REVISED FINAL FOUNDATION REPORT

5/N5-N1 Connector Separation (Widen)
Bridge No. 55-0226
Orange County, California
12-ORA-5, PM 6.7
Caltrans Project No. 1200020279 (EA 12-0F96E4)
EMI Project No. 11-137
Date: January 23, 2013

EARTH MECHANICS, INC.

Geotechnical and Earthquake Engineering

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

January 23, 2013

EMI Project No. 11-137

TRC Solutions, Inc.
123 Technology Drive West
Irvine, California 92618

Attention: Dr. Ayman Salama, P.E.

Subject: Revised Final Foundation Report for 5/N5-N1 Connector Separation (Widen)
Bridge No. 55-0226
Orange County, California
12-ORA-5, PM 6.7
Caltrans Project No. 1200020279 (EA 12-0F96E4)

Dear Dr. Salama:

Attached please find the Revised Final Foundation Report for the subject bridge widening. This report contains the findings and conclusions of our field investigation and laboratory testing program. This report also contains our recommendations for the design and construction of the bridge foundations.

The previous version of the report dated January 19, 2013 was approved by Caltrans Office of Geotechnical Design South 1 (OGDS-1) and the approval memorandum dated January 22, 2013 is presented in Appendix D.

Earlier versions of this report dated April 23 and October 5, 2012 were submitted to Caltrans for review. OGDS-1 review comments were provided in memorandums dated August 31, 2012 and January 4, 2013. EMI responses to OGDS-1 comments were reviewed by the Caltrans Oversight Geo-Professional Dr. Sharid Amiri at the over-the-shoulder review meeting conducted at the EMI office on September 20, 2012 and January 9, 2013. The EMI oversight engineers, Mr. Lino Cheang and Mr. Raja Pirathiviraj on September 20, 2012, and Mr. Andrew Korkos, Mr. Mike Kapuskar and Mr. Raja Pirathiviraj on January 9, 2013, were the attendees of the meeting. Responses to Caltrans comments have been incorporated into this Foundation Report. Caltrans review comments, EMI responses, and email correspondences are provided in Appendix D.

We appreciate the opportunity to provide geotechnical design services for this project.

Sincerely,
EARTH MECHANICS, INC.

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REVISED FINAL FOUNDATION REPORT

5/N5-N1 CONNECTOR SEPARATION (WIDEN)
BRIDGE NO. 55-0226
ORANGE COUNTY, CALIFORNIA
12-ORA-5, PM 6.7
CALTRANS PROJECT NO. 1200020279 (EA 12-0F96E4)

Prepared for:

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EMI Project No. 11-137

January 23, 2013

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE OF STUDY

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI). It presents foundation design and construction recommendations for the proposed widening of 5/N5-N1 Connector Separation in Orange County, California. A site location map is presented in Figure 1-1.

EMI is a subconsultant to TRC Solutions, Inc. (TRC). The geotechnical services provided for this project included the following tasks:

- Collection and review of existing geotechnical information;
- Site-specific field exploration consisting of drilling and logging exploratory borings and cone penetration test (CPT) soundings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering calculations and analysis to develop foundation design and construction recommendations; and
- Preparation of this report presenting our findings, conclusions, and recommendations.

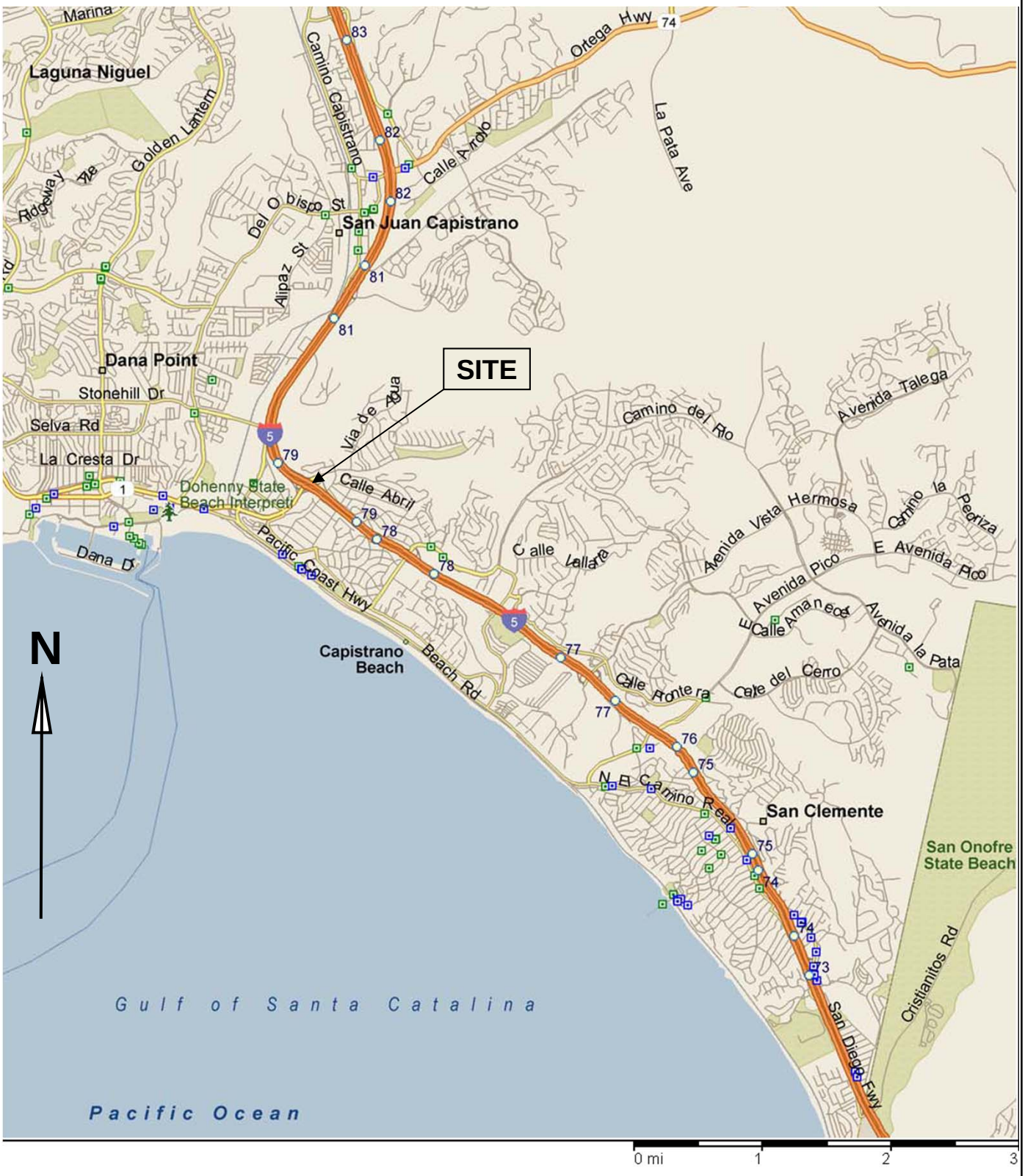
1.2 PROJECT DESCRIPTION

The California Department of Transportation (Caltrans), in cooperation with the Orange County Transportation Authority (OCTA) and the cities of Dana Point and San Juan Capistrano, proposes to improve the I-5 corridor. The project's southern terminus is approximately 0.6 mile south of the PCH/Camino Las Ramblas Interchange (I-5 Mainline Station 340+00) in the City of Dana Point. The northern terminus of the project is approximately 0.2 mile south of San Juan Creek Road (I-5 Mainline Station 465+00) in the City of San Juan Capistrano. The total project length along the I-5 corridor is approximately 2.5 miles. However, according to the Project Report prepared in October 2011, the proposed project improves the I-5 corridor from I-5 Mainline Stations 340+00 (southern project limit) to 407+50. From I-5 Mainline Stations 407+50 to 465+00 (northern project limit), the proposed project will consist primarily of restriping the existing pavements only. The proposed improvement project includes widening of three bridge structures; 5/N5-N1 Connector Separation (Bridge No. 55-0226), Route 5/1 Separation (Bridge No. 55-0510) and Camino Capistrano Undercrossing (Bridge No. 55-0227).

This foundation report addresses 5/N5-N1 Connector Separation widening.

1.3 AS-BUILT FOUNDATION DATA

This bridge was originally named "Route 5/1 Separation", and was constructed in 1960 as separate left and right bridges. The median was closed in a 1969 widening. In 1973, the connector separation was again widened at both sides. The existing structure is a three-span structure with a variable length of about 229 feet and a variable width of about 162 feet.



5/N5-N1 Connector Separation (Widen)	**SITE LOCATION MAP**
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Figure 1-1
Project No. 11-137	Date: 03-15-2012

The abutments and bents are supported on spread footings except for the left bridge bent footings in the 1973 widening; Bents 2 and 3 of the left bridge in the 1973 widening are supported on 16-inch diameter Cast-In-Drilled-Hole (CIDH) concrete piles. Pertinent foundation data as shown on the as-built plans is summarized in Table 1-1.

Table 1-1. As-Built Foundation Data

Bridge		Support	Foundation Type	Bottom of Footing Elevation (feet)	Design Load
Original Bridge in 1960	Right Bridge (I-5 NB)	Abutment 1	Shallow Footing	+176.5 and +177.5	4 ksf
		Bents 2 and 3	Shallow Footing	+155.0	6 ksf
		Abutment 4	Shallow Footing	+171.0 and +172.0	4 ksf
	Left Bridge (I-5 SB)	Abutment 1	Shallow Footing	+171.0 and +172.0	4 ksf
		Bents 2 and 3	Shallow Footing	+155.0	6 ksf
		Abutment 4	Shallow Footing	+166.0 and +167.5	4 ksf
1969 Median Widening	Right and Left Bridges (I-5 NB and SB)	Abutment 1	Shallow Footing	+172.0 and +175.0	4 ksf
		Bents 2 and 3	Shallow Footing	+152.0 and +155.0	6 ksf
		Abutment 4	Shallow Footing	+167.5 and +169.5	4 ksf
1973 Widening	Right Bridge (I-5 NB)	Abutment 1	Shallow Footing	+177.5	4 ksf
		Bents 2 and 3	Shallow Footing	+155.0	6 ksf
		Abutment 4	Shallow Footing	+172.0	4 ksf
	Left Bridge (I-5 SB)	Abutment 1	Shallow Footing	+167.5	4 ksf
		Bents 2 and 3[1]	16-inch CIDH	+150.0 to +157.0	90 kips
		Abutment 4	Shallow Footing	+161.5	4 ksf

Note:
1. The specified pile tip elevation is +120.0 feet

The existing connector separation bridge will be widened in the I-5 northbound (NB) direction by a maximum width of 9'-6"± and in the I-5 southbound (SB) direction by a maximum width of 9'-10"±.

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 FIELD INVESTIGATION

As-built Log-of-Test-Borings (LOTB) sheets are included in Appendix A. The as-built LOTB sheet for the original bridge construction shows two rotary borings drilled in June and December 1955. The as-built LOTB sheet for the 1969 widening shows five penetration borings and one rotary boring drilled in October 1965. The as-built LOTB sheet for the 1973 widening shows four penetration borings and one rotary boring; two penetration borings were drilled in October 1965 and other three borings were drilled in January 1968. The top-of-hole elevations vary from about +152 to +178 feet, and the deepest boring was advanced to about elevation +75 feet. Existing grade at the freeway surface is between elevations +178 and +190 feet.

To supplement the existing subsurface information, six soil borings and two CPT soundings were performed between September 27 and October 6, 2011. The exploration locations were field surveyed using California Coordinate System (CCS) 83 (1991.35) Zone 6 and vertical datum NAVD 1988 to obtain coordinates and elevations and establish stations and offsets. Boring information, including surveyed locations and elevations, are summarized in Table 2-1. Locations of the borings and CPTs are shown on the LOTB sheets provided in Appendix A.

Table 2-1. Geotechnical Exploration Information

Boring/ CPT	Easting	Northing	Station (A-Line) (feet)	Offset (feet)	Top of Boring El. (feet)	Bottom of Boring El. (feet)	Ground Water El. (feet)	Drilling Method
A-11-316	6,129,314	2,116,186	361+81	87 Rt	+192.6	+91.1	+168.6	HSA
A-11-317	6,128,966	2,116,220	364+78	104 Lt	+179.3	+78.8	NE	HSA
CPT-11-318	6,129,171	2,116,296	363+60	80 Rt	+165.5	+140.6	NM	CPT
A-11-319	6,128,859	2,116,300	366+17	98 Lt	+152.4	+70.9	+137.4	HSA
A-11-320	6,129,117	2,116,336	364+25	79 Rt	+166.6	+85.1	NE	HSA
CPT-11-321	6,128,816	2,116,323	366+68	101 Lt	+152.7	+72.6	NM	CPT
A-11-322	6,129,042	2,116,418	365+30	101 Rt	+186.7	+85.2	NE	HSA
A-11-323	6,128,742	2,116,378	367+63	91 Lt	+173.0	+72.3	NE	HSA

Notes:
(1) A-Line = I-5 Mainline; NE = Not Encountered; NM = Not Measured.
(2) CPT = Cone Penetration Test; HSA = Hollow-Stem Auger.
(3) Exploration locations were field surveyed using California Coordinate System (CCS) 83 (1991.35) Zone 6 and vertical datum NAVD 1988.

The HSA borings were drilled using a truck-mounted drill rig equipped with 8-inch diameter hollow-stem augers. Sampling was performed by alternating the Modified California Drive (MCD) sampler and Standard Penetration Test (SPT) sampler. The soil sampling interval was generally 5 feet.

Relatively undisturbed soil samples were obtained using a 3.25-inch outer diameter MCD sampler lined with brass rings. Each of these brass rings is 1-inch long with a 2.5-inch outside

diameter. The SPT sampler (1.4-inch inside diameter) was also used to obtain soil samples. The MCD and SPT samplers were driven 18 inches into the ground or until refusal was encountered using a 140-lb automatic trip hammer free falling from a height of 30 inches. The numbers of blows to advance the sampler each 6 inches of penetration were recorded. The number of blows for the final 12 inches or shorter of driving was recorded on the LOTB sheets. Charts published by Winterkorn and Fang (1975) can be used to determine a reduction factor used to convert blowcounts recorded using the California Drive sampler into SPT blowcounts. Using those charts, we obtained a reduction factor of 0.5 which was used for this project. The SPT hammer energy measurements for this drill rig were performed by SPT CAL under subcontract with 2R Drilling on April 14, 2011. The SPT hammer energy report is provided in Appendix A.

The CPT sounding was performed using an electronic cone penetrometer in general accordance with current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a projected cross sectional area of 1.55 in² (10 cm²) and a cylindrical friction sleeve with a surface area of 23.25 in² (150 cm²). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all-wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the testing equipment. The computer generated graphical logs include tip resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

Seismic Cone Penetration Test (SCPT) was performed in CPT-11-321 to measure shear wave velocities (V_S) at various depths. The SCPT was pushed into the ground at the standard rate. The penetration was stopped at desired depths and shear waves were generated at the surface by hitting a beam with a sledge hammer. The time for the shear waves to reach the seismometer was measured and the V_S was calculated. The time measurements and the calculated V_S values at each depth are presented in Appendix A.

2.2 LABORATORY TESTING

Soil samples considered representative of the subsurface conditions were tested to obtain or derive relevant physical and engineering soil properties. The laboratory tests were conducted in general accordance with California Test Methods or American Society for Testing and Materials (ASTM) Standards. The laboratory tests conducted to supplement the observations recorded during the field investigation and to obtain design parameters are presented in Table 2-2. Laboratory test results are included in Appendix B.

