	8	[0.25]	31				
50'	24		push 12"-2-3	2	[0.5]	28	30	18	OL	
55'	24	Gray clayey silt/silty clay w/ shell frags & decayed roots, organic	push 12"-5-5	5	[0.5]	41				
60'	24		3-3-4-5	7		42				
65'	24	Gray clayey silty sand/ sandy silty clay, organic	3-5-5-8	10		34				
70'	24	(w/ traces of cemented sand)	3-5-5-7	10	[0.5]	27				
75'	24	(w/ traces of cemented sand)	4-3-5-7	8		30				
80'	24	Gray clayey silt/silty clay w/ decayed wood, organic	4-5-7-8	12	[1.25]	31	52	23	OH	

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.**	2 (Approx. Sta. 25+00)
Project:	Channeling of Guayanilla River	**Sheet No.**	3 of 3
Date:	7/13/04 7/15/04		
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	100'
Ground Surf. Elev.:		**Water Depth: During Drilling**	25'
When finishing the boring:			

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
85'	24	Gray cemented sand, clayey silt & silty clay, organic	10-14-16-23	30		21				
90'	22		12-27-32-50/5"	59		18				
95'	24	Tannish brown clayey silt/silty clay w/ traces of fine sand (Old Alluvial)	13-19-18-24	37	[2.5]	27				
100'	24		14-20-27-38	47	5.2	28	36	16	CL	
		End of Boring 100'								
105'										
110'										
115'										
120'										

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		LOG OF BORING NO.	3		
Project:	Channeling of Guayanilla River	**Sheet No.**	1 of 2	**Date:**	7/15/04 7/16/04
Site Location:	Guayanilla, Puerto Rico	**Boring End At:**	70'		
Ground Surf.		**Water Depth:**		**When finishing**	
Elev.:		**During Drilling**	20'	**the boring:**	

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
2'	19	Fill - recovered as brown clay with few fine sand and rock fragments	10-17-21-23	38		11				
4'	20		10-8-11-13	19	[3.25]	28				
6'	21	(clayey)	7-9-10-11	18	[2.5]	29	56	25	CH	
8'	18	Brownish sandy silty clay/clayey silty sand with rock fragments (alluvial)	7-8-9-12	17	[1.25]	29				
10'	19	Brown clayey silt/silty clay with rock fragments and tiny roots, organic	6-9-8-7	17	[0.5]	30				
15'	15	(gray and brown)	1-2-4-4	6	[0.5]	43				
20'	24	Gray fine silty sand with rock fragments, organic	3-14-18-17	32		27				
25'	24	(silty, soft and wet)	3-7-11-10	18		32				
30'	24	Gray sandy silty clay/clayey silty sand with shell fragments	2-2-3-4	5	[1.0]	33				
35'	24	(sandy decayed wood)	4-5-5-9	10		23				
40'	24	Gray clayey silt/silty clay with decayed wood, organic	3-4-5-6	9	[0.5]	50	64	41	OH	

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.** 3	
Project:	Channeling of Guayanilla River	**Sheet No.** 2 of 2	**Date:** 7/15/04 7/16/04
Site Location:	Guayanilla, Puerto Rico	**Boring End At:** 70'	
Ground Surf.		**Water Depth:**	**When finishing**
Elev.:		**During Drilling** 20'	**the boring:**

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
45'	24	Gray sandy silty clay/ clayey silty sand, organic	4-5-7-16	12		27				
50'	24	Tannish brown sandy silty clay/clay silty sand (old alluvial)	5-18-29-37	47		26				
55'	24	Tannish brown clayey silt/silty clay	10-27-49-50/5"	76	[>4.5]	31	47	30	CL	
60'	18	(traces of fine sand and limestone fragments)	18-50-50/3"	100/9"		18				
65'	24		8-14-15-18	29	[3.25]	28				
70'	12	Tannish brown sandy clay/clayey sand with few pebbles	35-28-33-46	61		22				
		End of Boring 70'								
75'										
80'										

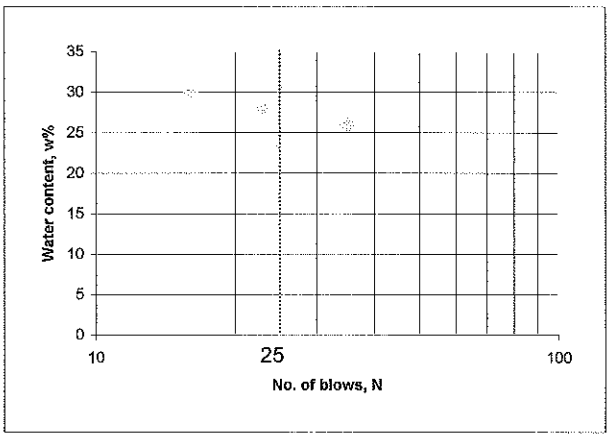
X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

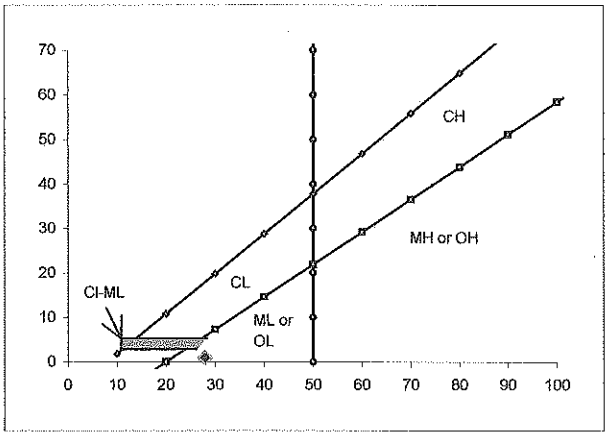
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 1	Sample No.: 9
Description of Soil: Gray sandy silty clay/clayey silty sand, organic		
Depth of Sample: 28' - 30'	Tested by: Juan Jose	Date: 7/12/04

Liquid Limit Determination

Can no.	196	195	169			
Wt. Of wet soil + can	27.26	26.54	27.45			
Wt. Of dry soil + can	24.21	23.32	23.81			
Wt. Of can	12.42	11.78	11.63	#N/A	#N/A	#N/A
Wt. Of dry soil	11.79	11.54	12.18	#N/A	#N/A	#N/A
Wt. Of moisture	3.05	3.22	3.64	#N/A	#N/A	#N/A
Water content, w%	26	28	30	0	0	0
No. of Blows, N	35	23	16			





AASHTO A-4 {1}

Flow Index	Liquid Limit	28
	Plastic Limit	27
	Plasticity Index	1

Plastic Limit Determination

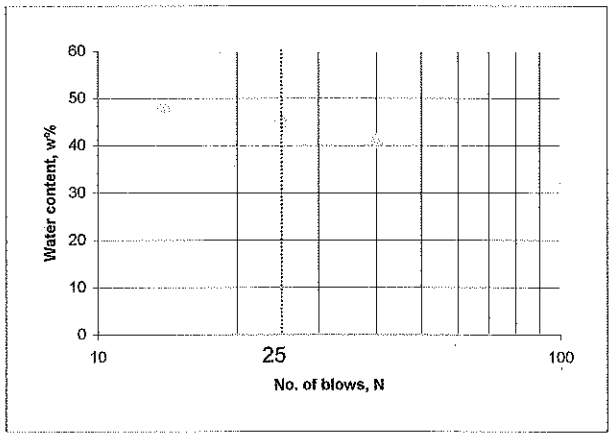
Can no.	232	215				
Wt. Of wet soil + can	6.18	6.3				
Wt. Of dry soil + can	5.78	5.87				
Wt. Of can	4.33	4.23	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	1.45	1.64	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.4	0.43	#N/A	#N/A	#N/A	#N/A
Water content, w%	28	26	#N/A	#N/A	#N/A	#N/A

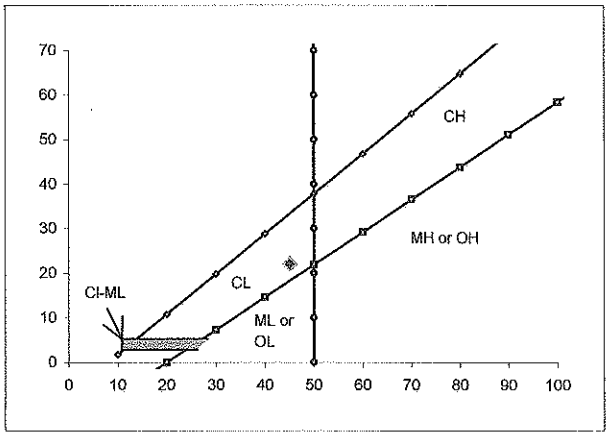
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 1	Sample No.: 11
Description of Soil: Gray clayey silt/silty clay w/ shell frags, organic		
Depth of Sample: 38' - 40'	Tested by: Juan Jose	Date: 7/12/04

Liquid Limit Determination

Can no.	214	244	235			
Wt. Of wet soil + can	6.7	7.86	7.85			
Wt. Of dry soil + can	5.98	6.8	6.75			
Wt. Of can	4.23	4.44	4.45	#N/A	#N/A	#N/A
Wt. Of dry soil	1.75	2.36	2.3	#N/A	#N/A	#N/A
Wt. Of moisture	0.72	1.06	1.1	#N/A	#N/A	#N/A
Water content, w%	41	45	48	0	0	0
No. of Blows, N	40	25	14			





AASHTO A-7-6 {25}

Flow Index	Liquid Limit	45
	Plastic Limit	23
	Plasticity Index	22

Plastic Limit Determination

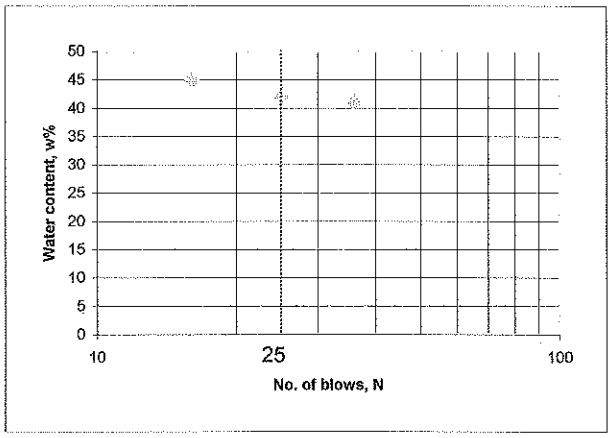
Can no.	207	230				
Wt. Of wet soil + can	6.75	6.43				
Wt. Of dry soil + can	6.28	6.03				
Wt. Of can	4.23	4.27	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	2.05	1.76	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.47	0.4	#N/A	#N/A	#N/A	#N/A
Water content, w%	23	23	#N/A	#N/A	#N/A	#N/A

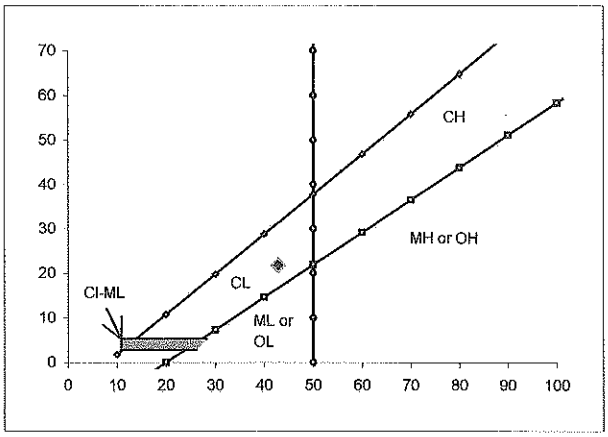
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 1	Sample No.: Shelby
Description of Soil: Gray clayey silt/silty clay and sandy silty clay/clayey silty sand, organic		
Depth of Sample: Sta. 13+00 (40' - 42') 1	Tested by: Luis M.	Date: 7/20/04

Liquid Limit Determination

Can no.	248	241	243			
Wt. Of wet soil + can	9.02	8.69	11.36			
Wt. Of dry soil + can	7.69	7.34	10.02			
Wt. Of can	4.48	4.14	7.02	#N/A	#N/A	#N/A
Wt. Of dry soil	3.21	3.2	3	#N/A	#N/A	#N/A
Wt. Of moisture	1.33	1.35	1.34	#N/A	#N/A	#N/A
Water content, w%	41	42	45	0	0	0
No. of Blows, N	36	25	16			





AASHTO A-7-6 {24}

Flow Index	Liquid Limit	43
	Plastic Limit	21
	Plasticity Index	22

Plastic Limit Determination

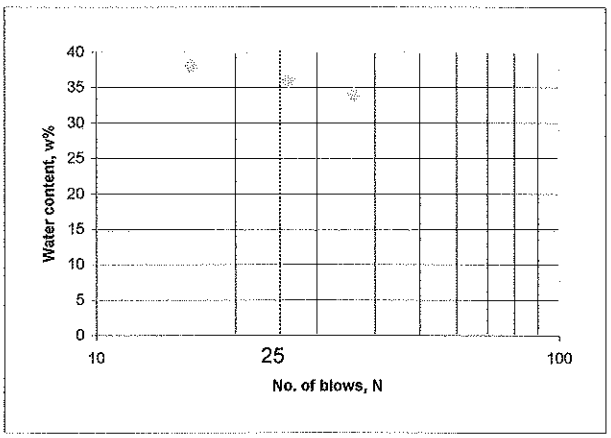
Can no.	238	240				
Wt. Of wet soil + can	5.9	6.08				
Wt. Of dry soil + can	5.62	5.77				
Wt. Of can	4.22	4.34	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	1.4	1.43	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.28	0.31	#N/A	#N/A	#N/A	#N/A
Water content, w%	20	22	#N/A	#N/A	#N/A	#N/A

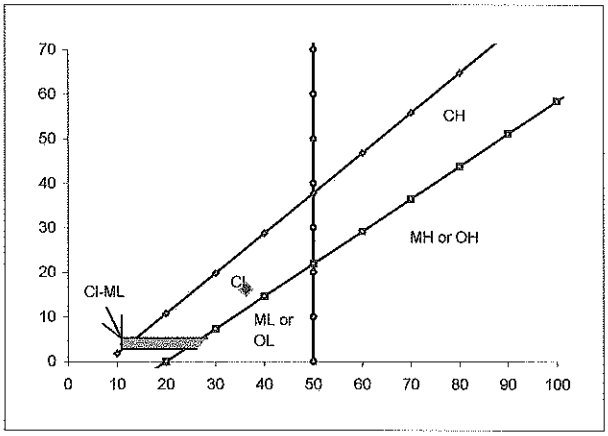
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 1	Sample No.: Shelby
Description of Soil: Gray clayey silt/silty clay and sandy silty clay/clayey silty sand, organic		
Depth of Sample: Sta. 13+00 (40' - 42') 2	Tested by: Luis M.	Date: 7/20/04

Liquid Limit Determination

Can no.	226	230	208			
Wt. Of wet soil + can	8.41	8.3	8.4			
Wt. Of dry soil + can	7.38	7.24	7.25			
Wt. Of can	4.31	4.27	4.22	#N/A	#N/A	#N/A
Wt. Of dry soil	3.07	2.97	3.03	#N/A	#N/A	#N/A
Wt. Of moisture	1.03	1.06	1.15	#N/A	#N/A	#N/A
Water content, w%	34	36	38	0	0	0
No. of Blows, N	36	26	16			





AASHTO A-6 {17}

Flow Index	Liquid Limit	36
	Plastic Limit	20
	Plasticity Index	16

Plastic Limit Determination

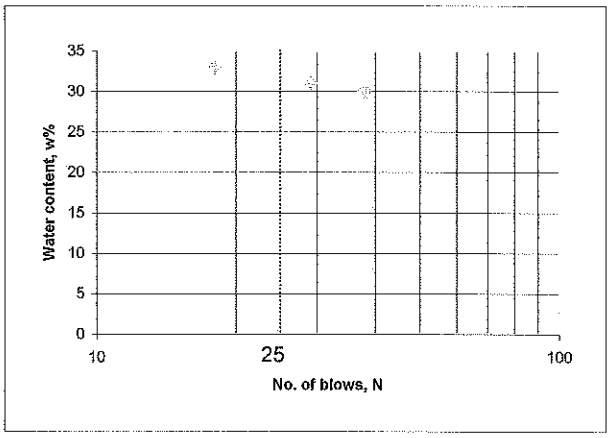
Can no.	229	207				
Wt. Of wet soil + can	6.31	6.39				
Wt. Of dry soil + can	5.99	6.03				
Wt. Of can	4.41	4.23	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	1.58	1.8	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.32	0.36	#N/A	#N/A	#N/A	#N/A
Water content, w%	20	20	#N/A	#N/A	#N/A	#N/A

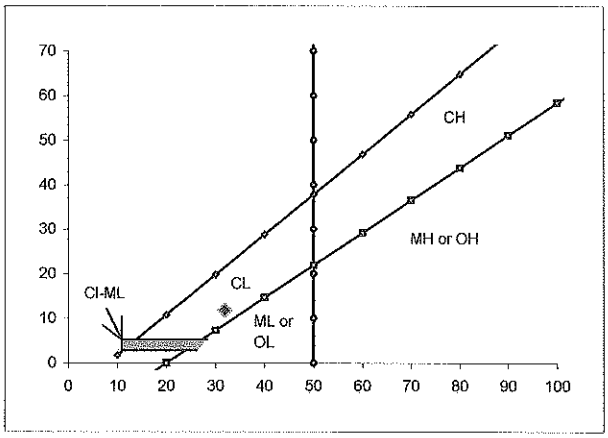
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 1	Sample No.: 13
Description of Soil: Gray sandy silty clay/clayey silty sand w/ shell frags, organic		
Depth of Sample: 48' - 50'	Tested by: Roberto	Date: 7/20/04

Liquid Limit Determination

Can no.	25	39	195			
Wt. Of wet soil + can	25.73	18.53	25.46			
Wt. Of dry soil + can	23.14	16.96	22.05			
Wt. Of can	14.58	11.92	11.78	#N/A	#N/A	#N/A
Wt. Of dry soil	8.56	5.04	10.27	#N/A	#N/A	#N/A
Wt. Of moisture	2.59	1.57	3.41	#N/A	#N/A	#N/A
Water content, w%	30	31	33	0	0	0
No. of Blows, N	38	29	18			





AASHTO A-6 {12}

Flow Index	Liquid Limit	32
	Plastic Limit	20
	Plasticity Index	12

Plastic Limit Determination

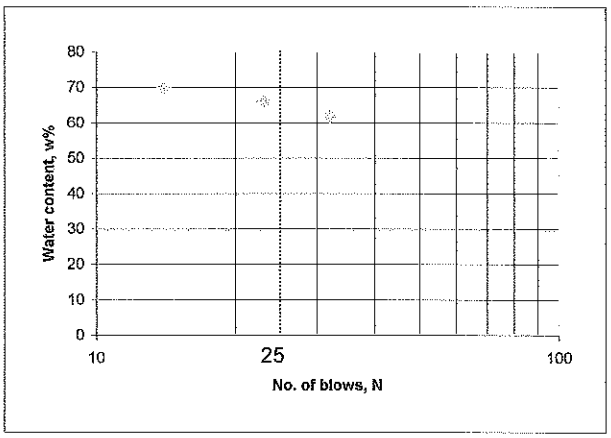
Can no.	216	238				
Wt. Of wet soil + can	6.62	6.37				
Wt. Of dry soil + can	6.23	6.01				
Wt. Of can	4.27	4.22	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	1.96	1.79	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.39	0.36	#N/A	#N/A	#N/A	#N/A
Water content, w%	20	20	#N/A	#N/A	#N/A	#N/A

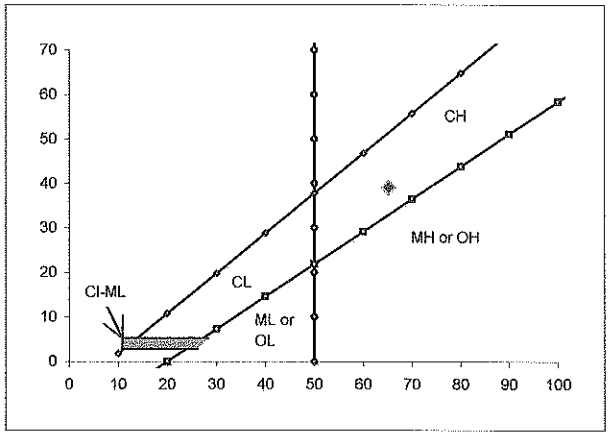
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 1	Sample No.: 20
Description of Soil: Tannish brown clayey silt/silty clay w/ traces of pebbles, gray mottled		
Depth of Sample: 83' - 85'	Tested by: Juan Jose	Date: 7/12/04

Liquid Limit Determination

Can no.	43	39	25			
Wt. Of wet soil + can	21.37	19.97	24.24			
Wt. Of dry soil + can	17.73	16.77	20.25			
Wt. Of can	11.84	11.92	14.58	#N/A	#N/A	#N/A
Wt. Of dry soil	5.89	4.85	5.67	#N/A	#N/A	#N/A
Wt. Of moisture	3.64	3.2	3.99	#N/A	#N/A	#N/A
Water content, w%	62	66	70	0	0	0
No. of Blows, N	32	23	14			





AASHTO A-7-6 {46}

Flow Index	Liquid Limit	65
	Plastic Limit	26
	Plasticity Index	39

Plastic Limit Determination

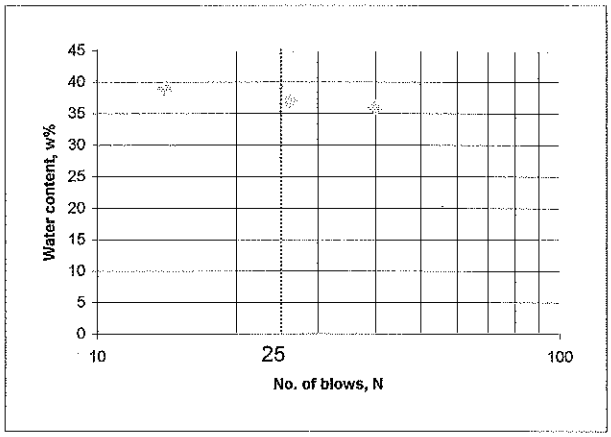
Can no.	208	223				
Wt. Of wet soil + can	6.18	5.74				
Wt. Of dry soil + can	5.77	5.45				
Wt. Of can	4.22	4.32	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	1.55	1.13	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.41	0.29	#N/A	#N/A	#N/A	#N/A
Water content, w%	26	26	#N/A	#N/A	#N/A	#N/A

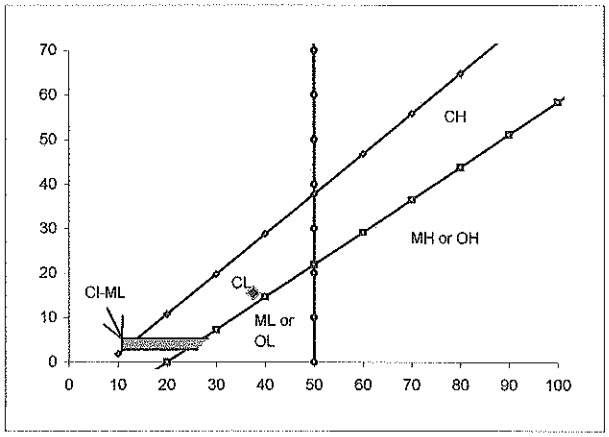
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 2	Sample No.: 2
Description of Soil: Brownish clay with traces of fine sand		
Depth of Sample: 2' - 4'	Tested by: Luis M.	Date: 7/28/04

Liquid Limit Determination

Can no.	248	214	235			
Wt. Of wet soil + can	7.9	8.41	9.29			
Wt. Of dry soil + can	7	7.29	7.93			
Wt. Of can	4.48	4.23	4.45	#N/A	#N/A	#N/A
Wt. Of dry soil	2.52	3.06	3.48	#N/A	#N/A	#N/A
Wt. Of moisture	0.9	1.12	1.36	#N/A	#N/A	#N/A
Water content, w%	36	37	39	0	0	0
No. of Blows, N	40	26	14			





AASHTO A-6 {17}

Flow Index	Liquid Limit	38
	Plastic Limit	22
	Plasticity Index	16

Plastic Limit Determination

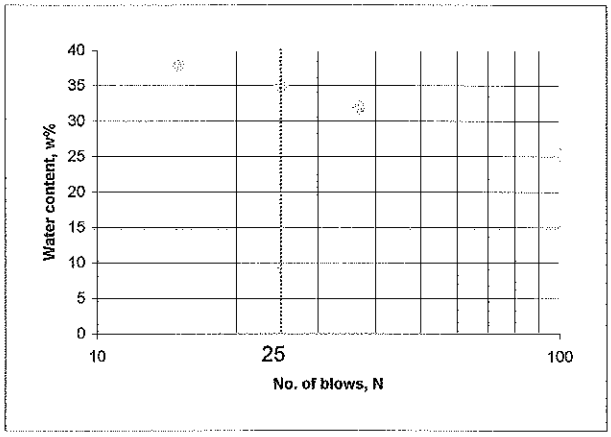
Can no.	246	203				
Wt. Of wet soil + can	6.43	6.58				
Wt. Of dry soil + can	6.03	6.17				
Wt. Of can	4.21	4.27	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	1.82	1.9	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.4	0.41	#N/A	#N/A	#N/A	#N/A
Water content, w%	22	22	#N/A	#N/A	#N/A	#N/A

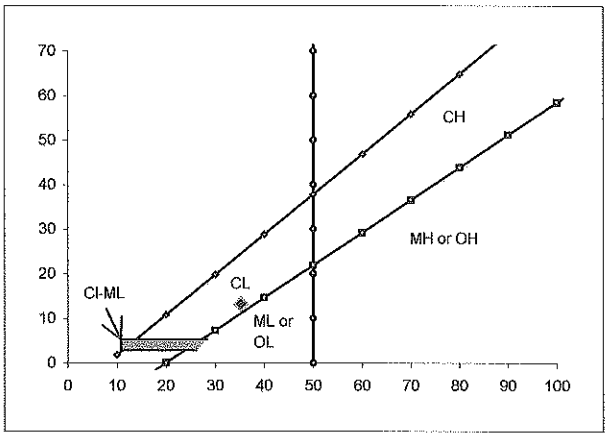
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 2	Sample No.: 4
Description of Soil: Brownish clay with traces of fine sand		
Depth of Sample: 6' - 8'	Tested by: Luis M.	Date: 7/28/04

Liquid Limit Determination

Can no.	216	252	219			
Wt. Of wet soil + can	7.64	9.97	9.04			
Wt. Of dry soil + can	6.82	8.49	7.7			
Wt. Of can	4.27	4.22	4.21	#N/A	#N/A	#N/A
Wt. Of dry soil	2.55	4.27	3.49	#N/A	#N/A	#N/A
Wt. Of moisture	0.82	1.48	1.34	#N/A	#N/A	#N/A
Water content, w%	32	35	38	0	0	0
No. of Blows, N	37	25	15			





AASHTO A-6 {14}

Flow Index	Liquid Limit	35
	Plastic Limit	22
	Plasticity Index	13

Plastic Limit Determination

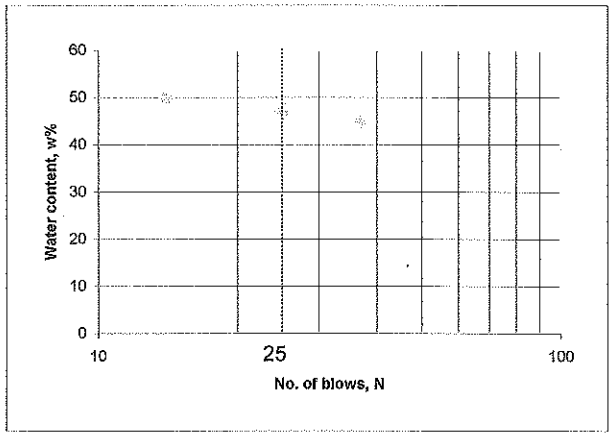
Can no.	244	215				
Wt. Of wet soil + can	6.63	6.44				
Wt. Of dry soil + can	6.24	6.04				
Wt. Of can	4.44	4.23	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	1.8	1.81	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.39	0.4	#N/A	#N/A	#N/A	#N/A
Water content, w%	22	22	#N/A	#N/A	#N/A	#N/A

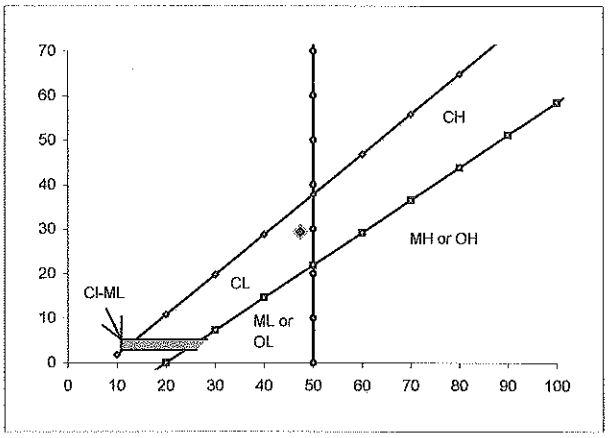
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 2	Sample No.: 10
Description of Soil: Gray clayey silt/silty clay w/ decayed wood, organic		
Depth of Sample: 33' - 35'	Tested by: Luis M.	Date: 7/19/04

Liquid Limit Determination

Can no.	222	209	232			
Wt. Of wet soil + can	7.59	9.28	7.83			
Wt. Of dry soil + can	6.59	7.69	6.67			
Wt. Of can	4.35	4.29	4.33	#N/A	#N/A	#N/A
Wt. Of dry soil	2.24	3.4	2.34	#N/A	#N/A	#N/A
Wt. Of moisture	1	1.59	1.16	#N/A	#N/A	#N/A
Water content, w%	45	47	50	0	0	0
No. of Blows, N	37	25	14			





AASHTO A-7-6 {32}

Flow Index	Liquid Limit	47
	Plastic Limit	18
	Plasticity Index	29

Plastic Limit Determination

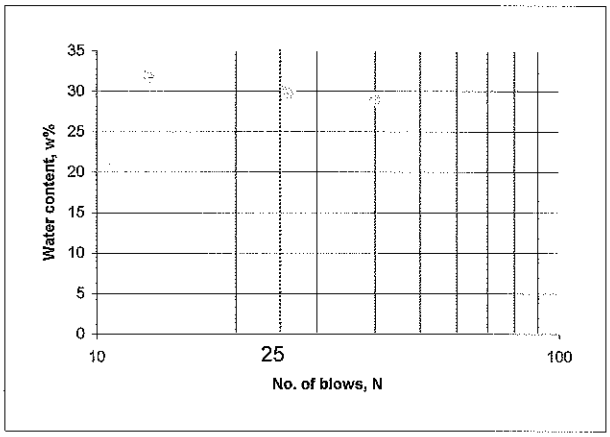
Can no.	250	207				
Wt. Of wet soil + can	6.3	6.35				
Wt. Of dry soil + can	6	6.03				
Wt. Of can	4.34	4.23	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	1.66	1.8	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.3	0.32	#N/A	#N/A	#N/A	#N/A
Water content, w%	18	18	#N/A	#N/A	#N/A	#N/A

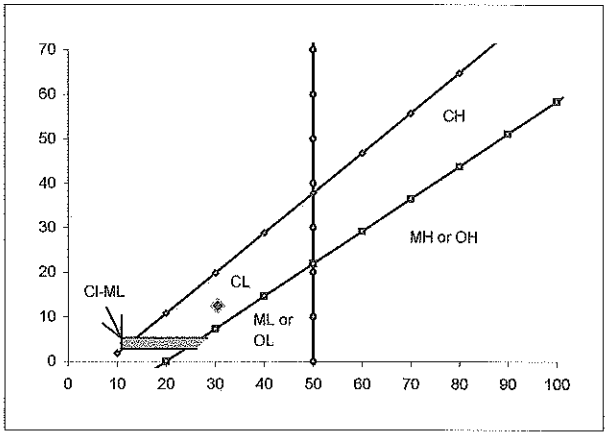
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 2	Sample No.: 13
Description of Soil: Gray clayey silty sand/sandy silty clay, organic		
Depth of Sample: 48' - 50'	Tested by: Luis M.	Date: 7/19/04

Liquid Limit Determination

Can no.	230	251	215			
Wt. Of wet soil + can	8.21	7.93	8.95			
Wt. Of dry soil + can	7.32	7.07	7.8			
Wt. Of can	4.27	4.2	4.23	#N/A	#N/A	#N/A
Wt. Of dry soil	3.05	2.87	3.57	#N/A	#N/A	#N/A
Wt. Of moisture	0.89	0.86	1.15	#N/A	#N/A	#N/A
Water content, w%	29	30	32	0	0	0
No. of Blows, N	40	26	13			





AASHTO A-6 {12}

Flow Index	Liquid Limit	30
	Plastic Limit	18
	Plasticity Index	12

Plastic Limit Determination

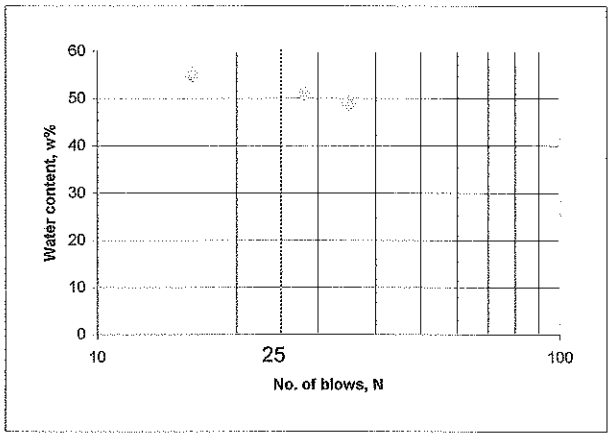
Can no.	201	226				
Wt. Of wet soil + can	6.22	6.58				
Wt. Of dry soil + can	5.93	6.23				
Wt. Of can	4.31	4.31	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	1.62	1.92	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.29	0.35	#N/A	#N/A	#N/A	#N/A
Water content, w%	18	18	#N/A	#N/A	#N/A	#N/A

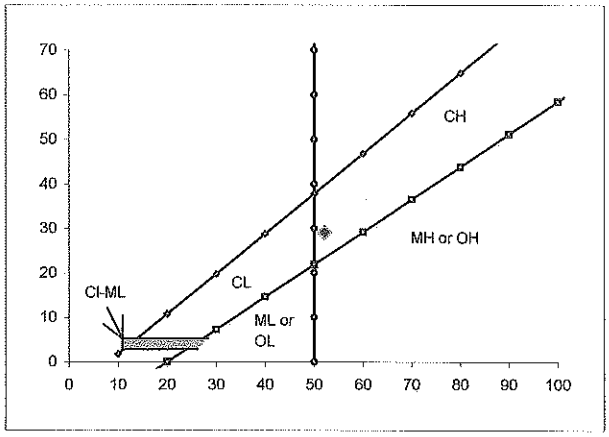
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 2	Sample No.: 19
Description of Soil: Gray clayey silt/silty clay w/ decayed wood, organic		
Depth of Sample: 78' - 80'	Tested by: Luis M.	Date: 7/20/04

Liquid Limit Determination

Can no.	62	74	72			
Wt. Of wet soil + can	15.39	15.37	14.71			
Wt. Of dry soil + can	13.69	13.48	12.96			
Wt. Of can	10.19	9.74	9.75	#N/A	#N/A	#N/A
Wt. Of dry soil	3.5	3.74	3.21	#N/A	#N/A	#N/A
Wt. Of moisture	1.7	1.89	1.75	#N/A	#N/A	#N/A
Water content, w%	49	51	55	0	0	0
No. of Blows, N	35	28	16			





AASHTO A-7-6 {33}

Flow Index	Liquid Limit	52
	Plastic Limit	23
	Plasticity Index	29

Plastic Limit Determination

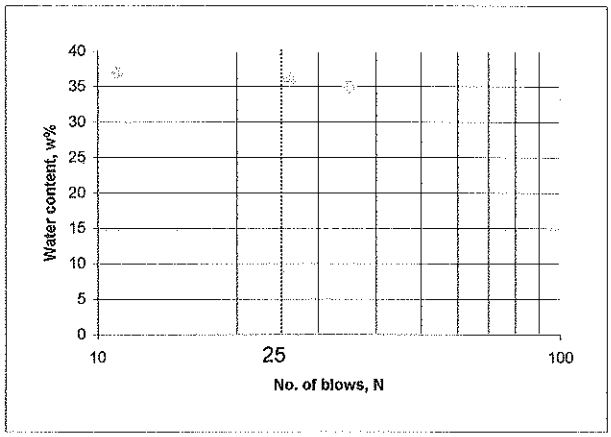
Can no.	202	249				
Wt. Of wet soil + can	6.78	6.82				
Wt. Of dry soil + can	6.3	6.33				
Wt. Of can	4.23	4.2	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	2.07	2.13	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.48	0.49	#N/A	#N/A	#N/A	#N/A
Water content, w%	23	23	#N/A	#N/A	#N/A	#N/A

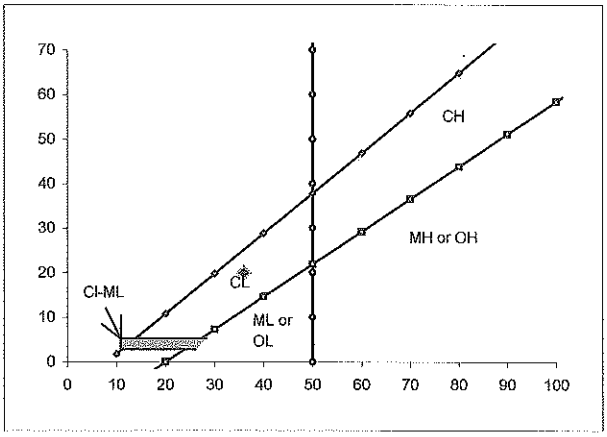
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 2	Sample No.: 23
Description of Soil: Tannish brown clayey silt/silty clay w/ traces of sand		
Depth of Sample: 98' - 100'	Tested by: Luis M.	Date: 7/19/04

Liquid Limit Determination

Can no.	247	203	223			
Wt. Of wet soil + can	8.97	9.17	8.81			
Wt. Of dry soil + can	7.74	7.87	7.59			
Wt. Of can	4.21	4.27	4.32	#N/A	#N/A	#N/A
Wt. Of dry soil	3.53	3.6	3.27	#N/A	#N/A	#N/A
Wt. Of moisture	1.23	1.3	1.22	#N/A	#N/A	#N/A
Water content, w%	35	36	37	0	0	0
No. of Blows, N	35	26	11			





AASHTO A-6 {20}

Flow Index	Liquid Limit	36
	Plastic Limit	16
	Plasticity Index	20

Plastic Limit Determination

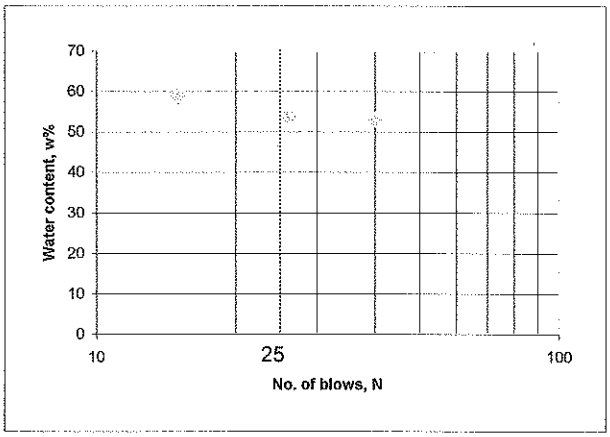
Can no.	238	216				
Wt. Of wet soil + can	5.85	6.3				
Wt. Of dry soil + can	5.62	6.02				
Wt. Of can	4.22	4.27	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	1.4	1.75	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.23	0.28	#N/A	#N/A	#N/A	#N/A
Water content, w%	16	16	#N/A	#N/A	#N/A	#N/A

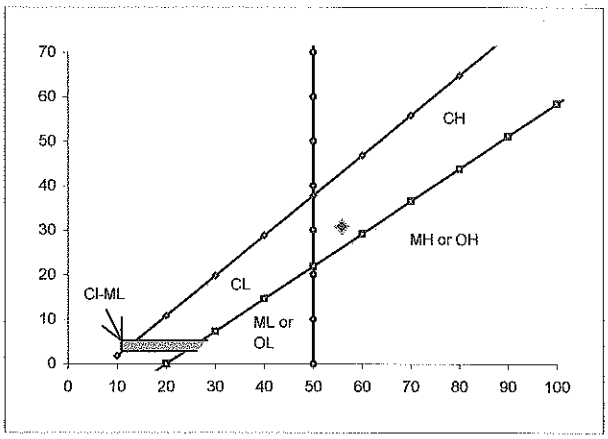
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 3	Sample No.: 3
Description of Soil: Brownish clay/sity clay with traces of fine sand		
Depth of Sample: 4' - 6'	Tested by: Luis M.	Date: 7/28/04

Liquid Limit Determination

Can no.	249	211	221			
Wt. Of wet soil + can	8.17	8.29	9.17			
Wt. Of dry soil + can	6.8	6.87	7.42			
Wt. Of can	4.2	4.23	4.45	#N/A	#N/A	#N/A
Wt. Of dry soil	2.6	2.64	2.97	#N/A	#N/A	#N/A
Wt. Of moisture	1.37	1.42	1.75	#N/A	#N/A	#N/A
Water content, w%	53	54	59	0	0	0
No. of Blows, N	40	26	15			





AASHTO A-7-6 {36}

Flow Index	Liquid Limit	56
	Plastic Limit	25
	Plasticity Index	31

Plastic Limit Determination

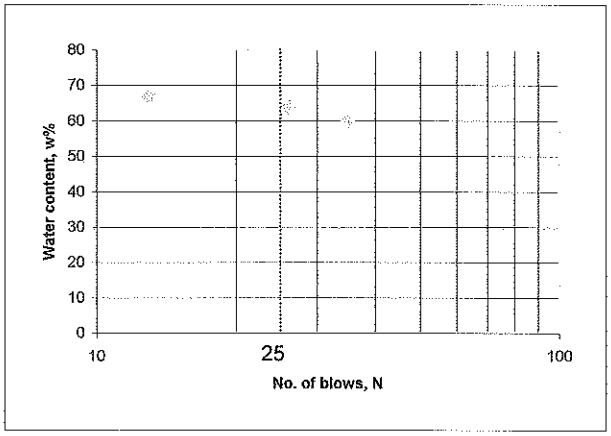
Can no.	147	209				
Wt. Of wet soil + can	9.12	7.4				
Wt. Of dry soil + can	8.71	6.78				
Wt. Of can	7.1	4.29	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	1.61	2.49	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.41	0.62	#N/A	#N/A	#N/A	#N/A
Water content, w%	25	25	#N/A	#N/A	#N/A	#N/A

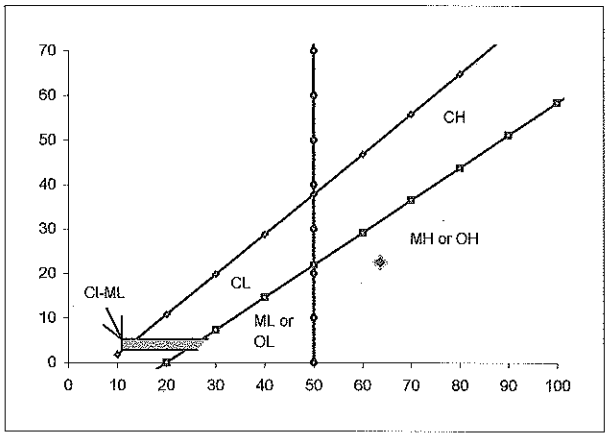
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 3	Sample No.: 11
Description of Soil: Gray clayey silt/silty clay w/ decayed wood, organic		
Depth of Sample: 38' - 40'	Tested by: Roberto	Date: 7/20/04