Table 2-2. Explanation of Laboratory Tests Performed

Type of Test	Applicable Test Method	Purpose
Unit Weight	ASTM D 4767	Estimate in-situ unit soil weight
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
Percent Passing No. 200 Sieve	ASTM D 1140	Determine the percentage of fine grained particles of soil
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
Direct Shear	ASTM D 3080	Determine strength parameters of coarse-grained soil
Unconsolidated Undrained Triaxial	ASTM D 2850	Estimate strength parameters of fine-grained soil
Soil pH	CT 532/643	Determine corrosion potential of soil
Minimum Resistivity	CT 532/643	Determine corrosion potential of soil
Sulfate Content	CT 417	Determine corrosion potential of soil
Chloride Content	CT 422	Determine corrosion potential of soil

Notes:
1. ASTM = American Society for Testing and Materials.
2. CT = California Test Method.

3.0 GEOLOGY

3.1 PHYSIOGRAPHY

The project area is in the northwestern part of the Peninsular Ranges physiographic province. The Peninsular Ranges comprise a northwest-southeast trending group of fault-bounded ranges between the Salton Trough and the Pacific Ocean. The Santa Ana Mountains, Puente Hills, and San Joaquin Hills are ranges within the Peninsular Ranges.

The site is located on the low lying rolling hills westerly of the Santa Ana Mountains at the southerly end of the San Joaquin Hills in an area referred to as the Capistrano Embayment.

3.2 GEOLOGIC STRUCTURE

The geological structure at the site consists of slightly to moderately folded bedrock of the Capistrano formation overlain by horizontally bedded Quaternary terrace deposits and alluvium without any notable geological structures such as faults, folds, or unconformities. The northerly portion of the project is underlain by deposits of the McCracken Hill landslide which is described in Section 3.3.

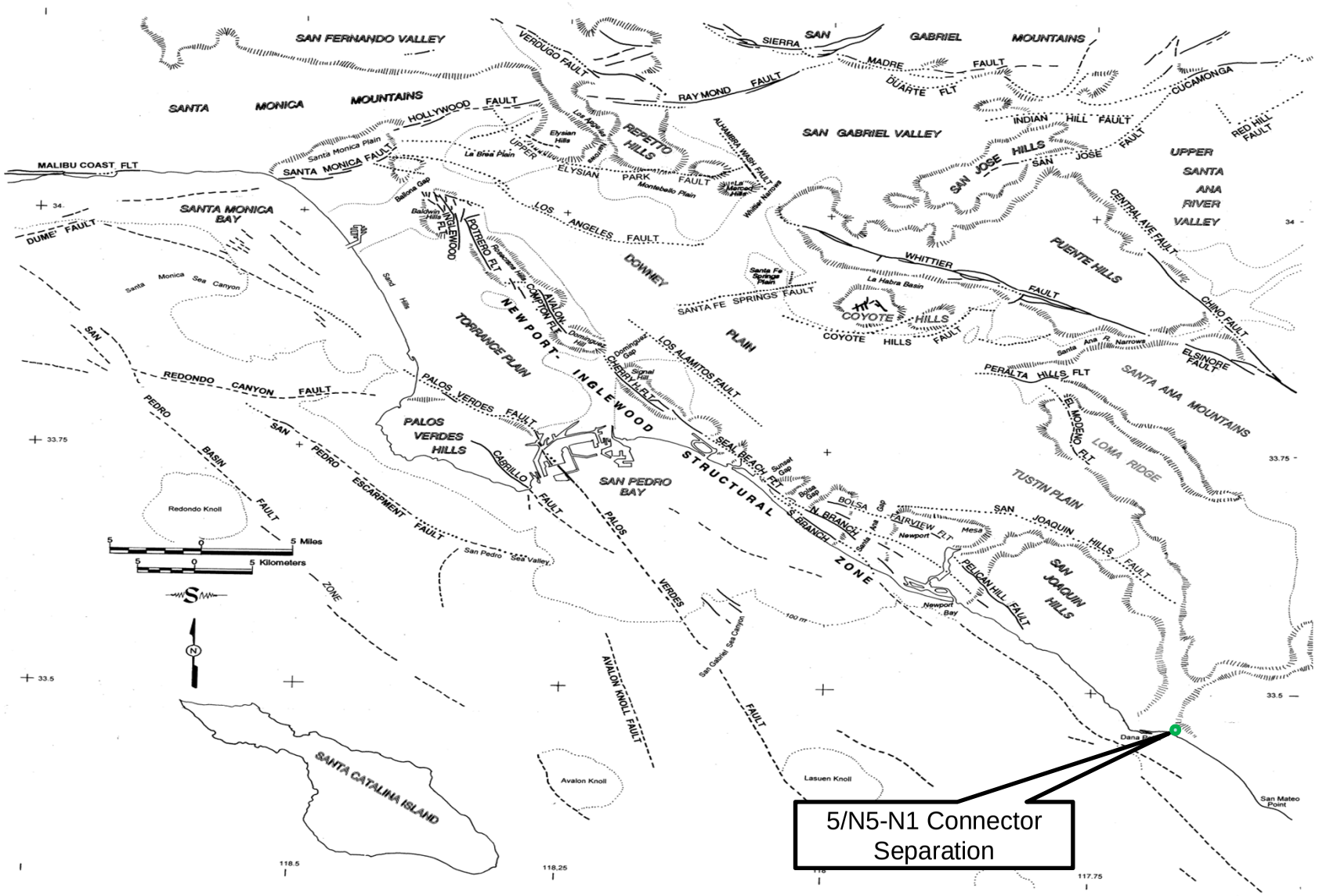
The Capistrano Formation is widespread throughout the southern part of Orange County, which is known geologically as the Capistrano Embayment. The Capistrano Embayment is the name given to the structural/stratigraphic block west of the Cristianitos Fault. Geologic faults in the region are shown on Figure 3-1. Geological structure in the Capistrano Embayment area consists primarily of a broad, gentle syncline of the Monterey and Capistrano Formations between the San Joaquin Hills and the Santa Ana Mountains. This structure originated as a deep submarine structural trough that has since been uplifted at least 3000 feet from the marine environment to its present position above sea level (Ehlig, 1989). Subsequent regional uplift during the late Pliocene and Pleistocene time resulted in folding of the bedrock units.

The bedrock of the Capistrano Formation underlying the site was found to be massive to poorly bedded. Where bedding was observed, the strikes were generally to the northeast with shallow dips less than about 10 degrees westerly. Throughout the project corridor, the dominant structural pattern is high-angle joints and fractures within the Capistrano bedrock.

Pleistocene Terrace Deposits unconformaly overlie the Capistrano Formation. The contact is generally undulatory, with a slight overall dip seaward averaging about 2 degrees. This erosional contact is marked by cobble and boulder rich beds of varying thicknesses.

3.3 GEOLOGIC HAZARD

The geological hazards present at the site include earthquake shaking and landsliding. The site lies outside identified tsunami inundation zones (CGS, 2009), and there are no large bodies of water within the site area that could generate a seiche. There are no volcanos in the region and there are no known active surface faults within the project area so ground rupture is not a factor. As shown in Figure 3-2, the California Geological Survey (CGS, 2001a) has indicated that the project alignment has a low susceptibility to liquefaction during a strong earthquake. The potential for liquefaction is discussed in detail in Section 5.4.



5/N5-N1 Connector Separation (Widen)

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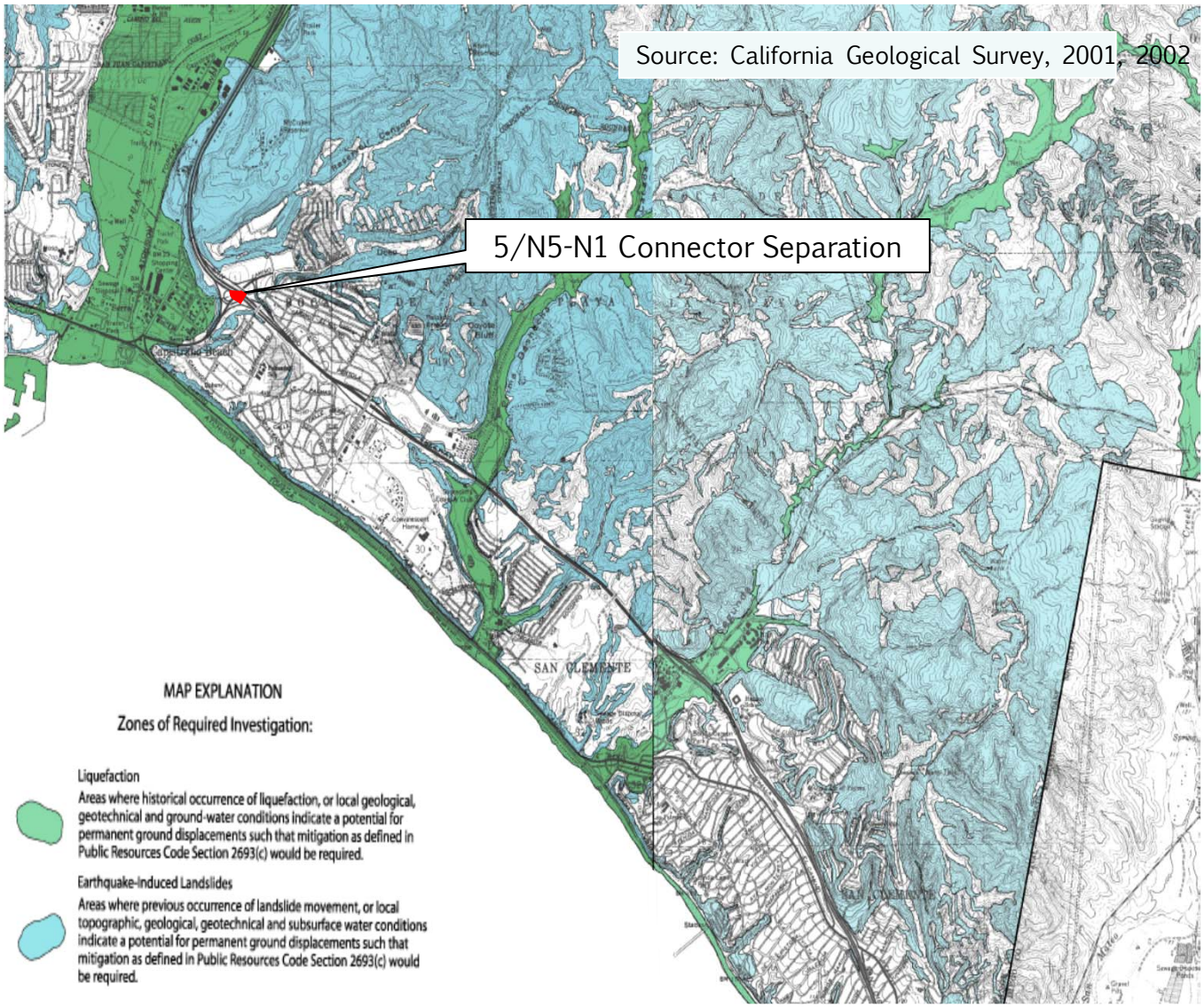
REGIONAL MAP OF ACTIVE FAULTS AND PHYSIOGRAPHY

Figure 3-1

Project No. 11-137

Date: 03-01-12

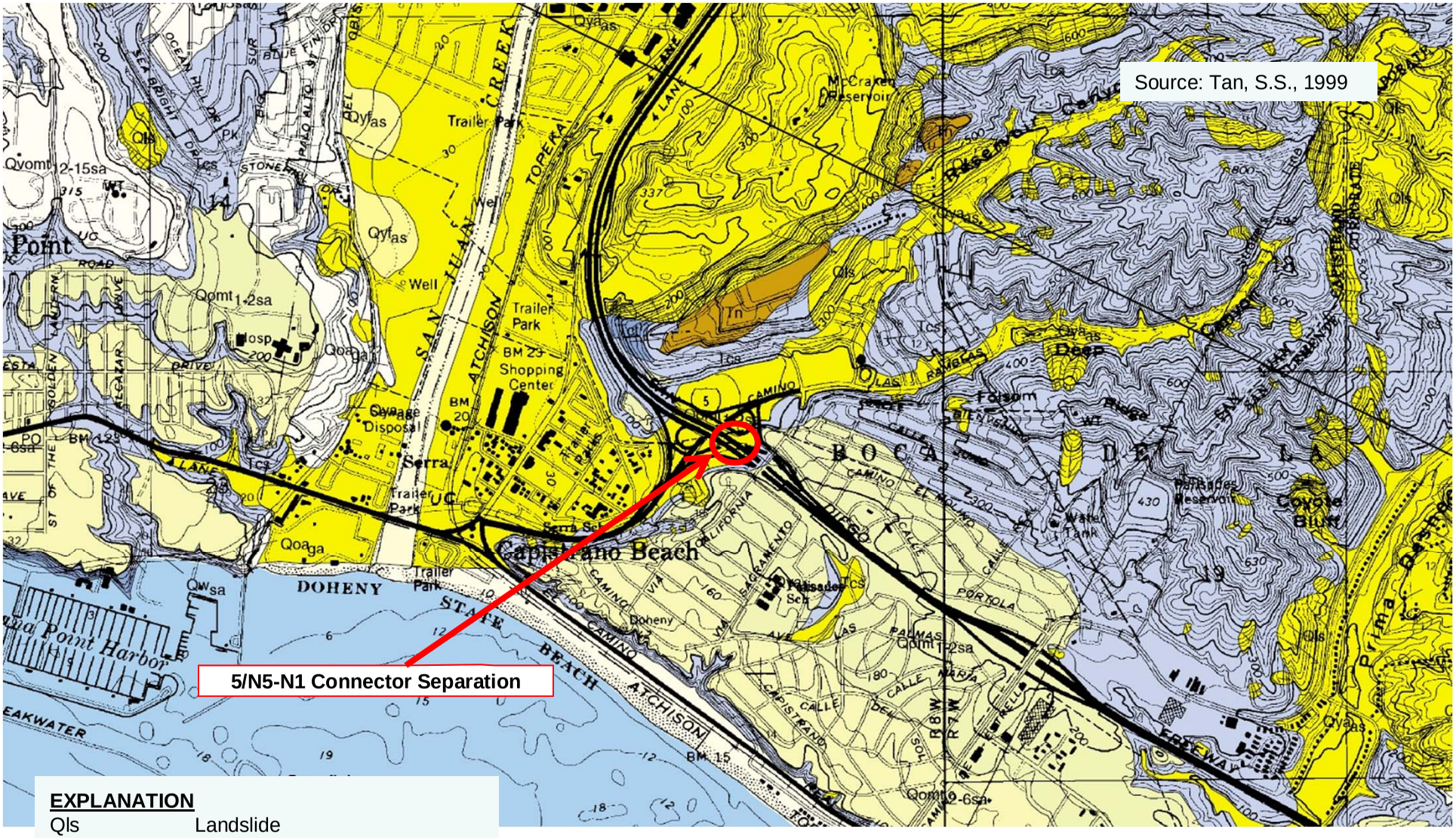


5/N5-N1 Connector Separation (Widen)	**MAP OF LIQUEFACTION POTENTIAL**
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Figure 3-2
Project No. 11-137	Date: 03-01-12

The Capistrano Formation bedrock underlying the majority of the site is notoriously susceptible to landsliding. The landslides are shown in Figure 3-3. At the north of PCH/Camino Las Ramblas Interchange, the I-5 alignment traverses the McCracken Hill Landslide. The remnant headscarp of this ancient landslide is defined by a west to northwest facing slope that extends for about 7000 feet on the eastern side of the I-5 Freeway (AMEC, 2006a and 2006b). It is believed that the landslide occurred between 11,000 to 30,000 years ago when the sea level was lower than present day and San Juan Creek carved a deep channel on its course to the Pacific Ocean. During the Pleistocene, the climate was considerably wetter than present day and this combined with the loss of support at the toe of the slope due to erosion by San Juan Creek are believed to have been causative factors in the landslide failure. Since the landslide failure, a considerable thickness of alluvium has infilled the ancestral San Juan Creek channel with deposits more than 130 feet thick forming a natural buttress for the landslide mass. Extensive investigations of the landslide performed by Leighton and Associates (Leighton, 2004) and AMEC (AMEC, 2006a, 2006b, and 2000a through 2000e) in conjunction with proposed residential developments in the area indicate that the landslide is stable.