Liquid Limit Determination

Can no.	29	45	64			
Wt. Of wet soil + can	21.34	20.59	16.48			
Wt. Of dry soil + can	18.74	17.23	13.54			
Wt. Of can	14.44	11.97	9.14	#N/A	#N/A	#N/A
Wt. Of dry soil	4.3	5.26	4.4	#N/A	#N/A	#N/A
Wt. Of moisture	2.6	3.36	2.94	#N/A	#N/A	#N/A
Water content, w%	60	64	67	0	0	0
No. of Blows, N	35	26	13			





AASHTO A-7-5 {31}

Flow Index	Liquid Limit	64
	Plastic Limit	41
	Plasticity Index	23

Plastic Limit Determination

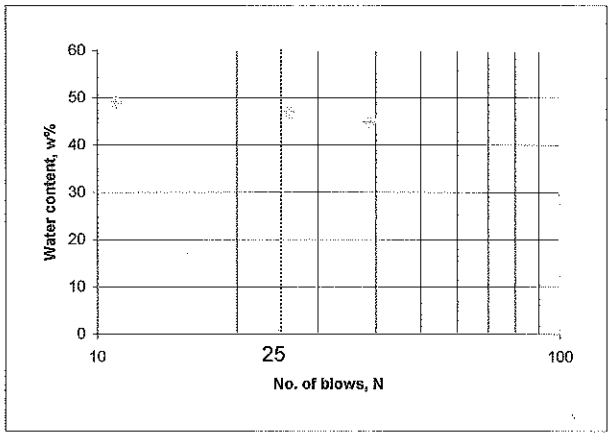
Can no.	221	211				
Wt. Of wet soil + can	7.84	7.69				
Wt. Of dry soil + can	6.86	6.69				
Wt. Of can	4.45	4.23	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	2.41	2.46	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.98	1	#N/A	#N/A	#N/A	#N/A
Water content, w%	41	41	#N/A	#N/A	#N/A	#N/A

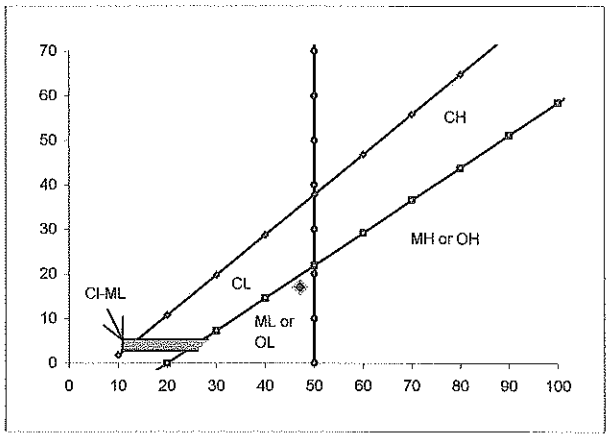
Atterberg Limits Determination

Project: Channeling of Guayanilla River	Job No.: GEO-2004-532	
Location of Project: Guayanilla, Puerto Rico	Boring No.: 3	Sample No.: 14
Description of Soil: Tannish brown clayey silt/silty clay		
Depth of Sample: 53' - 55'	Tested by: Roberto	Date: 7/20/04

Liquid Limit Determination

Can no.	252	231	219			
Wt. Of wet soil + can	12.52	13.5	13.51			
Wt. Of dry soil + can	9.93	10.54	10.44			
Wt. Of can	4.22	4.21	4.21	#N/A	#N/A	#N/A
Wt. Of dry soil	5.71	6.33	6.23	#N/A	#N/A	#N/A
Wt. Of moisture	2.59	2.96	3.07	#N/A	#N/A	#N/A
Water content, w%	45	47	49	0	0	0
No. of Blows, N	39	26	11			





AASHTO A-7-5 {21}

Flow Index	Liquid Limit	47
	Plastic Limit	30
	Plasticity Index	17

Plastic Limit Determination

Can no.	201	208				
Wt. Of wet soil + can	6.64	6.72				
Wt. Of dry soil + can	6.1	6.14				
Wt. Of can	4.31	4.22	#N/A	#N/A	#N/A	#N/A
Wt. Of dry soil	1.79	1.92	#N/A	#N/A	#N/A	#N/A
Wt. Of moisture	0.54	0.58	#N/A	#N/A	#N/A	#N/A
Water content, w%	30	30	#N/A	#N/A	#N/A	#N/A

SETTLEMENT RESULTS

Geo ENGINEERING

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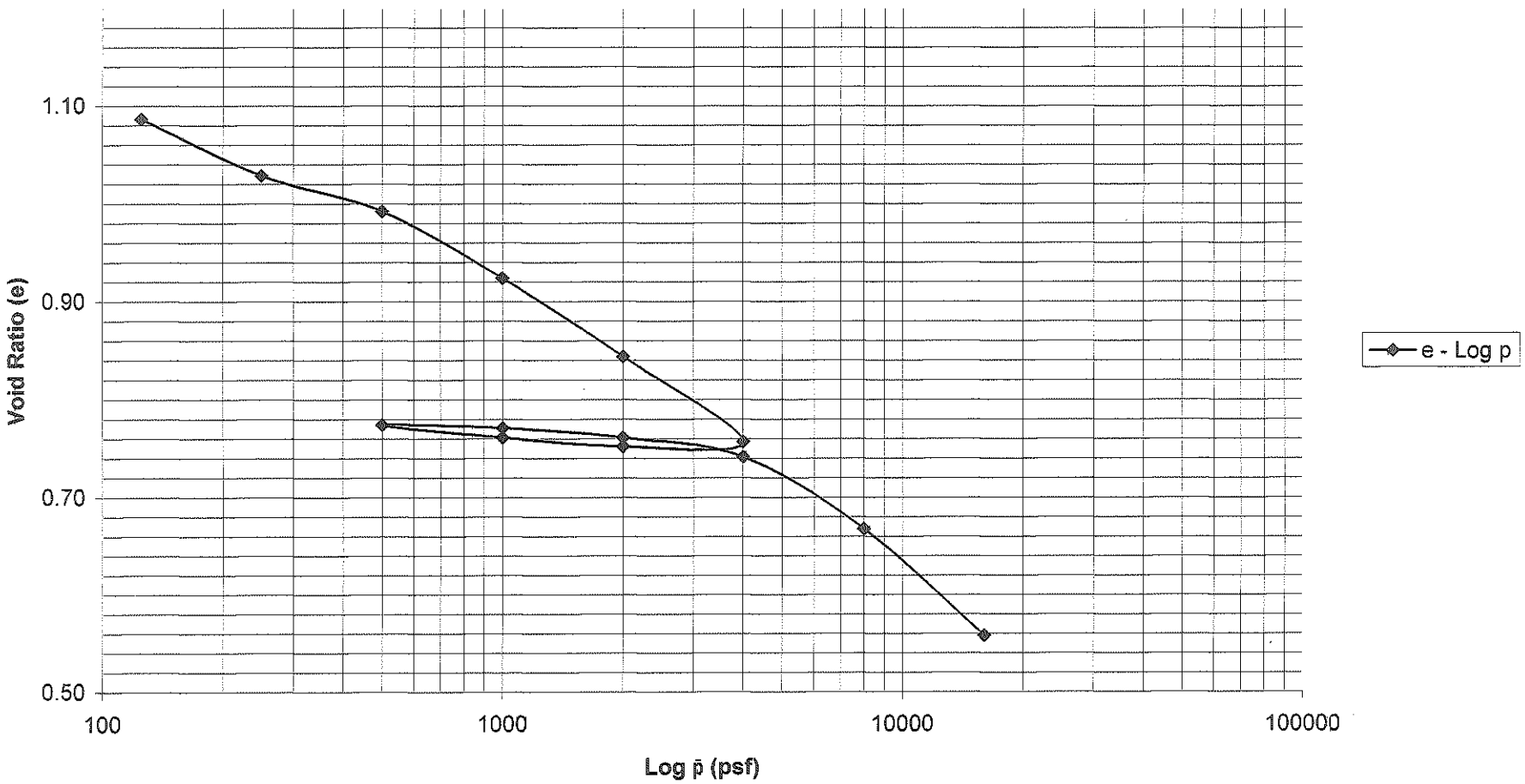
e - Log p̄

Channeling of Guayanilla River
B-1 (Approx. Sta. 13+00) 40'-42'



e - Log p̄

Channeling of Guayanilla River
B-1 (Approx. Sta. 13+00) 40'-42'
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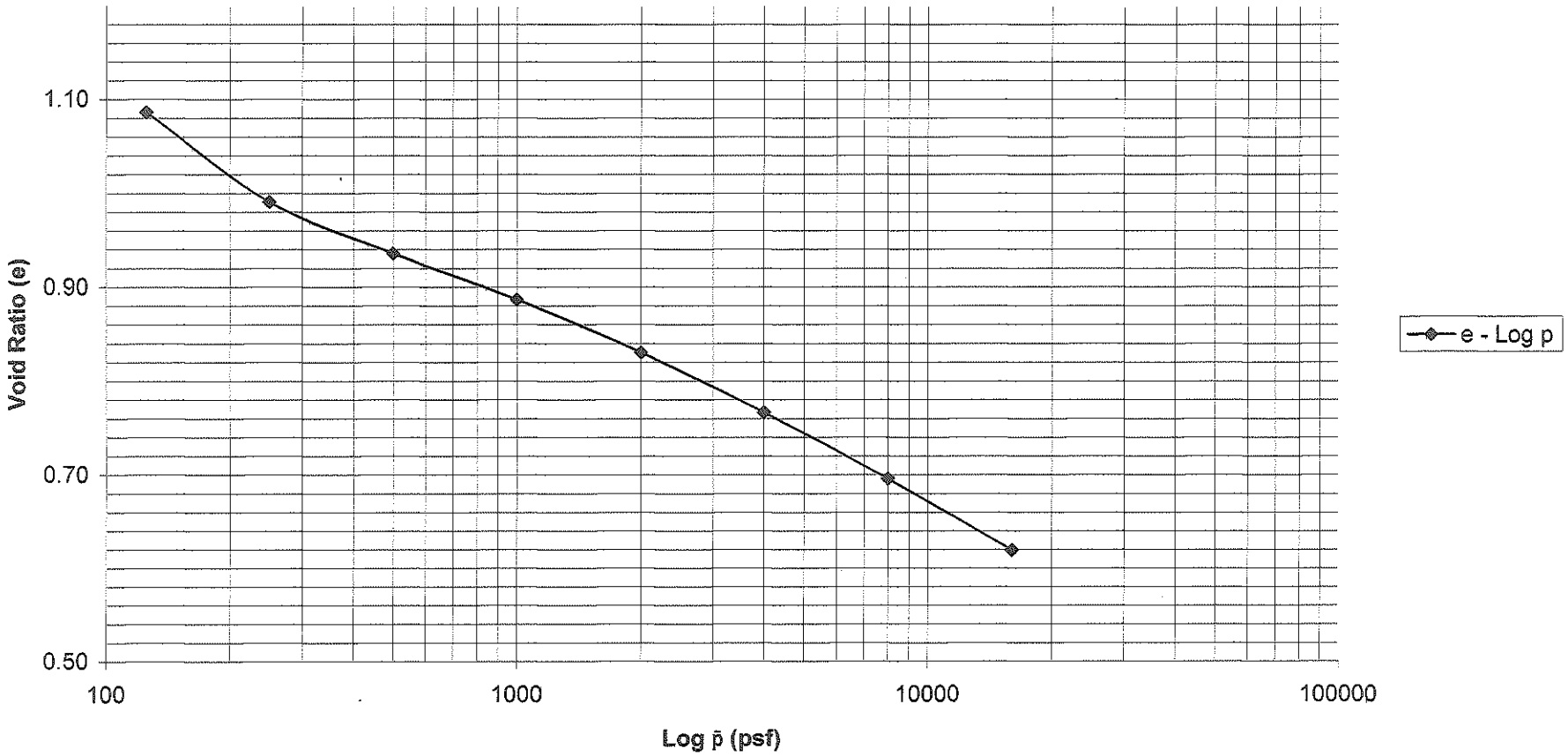
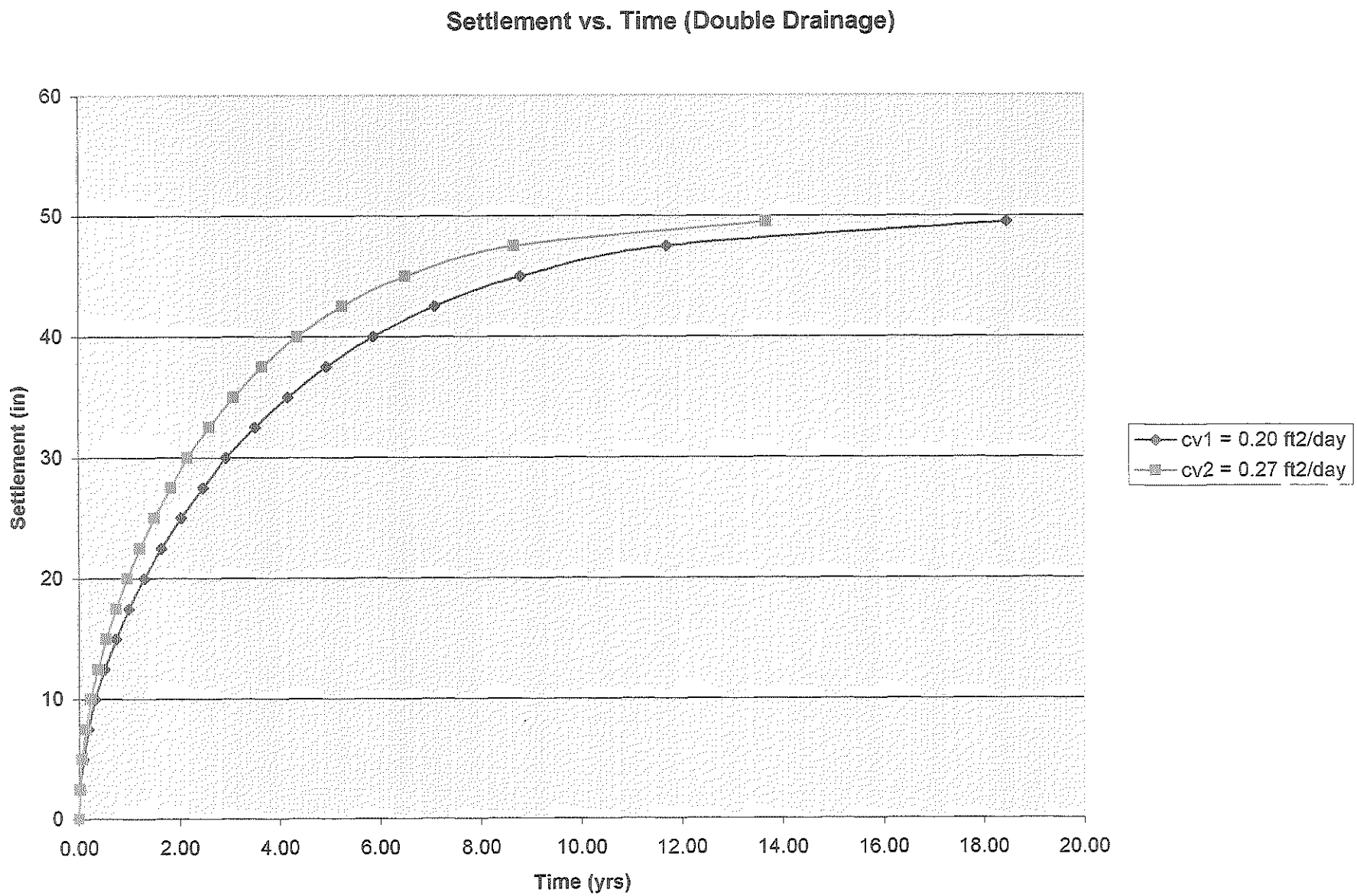
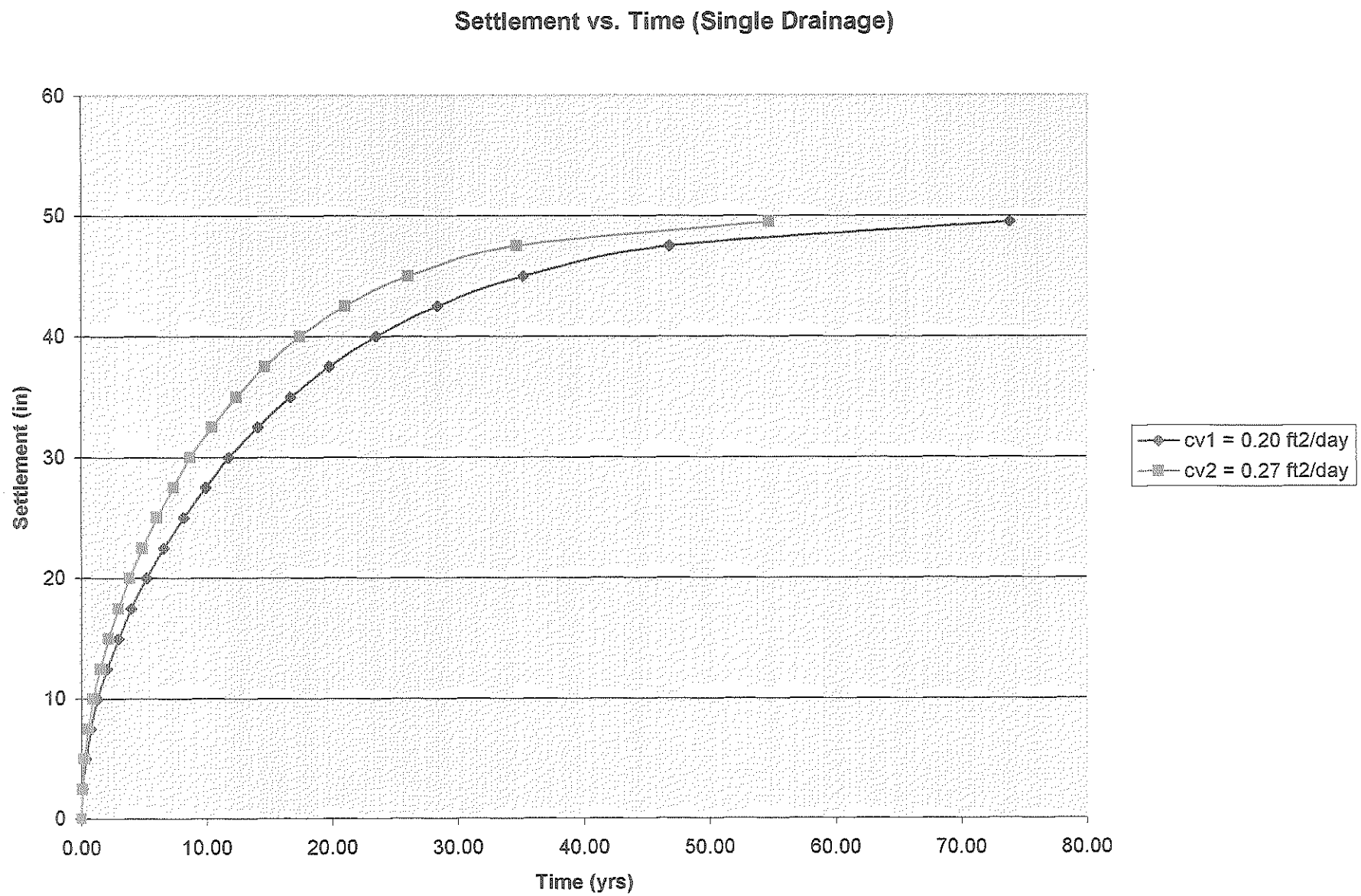



Settlement vs. Time (Double Drainage)
Settlement (in)
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
Time (yrs)
cv1 = 0.20 ft2/day
cv2 = 0.27 ft2/day


Settlement vs. Time (Single Drainage)
Settlement (in)
60
50
40
30
20
10
0
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
Time (yrs)
cv1 = 0.20 ft2/day
cv2 = 0.27 ft2/day

FEM ANALYSIS RESULTS

Geo ENGINEERING

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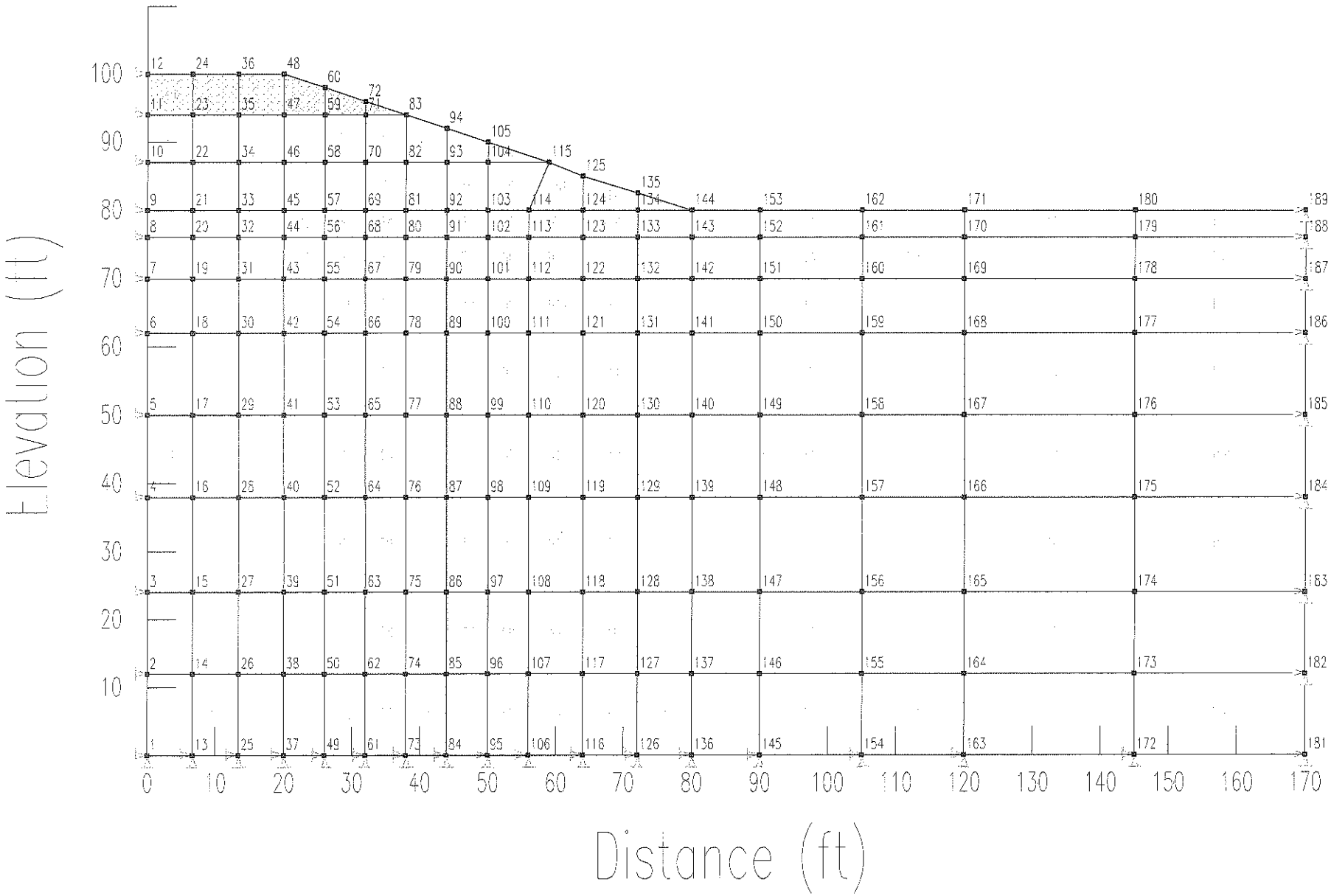
FEM Model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Distance (ft)
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30
40
50
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70
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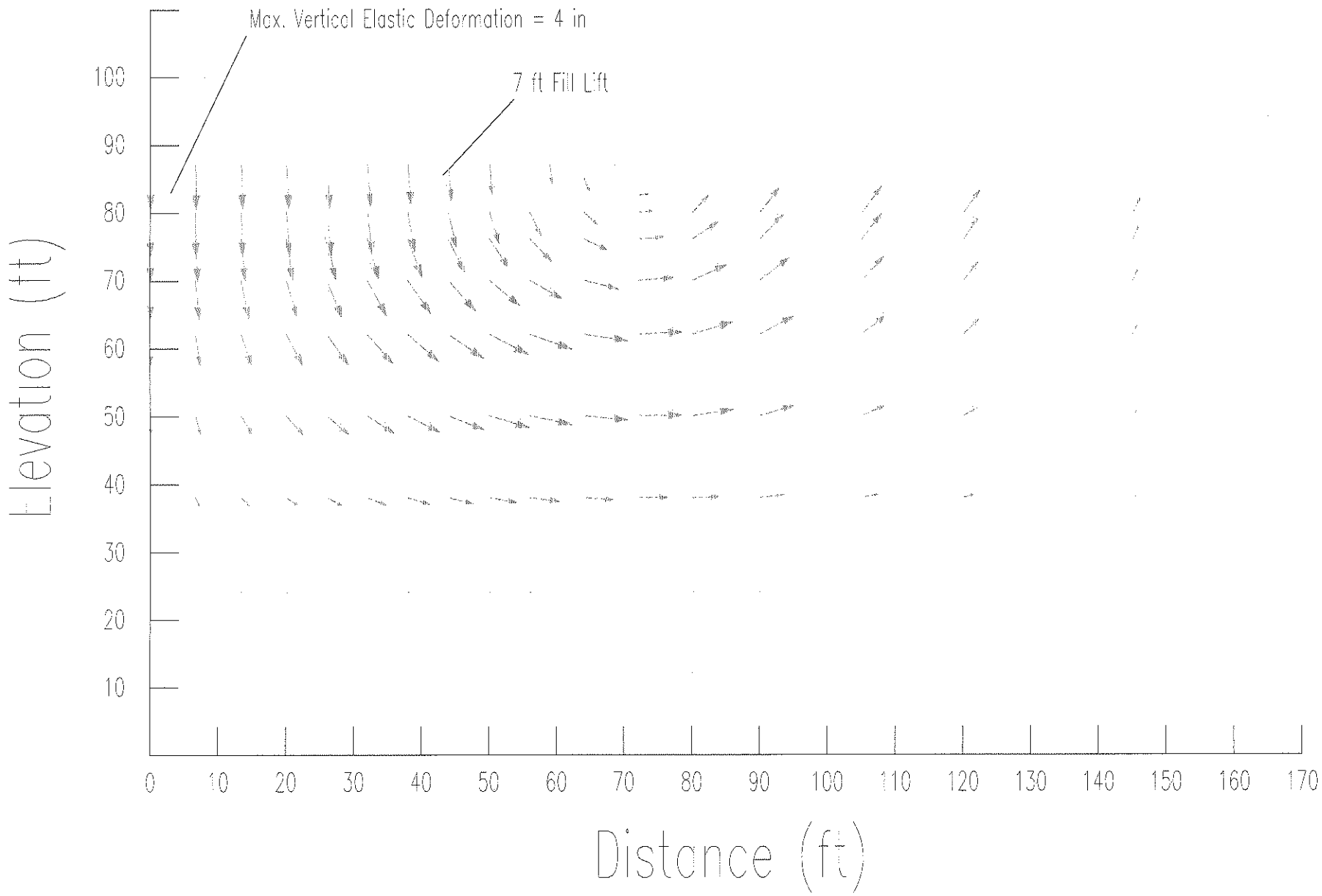
90
100
110
120
130
140
150
160
170


Max. Vertical Elastic Deformation = 4 in
7 ft Fill Lift
Elevation (ft)
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80
70
60
50
40
30
20
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0
10
20
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40
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60
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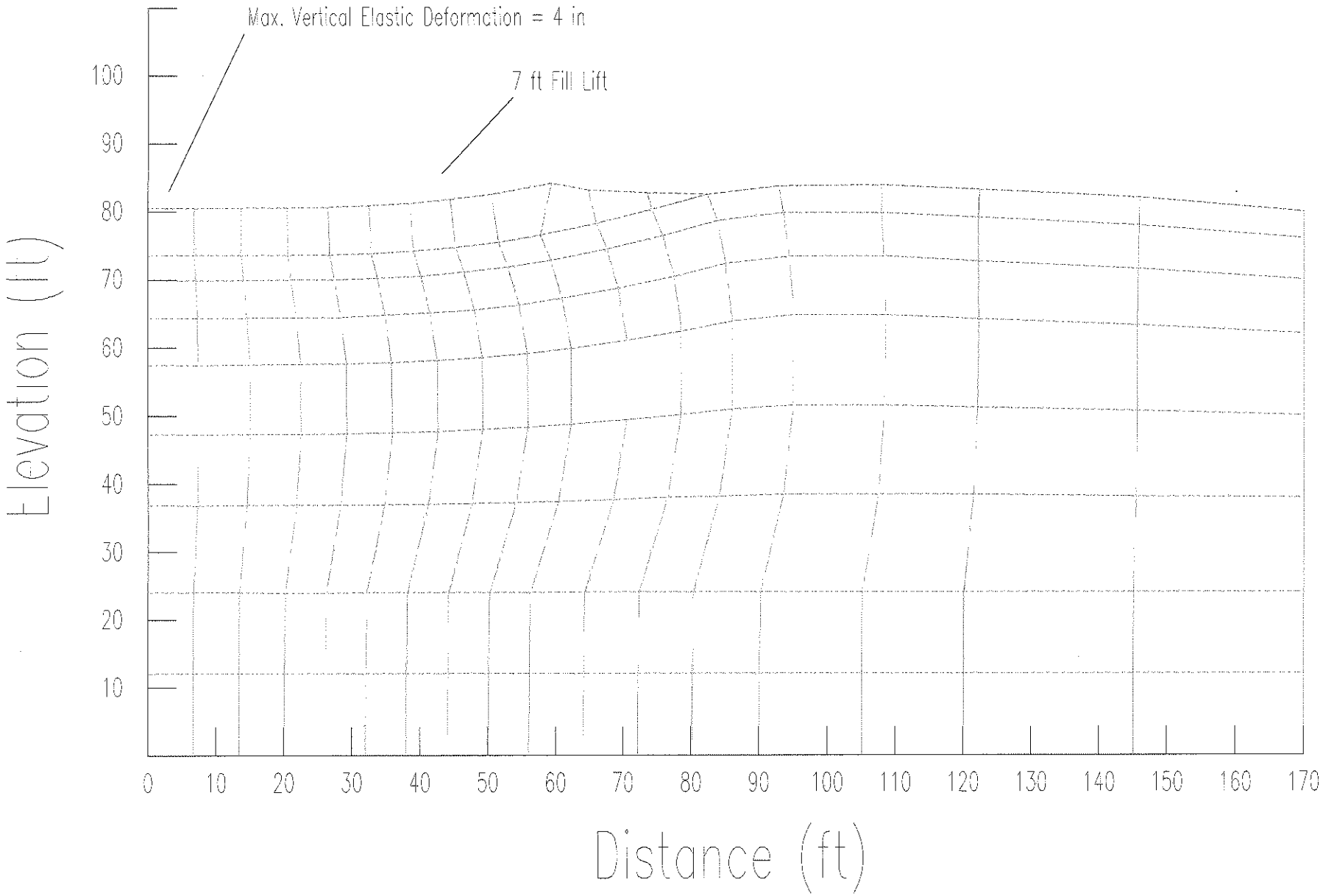
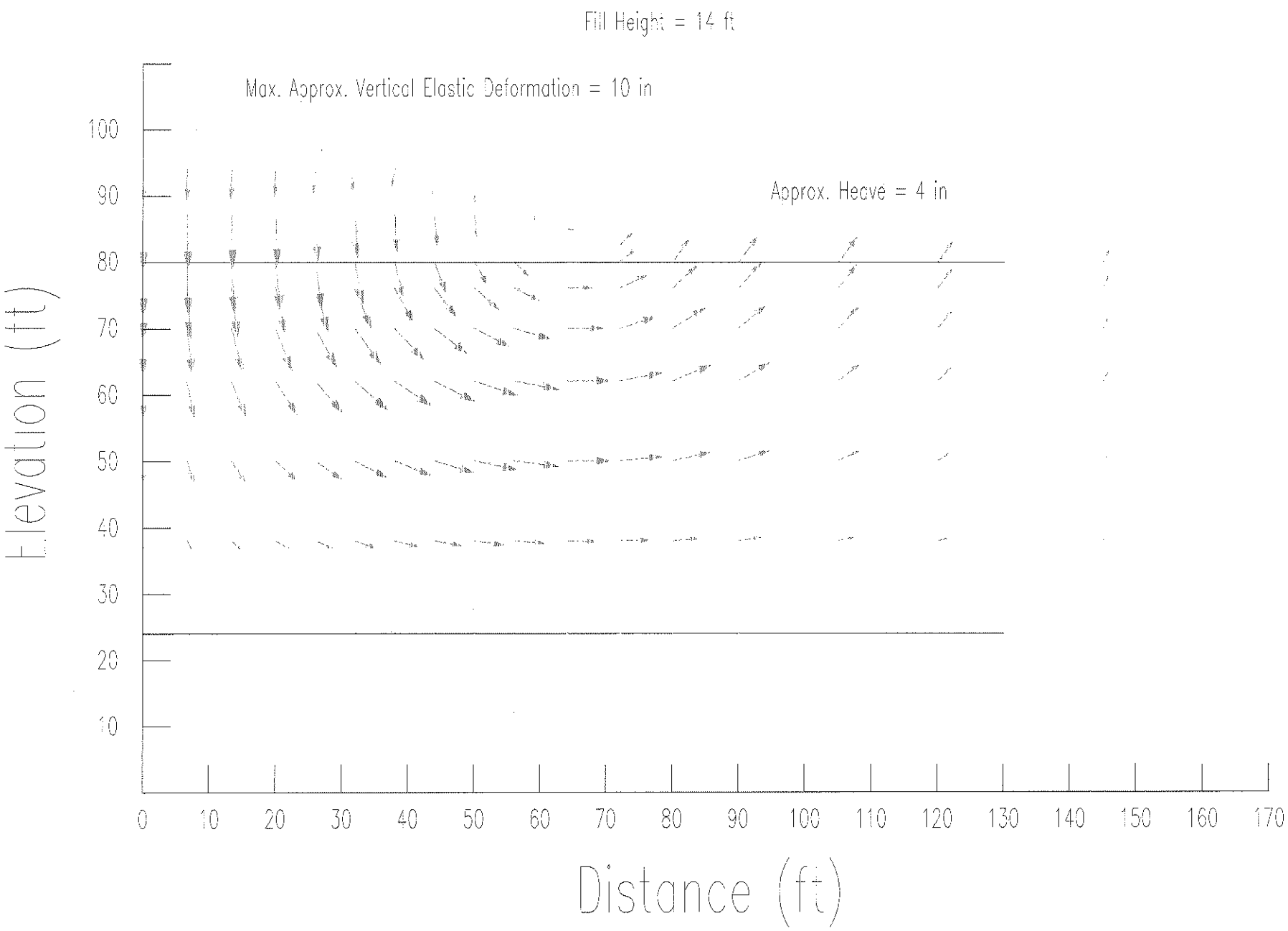
80
90
100
110
120
130
140
150
160
170
Distance (ft)


Max. Vertical Elastic Deformation = 4 in
7 ft Fill Lift
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Distance (ft)


Fill Height = 14 ft
Max. Approx. Vertical Elastic Deformation = 10 in
Approx. Heave = 4 in
Elevation (ft)
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90
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70
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50
40
30
20
10
0
10
20
30
40
50
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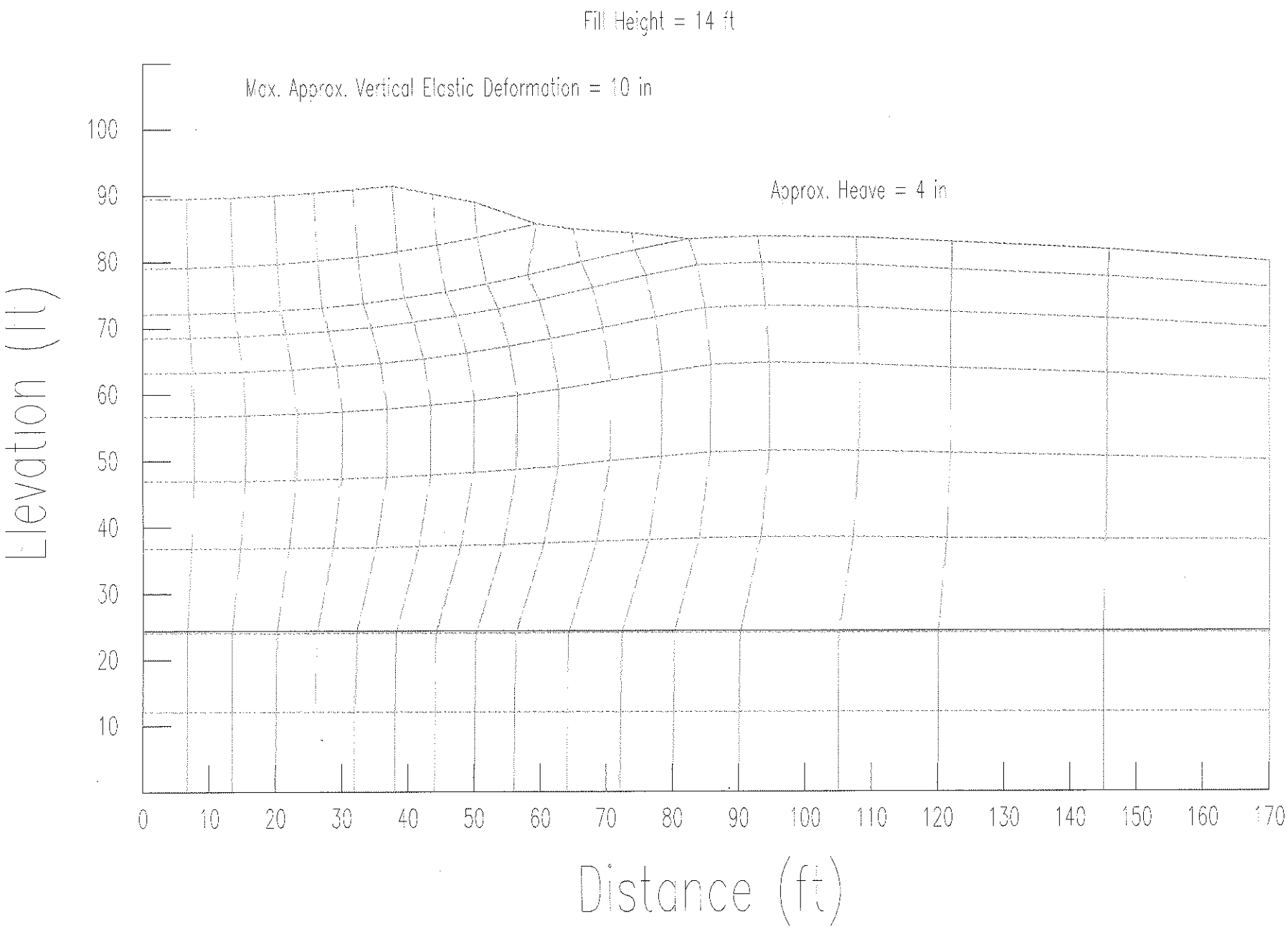
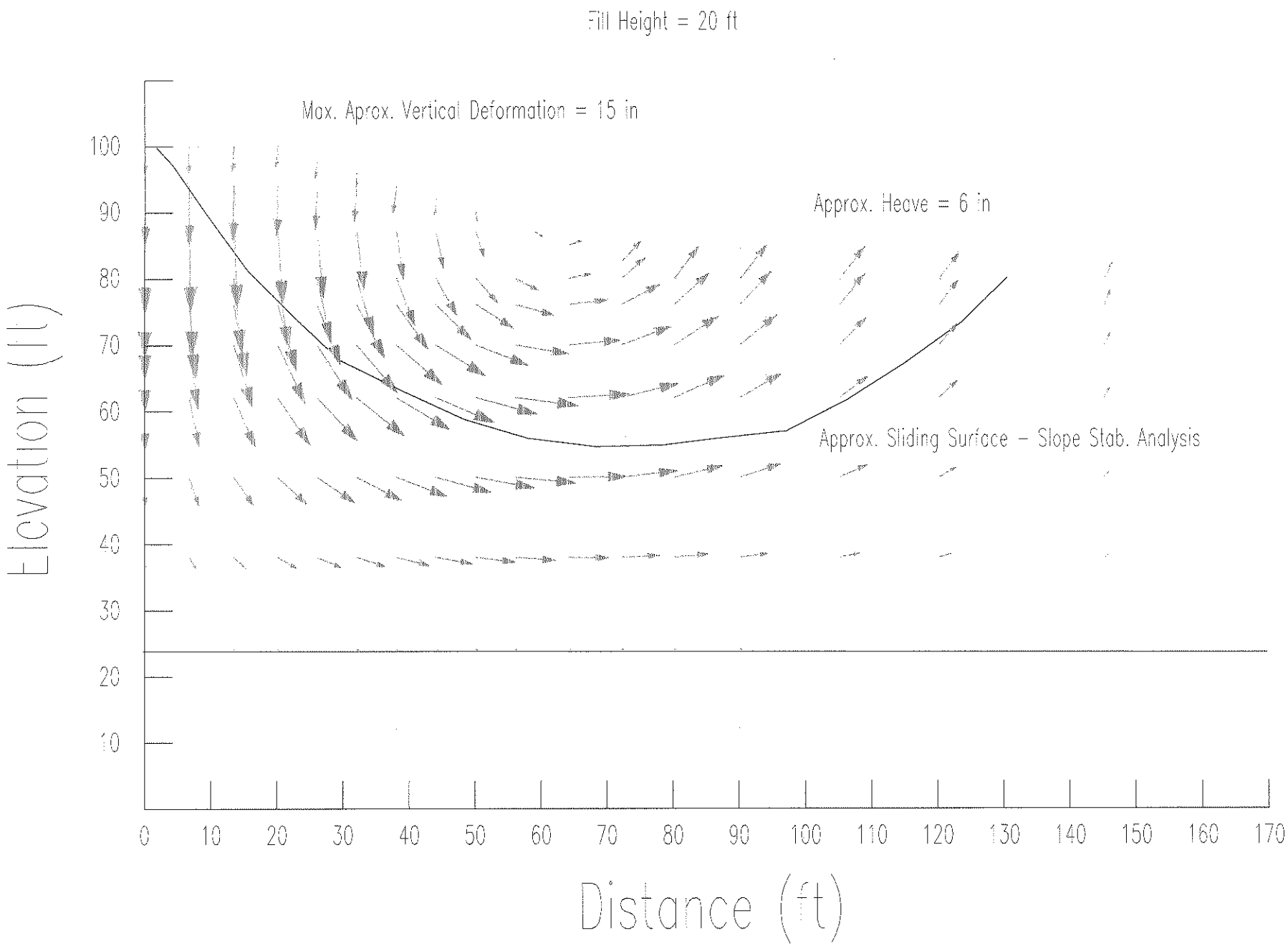
80
90
100
110
120
130
140
150
160
170
Distance (ft)


Fill Height = 14 ft
Max. Approx. Vertical Elastic Deformation = 10 in
Approx. Heave = 4 in
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Distance (ft)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Max. Aprox. Vertical Deformation = 15 in
Approx. Heave = 6 in
Approx. Sliding Surface - Slope Stab. Analysis
Elevation (ft)
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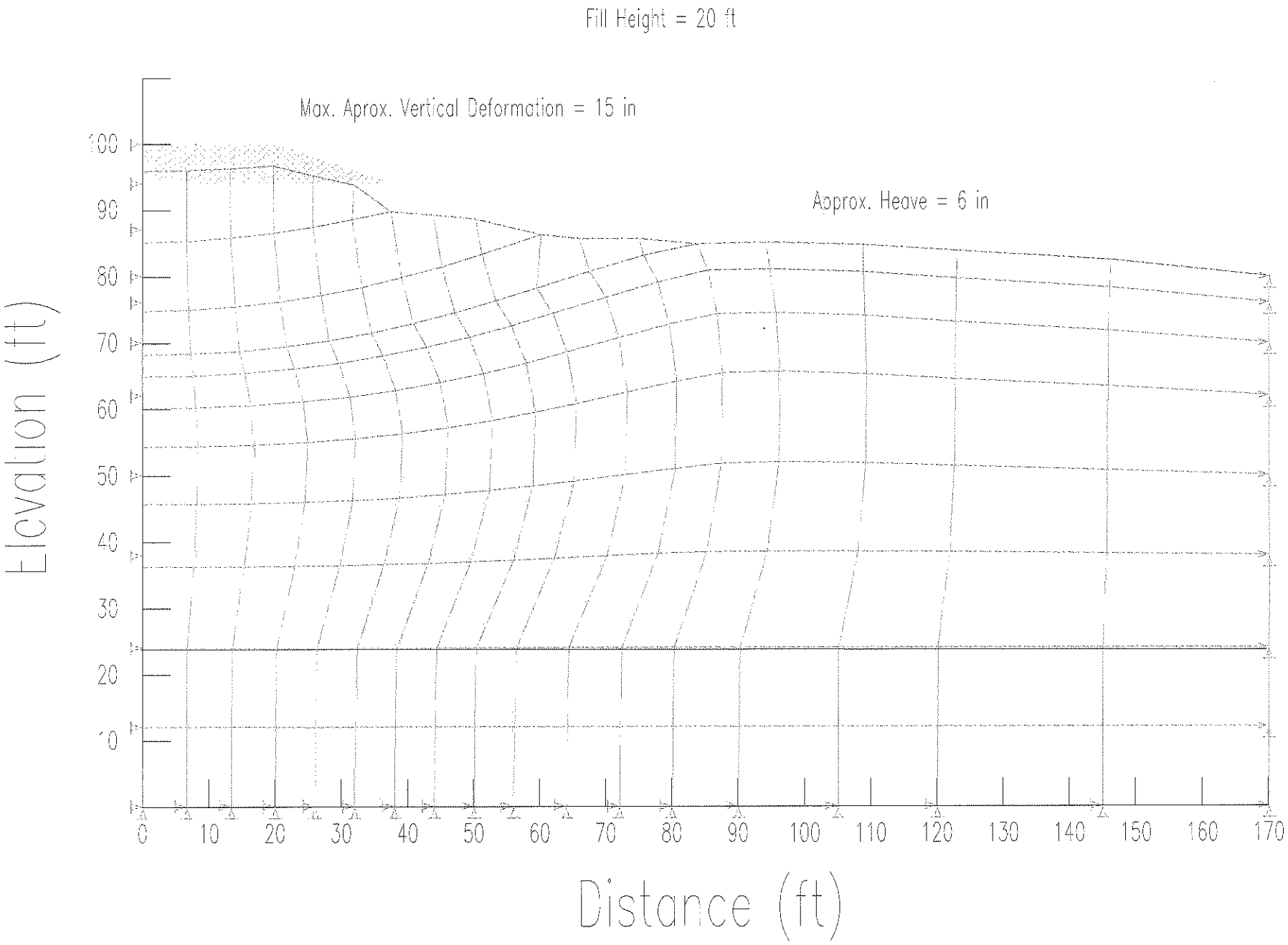
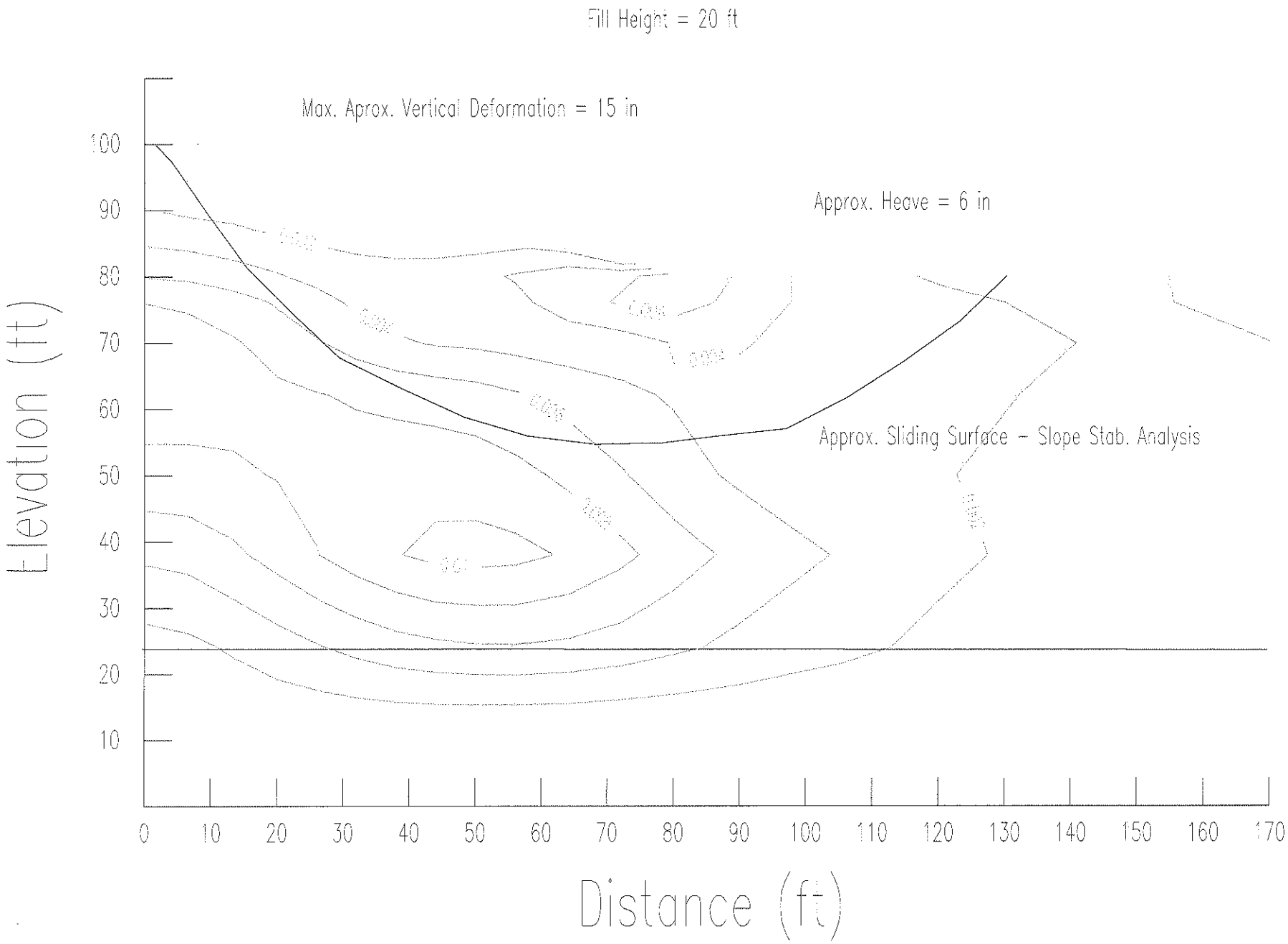
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Distance (ft)


Fill Height = 20 ft
Max. Aprox. Vertical Deformation = 15 in
Aoprox. Heave = 6 in
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Distance (ft)


Fill Height = 20 ft
Max. Aprox. Vertical Deformation = 15 in
Approx. Heave = 6 in
Approx. Sliding Surface - Slope Stab. Analysis
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Distance (ft)

```
TITLE
Dike - Guayanilla River
Settlement Analysis
04/07/30

ANALYSIS
    1      1 +6.2400e+001 +8.0000e+001 +8.0000e+001
CONVERGE
   10 +1.0000e+000
LOAD
    1
MATERIAL        5
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+4.3200e+004 +2.0000e+002 +0.0000e+000 +0.0000e+000 +0.0000e+000
+4.9000e-001 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
    2      4      2      0      0      0 +0.0000e+000 +7.5000e-001
+1.2000e+006 +2.0000e+003 +0.0000e+000 +0.0000e+000 +0.0000e+000
+4.0000e-001 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
    3      4      2      0      0      0 +0.0000e+000 +5.6000e-001
+1.5000e+006 +2.5000e+003 +0.0000e+000 +0.0000e+000 +0.0000e+000
+3.5000e-001 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
    4      4      2      0      0      0 +0.0000e+000 +5.6000e-001
+1.5000e+006 +2.5000e+003 +0.0000e+000 +0.0000e+000 +0.0000e+000
+3.5000e-001 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
    5      4      2      0      0      0 +1.2500e+002 +5.6000e-001
+1.5000e+006 +2.5000e+003 +0.0000e+000 +0.0000e+000 +0.0000e+000
+3.5000e-001 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
BCFUNCTION      0
ACFUNCTION      0
ERFUNCTION      0
BFUNCTION       0
NODE          189
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    2 +0.0000e+000 +1.2000e+001 +0.0000e+000 +0.0000e+000 +0.0000e+000 100000
    3 +0.0000e+000 +2.4000e+001 +0.0000e+000 +0.0000e+000 +0.0000e+000 100000
    4 +0.0000e+000 +3.8000e+001 +0.0000e+000 +0.0000e+000 +0.0000e+000 100000
    5 +0.0000e+000 +5.0000e+001 +0.0000e+000 +0.0000e+000 +0.0000e+000 100000
    6 +0.0000e+000 +6.2000e+001 +0.0000e+000 +0.0000e+000 +0.0000e+000 100000
    7 +0.0000e+000 +7.0000e+001 +0.0000e+000 +0.0000e+000 +0.0000e+000 100000
    8 +0.0000e+000 +7.6000e+001 +0.0000e+000 +0.0000e+000 +0.0000e+000 100000
    9 +0.0000e+000 +8.0000e+001 +0.0000e+000 +0.0000e+000 +0.0000e+000 100000
   10 +0.0000e+000 +8.7000e+001 +0.0000e+000 +0.0000e+000 +0.0000e+000 100000
   11 +0.0000e+000 +9.4000e+001 +0.0000e+000 +0.0000e+000 +0.0000e+000 100000
   12 +0.0000e+000 +1.0000e+002 +0.0000e+000 +0.0000e+000 +0.0000e+000 100000
```

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15	+6.6667e+000	+2.4000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
16	+6.6667e+000	+3.8000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
17	+6.6667e+000	+5.0000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
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21	+6.6667e+000	+8.0000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
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169	+1.2000e+002	+7.0000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
170	+1.2000e+002	+7.6000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
171	+1.2000e+002	+8.0000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
172	+1.4500e+002	+0.0000e+000	+0.0000e+000	+0.0000e+000	+0.0000e+000	100100
173	+1.4500e+002	+1.2000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
174	+1.4500e+002	+2.4000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
175	+1.4500e+002	+3.8000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
176	+1.4500e+002	+5.0000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
177	+1.4500e+002	+6.2000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
178	+1.4500e+002	+7.0000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
179	+1.4500e+002	+7.6000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
180	+1.4500e+002	+8.0000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	000000
181	+1.7000e+002	+0.0000e+000	+0.0000e+000	+0.0000e+000	+0.0000e+000	100100
182	+1.7000e+002	+1.2000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	100100
183	+1.7000e+002	+2.4000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	100100
184	+1.7000e+002	+3.8000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	100100
185	+1.7000e+002	+5.0000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	100100
186	+1.7000e+002	+6.2000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	100100
187	+1.7000e+002	+7.0000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	100100
188	+1.7000e+002	+7.6000e+001	+0.0000e+000	+0.0000e+000	+0.0000e+000	100100

189 +1.7000e+002 +8.0000e+001 +0.0000e+000 +0.0000e+000 +0.0000e+000 100100

ELEMENT 163

1	13	14	2	1	0	0	0	0	2	4	+1.0000e+000
2	14	15	3	2	0	0	0	0	2	4	+1.0000e+000
3	15	16	4	3	0	0	0	0	1	4	+1.0000e+000
4	16	17	5	4	0	0	0	0	1	4	+1.0000e+000
5	17	18	6	5	0	0	0	0	1	4	+1.0000e+000
6	18	19	7	6	0	0	0	0	1	4	+1.0000e+000
7	19	20	8	7	0	0	0	0	1	4	+1.0000e+000
8	20	21	9	8	0	0	0	0	1	4	+1.0000e+000
9	21	22	10	9	0	0	0	0	3	4	+1.0000e+000
10	22	23	11	10	0	0	0	0	4	4	+1.0000e+000
11	23	24	12	11	0	0	0	0	5	4	+1.0000e+000
12	25	26	14	13	0	0	0	0	2	4	+1.0000e+000
13	26	27	15	14	0	0	0	0	2	4	+1.0000e+000
14	27	28	16	15	0	0	0	0	1	4	+1.0000e+000
15	28	29	17	16	0	0	0	0	1	4	+1.0000e+000
16	29	30	18	17	0	0	0	0	1	4	+1.0000e+000
17	30	31	19	18	0	0	0	0	1	4	+1.0000e+000
18	31	32	20	19	0	0	0	0	1	4	+1.0000e+000
19	32	33	21	20	0	0	0	0	1	4	+1.0000e+000
20	33	34	22	21	0	0	0	0	3	4	+1.0000e+000
21	34	35	23	22	0	0	0	0	4	4	+1.0000e+000
22	35	36	24	23	0	0	0	0	5	4	+1.0000e+000
23	37	38	26	25	0	0	0	0	2	4	+1.0000e+000
24	38	39	27	26	0	0	0	0	2	4	+1.0000e+000
25	39	40	28	27	0	0	0	0	1	4	+1.0000e+000
26	40	41	29	28	0	0	0	0	1	4	+1.0000e+000
27	41	42	30	29	0	0	0	0	1	4	+1.0000e+000
28	42	43	31	30	0	0	0	0	1	4	+1.0000e+000
29	43	44	32	31	0	0	0	0	1	4	+1.0000e+000
30	44	45	33	32	0	0	0	0	1	4	+1.0000e+000
31	45	46	34	33	0	0	0	0	3	4	+1.0000e+000
32	46	47	35	34	0	0	0	0	4	4	+1.0000e+000
33	47	48	36	35	0	0	0	0	5	4	+1.0000e+000
34	47	59	60	48	0	0	0	0	5	4	+1.0000e+000
35	49	50	38	37	0	0	0	0	2	4	+1.0000e+000
36	50	51	39	38	0	0	0	0	2	4	+1.0000e+000
37	51	52	40	39	0	0	0	0	1	4	+1.0000e+000
38	52	53	41	40	0	0	0	0	1	4	+1.0000e+000
39	53	54	42	41	0	0	0	0	1	4	+1.0000e+000
40	54	55	43	42	0	0	0	0	1	4	+1.0000e+000
41	55	56	44	43	0	0	0	0	1	4	+1.0000e+000
42	56	57	45	44	0	0	0	0	1	4	+1.0000e+000

43	57	58	46	45	0	0	0	0	3	4	+1.0000e+000
44	58	59	47	46	0	0	0	0	4	4	+1.0000e+000
45	59	71	72	60	0	0	0	0	5	4	+1.0000e+000
46	61	62	50	49	0	0	0	0	2	4	+1.0000e+000
47	62	63	51	50	0	0	0	0	2	4	+1.0000e+000
48	63	64	52	51	0	0	0	0	1	4	+1.0000e+000
49	64	65	53	52	0	0	0	0	1	4	+1.0000e+000
50	65	66	54	53	0	0	0	0	1	4	+1.0000e+000
51	66	67	55	54	0	0	0	0	1	4	+1.0000e+000
52	67	68	56	55	0	0	0	0	1	4	+1.0000e+000
53	68	69	57	56	0	0	0	0	1	4	+1.0000e+000
54	69	70	58	57	0	0	0	0	3	4	+1.0000e+000
55	70	71	59	58	0	0	0	0	4	4	+1.0000e+000
56	71	83	72	0	0	0	0	0	5	3	+1.0000e+000
57	73	74	62	61	0	0	0	0	2	4	+1.0000e+000
58	74	75	63	62	0	0	0	0	2	4	+1.0000e+000
59	75	76	64	63	0	0	0	0	1	4	+1.0000e+000
60	76	77	65	64	0	0	0	0	1	4	+1.0000e+000
61	77	78	66	65	0	0	0	0	1	4	+1.0000e+000
62	78	79	67	66	0	0	0	0	1	4	+1.0000e+000
63	79	80	68	67	0	0	0	0	1	4	+1.0000e+000
64	80	81	69	68	0	0	0	0	1	4	+1.0000e+000
65	81	82	70	69	0	0	0	0	3	4	+1.0000e+000
66	82	83	71	70	0	0	0	0	4	4	+1.0000e+000
67	83	82	93	94	0	0	0	0	4	4	+1.0000e+000
68	84	85	74	73	0	0	0	0	2	4	+1.0000e+000
69	85	86	75	74	0	0	0	0	2	4	+1.0000e+000
70	86	87	76	75	0	0	0	0	1	4	+1.0000e+000
71	87	88	77	76	0	0	0	0	1	4	+1.0000e+000
72	88	89	78	77	0	0	0	0	1	4	+1.0000e+000
73	89	90	79	78	0	0	0	0	1	4	+1.0000e+000
74	90	91	80	79	0	0	0	0	1	4	+1.0000e+000
75	91	92	81	80	0	0	0	0	1	4	+1.0000e+000
76	92	93	82	81	0	0	0	0	3	4	+1.0000e+000
77	94	93	104	105	0	0	0	0	4	4	+1.0000e+000
78	95	96	85	84	0	0	0	0	2	4	+1.0000e+000
79	96	97	86	85	0	0	0	0	2	4	+1.0000e+000
80	97	98	87	86	0	0	0	0	1	4	+1.0000e+000
81	98	99	88	87	0	0	0	0	1	4	+1.0000e+000
82	99	100	89	88	0	0	0	0	1	4	+1.0000e+000
83	100	101	90	89	0	0	0	0	1	4	+1.0000e+000
84	101	102	91	90	0	0	0	0	1	4	+1.0000e+000
85	102	103	92	91	0	0	0	0	1	4	+1.0000e+000
86	103	104	93	92	0	0	0	0	3	4	+1.0000e+000

87	104	115	105	0	0	0	0	0	4	3	+1.0000e+000
88	104	103	114	115	0	0	0	0	3	4	+1.0000e+000
89	106	107	96	95	0	0	0	0	2	4	+1.0000e+000
90	107	108	97	96	0	0	0	0	2	4	+1.0000e+000
91	107	106	116	117	0	0	0	0	2	4	+1.0000e+000
92	108	109	98	97	0	0	0	0	1	4	+1.0000e+000
93	109	110	99	98	0	0	0	0	1	4	+1.0000e+000
94	110	111	100	99	0	0	0	0	1	4	+1.0000e+000
95	111	112	101	100	0	0	0	0	1	4	+1.0000e+000
96	112	113	102	101	0	0	0	0	1	4	+1.0000e+000
97	113	114	103	102	0	0	0	0	1	4	+1.0000e+000
98	115	114	124	125	0	0	0	0	3	4	+1.0000e+000
99	117	118	108	107	0	0	0	0	2	4	+1.0000e+000
100	118	119	109	108	0	0	0	0	1	4	+1.0000e+000
101	119	120	110	109	0	0	0	0	1	4	+1.0000e+000
102	120	121	111	110	0	0	0	0	1	4	+1.0000e+000
103	121	122	112	111	0	0	0	0	1	4	+1.0000e+000
104	122	123	113	112	0	0	0	0	1	4	+1.0000e+000
105	123	124	114	113	0	0	0	0	1	4	+1.0000e+000
106	125	124	134	135	0	0	0	0	3	4	+1.0000e+000
107	126	127	117	116	0	0	0	0	2	4	+1.0000e+000
108	127	128	118	117	0	0	0	0	2	4	+1.0000e+000
109	128	129	119	118	0	0	0	0	1	4	+1.0000e+000
110	129	130	120	119	0	0	0	0	1	4	+1.0000e+000
111	130	131	121	120	0	0	0	0	1	4	+1.0000e+000
112	131	132	122	121	0	0	0	0	1	4	+1.0000e+000
113	132	133	123	122	0	0	0	0	1	4	+1.0000e+000
114	133	134	124	123	0	0	0	0	1	4	+1.0000e+000
115	135	134	144	0	0	0	0	0	3	3	+1.0000e+000
116	136	137	127	126	0	0	0	0	2	4	+1.0000e+000
117	137	138	128	127	0	0	0	0	2	4	+1.0000e+000
118	138	139	129	128	0	0	0	0	1	4	+1.0000e+000
119	139	140	130	129	0	0	0	0	1	4	+1.0000e+000
120	140	141	131	130	0	0	0	0	1	4	+1.0000e+000
121	141	142	132	131	0	0	0	0	1	4	+1.0000e+000
122	142	143	133	132	0	0	0	0	1	4	+1.0000e+000
123	143	144	134	133	0	0	0	0	1	4	+1.0000e+000
124	145	146	137	136	0	0	0	0	2	4	+1.0000e+000
125	146	147	138	137	0	0	0	0	2	4	+1.0000e+000
126	147	148	139	138	0	0	0	0	1	4	+1.0000e+000
127	148	149	140	139	0	0	0	0	1	4	+1.0000e+000
128	149	150	141	140	0	0	0	0	1	4	+1.0000e+000
129	150	151	142	141	0	0	0	0	1	4	+1.0000e+000
130	151	152	143	142	0	0	0	0	1	4	+1.0000e+000

131	152	153	144	143	0	0	0	0	1	4	+1.0000e+000
132	154	155	146	145	0	0	0	0	2	4	+1.0000e+000
133	155	156	147	146	0	0	0	0	2	4	+1.0000e+000
134	156	157	148	147	0	0	0	0	1	4	+1.0000e+000
135	157	158	149	148	0	0	0	0	1	4	+1.0000e+000
136	158	159	150	149	0	0	0	0	1	4	+1.0000e+000
137	159	160	151	150	0	0	0	0	1	4	+1.0000e+000
138	160	161	152	151	0	0	0	0	1	4	+1.0000e+000
139	161	162	153	152	0	0	0	0	1	4	+1.0000e+000
140	163	164	155	154	0	0	0	0	2	4	+1.0000e+000
141	164	165	156	155	0	0	0	0	2	4	+1.0000e+000
142	165	166	157	156	0	0	0	0	1	4	+1.0000e+000
143	166	167	158	157	0	0	0	0	1	4	+1.0000e+000
144	167	168	159	158	0	0	0	0	1	4	+1.0000e+000
145	168	169	160	159	0	0	0	0	1	4	+1.0000e+000
146	169	170	161	160	0	0	0	0	1	4	+1.0000e+000
147	170	171	162	161	0	0	0	0	1	4	+1.0000e+000
148	172	173	164	163	0	0	0	0	2	4	+1.0000e+000
149	173	174	165	164	0	0	0	0	2	4	+1.0000e+000
150	174	175	166	165	0	0	0	0	1	4	+1.0000e+000
151	175	176	167	166	0	0	0	0	1	4	+1.0000e+000
152	176	177	168	167	0	0	0	0	1	4	+1.0000e+000
153	177	178	169	168	0	0	0	0	1	4	+1.0000e+000
154	178	179	170	169	0	0	0	0	1	4	+1.0000e+000
155	179	180	171	170	0	0	0	0	1	4	+1.0000e+000
156	181	182	173	172	0	0	0	0	2	4	+1.0000e+000
157	182	183	174	173	0	0	0	0	2	4	+1.0000e+000
158	183	184	175	174	0	0	0	0	1	4	+1.0000e+000
159	184	185	176	175	0	0	0	0	1	4	+1.0000e+000
160	185	186	177	176	0	0	0	0	1	4	+1.0000e+000
161	186	187	178	177	0	0	0	0	1	4	+1.0000e+000
162	187	188	179	178	0	0	0	0	1	4	+1.0000e+000
163	188	189	180	179	0	0	0	0	1	4	+1.0000e+000

Dike - Guayanilla River
Settlement Analysis
04/07/30

1 = Step Number

Node#	Displ-X	Displ-Y	Force-X	Force-Y
1	+0.000000E+000	+0.000000E+000	+3.262164E+004	+3.015526E+004
2	+0.000000E+000	-4.447368E-003	+5.774002E+004	-4.800014E+003
3	+0.000000E+000	-1.083616E-002	+6.356518E+004	-4.966682E+003
4	+0.000000E+000	-6.481355E-002	+5.539283E+004	-4.766695E+003
5	+0.000000E+000	-1.483389E-001	+3.900069E+004	-4.400023E+003
6	+0.000000E+000	-2.402486E-001	+2.504020E+004	-3.666611E+003
7	+0.000000E+000	-2.933437E-001	+1.233292E+004	-2.566636E+003
8	+0.000000E+000	-3.216576E-001	+6.274452E+003	-1.833387E+003
9	+0.000000E+000	-3.340530E-001	-3.940916E+003	-2.191720E+003
10	+0.000000E+000	-3.398121E-001	-6.037311E+003	-1.458366E+003
11	+0.000000E+000	+0.000000E+000	+0.000000E+000	+0.000000E+000
12	+0.000000E+000	+0.000000E+000	+0.000000E+000	+0.000000E+000
13	+0.000000E+000	+0.000000E+000	-3.764512E+002	+6.027787E+004
14	+1.387642E-003	-4.415860E-003		
15	+2.538587E-003	-1.076640E-002		
16	+3.144832E-002	-6.453697E-002		
17	+4.308109E-002	-1.478890E-001		
18	+4.058454E-002	-2.398014E-001		
19	+2.992268E-002	-2.930491E-001		
20	+1.739586E-002	-3.216006E-001		
21	+8.078316E-003	-3.340977E-001		
22	+7.468458E-003	-3.398153E-001		
23	+0.000000E+000	+0.000000E+000		
24	+0.000000E+000	+0.000000E+000		
25	+0.000000E+000	+0.000000E+000	-7.435469E+002	+6.018879E+004
26	+2.749074E-003	-4.321813E-003		
27	+5.058592E-003	-1.055642E-002		
28	+6.270786E-002	-6.368204E-002		
29	+8.612993E-002	-1.464514E-001		
30	+8.138180E-002	-2.383896E-001		
31	+6.025327E-002	-2.920334E-001		
32	+3.526445E-002	-3.209883E-001		
33	+1.646696E-002	-3.337822E-001		
34	+1.435888E-002	-3.393800E-001		
35	+0.000000E+000	+0.000000E+000		
36	+0.000000E+000	+0.000000E+000		

37	+0.000000E+000	+0.000000E+000	-1.026012E+003	+5.704883E+004
38	+4.056402E-003	-4.167632E-003		
39	+7.534069E-003	-1.019883E-002		
40	+9.351201E-002	-6.205745E-002		
41	+1.289913E-001	-1.435082E-001		
42	+1.225149E-001	-2.350142E-001		
43	+9.109504E-002	-2.890178E-001		
44	+5.394829E-002	-3.185794E-001		
45	+2.545427E-002	-3.318056E-001		
46	+2.013778E-002	-3.372218E-001		
47	+0.000000E+000	+0.000000E+000		
48	+0.000000E+000	+0.000000E+000		
49	+0.000000E+000	+0.000000E+000	-1.242750E+003	+5.389171E+004
50	+5.162679E-003	-3.983855E-003		
51	+9.691682E-003	-9.756689E-003		
52	+1.204724E-001	-5.973780E-002		
53	+1.670295E-001	-1.388561E-001		
54	+1.596329E-001	-2.289823E-001		
55	+1.195237E-001	-2.831339E-001		
56	+7.158087E-002	-3.132315E-001		
57	+3.431972E-002	-3.269240E-001		
58	+2.391754E-002	-3.320977E-001		
59	+0.000000E+000	+0.000000E+000		
60	+0.000000E+000	+0.000000E+000		
61	+0.000000E+000	+0.000000E+000	-1.475305E+003	+5.371939E+004
62	+6.178755E-003	-3.762572E-003		
63	+1.174102E-002	-9.199651E-003		
64	+1.462009E-001	-5.644024E-002		
65	+2.039101E-001	-1.317765E-001		
66	+1.963463E-001	-2.189160E-001		
67	+1.484398E-001	-2.723445E-001		
68	+9.003126E-002	-3.028142E-001		
69	+4.402260E-002	-3.169426E-001		
70	+2.608465E-002	-3.218265E-001		
71	+0.000000E+000	+0.000000E+000		
72	+0.000000E+000	+0.000000E+000		
73	+0.000000E+000	+0.000000E+000	-1.673785E+003	+5.353530E+004
74	+7.081522E-003	-3.512593E-003		
75	+1.363355E-002	-8.538689E-003		
76	+1.700785E-001	-5.202266E-002		
77	+2.387537E-001	-1.217216E-001		
78	+2.317848E-001	-2.036643E-001		
79	+1.772089E-001	-2.550035E-001		
80	+1.092081E-001	-2.851515E-001		

81	+5.457491E-002	-2.995321E-001		
82	+2.648058E-002	-3.040602E-001		
83	+0.000000E+000	+0.000000E+000		
84	+0.000000E+000	+0.000000E+000	-1.836725E+003	+5.334922E+004
85	+7.850317E-003	-3.247501E-003		
86	+1.531286E-002	-7.792917E-003		
87	+1.913505E-001	-4.636537E-002		
88	+2.703963E-001	-1.081429E-001		
89	+2.647267E-001	-1.819894E-001		
90	+2.047495E-001	-2.293551E-001		
91	+1.284649E-001	-2.579925E-001		
92	+6.584188E-002	-2.722235E-001		
93	+2.515460E-002	-2.764169E-001		
94	+0.000000E+000	+0.000000E+000		
95	+0.000000E+000	+0.000000E+000	-1.966559E+003	+5.316567E+004
96	+8.471706E-003	-2.978500E-003		
97	+1.671802E-002	-7.002922E-003		
98	+2.091522E-001	-3.943318E-002		
99	+2.973711E-001	-9.065855E-002		
100	+2.935173E-001	-1.526848E-001		
101	+2.297349E-001	-1.937224E-001		
102	+1.468845E-001	-2.197660E-001		
103	+7.731496E-002	-2.331795E-001		
104	+2.232936E-002	-2.364754E-001		
105	+0.000000E+000	+0.000000E+000		
106	+0.000000E+000	+0.000000E+000	-2.415818E+003	+6.180584E+004
107	+8.935342E-003	-2.702349E-003		
108	+1.783400E-002	-6.232203E-003		
109	+2.225898E-001	-3.177346E-002		
110	+3.177985E-001	-6.916763E-002		
111	+3.159845E-001	-1.146095E-001		
112	+2.504425E-001	-1.461682E-001		
113	+1.637720E-001	-1.680067E-001		
114	+8.749424E-002	-1.801523E-001		
115	+1.913081E-002	-1.540904E-001		
116	+0.000000E+000	+0.000000E+000	-2.831354E+003	+7.033016E+004
117	+9.255624E-003	-2.278887E-003		
118	+1.865612E-002	-4.760439E-003		
119	+2.318544E-001	-1.776850E-002		
120	+3.321618E-001	-3.358035E-002		
121	+3.329507E-001	-5.342731E-002		
122	+2.686741E-001	-6.981783E-002		
123	+1.817504E-001	-8.428000E-002		
124	+1.004800E-001	-9.405034E-002		

125	+3.915970E-002	-9.654413E-002		
126	+0.000000E+000	+0.000000E+000	-2.821258E+003	+7.001473E+004
127	+9.201293E-003	-1.870655E-003		
128	+1.848718E-002	-3.300552E-003		
129	+2.293668E-001	-2.458515E-003		
130	+3.290068E-001	+7.673585E-003		
131	+3.316179E-001	+2.002407E-002		
132	+2.728281E-001	+2.370545E-002		
133	+1.925507E-001	+1.966195E-002		
134	+1.105820E-001	+1.382365E-002		
135	+7.335102E-002	+1.236755E-002		
136	+0.000000E+000	+0.000000E+000	-3.072049E+003	+7.835635E+004
137	+8.806926E-003	-1.481631E-003		
138	+1.729644E-002	-1.916846E-003		
139	+2.143690E-001	+1.248035E-002		
140	+3.060721E-001	+4.869211E-002		
141	+3.090914E-001	+9.469947E-002		
142	+2.583465E-001	+1.207302E-001		
143	+1.920020E-001	+1.319451E-001		
144	+1.199421E-001	+1.299462E-001		
145	+0.000000E+000	+0.000000E+000	-3.821268E+003	+1.079332E+005
146	+7.879427E-003	-9.351627E-004		
147	+1.469186E-002	-3.224073E-004		
148	+1.826947E-001	+2.422719E-002		
149	+2.582326E-001	+7.635355E-002		
150	+2.612624E-001	+1.392826E-001		
151	+2.235740E-001	+1.742509E-001		
152	+1.775008E-001	+1.903012E-001		
153	+1.442712E-001	+1.907069E-001		
154	+0.000000E+000	+0.000000E+000	-3.625578E+003	+1.281787E+005
155	+5.921075E-003	-3.285575E-004		
156	+1.016322E-002	+8.407274E-004		
157	+1.275130E-001	+2.704818E-002		
158	+1.777979E-001	+7.961822E-002		
159	+1.824727E-001	+1.413216E-001		
160	+1.654578E-001	+1.757146E-001		
161	+1.497886E-001	+1.930096E-001		
162	+1.467733E-001	+1.990940E-001		
163	+0.000000E+000	+0.000000E+000	-2.878164E+003	+1.691069E+005
164	+3.836285E-003	+1.349984E-005		
165	+6.182837E-003	+1.195802E-003		
166	+7.847970E-002	+2.217547E-002		
167	+1.083395E-001	+6.243015E-002		
168	+1.140140E-001	+1.096168E-001		

169	+1.109197E-001	+1.378256E-001		
170	+1.118482E-001	+1.560020E-001		
171	+1.187534E-001	+1.664418E-001		
172	+0.000000E+000	+0.000000E+000	-1.603770E+003	+2.104541E+005
173	+1.365331E-003	-1.175249E-004		
174	+1.664884E-003	+3.865735E-004		
175	+2.244497E-002	+1.179936E-002		
176	+2.975953E-002	+3.478703E-002		
177	+3.309883E-002	+6.261957E-002		
178	+3.570679E-002	+8.130790E-002		
179	+4.004817E-002	+9.592678E-002		
180	+4.981851E-002	+1.065860E-001		
181	+0.000000E+000	+0.000000E+000	-3.049899E+004	+1.048404E+005
182	+0.000000E+000	+0.000000E+000	-5.582025E+004	-1.766021E+004
183	+0.000000E+000	+0.000000E+000	-5.355763E+004	-1.751145E+004
184	+0.000000E+000	+0.000000E+000	-4.732569E+004	-1.611765E+004
185	+0.000000E+000	+0.000000E+000	-3.060648E+004	-1.600261E+004
186	+0.000000E+000	+0.000000E+000	-1.766221E+004	-1.340759E+004
187	+0.000000E+000	+0.000000E+000	-7.758228E+003	-8.999146E+003
188	+0.000000E+000	+0.000000E+000	-3.571717E+003	-5.294998E+003
189	+0.000000E+000	+0.000000E+000	-1.777449E+003	-1.058389E+004

Dike - Guayanilla River
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1 = Step Number

Node#	Displ-X	Displ-Y	Force-X	Force-Y
1	+0.000000E+000	+0.000000E+000	+3.448253E+004	+3.181485E+004
2	+0.000000E+000	-8.023317E-003	+5.918022E+004	-4.800006E+003
3	+0.000000E+000	-2.034968E-002	+7.309961E+004	-4.966668E+003
4	+0.000000E+000	-1.346590E-001	+6.281705E+004	-4.766693E+003
5	+0.000000E+000	-3.269642E-001	+4.666134E+004	-4.400031E+003
6	+0.000000E+000	-5.559370E-001	+3.181533E+004	-3.666609E+003
7	+0.000000E+000	-6.963209E-001	+1.816773E+004	-2.566629E+003
8	+0.000000E+000	-7.736642E-001	+1.092777E+004	-1.833437E+003
9	+0.000000E+000	-8.061148E-001	-1.343247E+004	-2.191898E+003
10	+0.000000E+000	-8.208768E-001	-1.073518E+004	-2.916683E+003
11	+0.000000E+000	-4.807059E-001	+6.953244E+003	-1.458273E+003
12	+0.000000E+000	+0.000000E+000	+0.000000E+000	+0.000000E+000
13	+0.000000E+000	+0.000000E+000	-7.629453E+002	+6.358219E+004
14	+2.892114E-003	-7.959233E-003		
15	+5.480084E-003	-2.018645E-002		
16	+7.203214E-002	-1.336476E-001		
17	+1.080286E-001	-3.242216E-001		
18	+1.114379E-001	-5.507959E-001		
19	+8.749065E-002	-6.898417E-001		
20	+5.197024E-002	-7.669988E-001		
21	+2.616959E-002	-7.995809E-001		
22	+1.153986E-002	-8.142455E-001		
23	-9.834005E-003	-4.740625E-001		
24	+0.000000E+000	+0.000000E+000		
25	+0.000000E+000	+0.000000E+000	-1.502578E+003	+6.345276E+004
26	+5.710786E-003	-7.768343E-003		
27	+1.086883E-002	-1.968735E-002		
28	+1.428161E-001	-1.305797E-001		
29	+2.138008E-001	-3.159677E-001		
30	+2.202949E-001	-5.355865E-001		
31	+1.736148E-001	-6.706309E-001		
32	+1.045837E-001	-7.468148E-001		
33	+5.245563E-002	-7.795337E-001		
34	+2.243927E-002	-7.939115E-001		
35	-1.961315E-002	-4.541508E-001		
36	+0.000000E+000	+0.000000E+000		

37	+0.000000E+000	+0.000000E+000	-2.061730E+003	+6.009737E+004
38	+8.378839E-003	-7.457197E-003		
39	+1.604702E-002	-1.882663E-002		
40	+2.110058E-001	-1.250384E-001		
41	+3.150887E-001	-3.015788E-001		
42	+3.241460E-001	-5.096474E-001		
43	+2.566522E-001	-6.379424E-001		
44	+1.579195E-001	-7.120540E-001		
45	+7.887682E-002	-7.447793E-001		
46	+3.210801E-002	-7.586480E-001		
47	-2.921828E-002	-4.210622E-001		
48	+0.000000E+000	+0.000000E+000		
49	+0.000000E+000	+0.000000E+000	-2.492273E+003	+5.673240E+004
50	+1.058851E-002	-7.098560E-003		
51	+2.043485E-002	-1.782221E-002		
52	+2.689371E-001	-1.182070E-001		
53	+4.003714E-001	-2.831231E-001		
54	+4.111483E-001	-4.760772E-001		
55	+3.273795E-001	-5.956646E-001		
56	+2.058326E-001	-6.665407E-001		
57	+1.029534E-001	-6.990216E-001		
58	+3.932352E-002	-7.126006E-001		
59	-3.772041E-002	-3.801240E-001		
60	+0.000000E+000	+0.000000E+000		
61	+0.000000E+000	+0.000000E+000	-2.946156E+003	+5.649042E+004
62	+1.256739E-002	-6.666481E-003		
63	+2.447371E-002	-1.663375E-002		
64	+3.222937E-001	-1.090436E-001		
65	+4.779841E-001	-2.586762E-001		
66	+4.899014E-001	-4.323190E-001		
67	+3.926530E-001	-5.405577E-001		
68	+2.522618E-001	-6.064646E-001		
69	+1.274743E-001	-6.379544E-001		
70	+4.476069E-002	-6.507400E-001		
71	-4.563020E-002	-3.286418E-001		
72	+0.000000E+000	+0.000000E+000		
73	+0.000000E+000	+0.000000E+000	-3.323211E+003	+5.618938E+004
74	+1.427893E-002	-6.185484E-003		
75	+2.811401E-002	-1.522580E-002		
76	+3.695906E-001	-9.741034E-002		
77	+5.458859E-001	-2.277619E-001		
78	+5.583909E-001	-3.775959E-001		
79	+4.505337E-001	-4.715668E-001		
80	+2.954344E-001	-5.303714E-001		

81	+1.518164E-001	-5.597955E-001		
82	+4.792546E-002	-5.712779E-001		
83	-5.211846E-002	-2.673653E-001		
84	+0.000000E+000	+0.000000E+000	-3.626463E+003	+5.587337E+004
85	+1.569590E-002	-5.683803E-003		
86	+3.118606E-002	-1.368895E-002		
87	+4.091979E-001	-8.303785E-002		
88	+6.018249E-001	-1.897095E-001		
89	+6.144058E-001	-3.107602E-001		
90	+4.987852E-001	-3.871946E-001		
91	+3.331730E-001	-4.364832E-001		
92	+1.747841E-001	-4.625924E-001		
93	+4.888034E-002	-4.727854E-001		
94	-3.526380E-002	-1.966306E-001		
95	+0.000000E+000	+0.000000E+000	-3.871600E+003	+5.555133E+004
96	+1.679095E-002	-5.157910E-003		
97	+3.362813E-002	-1.207613E-002		
98	+4.391974E-001	-6.640016E-002		
99	+6.432315E-001	-1.446794E-001		
100	+6.553516E-001	-2.309707E-001		
101	+5.351223E-001	-2.863206E-001		
102	+3.634288E-001	-3.241111E-001		
103	+1.951872E-001	-3.457957E-001		
104	+4.802480E-002	-3.530754E-001		
105	-1.446575E-002	-1.172275E-001		
106	+0.000000E+000	+0.000000E+000	-4.724012E+003	+6.440638E+004
107	+1.754548E-002	-4.605663E-003		
108	+3.540699E-002	-1.046819E-002		
109	+4.582969E-001	-4.882044E-002		
110	+6.669089E-001	-9.348422E-002		
111	+6.781796E-001	-1.380821E-001		
112	+5.571574E-001	-1.682240E-001		
113	+3.848658E-001	-1.924846E-001		
114	+2.114650E-001	-2.088697E-001		
115	+4.765628E-002	-1.444760E-001		
116	+0.000000E+000	+0.000000E+000	-5.482379E+003	+7.301342E+004
117	+1.790164E-002	-3.729152E-003		
118	+3.625083E-002	-7.264330E-003		
119	+4.638404E-001	-1.770204E-002		
120	+6.684558E-001	-1.486712E-002		
121	+6.781754E-001	-3.727857E-003		
122	+5.627206E-001	-7.411316E-004		
123	+3.985307E-001	-6.690443E-003		
124	+2.252393E-001	-1.483344E-002		