In addition, a smaller landslide is present along the PCH NB on-ramp to I-5 SB. The slope ascending from the PCH NB on-ramp to I-5 SB is underlain by Quaternary Terrace Deposits overlying bedrock of the Capistrano Formation. A landslide measuring approximately 150 feet wide by 300 feet long was observed on this slope during field mapping. Research of files at the City of Dana Point did not reveal any geologic reports relating to the landslide or details of when it occurred. Based on the geomorphology of the slide it appears to have been a shallow failure involving the Terrace Deposits and possibly the weathered upper portion of the underlying bedrock. It is estimated the landslide is likely less than about 30 feet deep. Proposed grading performed in conjunction with the project is not considered to have an impact on this landslide.

Bedrock exposures along Via Canon (southwesterly of the landslide, outside the limits of the geologic map) indicate that the bedding is variable but generally dips south to southeast at angles ranging from 5 to 22 degrees. This bedding orientation is generally considered favorable to the gross stability of the slope.



5/N5-N1 Connector Separation (Widen)	**GEOLOGICAL MAP**
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Figure 3-3
Project No. 11-137	Date: 03-01-12

4.0 SUBSURFACE CONDITIONS

4.1 SOIL CONDITIONS

The roadway elevation of the existing I-5 NB to PCH NB connector is between +165 feet and +152 feet and the roadway elevation of I-5 is between +180 feet and +190 feet. Based on the recent field investigation and as-built LOTB sheets, the site is underlain primarily by alluvium and bedrock of Capistrano Formation. The alluvium includes primarily silty sand, sand with silt, sand and lean clay. The bedrock of Capistrano Formation includes primarily claystone and siltstone. Based on the recent field investigation and the as-built LOTB sheets, bedrock contact is near elevation +162 feet at the right bridge abutments and bents. At the left bridge, the bedrock contact varies between elevations +165 feet and +153 feet near Abutments 1 and 4, respectively; Near Bents 2 and 3, bedrock contact is near elevation +107 feet.

4.2 IDEALIZED SOIL PROFILE

The idealized soil profile and design strength parameters for foundation design are presented in Table 4-1 and shown in Figure 4-1. The strength parameters for the coarse-grained and fine-grained soils in Table 4-1 were based on either correlations with SPT blowcounts (Lam and Martin, 1986) or CPT data (Robertson and Campanella, 1989) or laboratory test results. Within the project limits, undrained shear strengths of the bedrock obtained from all the laboratory UU-tests range from 7,900 to 10,300 psf. Undrained shear strengths of the bedrock obtained from all the CPT correlations vary from 2,000 to over 10,000 psf. Based on this, it appears the laboratory measured shear strength is close to the average shear strength obtained from the CPT correlation. A closer examination of the CPT interpreted logs show a majority of the undrained shear strength values immediately below the bedrock contact varies from 2,000 to 6,000 psf. Conservatively, an undrained shear strength value of 3,000 psf was selected for the bedrock.

Table 4-1. Idealized Soil Profile and Strength Parameters

Approximate Elevation (feet)	Predominant Soil Type	Equivalent SPT Blowcount* (blows/foot)	Total Unit Weight (pcf)	Friction Angle (degree)	Cohesion / Undrained Shear Strength (psf)
Right Bridge (I-5 Northbound)					
Abutments 1 and 4, and Bents 2 and 3 (A-11-316, CPT-11-318, A-11-320 and A-11-322)					
+193 to +162	Silty Sand/ Sand with Silt	2 to >50 Average = 28	120	32	100
+162 to +85	Bedrock – Elastic Silt, Fat Clay	25 to >50 Average = 44	120	-	3000

Approximate Elevation (feet)	Predominant Soil Type	Equivalent SPT Blowcount* (blows/foot)	Total Unit Weight (pcf)	Friction Angle (degree)	Cohesion / Undrained Shear Strength (psf)
Left Bridge (I-5 Southbound)					
Abutments 1 and 4 (A-11-317 and A-11-323)					
+180 to +160	Silty Sand/ Sand with Silt	13 to 26 Average = 22	120	32	100
+160 to +72	Bedrock – Elastic Silt, Fat Clay	20 to >50 Average = 44	120	-	3000
Bents 2 and 3 (A-11-319 and CPT-11-321)					
+155 to +148	Silty Sand	8 to (14) Average = 11	120	30	100
+148 to +127	Lean and Fat Clay	4 to 8 Average = 6	115	-	1500
+127 to +117	Sand and Sand with Silt	(6) to 17 Average = 12	120	30	100
+117 to +107	Lean Clay	8 to 22 Average = 14	115	-	2000
+107 to +71	Bedrock – Elastic Silt, Fat Clay	16 to (42) Average = 28	120	-	3000

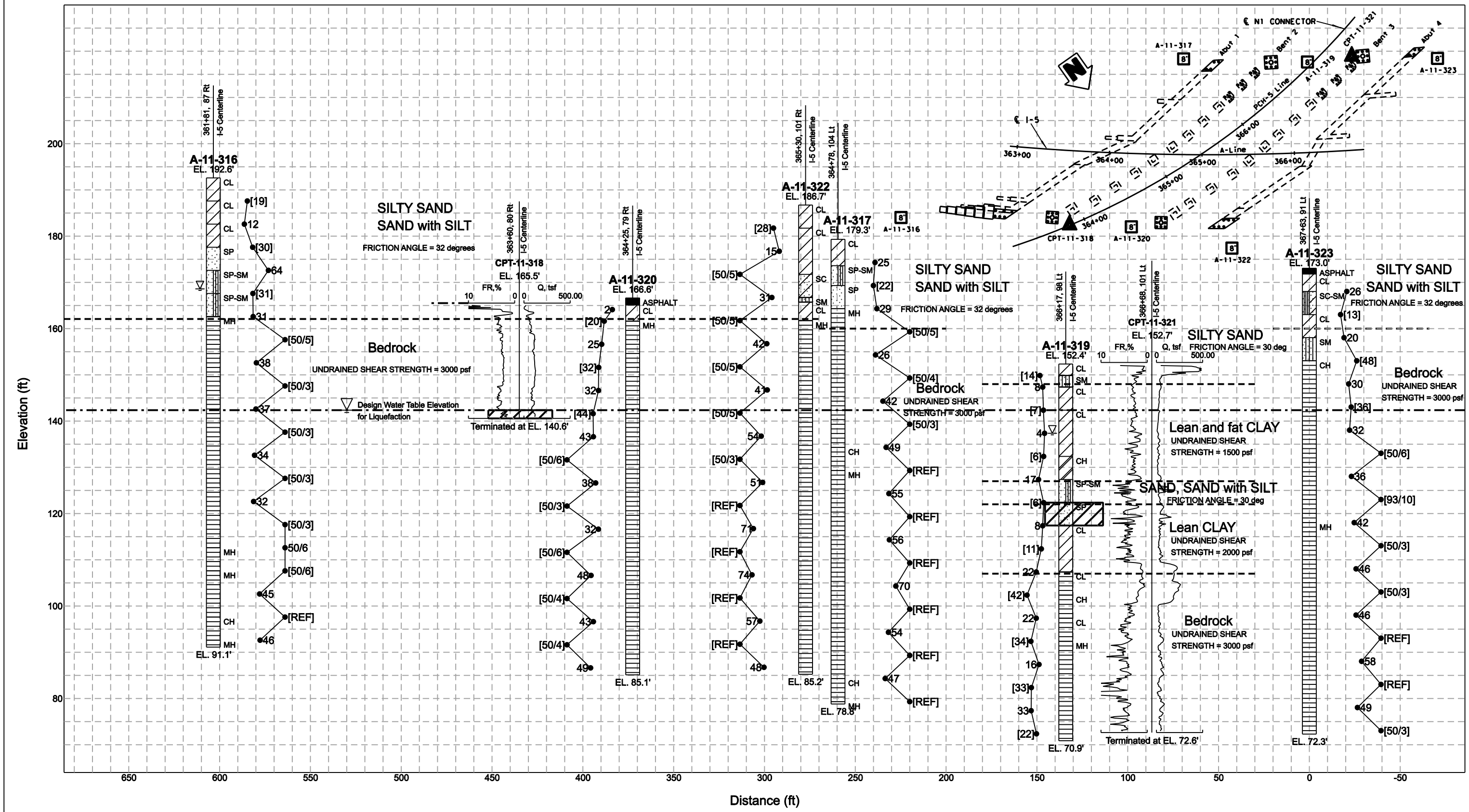
* Values in ( ) are converted SPT blowcounts corrected for sampler size; correction factor from Modified California Drive sampler blowcounts to SPT blowcounts is 0.5.

4.3 GROUNDWATER CONDITIONS

Groundwater was encountered in two borings at elevations +137.4 feet and +168.6 feet during the recent field investigation. According to the as-built LOTB sheet for the 1969 widening, groundwater was encountered between elevations +135 and +155 feet. Groundwater was not encountered in any of the borings performed for the 1955 original bridge and the 1973 widening.

The above data indicate that the groundwater encountered during EMI investigation in September and October of 2011 appears to be perched water. Nevertheless, groundwater during construction will likely be different from those reported above because groundwater level can fluctuate due to variations in seasonal precipitation, irrigation, groundwater injection or extraction, or numerous other man-made and natural influences.

Based on California Geological Survey, Division of Mines and Geology (CGS, 2001b), the highest historical groundwater at the project site is 5 to 10 feet below the ground surface. So, there is a major discrepancy between the CGS data and measured groundwater data described above. Based on our past experience, the CGS historical high groundwater data is often based on limited data and may or may not reflect actual site conditions. We believe the historical high groundwater data reported by CGS is likely to be either a perched water zone or the original ground surface is significantly lower than the current ground surface. In both cases, it does not appear to be representative of the site conditions. However, a conservative groundwater depth of 10 feet below the I-5 NB to PCH NB connector roadway is used for the liquefaction analyses.



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5/N5-N1 Connector Separation (Widen)
Bridge No. 55-0226

Idealized Soil Profile

Date: 01-12-2013

Project No.: 11-137

Figure 4-1

5.0 SEISMICITY AND GEO-SEISMIC HAZARDS

5.1 SEISMIC STUDY

The project is in seismically active Southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, earthquake focal-mechanism solutions, and geodetic measurements. These data suggest crustal shortening of between 0.2 and 0.35 inch per year across the greater Los Angeles area (Argus et al., 1999).

Historical earthquake epicenter maps show widespread seismicity throughout the region. Although historical earthquakes occur in proximity to known faults, they are difficult to directly associate with mapped faults. Part of this difficulty is due to the fact that the basin is underlain by several poorly known subsurface thrust faults, generally referred to as blind thrust faults. Ward (1994) estimated that about 40 percent of seismic moment cannot be associated with known faults. Earthquakes occur primarily as loose clusters along the Newport-Inglewood Structural Zone (NISZ), the southern margin of the Santa Monica Mountains, the margin between the Santa Susana-San Fernando Valley and the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. There is no clustering or alignment of earthquakes in proximity to the site. There are fewer earthquakes in the site region than anywhere else in the Los Angeles Basin area. This apparent lack of earthquake activity suggests that the site area is tectonically stable and suggests that there are no unrecognized active faults at the site.

The largest historical earthquake within the Los Angeles Basin was the 1933 Long Beach event which had a moment magnitude (M_W) of about 6.4 (M_L = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the NISZ (Benioff, 1938). The association was based on abundant ground failures along the NISZ trend but no unequivocal surface rupture was identified. Reevaluation of the seismicity data by Hauksson and Gross (1991) relocated the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

Other major earthquakes in the region include the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred in the San Fernando Valley region. The 1994 earthquake had a M_W of about 6.7 (M_S = 6.8, M_L = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1.2 or 1.9 miles to 14 miles (Hauksson et al, 1995). The causative fault was never identified with certainty. The event may have occurred on an eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping feature fault bounding the Ventura Basin and the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (M_W = 6.7, M_S = 6.4, M_L = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults were involved such as the Sylmar fault, Tujunga fault, and Lakeview fault. These faults are commonly considered to be

part of the Sierra Madre fault system which extends easterly from the San Fernando Valley, along the base of the San Gabriel Mountains on the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The 1987 Whittier earthquake (M_L = 5.9, M_W = 5.9) occurred on a subsurface fault dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This event did not rupture the ground surface.

A magnitude 5.4 earthquake occurred at a depth of about 9 miles on 29 July 2008. The epicenter was in the Chino Hills area between the Chino fault and the Whittier fault. Preliminary data were inconclusive with regard to the causative fault. Detailed analysis by Shao and Hauksson (2009) indicated a rupture plane striking N71°W, dipping 62 degrees northeast. They suggested a preference for the Whittier fault being the causative fault but were uncertain, primarily because the Whittier fault is supposed to dip at about 80 degrees. The aftershock pattern formed a subhorizontal alignment indicating the possibility that the event could have been associated with a subsurface thrust fault such as one of the blind faults of the Puente Hills Blind Thrust Fault System or with a blind fault under the Peralta Hills.

Another significant earthquake was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown because of the sparse population at the time, but geological studies (Jacoby et al., 1987; Fumal et al., 1993; Weldon et al., 2004) postulate that it did not occur in the Capistrano area, but rather was a large (M_W > 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Portola′ expedition as they camped near the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the Los Angeles area but it could just as well have been a distant event that shook a wide area as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, 1992 Landers event).

5.2 GROUND RUPTURE

There are no active faults through the project area, therefore the potential for ground rupture is remote to nil.

5.3 CALTRANS ARS CURVE

5.3.1 Development of V_s^{30}

A small-strain shear wave velocity (V_s^{30}) of 902 feet per seconds (ft/sec) was calculated using the measurements obtained by a seismic cone deployed in CPT-11-321 for the upper 100 feet of subsurface materials. A V_s^{30} of 847 ft/sec was also calculated using correlations with SPT blowcounts (Caltrans, 2009e) for the upper 100 feet of subsurface materials obtained from the soil boring A-11-319 closest to CPT-11-321. The calculated V_s^{30} obtained from Boring A-11-319 and the remaining borings were normalized using the ratio of (902/847). The calculated and normalized V_s^{30} values are presented in Table 5-1.

Table 5-1. Small Strain Shear-Wave Velocity V_S^{30}

Boring/CPT	Source of Shear-Wave Velocity	Small Strain Shear-Wave Velocity V_S^{30} (feet/sec)	
		Calculated	Normalized
A-11-316	SPT Correlations	1208	1287
A-11-317	SPT Correlations	1343	1430
A-11-319	SPT Correlations	847	902
A-11-320	SPT Correlations	1290	1374
CPT-11-321	Field Measurements	902	902
A-11-322	SPT Correlations	1328	1414
A-11-323	SPT Correlations	1244	1324

5.3.2 Development of Caltrans ARS Curve

To develop the ARS curves in accordance with the 2010 Seismic Design Criteria (SDC) (Caltrans, 2010a) and Geotechnical Services Design Manual (Caltrans, 2009e) procedures, we considered the following response spectra. The resulting ARS curve is the envelop of all the following spectra:

- Deterministic Criteria based on late-Quaternary faults in the 2007 fault database (Shantz and Merriam, 2009 and Caltrans, 2009a and 2009c).
- Probabilistic Criteria based on 5% in 50 years probability of exceedance ground motion.
- Minimum Deterministic Spectrum based on a Mw = 6.5 strike-slip event occurring at a distance of 7.5 miles (12 km) from the site.

We used the Caltrans Deterministic Response Spectrum Spreadsheet as recommended by the Geotechnical Services Design Manual (Caltrans, 2009e) to develop the deterministic ARS curves. The spreadsheet uses the arithmetic average of two Next Generation Attenuation (NGA) relationships developed by Chiou-Youngs (2008) and Campbell-Bozorgnia (2008) with user-provided input parameters as listed in Table 5-2. Results obtained from the spreadsheet were then verified with the Caltrans online web tool (Caltrans, 2009b).

The probabilistic response spectrum is based on data from the 2008 United States Geological Survey (USGS, 2008a) National Seismic Hazard Map for the 5% in 50 years probability of exceedance (975-year return period) ground motion. To develop the probabilistic spectrum, the Caltrans Probabilistic Response Spectrum Spreadsheet and the USGS Interactive Deaggregation Tool (USGS, 2008b) were used. Results obtained from both the spreadsheet and deaggregation tool were then verified with the Caltrans online web tool (Caltrans, 2009b).

Table 5-2. Site Characteristics and Deterministic Controlling Fault Parameters

Site Characteristics	
Site Coordinates	Latitude = 33.4670 degrees Longitude = -117.6699 degrees
Depth to V_s=1.0 km/s, $Z_{1.0}$	Site is not in deep sedimentary basin, therefore basin amplification factors = 1
Depth to V_s=2.5 km/s, $Z_{2.5}$	
Deterministic Controlling Fault Parameters	
Fault Name	Newport-Inglewood-Rose Canyon Fault (Offshore or Dana Point)
Fault ID	222
Fault Type	Right Lateral Strike Slip (RLSS)
Fault Dip	90 degrees
Dip Direction	Vertical
Top of Rupture Plane	0 miles (0 km)
Bottom of Rupture Plane	8.12 miles (13 km)
R_{RUP}[1]	3.84 miles (6.15 km)
R_{JB}[2]	3.84 miles (6.15 km)
R_X[3]	3.84 miles (6.15 km)
F_{rv} (1 for reverse, 0 for others)	0
F_{nm} (1 for normal, 0 for others)	0
Hang Wall	No
Near-Field Factor Required	Yes, up to 1.2

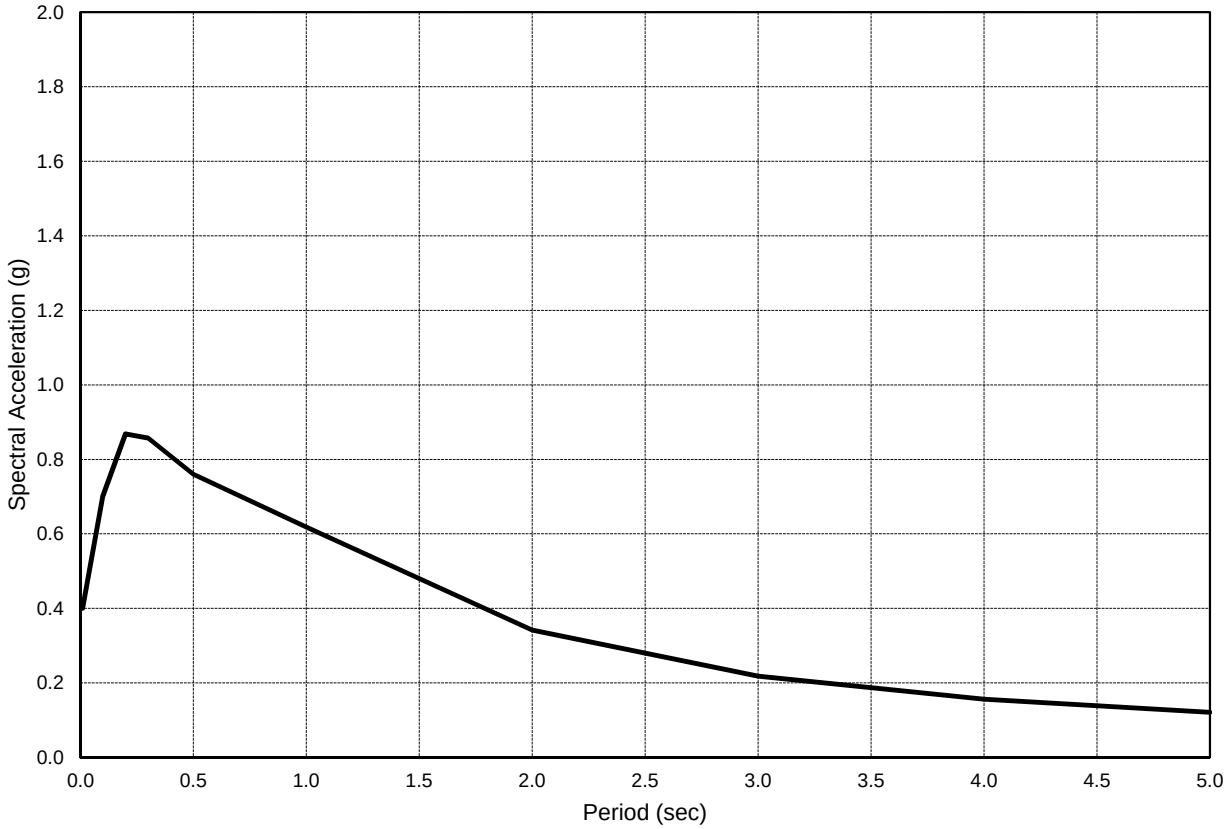
Note:
1. R_{RUP} = closest distance from the site to the fault rupture plane.
2. R_{JB} = Joyner-Boore distance; the shortest horizontal distance to the surface projection of the rupture area.
3. R_X = horizontal distance from the site to the fault trace or surface projection of the top of the rupture plane.

ARS curves were developed for each normalized V_s^{30} presented in Table 5-1. The design ARS curve is the mathematical mean of all the ARS curves, and this design ARS curve is presented in Figure 5-1 together with the digitized coordinates. As shown in Figure 5-1, a peak ground acceleration (PGA) of 0.40g is obtained from the design ARS curve.

5.4 LIQUEFACTION

Liquefaction analysis was performed using the available site-specific subsurface information from borings and CPTs. As discussed in Section 4.3, there is a major discrepancy between CGS groundwater data and measured groundwater data. A conservative groundwater depth of 10 feet below the I-5 NB to PCH NB connector roadway is used for the liquefaction analyses.

The liquefaction potential of saturated, granular materials below the groundwater table was evaluated using the procedures outlined by Seed et al. (1983), Seed and Harder (1990), and updated by NCEER (1997). Results of the liquefaction analyses are included in Appendix C. Based on the analyses, granular materials susceptible to liquefaction were encountered only in one boring and one CPT using a very conservative groundwater depth.



Latitude = 33.4670 ^{o}
Longitude = -117.6699 ^{o}
Damping Ratio = 5%

Spectral Coordinates	
	Acc. (g)
Period (sec)	Design
0.010	0.400
0.100	0.701
0.200	0.869
0.300	0.857
0.500	0.760
1.000	0.618
2.000	0.342
3.000	0.218
4.000	0.156
5.000	0.121

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Design ARS Curve

Figure 5-1

The liquefiable layer in the boring is about 5.0 feet thick which coincides with the soil sampling interval. Therefore, actual thickness of the liquefiable layer could be less than 5 feet; CPT indicates that the liquefiable layer near the same elevation is less than 1.0 foot. The liquefiable layers in the boring and CPT are less than 1.5 feet thick, and they are isolated and discontinuous. Therefore, the liquefaction potential is concluded to be low. Furthermore, as discussed in Section 3.3, the California Geological Survey (CGS, 2001a) has also indicated that the project alignment has a low susceptibility to liquefaction during a strong earthquake.

5.5 LATERAL SPREAD

Since the liquefaction potential at the project site is low, liquefaction induced lateral spreading is also considered low. Therefore, lateral spreading is not considered a design issue.

5.6 SEISMIC SETTLEMENT

The seismically-induced settlements are presented in Appendix C. In the liquefiable layers, seismically-induced settlements are expected to be no more than 0.5 inches. Since these liquefiable layers are relatively thin, isolated and discontinuous, the seismically-induced settlement is not expected to adversely impact the bridge widening.

6.0 SOIL CORROSIVITY

Six soil samples were tested for pH, minimum resistivity, soluble chloride content and soluble sulfate content. The test results are summarized in Table 6-1. Minimum resistivities were between 300 and 2,200 ohm-cm. The pH values were between 6.7 and 7.7. The soluble sulfate measurements were between 150 and 5,060 parts per million (ppm), and the soluble chloride measurements were between 204 and 1,699 ppm.

Table 6-1. Soil Corrosion Test Results

Boring	Location (A-Line Stations)		Sample Depth (feet)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Soluble Sulfate Content (ppm)	Soluble Chloride Content (ppm)
	Station (feet)	Offset (feet)						
A-11-316	361+81	87 Rt	5.0	CL	310	7.2	5,060	1,187
A-11-317	364+78	104 Lt	5.0	CL to SP-SM	840	7.3	500	296
A-11-319	366+17	98 Lt	10.0	CL	560	6.7	2,600	266
A-11-320	364+25	79 Rt	5.0	MH	300	6.8	1,160	1,699
A-11-322	365+30	101 Rt	0-5.0	SC	500	7.5	1,574	1,200
A-11-323	367+63	91 Lt	5.0	SM	2,200	7.7	150	204

Based on the Caltrans Corrosion Guidelines (2003c), soils are considered corrosive if the pH is 5.5 or less, or the sulfate concentration is 2,000 ppm or greater, or the chloride concentration is 500 ppm or greater. Based on the test results and the Caltrans criteria, the on-site soils are considered to be corrosive to bare metals and concrete.

For the above measured chloride concentration, minimum concrete cover over reinforcement should be in accordance with Table 8.22.1 of the Caltrans BDS (Caltrans, 2003a) for "Corrosive soil above MLLW level with chloride concentration between 500 and 5,000 ppm". For the above measured sulfate concentration, cement type should be in accordance with Table 8.22.2 of the Caltrans BDS (Caltrans, 2003a) for "Sulfate Concentration from 2,000 to 15,000". Additional corrosion protection requirements for concrete structural members are presented in Section 8.22 of the Caltrans BDS (Caltrans, 2003b).

7.0 SCOUR

This site is located within an area that is presently improved; roadway surfaces are paved and drainage is controlled by engineered facilities. Therefore, scour is not considered a design issue.

8.0 FOUNDATION RECOMMENDATIONS

8.1 5/N5-N1 CONNECTOR SEPARATION WIDENING

8.1.1 Foundation Type

The as-built foundation data are summarized in Table 1-1.

According to the structural engineers, spread footings are not suitable because of higher footing pressures and lateral demand at the abutments and bents. Additionally, settlement calculations were performed at the abutments and bents using the as-built bearing pressures. The settlement of the abutments and bents spread footing is estimated to be larger than 1-inch with 5-feet of overexcavation below the footing bottom. The settlement calculations at abutments and bent footings are presented in Appendix C.

Based on the settlement estimates and structural demand, deep foundation is recommended for the proposed widening. Both driven and Cast-in-Drilled-Hole (CIDH) piles are feasible. However, hard driving is anticipated because of shallow bedrock. Therefore, we recommend CIDH piles for the proposed widening which matches the pile type used in the 1973 widening. Twenty-four-inch diameter CIDH piles are recommended (1) to limit the pile length over pile diameter ratio to less than 30, and (2) due to the high possibility of encountering groundwater during pile construction. According to Caltrans Memo To Designers (Caltrans, 2008), the minimum CIDH pile diameter for a wet construction is 24 inches.

8.1.2 Foundation Data Provided by Structural Designers

Per Caltrans policy, LRFD Service-I Limit State load combinations and Working Stress Design (WSD) method provided in the Caltrans Bridge Design Specifications (2003b) are used for design of the abutment footings. The LRFD Service-I Limit State, Strength Limit State, and Extreme Event Limit State load combinations are used for the design of the bent footing.

The foundation design data sheets for Right and Left Bridges are presented in Table 8-1. Foundation loads for Right and Left Bridges were provided by the structural designers following the latest Caltrans Memo To Designers (Caltrans, 2008) and presented in Table 8-2.

Table 8-1. Foundation Design Data Sheet

Support No.	Design Method	Pile Type	Finished Grade Elevation (feet)	Cut-off Elevation (feet)	Pile Cap Size (feet)		Permissible Settlement under Service Load (inch)	Number of Pile per Support
					B	L		
Right Bridge (I-5 Northbound)								
Abut 1	WSD	24" CIDH	+180.74	+174.08	19.24	10.06	1	6
Bent 2	LRFD	24" CIDH	+165.25	+157.75	13.00	13.00	1	8
Bent 3	LRFD	24" CIDH	+165.39	+158.25	13.00	13.00	1	8
Abut 4	WSD	24" CIDH	+180.00	+170.71	10.00	19.55	1	6

Support No.	Design Method	Pile Type	Finished Grade Elevation (feet)	Cut-off Elevation (feet)	Pile Cap Size (feet)		Permissible Settlement under Service Load (inch)	Number of Pile per Support
					B	L		
Left Bridge (I-5 Southbound)								
Abut 1	WSD	24" CIDH	+171.50	+166.12	7.00	17.61	1	4
Bent 2	LRFD	24" CIDH	+157.40	+150.75	14.00	14.00	1	8
Bent 3	LRFD	24" CIDH	+152.00	+145.75	14.00	14.00	1	8
Abut 4	WSD	24" CIDH	+167.04	+160.31	7.00	14.37	1	4

Table 8-2. Foundation Design Loads

Support No.	Service-I Limit State (kips)			Strength Limit State (Controlling Group, kips)				Extreme Event Limit State (Controlling Group, kips)			
	Total Load		Permanent Loads	Compression		Tension		Compression		Tension	
	Per Support	Max. Per Pile	Per Support	Per Support	Max. Per Pile	Per Support	Max. Per Pile	Per Support	Max. Per Pile	Per Support	Max. Per Pile
Right Bridge (I-5 Northbound)											
Abut 1	660	183	590	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bent 2	768	N/A	610	1117	188	0	0	622	332	N/A	176
Bent 3	797	N/A	620	1218	193	0	0	631	342	N/A	184
Abut 4	616	127	538	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Left Bridge (I-5 Southbound)											
Abut 1	394	152	318	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bent 2	774	N/A	592	1216	194	0	0	589	340	N/A	192
Bent 3	726	N/A	556	1115	188	0	0	557	320	N/A	180
Abut 4	334	134	262	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

8.1.3 Axial Pile Capacity

Abutments 1 and 4, and Bents 2 and 3 foundation design recommendations are presented in Table 8-3 and Table 8-4, respectively. The Pile Data Table for the contract plans is presented in Table 8-5.

A pile-group efficiency factor (GEF) of 0.65 is used for a center-to-center pile spacing of 2.5 times the pile diameter, and a GEF of 1.0 is used for a center-to-center spacing of 4.0 times the pile diameter or greater (Section 10.8.3.6.3, AASHTO, 2007). Linear interpolation can be used to determine the GEF for intermediate spacings. Based on the layouts provided by the structural designers, GEF of 0.75 is used for Right and Left Bridge abutments, and GEF of 0.6 and 0.65 are used for Right Bridge and Left Bridge bents, respectively.