125	+9.982249E-002	-1.866612E-002		
126	+0.000000E+000	+0.000000E+000	-5.375271E+003	+7.238738E+004
127	+1.747112E-002	-2.905484E-003		
128	+3.499657E-002	-4.366444E-003		
129	+4.451675E-001	+1.171501E-002		
130	+6.351308E-001	+6.261414E-002		
131	+6.432803E-001	+1.308407E-001		
132	+5.412847E-001	+1.680117E-001		
133	+3.962436E-001	+1.808205E-001		
134	+2.324222E-001	+1.786642E-001		
135	+1.742499E-001	+1.762585E-001		
136	+0.000000E+000	+0.000000E+000	-5.702961E+003	+8.064492E+004
137	+1.638095E-002	-2.163046E-003		
138	+3.191654E-002	-1.891084E-003		
139	+4.047231E-001	+3.626285E-002		
140	+5.701205E-001	+1.260747E-001		
141	+5.765184E-001	+2.399624E-001		
142	+4.915502E-001	+3.078226E-001		
143	+3.762609E-001	+3.419968E-001		
144	+2.476182E-001	+3.435721E-001		
145	+0.000000E+000	+0.000000E+000	-6.857131E+003	+1.104382E+005
146	+1.428800E-002	-1.251842E-003		
147	+2.648575E-002	+5.208018E-004		
148	+3.364298E-001	+5.093580E-002		
149	+4.676867E-001	+1.549757E-001		
150	+4.740387E-001	+2.780055E-001		
151	+4.128609E-001	+3.475905E-001		
152	+3.375618E-001	+3.809567E-001		
153	+2.859327E-001	+3.842531E-001		
154	+0.000000E+000	+0.000000E+000	-6.331668E+003	+1.304232E+005
155	+1.044954E-002	-4.152126E-004		
156	+1.797144E-002	+1.877144E-003		
157	+2.303738E-001	+5.063106E-002		
158	+3.169865E-001	+1.464847E-001		
159	+3.265831E-001	+2.574856E-001		
160	+3.011523E-001	+3.206180E-001		
161	+2.796764E-001	+3.536323E-001		
162	+2.798688E-001	+3.667231E-001		
163	+0.000000E+000	+0.000000E+000	-4.957820E+003	+1.710348E+005
164	+6.677936E-003	+6.379627E-005		
165	+1.083134E-002	+2.191028E-003		
166	+1.409898E-001	+3.991808E-002		
167	+1.934145E-001	+1.114864E-001		
168	+2.043529E-001	+1.941753E-001		

169	+2.012189E-001	+2.447026E-001		
170	+2.065983E-001	+2.782068E-001		
171	+2.210031E-001	+2.981403E-001		
172	+0.000000E+000	+0.000000E+000	-2.767783E+003	+2.124006E+005
173	+2.363804E-003	-2.519364E-004		
174	+2.886101E-003	+5.731410E-004		
175	+4.035541E-002	+2.085725E-002		
176	+5.404072E-002	+6.199074E-002		
177	+6.053583E-002	+1.116564E-001		
178	+6.481723E-002	+1.453975E-001		
179	+7.331848E-002	+1.720896E-001		
180	+9.088126E-002	+1.917096E-001		
181	+0.000000E+000	+0.000000E+000	-3.092498E+004	+1.054999E+005
182	+0.000000E+000	+0.000000E+000	-5.667769E+004	-1.740055E+004
183	+0.000000E+000	+0.000000E+000	-5.393878E+004	-1.657092E+004
184	+0.000000E+000	+0.000000E+000	-4.839765E+004	-1.460248E+004
185	+0.000000E+000	+0.000000E+000	-3.162799E+004	-1.540524E+004
186	+0.000000E+000	+0.000000E+000	-1.891457E+004	-1.324177E+004
187	+0.000000E+000	+0.000000E+000	-8.955256E+003	-8.599971E+003
188	+0.000000E+000	+0.000000E+000	-4.786122E+003	-4.048734E+003
189	+0.000000E+000	+0.000000E+000	-2.928095E+003	-1.695024E+004

Dike - Guayanilla River
Settlement Analysis
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1 = Step Number

Node#	Displ-X	Displ-Y	Force-X	Force-Y
1	+0.000000E+000	+0.000000E+000	+3.611051E+004	+3.265598E+004
2	+0.000000E+000	-1.074855E-002	+6.201585E+004	-4.799977E+003
3	+0.000000E+000	-2.818412E-002	+8.054864E+004	-4.966656E+003
4	+0.000000E+000	-1.820309E-001	+6.710872E+004	-4.766693E+003
5	+0.000000E+000	-4.503812E-001	+5.083553E+004	-4.400027E+003
6	+0.000000E+000	-7.846743E-001	+3.500149E+004	-3.666619E+003
7	+0.000000E+000	-1.002981E+000	+2.065607E+004	-2.566629E+003
8	+0.000000E+000	-1.135282E+000	+1.319909E+004	-1.833484E+003
9	+0.000000E+000	-1.197792E+000	-1.441622E+004	-2.191969E+003
10	+0.000000E+000	-1.244301E+000	-2.072527E+004	-2.916833E+003
11	+0.000000E+000	-9.112778E-001	+7.343078E+003	-2.708291E+003
12	+0.000000E+000	-4.273592E-001	+1.073411E+004	-1.250063E+003
13	+0.000000E+000	+0.000000E+000	-1.062707E+003	+6.523756E+004
14	+4.175252E-003	-1.066356E-002		
15	+7.859308E-003	-2.798224E-002		
16	+9.978515E-002	-1.808190E-001		
17	+1.564148E-001	-4.466974E-001		
18	+1.711961E-001	-7.770448E-001		
19	+1.480658E-001	-9.922132E-001		
20	+1.031994E-001	-1.122408E+000		
21	+6.424037E-002	-1.183662E+000		
22	+3.060537E-002	-1.228201E+000		
23	-9.943681E-003	-8.948003E-001		
24	-1.615095E-002	-4.176922E-001		
25	+0.000000E+000	+0.000000E+000	-2.095988E+003	+6.503386E+004
26	+8.264523E-003	-1.041402E-002		
27	+1.561684E-002	-2.729877E-002		
28	+1.979555E-001	-1.769733E-001		
29	+3.092849E-001	-4.352699E-001		
30	+3.374427E-001	-7.535806E-001		
31	+2.909395E-001	-9.592832E-001		
32	+2.026683E-001	-1.083197E+000		
33	+1.247596E-001	-1.140998E+000		
34	+5.840580E-002	-1.180320E+000		
35	-2.000539E-002	-8.462865E-001		
36	-3.073353E-002	-3.895467E-001		

37	+0.000000E+000	+0.000000E+000	-2.896410E+003	+6.149424E+004
38	+1.216274E-002	-9.990880E-003		
39	+2.304623E-002	-2.602287E-002		
40	+2.927060E-001	-1.692253E-001		
41	+4.548346E-001	-4.139430E-001		
42	+4.937598E-001	-7.116046E-001		
43	+4.236625E-001	-9.017396E-001		
44	+2.956673E-001	-1.016066E+000		
45	+1.790782E-001	-1.069185E+000		
46	+8.136790E-002	-1.101743E+000		
47	-3.045490E-002	-7.685115E-001		
48	-4.186373E-002	-3.457530E-001		
49	+0.000000E+000	+0.000000E+000	-3.564906E+003	+5.791361E+004
50	+1.540186E-002	-9.458107E-003		
51	+2.930788E-002	-2.447586E-002		
52	+3.729982E-001	-1.594554E-001		
53	+5.759674E-001	-3.858909E-001		
54	+6.215608E-001	-6.564106E-001		
55	+5.310503E-001	-8.271798E-001		
56	+3.721461E-001	-9.303071E-001		
57	+2.219985E-001	-9.787568E-001		
58	+9.717204E-002	-1.005284E+000		
59	-4.023386E-002	-6.763790E-001		
60	-3.493245E-002	-2.955310E-001		
61	+0.000000E+000	+0.000000E+000	-4.247824E+003	+5.754345E+004
62	+1.828163E-002	-8.717578E-003		
63	+3.502756E-002	-2.249155E-002		
64	+4.463972E-001	-1.456514E-001		
65	+6.840488E-001	-3.475528E-001		
66	+7.331127E-001	-5.835236E-001		
67	+6.240923E-001	-7.305734E-001		
68	+4.401030E-001	-8.202310E-001		
69	+2.596902E-001	-8.633715E-001		
70	+1.080321E-001	-8.846133E-001		
71	-4.980617E-002	-5.647042E-001		
72	-2.388942E-002	-2.357716E-001		
73	+0.000000E+000	+0.000000E+000	-4.759973E+003	+5.721730E+004
74	+2.066160E-002	-7.863149E-003		
75	+4.003154E-002	-1.986651E-002		
76	+5.104362E-001	-1.274167E-001		
77	+7.756776E-001	-2.985701E-001		
78	+8.251417E-001	-4.932200E-001		
79	+7.004504E-001	-6.128722E-001		
80	+4.978839E-001	-6.870207E-001		

81	+2.922060E-001	-7.240341E-001		
82	+1.146952E-001	-7.403702E-001		
83	-5.864745E-002	-4.375513E-001		
84	+0.000000E+000	+0.000000E+000	-5.090014E+003	+5.700093E+004
85	+2.244905E-002	-7.022568E-003		
86	+4.393476E-002	-1.685493E-002		
87	+5.625259E-001	-1.051728E-001		
88	+8.475294E-001	-2.392713E-001		
89	+8.948281E-001	-3.862767E-001		
90	+7.582122E-001	-4.754374E-001		
91	+5.438945E-001	-5.324205E-001		
92	+3.186299E-001	-5.624319E-001		
93	+1.175582E-001	-5.745463E-001		
94	-2.091704E-002	-2.992604E-001		
95	+0.000000E+000	+0.000000E+000	-5.368479E+003	+5.680959E+004
96	+2.359123E-002	-6.265993E-003		
97	+4.652248E-002	-1.408016E-002		
98	+6.002223E-001	-7.973916E-002		
99	+8.963016E-001	-1.708202E-001		
100	+9.395081E-001	-2.636454E-001		
101	+7.958606E-001	-3.194361E-001		
102	+5.769925E-001	-3.581390E-001		
103	+3.384947E-001	-3.809471E-001		
104	+1.182149E-001	-3.888803E-001		
105	+2.383449E-002	-1.538334E-001		
106	+0.000000E+000	+0.000000E+000	-6.604021E+003	+6.580798E+004
107	+2.418005E-002	-5.415116E-003		
108	+4.805993E-002	-1.175497E-002		
109	+6.215616E-001	-5.402352E-002		
110	+9.184589E-001	-9.604915E-002		
111	+9.565591E-001	-1.283842E-001		
112	+8.122652E-001	-1.480803E-001		
113	+5.967732E-001	-1.678615E-001		
114	+3.525092E-001	-1.832282E-001		
115	+1.224440E-001	-9.115124E-002		
116	+0.000000E+000	+0.000000E+000	-7.418203E+003	+7.445172E+004
117	+2.407465E-002	-4.196167E-003		
118	+4.812325E-002	-7.450727E-003		
119	+6.214318E-001	-1.136999E-002		
120	+9.057180E-001	+1.139039E-002		
121	+9.372063E-001	+5.372658E-002		
122	+8.017422E-001	+7.770485E-002		
123	+6.020077E-001	+8.319303E-002		
124	+3.598412E-001	+7.955273E-002		

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125 +1.969150E-001 +7.574224E-002
126 +0.000000E+000 +0.000000E+000 -7.075324E+003 +7.359784E+004
127 +2.300646E-002 -3.169435E-003
128 +4.558492E-002 -3.960206E-003
129 +5.891494E-001 +2.520891E-002
130 +8.477213E-001 +1.077393E-001
131 +8.739383E-001 +2.193172E-001
132 +7.571095E-001 +2.843523E-001
133 +5.841960E-001 +3.137946E-001
134 +3.608781E-001 +3.172010E-001
135 +2.939399E-001 +3.146917E-001
136 +0.000000E+000 +0.000000E+000 -7.327898E+003 +8.181011E+004
137 +2.120575E-002 -2.314884E-003
138 +4.100526E-002 -1.205573E-003
139 +5.305446E-001 +5.329538E-002
140 +7.528668E-001 +1.793141E-001
141 +7.745788E-001 +3.403565E-001
142 +6.802064E-001 +4.385185E-001
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144 +3.759766E-001 +4.994693E-001
145 +0.000000E+000 +0.000000E+000 -8.649508E+003 +1.118243E+005
146 +1.823764E-002 -1.355886E-003
147 +3.378303E-002 +1.131350E-003
148 +4.388911E-001 +6.669508E-002
149 +6.143013E-001 +2.028905E-001
150 +6.337344E-001 +3.659021E-001
151 +5.683298E-001 +4.605994E-001
152 +4.780866E-001 +5.095991E-001
153 +4.107324E-001 +5.187116E-001
154 +0.000000E+000 +0.000000E+000 -7.939584E+003 +1.318751E+005
155 +1.325661E-002 -5.283442E-004
156 +2.305520E-002 +2.309113E-003
157 +3.016625E-001 +6.430207E-002
158 +4.174442E-001 +1.876378E-001
159 +4.380923E-001 +3.323928E-001
160 +4.128279E-001 +4.174201E-001
161 +3.875214E-001 +4.644146E-001
162 +3.881158E-001 +4.844811E-001
163 +0.000000E+000 +0.000000E+000 -6.270893E+003 +1.724983E+005
164 +8.515337E-003 +1.465280E-005
165 +1.404170E-002 +2.672583E-003
166 +1.862597E-001 +5.140575E-002
167 +2.567278E-001 +1.442593E-001
168 +2.760355E-001 +2.531269E-001
```

169	+2.750693E-001	+3.214073E-001		
170	+2.830896E-001	+3.676093E-001		
171	+3.019850E-001	+3.953785E-001		
172	+0.000000E+000	+0.000000E+000	-3.575592E+003	+2.139437E+005
173	+3.071495E-003	-3.984568E-004		
174	+3.766912E-003	+6.032841E-004		
175	+5.428718E-002	+2.734607E-002		
176	+7.301924E-002	+8.188671E-002		
177	+8.275630E-002	+1.485387E-001		
178	+8.846272E-002	+1.944498E-001		
179	+9.973791E-002	+2.308897E-001		
180	+1.229958E-001	+2.576111E-001		
181	+0.000000E+000	+0.000000E+000	-3.125437E+004	+1.060149E+005
182	+0.000000E+000	+0.000000E+000	-5.734552E+004	-1.719819E+004
183	+0.000000E+000	+0.000000E+000	-5.428085E+004	-1.575310E+004
184	+0.000000E+000	+0.000000E+000	-4.944488E+004	-1.331168E+004
185	+0.000000E+000	+0.000000E+000	-3.263463E+004	-1.497208E+004
186	+0.000000E+000	+0.000000E+000	-2.003554E+004	-1.310250E+004
187	+0.000000E+000	+0.000000E+000	-9.921488E+003	-8.352898E+003
188	+0.000000E+000	+0.000000E+000	-5.727760E+003	-3.145975E+003
189	+0.000000E+000	+0.000000E+000	-3.820107E+003	-2.192891E+004

SLOPE STABILITY ANALYSIS RESULTS

Geo ENGINEERING

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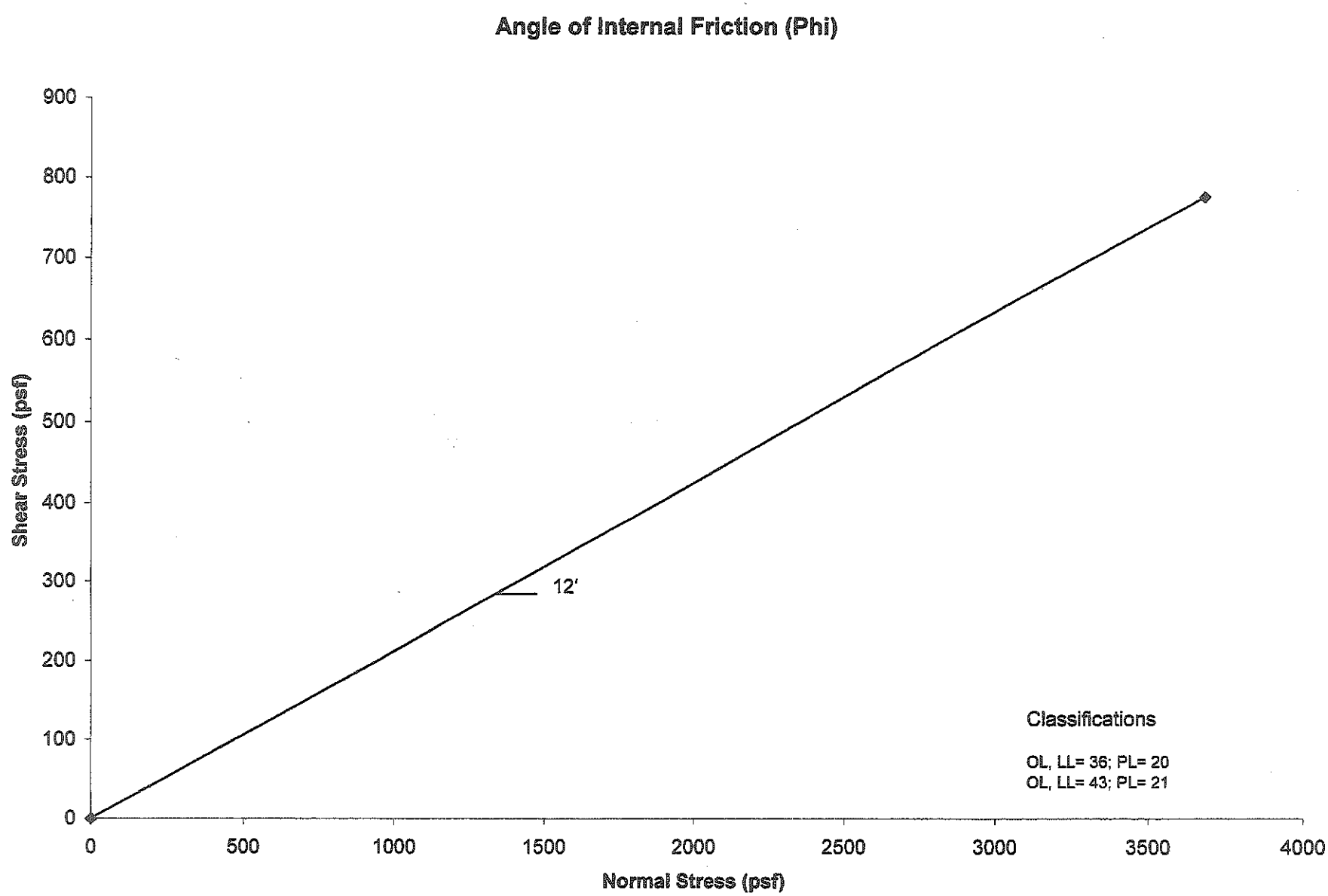
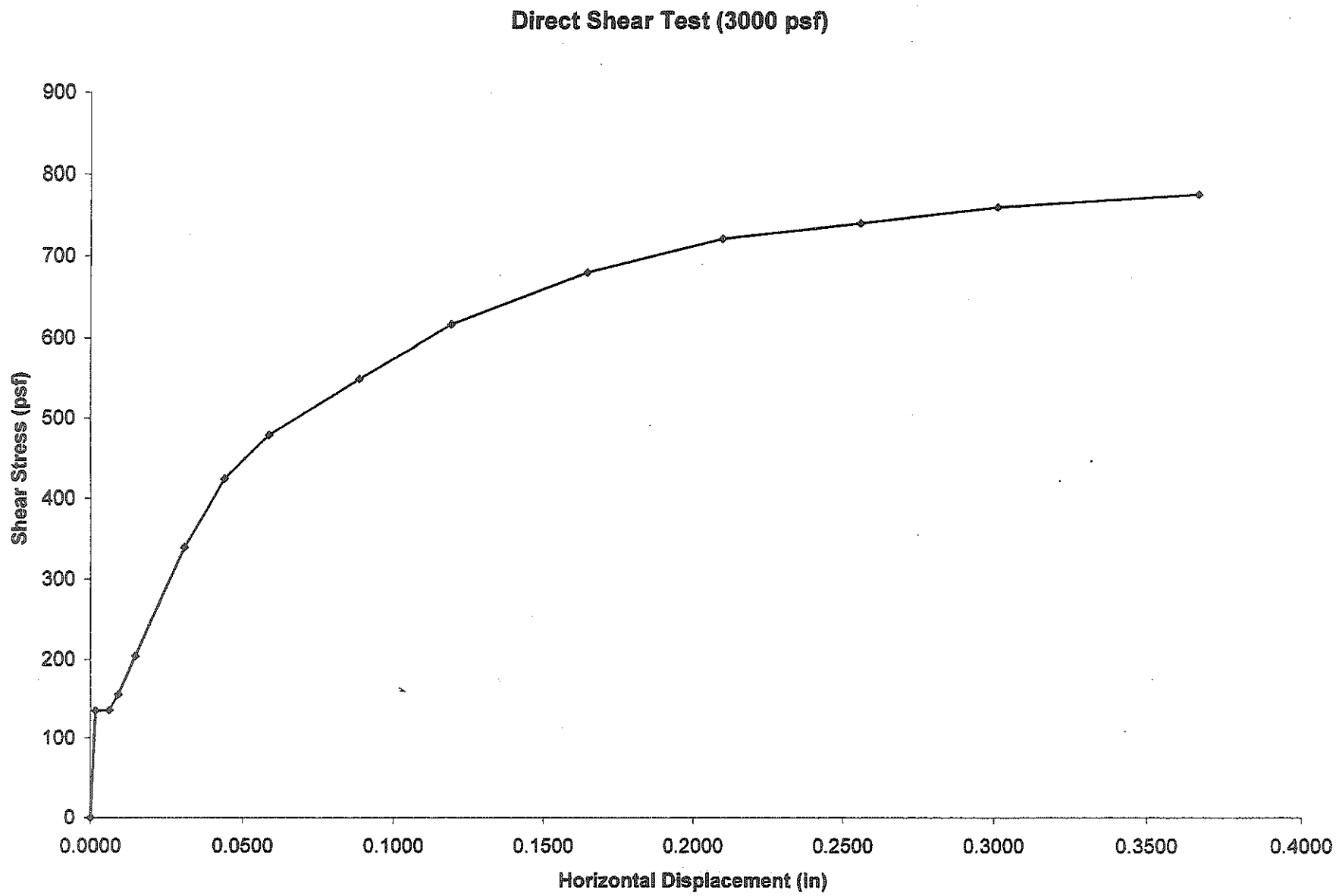
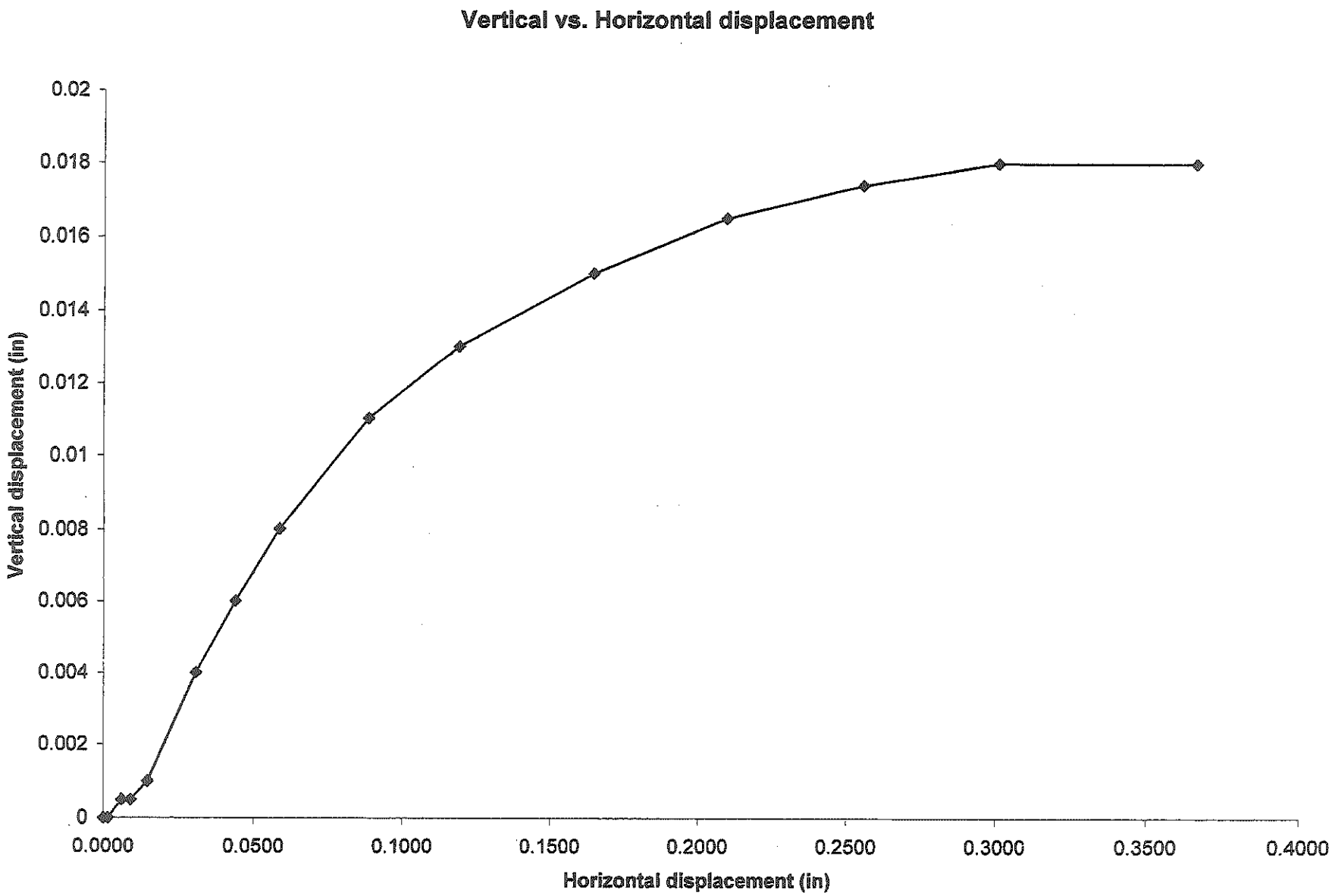
Fax (787) 706-0183


Angle of Internal Friction (Phi)
Shear Stress (psf)
900
800
700
600
500
400
300
200
100
0
0
500
1000
1500
2000
2500
3000
3500
4000
Normal Stress (psf)
12'
Classifications
OL, LL= 36; PL= 20
OL, LL= 43; PL= 21

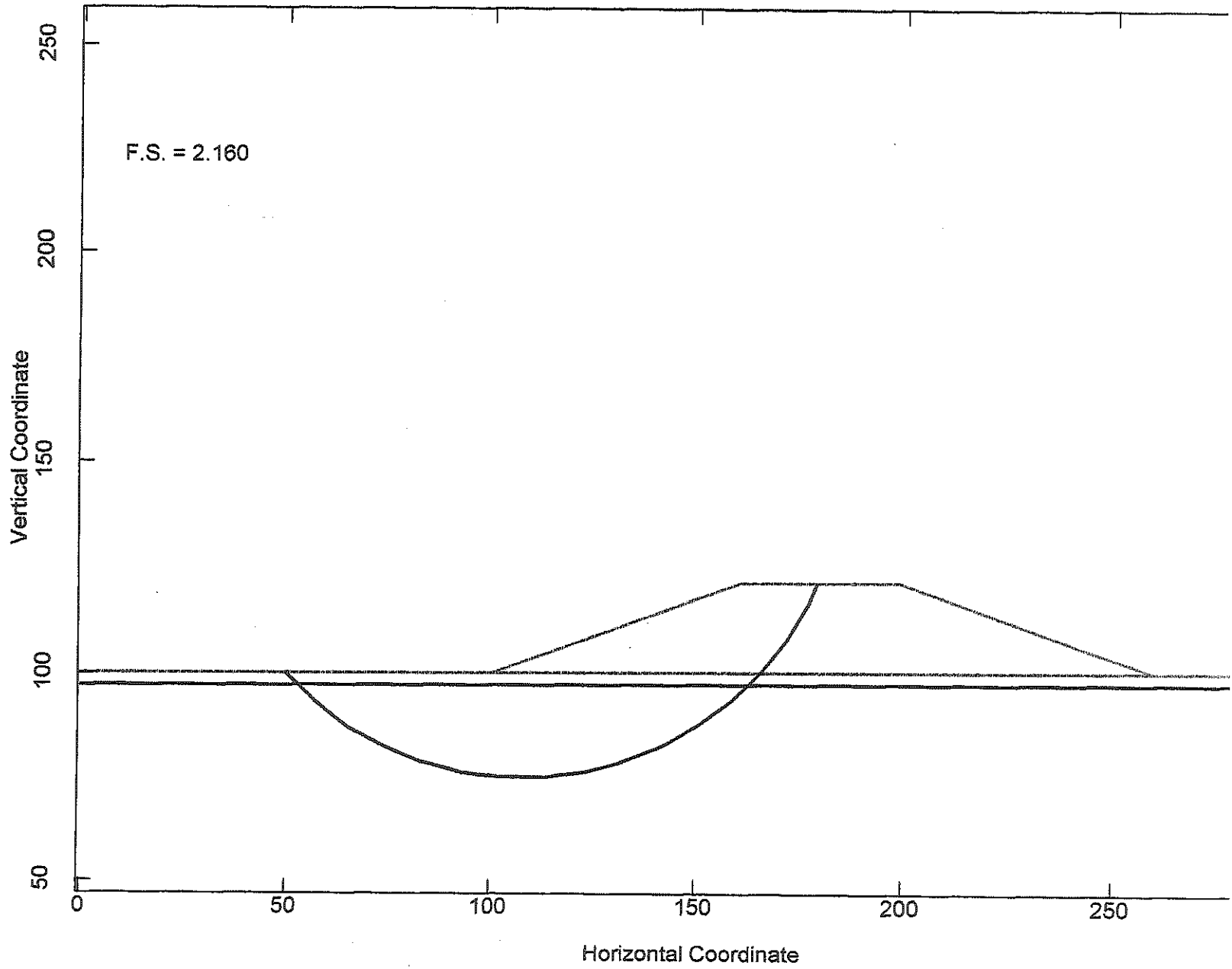

Direct Shear Test (3000 psf)
Shear Stress (psf)
900
800
700
600
500
400
300
200
100
0
0.0000
0.0500
0.1000
0.1500
0.2000
0.2500
0.3000
0.3500
0.4000
Horizontal Displacement (in)


Vertical vs. Horizontal displacement
Vertical displacement (in)
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0.0000
0.0500
0.1000
0.1500
0.2000
0.2500
0.3000
0.3500
0.4000
Horizontal displacement (in)

Geo - **ENGINEERING** **DIRECT SHEAR TEST**

Job: *Canalization of Rio Guayanilla*	**Initial Vert Strs:** 3000 psf	**Date:** 7/30/2004	
Soil Description:	**Initial Vert Load:** 102 lb	**Area:** *.034 ft2*	**Diam:** 2.5"
Light gray Sandy Silty Clay-Clayey Silty Sand	**Load Rate:** .003 in/min	**By:** fdc	**Sheet 1 of 1**

Time (min:sec)	Vert Disp Read	Vert Displ	Horiz Displ Read	Horiz Displ (in)	Ring Load Read	Ring Load (lb)	Normal Strs corr (psf)	Shear Strs corr (psf)
0	793	0	2500	0.00	0	0.00	3000.00	0.00
30	793	0	2485	0.00	0	4.61	2994.51	135.29
2:00	792.5	0.0005	2440	0.01	0	4.61	3001.39	135.60
3:00	792.5	0.0005	2410	0.01	1	5.29	3006.00	155.78
5:00	792	0.001	2354	0.01	3.4	6.91	3014.63	204.30
10:30	789	0.004	2193	0.03	10	11.39	3039.74	339.30
15:00	787	0.006	2061	0.04	14	14.10	3060.65	422.97
20:00	785	0.008	1914	0.06	16.5	15.79	3084.26	477.47
30:00	782	0.011	1615	0.09	19.5	17.82	3133.42	547.53
40:00	780	0.013	1310	0.12	22.3	19.72	3185.19	615.83
55:00	778	0.015	857	0.16	24.5	21.21	3265.25	679.04
1:10:00	776.5	0.0165	407	0.21	25.6	21.96	3348.76	720.88
1:25:00	775.6	0.0174	2448	0.26	25.6	21.96	3438.33	740.16
1:40:00	775	0.018	1995	0.30	25.6	21.96	3531.37	760.19
2:08:00	775	0.018	1340	0.37	25	21.55	3674.74	776.41
3:08:00	774	0.019	2480	0.50	25	21.55	4010.68	847.39


F.S. = 2.160
Vertical Coordinate
250
200
150
100
50
0
50
100
150
200
250
Horizontal Coordinate

Dique-Guayanilla-Bor1 (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date: 07/30/2004
Time of Run: 5:48:16 PM
Run By:
Input Data Filename: ENS16.tmp
Output Filename: ENS17.tmp
Plotted Output Filename: ENS18.tmp

PROBLEM DESCRIPTION Dike - Guayanilla - Bor 1

BOUNDARY COORDINATES

5 Top Boundaries
7 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	100.00	100.00	100.00	2
2	100.00	100.00	161.00	121.00	1
3	161.00	121.00	199.00	121.00	1
4	199.00	121.00	260.00	100.00	1
5	260.00	100.00	300.00	100.00	2
6	100.00	100.00	260.00	100.00	2
7	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	125.0	125.0	2500.0	.0	.00	.0	1
2	110.0	110.0	260.0	.0	.00	.0	1
3	120.0	120.0	2000.0	.0	.00	.0	1

1

Dique-Guayanilla-Bor1 (StablPro Output Report)
1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 161.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

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

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

Failure Surface Specified By 17 Coordinate Points

Dique-Guayanilla-Bor1 (StablPro Output Report)

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.24	93.10
3	65.30	87.18
4	74.04	82.32
5	83.33	78.62
6	93.01	76.12
7	102.93	74.87
8	112.93	74.89
9	122.85	76.18
10	132.52	78.71
11	141.79	82.46
12	150.52	87.34
13	158.55	93.30
14	165.76	100.23
15	172.04	108.01
16	177.27	116.53
17	179.29	121.00

*** 2.160 ***

Individual data on the 21 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	3.1	519.4	.0	.0	.0	.0	.0	.0	.0
2	4.1	2227.4	.0	687.4	.0	.0	.0	.0	.0
3	8.1	8738.5	.0	4281.3	.0	.0	.0	.0	.0
4	8.7	14666.3	.0	7644.4	.0	.0	.0	.0	.0
5	9.3	19954.1	.0	10315.3	.0	.0	.0	.0	.0
6	9.7	24107.1	.0	12251.0	.0	.0	.0	.0	.0
7	7.0	18703.0	.0	9374.5	.0	.0	.0	.0	.0
8	2.9	8227.8	.0	4045.5	.0	.0	.0	.0	.0
9	10.0	31046.1	.0	13803.6	.0	.0	.0	.0	.0
10	9.9	34323.8	.0	13395.5	.0	.0	.0	.0	.0
11	9.7	35523.3	.0	12202.4	.0	.0	.0	.0	.0
12	9.3	34632.7	.0	10243.4	.0	.0	.0	.0	.0
13	8.7	31815.9	.0	7550.3	.0	.0	.0	.0	.0
14	8.0	27401.2	.0	4166.6	.0	.0	.0	.0	.0
15	2.5	7790.6	.0	534.7	.0	.0	.0	.0	.0
16	1.4	4244.2	.0	81.6	.0	.0	.0	.0	.0
17	3.1	8714.1	.0	.0	.0	.0	.0	.0	.0
18	.2	619.9	.0	.0	.0	.0	.0	.0	.0
19	6.3	13239.1	.0	.0	.0	.0	.0	.0	.0
20	5.2	5711.5	.0	.0	.0	.0	.0	.0	.0
21	2.0	562.6	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00

2	57.35	93.22
3	65.48	87.40
4	74.28	82.65
5	83.61	79.03
6	93.31	76.61
7	103.24	75.42
8	113.24	75.48
9	123.15	76.78
10	132.82	79.32
11	142.10	83.04
12	150.85	87.90
13	158.92	93.81
14	166.18	100.67
15	172.53	108.40
16	177.87	116.86
17	179.81	121.00

*** 2.161 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.36	93.23
3	65.52	87.45
4	74.34	82.74
5	83.69	79.18
6	93.40	76.82
7	103.34	75.71
8	113.34	75.85
9	123.24	77.26
10	132.89	79.90
11	142.12	83.74
12	150.80	88.71
13	158.78	94.73
14	165.94	101.72
15	172.16	109.54
16	177.35	118.09
17	178.64	121.00

*** 2.198 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.24	92.99
3	76.30	87.06
4	85.11	82.33
5	94.50	78.89

6	104.28	76.81
7	114.26	76.14
8	124.23	76.88
9	134.00	79.03
10	143.36	82.53
11	152.14	87.33
12	160.15	93.31
13	167.23	100.37
14	173.25	108.36
15	178.07	117.12
16	179.54	121.00

*** 2.225 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.34	93.09
3	76.47	87.27
4	85.34	82.65
5	94.77	79.31
6	104.57	77.32
7	114.55	76.73
8	124.52	77.55
9	134.27	79.75
10	143.62	83.30
11	152.38	88.13
12	160.38	94.13
13	167.45	101.20
14	173.47	109.19
15	178.30	117.94
16	179.47	121.00

*** 2.232 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.29	93.15
3	65.39	87.29
4	74.18	82.53
5	83.52	78.94
6	93.24	76.58
7	103.18	75.50
8	113.18	75.70
9	123.06	77.19
10	132.68	79.94
11	141.86	83.91

12	150.45	89.02
13	158.31	95.20
14	165.31	102.34
15	171.33	110.33
16	176.28	119.02
17	177.09	121.00

*** 2.232 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.33	93.19
3	65.47	87.39
4	74.29	82.68
5	83.64	79.14
6	93.38	76.84
7	103.32	75.81
8	113.32	76.07
9	123.20	77.62
10	132.80	80.42
11	141.96	84.44
12	150.52	89.60
13	158.35	95.82
14	165.32	103.00
15	171.30	111.01
16	176.20	119.73
17	176.71	121.00

*** 2.245 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.18	92.93
3	76.19	86.94
4	84.98	82.17
5	94.36	78.70
6	104.14	76.61
7	114.11	75.94
8	124.09	76.70
9	133.84	78.89
10	143.19	82.45
11	151.93	87.31
12	159.88	93.38
13	166.88	100.52
14	172.79	108.59
15	177.48	117.42

16	178.76	121.00

*** 2.246 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.11	92.96
3	65.08	86.93
4	73.79	82.01
5	83.07	78.29
6	92.76	75.83
7	102.70	74.68
8	112.69	74.86
9	122.58	76.36
10	132.18	79.16
11	141.32	83.21
12	149.85	88.44
13	157.61	94.75
14	164.46	102.04
15	170.28	110.16
16	174.98	118.99
17	175.72	121.00

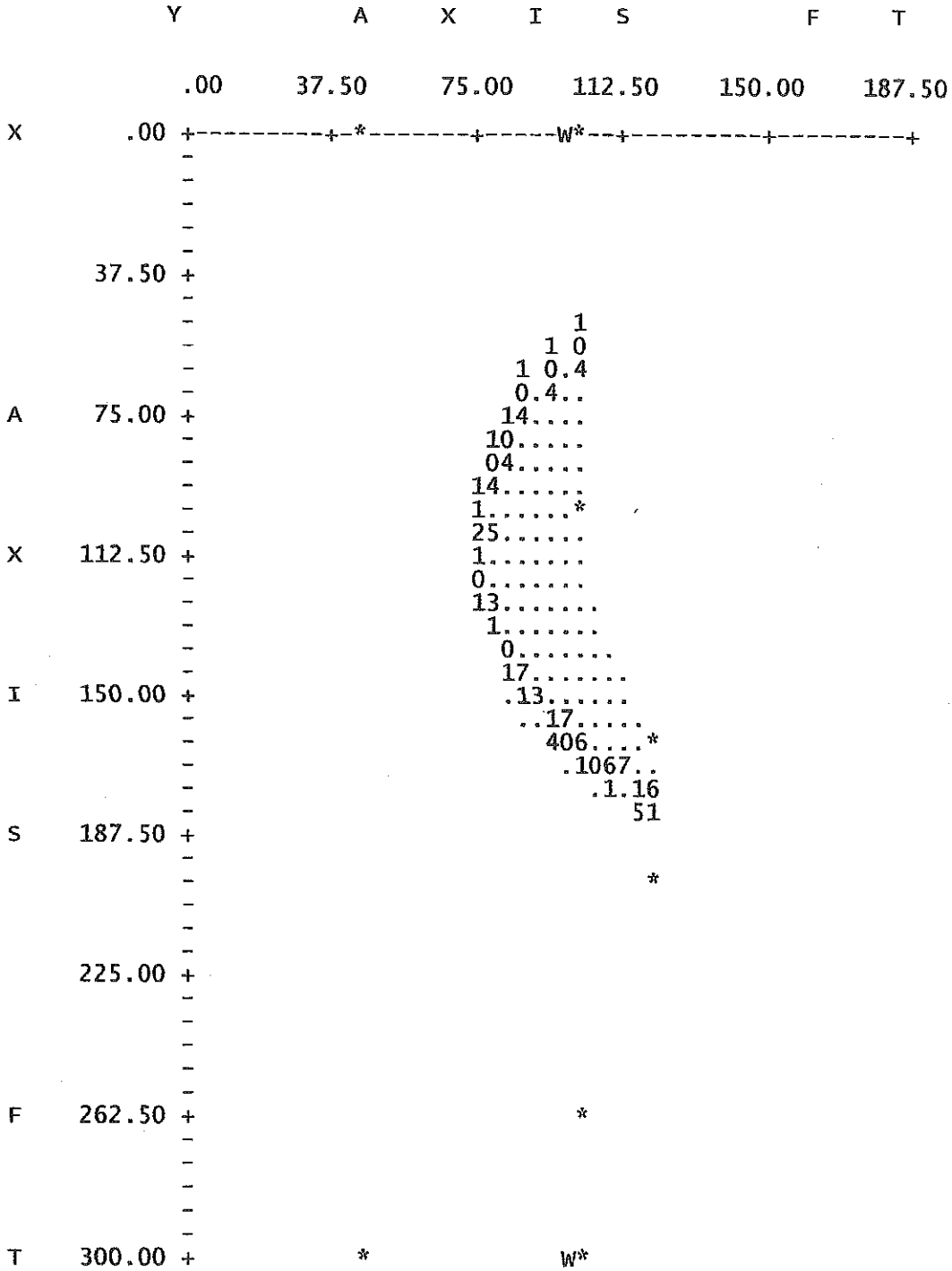
*** 2.255 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	55.56	100.00
2	62.71	93.01
3	70.76	87.08
4	79.55	82.32
5	88.92	78.81
6	98.68	76.63
7	108.65	75.83
8	118.63	76.40
9	128.44	78.35
10	137.88	81.63
11	146.79	86.19
12	154.97	91.93
13	162.29	98.75
14	168.59	106.51
15	173.77	115.07
16	176.31	121.00

*** 2.275 ***

1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37.50
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X 112.50
I 150.00
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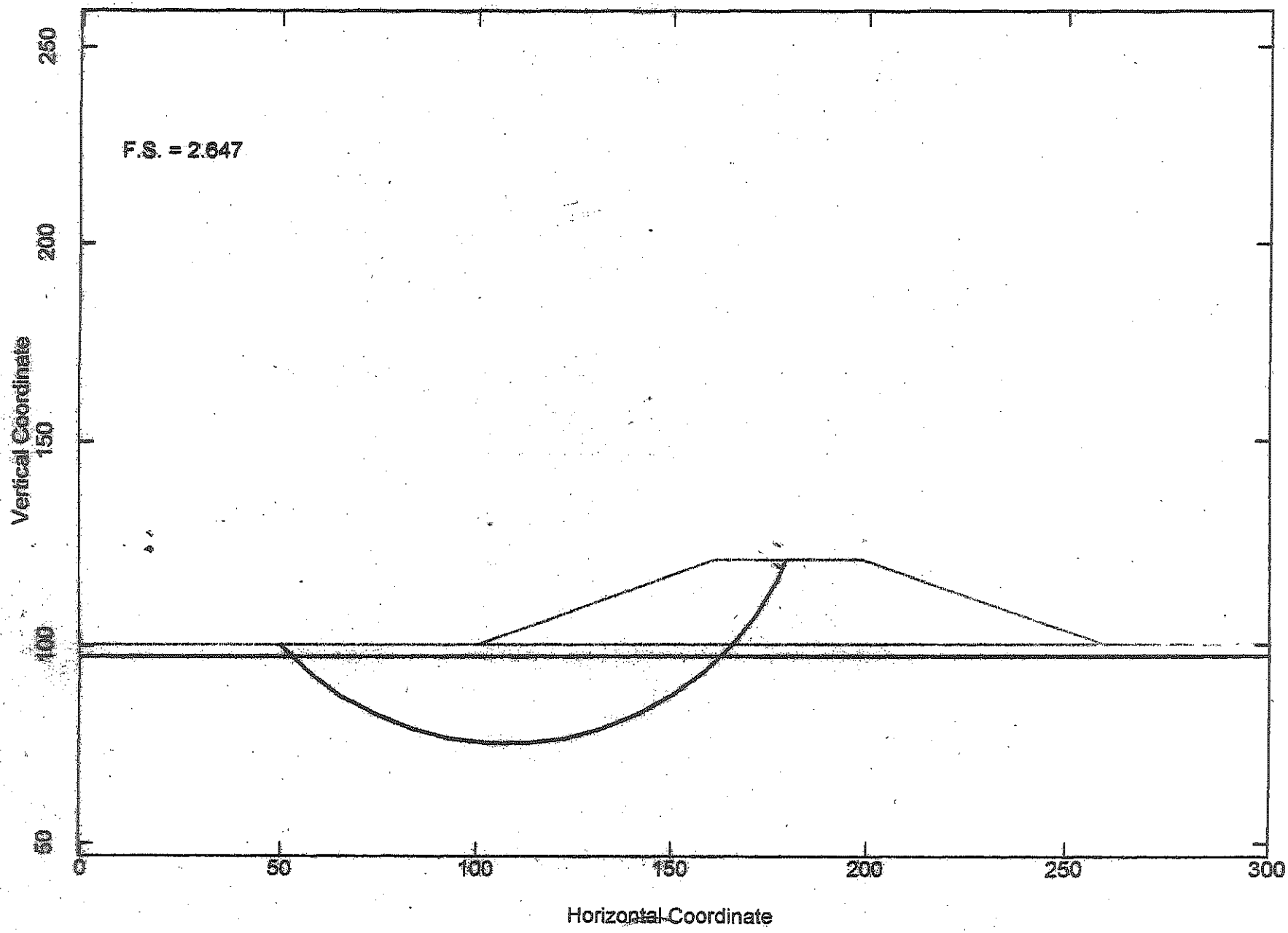
F 262.50
T 300.00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150
100
50
0
50
100
150
200
250
300
Horizontal Coordinate

Dique-Guayanilla-Bor1 (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date:	07/30/2004
Time of Run:	6:05:33 PM
Run By:	
Input Data Filename:	ENS2B.tmp
Output Filename:	ENS2C.tmp
Plotted Output Filename:	ENS2D.tmp

PROBLEM DESCRIPTION Dike - Guayanilla - Bor 1

BOUNDARY COORDINATES

5 Top Boundaries
7 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	100.00	100.00	100.00	2
2	100.00	100.00	161.00	121.00	1
3	161.00	121.00	199.00	121.00	1
4	199.00	121.00	260.00	100.00	1
5	260.00	100.00	300.00	100.00	2
6	100.00	100.00	260.00	100.00	2
7	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	125.0	125.0	2500.0	.0	.00	.0	1
2	110.0	110.0	500.0	.0	.00	.0	1
3	120.0	120.0	2000.0	.0	.00	.0	1

1

Dique-Guayanilla-Bor1 (StablPro Output Report)
1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 161.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

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

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

Failure Surface Specified By 17 Coordinate Points

Dique-Guayanilla-Bor1 (StablPro Output Report)

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.24	93.10
3	65.30	87.18
4	74.04	82.32
5	83.33	78.62
6	93.01	76.12
7	102.93	74.87
8	112.93	74.89
9	122.85	76.18
10	132.52	78.71
11	141.79	82.46
12	150.52	87.34
13	158.55	93.30
14	165.76	100.23
15	172.04	108.01
16	177.27	116.53
17	179.29	121.00

*** 2.647 ***

Individual data on the 21 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	3.1	519.4	.0	.0	.0	.0	.0	.0	.0
2	4.1	2227.4	.0	687.4	.0	.0	.0	.0	.0
3	8.1	8738.5	.0	4281.3	.0	.0	.0	.0	.0
4	8.7	14666.3	.0	7644.4	.0	.0	.0	.0	.0
5	9.3	19954.1	.0	10315.3	.0	.0	.0	.0	.0
6	9.7	24107.1	.0	12251.0	.0	.0	.0	.0	.0
7	7.0	18703.0	.0	9374.5	.0	.0	.0	.0	.0
8	2.9	8227.8	.0	4045.5	.0	.0	.0	.0	.0
9	10.0	31046.1	.0	13803.6	.0	.0	.0	.0	.0
10	9.9	34323.8	.0	13395.5	.0	.0	.0	.0	.0
11	9.7	35523.3	.0	12202.4	.0	.0	.0	.0	.0
12	9.3	34632.7	.0	10243.4	.0	.0	.0	.0	.0
13	8.7	31815.9	.0	7550.3	.0	.0	.0	.0	.0
14	8.0	27401.2	.0	4166.6	.0	.0	.0	.0	.0
15	2.5	7790.6	.0	534.7	.0	.0	.0	.0	.0
16	1.4	4244.2	.0	81.6	.0	.0	.0	.0	.0
17	3.1	8714.1	.0	.0	.0	.0	.0	.0	.0
18	.2	619.9	.0	.0	.0	.0	.0	.0	.0
19	6.3	13239.1	.0	.0	.0	.0	.0	.0	.0
20	5.2	5711.5	.0	.0	.0	.0	.0	.0	.0
21	2.0	562.6	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00

2	57.35	93.22
3	65.48	87.40
4	74.28	82.65
5	83.61	79.03
6	93.31	76.61
7	103.24	75.42
8	113.24	75.48
9	123.15	76.78
10	132.82	79.32
11	142.10	83.04
12	150.85	87.90
13	158.92	93.81
14	166.18	100.67
15	172.53	108.40
16	177.87	116.86
17	179.81	121.00

*** 2.651 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.24	92.99
3	76.30	87.06
4	85.11	82.33
5	94.50	78.89
6	104.28	76.81
7	114.26	76.14
8	124.23	76.88
9	134.00	79.03
10	143.36	82.53
11	152.14	87.33
12	160.15	93.31
13	167.23	100.37
14	173.25	108.36
15	178.07	117.12
16	179.54	121.00

*** 2.681 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.34	93.09
3	76.47	87.27
4	85.34	82.65
5	94.77	79.31
6	104.57	77.32

7	114.55	76.73
8	124.52	77.55
9	134.27	79.75
10	143.62	83.30
11	152.38	88.13
12	160.38	94.13
13	167.45	101.20
14	173.47	109.19
15	178.30	117.94
16	179.47	121.00

*** 2.691 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.36	93.23
3	65.52	87.45
4	74.34	82.74
5	83.69	79.18
6	93.40	76.82
7	103.34	75.71
8	113.34	75.85
9	123.24	77.26
10	132.89	79.90
11	142.12	83.74
12	150.80	88.71
13	158.78	94.73
14	165.94	101.72
15	172.16	109.54
16	177.35	118.09
17	178.64	121.00

*** 2.692 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.18	92.93
3	76.19	86.94
4	84.98	82.17
5	94.36	78.70
6	104.14	76.61
7	114.11	75.94
8	124.09	76.70
9	133.84	78.89
10	143.19	82.45
11	151.93	87.31

12	159.88	93.38
13	166.88	100.52
14	172.79	108.59
15	177.48	117.42
16	178.76	121.00

*** 2.703 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.29	93.15
3	65.39	87.29
4	74.18	82.53
5	83.52	78.94
6	93.24	76.58
7	103.18	75.50
8	113.18	75.70
9	123.06	77.19
10	132.68	79.94
11	141.86	83.91
12	150.45	89.02
13	158.31	95.20
14	165.31	102.34
15	171.33	110.33
16	176.28	119.02
17	177.09	121.00

*** 2.728 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.33	93.19
3	65.47	87.39
4	74.29	82.68
5	83.64	79.14
6	93.38	76.84
7	103.32	75.81
8	113.32	76.07
9	123.20	77.62
10	132.80	80.42
11	141.96	84.44
12	150.52	89.60
13	158.35	95.82
14	165.32	103.00
15	171.30	111.01
16	176.20	119.73

17	176.71	121.00

*** 2.743 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.11	92.96
3	65.08	86.93
4	73.79	82.01
5	83.07	78.29
6	92.76	75.83
7	102.70	74.68
8	112.69	74.86
9	122.58	76.36
10	132.18	79.16
11	141.32	83.21
12	149.85	88.44
13	157.61	94.75
14	164.46	102.04
15	170.28	110.16
16	174.98	118.99
17	175.72	121.00

*** 2.749 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	55.56	100.00
2	62.71	93.01
3	70.76	87.08
4	79.55	82.32
5	88.92	78.81
6	98.68	76.63
7	108.65	75.83
8	118.63	76.40
9	128.44	78.35
10	137.88	81.63
11	146.79	86.19
12	154.97	91.93
13	162.29	98.75
14	168.59	106.51
15	173.77	115.07
16	176.31	121.00

*** 2.754 ***

1