The pile capacity calculations are presented in Appendix C. The nominal resistances presented in Table 8-5 for the abutment and bent piles are determined as follows:

- Abutment 1 piles of the Right Bridge are controlled by the Service-I Limit State "Maximum Per Pile Load".
- Abutment 4 piles of the Right Bridge are controlled by the Service-I Limit State "Compression Per Support".
- Bents 2 and 3 piles of the Right Bridge are controlled by the Strength Limit State "Compression Per Support".
- Abutments 1 and 4 piles of the Left Bridge are controlled by the Service-I Limit State "Maximum Per Pile Load".
- Bents 2 and 3 piles of the Left Bridge are controlled by the Extreme Event Limit State "Maximum Per Pile Load".

The pile capacity is also based on soil resistance only and may be further limited by the pile-head connection details and the strength of the pile materials.

Table 8-3. Abutments Foundation Design Recommendations

Support	Pile	Cut-off Elevation (feet)	LRFD Service-I Limit State Load per Support (kips)		LRFD Service-I Limit State Total Load per Pile (Compression) (kips)	Nominal Resistance (kips)	Design Tip Elevations (feet)	Specified Tip Elevation (feet)
			Total	Permanent				
Right Bridge (I-5 Northbound)								
Abut 1	24" CIDH	+174.08	660	590	183	370	+125 (a) +156 (c) +146 (d)	+125
Abut 4	24" CIDH	+170.71	616	538	127	280	+133 (a) +152 (c) +142 (d)	+133
Left Bridge (I-5 Southbound)								
Abut 1	24" CIDH	+166.12	394	318	152	310	+122 (a) +137 (d)	+122
Abut 4	24" CIDH	+160.31	334	262	134	270	+119 (a) +131 (d)	+119

Notes:

1. Design tip elevations are controlled by the following demands: (a) Compression, (c) Settlement and (d) Lateral Load.
2. For Right Bridge, there are no design tip elevations for Tension at Abutments 1 and 4.
3. For Left Bridge, there are no design tip elevations for Tension and Settlement at Abutments 1 and 4.
4. For Right Bridge, the specified tip elevations for Abutments 1 and 4 shall not be raised above the design tip elevations for Settlement and Lateral Load.
5. For Left Bridge, the specified tip elevations for Abutments 1 and 4 shall not be raised above the design tip elevations for Lateral Load.

Table 8-4. Bent Foundation Design Recommendations

Support Location	Pile Type	Cut-off Elevation (feet)	Service-I Limit State Loads per Support (kips)	Total Permissible Support Settlement (inch)	Required Factored Nominal Resistance (kips)				Design Tip Elevations (feet)	Specified tip Elevation (feet)
					Strength Limit		Extreme Event			
					Comp. (ϕ=0.7)	Tension (ϕ=0.7)	Comp. (ϕ=1.0)	Tension (ϕ=1.0)		
Right Bridge (I-5 Northbound)										
Bent 2	24" CIDH	+157.75	768	1	188	0	332	176	+119 (a-I) +117 (a-II) +124 (b-II) +137 (c) +127 (d)	+117
Bent 3	24" CIDH	+158.25	797	1	193	0	342	184	+117 (a-I) +118 (a-II) +125 (b-II) +138 (c) +128 (d)	+117
Left Bridge (I-5 Southbound)										
Bent 2	24" CIDH	+150.75	774	1	194	0	340	192	+98 (a-I) +98 (a-II) +102 (b-II) +126 (c) +120 (d)	+98
Bent 3	24" CIDH	+145.75	726	1	188	0	320	180	+97 (a-I) +96 (a-II) +101 (b-II) +121 (c) +115 (d)	+96

Notes:

1. Design tip elevations are controlled by the following demands: (a-I) Compression (Strength Limit), (a-II) Compression (Extreme Event), (b-II) Tension (Extreme Event), (c) Settlement and (d) Lateral Load.
2. For Right and Left Bridges, there are no design tip elevations for Tension (Strength Limit) at Bents 2 and 3.
3. For Right and Left Bridges, the Specified tip elevations for Bents 2 and 3 shall not be raised above the design tip elevations for Tension, Settlement and Lateral Load.

Table 8-5. Pile Data Table

Location	Pile Type	Nominal Resistance (kips)		Design Tip Elevations (feet)	Specified Tip Elevation (feet)
		Compression	Tension		
Right Bridge (I-5 Northbound)					
Abut 1	24" CIDH	370	0	+125 (a) +156 (c) +146 (d)	+125
Bent 2	24" CIDH	360	190	+117 (a) +124 (b) +137 (c) +127 (d)	+117
Bent 3	24" CIDH	370	190	+117 (a) +125 (b) +138 (c) +128 (d)	+117
Abut 4	24" CIDH	280	0	+133 (a) +152 (c) +142 (d)	+133
Left Bridge (I-5 Southbound)					
Abut 1	24" CIDH	310	0	+122 (a) +137 (d)	+122
Bent 2	24" CIDH	340	200	+98 (a) +102 (b) +126 (c) +120 (d)	+98
Bent 3	24" CIDH	320	180	+96 (a) +101 (b) +121 (c) +115 (d)	+96
Abut 4	24" CIDH	270	0	+119 (a) +131 (d)	+119

Notes:

1. Design tip elevations are controlled by the following demands: (a) Compression, (b) Tension, (c) Settlement and (d) Lateral Load.
2. For Right Bridge, there are no design tip elevations for Tension at Abutments 1 and 4.
3. For Left Bridge, there are no design tip elevations for Tension and Settlement at Abutments 1 and 4.
4. For Right Bridge, the specified tip elevations for Abutments 1 and 4 shall not be raised above the design tip elevations for Settlement and Lateral Load.
5. For Left Bridge, the specified tip elevations for Abutments 1 and 4 shall not be raised above the design tip elevation for Lateral Load.
6. For Right and Left Bridges, the specified tip elevations for Bents 2 and 3 shall not be raised above the design tip elevations for Tension, Settlement and Lateral Load.

8.1.4 Lateral Pile Capacity

8.1.4.1 Lateral Pile Solutions

Results of lateral pile analysis in terms of pile-head shear and lateral deflection for a free-head condition are presented in Appendix C and summarized in Table 8-6. The maximum bending moment and the location of maximum moment are also presented. The solutions presented in Table 8-6 are entirely based on soil resistance and linear pile properties. Therefore, these values may be limited by the flexural strength (plastic moment) of the piles and pile-head connection details. Based on the pile layout provided by the structural designers, group efficiency factors of 0.7 and 0.52 were used for the right bridge abutment and bent piles, respectively. The group efficiency factor at the left bridge abutments and bents is 0.6. Lateral solutions are provided for pile-head deflections from 0.25 to 5 inches at each support, and linear interpolation can be used for solutions between pile-head deflections of 0.25 and 5 inches.

Table 8-6. Lateral Pile Solutions

Support Location	Pile Head Deflection (inch)	Pile Head Shear (kips)	Maximum Moment (kip-in)	Depth to Maximum Moment from Pile Top (feet)
Right Bridge				
Abutments 1 and 4 (24-inch CIDH)	¼	16.9	674	6.5
	½	26.8	1213	7.0
	1	43.8	2183	7.5
	2	66.9	3913	8.0
	5	104.7	8013	9.5
Bents 2 and 3 (24-inch CIDH)	¼	32.5	1019	5.5
	½	46.4	1644	6.0
	1	66.1	2649	6.5
	2	94.4	4280	7.5
	5	141.7	8012	8.5
Left Bridge				
Abutments 1 and 4 (24-inch CIDH)	¼	18.0	864	7.0
	½	28.3	1471	7.0
	1	44.8	2483	7.5
	2	66.6	4143	8.0
	5	102.4	7858	9.5
Bents 2 and 3 (24-inch CIDH)	¼	20.8	769	6.0
	½	29.7	1239	7.0
	1	42.3	1995	7.5
	2	60.5	3236	8.5
	5	95.1	6152	10.0

8.1.4.2 Lateral Load Resistance of Bent Pile Footing

Passive earth pressure at the bent pile cap can be used to resist a portion of the lateral loads transferred to the soil. For static design, the passive soil resistance against the embedded face of the bent pile cap should be neglected. Under earthquake loading, this ultimate passive soil resistance should be added to the pile group capacity to determine the total lateral resistance of the pile footing. At the bent location, the ultimate passive soil resistance against the pile footing is estimated to be equal to a maximum equivalent fluid pressure of 375 psf per foot of depth. Note that development of full passive earth pressure requires a lateral pile cap displacement equal to approximately 2 percent of the embedded height (measured from the nearest and lowest ground surface to the bottom of the pile cap). For displacement magnitudes smaller than what is required to mobilize full resistance, the actual resistance magnitude should be determined by linearly interpolating between zero and the full resistance.

8.2 WINGWALL

A Caltrans Standard Type 1 retaining wall is proposed just north of Abutment 1. The retaining wall pertinent data are presented in Table 8-7.

Table 8-7. Retaining Wall Pertinent Data

Location ("E" Line)		Length (feet)	Height (feet)	Bottom of Footing Elevation (feet)	Backfill Slope Condition	Wall Face Slope Condition
Begin Wall	End Wall					
362+24 11.5 Rt	362+82 11.5 Rt	58.0	4 to 14	+176.7 to +186.7	Level	1.75H:1V

Minimum footing embedment and offset (from a slope face) should conform to Section 4.4.5.1 of the Caltrans Bridge Design Specifications (2003b).

8.2.1 Bearing Capacity and Settlement

Soil settlement calculations were performed for the wall foundations using the footing bottom elevation shown on the wall plans, the Service Limit State bearing stress, and footing width as shown in the Caltrans Standard Plans (Caltrans, 2010b). As shown in Appendix C, the calculated maximum settlement is about 1 inch provided overexcavation and recompaction are performed for the soils below the footing bottom. The recommended minimum overexcavation depths are 1 feet for wall heights up to 8 feet, and 3 feet for wall heights between 10 and 14 feet.

Soil bearing capacity calculations were also performed using the footing bottom elevation presented in wall plans and the above recommended overexcavation and recompaction depth. Based on these calculations included in Appendix C, the factored gross nominal bearing resistance for Strength Limit State exceeds the bearing stresses for the Strength Limit State presented in the Caltrans Standard Plans (Caltrans, 2010b).

The horizontal limits of the overexcavation should begin one foot from each edge of the footing bottom and extending downward at a 45-degree imaginary plane until the plane intersects the recommended minimum overexcavation depth. In some areas, the 45-degree imaginary plane

could intersect temporary shoring. In this case only, the horizontal limit of the overexcavation should begin from the edge of the footing bottom and extending out a minimum of 1 foot and down until the plane intersects the recommended minimum overexcavation depth. Caltrans Structure Backfill should be used for backfilling with a minimum relative compaction of 95% of maximum density as determined by Caltrans Test Method 216. The overexcavation bottom should be proof rolled prior to backfilling. Further, the overexcavation bottom should be inspected by a qualified geotechnical engineer or technician to confirm the presence of an unyielding and competent surface.

8.2.2 Lateral Load Resistance

Resistance to lateral loads may be developed by a combination of friction acting at the base of the wall and passive earth pressure. A maximum passive equivalent fluid pressure of 120 psf per foot and a frictional coefficient of 0.45 can be used for foundation design for loading away from the slope face. The embedment (for passive resistance) should be measured from the lowest adjacent grade. We recommend 100% of the base friction for static loading. For seismic loading, we recommend combining 100% of the passive resistance and 100% of the base friction.

Global stability analyses were performed at the maximum wall height location. The soil strength parameters in Table 4-1 were used in the static and pseudo-static analysis and the results are presented in Appendix C. The factor-of-safety for a deep-seated failure is greater than the minimum required 1.5 under static condition with a 2-foot soil surcharge to represent traffic loading. Stability analysis for the pseudo-static condition was performed using a seismic coefficient equal to 0.133. Analysis indicates that the calculated factor of safety is greater than the required minimum of 1.1 under pseudo-static condition.

8.3 EMBANKMENTS SETTLEMENT AND SLOPE STABILITY

8.3.1 Settlement and Settlement Period

Fill will need to be placed to construct the approaches to the bridge widening. Up to 25 feet of sliver fill will be placed to construct the approaches to Abutments 1 and 4. Based on the onsite soil type, calculated ground subsidence at Abutments 1 and 4 is estimated to be less than 1 inch. We recommend a minimum settlement period of 5 days.

8.3.2 Slope Stability

Global stability analyses were conducted for both static and pseudo-static conditions for the bridge approach embankment slope. The analysis was performed using the computer program SLIDE 5.0 (Rocscience, 2006). The soil strength parameters in Table 4-1 were used in the static and pseudo-static analysis and the results are presented in Appendix C.

The calculated factor of safety for a deep-seated failure is greater than the minimum required 1.5 under static condition with a 2-foot soil surcharge to represent traffic loading. Slope stability analysis under pseudo-static condition was performed using a seismic coefficient equal to 0.133 (which is the smaller of either one-third the horizontal peak ground acceleration or 0.2g) in accordance with guidelines provided in Section 3.10 of the Caltrans Guidelines for Structures

Foundation Reports (Caltrans, 2009d). Analysis indicates that the calculated factor of safety is greater than the required minimum of 1.1 under pseudo-static condition.

For embankment slopes with a gradient of 2H:1V or flatter, surficial stability should not be a design concern. If slope paving is proposed for embankment slopes with a gradient of 1.5H:1V, then surficial stability is also not a design concern. If slope paving is not used for the 1.5H:1V slopes, it is recommended that the upper 4 feet of any new 1.5H:1V slope face be covered with materials with a minimum internal friction angle of 27 degrees and a minimum cohesion of 200 psf. This select material should be properly keyed and benched into the sloping ground. In all cases, proper maintenance with erosion protection and drainage control in accordance with Section 21 of Caltrans Standard Specifications (Caltrans, 2010c) are also recommended.

8.4 BRIDGE ABUTMENT WALL DESIGN

8.4.1 Abutment Earth Pressures

If abutment walls are free to move laterally at the top, a static active lateral earth pressure of 36 psf per foot of depth is recommended for a free draining, level and compacted backfill. If lateral movement at the top of abutment walls is restrained, the lateral earth pressure for a free draining, level and compacted backfill should follow Section 5.5.5.11 of the Caltrans BDS (Caltrans, 2004). For this condition, we recommend a coefficient of active lateral earth pressure of 0.3, a coefficient of at-rest lateral earth pressure of 0.46 and a soil unit weight of 120 lb/ft^3. If applicable, a uniform lateral pressure of at least 72 psf due to vehicle loads, equivalent to a vertical pressure produced by at least 2 feet of earth, should be added to the above lateral earth pressure.

8.4.2 Passive Resistance of Abutment Backfill

Under seismic loading, an ultimate passive earth pressure of 5 ksf may be used for the approach backfill and abutment walls with a height equal to or greater than 5.5 feet. For abutment walls with heights less than 5.5 feet, the passive pressure may be calculated proportionally (e.g., for a 4-foot high wall, the passive pressure is [4/5.5] x 5 ksf = 3.64 ksf. The horizontal movement at which the maximum passive pressure is expected to be fully mobilized can be determined following the procedure outlined in Section 7.8.1 of the Caltrans SDC (2010a).

9.0 CONSTRUCTION RECOMMENDATIONS

9.1 EARTHWORK

Earthwork should be performed in accordance with Caltrans Standard Specifications, Section 19 (Caltrans, 2010c). Appropriate measures should be taken to prevent damage to adjacent structures and utilities. Any design and construction of temporary sloping, sheeting, or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

During the recent field investigation conducted between September 27 and October 6, 2011, groundwater was encountered at elevations +137.4 feet and +168.6 feet. According to the attached as-built LOTB sheet for the 1969 widening, groundwater was encountered between elevations +135 and +155 feet. Using the above groundwater measurements, a wet construction will be required for the CIDH piles. Groundwater is not anticipated to be encountered during pile footing construction. However, groundwater level can fluctuate due to seasonal rainfall amount, local irrigation and groundwater recharge program and other man-made conditions. If groundwater is encountered during pile footing construction, it should be controlled in accordance with Section 19-3.03D of the Caltrans Standard Specifications (2010c).

9.2 PILE CONSTRUCTION

Difficult pile installation is anticipated due to the presence of localized dense and hard soil layers, above and below the bedrock contact, caving soils and high groundwater. Construction of CIDH piles should follow Section 49-3 of the Caltrans Standard Specifications (2010c). The Contractor should be required to drill the bottom of the shaft boring with a clean-out bucket to ensure adequate removal of loose soils. Both clean-out and concrete placement should be addressed in the specifications. The shaft borings should be inspected and approved by the Resident Engineer prior to installation of reinforcement. Per latest Caltrans requirement, 3-inch of concrete cover over reinforcement should be provided to improve the construction of the CIDH piles.

Based on groundwater measurements shown on the current and as-built LOTB sheets in Appendix A, a wet construction is anticipated. Contractor should be fully prepared to implement the Caltrans Standard Specifications and Special Provisions for a wet construction. Localized dewatering is not recommended because the operation could induce soil settlement which could damage buried utilities and nearby structures including the existing bridge.

On-site earth materials are generally fine-grained and contain a few thin layers of granular soil. Granular soils are susceptible to caving. The use of temporary casing is left to the contractor's discretion. If temporary casing is used, vibratory and oversized predrilling techniques for casing installation are not allowed. Temporary casing should be placed tight in the borehole. The casing should be pulled as the concrete is being poured while always maintaining at least a 5-foot head

of concrete inside the casing. If any boring becomes bell-shaped and cannot be advanced due to severe caving, all loose material should be removed from the bottom of the boring and the caved region filled with low strength sand-cement slurry. Drilling may continue when the slurry has reached its initial set.

9.3 BACKDRAIN AND BACKFILL REQUIREMENTS FOR ABUTMENT WALLS

Caltrans Structure Backfill should be used as backfill material behind the bridge abutment walls as shown in Figure 9-1. Backfill should be compacted in accordance with Section 19-5 of the Caltrans Standard Specifications (2010c). Backfill should be placed in loose lifts not exceeding 8 inches in thickness, moisture-conditioned to near optimum moisture content, and compacted to at least 95 percent relative compaction. The relative compaction should be based on the maximum density determined by California Test Method 216. Jetting or flooding to compact backfill is not recommended. Heavy compaction equipment, such as vibratory rollers, dozers, or loaders, should not be used adjacent to the abutment walls in order to avoid damaging the walls due to large lateral earth pressures.

Backdrains should be installed behind abutment walls to relieve hydrostatic pressure. Backdrains should be constructed in accordance with Bridge Detail 3-1 on Sheet B0-3 per Caltrans Standard Plans (2010b) or the geocomposite drain alternative per Section 6 of the Caltrans Bridge Design Details (1992).

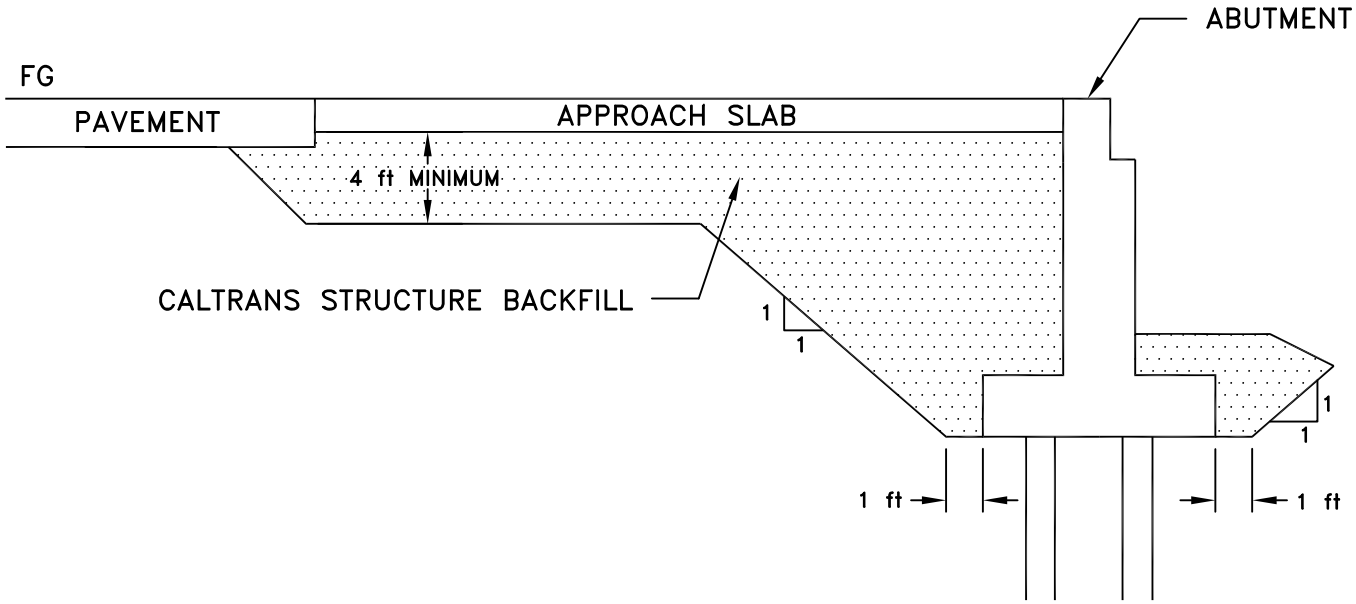
9.4 REVIEW OF CONSTRUCTION PLANS

Recommendations contained in this report are based on draft plans. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents. Recommendations contained in this report may require modification or additional recommendations may be necessary based on the final design.

9.5 GEOTECHNICAL OBSERVATION AND TESTING

It is recommended that inspections and testing be performed by the geotechnical consultant during the following stages of construction:

- Grading operations, including excavations and placement of compacted fill
- Shoring installation
- Footing excavations and pile constructions
- Backdrain installation and backfilling of bridge abutment walls
- Removal or installation of support of buried utilities or structures
- When any unusual subsurface conditions are encountered



NO SCALE

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	5/N5-N1 Connector Separation (Widen)	BRIDGE ABUTMENT WALL BACKFILL
	Project No. 11-137 / Date: 01-18-2013	FIGURE 9-1

10.0 LIMITATIONS

This report is intended for the use of OCTA, TRC and Caltrans for design and construction of the 5/N5-N1 Connector Separation (Bridge No. 55-0226). This report is based on the project as described and the information obtained from the exploratory borings at the approximate locations indicated on the attached LOTB sheets. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. In addition, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site. However, subsurface conditions and characteristics of soils between exploratory borings can vary. The findings reflect an interpretation of the direct evidence obtained. The recommendations presented in this report are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Such changes or variations may require a re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained in this report are applicable to the specific design element(s) and location(s) which is (are) the subject of this report. They have no applicability to any other design elements or to any other locations and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI has no responsibility for construction means, methods, techniques, sequences, or procedures; for safety precautions or programs in connection with the construction; for the acts or omissions of the CONTRACTOR or any other person performing any of the construction; or for the failure of any worker to carry out the construction in accordance with the Final Construction Drawings and Specifications.

Services performed by EMI have been conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.

11.0 REFERENCES

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Appendix A

LOG OF TEST BORING SHEETS

BENCH MARK

Designation: F-785 Elev = 75.717 feet (NAVD 88); 73.413 feet (NGVD29)
Described by OCS 2003 - Found 3¼" US Coast and Geodectic Survey Bronzed Disk Stamped "F 785 1946", Set in the Top of a Concrete Bridge Abutment. Monument is Located in the Southwesterly Corner of the Atchinso\Topeka and Santa Fe Railway Overcrossing of San Mateo Creek, 69 ft. Northerly Along the Railway from the Centerline of the Interstate 5 Freeway Southbound Onramp at Camino Capistrano Prolonged to the West and 150± Westerly from the Centerline of Camino Capistrano. Monument is Set 2.0 ft. below the Tracks.

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
12	ORA	5	6.2/8.7		

GEOTECHNICAL PROFESSIONAL DATE

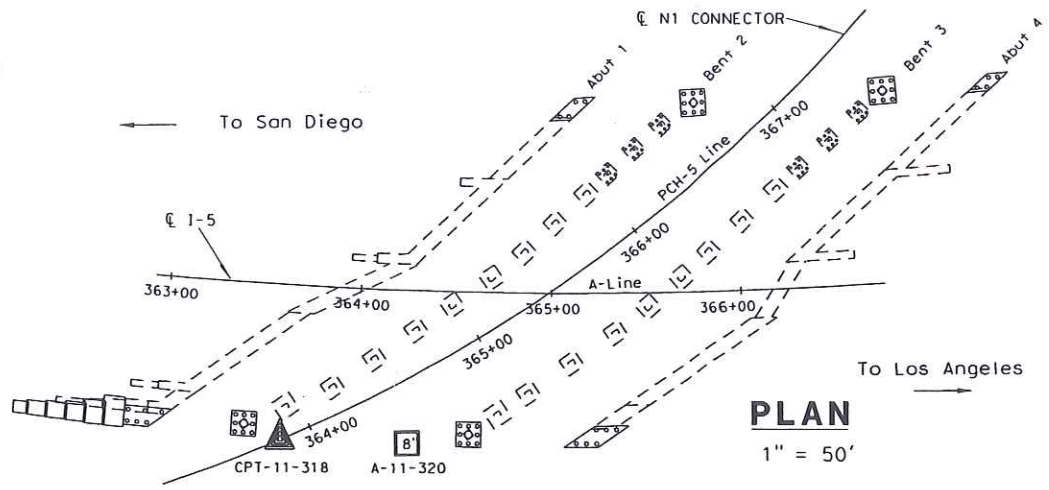
PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — S. PIRATHIVIRAJ — NO. GE 2963 — EXP. 12-31-13 — GEOTECHNICAL — STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ORANGE COUNTY TRANSPORTATION AUTHORITY
550 S. MAIN STREET
ORANGE, CA 92863-1584

EARTH MECHANICS, INC.
17800 NEWHOPE STREET, SUITE B
FOUNTAIN VALLEY, CA 92708



PLAN
1" = 50'

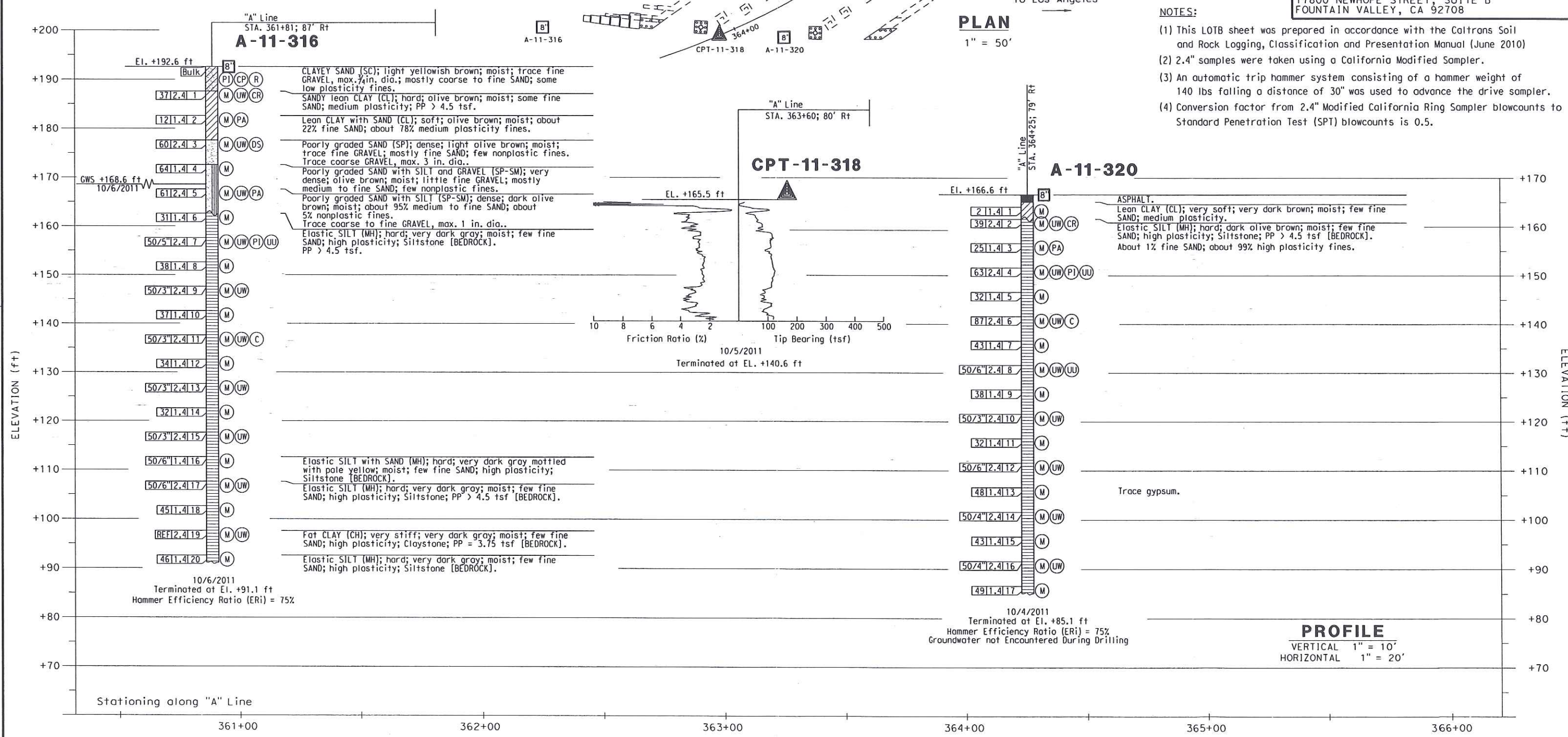
NOTES:

(1) This LOTB sheet was prepared in accordance with the Caltrans Soil and Rock Logging, Classification and Presentation Manual (June 2010)

(2) 2.4" samples were taken using a California Modified Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

(4) Conversion factor from 2.4" Modified California Ring Sampler blowcounts to Standard Penetration Test (SPT) blowcounts is 0.5.