```
                Y            A     X     I     S            F     T

                .00      37.50     75.00    112.50    150.00    187.50
X          .00 +---------+-*-------+-----W*--+---------+---------+
               -
               -
               -
               -
               -
        37.50 +
               -
               -                          1
               -                        1 0
               -                      1 0.3
               -                      0.3..
A       75.00 +                      13....
               -                    10.....
               -                    03.....
               -                   13......
               -                   1......*
               -                   24......
X      112.50 +                    1.......
               -                   0.......
               -                   13.......
               -                    1.......
               -                     0.......
               -                     18.......
I      150.00 +                      .14......
               -                      ..18.....
               -                        307....*
               -                         .1078..
               -                           .1.17
               -                              41
S      187.50 +
               -
               -                              *
               -
               -
               -
        225.00 +
               -
               -
               -
               -
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F      262.50 +                          *
               -
               -
               -
               -
               -
T      300.00 +            *             W*
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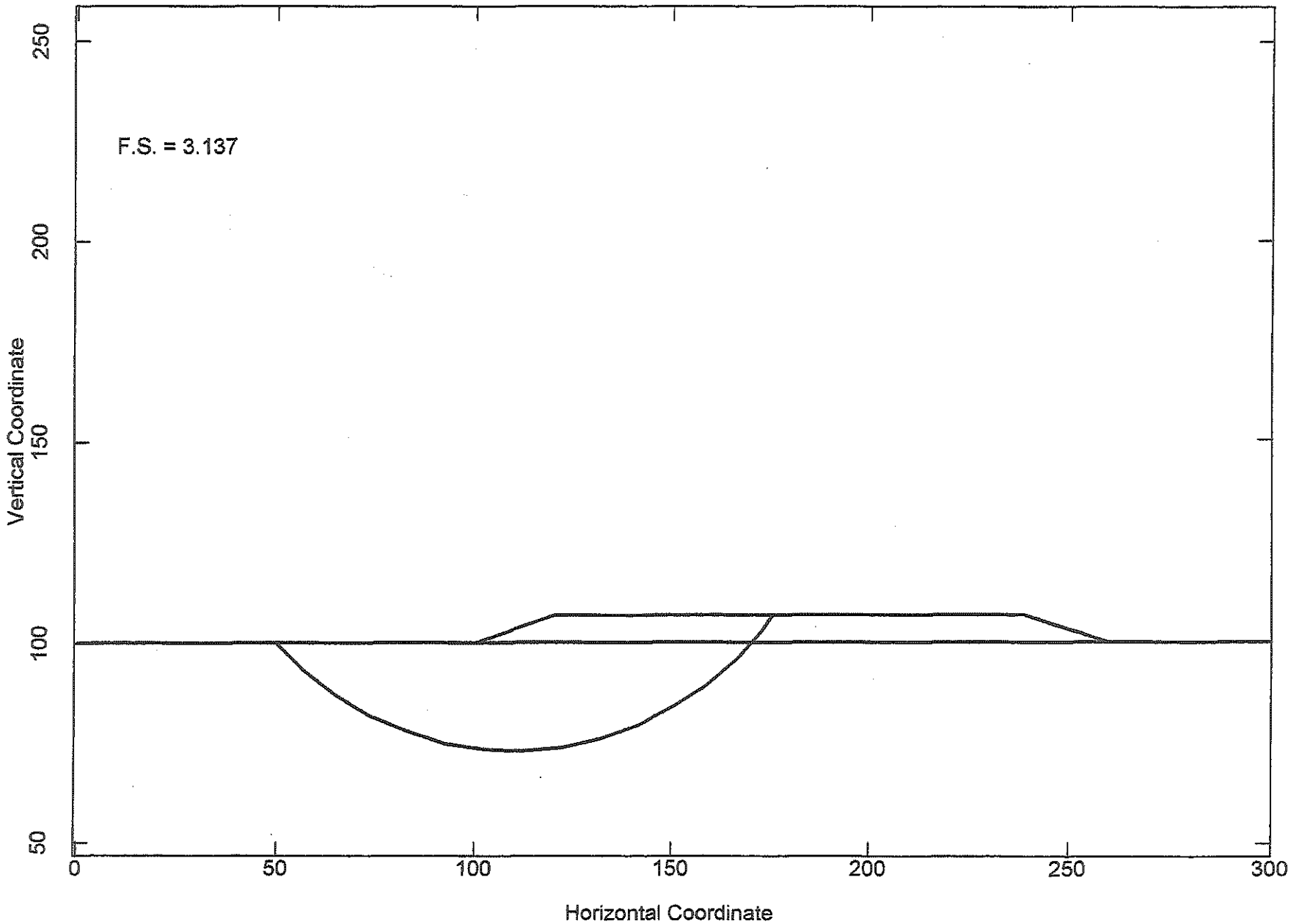
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250
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Horizontal Coordinate

Dique-Guayanilla-Bor1-1stConstStage-7fthigh (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date:	07/31/2004
Time of Run:	3:27:32 PM
Run By:	
Input Data Filename:	ENSD.tmp
Output Filename:	ENSE.tmp
Plotted Output Filename:	ENSF.tmp

PROBLEM DESCRIPTION Dike - Guayanilla - Bor 1- 1st Const. St
age- 7 ft high Dike

BOUNDARY COORDINATES

5 Top Boundaries
7 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	100.00	100.00	100.00	2
2	100.00	100.00	120.00	107.00	1
3	120.00	107.00	239.00	107.00	1
4	239.00	107.00	260.00	100.00	1
5	260.00	100.00	300.00	100.00	2
6	100.00	100.00	260.00	100.00	2
7	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	125.0	125.0	2500.0	.0	.00	.0	1
2	110.0	110.0	260.0	.0	.00	.0	1
3	120.0	120.0	2000.0	.0	.00	.0	1

1

Dique-Guayanilla-Bor1-1stConstStage-7fthigh (StablPro Output Report)
1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 161.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

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

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

Failure Surface Specified By 16 Coordinate Points

Dique-Guayanilla-Bor1-1stConstStage-7fthigh (StablPro Output Report)

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.11	92.96
3	65.03	86.86
4	73.65	81.79
5	82.83	77.82
6	92.43	75.02
7	102.30	73.44
8	112.29	73.08
9	122.25	73.97
10	132.03	76.09
11	141.46	79.40
12	150.42	83.85
13	158.75	89.38
14	166.33	95.90
15	173.05	103.31
16	175.64	107.00

*** 3.137 ***

Individual data on the 20 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	3.0	499.9	.0	.0	.0	.0	.0	.0	.0
2	4.1	2250.0	.0	722.4	.0	.0	.0	.0	.0
3	7.9	8791.0	.0	4422.5	.0	.0	.0	.0	.0
4	8.6	14858.7	.0	7909.2	.0	.0	.0	.0	.0
5	9.2	20392.1	.0	10729.6	.0	.0	.0	.0	.0
6	9.6	24898.8	.0	12840.4	.0	.0	.0	.0	.0
7	7.6	21316.1	.0	10811.3	.0	.0	.0	.0	.0
8	2.3	6787.8	.0	3397.6	.0	.0	.0	.0	.0
9	10.0	32586.6	.0	14814.2	.0	.0	.0	.0	.0
10	7.7	27971.6	.0	11381.5	.0	.0	.0	.0	.0
11	2.3	8449.0	.0	3265.4	.0	.0	.0	.0	.0
12	9.8	35397.3	.0	13709.4	.0	.0	.0	.0	.0
13	9.4	31359.1	.0	12016.5	.0	.0	.0	.0	.0
14	9.0	25931.0	.0	9594.0	.0	.0	.0	.0	.0
15	8.3	19558.0	.0	6479.3	.0	.0	.0	.0	.0
16	7.6	12774.7	.0	2720.5	.0	.0	.0	.0	.0
17	1.0	1262.7	.0	51.0	.0	.0	.0	.0	.0
18	2.7	2829.1	.0	.0	.0	.0	.0	.0	.0
19	3.0	2004.3	.0	.0	.0	.0	.0	.0	.0
20	2.6	598.5	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.24	93.10
3	65.24	87.11

4	73.90	82.10
5	83.09	78.15
6	92.68	75.31
7	102.53	73.63
8	112.52	73.12
9	122.50	73.80
10	132.32	75.65
11	141.86	78.65
12	150.98	82.75
13	159.55	87.90
14	167.45	94.03
15	174.58	101.05
16	179.33	107.00

*** 3.142 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.07	92.93
3	65.00	86.83
4	73.64	81.80
5	82.86	77.93
6	92.50	75.29
7	102.41	73.90
8	112.41	73.81
9	122.34	75.01
10	132.03	77.48
11	141.32	81.17
12	150.05	86.04
13	158.09	91.99
14	165.29	98.93
15	171.54	106.74
16	171.70	107.00

*** 3.154 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.35	93.22
3	65.43	87.33
4	74.14	82.42
5	83.36	78.55
6	92.97	75.78
7	102.84	74.15
8	112.83	73.67
9	122.80	74.35

10	132.63	76.18
11	142.19	79.14
12	151.33	83.19
13	159.94	88.28
14	167.90	94.32
15	175.11	101.26
16	179.84	107.00

*** 3.177 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.29	93.15
3	65.34	87.22
4	74.04	82.30
5	83.27	78.45
6	92.90	75.74
7	102.78	74.20
8	112.77	73.86
9	122.74	74.71
10	132.53	76.76
11	142.00	79.95
12	151.02	84.26
13	159.47	89.63
14	167.21	95.96
15	174.13	103.17
16	177.01	107.00

*** 3.183 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.36	93.23
3	65.47	87.37
4	74.20	82.50
5	83.44	78.68
6	93.07	75.97
7	102.94	74.41
8	112.94	74.01
9	122.91	74.78
10	132.72	76.71
11	142.24	79.77
12	151.33	83.93
13	159.88	89.12
14	167.76	95.27
15	174.87	102.31

16	178.61	107.00

*** 3.197 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.33	93.19
3	65.41	87.31
4	74.15	82.44
5	83.40	78.65
6	93.04	75.98
7	102.93	74.50
8	112.92	74.20
9	122.88	75.10
10	132.66	77.18
11	142.12	80.42
12	151.13	84.76
13	159.55	90.15
14	167.27	96.51
15	174.17	103.75
16	176.61	107.00

*** 3.198 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	55.56	100.00
2	62.71	93.01
3	70.70	87.00
4	79.40	82.07
5	88.67	78.30
6	98.34	75.76
7	108.25	74.48
8	118.25	74.48
9	128.17	75.77
10	137.84	78.33
11	147.10	82.11
12	155.79	87.05
13	163.78	93.07
14	170.93	100.06
15	176.39	107.00

*** 3.200 ***

Dique-Guayanilla-Bor1-1stConstStage-7fthigh (StablPro Output Report)

1

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.25	93.11
3	65.31	87.19
4	74.05	82.33
5	83.33	78.62
6	93.01	76.11
7	102.93	74.84
8	112.93	74.83
9	122.85	76.08
10	132.54	78.57
11	141.83	82.27
12	150.58	87.11
13	158.65	93.01
14	165.91	99.89
15	171.74	107.00

*** 3.216 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.18	92.93
3	76.14	86.87
4	84.83	81.92
5	94.10	78.18
6	103.79	75.72
7	113.73	74.57
8	123.73	74.76
9	133.61	76.28
10	143.20	79.11
11	152.33	83.20
12	160.82	88.47
13	168.54	94.83
14	175.34	102.16
15	178.74	107.00

*** 3.254 ***

1

```
          Y            A     X     I     S            F     T

          .00      37.50     75.00     112.50     150.00     187.50
X       .00 +---------+-*-------+-----W*--+---------+---------+
```

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                -
                -
                -
                -
                -
        37.50   +
                -
                -                          1
                -                        1 8
                -                      1 8.0
                -                      8.0..
  A     75.00   +                     10....
                -                    18.....
                -                    80.....
                -                   10......
                -                   1......*
                -                   8......
  X    112.50   +                  13.......
                -                   8.......  *
                -                   1.......
                -                   13......
                -                    8.......
                -                    13.....
  I    150.00   +                     13.....
                -                      813...
                -                      2483...
                -                        21833
                -                         .211
                -                           .2
  S    187.50   +
                -
                -
                -
                -
        225.00  +
                -
                -                            *
                -
                -
                -
  F    262.50   +                          *
                -
                -
                -
                -
  T    300.00   +            *             W*
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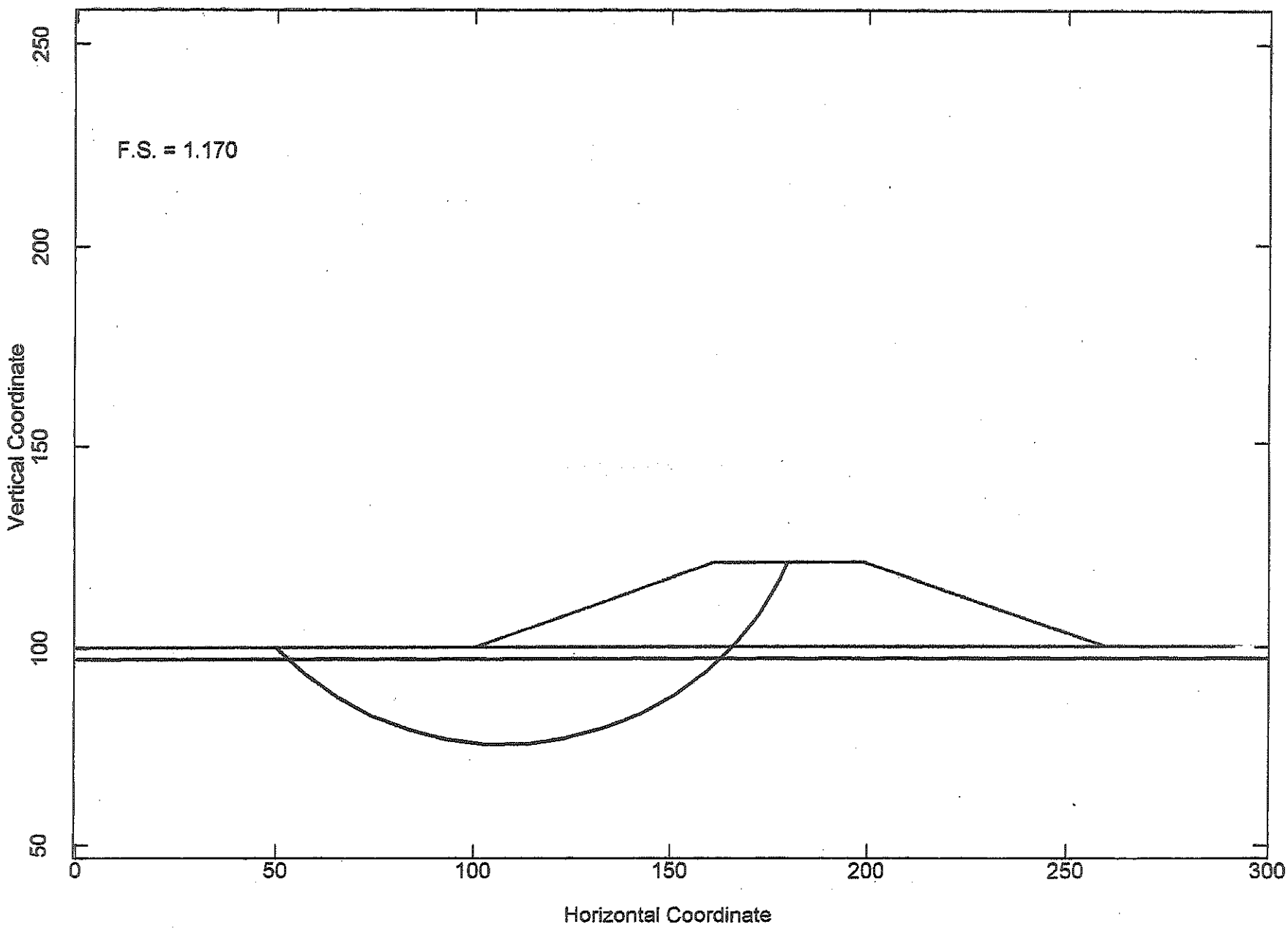
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250
300
Horizontal Coordinate

Dique-Guayanilla-Bor1Seismic-Condition (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date:	07/31/2004
Time of Run:	4:13:48 PM
Run By:	
Input Data Filename:	ENS29.tmp
Output Filename:	ENS2A.tmp
Plotted Output Filename:	ENS2B.tmp

PROBLEM DESCRIPTION Dike - Guayanilla - Bor 1-Seismic Cond

BOUNDARY COORDINATES

5 Top Boundaries
7 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	100.00	100.00	100.00	2
2	100.00	100.00	161.00	121.00	1
3	161.00	121.00	199.00	121.00	1
4	199.00	121.00	260.00	100.00	1
5	260.00	100.00	300.00	100.00	2
6	100.00	100.00	260.00	100.00	2
7	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	125.0	125.0	2500.0	.0	.00	.0	1
2	110.0	110.0	260.0	.0	.00	.0	1
3	120.0	120.0	2000.0	.0	.00	.0	1

1

Dique-Guayanilla-Bor1Seismic-Condition (StablPro Output Report)
1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

A Horizontal Earthquake Loading Coefficient
Of .200 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .000 Has Been Assigned

Cavitation Pressure = .0 F/L^2

1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 161.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

Dique-Guayanilla-Bor1Seismic-Condition (StablPro Output Report)
Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

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

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.35	93.22
3	65.48	87.40
4	74.28	82.65
5	83.61	79.03
6	93.31	76.61
7	103.24	75.42
8	113.24	75.48
9	123.15	76.78
10	132.82	79.32
11	142.10	83.04
12	150.85	87.90
13	158.92	93.81
14	166.18	100.67
15	172.53	108.40
16	177.87	116.86
17	179.81	121.00

*** 1.170 ***

Individual data on the 21 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	3.2	535.9	.0	.0	.0	.0	107.2	.0	.0
2	4.1	2205.4	.0	658.7	.0	.0	441.1	.0	.0
3	8.1	8674.0	.0	4175.7	.0	.0	1734.8	.0	.0
4	8.8	14493.6	.0	7472.3	.0	.0	2898.7	.0	.0
5	9.3	19648.8	.0	10083.0	.0	.0	3929.8	.0	.0
6	9.7	23668.9	.0	11967.0	.0	.0	4733.8	.0	.0
7	6.7	17515.0	.0	8745.2	.0	.0	3503.0	.0	.0
8	3.2	8905.7	.0	4349.4	.0	.0	1781.1	.0	.0
9	10.0	30550.4	.0	13448.2	.0	.0	6110.1	.0	.0
10	9.9	33792.7	.0	13022.4	.0	.0	6758.5	.0	.0
11	9.7	35004.3	.0	11823.7	.0	.0	7000.9	.0	.0
12	9.3	34174.2	.0	9870.9	.0	.0	6834.8	.0	.0
13	8.7	31459.5	.0	7194.7	.0	.0	6291.9	.0	.0
14	8.1	27173.9	.0	3836.9	.0	.0	5434.8	.0	.0
15	2.1	6573.8	.0	395.5	.0	.0	1314.8	.0	.0
16	1.3	3913.1	.0	68.0	.0	.0	782.6	.0	.0
17	3.2	8853.8	.0	.0	.0	.0	1770.8	.0	.0
18	.7	1843.8	.0	.0	.0	.0	368.8	.0	.0

19	6.4	13071.2	.0	.0	.0	.0	2614.2	.0	.0
20	5.3	5586.0	.0	.0	.0	.0	1117.2	.0	.0
21	1.9	502.5	.0	.0	.0	.0	100.5	.0	.0

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.24	93.10
3	65.30	87.18
4	74.04	82.32
5	83.33	78.62
6	93.01	76.12
7	102.93	74.87
8	112.93	74.89
9	122.85	76.18
10	132.52	78.71
11	141.79	82.46
12	150.52	87.34
13	158.55	93.30
14	165.76	100.23
15	172.04	108.01
16	177.27	116.53
17	179.29	121.00

*** 1.170 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.36	93.23
3	65.52	87.45
4	74.34	82.74
5	83.69	79.18
6	93.40	76.82
7	103.34	75.71
8	113.34	75.85
9	123.24	77.26
10	132.89	79.90
11	142.12	83.74
12	150.80	88.71
13	158.78	94.73
14	165.94	101.72
15	172.16	109.54
16	177.35	118.09
17	178.64	121.00

*** 1.193 ***

Failure Surface Specified By 17 Coordinate Points

Dique-Guayanilla-Bor1Seismic-Condition (StablPro Output Report)

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.29	93.15
3	65.39	87.29
4	74.18	82.53
5	83.52	78.94
6	93.24	76.58
7	103.18	75.50
8	113.18	75.70
9	123.06	77.19
10	132.68	79.94
11	141.86	83.91
12	150.45	89.02
13	158.31	95.20
14	165.31	102.34
15	171.33	110.33
16	176.28	119.02
17	177.09	121.00

*** 1.214 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.33	93.19
3	65.47	87.39
4	74.29	82.68
5	83.64	79.14
6	93.38	76.84
7	103.32	75.81
8	113.32	76.07
9	123.20	77.62
10	132.80	80.42
11	141.96	84.44
12	150.52	89.60
13	158.35	95.82
14	165.32	103.00
15	171.30	111.01
16	176.20	119.73
17	176.71	121.00

*** 1.223 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)

1	50.00	100.00
2	57.11	92.96
3	65.08	86.93
4	73.79	82.01
5	83.07	78.29
6	92.76	75.83
7	102.70	74.68
8	112.69	74.86
9	122.58	76.36
10	132.18	79.16
11	141.32	83.21
12	149.85	88.44
13	157.61	94.75
14	164.46	102.04
15	170.28	110.16
16	174.98	118.99
17	175.72	121.00

*** 1.229 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.77	93.70
3	66.23	88.38
4	75.28	84.12
5	84.78	80.98
6	94.58	79.02
7	104.55	78.24
8	114.54	78.68
9	124.41	80.32
10	134.00	83.13
11	143.19	87.08
12	151.83	92.11
13	159.81	98.15
14	166.99	105.10
15	173.29	112.87
16	178.39	121.00

*** 1.248 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.24	92.99
3	76.30	87.06
4	85.11	82.33

5	94.50	78.89
6	104.28	76.81
7	114.26	76.14
8	124.23	76.88
9	134.00	79.03
10	143.36	82.53
11	152.14	87.33
12	160.15	93.31
13	167.23	100.37
14	173.25	108.36
15	178.07	117.12
16	179.54	121.00

*** 1.250 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.34	93.09
3	76.47	87.27
4	85.34	82.65
5	94.77	79.31
6	104.57	77.32
7	114.55	76.73
8	124.52	77.55
9	134.27	79.75
10	143.62	83.30
11	152.38	88.13
12	160.38	94.13
13	167.45	101.20
14	173.47	109.19
15	178.30	117.94
16	179.47	121.00

*** 1.254 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.18	92.93
3	76.19	86.94
4	84.98	82.17
5	94.36	78.70
6	104.14	76.61
7	114.11	75.94
8	124.09	76.70
9	133.84	78.89
10	143.19	82.45

11	151.93	87.31
12	159.88	93.38
13	166.88	100.52
14	172.79	108.59
15	177.48	117.42
16	178.76	121.00

*** 1.264 ***

1

```
                Y            A     X     I     S            F     T

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               -
               -
               -
               -
               -
        37.50 +
               -
               -                          1
               -                        1 .
               -                      1 ..8
               -                      .78..
A       75.00 +                     18....
               -                   1......
               -                   .7.....
               -                 17......
               -                 2......*
               -                 17......
X      112.50 +                  17......
               -                 ........
               -                 13.......
               -                  17......
               -                    ........
               -                    15.......
I      150.00 +                    .137.....
               -                     ..15.....
               -                       874....*
               -                        .1745..
               -                          .1714
               -                             91
S      187.50 +
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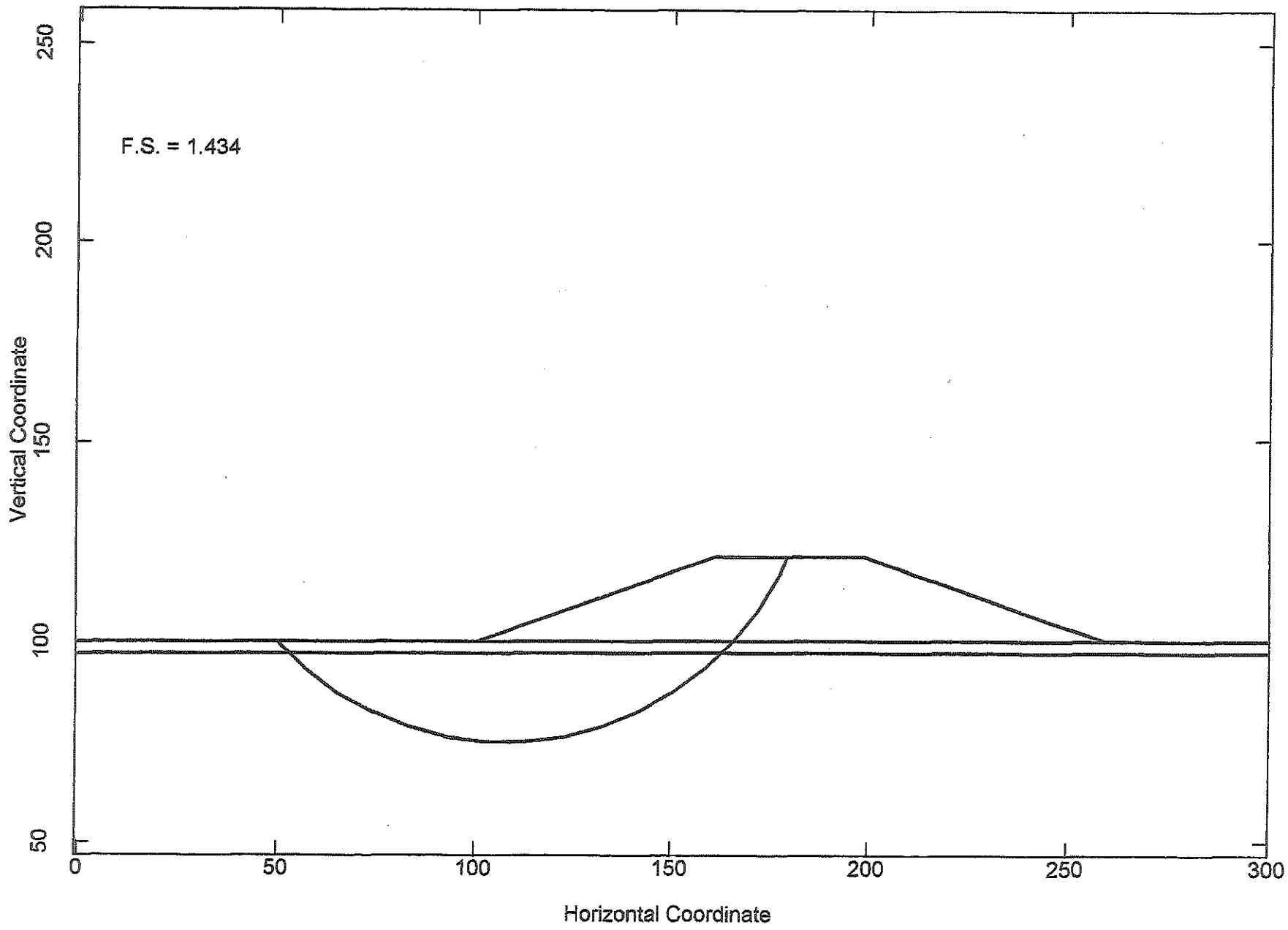
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Horizontal Coordinate

Dique-Guayanilla-Bor1Seismic-Condition (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date: 07/31/2004
Time of Run: 4:19:53 PM
Run By:
Input Data Filename: ENS30.tmp
Output Filename: ENS31.tmp
Plotted Output Filename: ENS32.tmp

PROBLEM DESCRIPTION Dike - Guayanilla - Bor 1-Seismic Cond

BOUNDARY COORDINATES

5 Top Boundaries
7 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	100.00	100.00	100.00	2
2	100.00	100.00	161.00	121.00	1
3	161.00	121.00	199.00	121.00	1
4	199.00	121.00	260.00	100.00	1
5	260.00	100.00	300.00	100.00	2
6	100.00	100.00	260.00	100.00	2
7	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	125.0	125.0	2500.0	.0	.00	.0	1
2	110.0	110.0	500.0	.0	.00	.0	1
3	120.0	120.0	2000.0	.0	.00	.0	1

1

Dique-Guayanilla-Bor1Seismic-Condition (StablPro Output Report)
1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

A Horizontal Earthquake Loading Coefficient
Of .200 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .000 Has Been Assigned

Cavitation Pressure = .0 F/L^2

1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 161.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

Dique-Guayanilla-Bor1Seismic-Condition (StablPro Output Report)
Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

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

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.24	93.10
3	65.30	87.18
4	74.04	82.32
5	83.33	78.62
6	93.01	76.12
7	102.93	74.87
8	112.93	74.89
9	122.85	76.18
10	132.52	78.71
11	141.79	82.46
12	150.52	87.34
13	158.55	93.30
14	165.76	100.23
15	172.04	108.01
16	177.27	116.53
17	179.29	121.00

*** 1.434 ***

Individual data on the 21 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	3.1	519.4	.0	.0	.0	.0	103.9	.0	.0
2	4.1	2227.4	.0	687.4	.0	.0	445.5	.0	.0
3	8.1	8738.5	.0	4281.3	.0	.0	1747.7	.0	.0
4	8.7	14666.3	.0	7644.4	.0	.0	2933.3	.0	.0
5	9.3	19954.1	.0	10315.3	.0	.0	3990.8	.0	.0
6	9.7	24107.1	.0	12251.0	.0	.0	4821.4	.0	.0
7	7.0	18703.0	.0	9374.5	.0	.0	3740.6	.0	.0
8	2.9	8227.8	.0	4045.5	.0	.0	1645.6	.0	.0
9	10.0	31046.1	.0	13803.6	.0	.0	6209.2	.0	.0
10	9.9	34323.8	.0	13395.5	.0	.0	6864.8	.0	.0
11	9.7	35523.3	.0	12202.4	.0	.0	7104.7	.0	.0
12	9.3	34632.7	.0	10243.4	.0	.0	6926.5	.0	.0
13	8.7	31815.9	.0	7550.3	.0	.0	6363.2	.0	.0
14	8.0	27401.2	.0	4166.6	.0	.0	5480.2	.0	.0
15	2.5	7790.6	.0	534.7	.0	.0	1558.1	.0	.0
16	1.4	4244.2	.0	81.6	.0	.0	848.8	.0	.0
17	3.1	8714.1	.0	.0	.0	.0	1742.8	.0	.0
18	.2	619.9	.0	.0	.0	.0	124.0	.0	.0

19	6.3	13239.1	.0	.0	.0	.0	2647.8	.0	.0
20	5.2	5711.5	.0	.0	.0	.0	1142.3	.0	.0
21	2.0	562.6	.0	.0	.0	.0	112.5	.0	.0

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.35	93.22
3	65.48	87.40
4	74.28	82.65
5	83.61	79.03
6	93.31	76.61
7	103.24	75.42
8	113.24	75.48
9	123.15	76.78
10	132.82	79.32
11	142.10	83.04
12	150.85	87.90
13	158.92	93.81
14	166.18	100.67
15	172.53	108.40
16	177.87	116.86
17	179.81	121.00

*** 1.435 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.36	93.23
3	65.52	87.45
4	74.34	82.74
5	83.69	79.18
6	93.40	76.82
7	103.34	75.71
8	113.34	75.85
9	123.24	77.26
10	132.89	79.90
11	142.12	83.74
12	150.80	88.71
13	158.78	94.73
14	165.94	101.72
15	172.16	109.54
16	177.35	118.09
17	178.64	121.00

*** 1.461 ***

Failure Surface Specified By 17 Coordinate Points

Dique-Guayanilla-Bor1Seismic-Condition (StablPro Output Report)

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.29	93.15
3	65.39	87.29
4	74.18	82.53
5	83.52	78.94
6	93.24	76.58
7	103.18	75.50
8	113.18	75.70
9	123.06	77.19
10	132.68	79.94
11	141.86	83.91
12	150.45	89.02
13	158.31	95.20
14	165.31	102.34
15	171.33	110.33
16	176.28	119.02
17	177.09	121.00

*** 1.484 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.33	93.19
3	65.47	87.39
4	74.29	82.68
5	83.64	79.14
6	93.38	76.84
7	103.32	75.81
8	113.32	76.07
9	123.20	77.62
10	132.80	80.42
11	141.96	84.44
12	150.52	89.60
13	158.35	95.82
14	165.32	103.00
15	171.30	111.01
16	176.20	119.73
17	176.71	121.00

*** 1.494 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)

1	50.00	100.00
2	57.11	92.96
3	65.08	86.93
4	73.79	82.01
5	83.07	78.29
6	92.76	75.83
7	102.70	74.68
8	112.69	74.86
9	122.58	76.36
10	132.18	79.16
11	141.32	83.21
12	149.85	88.44
13	157.61	94.75
14	164.46	102.04
15	170.28	110.16
16	174.98	118.99
17	175.72	121.00

*** 1.499 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.24	92.99
3	76.30	87.06
4	85.11	82.33
5	94.50	78.89
6	104.28	76.81
7	114.26	76.14
8	124.23	76.88
9	134.00	79.03
10	143.36	82.53
11	152.14	87.33
12	160.15	93.31
13	167.23	100.37
14	173.25	108.36
15	178.07	117.12
16	179.54	121.00

*** 1.506 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.34	93.09
3	76.47	87.27
4	85.34	82.65

5	94.77	79.31
6	104.57	77.32
7	114.55	76.73
8	124.52	77.55
9	134.27	79.75
10	143.62	83.30
11	152.38	88.13
12	160.38	94.13
13	167.45	101.20
14	173.47	109.19
15	178.30	117.94
16	179.47	121.00

*** 1.512 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	100.00
2	68.18	92.93
3	76.19	86.94
4	84.98	82.17
5	94.36	78.70
6	104.14	76.61
7	114.11	75.94
8	124.09	76.70
9	133.84	78.89
10	143.19	82.45
11	151.93	87.31
12	159.88	93.38
13	166.88	100.52
14	172.79	108.59
15	177.48	117.42
16	178.76	121.00

*** 1.521 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	100.00
2	57.77	93.70
3	66.23	88.38
4	75.28	84.12
5	84.78	80.98
6	94.58	79.02
7	104.55	78.24
8	114.54	78.68
9	124.41	80.32
10	134.00	83.13

11	143.19	87.08
12	151.83	92.11
13	159.81	98.15
14	166.99	105.10
15	173.29	112.87
16	178.39	121.00

*** 1.527 ***

1

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                Y            A     X     I     S            F     T

                .00      37.50     75.00    112.50    150.00    187.50
X            .00 +---------+-*-------+-----W*--+---------+---------+
                -
                -
                -
                -
                -
          37.50 +
                -
                -                          1
                -                        1 .
                -                      1 ..7
                -                      .07..
A        75.00 +                     17....
                -                   1......
                -                   .7.....
                -                  17......
                -                  1......*
                -                  28......
X       112.50 +                   10......
                -                  .......
                -                  13......
                -                   10.....
                -                    .......
                -                    15......
I       150.00 +                    .130....
                -                     ..15....
                -                       704....*
                -                        .1045..
                -                          .1014
                -                             81
S       187.50 +
                -
                -                             *
                -
                -
                -
          225.00 +
                -
                -
                -
                -
                -
F       262.50 +                           *
                -
```