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

NOTES:

TIME PLOTTED => $TIME
DATE PLOTTED => $DATE
USERNAME => $USER

DESIGN OVERSIGHT	DRAWN BY	J. Fang	R. Jie		PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	S. PIRATHIVIRAJ PROJECT ENGINEER	BRIDGE NO. 55-0226 / POST MILES 6.70
SIGN OFF DATE	CHECKED BY	S. PIRATHIVIRAJ	FIELD INVESTIGATION BY: DATE: 9/2011, 10/2011				

5/N5-N1 CONNECTOR SEPARATION (WIDEN)

LOG OF TEST BORINGS 1 OF 6

GS GEOTECHNICAL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 7/16/10)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

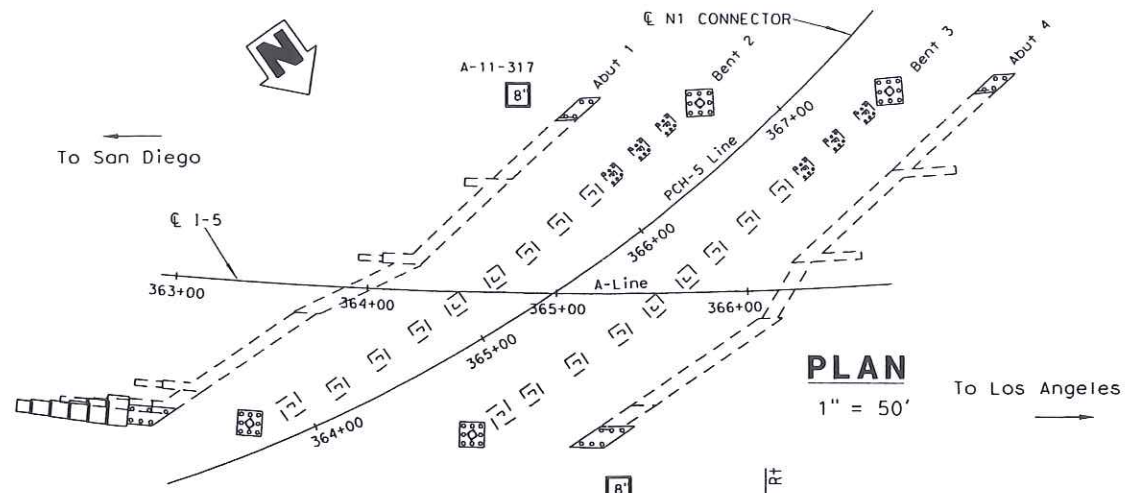
UNIT: 2998
PROJECT NUMBER & PHASE: 12000202791

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES | SHEET | OF

BENCH MARK

Designation: F-785 Elev = 75.717 feet (NAVD 88); 73.413 feet (NGVD29)
Described by OCS 2003 - Found 3¾" US Coast and Geodectic Survey Bronzed Disk Stamped "f 785 1946", Set in the Top of a Concrete Bridge Abutment. Monument is Located in the Southwesterly Corner of the Atchinso\Topeka and Santa Fe Railway Overcrossing of San Mateo Creek, 69 ft. Northerly Along the Railway from the Centerline of the Interstate 5 Freeway Southbound Onramp at Camino Capistrano Prolonged to the West and 150± Westerly from the Centerline of Camino Capistrano. Monument is Set 2.0 ft. below the Tracks.



PLAN
1" = 50'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
12	ORA	5	6.2/8.7		

GEOTECHNICAL PROFESSIONAL DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — S. PIRATHIVIRAJ — NO. GE 2963 — EXP. 12-31-13 — GEOTECHNICAL — STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ORANGE COUNTY TRANSPORTATION AUTHORITY
550 S. MAIN STREET
ORANGE, CA 92863-1584

EARTH MECHANICS, INC.
17800 NEWHOPE STREET, SUITE B
FOUNTAIN VALLEY, CA 92708

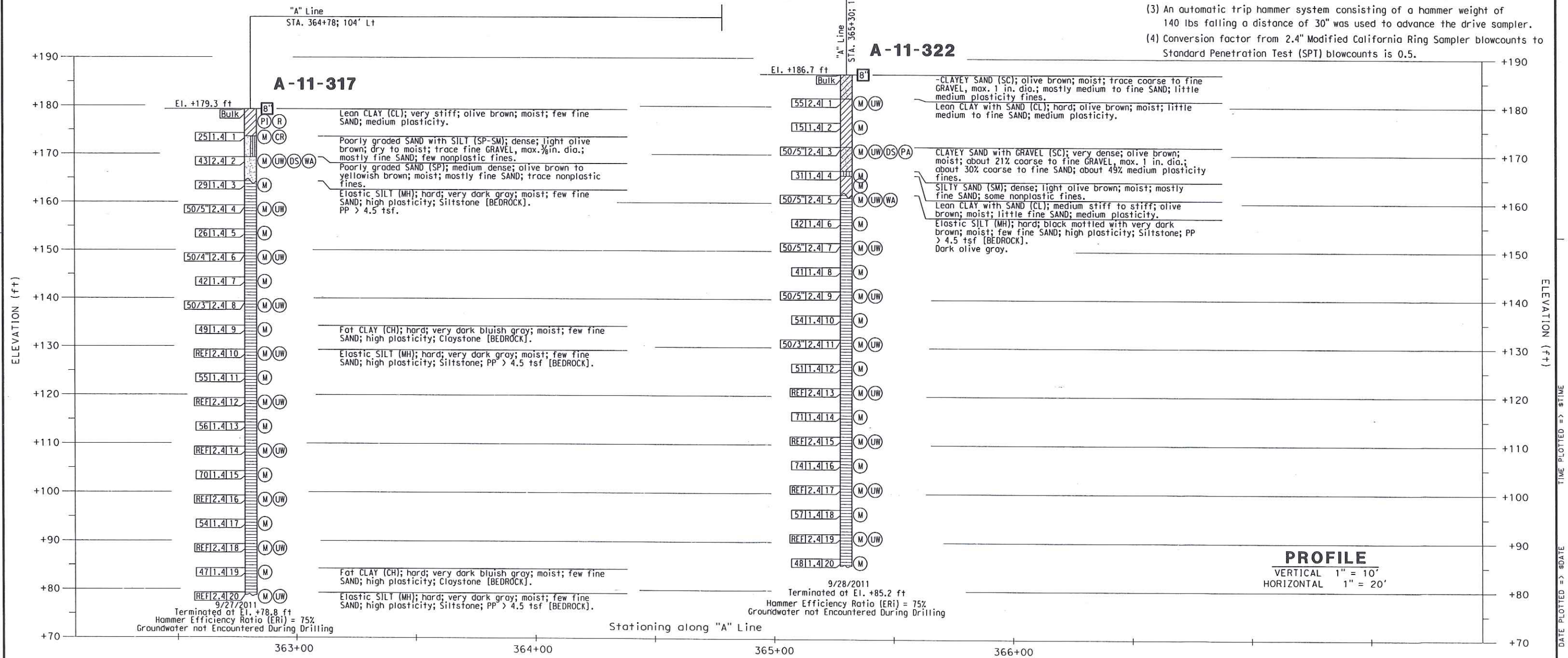
NOTES:

(1) This LOTB sheet was prepared in accordance with the Caltrans Soil and Rock Logging, Classification and Presentation Manual (June 2010)

(2) 2.4" samples were taken using a California Modified Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

(4) Conversion factor from 2.4" Modified California Ring Sampler blowcounts to Standard Penetration Test (SPT) blowcounts is 0.5.



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY	J. Fang	R. Jie		PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	S. PIRATHIVIRAJ	BRIDGE NO. 55-0226	5/N5-N1 CONNECTOR SEPARATION (WIDEN)
SIGN OFF DATE	CHECKED BY	S. PIRATHIVIRAJ	FIELD INVESTIGATION BY: DATE: 9/2011, 10/2011			PROJECT ENGINEER	POST MILES 6.70	LOG OF TEST BORINGS 2 OF 6

GS GEOTECHNICAL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 7/16/10)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

UNIT: 2998
PROJECT NUMBER & PHASE: 12000202791

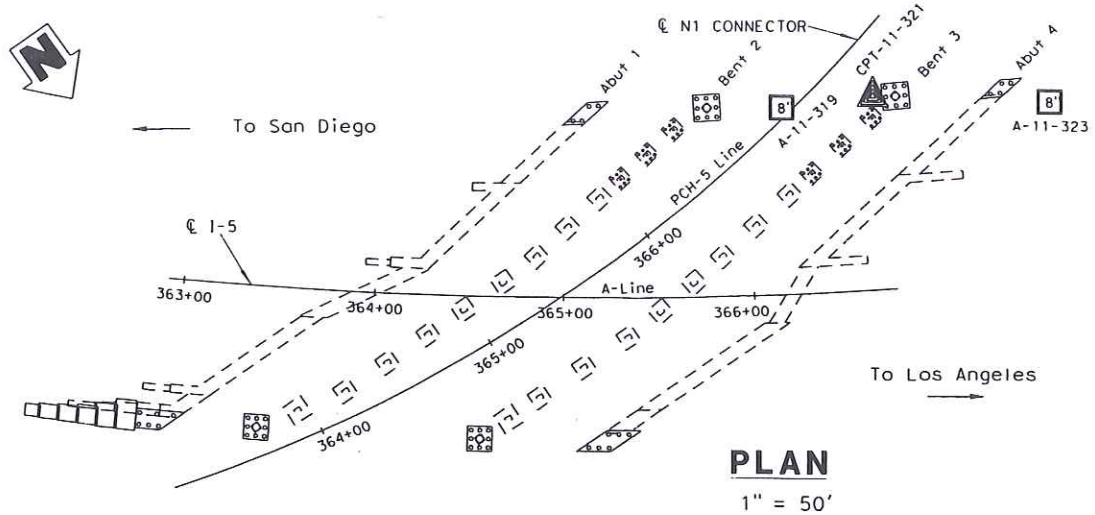
DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES | SHEET | OF

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

BENCH MARK

Designation: F-785 Elev = 75.717 feet (NAVD 88); 73.413 feet (NGVD29)
Described by OCS 2003 - Found 3¾" US Coast and Geodectic Survey Bronzed Disk Stamped "F 785 1946", Set in the Top of a Concrete Bridge Abutment. Monument is Located in the Southwesterly Corner of the Atchinso\Topeka and Santa Fe Railway Overcrossing of San Mateo Creek, 69 ft. Northerly Along the Railway from the Centerline of the Interstate 5 Freeway Southbound Onramp at Camino Capistrano Prolonged to the West and 150± Westerly from the Centerline of Camino Capistrano. Monument is Set 2.0 ft. below the Tracks.



PLAN
1" = 50'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
12	ORA	5	6.2/8.7		

GEOTECHNICAL PROFESSIONAL DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — S. PIRATHIVIRAJ — NO. GE 2963 — EXP. 12-31-13 — GEOTECHNICAL — STATE OF CALIFORNIA

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ORANGE COUNTY TRANSPORTATION AUTHORITY
550 S. MAIN STREET
ORANGE, CA 92863-1584

EARTH MECHANICS, INC.
17800 NEWHOPE STREET, SUITE B
FOUNTAIN VALLEY, CA 92708

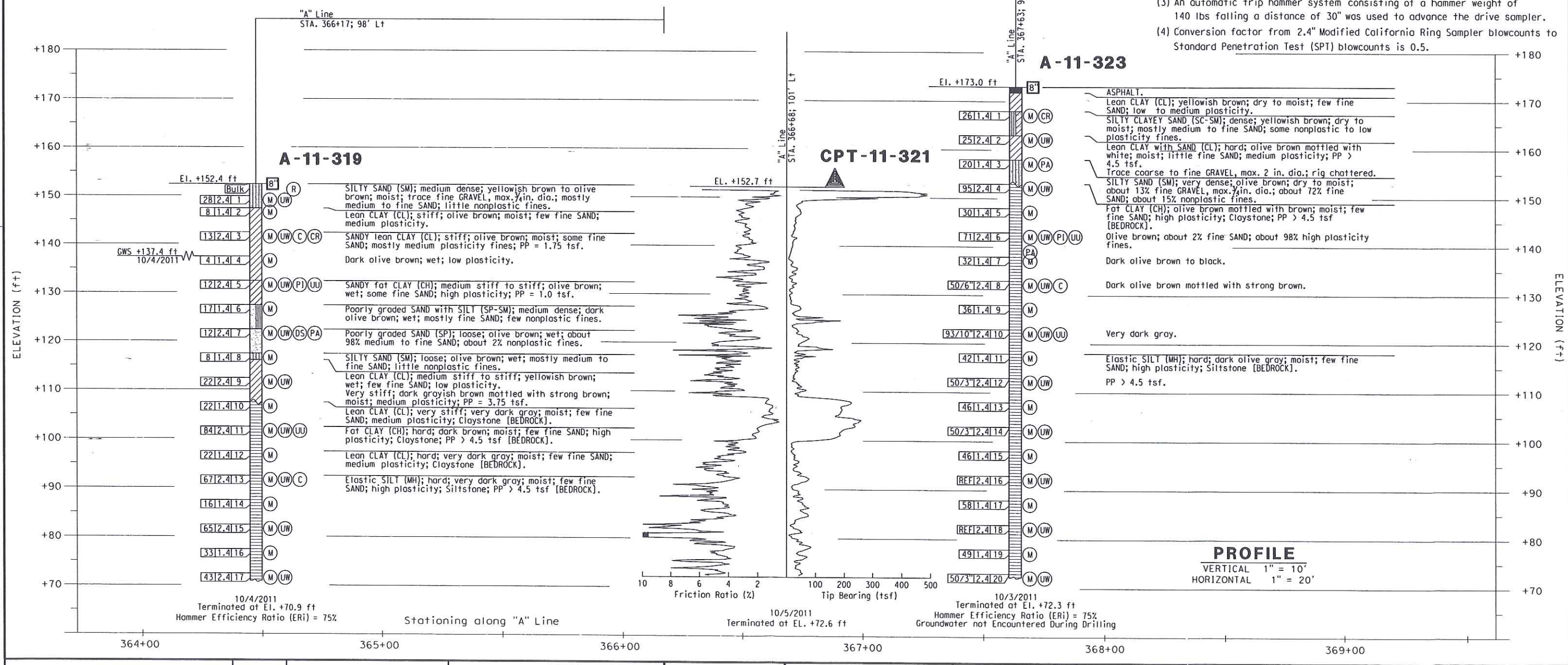
NOTES:

(1) This LOTB sheet was prepared in accordance with the Caltrans Soil and Rock Logging, Classification and Presentation Manual (June 2010)

(2) 2.4" samples were taken using a California Modified Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

(4) Conversion factor from 2.4" Modified California Ring Sampler blowcounts to Standard Penetration Test (SPT) blowcounts is 0.5.