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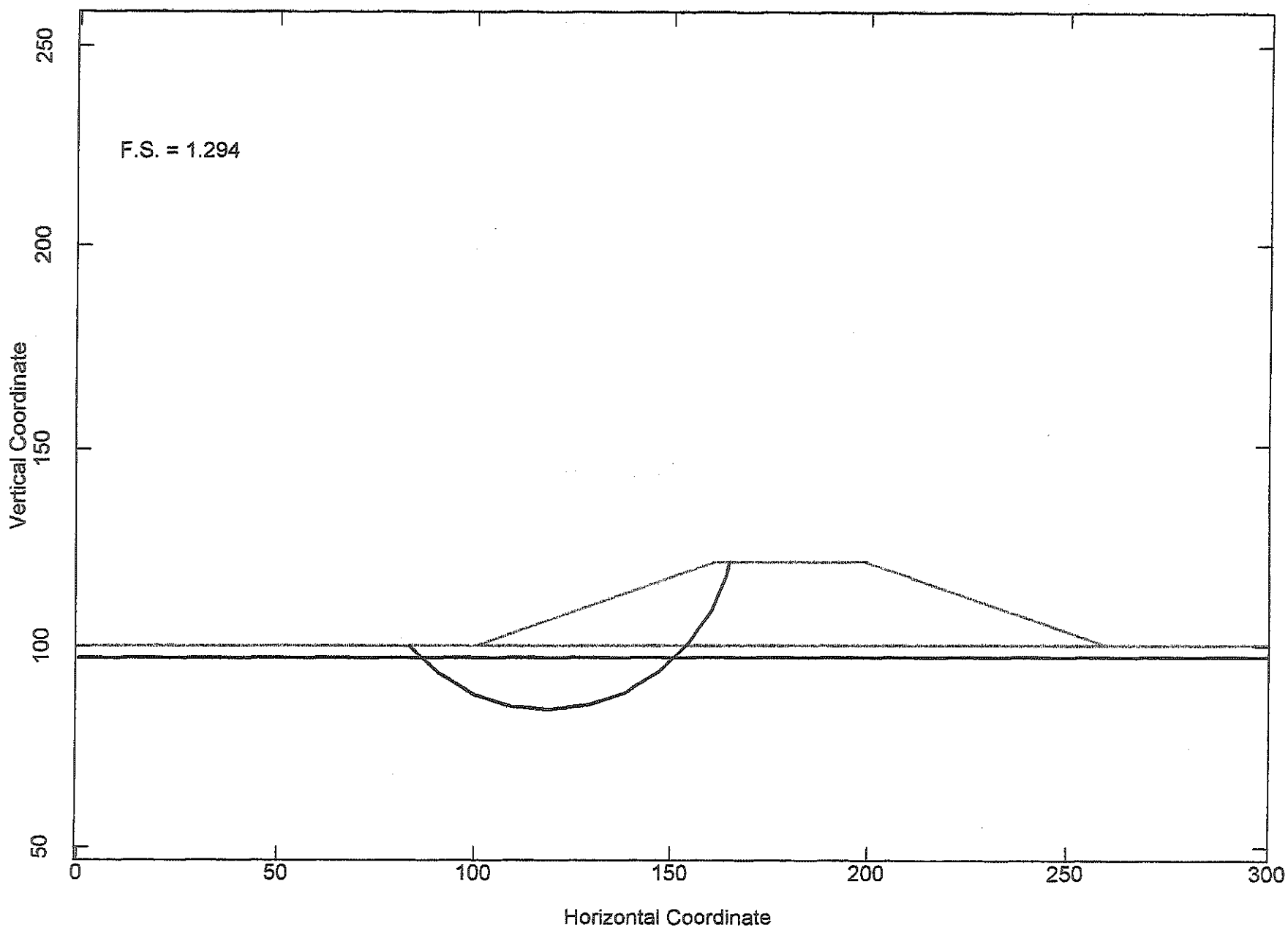
                -
                -
                -
                -
T     300.00 +            *              W*
```


F.S. = 1.294
Vertical Coordinate
250
200
150
100
50
0
50
100
150
200
250
300
Horizontal Coordinate

Dique-Guayanilla-Bor1-Long-Term (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date:	08/06/2004
Time of Run:	9:15:18 AM
Run By:	
Input Data Filename:	ENS4F.tmp
Output Filename:	ENS50.tmp
Plotted Output Filename:	ENS51.tmp

PROBLEM DESCRIPTION Dike - Guayanilla - Bor 1-Long-Term

BOUNDARY COORDINATES

5 Top Boundaries
7 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	100.00	100.00	100.00	2
2	100.00	100.00	161.00	121.00	1
3	161.00	121.00	199.00	121.00	1
4	199.00	121.00	260.00	100.00	1
5	260.00	100.00	300.00	100.00	2
6	100.00	100.00	260.00	100.00	2
7	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	125.0	125.0	.0	30.0	.00	.0	1
2	110.0	110.0	100.0	15.0	.00	.0	1
3	120.0	120.0	200.0	25.0	.00	.0	1

1

Dique-Guayanilla-Bor1-Long-Term (StablPro Output Report)
1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 161.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

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

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

Failure Surface Specified By 12 Coordinate Points

Dique-Guayanilla-Bor1-Long-Term (StablPro Output Report)

Point No.	X-Surf (L)	Y-Surf (L)
1	83.33	100.00
2	90.76	93.30
3	99.42	88.31
4	108.95	85.25
5	118.90	84.26
6	128.83	85.38
7	138.31	88.56
8	146.91	93.67
9	154.25	100.46
10	160.00	108.65
11	163.89	117.85
12	164.50	121.00

*** 1.294 ***

Individual data on the 16 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	3.3	548.6	.0	.0	.0	.0	.0	.0	.0
2	4.1	2186.9	.0	637.2	.0	.0	.0	.0	.0
3	8.7	8764.2	.0	3865.1	.0	.0	.0	.0	.0
4	.6	746.0	.0	331.3	.0	.0	.0	.0	.0
5	8.9	14819.0	.0	6045.1	.0	.0	.0	.0	.0
6	10.0	22646.3	.0	7640.0	.0	.0	.0	.0	.0
7	9.9	26796.4	.0	7599.6	.0	.0	.0	.0	.0
8	9.5	27280.9	.0	6257.0	.0	.0	.0	.0	.0
9	8.6	24175.7	.0	3672.0	.0	.0	.0	.0	.0
10	3.6	9392.2	.0	510.2	.0	.0	.0	.0	.0
11	3.2	7801.2	.0	.0	.0	.0	.0	.0	.0
12	.5	1143.9	.0	.0	.0	.0	.0	.0	.0
13	5.7	10854.0	.0	.0	.0	.0	.0	.0	.0
14	1.0	1380.1	.0	.0	.0	.0	.0	.0	.0
15	2.9	2375.4	.0	.0	.0	.0	.0	.0	.0
16	.6	118.3	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	83.33	100.00
2	90.42	92.95
3	98.84	87.55
4	108.21	84.05
5	118.11	82.61
6	128.08	83.29
7	137.69	86.05
8	146.50	90.79
9	154.11	97.27
10	160.18	105.22
11	164.44	114.27

12	166.00	121.00

*** 1.295 ***

1

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	83.33	100.00
2	90.55	93.08
3	99.04	87.79
4	108.43	84.36
5	118.33	82.92
6	128.31	83.55
7	137.95	86.22
8	146.83	90.81
9	154.59	97.12
10	160.88	104.89
11	165.44	113.79
12	167.41	121.00

*** 1.296 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	88.89	100.00
2	95.96	92.93
3	104.46	87.66
4	113.94	84.48
5	123.90	83.56
6	133.81	84.93
7	143.13	88.53
8	151.39	94.17
9	158.14	101.56
10	163.02	110.28
11	165.77	119.90
12	165.82	121.00

*** 1.297 ***

1

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)

1	88.89	100.00
2	95.96	92.93
3	104.49	87.71
4	114.01	84.64
5	123.98	83.89
6	133.85	85.50
7	143.07	89.37
8	151.12	95.30
9	157.56	102.96
10	162.02	111.91
11	164.11	121.00

*** 1.298 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	83.33	100.00
2	90.41	92.93
3	98.74	87.41
4	108.02	83.66
5	117.85	81.84
6	127.85	82.02
7	137.61	84.18
8	146.75	88.25
9	154.89	94.05
10	161.71	101.37
11	166.93	109.89
12	170.36	119.29
13	170.61	121.00

*** 1.301 ***

1

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	77.78	100.00
2	85.05	93.14
3	93.49	87.77
4	102.78	84.08
5	112.61	82.21
6	122.61	82.22
7	132.43	84.11
8	141.71	87.81
9	150.14	93.20
10	157.40	100.07
11	163.24	108.19
12	167.45	117.26
13	168.38	121.00

*** 1.304 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	88.89	100.00
2	96.69	93.75
3	105.65	89.30
4	115.35	86.86
5	125.34	86.54
6	135.18	88.35
7	144.40	92.21
8	152.60	97.94
9	159.38	105.29
10	164.45	113.91
11	166.78	121.00

*** 1.305 ***

1

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	88.89	100.00
2	96.50	93.51
3	105.30	88.77
4	114.90	85.98
5	124.88	85.27
6	134.78	86.67
7	144.17	90.12
8	152.62	95.47
9	159.75	102.47
10	165.26	110.82
11	168.89	120.14
12	169.03	121.00

*** 1.306 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	83.33	100.00
2	90.92	93.49
3	99.62	88.55
4	109.10	85.36

5	119.01	84.04
6	128.99	84.65
7	138.67	87.15
8	147.70	91.46
9	155.73	97.42
10	162.47	104.80
11	167.68	113.34
12	170.53	121.00

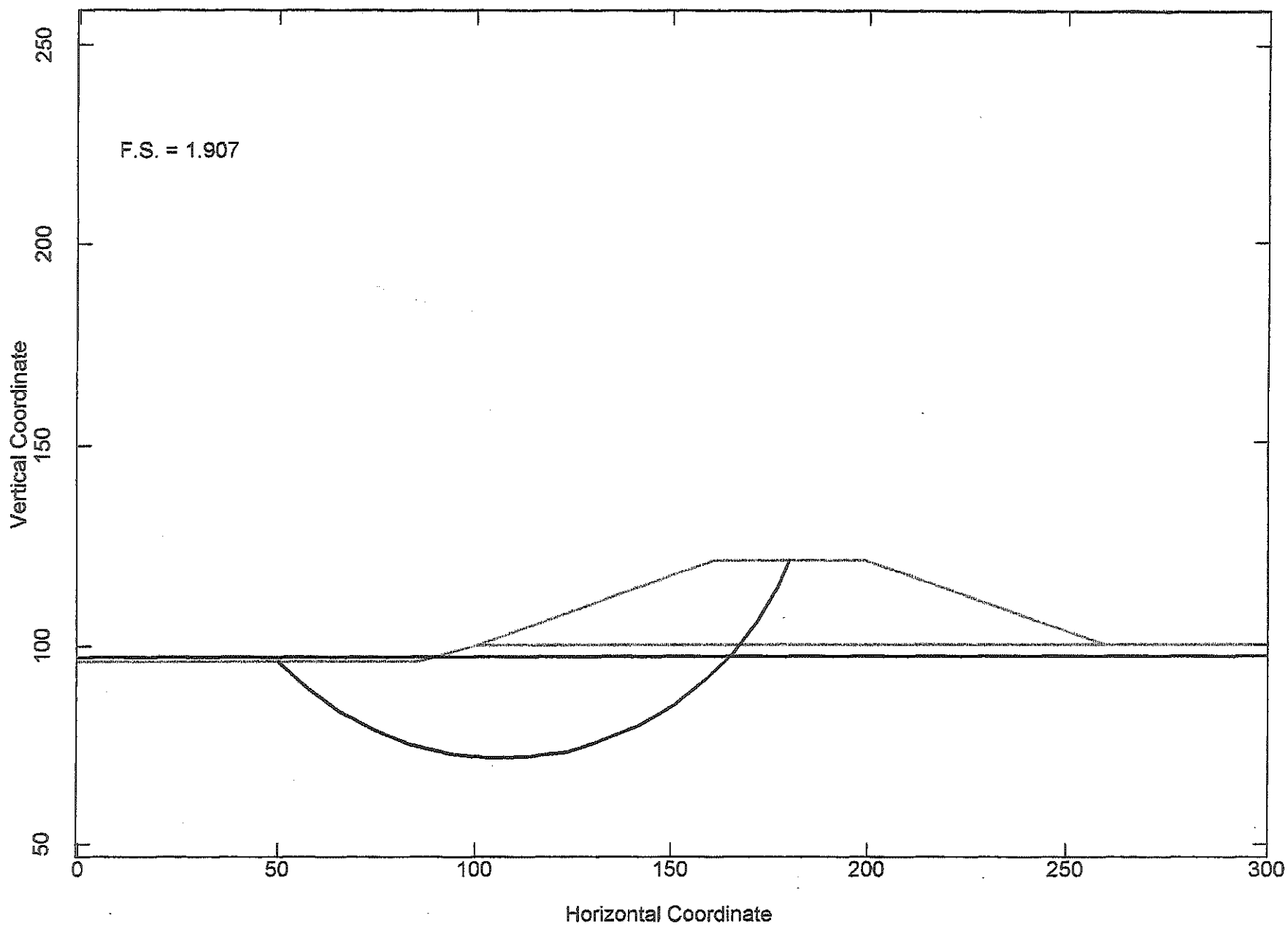
*** 1.307 ***

1

```
                Y            A     X     I     S            F     T

                .00     37.50     75.00    112.50    150.00    187.50
X          .00 +---------+-*-------+-----W*--+---------+---------+
               -
               -
               -
               -
               -
        37.50 +
               -
               -                                .
               -                              . .
               -                            . ...
               -                            ....
A       75.00 +                           .....7
               -                         ......1
               -                         ....2.4
               -                        ...7.1..
               -                        ..721..*
               -                        ..218...
X      112.50 +                        ..74....
               -                        ..1.....
               -                        ..28.....
               -                         .31.....
               -                          621.....
               -                          .728.....
I      150.00 +                          ..018....
               -                           ..621....
               -                             ..62121*
               -                              ...6072
               -                                .....
               -                                   ..
S      187.50 +
               -
               -                                   *
               -
               -
               -
        225.00 +
               -
               -
               -
               -
               -
```

```
F    262.50 +                                *
            -
            -
            -
            -
            -
T    300.00 +            *               W*
```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150
200
250
300
Horizontal Coordinate

Dique-Guayanilla-Bor1-Dredging (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date:	08/05/2004
Time of Run:	6:46:59 PM
Run By:	
Input Data Filename:	ENS35.tmp
Output Filename:	ENS36.tmp
Plotted Output Filename:	ENS37.tmp

PROBLEM DESCRIPTION Dike - Guayanilla - Bor 1

BOUNDARY COORDINATES

6 Top Boundaries
8 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	96.00	85.00	96.00	2
2	85.00	96.00	100.00	100.00	2
3	100.00	100.00	161.00	121.00	1
4	161.00	121.00	199.00	121.00	1
5	199.00	121.00	260.00	100.00	1
6	260.00	100.00	300.00	100.00	2
7	100.00	100.00	260.00	100.00	2
8	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	125.0	125.0	2500.0	.0	.00	.0	1
2	110.0	110.0	260.0	.0	.00	.0	1
3	120.0	120.0	2000.0	.0	.00	.0	1

1

Dique-Guayanilla-Bor1-Dredging (StablPro Output Report)

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

1

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

Janbu s Empirical Coef. is being used for
shear angle = 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 161.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

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

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

Failure Surface Specified By 17 Coordinate Points

Dique-Guayanilla-Bor1-Dredging (StablPro Output Report)

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.35	89.22
3	65.49	83.42
4	74.31	78.70
5	83.66	75.14
6	93.38	72.79
7	103.32	71.69
8	113.31	71.87
9	123.21	73.31
10	132.84	75.99
11	142.06	79.87
12	150.71	84.89
13	158.65	90.97
14	165.75	98.01
15	171.91	105.89
16	177.02	114.48
17	179.84	121.00

*** 1.907 ***

Individual data on the 21 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	7.3	2741.3	458.4	2740.9	.0	.0	.0	.0	.0
2	8.1	8678.9	508.4	6666.8	.0	.0	.0	.0	.0
3	8.8	14492.0	550.2	9948.0	.0	.0	.0	.0	.0
4	9.3	19613.9	583.1	12531.4	.0	.0	.0	.0	.0
5	1.3	3110.5	83.9	1901.6	.0	.0	.0	.0	.0
6	8.4	21481.6	.0	12473.6	.0	.0	.0	.0	.0
7	6.6	19451.0	.0	10220.6	.0	.0	.0	.0	.0
8	3.3	10493.0	.0	5229.1	.0	.0	.0	.0	.0
9	10.0	34615.5	.0	15737.7	.0	.0	.0	.0	.0
10	9.9	37617.6	.0	15234.3	.0	.0	.0	.0	.0
11	9.6	38482.4	.0	13947.7	.0	.0	.0	.0	.0
12	9.2	37220.7	.0	11898.7	.0	.0	.0	.0	.0
13	8.6	34019.0	.0	9120.5	.0	.0	.0	.0	.0
14	7.9	29226.3	.0	5657.8	.0	.0	.0	.0	.0
15	2.4	8091.9	.0	1004.8	.0	.0	.0	.0	.0
16	3.7	11801.2	.0	606.8	.0	.0	.0	.0	.0
17	1.0	2950.0	.0	.0	.0	.0	.0	.0	.0
18	1.6	4257.8	.0	.0	.0	.0	.0	.0	.0
19	4.6	10381.9	.0	.0	.0	.0	.0	.0	.0
20	5.1	6904.4	.0	.0	.0	.0	.0	.0	.0
21	2.8	1149.7	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)

1	50.00	96.00
2	57.24	89.10
3	65.31	83.19
4	74.07	78.37
5	83.38	74.72
6	93.08	72.29
7	103.01	71.13
8	113.01	71.26
9	122.91	72.68
10	132.54	75.36
11	141.75	79.26
12	150.38	84.31
13	158.29	90.42
14	165.35	97.51
15	171.43	105.45
16	176.45	114.10
17	179.33	121.00

*** 1.914 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.36	89.23
3	65.53	83.46
4	74.37	78.79
5	83.74	75.28
6	93.47	73.00
7	103.42	71.98
8	113.42	72.25
9	123.30	73.79
10	132.90	76.58
11	142.06	80.58
12	150.64	85.72
13	158.50	91.91
14	165.49	99.06
15	171.51	107.04
16	176.46	115.73
17	178.63	121.00

*** 1.944 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.29	89.15
3	65.40	83.31
4	74.21	78.58

5	83.57	75.04
6	93.30	72.76
7	103.25	71.77
8	113.25	72.09
9	123.12	73.71
10	132.69	76.61
11	141.80	80.73
12	150.29	86.01
13	158.02	92.35
14	164.86	99.65
15	170.68	107.78
16	175.39	116.61
17	177.04	121.00

*** 1.987 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.77	89.70
3	66.25	84.40
4	75.31	80.18
5	84.83	77.11
6	94.65	75.23
7	104.63	74.57
8	114.61	75.14
9	124.45	76.93
10	133.99	79.92
11	143.10	84.05
12	151.63	89.28
13	159.45	95.51
14	166.44	102.65
15	172.51	110.60
16	177.56	119.24
17	178.31	121.00

*** 1.994 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.33	89.19
3	65.48	83.40
4	74.32	78.73
5	83.69	75.25
6	93.44	73.02
7	103.40	72.09
8	113.39	72.47

9	123.25	74.15
10	132.81	77.10
11	141.89	81.27
12	150.36	86.60
13	158.05	92.99
14	164.84	100.33
15	170.62	108.49
16	175.28	117.34
17	176.64	121.00

*** 1.998 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	55.56	96.00
2	63.27	89.63
3	71.74	84.32
4	80.83	80.16
5	90.39	77.21
6	100.25	75.53
7	110.24	75.15
8	120.20	76.08
9	129.95	78.29
10	139.33	81.75
11	148.18	86.40
12	156.35	92.17
13	163.70	98.95
14	170.11	106.63
15	175.46	115.07
16	178.21	121.00

*** 2.023 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.11	88.96
3	65.09	82.95
4	73.82	78.06
5	83.12	74.39
6	92.83	72.00
7	102.77	70.94
8	112.77	71.22
9	122.63	72.85
10	132.19	75.79
11	141.27	79.98
12	149.70	85.36
13	157.33	91.83

14	164.02	99.26
15	169.66	107.52
16	174.13	116.46
17	175.67	121.00

*** 2.028 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.24	88.99
3	76.31	83.08
4	85.14	78.38
5	94.55	74.99
6	104.34	72.99
7	114.33	72.41
8	124.29	73.27
9	134.03	75.55
10	143.34	79.19
11	152.03	84.14
12	159.93	90.27
13	166.86	97.48
14	172.69	105.60
15	177.30	114.48
16	179.57	121.00

*** 2.028 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	55.56	96.00
2	62.71	89.01
3	70.77	83.10
4	79.58	78.37
5	88.97	74.91
6	98.74	72.81
7	108.72	72.09
8	118.69	72.78
9	128.48	74.86
10	137.87	78.29
11	146.69	82.99
12	154.77	88.89
13	161.94	95.85
14	168.07	103.76
15	173.03	112.44
16	176.44	121.00

Dique-Guayanilla-Bor1-Dredging (StablPro Output Report)
*** 2.029 ***

1

```
                Y            A      X      I      S             F      T

                .00      37.50  75.00  112.50  150.00  187.50
X          .00 +---------+-*-------+------*---+---------+---------+
                -
                -
                -
                -
                -
        37.50 +
                -
                -                          1
                -                        1 7
                -                      1 7.9
                -                      759..
A       75.00 +                      19....
                -                    17.....
                -                    05....*
                -                   15......
                -                   27......*
                -                   15.......
X      112.50 +                     15......
                -                   07.......
                -                   215......
                -                    15.......
                -                     07......
                -                     14.......
I      150.00 +                      .215.......
                -                       .13......
                -                       9524....*
                -                         1523...
                -                           15214
                -                               .1
S      187.50 +
                -
                -                               *
                -
                -
                -
        225.00 +
                -
                -
                -
                -
                -
F      262.50 +                            *
                -
                -
                -
                -
                -
T      300.00 +            *               W*
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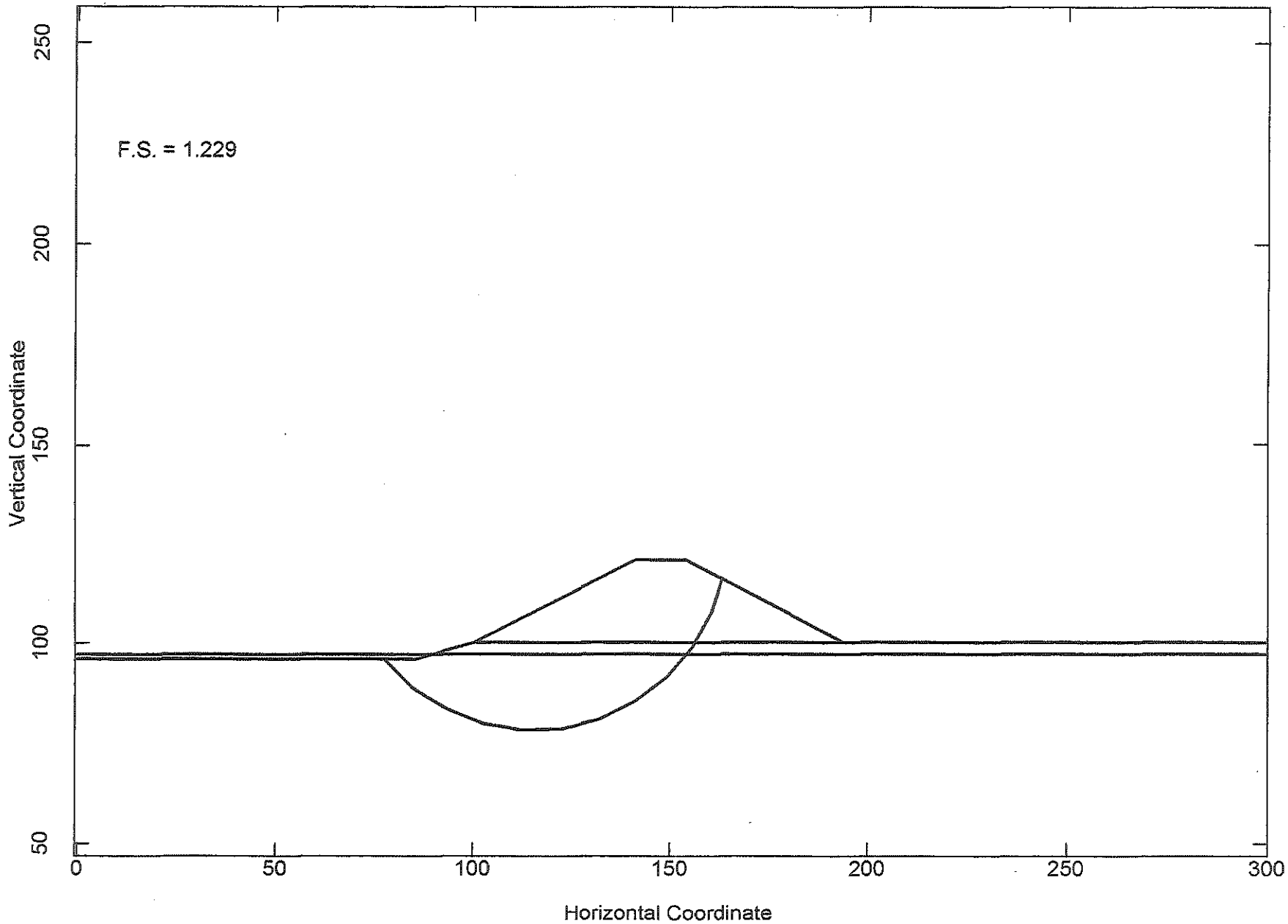
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150
200
250
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Horizontal Coordinate

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date: 08/06/2004
Time of Run: 11:51:27 AM
Run By:
Input Data Filename: ENS9E.tmp
Output Filename: ENS9F.tmp
Plotted Output Filename: ENSA0.tmp

PROBLEM DESCRIPTION Dike - Guayanilla -Jetty-Short-Term-Bor
1

BOUNDARY COORDINATES

6 Top Boundaries
8 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	96.00	85.00	96.00	2
2	85.00	96.00	100.00	100.00	2
3	100.00	100.00	141.00	121.00	1
4	141.00	121.00	154.00	121.00	1
5	154.00	121.00	194.00	100.00	1
6	194.00	100.00	300.00	100.00	2
7	100.00	100.00	260.00	100.00	2
8	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	100.0	100.0	.0	60.0	.00	.0	1
2	110.0	110.0	500.0	.0	.00	.0	1
3	120.0	120.0	2000.0	.0	.00	.0	1

1

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 141.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

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

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

Failure Surface Specified By 12 Coordinate Points

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)

Point No.	X-Surf (L)	Y-Surf (L)
1	77.78	96.00
2	84.88	88.96
3	93.27	83.51
4	102.59	79.89
5	112.45	78.25
6	122.44	78.65
7	132.14	81.08
8	141.14	85.44
9	149.07	91.54
10	155.58	99.13
11	160.41	107.89
12	162.99	116.28

*** 1.229 ***

Individual data on the 17 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	7.1	2749.9	443.1	2820.9	.0	.0	.0	.0	.0
2	.1	94.2	7.6	72.7	.0	.0	.0	.0	.0
3	8.3	9916.3	.0	6644.0	.0	.0	.0	.0	.0
4	6.7	12515.4	.0	6668.8	.0	.0	.0	.0	.0
5	2.6	5752.3	.0	2876.6	.0	.0	.0	.0	.0
6	9.9	26508.3	.0	11187.9	.0	.0	.0	.0	.0
7	10.0	32615.4	.0	11575.3	.0	.0	.0	.0	.0
8	9.7	35042.6	.0	10691.3	.0	.0	.0	.0	.0
9	8.9	32930.3	.0	8457.2	.0	.0	.0	.0	.0
10	.1	533.9	.0	115.8	.0	.0	.0	.0	.0
11	7.9	26667.2	.0	5309.5	.0	.0	.0	.0	.0
12	4.7	12785.8	.0	1224.6	.0	.0	.0	.0	.0
13	.3	604.0	.0	.0	.0	.0	.0	.0	.0
14	1.6	3560.1	.0	.0	.0	.0	.0	.0	.0
15	.5	982.8	.0	.0	.0	.0	.0	.0	.0
16	4.3	6450.7	.0	.0	.0	.0	.0	.0	.0
17	2.6	1258.3	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	72.22	96.00
2	79.30	88.93
3	87.59	83.34
4	96.78	79.41
5	106.55	77.29
6	116.55	77.06
7	126.41	78.72
8	135.78	82.23
9	144.31	87.44

10	151.71	94.17
11	157.70	102.18
12	162.06	111.18
13	163.37	116.08

*** 1.237 ***

1

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	66.67	96.00
2	73.75	88.94
3	81.95	83.21
4	91.01	79.00
5	100.68	76.41
6	110.64	75.54
7	120.60	76.41
8	130.26	79.00
9	139.33	83.21
10	147.53	88.94
11	154.61	96.00
12	160.36	104.18
13	164.61	113.23
14	165.13	115.16

*** 1.251 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	77.78	96.00
2	84.90	88.98
3	93.45	83.80
4	102.98	80.75
5	112.95	80.00
6	122.82	81.58
7	132.06	85.42
8	140.15	91.29
9	146.65	98.89
10	151.22	107.79
11	153.59	117.50
12	153.61	121.00

*** 1.253 ***

1

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	77.78	96.00
2	85.05	89.14
3	93.68	84.08
4	103.22	81.08
5	113.19	80.30
6	123.08	81.77
7	132.39	85.41
8	140.65	91.05
9	147.43	98.40
10	152.40	107.08
11	155.29	116.65
12	155.54	120.19

*** 1.261 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.29	89.04
3	76.51	83.34
4	85.54	79.05
5	95.15	76.29
6	105.09	75.12
7	115.07	75.58
8	124.86	77.66
9	134.17	81.30
10	142.77	86.40
11	150.43	92.83
12	156.94	100.42
13	162.13	108.97
14	164.71	115.38

*** 1.271 ***

1

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	66.67	96.00
2	73.89	89.09
3	82.26	83.61
4	91.48	79.74
5	101.25	77.62
6	111.25	77.32
7	121.13	78.85

8	130.57	82.15
9	139.25	87.12
10	146.88	93.58
11	153.20	101.33
12	158.00	110.10
13	160.47	117.61

*** 1.275 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	72.22	96.00
2	79.59	89.24
3	88.03	83.88
4	97.29	80.10
5	107.07	78.02
6	117.07	77.69
7	126.96	79.14
8	136.44	82.32
9	145.22	87.12
10	153.00	93.39
11	159.56	100.95
12	164.67	109.54
13	166.51	114.43

*** 1.275 ***

1

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	66.67	96.00
2	74.04	89.24
3	82.44	83.83
4	91.64	79.90
5	101.37	77.57
6	111.35	76.92
7	121.29	77.95
8	130.92	80.64
9	139.96	84.91
10	148.16	90.65
11	155.27	97.68
12	161.10	105.80
13	165.48	114.79
14	165.52	114.95

*** 1.283 ***

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.37	89.12
3	76.60	83.44
4	85.61	79.11
5	95.19	76.24
6	105.10	74.88
7	115.10	75.08
8	124.94	76.83
9	134.40	80.08
10	143.23	84.76
11	151.24	90.76
12	158.21	97.93
13	163.99	106.09
14	167.79	113.76

*** 1.288 ***

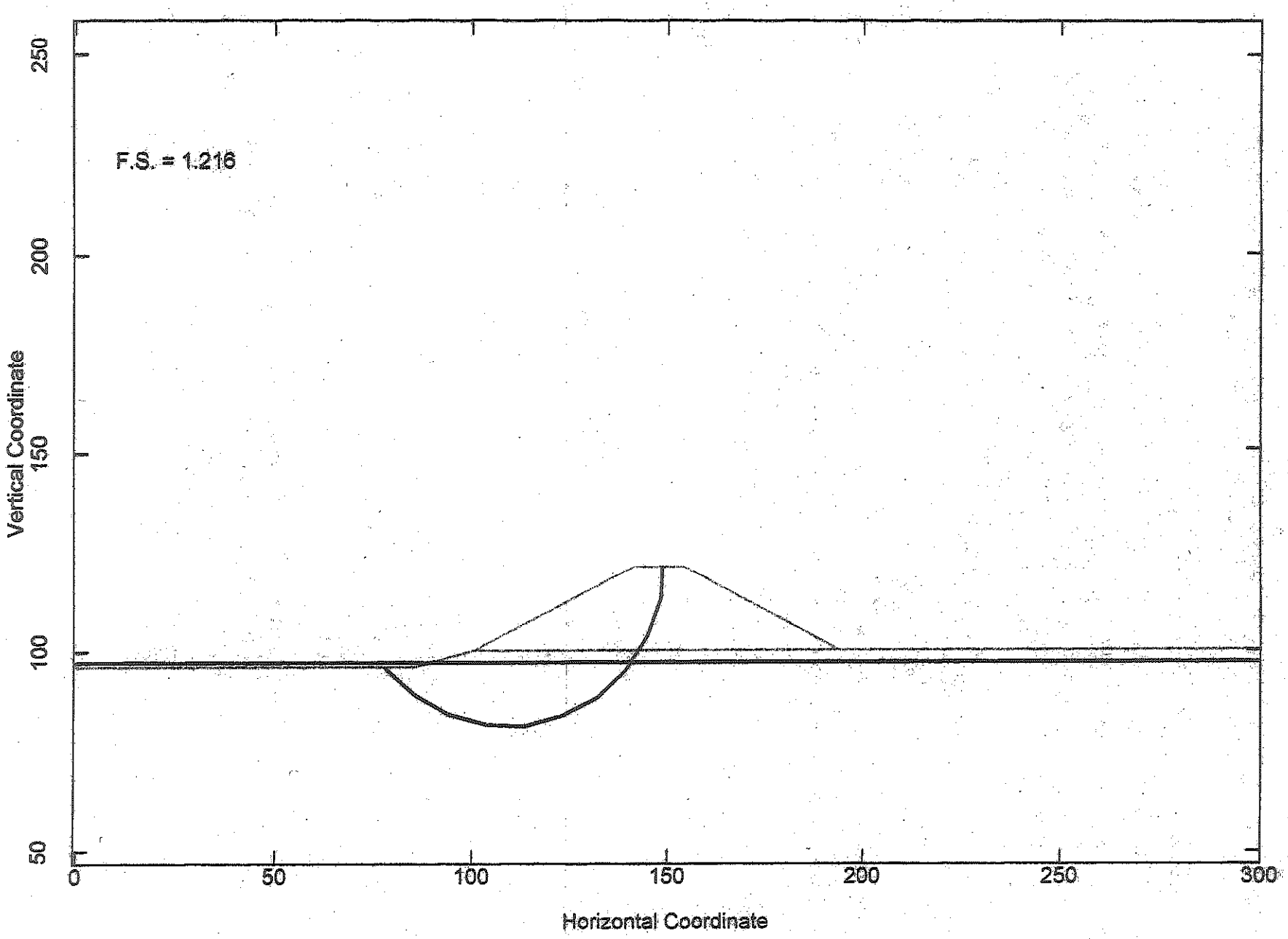
1

```
                Y            A     X     I     S            F     T

                .00      37.50     75.00    112.50    150.00    187.50
X          .00 +---------+-*-------+-----*---+---------+---------+
               -
               -
               -
               -
               -
         37.50 +
               -
               -                          .
               -                        . .
               -                      . ..6
               -                      ..6.3
A        75.00 +                     .6.3.1
               -                    ..3.2..
               -                    .62.1.*
               -                   .621....
               -                   .314....*
               -                   .625.....
X       112.50 +                   .31......
               -                   .32.......
               -                   .014......
               -                   ..314.......
               -                    .0274...... .
               -                    ...15.4.....*
I       150.00 +                     ...125..4...
               -                     ....12.7.4*
               -                      ....83121.
               -                        .....08
               -                         .....
```

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)

```
                -                                  ..
S     187.50 +                                   *
                -
                -
                -
                -
                -
      225.00 +
                -
                -
                -
                -
                -
F     262.50 +                                   *
                -
                -
                -
                -
                -
T     300.00 +            *                     W*
```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Vertical Coordinate
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200
150
100
50
0
50
100
150
200
250
300
Horizontal Coordinate

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date: 08/06/2004
Time of Run: 11:57:28 AM
Run By:
Input Data Filename: ENSAC.tmp
Output Filename: ENSAD.tmp
Plotted Output Filename: ENSAE.tmp

PROBLEM DESCRIPTION Dike - Guayanilla -Jetty-Long-Term-Bor 1

BOUNDARY COORDINATES

6 Top Boundaries
8 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	96.00	85.00	96.00	2
2	85.00	96.00	100.00	100.00	2
3	100.00	100.00	141.00	121.00	1
4	141.00	121.00	154.00	121.00	1
5	154.00	121.00	194.00	100.00	1
6	194.00	100.00	300.00	100.00	2
7	100.00	100.00	260.00	100.00	2
8	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	100.0	100.0	.0	60.0	.00	.0	1
2	110.0	110.0	100.0	15.0	.00	.0	1
3	120.0	120.0	200.0	25.0	.00	.0	1

1

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 141.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

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

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

Failure Surface Specified By 11 Coordinate Points

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)

Point No.	X-Surf (L)	Y-Surf (L)
1	77.78	96.00
2	85.02	89.10
3	93.74	84.21
4	103.40	81.63
5	113.40	81.53
6	123.11	83.92
7	131.93	88.63
8	139.30	95.39
9	144.77	103.76
10	147.99	113.23
11	148.60	121.00

*** 1.216 ***

Individual data on the 15 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	7.2	2734.9	450.6	2766.2	.0	.0	.0	.0	.0
2	.0	12.0	1.0	10.8	.0	.0	.0	.0	.0
3	8.7	10087.0	.0	6455.9	.0	.0	.0	.0	.0
4	6.3	10876.6	.0	5509.9	.0	.0	.0	.0	.0
5	3.4	6997.7	.0	3275.4	.0	.0	.0	.0	.0
6	10.0	24559.5	.0	9619.8	.0	.0	.0	.0	.0
7	9.7	27536.0	.0	8907.3	.0	.0	.0	.0	.0
8	8.8	25742.4	.0	6692.2	.0	.0	.0	.0	.0
9	7.4	19929.9	.0	3113.0	.0	.0	.0	.0	.0
10	1.1	2586.8	.0	96.7	.0	.0	.0	.0	.0
11	.6	1520.5	.0	.0	.0	.0	.0	.0	.0
12	1.3	2906.6	.0	.0	.0	.0	.0	.0	.0
13	2.5	4696.9	.0	.0	.0	.0	.0	.0	.0
14	3.2	4028.4	.0	.0	.0	.0	.0	.0	.0
15	.6	234.4	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	72.22	96.00
2	79.49	89.13
3	88.13	84.10
4	97.69	81.17
5	107.67	80.49
6	117.54	82.10
7	126.78	85.91
8	134.91	91.73
9	141.51	99.25
10	146.21	108.08
11	148.79	117.74
12	148.89	121.00

*** 1.218 ***

1

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	77.78	96.00
2	84.90	88.98
3	93.45	83.80
4	102.98	80.75
5	112.95	80.00
6	122.82	81.58
7	132.06	85.42
8	140.15	91.29
9	146.65	98.89
10	151.22	107.79
11	153.59	117.50
12	153.61	121.00

*** 1.225 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	77.78	96.00
2	85.05	89.14
3	93.68	84.08
4	103.22	81.08
5	113.19	80.30
6	123.08	81.77
7	132.39	85.41
8	140.65	91.05
9	147.43	98.40
10	152.40	107.08
11	155.29	116.65
12	155.54	120.19

*** 1.243 ***

1

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00

2	68.21	88.95
3	76.49	83.35
4	85.66	79.37
5	95.42	77.17
6	105.41	76.81
7	115.30	78.31
8	124.73	81.62
9	133.39	86.62
10	140.98	93.14
11	147.22	100.95
12	151.90	109.79
13	154.87	119.34
14	155.00	120.47

*** 1.256 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.21	88.96
3	76.54	83.42
4	85.78	79.60
5	95.59	77.63
6	105.59	77.60
7	115.40	79.49
8	124.67	83.25
9	133.04	88.72
10	140.19	95.71
11	145.86	103.95
12	149.83	113.13
13	151.54	121.00

*** 1.262 ***

1

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	72.22	96.00
2	79.96	89.67
3	88.95	85.29
4	98.71	83.11
5	108.71	83.25
6	118.41	85.69
7	127.28	90.31
8	134.85	96.85
9	140.69	104.96
10	144.51	114.20
11	145.60	121.00

*** 1.264 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	66.67	96.00
2	73.89	89.09
3	82.26	83.61
4	91.48	79.74
5	101.25	77.62
6	111.25	77.32
7	121.13	78.85
8	130.57	82.15
9	139.25	87.12
10	146.88	93.58
11	153.20	101.33
12	158.00	110.10
13	160.47	117.61

*** 1.274 ***

1

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.41	89.17
3	76.91	83.89
4	86.27	80.38
5	96.14	78.76
6	106.13	79.09
7	115.87	81.38
8	124.97	85.52
9	133.09	91.36
10	139.91	98.67
11	145.18	107.17
12	148.68	116.54
13	149.41	121.00

*** 1.275 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	55.56	96.00

2	62.68	88.99
3	70.94	83.34
4	80.05	79.23
5	89.75	76.79
6	99.73	76.10
7	109.67	77.17
8	119.27	79.97
9	128.22	84.42
10	136.25	90.38
11	143.11	97.66
12	148.58	106.03
13	152.49	115.24
14	153.81	121.00

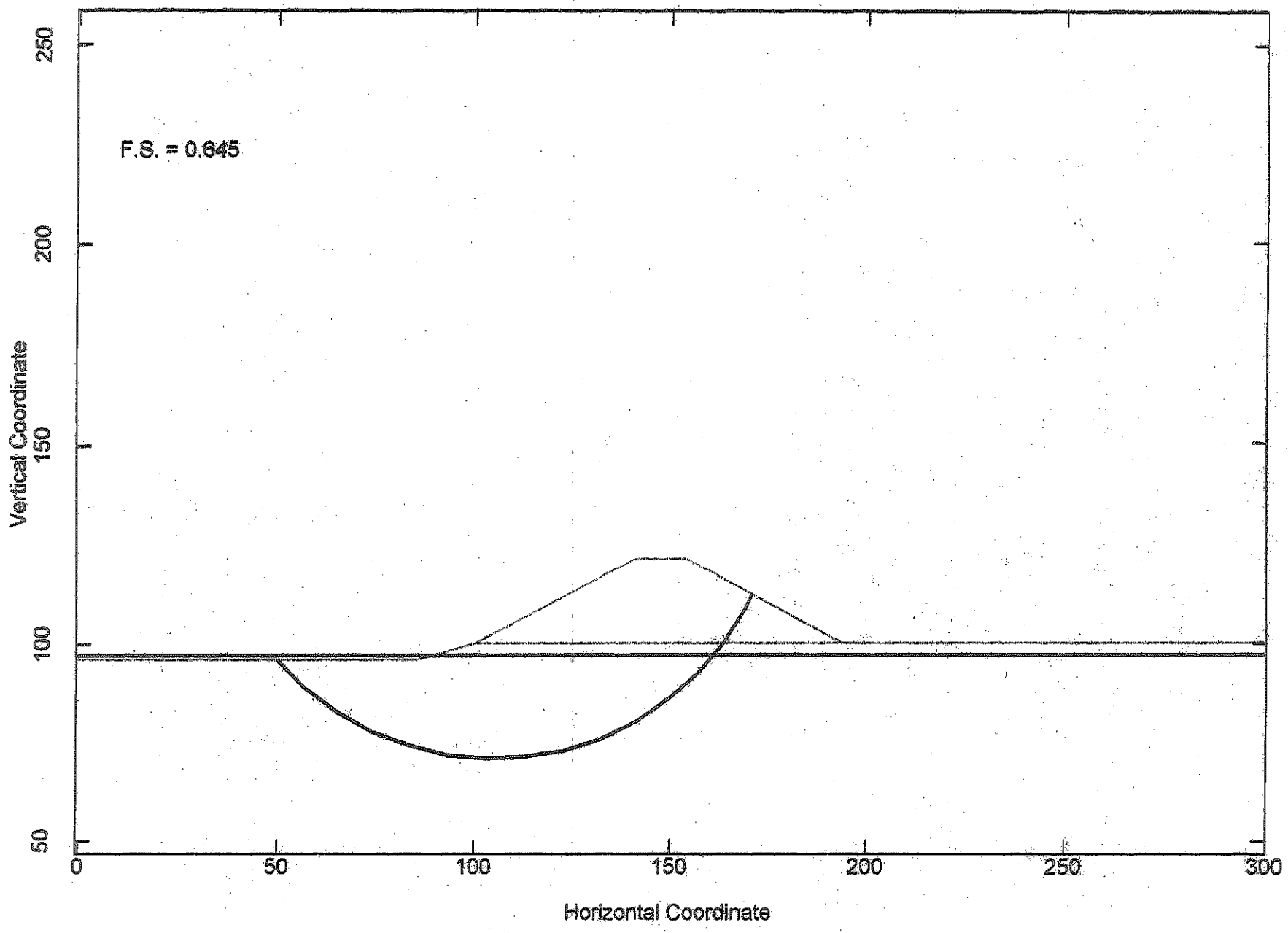
*** 1.291 ***

1

```
                Y          A     X     I     S          F     T

                .00     37.50     75.00    112.50    150.00    187.50
X          .00 +---------+-*-------+-----*---+---------+---------+
                -
                -
                -
                -
                -
         37.50 +
                -
                -
                -                          .
                -                        . 0
                -                      . 0.5
                -                      0.5.8
A        75.00 +                      .5.8.1
                -                     .08.2..
                -                     05271.*
                -                    ..51....
                -                    .082....*
                -                    .521.....
X       112.50 +                     ..31.....
                -                    ..827.....
                -                    ...127....
                -                    ...831......
                -                     ...8216.... .
                -                     ....452.127.*
I       150.00 +                      ....84503121
                -                      .....8.8.3*
                -                       ........8.
                -                         .......
                -                         '.....
                -                            ..
S       187.50 +                            *
                -
                -
                -
                -
        225.00 +
```

```
                 -
                 -
                 -
                 -
                 -
F      262.50 +                          *
                 -
                 -
                 -
                 -
                 -
T      300.00 +            *             W*
```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Vertical Coordinate
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200
150
100
50
0
50
100
150
200
250
300
Horizontal Coordinate

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date:	08/06/2004
Time of Run:	12:02:15 PM
Run By:	
Input Data Filename:	ENSB3.tmp
Output Filename:	ENSB4.tmp
Plotted Output Filename:	ENSB5.tmp

PROBLEM DESCRIPTION Dike - Guayanilla -Jetty-Seismic-Bor 1

BOUNDARY COORDINATES

6 Top Boundaries
8 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	96.00	85.00	96.00	2
2	85.00	96.00	100.00	100.00	2
3	100.00	100.00	141.00	121.00	1
4	141.00	121.00	154.00	121.00	1
5	154.00	121.00	194.00	100.00	1
6	194.00	100.00	300.00	100.00	2
7	100.00	100.00	260.00	100.00	2
8	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	100.0	100.0	.0	60.0	.00	.0	1
2	110.0	110.0	500.0	.0	.00	.0	1
3	120.0	120.0	2000.0	.0	.00	.0	1

1

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

A Horizontal Earthquake Loading Coefficient
Of .200 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .000 Has Been Assigned

Cavitation Pressure = .0 F/L^2

1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 141.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)

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

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

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.11	88.96
3	65.10	82.96
4	73.84	78.10
5	83.16	74.47
6	92.88	72.13
7	102.83	71.15
8	112.83	71.52
9	122.68	73.25
10	132.20	76.30
11	141.22	80.62
12	149.57	86.13
13	157.09	92.71
14	163.65	100.26
15	169.12	108.63
16	170.80	112.18

*** .645 ***

Individual data on the 21 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	7.1	2749.9	443.4	2819.4	.0	.0	550.0	.0	.0
2	8.0	8829.9	498.9	6888.4	.0	.0	1766.0	.0	.0
3	8.7	14872.5	545.2	10279.3	.0	.0	2974.5	.0	.0
4	9.3	20212.0	581.4	12929.2	.0	.0	4042.4	.0	.0
5	1.8	4408.7	115.0	2689.9	.0	.0	881.7	.0	.0
6	7.9	20785.3	.0	12098.9	.0	.0	4157.1	.0	.0
7	7.1	21349.5	.0	11255.0	.0	.0	4269.9	.0	.0
8	2.8	9155.2	.0	4568.7	.0	.0	1831.0	.0	.0
9	10.0	35516.4	.0	16014.6	.0	.0	7103.3	.0	.0
10	9.8	38870.8	.0	15358.0	.0	.0	7774.2	.0	.0
11	9.5	39802.3	.0	13866.1	.0	.0	7960.5	.0	.0
12	8.8	37399.2	.0	11318.3	.0	.0	7479.8	.0	.0
13	.2	925.6	.0	248.3	.0	.0	185.1	.0	.0
14	8.3	32801.5	.0	8502.1	.0	.0	6560.3	.0	.0
15	4.4	15126.3	.0	3283.9	.0	.0	3025.3	.0	.0
16	3.1	9177.7	.0	1445.6	.0	.0	1835.5	.0	.0
17	3.7	8957.0	.0	759.1	.0	.0	1791.4	.0	.0
18	2.6	4792.6	.0	.0	.0	.0	958.5	.0	.0

19	.2	363.0	.0	.0	.0	.0	72.6	.0	.0
20	5.5	5498.5	.0	.0	.0	.0	1099.7	.0	.0
21	1.7	372.1	.0	.0	.0	.0	74.4	.0	.0

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.24	89.10
3	65.27	83.14
4	73.97	78.21
5	83.20	74.37
6	92.84	71.70
7	102.73	70.22
8	112.73	69.97
9	122.68	70.94
10	132.44	73.12
11	141.86	76.48
12	150.79	80.97
13	159.11	86.52
14	166.69	93.04
15	173.42	100.44
16	178.76	108.00

*** .646 ***

1

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	55.56	96.00
2	62.71	89.01
3	70.77	83.10
4	79.59	78.37
5	88.98	74.93
6	98.76	72.84
7	108.73	72.15
8	118.71	72.86
9	128.48	74.96
10	137.87	78.41
11	146.68	83.14
12	154.73	89.07
13	161.88	96.06
14	167.97	103.99
15	172.19	111.45

*** .649 ***

Failure Surface Specified By 16 Coordinate Points

Point	X-Surf	Y-Surf

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)

No.	(L)	(L)
1	50.00	96.00
2	57.29	89.15
3	65.39	83.29
4	74.19	78.53
5	83.52	74.95
6	93.24	72.59
7	103.18	71.51
8	113.18	71.72
9	123.07	73.22
10	132.68	75.98
11	141.85	79.95
12	150.44	85.08
13	158.30	91.27
14	165.29	98.42
15	171.30	106.41
16	173.71	110.65

*** .650 ***

1

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.18	88.93
3	76.17	82.92
4	84.93	78.08
5	94.27	74.51
6	104.02	72.29
7	113.98	71.45
8	123.97	72.01
9	133.77	73.96
10	143.21	77.26
11	152.10	81.85
12	160.25	87.64
13	167.52	94.50
14	173.76	102.32
15	177.50	108.66

*** .651 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.33	89.19
3	65.47	83.40
4	74.30	78.70
5	83.67	75.19

6	93.41	72.93
7	103.36	71.94
8	113.36	72.26
9	123.22	73.87
10	132.80	76.74
11	141.93	80.83
12	150.44	86.07
13	158.21	92.37
14	165.09	99.63
15	170.98	107.71
16	172.83	111.11

*** .651 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.36	89.23
3	65.50	83.42
4	74.29	78.65
5	83.60	74.99
6	93.28	72.51
7	103.20	71.23
8	113.20	71.17
9	123.13	72.35
10	132.84	74.73
11	142.19	78.28
12	151.03	82.96
13	159.23	88.68
14	166.67	95.37
15	173.23	102.92
16	177.20	108.82

*** .652 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.35	89.22
3	65.45	83.35
4	74.19	78.50
5	83.45	74.72
6	93.09	72.08
7	102.98	70.60
8	112.98	70.31
9	122.94	71.21
10	132.72	73.30
11	142.18	76.53

12	151.19	80.87
13	159.62	86.26
14	167.35	92.60
15	174.26	99.83
16	179.93	107.39

*** .652 ***

1

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	66.67	96.00
2	73.76	88.96
3	81.87	83.09
4	90.78	78.55
5	100.28	75.45
6	110.15	73.85
7	120.15	73.80
8	130.04	75.29
9	139.58	78.30
10	148.54	82.74
11	156.70	88.51
12	163.87	95.48
13	169.88	103.48
14	173.70	110.66

*** .654 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.24	88.99
3	76.26	83.02
4	85.02	78.19
5	94.35	74.59
6	104.09	72.30
7	114.04	71.35
8	124.03	71.77
9	133.88	73.53
10	143.39	76.62
11	152.39	80.97
12	160.72	86.51
13	168.22	93.12
14	174.75	100.70
15	179.30	107.72

*** .656 ***

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)

1

```
                Y            A      X      I      S              F      T

                .00       37.50  75.00  112.50  150.00         187.50
X          .00 +---------+-*-------+-----*---+---------+---------+
                -
                -
                -
                -
                -
          37.50 +
                -
                -
                -                          1
                -                        1 3
                -                      1 3.5
A        75.00 +                       3.5.9
                -                     15.9..
                -                    139....
                -                    35....*
                -                   159.....
                -                   19......*
X       112.50 +                    3........
                -                   19.......
                -                   39........
                -                   21........
                -                   21.........
                -                    .3........ .
I       150.00 +                    213........*
                -                    .21........
                -                     .231......*
                -                      5.931.....
                -                        2..311.
                -                         .2.53
S       187.50 +                           .2
                -
                -                         *
                -
                -
          225.00 +
                -
                -
                -
                -
F       262.50 +                         *
                -
                -
                -
                -
T       300.00 +          *             W*
```

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date: 08/06/2004
Time of Run: 12:05:44 PM
Run By:
Input Data Filename: ENSBA.tmp
Output Filename: ENSBB.tmp
Plotted Output Filename: ENSBC.tmp

PROBLEM DESCRIPTION Dike - Guayanilla -Jetty-Seismic-Bor 1

BOUNDARY COORDINATES

6 Top Boundaries
8 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	96.00	85.00	96.00	2
2	85.00	96.00	100.00	100.00	2
3	100.00	100.00	141.00	121.00	1
4	141.00	121.00	154.00	121.00	1
5	154.00	121.00	194.00	100.00	1
6	194.00	100.00	300.00	100.00	2
7	100.00	100.00	260.00	100.00	2
8	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	100.0	100.0	.0	60.0	.00	.0	1
2	110.0	110.0	857.0	.0	.00	.0	1
3	120.0	120.0	2000.0	.0	.00	.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

A Horizontal Earthquake Loading Coefficient
Of .200 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .000 Has Been Assigned

Cavitation Pressure = .0 F/L^2

1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 141.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)

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

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

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.11	88.96
3	65.10	82.96
4	73.84	78.10
5	83.16	74.47
6	92.88	72.13
7	102.83	71.15
8	112.83	71.52
9	122.68	73.25
10	132.20	76.30
11	141.22	80.62
12	149.57	86.13
13	157.09	92.71
14	163.65	100.26
15	169.12	108.63
16	170.80	112.18

*** 1.093 ***

Individual data on the 21 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	7.1	2749.9	443.4	2819.4	.0	.0	550.0	.0	.0
2	8.0	8829.9	498.9	6888.4	.0	.0	1766.0	.0	.0
3	8.7	14872.5	545.2	10279.3	.0	.0	2974.5	.0	.0
4	9.3	20212.0	581.4	12929.2	.0	.0	4042.4	.0	.0
5	1.8	4408.7	115.0	2689.9	.0	.0	881.7	.0	.0
6	7.9	20785.3	.0	12098.9	.0	.0	4157.1	.0	.0
7	7.1	21349.5	.0	11255.0	.0	.0	4269.9	.0	.0
8	2.8	9155.2	.0	4568.7	.0	.0	1831.0	.0	.0
9	10.0	35516.4	.0	16014.6	.0	.0	7103.3	.0	.0
10	9.8	38870.8	.0	15358.0	.0	.0	7774.2	.0	.0
11	9.5	39802.3	.0	13866.1	.0	.0	7960.5	.0	.0
12	8.8	37399.2	.0	11318.3	.0	.0	7479.8	.0	.0
13	.2	925.6	.0	248.3	.0	.0	185.1	.0	.0
14	8.3	32801.5	.0	8502.1	.0	.0	6560.3	.0	.0
15	4.4	15126.3	.0	3283.9	.0	.0	3025.3	.0	.0
16	3.1	9177.7	.0	1445.6	.0	.0	1835.5	.0	.0
17	3.7	8957.0	.0	759.1	.0	.0	1791.4	.0	.0
18	2.6	4792.6	.0	.0	.0	.0	958.5	.0	.0

19	.2	363.0	.0	.0	.0	.0	72.6	.0	.0
20	5.5	5498.5	.0	.0	.0	.0	1099.7	.0	.0
21	1.7	372.1	.0	.0	.0	.0	74.4	.0	.0

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	55.56	96.00
2	62.71	89.01
3	70.77	83.10
4	79.59	78.37
5	88.98	74.93
6	98.76	72.84
7	108.73	72.15
8	118.71	72.86
9	128.48	74.96
10	137.87	78.41
11	146.68	83.14
12	154.73	89.07
13	161.88	96.06
14	167.97	103.99
15	172.19	111.45

*** 1.101 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.24	89.10
3	65.27	83.14
4	73.97	78.21
5	83.20	74.37
6	92.84	71.70
7	102.73	70.22
8	112.73	69.97
9	122.68	70.94
10	132.44	73.12
11	141.86	76.48
12	150.79	80.97
13	159.11	86.52
14	166.69	93.04
15	173.42	100.44
16	178.76	108.00

*** 1.101 ***

Failure Surface Specified By 16 Coordinate Points

Point	X-Surf	Y-Surf

Dique-Guayanilla-Jetty-Dredging (StablPro Output Report)

No.	(L)	(L)
1	50.00	96.00
2	57.29	89.15
3	65.39	83.29
4	74.19	78.53
5	83.52	74.95
6	93.24	72.59
7	103.18	71.51
8	113.18	71.72
9	123.07	73.22
10	132.68	75.98
11	141.85	79.95
12	150.44	85.08
13	158.30	91.27
14	165.29	98.42
15	171.30	106.41
16	173.71	110.65

*** 1.103 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.33	89.19
3	65.47	83.40
4	74.30	78.70
5	83.67	75.19
6	93.41	72.93
7	103.36	71.94
8	113.36	72.26
9	123.22	73.87
10	132.80	76.74
11	141.93	80.83
12	150.44	86.07
13	158.21	92.37
14	165.09	99.63
15	170.98	107.71
16	172.83	111.11

*** 1.105 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.18	88.93
3	76.17	82.92
4	84.93	78.08

5	94.27	74.51
6	104.02	72.29
7	113.98	71.45
8	123.97	72.01
9	133.77	73.96
10	143.21	77.26
11	152.10	81.85
12	160.25	87.64
13	167.52	94.50
14	173.76	102.32
15	177.50	108.66

*** 1.109 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.36	89.23
3	65.50	83.42
4	74.29	78.65
5	83.60	74.99
6	93.28	72.51
7	103.20	71.23
8	113.20	71.17
9	123.13	72.35
10	132.84	74.73
11	142.19	78.28
12	151.03	82.96
13	159.23	88.68
14	166.67	95.37
15	173.23	102.92
16	177.20	108.82

*** 1.110 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	66.67	96.00
2	73.76	88.96
3	81.87	83.09
4	90.78	78.55
5	100.28	75.45
6	110.15	73.85
7	120.15	73.80
8	130.04	75.29
9	139.58	78.30
10	148.54	82.74
11	156.70	88.51

12	163.87	95.48
13	169.88	103.48
14	173.70	110.66

*** 1.111 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.35	89.22
3	65.45	83.35
4	74.19	78.50
5	83.45	74.72
6	93.09	72.08
7	102.98	70.60
8	112.98	70.31
9	122.94	71.21
10	132.72	73.30
11	142.18	76.53
12	151.19	80.87
13	159.62	86.26
14	167.35	92.60
15	174.26	99.83
16	179.93	107.39

*** 1.113 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.24	88.99
3	76.26	83.02
4	85.02	78.19
5	94.35	74.59
6	104.09	72.30
7	114.04	71.35
8	124.03	71.77
9	133.88	73.53
10	143.39	76.62
11	152.39	80.97
12	160.72	86.51
13	168.22	93.12
14	174.75	100.70
15	179.30	107.72

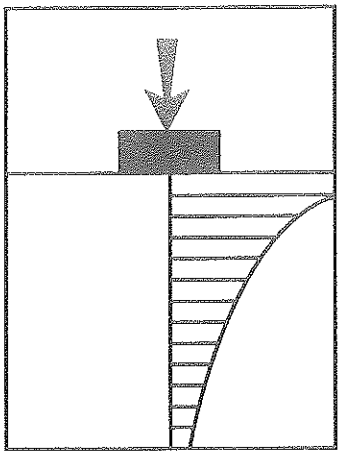
*** 1.119 ***

1

```
                Y            A     X     I     S            F     T

                .00     37.50     75.00    112.50    150.00    187.50
X          .00 +---------+-*-------+-----*---+---------+---------+
                -
                -
                -
                -
                -
         37.50 +
                -
                -                          1
                -                        1 2
                -                      1 2.6
                -                      2.6.8
A        75.00 +                     16.8..
                -                    128....
                -                    26....*
                -                   168.....
                -                   18......*
                -                   2........
X       112.50 +                    18.......
                -                   28........
                -                   31........
                -                   31..........
                -                    .2......... .
                -                    312.........*
I       150.00 +                     .31........
                -                     .321......*
                -                      6.821.....
                -                        3..211.
                -                         .3.62
                -                           .3
S       187.50 +                            *
                -
                -
                -
                -
                -
         225.00 +
                -
                -
                -
                -
                -
F       262.50 +                            *
                -
                -
                -
                -
                -
T       300.00 +            *               W*
```

ADDENDUM TO STABILITY STUDIES OF LEVEE CANALIZATION OF GUAYANILLA RIVER GUAYANILLA, PUERTO RICO



Geo
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SAN JUAN, PUERTO RICO 00919-1743
www.qdsa.com

ARAM
03 MAR 2005

28 de febrero de 2005

10-Marzo-2005
A: Gisela Melendez
DE: J Caballero
Para su información y acción correspondiente.

Sr. Ernesto Díaz
Administrador Interino
Administración de Recursos Naturales
Departamento de Recursos Naturales y Ambientales
PO Box 9066600
San Juan, Puerto Rico 00906-6600

RE: SERVICIOS DE SUPERVISIÓN
CANALIZACIÓN RÍO GUAYANILLA
GUAYANILLA, P.R.

Estimado señor Díaz:

Sirva la presente para confirmar nuestra recomendación al Ing. Jaime Caballero, Director de Diseño del Área de Recursos de Agua y Minerales, respecto a la construcción del pedraplén de la Primera Fase de la Canalización del Río Guayanilla según se muestra en los planos de construcción. Nuestra recomendación fue hecha el jueves 24 de febrero de 2005. A continuación resumimos los factores que nos llevaron a esa recomendación.

Transfondo

Los terrenos donde ubica el canal en cuestión contienen capas profundas de suelos blandos por lo que se espera que lo diques, así como el pedraplén experimenten asentamientos a corto y largo plazo. Para evaluar en detalle esta situación, el DRNA contrató los servicios del Dr. Carlos E. Rodríguez, a través de su firma Geo Engineering.

Stability Studies of Levee, Canalization of Guayanilla River, Guayanilla, P.R.

El 5 de agosto de 2004, Geo Engineering emitió un informe en el que evaluaba el posible comportamiento del dique y el terreplén con datos recopilados en un barreno cercano a la progresiva 13+00. Las evaluaciones apuntaban a que el pedraplén tendría una estabilidad marginal, con un Factor de Seguridad para condiciones estáticas de alrededor de 1.20 y que a causa del asentamiento podría sufrir grandes deformaciones. Esto porque su naturaleza, de piedras sueltas entre sí, desalentaría el asentamiento total como una sola masa, para alentar un asentamiento separado de sus componentes. Se estima que la estructura podría experimentar un asentamiento total de alrededor de 50 pulgadas, de las cuales, 8 ó 10 podrían ocurrir en pocos meses y el resto dentro de un período de 15 años. Además, de ocurrir el terremoto de diseño a corto plazo, el pedraplén fallaría. La estabilidad del pedraplén aumentaría con los años

1 marzo/05
mlal

M/Control de Inundaciones Ciales/ED-2-28-2005

a causa de la consolidación del suelo. Luego de ocurrir cierta consolidación, aumentaría su estabilidad a un Factor de Seguridad de 1.1. En el informe se recomienda proveer algún tipo de fundación (tierra reforzada o gaviones) para darle más rigidez al pedraplén.

Addendum

El ***Stability Studies of Levee*** se hizo con datos obtenidos de un barreno en la progresiva 13+00, a unos 200 metros de la localización del pedraplén, el cual se extiende entre las progresivas 10+55 y 11+00. Luego de discusiones entre el Dr. Rodríguez, el DRNA, Soil Tech (firma que preparó el estudio geotécnico preliminar para el diseño de las obras) y QDSA, se acordó realizar un Addendum por parte de Geo Engineering para evaluar el área donde se construirá el pedraplén. Se hicieron dos (2) perforaciones y el 10 de febrero de 2005 se publicó el Addendum. En este se indica que los terrenos donde ubicará el pedraplén es de la misma naturaleza que el terreno de la progresiva 13+00 por lo que los hallazgos del ***Stability Studies of Levee*** siguen vigentes.

El Addendum descarta la tierra reforzada y evalúa una base de gaviones para aumentar la estabilidad del pedraplén. Se sugiere una base de 4 pies y una de 6 pies. Los factores de seguridad para la ocurrencia del terremoto de diseño serían como sigue:

	Factor de Seguridad Para Base de Gaviones de:	
	4 pies	**6 pies**
Ocurrencia a Corto Plazo	1.00	1.10
Ocurrencia a Largo Plazo	1.20	1.26

El Addendum deja abierta la implantación de la base de gaviones a una evaluación más amplia que no sólo incluya el aspecto de estabilidad, sino elementos de riesgo de daños a vida y propiedad y elementos de costos.

Elementos de Costo

El costo estimado de la base de gaviones de cuatro (4) pies fluctuaría entre $180,000 y $275,000, sin contar el costo del dragado necesario para colocar los gaviones. En el caso de los gaviones de seis (6) pies, su costo fluctuaría entre $275,000 y $400,000, sin contar el dragado adicional. El costo del pedraplén según diseñado es de alrededor de $200,000. Sumando este costo a los de la base, el costo del pedraplén terminado sobre su base fluctuaría desde más de $380,000 hasta más de $675,000.

Elementos de Riesgo

De ocurrir el terremoto de diseño (7.5 en Escala Richter) habrá graves daños a vida y propiedad a causa de los efectos directos del sismo sobre estructuras tales como edificios, puentes, carreteras, utilidades, etc. El pedraplén está ubicado en la playa,

justo donde el canal descarga sus aguas al mar. Una falla de esta estructura no representaría peligro inminente para propiedades ni personas. Las consecuencias serían el desmoronamiento del terraplén y algún daño a la parte del dique de tierra más próxima al mar. En tal caso, habrá un costo de restauración que se podría estimar entre $200,000 y $400,000.

Razonamiento

Nos parece que la introducción de una base para el pedraplén encarecería aún más este proyecto, el cual ya se ha visto afectado por varios aumentos en sus costos. Como el riesgo de daños a propiedades y vidas en caso de un terremoto de magnitud considerable a corto plazo, que produjera la falla del pedraplén, es casi inexistente, y como la estabilidad de la obra va aumentando con el paso de los años, recomendamos que la obra se construya según diseñada en los planos del proyecto.

Hacemos hincapié en que es de gran importancia mantener un programa de vigilancia a corto y largo plazo para detectar desplazamientos significativos tanto en los diques de tierra como en el pedraplén, para hacer las correcciones pertinentes y mantener la rasante y estructura de éstos a elevaciones y geometría cónsonas con su propósito.

Cordialmente,

QUIÑONES, DIEZ, SILVA Y ASOCIADOS, CSP

Ángel (7) Silva Molinari

A(7)SM/mmr

c: Ing. Jaime Caballero, ***DRN***

ADDENDUM TO STABILITY STUDIES OF LEVEE CANALIZATION OF GUAYANILLA RIVER GUAYANILLA, PUERTO RICO

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10 de febrero de 2005

Ing. Jaime Caballero
Director, División de Diseño
Administración de Recursos Naturales, DRNA
P.O. Box 9066600 Pta. de Tierra Station
San Juan, P.R., 00906

Re: **"Proyecto de Canalización del Río Guayanilla Etapa I Fase I"**
Guayanilla, Puerto Rico
(GEO-2004-532)

Estimado Ing. Caballero:

Según solicitado, estamos sometiendo nuestras recomendaciones para incrementar la estabilidad del pedraplén ("jetty") del proyecto de referencia bajo condiciones sísmicas a corto plazo.

Para esta evaluación se llevó a cabo dos barrenos profundos y los mismos confirmaron la presencia de los suelos orgánicos comprimibles detectados previamente en el área del dique. El espesor y las propiedades índices de estos suelos son prácticamente las mismas que las obtenidas anteriormente. Es por ello que estimamos que el comportamiento y las conclusiones previamente determinadas para el pedraplén sobre su estabilidad bajo condiciones sísmicas son aún válidos. Estamos incluyendo los registros ("boring logs") de los barrenos adicionales.

Para incrementar la estabilidad del pedraplén bajo condiciones sísmicas a corto plazo será necesario instalar una base de gaviones debajo del pedraplén. La base de gaviones deberá extenderse además aproximadamente 6 pies a cada lado de los límites de la base del pedraplén. Se seleccionó la solución a base de gaviones por la facilidad de construcción de los mismos y la presencia de agua. De hecho, se deberá consultar al diseñador del proyecto (QDSA) sobre la posibilidad de que esta base de gaviones forme parte del pedraplén. La malla y la piedra de los gaviones deberán cumplir con las especificaciones para gaviones del proyecto.

Si el espesor de la base de gaviones es de 4 pies, el Factor de Seguridad (FS) para una condición sísmica a corto plazo (de varios meses) será cercano a uno y la estabilidad del pedraplén será marginal. Si el espesor de la base de gaviones es de 6 pies, el FS aumentará a un valor aproximado de 1.1 y la estabilidad del pedraplén tendrá un cierto margen de seguridad contra una falla a corto plazo. Para lograr un FS mayor se requeriría un espesor mayor que resultaría demasiado costoso para el proyecto. Se debe tomar en cuenta que el FS irá aumentando conforme el suelo comprimible se va consolidando hasta alcanzar el valor aproximado de 1.2 para una base de gaviones de 4 pies de espesor y 1.26 para una base de gaviones de 6 pies de espesor para una consolidación avanzada que debe ocurrir en un período de varios años. Estos valores de FS de 1.2 y 1.26 pueden considerarse aceptables tomando en cuenta las condiciones de asentamientos considerables que se desarrollarán debido al peso del pedraplén.

4' ó 6'

Se deberá informar al Ing. Sánchez de QDSA sobre esta solución para que pueda hacer un estimado de costo para las dos alternativas de espesor de la base de gaviones antes de proceder con planos de construcción. La selección de la base de gaviones dependerá del riesgo que el Departamento (DRNA) decida asumir versus el costo de las solución.

En caso de tener cualquier pregunta al respecto, favor de comunicarse con nosotros.

Cordialmente,

Geo ENGINEERING

Carlos E. Rodríguez Pérez, Ph.D., P.E.
Ingeniero Geotécnico Consultor

Anejos

Geo ENGINEERING

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Fax (787) 706-0183

Geo-ENGINEERING **LOG OF BORING NO.** 1

Project: Canalization of the Guayanilla River Area of Jetty **Sheet No.** 1 of 2 **Date:** 22/11/04 23/11/04

Site Location: Guayanilla, Puerto Rico **Boring End At:** 80'

Ground Surf. Elev.: **Water Depth: During Drilling** 2' **When finishing the boring:**

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
2'	10	Fill - Recovered as brown clay with tiny roots and traces of fine sand	3-3-3-4	6		20				
4'	18	Grayish brown medium to coarse sand, slightly organic with few pebbles	5-8-8-7	16		23				
6'	24	(Gray with lumps of clayey silt/silty clay)	4-3-3-2	6		18				
8'	24	Gray organic fine silty sand with some pebbles	5-4-3-3	7		22				
10'	24		3-2-1-3	3		18			SM	16
15'	24	Gray and brown sandy silty clay/clayey silt, organic	2-1-1-2	2		43				
20'	24	(Gray, more sandy)	2-2-2-3	4		36			SM	14
25'	24	Gray silty clay/clayey silt with shell and coral fragments, organic	1-Push	Push		69	51	20	OH	
30'	12		2-2-3-2	5		41				
35'	24	Coral fragments mixed with gray clayey silt/silty clay, organic	24-17-12-10	29		43				
40'	8		6-3-6-3	9		58				

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.** 1	
Project:	Canalization of the Guayanilla River Area of Jetty	**Sheet No.** 2 of 2	**Date:** 22/11/04 23/11/04
Site Location:	Guayanilla, Puerto Rico	**Boring End At:** 80'	
Ground Surf.		**Water Depth:**	**When finishing**
Elev.:		**During Drilling** 20'	**the boring:**

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
45'	20	(some clayey silt/silty clay)	9-8-4-4	12		47				
50'	24	Gray silty clay/clayey silt with few coral fragments	2-1-1-2	2		46	46	21	OL	
55'	24	(soft and wet)	2-2-2-2	4		51				
60'	12	Grayish brown silty clay/clayey silt, brown mottled (Old Alluvial)	3-4-9-12	13		33				
65'	22	(Tannish brown)	8-13-18-24	31	[2.25]	37				
70'	24	(Tannish brown)	11-14-16-21	30	[2.5]	35				
75'	24	(Tannish brown)	8-13-17-23	30	2.6	32	50	19	OH	
80'	10	(with few pebbles and medium to fine sand)	48-50/5"	50/5"		12				

End of Boring

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength {qu} = obtained w/hand penetrometer

Geo-ENGINEERING **LOG OF BORING NO.** 2

Project: Canalization of the Guayanilla River Area of Jetty **Sheet No.** 1 of 2 **Date:** 23/11/04 24/11/04

Site Location: Guayanilla, Puerto Rico **Boring End At:** 50'

Ground Surf. Elev.: **Water Depth: During Drilling** 2' **When finishing the boring:**

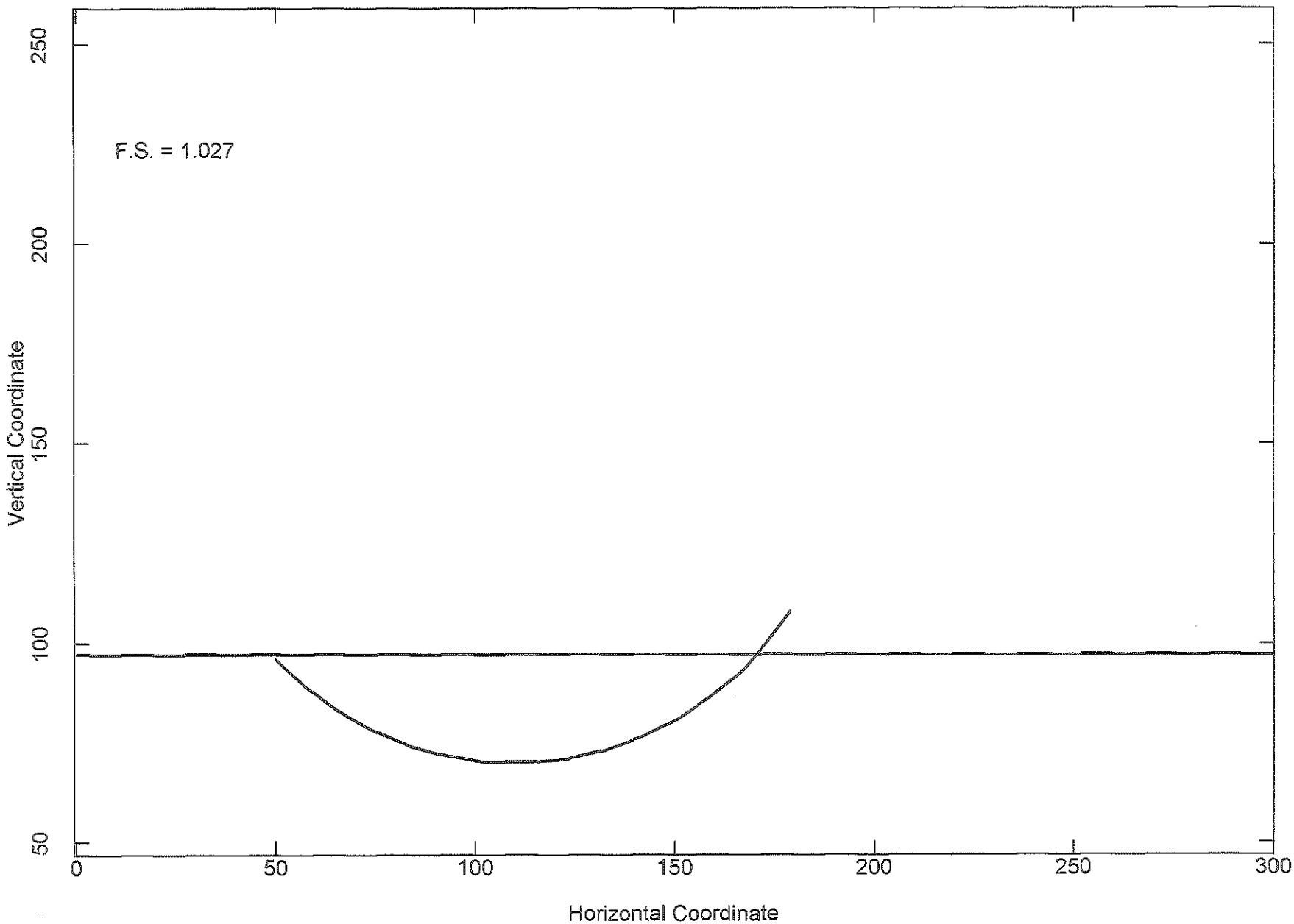
Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
2'	12	Fill - recovered as brown clay with tiny roots and traces of fine sand	3-5-3-2	8		17				
4'	13	Grayish brown medium to coarse sand, slightly organic with tiny roots and few pebbles	4-5-3-4	8		23				
6'	14	Gray medium to coarse sand with some clayey silt/ silty clay, decayed wood and traces of shell fragments, organic	3-2-4-2	6		45				
8'	22		1-1-2-1	3		27			SP	5
10'	24	(more sandy and traces of pebbles)	2-2-2-2	4		17				
15'	24	Gray and brown silty clay/clayey silt, organic	1-1-1-2	2		27				
20'	24	(Gray)	2-1-1-1	2		39	36	21	OL	
25'	24	(Gray)	1-2-2-1	4		42				
30'	24	Gray silty clay/clayey silt with shell fragments, organic	1-1-2-2	3		46	40	21	OL	
35'	20		1-1-1-1	2		39				
40'	24		2-1-1-1	2		52	48	20	OL	

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer

Geo-ENGINEERING		**LOG OF BORING NO.** 2	
Project:	Canalization of the Guayanilla River Area of Jetty	**Sheet No.** 2 of 2	**Date:** 23/11/04 24/11/04
Site Location:	Guayanilla, Puerto Rico	**Boring End At:** 50'	
Ground Surf.		**Water Depth:**	**When finishing**
Elev.:		**During Drilling** 2'	**the boring:**

Depth ft	Rec	Description of Material	Blows/6"	N bpf	qu tsf	W (%)	LL (%)	PL (%)	USCS	Finer (%)
45'	22	Coral and shell fragments mixed with gray silty clay/clayey silt, organic	2-3-8-9	11		50				
50'	8	(mainly coral)	31-16-8-4	24		38				
		End of Boring								
55'										
60'										
65'										
70'										
75'										
80'										

X = sample Rec. = Recovery (in.) qu = unconfined compressive strength [qu] = obtained w/hand penetrometer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Vertical Coordinate
Horizontal Coordinate
250
200
150
100
50
0
50
100
150
200
250
300

Dique-Guayanilla-Jetty-Dredging-Mat (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date: 02/11/2005
Time of Run: 11:10:54 AM
Run By:
Input Data Filename: ENS62.tmp
Output Filename: ENS63.tmp
Plotted Output Filename: ENS64.tmp

PROBLEM DESCRIPTION Dike - Guayanilla -Jetty-Seismic-Compact
ed Mat-Bor 1

BOUNDARY COORDINATES

6 Top Boundaries
10 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	96.00	85.00	96.00	2
2	85.00	96.00	100.00	100.00	2
3	100.00	100.00	141.00	121.00	1
4	141.00	121.00	154.00	121.00	1
5	154.00	121.00	194.00	100.00	1
6	194.00	100.00	300.00	100.00	2
7	100.00	100.00	194.00	100.00	4
8	85.00	96.00	193.00	96.00	2
9	193.00	96.00	194.00	100.00	2
10	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	100.0	100.0	.0	60.0	.00	.0	1
2	110.0	110.0	725.0	.0	.00	.0	1
3	120.0	120.0	2000.0	.0	.00	.0	1

Dique-Guayanilla-Jetty-Dredging-Mat (StablPro Output Report)
4 106.0 106.0 3000.0 40.0 .00 .0 1
1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

A Horizontal Earthquake Loading Coefficient
Of .200 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .000 Has Been Assigned

Cavitation Pressure = .0 F/L^2
1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 141.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

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

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

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.24	89.10
3	65.27	83.14
4	73.97	78.21
5	83.20	74.37
6	92.84	71.70
7	102.73	70.22
8	112.73	69.97
9	122.68	70.94
10	132.44	73.12
11	141.86	76.48
12	150.79	80.97
13	159.11	86.52
14	166.69	93.04
15	173.42	100.44
16	178.76	108.00

*** 1.027 ***

Individual data on the 22 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	7.2	2746.8	451.7	2776.4	.0	.0	549.4	.0	.0
2	8.0	8725.3	501.0	6788.7	.0	.0	1745.1	.0	.0
3	8.7	14664.5	542.8	10188.0	.0	.0	2932.9	.0	.0
4	9.2	20025.6	576.3	12923.2	.0	.0	4005.1	.0	.0
5	1.8	4323.8	112.1	2661.8	.0	.0	864.8	.0	.0
6	7.8	20917.6	.0	12291.4	.0	.0	4183.5	.0	.0
7	7.2	21960.8	.0	11671.5	.0	.0	4392.2	.0	.0
8	2.7	9026.6	.0	4576.1	.0	.0	1805.3	.0	.0
9	10.0	36678.6	.0	16786.8	.0	.0	7335.7	.0	.0
10	10.0	41208.6	.0	16562.8	.0	.0	8241.7	.0	.0
11	9.8	43640.7	.0	15578.9	.0	.0	8728.1	.0	.0
12	8.6	39838.1	.0	12676.4	.0	.0	7967.6	.0	.0
13	.9	4017.2	.0	1173.5	.0	.0	803.4	.0	.0
14	8.9	39536.3	.0	11401.8	.0	.0	7907.3	.0	.0
15	3.2	13015.5	.0	3596.9	.0	.0	2603.1	.0	.0

16	5.1	18516.8	.0	4674.5	.0	.0	3703.4	.0	.0
17	7.6	20774.1	.0	4505.7	.0	.0	4154.8	.0	.0
18	2.7	5242.0	.0	618.6	.0	.0	1048.4	.0	.0
19	.9	1489.6	.0	42.2	.0	.0	297.9	.0	.0
20	2.7	3631.0	.0	.0	.0	.0	726.2	.0	.0
21	.4	429.4	.0	.0	.0	.0	85.9	.0	.0
22	5.3	2766.3	.0	.0	.0	.0	553.3	.0	.0

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.18	88.93
3	76.17	82.92
4	84.93	78.08
5	94.27	74.51
6	104.02	72.29
7	113.98	71.45
8	123.97	72.01
9	133.77	73.96
10	143.21	77.26
11	152.10	81.85
12	160.25	87.64
13	167.52	94.50
14	173.76	102.32
15	177.50	108.66

*** 1.037 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.11	88.96
3	65.10	82.96
4	73.84	78.10
5	83.16	74.47
6	92.88	72.13
7	102.83	71.15
8	112.83	71.52
9	122.68	73.25
10	132.20	76.30
11	141.22	80.62
12	149.57	86.13
13	157.09	92.71
14	163.65	100.26
15	169.12	108.63
16	170.80	112.18

*** 1.038 ***

Dique-Guayanilla-Jetty-Dredging-Mat (StablPro Output Report)
Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	55.56	96.00
2	62.71	89.01
3	70.77	83.10
4	79.59	78.37
5	88.98	74.93
6	98.76	72.84
7	108.73	72.15
8	118.71	72.86
9	128.48	74.96
10	137.87	78.41
11	146.68	83.14
12	154.73	89.07
13	161.88	96.06
14	167.97	103.99
15	172.19	111.45

*** 1.039 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.35	89.22
3	65.45	83.35
4	74.19	78.50
5	83.45	74.72
6	93.09	72.08
7	102.98	70.60
8	112.98	70.31
9	122.94	71.21
10	132.72	73.30
11	142.18	76.53
12	151.19	80.87
13	159.62	86.26
14	167.35	92.60
15	174.26	99.83
16	179.93	107.39

*** 1.040 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00

2	57.36	89.23
3	65.50	83.42
4	74.29	78.65
5	83.60	74.99
6	93.28	72.51
7	103.20	71.23
8	113.20	71.17
9	123.13	72.35
10	132.84	74.73
11	142.19	78.28
12	151.03	82.96
13	159.23	88.68
14	166.67	95.37
15	173.23	102.92
16	177.20	108.82

*** 1.040 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.29	89.15
3	65.39	83.29
4	74.19	78.53
5	83.52	74.95
6	93.24	72.59
7	103.18	71.51
8	113.18	71.72
9	123.07	73.22
10	132.68	75.98
11	141.85	79.95
12	150.44	85.08
13	158.30	91.27
14	165.29	98.42
15	171.30	106.41
16	173.71	110.65

*** 1.045 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.24	88.99
3	76.26	83.02
4	85.02	78.19
5	94.35	74.59
6	104.09	72.30
7	114.04	71.35

8	124.03	71.77
9	133.88	73.53
10	143.39	76.62
11	152.39	80.97
12	160.72	86.51
13	168.22	93.12
14	174.75	100.70
15	179.30	107.72

*** 1.046 ***

1

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	66.67	96.00
2	73.76	88.96
3	81.87	83.09
4	90.78	78.55
5	100.28	75.45
6	110.15	73.85
7	120.15	73.80
8	130.04	75.29
9	139.58	78.30
10	148.54	82.74
11	156.70	88.51
12	163.87	95.48
13	169.88	103.48
14	173.70	110.66

*** 1.051 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.33	89.19
3	65.47	83.40
4	74.30	78.70
5	83.67	75.19
6	93.41	72.93
7	103.36	71.94
8	113.36	72.26
9	123.22	73.87
10	132.80	76.74
11	141.93	80.83
12	150.44	86.07
13	158.21	92.37
14	165.09	99.63
15	170.98	107.71
16	172.83	111.11

Dique-Guayanilla-Jetty-Dredging-Mat (StablPro Output Report)

```
***     1.053   ***

1

                Y            A     X     I     S            F     T

                .00      37.50     75.00    112.50    150.00    187.50
X          .00 +---------+-*-------+-----*---+---------+---------+
                -
                -
                -
                -
                -
        37.50 +
                -
                -                         1
                -                       1 4
                -                     1 4.2
                -                     4.2.9
A       75.00 +                     12.9..
                -                   149....
                -                   42....*
                -                  129.....
                -                  19......*
                -                  2........
X      112.50 +                    19.......
                -                  49........
                -                  13........
                -                  12..........
                -                   .4......... ,
                -                   124.........*
I      150.00 +                     .13.........
                -                    .143......*
                -                     2.943.....
                -                       1..433.
                -                        .1.24
                -                          .1
S      187.50 +                         **
                -
                -
                -
                -
        225.00 +
                -
                -
                -
                -
F      262.50 +
                -
                -
                -
                -
T      300.00 +            *              W*
```

Dique-Guayanilla-Jetty-Dredging-Mat (StablPro Input Report)

```
PROFIL
Dike - Guayanilla -Jetty-Seismic-Compacted Mat-Bor 1
10 6
0. 96. 85. 96. 2
85. 96. 100. 100. 2
100. 100. 141. 121. 1
141. 121. 154. 121. 1
154. 121. 194. 100. 1
194. 100. 300. 100. 2
100. 100. 194. 100. 4
85. 96. 193. 96. 2
193. 96. 194. 100. 2
0. 45. 300. 45. 3
SOIL
4
100. 100. 0. 60. 0. 0. 1
110. 110. 725. 0. 0. 0. 1
120. 120. 2000. 0. 0. 0. 1
106. 106. 3000. 40. 0. 0. 1
WATER
1 2 62.4
2
0. 97.
300. 97.
EQUAKE
0.2 0. 0.
CIRCLE
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50. 100. 141. 180.
10. 10. 0. 0.
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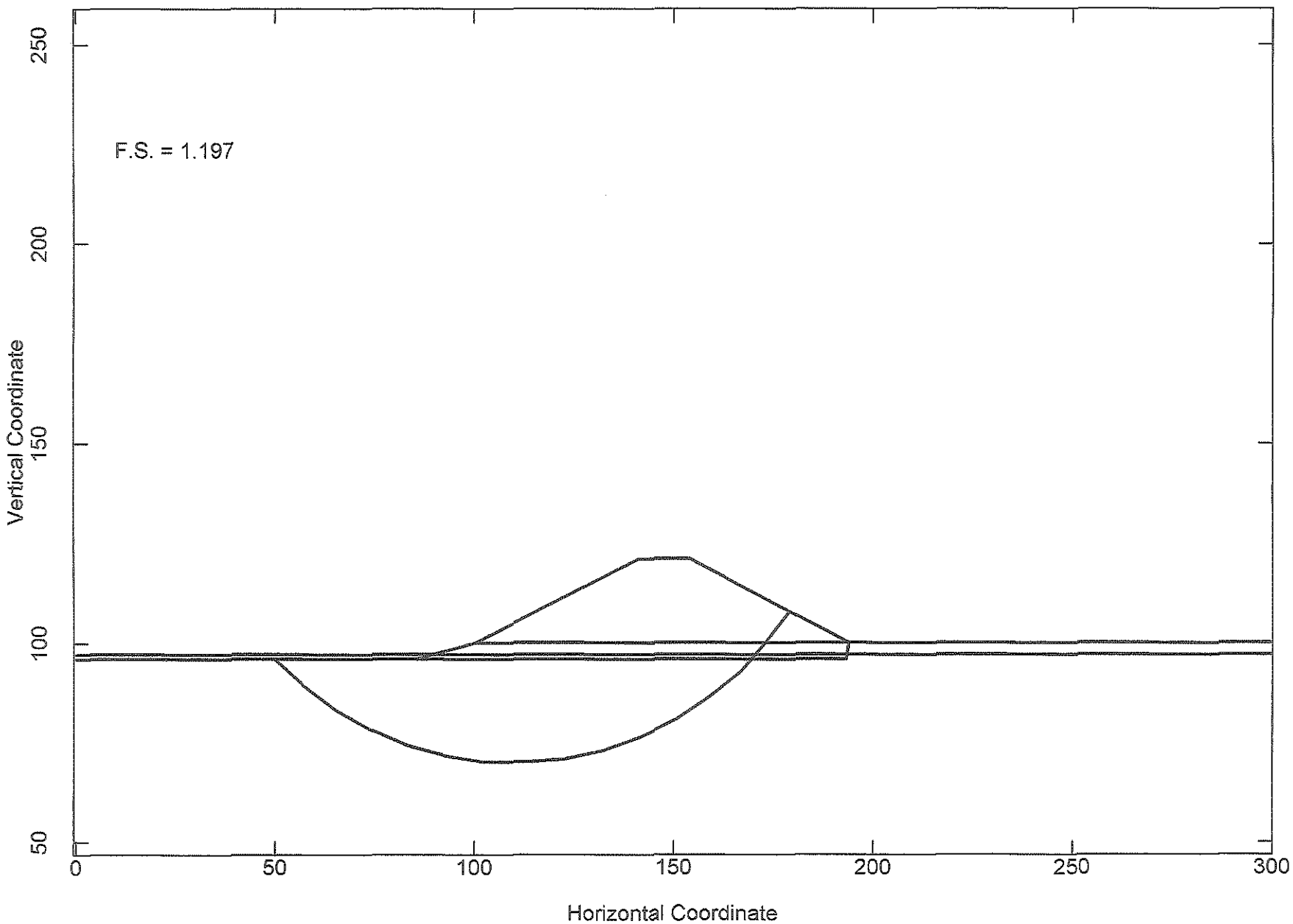
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100
50
0
50
100
150
200
250
300
Horizontal Coordinate

Dique-Guayanilla-Jetty-Dredging-Mat (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date: 02/11/2005
Time of Run: 10:57:18 AM
Run By:
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Output Filename: ENS40.tmp
Plotted Output Filename: ENS41.tmp

PROBLEM DESCRIPTION Dike - Guayanilla -Jetty-Seismic-Compact
ed Mat-Bor 1

BOUNDARY COORDINATES

6 Top Boundaries
10 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	96.00	85.00	96.00	2
2	85.00	96.00	100.00	100.00	2
3	100.00	100.00	141.00	121.00	1
4	141.00	121.00	154.00	121.00	1
5	154.00	121.00	194.00	100.00	1
6	194.00	100.00	300.00	100.00	2
7	100.00	100.00	194.00	100.00	4
8	85.00	96.00	193.00	96.00	2
9	193.00	96.00	194.00	100.00	2
10	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	100.0	100.0	.0	60.0	.00	.0	1
2	110.0	110.0	857.0	.0	.00	.0	1
3	120.0	120.0	2000.0	.0	.00	.0	1

Dique-Guayanilla-Jetty-Dredging-Mat (StablPro Output Report)
4 106.0 106.0 3000.0 40.0 .00 .0 1
1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

A Horizontal Earthquake Loading Coefficient
Of .200 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .000 Has Been Assigned

Cavitation Pressure = .0 F/L^2
1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 141.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

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

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

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.24	89.10
3	65.27	83.14
4	73.97	78.21
5	83.20	74.37
6	92.84	71.70
7	102.73	70.22
8	112.73	69.97
9	122.68	70.94
10	132.44	73.12
11	141.86	76.48
12	150.79	80.97
13	159.11	86.52
14	166.69	93.04
15	173.42	100.44
16	178.76	108.00

*** 1.197 ***

Individual data on the 22 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	7.2	2746.8	451.7	2776.4	.0	.0	549.4	.0	.0
2	8.0	8725.3	501.0	6788.7	.0	.0	1745.1	.0	.0
3	8.7	14664.5	542.8	10188.0	.0	.0	2932.9	.0	.0
4	9.2	20025.6	576.3	12923.2	.0	.0	4005.1	.0	.0
5	1.8	4323.8	112.1	2661.8	.0	.0	864.8	.0	.0
6	7.8	20917.6	.0	12291.4	.0	.0	4183.5	.0	.0
7	7.2	21960.8	.0	11671.5	.0	.0	4392.2	.0	.0
8	2.7	9026.6	.0	4576.1	.0	.0	1805.3	.0	.0
9	10.0	36678.6	.0	16786.8	.0	.0	7335.7	.0	.0
10	10.0	41208.6	.0	16562.8	.0	.0	8241.7	.0	.0
11	9.8	43640.7	.0	15578.9	.0	.0	8728.1	.0	.0
12	8.6	39838.1	.0	12676.4	.0	.0	7967.6	.0	.0
13	.9	4017.2	.0	1173.5	.0	.0	803.4	.0	.0
14	8.9	39536.3	.0	11401.8	.0	.0	7907.3	.0	.0
15	3.2	13015.5	.0	3596.9	.0	.0	2603.1	.0	.0

16	5.1	18516.8	.0	4674.5	.0	.0	3703.4	.0	.0
17	7.6	20774.1	.0	4505.7	.0	.0	4154.8	.0	.0
18	2.7	5242.0	.0	618.6	.0	.0	1048.4	.0	.0
19	.9	1489.6	.0	42.2	.0	.0	297.9	.0	.0
20	2.7	3631.0	.0	.0	.0	.0	726.2	.0	.0
21	.4	429.4	.0	.0	.0	.0	85.9	.0	.0
22	5.3	2766.3	.0	.0	.0	.0	553.3	.0	.0

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.11	88.96
3	65.10	82.96
4	73.84	78.10
5	83.16	74.47
6	92.88	72.13
7	102.83	71.15
8	112.83	71.52
9	122.68	73.25
10	132.20	76.30
11	141.22	80.62
12	149.57	86.13
13	157.09	92.71
14	163.65	100.26
15	169.12	108.63
16	170.80	112.18

*** 1.207 ***

1

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.18	88.93
3	76.17	82.92
4	84.93	78.08
5	94.27	74.51
6	104.02	72.29
7	113.98	71.45
8	123.97	72.01
9	133.77	73.96
10	143.21	77.26
11	152.10	81.85
12	160.25	87.64
13	167.52	94.50
14	173.76	102.32
15	177.50	108.66

*** 1.208 ***

Dique-Guayanilla-Jetty-Dredging-Mat (StablPro Output Report)
Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	55.56	96.00
2	62.71	89.01
3	70.77	83.10
4	79.59	78.37
5	88.98	74.93
6	98.76	72.84
7	108.73	72.15
8	118.71	72.86
9	128.48	74.96
10	137.87	78.41
11	146.68	83.14
12	154.73	89.07
13	161.88	96.06
14	167.97	103.99
15	172.19	111.45

*** 1.209 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.36	89.23
3	65.50	83.42
4	74.29	78.65
5	83.60	74.99
6	93.28	72.51
7	103.20	71.23
8	113.20	71.17
9	123.13	72.35
10	132.84	74.73
11	142.19	78.28
12	151.03	82.96
13	159.23	88.68
14	166.67	95.37
15	173.23	102.92
16	177.20	108.82

*** 1.211 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00

2	57.35	89.22
3	65.45	83.35
4	74.19	78.50
5	83.45	74.72
6	93.09	72.08
7	102.98	70.60
8	112.98	70.31
9	122.94	71.21
10	132.72	73.30
11	142.18	76.53
12	151.19	80.87
13	159.62	86.26
14	167.35	92.60
15	174.26	99.83
16	179.93	107.39

*** 1.212 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.29	89.15
3	65.39	83.29
4	74.19	78.53
5	83.52	74.95
6	93.24	72.59
7	103.18	71.51
8	113.18	71.72
9	123.07	73.22
10	132.68	75.98
11	141.85	79.95
12	150.44	85.08
13	158.30	91.27
14	165.29	98.42
15	171.30	106.41
16	173.71	110.65

*** 1.214 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.24	88.99
3	76.26	83.02
4	85.02	78.19
5	94.35	74.59
6	104.09	72.30
7	114.04	71.35

8	124.03	71.77
9	133.88	73.53
10	143.39	76.62
11	152.39	80.97
12	160.72	86.51
13	168.22	93.12
14	174.75	100.70
15	179.30	107.72

*** 1.219 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.33	89.19
3	65.47	83.40
4	74.30	78.70
5	83.67	75.19
6	93.41	72.93
7	103.36	71.94
8	113.36	72.26
9	123.22	73.87
10	132.80	76.74
11	141.93	80.83
12	150.44	86.07
13	158.21	92.37
14	165.09	99.63
15	170.98	107.71
16	172.83	111.11

*** 1.223 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	66.67	96.00
2	73.76	88.96
3	81.87	83.09
4	90.78	78.55
5	100.28	75.45
6	110.15	73.85
7	120.15	73.80
8	130.04	75.29
9	139.58	78.30
10	148.54	82.74
11	156.70	88.51
12	163.87	95.48
13	169.88	103.48
14	173.70	110.66

Dique-Guayanilla-Jetty-Dredging-Mat (StablPro Output Report)

*** 1.223 ***

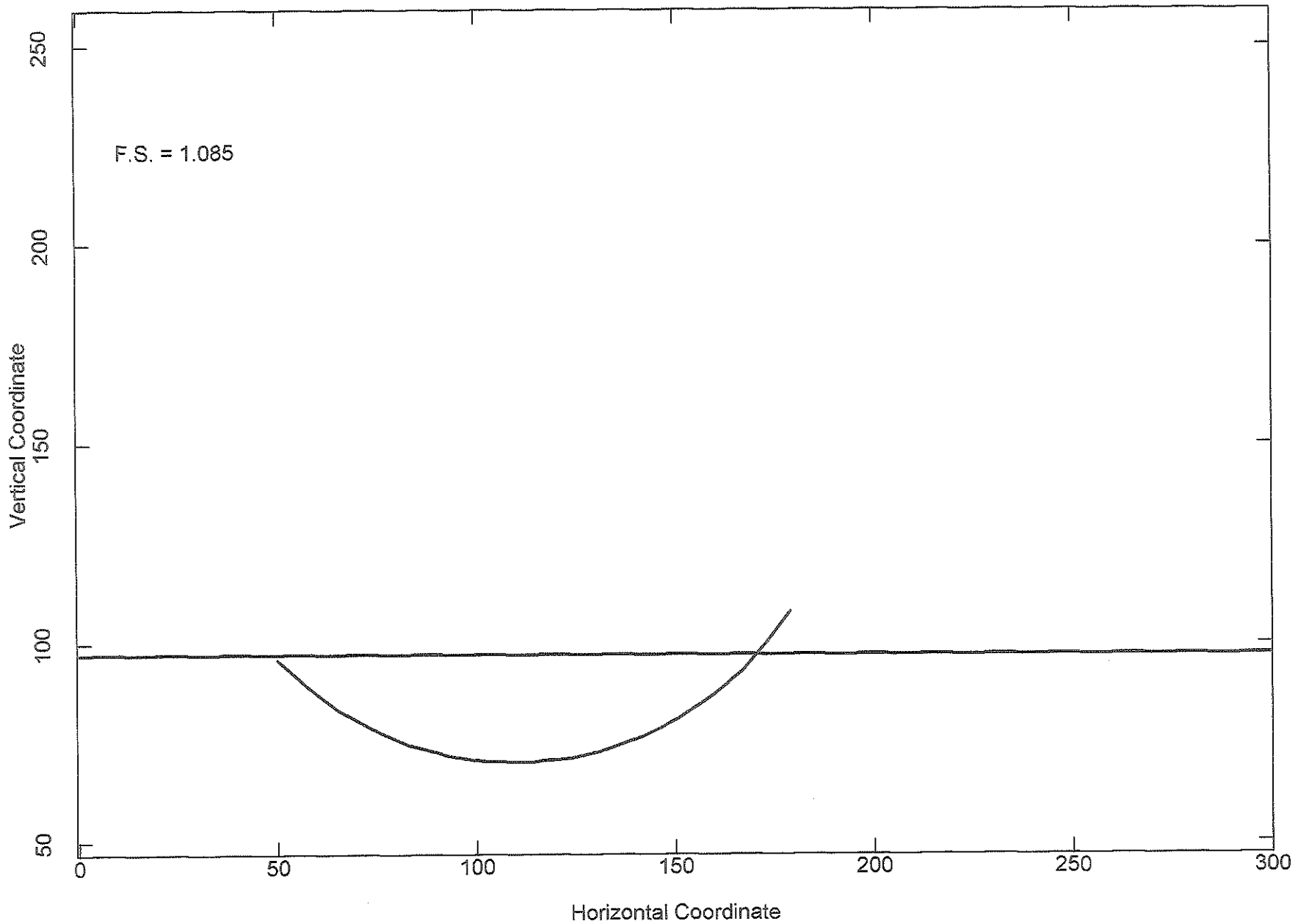
1

```
                Y            A     X     I     S            F     T

                .00      37.50     75.00    112.50    150.00    187.50
X          .00 +---------+-*-------+-----*---+---------+---------+
                -
                -
                -
                -
                -
        37.50 +
                -
                -                          1
                -                        1 4
                -                      1 4.3
                -                      4.3.0
A       75.00 +                      13.0..
                -                    140....
                -                    43....*
                -                   130.....
                -                   10......*
                -                   3........
X      112.50 +                     10.......
                -                   40........
                -                   12........
                -                   12..........
                -                    .4.........  .
                -                    124.........*
I      150.00 +                       .12........
                -                      .142......*
                -                       3.042.....
                -                         1..422.
                -                          .1.34
                -                            .1
S      187.50 +                           **
                -
                -
                -
                -
                -
        225.00 +
                -
                -
                -
                -
                -
F      262.50 +
                -
                -
                -
                -
                -
T      300.00 +            *              W*
```

Dique-Guayanilla-Jetty-Dredging-Mat (StablPro Input Report)

```
PROFIL
Dike - Guayanilla -Jetty-Seismic-Compacted Mat-Bor 1
10 6
0. 96. 85. 96. 2
85. 96. 100. 100. 2
100. 100. 141. 121. 1
141. 121. 154. 121. 1
154. 121. 194. 100. 1
194. 100. 300. 100. 2
100. 100. 194. 100. 4
85. 96. 193. 96. 2
193. 96. 194. 100. 2
0. 45. 300. 45. 3
SOIL
4
100. 100. 0. 60. 0. 0. 1
110. 110. 857. 0. 0. 0. 1
120. 120. 2000. 0. 0. 0. 1
106. 106. 3000. 40. 0. 0. 1
WATER
1 2 62.4
2
0. 97.
300. 97.
EQUAKE
0.2 0. 0.
CIRCLE
1 2
10 20
50. 100. 141. 180.
10. 10. 0. 0.
```


F.S. = 1.085
Vertical Coordinate
250
200
150
100
50
0
50
100
150
200
250
300
Horizontal Coordinate

Dique-Guayanilla-Jetty-Dredging-6ft-Mat (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date: 02/11/2005
Time of Run: 11:39:56 AM
Run By:
Input Data Filename: ENS69.tmp
Output Filename: ENS6A.tmp
Plotted Output Filename: ENS6B.tmp

PROBLEM DESCRIPTION Dike - Guayanilla -Jetty-Seismic-Compact
ed Mat-Bor 1

BOUNDARY COORDINATES

6 Top Boundaries
11 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	96.00	85.00	96.00	2
2	85.00	96.00	100.00	100.00	2
3	100.00	100.00	141.00	121.00	1
4	141.00	121.00	154.00	121.00	1
5	154.00	121.00	194.00	100.00	1
6	194.00	100.00	300.00	100.00	2
7	100.00	100.00	194.00	100.00	4
8	85.00	96.00	86.00	94.00	2
9	86.00	94.00	193.00	94.00	2
10	193.00	94.00	194.00	100.00	2
11	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	100.0	100.0	.0	60.0	.00	.0	1
2	110.0	110.0	725.0	.0	.00	.0	1

Dique-Guayanilla-Jetty-Dredging-6ft-Mat (StablPro Output Report)

3	120.0	120.0	2000.0	.0	.00	.0	1
4	106.0	106.0	3000.0	40.0	.00	.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

A Horizontal Earthquake Loading Coefficient
Of .200 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .000 Has Been Assigned

Cavitation Pressure = .0 F/L^2

1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 141.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

Dique-Guayanilla-Jetty-Dredging-6ft-Mat (StablPro Output Report)
10.00 ft. Line Segments Define Each Trial Failure Surface.

1

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

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

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.24	89.10
3	65.27	83.14
4	73.97	78.21
5	83.20	74.37
6	92.84	71.70
7	102.73	70.22
8	112.73	69.97
9	122.68	70.94
10	132.44	73.12
11	141.86	76.48
12	150.79	80.97
13	159.11	86.52
14	166.69	93.04
15	173.42	100.44
16	178.76	108.00

*** 1.085 ***

Individual data on the 23 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	7.2	2746.8	451.7	2776.4	.0	.0	549.4	.0	.0
2	8.0	8725.3	501.0	6788.7	.0	.0	1745.1	.0	.0
3	8.7	14664.5	542.8	10188.0	.0	.0	2932.9	.0	.0
4	9.2	20025.6	576.3	12923.2	.0	.0	4005.1	.0	.0
5	1.8	4323.8	112.1	2661.8	.0	.0	864.8	.0	.0
6	1.0	2463.7	56.0	1506.5	.0	.0	492.7	.0	.0
7	6.8	18453.9	.0	10784.9	.0	.0	3690.8	.0	.0
8	7.2	21960.8	.0	11671.5	.0	.0	4392.2	.0	.0
9	2.7	9004.8	.0	4576.1	.0	.0	1801.0	.0	.0
10	10.0	36598.6	.0	16786.8	.0	.0	7319.7	.0	.0
11	10.0	41129.0	.0	16562.8	.0	.0	8225.8	.0	.0
12	9.8	43562.6	.0	15578.9	.0	.0	8712.5	.0	.0
13	8.6	39769.6	.0	12676.4	.0	.0	7953.9	.0	.0
14	.9	4010.3	.0	1173.5	.0	.0	802.1	.0	.0

15	8.9	39464.8	.0	11401.8	.0	.0	7893.0	.0	.0
16	3.2	12989.8	.0	3596.9	.0	.0	2598.0	.0	.0
17	5.1	18475.8	.0	4674.5	.0	.0	3695.2	.0	.0
18	7.6	20713.5	.0	4505.7	.0	.0	4142.7	.0	.0
19	.9	1829.6	.0	281.4	.0	.0	365.9	.0	.0
20	2.7	4887.8	.0	379.4	.0	.0	977.6	.0	.0
21	2.7	3631.0	.0	.0	.0	.0	726.2	.0	.0
22	.4	429.4	.0	.0	.0	.0	85.9	.0	.0
23	5.3	2766.3	.0	.0	.0	.0	553.3	.0	.0

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.18	88.93
3	76.17	82.92
4	84.93	78.08
5	94.27	74.51
6	104.02	72.29
7	113.98	71.45
8	123.97	72.01
9	133.77	73.96
10	143.21	77.26
11	152.10	81.85
12	160.25	87.64
13	167.52	94.50
14	173.76	102.32
15	177.50	108.66

*** 1.098 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.35	89.22
3	65.45	83.35
4	74.19	78.50
5	83.45	74.72
6	93.09	72.08
7	102.98	70.60
8	112.98	70.31
9	122.94	71.21
10	132.72	73.30
11	142.18	76.53
12	151.19	80.87
13	159.62	86.26
14	167.35	92.60
15	174.26	99.83
16	179.93	107.39

*** 1.100 ***

Dique-Guayanilla-Jetty-Dredging-6ft-Mat (StablPro Output Report)

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.11	88.96
3	65.10	82.96
4	73.84	78.10
5	83.16	74.47
6	92.88	72.13
7	102.83	71.15
8	112.83	71.52
9	122.68	73.25
10	132.20	76.30
11	141.22	80.62
12	149.57	86.13
13	157.09	92.71
14	163.65	100.26
15	169.12	108.63
16	170.80	112.18

*** 1.106 ***

1

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.24	88.99
3	76.26	83.02
4	85.02	78.19
5	94.35	74.59
6	104.09	72.30
7	114.04	71.35
8	124.03	71.77
9	133.88	73.53
10	143.39	76.62
11	152.39	80.97
12	160.72	86.51
13	168.22	93.12
14	174.75	100.70
15	179.30	107.72

*** 1.107 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)

1	50.00	96.00
2	57.36	89.23
3	65.50	83.42
4	74.29	78.65
5	83.60	74.99
6	93.28	72.51
7	103.20	71.23
8	113.20	71.17
9	123.13	72.35
10	132.84	74.73
11	142.19	78.28
12	151.03	82.96
13	159.23	88.68
14	166.67	95.37
15	173.23	102.92
16	177.20	108.82

*** 1.107 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.29	89.15
3	65.39	83.29
4	74.19	78.53
5	83.52	74.95
6	93.24	72.59
7	103.18	71.51
8	113.18	71.72
9	123.07	73.22
10	132.68	75.98
11	141.85	79.95
12	150.44	85.08
13	158.30	91.27
14	165.29	98.42
15	171.30	106.41
16	173.71	110.65

*** 1.114 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	55.56	96.00
2	62.71	89.01
3	70.77	83.10
4	79.59	78.37
5	88.98	74.93

6	98.76	72.84
7	108.73	72.15
8	118.71	72.86
9	128.48	74.96
10	137.87	78.41
11	146.68	83.14
12	154.73	89.07
13	161.88	96.06
14	167.97	103.99
15	172.19	111.45

*** 1.115 ***

1

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.34	89.09
3	76.44	83.23
4	85.26	78.50
5	94.63	75.01
6	104.38	72.81
7	114.35	71.95
8	124.33	72.44
9	134.16	74.27
10	143.66	77.40
11	152.65	81.79
12	160.96	87.35
13	168.45	93.97
14	174.98	101.55
15	179.06	107.84

*** 1.116 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.33	89.19
3	65.47	83.40
4	74.30	78.70
5	83.67	75.19
6	93.41	72.93
7	103.36	71.94
8	113.36	72.26
9	123.22	73.87
10	132.80	76.74
11	141.93	80.83
12	150.44	86.07
13	158.21	92.37

14	165.09	99.63
15	170.98	107.71
16	172.83	111.11

*** 1.124 ***

1

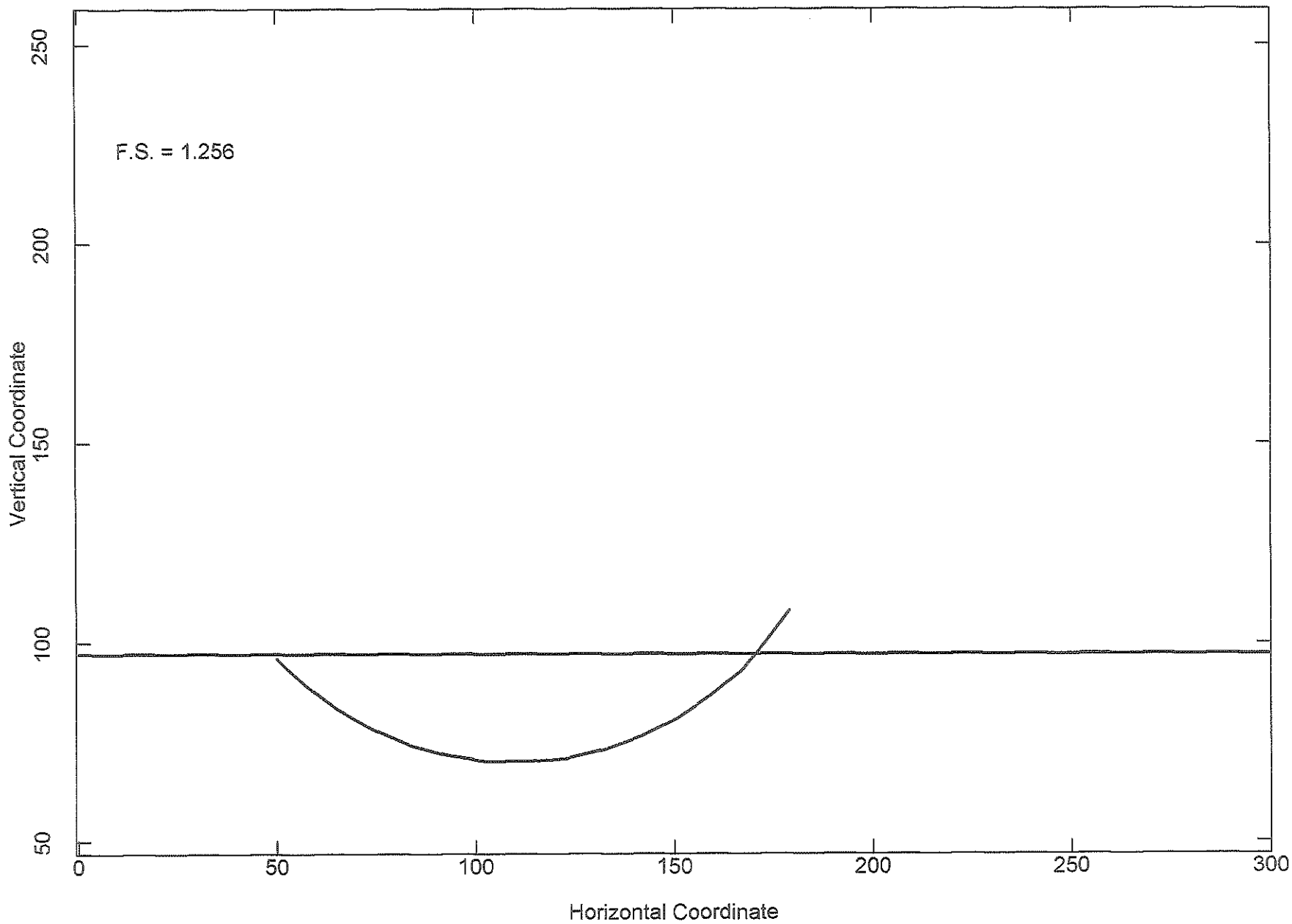
```
                Y            A     X     I     S            F     T

                .00      37.50     75.00    112.50    150.00    187.50
X          .00 +---------+-*-------+-----*---+---------+---------+
               -
               -
               -
               -
               -
         37.50 +
               -
               -                          1
               -                        1 8
               -                      1 8.2
               -                      8.2..
A        75.00 +                     12....
               -                    18.....
               -                    82...**
               -                   12......
               -                   1.......*
               -                   2........
X       112.50 +                   1........
               -                   8.........
               -                   14........
               -                   12..........
               -                    .8......... .
               -                    128.........*
I       150.00 +                     .14........
               -                     .164......*
               -                      2..74.....
               -                        1..744.
               -                         .1.27
               -                           .1
S       187.50 +
               -                        * *
               -
               -
               -
               -
         225.00 +
               -
               -
               -
               -
               -
F       262.50 +
               -
               -
               -
               -
```

```
T     300.00 +            *              W*
```

Dique-Guayanilla-Jetty-Dredging-6ft-Mat (StablPro Input Report)

```
PROFIL
Dike - Guayanilla -Jetty-Seismic-Compacted Mat-Bor 1
11 6
0. 96. 85. 96. 2
85. 96. 100. 100. 2
100. 100. 141. 121. 1
141. 121. 154. 121. 1
154. 121. 194. 100. 1
194. 100. 300. 100. 2
100. 100. 194. 100. 4
85. 96. 86. 94. 2
86. 94. 193. 94. 2
193. 94. 194. 100. 2
0. 45. 300. 45. 3
SOIL
4
100. 100. 0. 60. 0. 0. 1
110. 110. 725. 0. 0. 0. 1
120. 120. 2000. 0. 0. 0. 1
106. 106. 3000. 40. 0. 0. 1
WATER
1 2 62.4
2
0. 97.
300. 97.
EQUAKE
0.2 0. 0.
CIRCLE
1 2
10 20
50. 100. 141. 180.
10. 10. 0. 0.
```


F.S. = 1.256
Vertical Coordinate
Horizontal Coordinate
0
50
100
150
200
250
300
50
100
150
200
250

Dique-Guayanilla-Jetty-Dredging-6ft-Mat (StablPro Output Report)
** PCSTABL4M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method
(Consistent Units, F=Force, L=Length)

Run Date: 02/11/2005
Time of Run: 11:44:30 AM
Run By:
Input Data Filename: ENS70.tmp
Output Filename: ENS71.tmp
Plotted Output Filename: ENS72.tmp

PROBLEM DESCRIPTION Dike - Guayanilla -Jetty-Seismic-Compact
ed Mat-Bor 1

BOUNDARY COORDINATES

6 Top Boundaries
11 Total Boundaries

Boundary No.	X-Left (L)	Y-Left (L)	X-Right (L)	Y-Right (L)	Soil Type Below Bnd
1	.00	96.00	85.00	96.00	2
2	85.00	96.00	100.00	100.00	2
3	100.00	100.00	141.00	121.00	1
4	141.00	121.00	154.00	121.00	1
5	154.00	121.00	194.00	100.00	1
6	194.00	100.00	300.00	100.00	2
7	100.00	100.00	194.00	100.00	4
8	85.00	96.00	86.00	94.00	2
9	86.00	94.00	193.00	94.00	2
10	193.00	94.00	194.00	100.00	2
11	.00	45.00	300.00	45.00	3

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. F/L^3	Saturated Unit Wt. F/L^3	Cohesion Intercept F/L^2	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant F/L^2	Piez. Surface No.
1	100.0	100.0	.0	60.0	.00	.0	1
2	110.0	110.0	857.0	.0	.00	.0	1

Dique-Guayanilla-Jetty-Dredging-6ft-Mat (StablPro Output Report)

3	120.0	120.0	2000.0	.0	.00	.0	1
4	106.0	106.0	3000.0	40.0	.00	.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

THE POREPRESSURE MODEL CHOSEN IS:

Perpendicular

Unit Weight of Water = 62.40 F/L^3

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (L)	Y-Water (L)
1	.00	97.00
2	300.00	97.00

A Horizontal Earthquake Loading Coefficient
Of .200 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .000 Has Been Assigned

Cavitation Pressure = .0 F/L^2

1

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

Janbu s Empirical Coef. is being used for
both cohesion and shear angle greater than 0
200 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.00 L
and X = 100.00 L

Each Surface Terminates Between X = 141.00 L
and X = 180.00 L

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 10.00 L

Dique-Guayanilla-Jetty-Dredging-6ft-Mat (StablPro Output Report)
10.00 ft. Line Segments Define Each Trial Failure Surface.

1

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

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

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.24	89.10
3	65.27	83.14
4	73.97	78.21
5	83.20	74.37
6	92.84	71.70
7	102.73	70.22
8	112.73	69.97
9	122.68	70.94
10	132.44	73.12
11	141.86	76.48
12	150.79	80.97
13	159.11	86.52
14	166.69	93.04
15	173.42	100.44
16	178.76	108.00

*** 1.256 ***

Individual data on the 23 slices

Slice No.	Width (L)	Weight (F)	Water Force Top (F)	Water Force Bot (F)	Tie Force Norm (F)	Tie Force Tan (F)	Earthquake Force Hor (F)	Earthquake Force Ver (F)	Surcharge Load (F)
1	7.2	2746.8	451.7	2776.4	.0	.0	549.4	.0	.0
2	8.0	8725.3	501.0	6788.7	.0	.0	1745.1	.0	.0
3	8.7	14664.5	542.8	10188.0	.0	.0	2932.9	.0	.0
4	9.2	20025.6	576.3	12923.2	.0	.0	4005.1	.0	.0
5	1.8	4323.8	112.1	2661.8	.0	.0	864.8	.0	.0
6	1.0	2463.7	56.0	1506.5	.0	.0	492.7	.0	.0
7	6.8	18453.9	.0	10784.9	.0	.0	3690.8	.0	.0
8	7.2	21960.8	.0	11671.5	.0	.0	4392.2	.0	.0
9	2.7	9004.8	.0	4576.1	.0	.0	1801.0	.0	.0
10	10.0	36598.6	.0	16786.8	.0	.0	7319.7	.0	.0
11	10.0	41129.0	.0	16562.8	.0	.0	8225.8	.0	.0
12	9.8	43562.6	.0	15578.9	.0	.0	8712.5	.0	.0
13	8.6	39769.6	.0	12676.4	.0	.0	7953.9	.0	.0
14	.9	4010.3	.0	1173.5	.0	.0	802.1	.0	.0

15	8.9	39464.8	.0	11401.8	.0	.0	7893.0	.0	.0
16	3.2	12989.8	.0	3596.9	.0	.0	2598.0	.0	.0
17	5.1	18475.8	.0	4674.5	.0	.0	3695.2	.0	.0
18	7.6	20713.5	.0	4505.7	.0	.0	4142.7	.0	.0
19	.9	1829.6	.0	281.4	.0	.0	365.9	.0	.0
20	2.7	4887.8	.0	379.4	.0	.0	977.6	.0	.0
21	2.7	3631.0	.0	.0	.0	.0	726.2	.0	.0
22	.4	429.4	.0	.0	.0	.0	85.9	.0	.0
23	5.3	2766.3	.0	.0	.0	.0	553.3	.0	.0

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.18	88.93
3	76.17	82.92
4	84.93	78.08
5	94.27	74.51
6	104.02	72.29
7	113.98	71.45
8	123.97	72.01
9	133.77	73.96
10	143.21	77.26
11	152.10	81.85
12	160.25	87.64
13	167.52	94.50
14	173.76	102.32
15	177.50	108.66

*** 1.271 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.35	89.22
3	65.45	83.35
4	74.19	78.50
5	83.45	74.72
6	93.09	72.08
7	102.98	70.60
8	112.98	70.31
9	122.94	71.21
10	132.72	73.30
11	142.18	76.53
12	151.19	80.87
13	159.62	86.26
14	167.35	92.60
15	174.26	99.83
16	179.93	107.39

*** 1.272 ***

Dique-Guayanilla-Jetty-Dredging-6ft-Mat (StablPro Output Report)

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.11	88.96
3	65.10	82.96
4	73.84	78.10
5	83.16	74.47
6	92.88	72.13
7	102.83	71.15
8	112.83	71.52
9	122.68	73.25
10	132.20	76.30
11	141.22	80.62
12	149.57	86.13
13	157.09	92.71
14	163.65	100.26
15	169.12	108.63
16	170.80	112.18

*** 1.275 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.36	89.23
3	65.50	83.42
4	74.29	78.65
5	83.60	74.99
6	93.28	72.51
7	103.20	71.23
8	113.20	71.17
9	123.13	72.35
10	132.84	74.73
11	142.19	78.28
12	151.03	82.96
13	159.23	88.68
14	166.67	95.37
15	173.23	102.92
16	177.20	108.82

*** 1.280 ***

Failure Surface Specified By 15 Coordinate Points

Point	X-Surf	Y-Surf

No.	(L)	(L)
1	61.11	96.00
2	68.24	88.99
3	76.26	83.02
4	85.02	78.19
5	94.35	74.59
6	104.09	72.30
7	114.04	71.35
8	124.03	71.77
9	133.88	73.53
10	143.39	76.62
11	152.39	80.97
12	160.72	86.51
13	168.22	93.12
14	174.75	100.70
15	179.30	107.72

*** 1.281 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.29	89.15
3	65.39	83.29
4	74.19	78.53
5	83.52	74.95
6	93.24	72.59
7	103.18	71.51
8	113.18	71.72
9	123.07	73.22
10	132.68	75.98
11	141.85	79.95
12	150.44	85.08
13	158.30	91.27
14	165.29	98.42
15	171.30	106.41
16	173.71	110.65

*** 1.285 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	55.56	96.00
2	62.71	89.01
3	70.77	83.10
4	79.59	78.37
5	88.98	74.93

6	98.76	72.84
7	108.73	72.15
8	118.71	72.86
9	128.48	74.96
10	137.87	78.41
11	146.68	83.14
12	154.73	89.07
13	161.88	96.06
14	167.97	103.99
15	172.19	111.45

*** 1.286 ***

1

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	61.11	96.00
2	68.34	89.09
3	76.44	83.23
4	85.26	78.50
5	94.63	75.01
6	104.38	72.81
7	114.35	71.95
8	124.33	72.44
9	134.16	74.27
10	143.66	77.40
11	152.65	81.79
12	160.96	87.35
13	168.45	93.97
14	174.98	101.55
15	179.06	107.84

*** 1.291 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (L)	Y-Surf (L)
1	50.00	96.00
2	57.33	89.19
3	65.47	83.40
4	74.30	78.70
5	83.67	75.19
6	93.41	72.93
7	103.36	71.94
8	113.36	72.26
9	123.22	73.87
10	132.80	76.74
11	141.93	80.83
12	150.44	86.07
13	158.21	92.37

14	165.09	99.63
15	170.98	107.71
16	172.83	111.11

*** 1.295 ***

1

```
                Y            A     X     I     S            F     T

                .00     37.50     75.00    112.50    150.00    187.50
X          .00 +---------+-*-------+-----*---+---------+---------+
               -
               -
               -
               -
               -
         37.50 +
               -
               -                          1
               -                        1 8
               -                      1 8.2
               -                      8.2..
A        75.00 +                     12....
               -                    18.....
               -                    82...**
               -                   12......
               -                   1.......*
               -                   2........
X       112.50 +                   1........
               -                   8.........
               -                   14........
               -                   12..........
               -                    .8......... .
               -                    128.........*
I       150.00 +                     .14........
               -                     .154......*
               -                      2..74.....
               -                        1..744.
               -                         .1.27
               -                           .1
S       187.50 +
               -                        * *
               -
               -
               -
               -
         225.00 +
               -
               -
               -
               -
               -
F       262.50 +
               -
               -
               -
               -
```

```
T     300.00 +            *              W*
```

Dique-Guayanilla-Jetty-Dredging-6ft-Mat (StablPro Input Report)

```
PROFIL
Dike - Guayanilla -Jetty-Seismic-Compacted Mat-Bor 1
11 6
0. 96. 85. 96. 2
85. 96. 100. 100. 2
100. 100. 141. 121. 1
141. 121. 154. 121. 1
154. 121. 194. 100. 1
194. 100. 300. 100. 2
100. 100. 194. 100. 4
85. 96. 86. 94. 2
86. 94. 193. 94. 2
193. 94. 194. 100. 2
0. 45. 300. 45. 3
SOIL
4
100. 100. 0. 60. 0. 0. 1
110. 110. 857. 0. 0. 0. 1
120. 120. 2000. 0. 0. 0. 1
106. 106. 3000. 40. 0. 0. 1
WATER
1 2 62.4
2
0. 97.
300. 97.
EQUAKE
0.2 0. 0.
CIRCLE
1 2
10 20
50. 100. 141. 180.
10. 10. 0. 0.
```

Attachment G-8
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