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY	J. Fang	R. Jie	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	S. PIRATHIVIRAJ PROJECT ENGINEER	BRIDGE NO. 55-0226 / POST MILES 6.70
SIGN OFF DATE	CHECKED BY	S. PIRATHIVIRAJ	FIELD INVESTIGATION BY: DATE: 9/2011, 10/2011			5/N5-N1 CONNECTOR SEPARATION (WIDEN) LOG OF TEST BORINGS 3 OF 6

GS GEOTECHNICAL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 7/16/10)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

UNIT: 2998 PROJECT NUMBER & PHASE: 12000202791

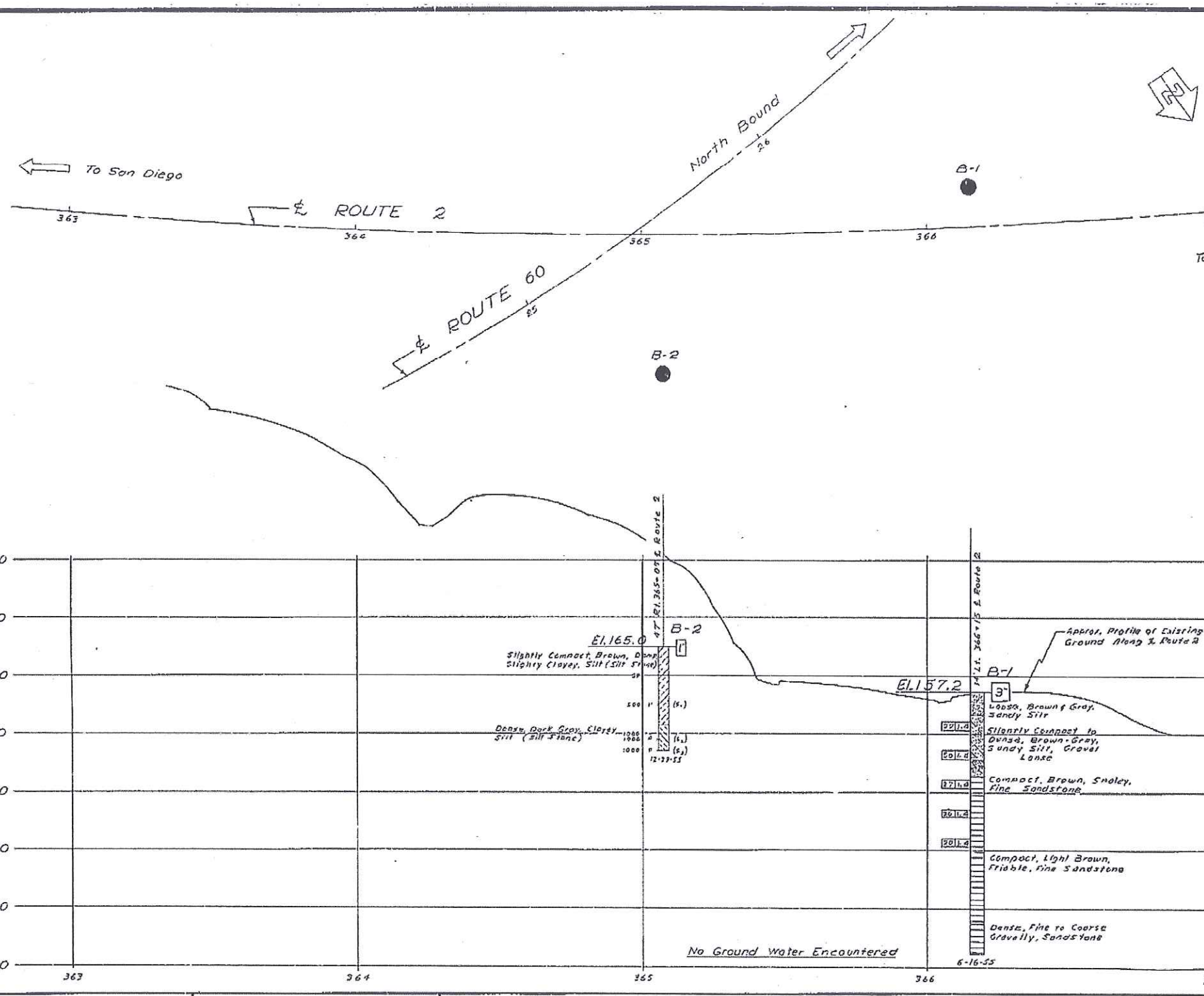
DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES | SHEET | OF

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

DIST.	COUNTY	ROUTE	SECTION	SHEET NO.	TOTAL SHEETS
VII	Org				

DATE APPROVED DECEMBER 15 1958



DIVISION OF ENGINEERING SERVICES - GEOTECHNICAL SERVICES

As-Built Log of Test Borings sheet is considered an informational document only. As such, the State of California registration seal with signature, license number and registration certificate expiration date confirm that this is a true and accurate copy of the original document. This drawing is available and presented only for the convenience of any bidder, contractor or other interested party.

DIST.	COUNTY	ROUTE	POST MILES-TOTAL PROJECT	Sheet No.	Total Sheets
12	ORA	5	6.2/8.7		

GEOTECHNICAL PROFESSIONAL — DATE

5/N5-N1 CONNECTOR SEPARATION (WIDEN)

LOG OF TEST BORINGS 4 OF 6

NOTE: A COPY OF THIS LOG OF TEST BORINGS IS AVAILABLE AT OFFICE OF STRUCTURE MAINTENANCE AND INVESTIGATIONS, SACRAMENTO, CALIFORNIA

UNIT:
PROJECT NUMBER & PHASE: 12000202791

BRIDGE No.	Sheet	of
55-0226	X	X

Revisions made to this Log of Test Borings from the original ___ Log of Test Borings are the addition of the following table and notes:

Boring	Station	Offset from C/L Rte. 101

REGISTERED PROFESSIONAL ENGINEER
S. PIRATHIVIRAJ
NO. GE 2963
EXP. 12-31-13
GEOTECHNICAL
STATE OF CALIFORNIA

AS BUILT PLANS
Contract No. 060-7VC2
Date Completed
Document No. 7000229 3

B.M. #37-a-SCle-54
L & T in P.C.C. Curb on N.W. Cor. of Int. of Via Serra & Via Corona. 18' W. & 42' N. of Int. Elev. 73.45

THIS SET OF PLANS HAS BEEN CORRECTED TO CORRESPOND TO THE "AS BUILT" PRINTS DATED 10-6-60, AS SUBMITTED BY RESIDENT ENGINEER C.R. Hall
TRACINGS CORRECTED BY: VJ DATE: 3-21-62

CLASSIFICATION OF MATERIAL BASED ON STANDARD GRADE SIZE LIMITS

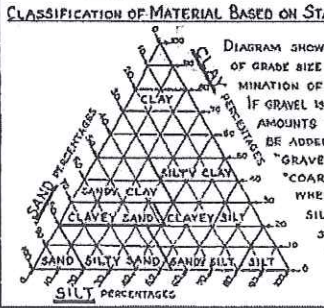


DIAGRAM SHOWING THE BASIS FOR ESTIMATES OF GRADE SIZE DISTRIBUTION USED IN DETERMINATION OF CLASS NAMES.

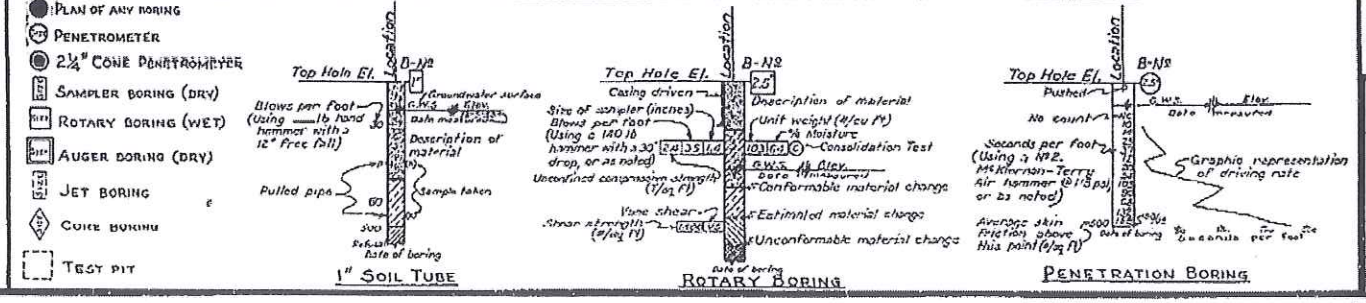
IF GRAVEL IS PRESENT IN APPRECIABLE AMOUNTS THE TERM "GRAVELLY" MAY BE ADDED TO THE CLASS NAME, VIZ. "GRAVELLY SAND". THE TERMS "COARSE", "MEDIUM" AND "FINE" WHEN USED TO DESCRIBE SAND, SILT AND GRAVEL REFER TO STANDARD GRADE SIZE LIMITS.

LEGEND OF EARTH MATERIALS

- GRAVEL
- SAND
- SILT
- CLAY
- SANDY CLAY OR CLAYEY SAND
- SANDY SILT OR SILTY SAND
- SILTY CLAY OR CLAYEY SILT
- PEAT AND/OR ORGANIC MATTER
- FILL MATERIAL
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

LEGEND OF BORING OPERATIONS

- PLAN OF ANY BORING
- PENETROMETER
- 2½" CONE PENETROMETER
- SAMPLER BORING (DRY)
- ROTARY BORING (WET)
- AUGER BORING (DRY)
- JET BORING
- CORE BORING
- TEST PIT



NOTES

The contractor's attention is directed to Section 2, Article (c) of the Standard Specifications and to the Special Provisions accompanying this set of plans.

Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis.

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

RTE. 2/60 SEPARATION

LOG OF TEST BORINGS

SCALE Horiz. 1"=20' Vert. 1"=10' | BRIDGE 55-226 X | FED. E-51 | DRAWING 12-4306-12

PREL. DRAWING NO. P. 4306 | 12

FED. ROAD DIV. NO.	STATE	F. A. PROJECT NO.	SHEET NO.	TOTAL SHEETS
7	CALIF.			

DIST.	COUNTY	ROUTE	POST MILES	SHEET NO.	TOTAL SHEETS
07	Ora.	5	8.9/9.3	225	394

DATE SUBMITTED: FEBRUARY 27, 1967

N 475, 869.60
E 1,067, 605.02

BENCH MARK

BM # 362-2A-60 Elev. 185.70
Set a standard brass cap monument
4' right of ℄ Freeway Station 362 + 90.88 B.C.

℄ SAN DIEGO FWY.

PLAN
Scale: 1" = 20'

STA. LINE RTE. 60

B-1 B-2 B-3 B-4 B-5 B-6

363 364 365 366 367

25 26 27 2A

AS BUILT PLANS
Contract No. 07-105224
Date Completed
Document No. 70000770

AS BUILT
CORRECTIONS BY Trujillo ndt 7-17-69
CONTRACT NO. 07-105224
DATE 3/17/68

LEGEND OF BORING OPERATIONS

Penetrometer; 2½" Cone Penetrometer (psf); Sampler Boring (psf); Rotary Boring (wet); Auger Boring (dry); Jet Boring; Core Boring; Test Pit

LEGEND OF EARTH MATERIALS

Gravel; Sand; Silt; Clay; Silty Clay or Clayey Silt; Peat or Organic Matter; Fill Material; Igneous Rock; Sandy Clay or Clayey Sand; Sedimentary Rock; Sandy Silt or Silty Sand; Metamorphic Rock

CLASSIFICATION OF MATERIAL BASED ON STANDARD GRADE SIZE LIMITS

Diagram showing the sizes the standard of grade size limitations used in determining the classification of coarse grained materials. Reference is made to the terms "gravelly" may be added to the main name, viz., "gravelly sand". Reference to the terms "coarse", "medium" and "fine" when used to describe sand, shall be in accordance with the standard grade size limits.

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis.

BRIDGE DEPARTMENT
ENGINEERING GEOLOGY SECTION

Approved for Recommendation: [signature]
Engineering Geologist

DIVISION OF ENGINEERING SERVICES - GEOTECHNICAL SERVICES

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DIST.	COUNTY	ROUTE	POST MILES-TOTAL PROJECT	Sheet No.	Total Sheets
12	ORA	5	6.2/8.7		

GEOTECHNICAL PROFESSIONAL [signature] DATE

5/N5-N1 CONNECTOR SEPARATION (WIDEN)

LOG OF TEST BORINGS 5 OF 6

NOTE: A COPY OF THIS LOG OF TEST BORINGS IS AVAILABLE AT OFFICE OF STRUCTURE MAINTENANCE AND INVESTIGATIONS, SACRAMENTO, CALIFORNIA

UNIT:
PROJECT NUMBER & PHASE: 12000202791

BRIDGE No.	Sheet	of
55-0226	X	X

Revisions made to this Log of Test Borings from the original ____ Log of Test Borings are the addition of the following table and notes:

Boring	Station	Offset from C/L Rte. 101

REGISTERED PROFESSIONAL ENGINEER
S. PIRATHIVIRAJ
NO. GE 2963
EXP. 12-31-13
GEOTECHNICAL
STATE OF CALIFORNIA

180 170 160 150 140 130 120

10-28-65 B-3 161± 10 FT. Sta. 362+74 ℄ SAN DIEGO FWY.

10-28-65 B-1 162± 10 FT. Sta. 364+67 ℄ SAN DIEGO FWY.

10-28-65 B-4 156± On line Sta. 364+72 ℄ SAN DIEGO FWY. GWS

10-28-65 B-2 157± On line Sta. 366+63 ℄ SAN DIEGO FWY.

Slightly compact, greenish-brown silt.

Compact, grey-brown, micaceous silt.

GWS 138± 10-28-65

Compact, dark grey to brown, micaceous silt with some thin layers of very fine sand.

Very dense, grey-green, micaceous, siltstone.

10-28-65 B-5 152± 68 FT. Sta. 365+71 ℄ SAN DIEGO FWY.

Approx. existing ground line along ℄ SAN DIEGO FWY.

10-28-65 B-6 155± 74 FT. Sta. 368+37 ℄ SAN DIEGO FWY.

361 365 366 367

PROFILE
Scale: Vert. 1" = 10'
Horiz. 1" = 20'

SHEET	OF
10.1	10

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

ROUTE 5/1 SEPARATION WIDENING

LOG OF TEST BORINGS

SCALE As Noted	BRIDGE 55-226	FILE	DRAWING 55226-23

Charge: 07209 Disregard prism bearing center numbers → PREL. DRAWING No. PR-

225

DIST.	COUNTY	ROUTE	SECTION	SHEET NO.	TOTAL SHEETS
07	ORA	5.1		171	171

DESIGN SECTION SUPERVISOR — REGISTERED CIVIL ENGINEER NO. 6298

DATE APPROVED May 24, 1971

DIVISION OF ENGINEERING SERVICES - GEOTECHNICAL SERVICES

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DIST.	COUNTY	ROUTE	POST MILES-TOTAL PROJECT	Sheet No.	Total Sheets
12	ORA	5	6.2/8.7		

PLAN

GEOTECHNICAL PROFESSIONAL — DATE

5/N5-N1 CONNECTOR SEPARATION (WIDEN)

LOG OF TEST BORINGS 6 OF 6

NOTE: A COPY OF THIS LOG OF TEST BORINGS IS AVAILABLE AT OFFICE OF STRUCTURE MAINTENANCE AND INVESTIGATIONS, SACRAMENTO, CALIFORNIA

UNIT: PROJECT NUMBER & PHASE: 12000202791

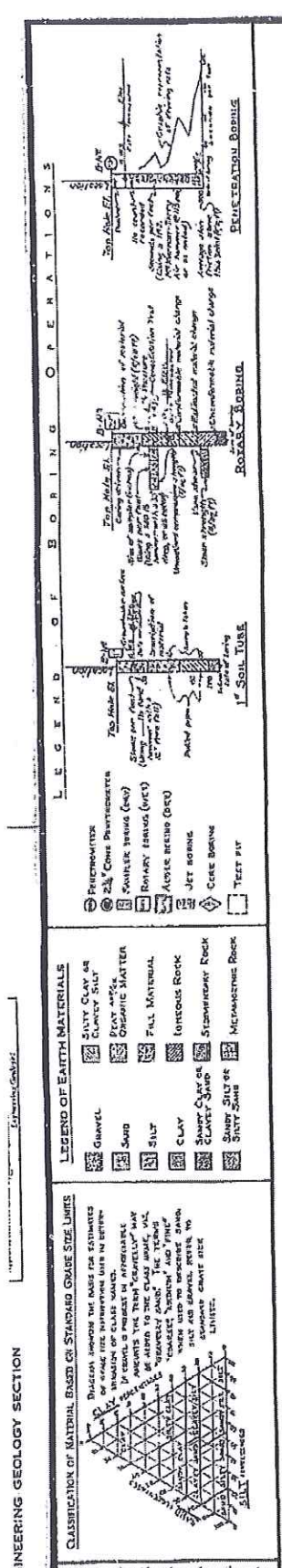
BRIDGE No.	Sheet	of
55-0226	1	1

Revisions made to this Log of Test Borings from the original ___ Log of Test Borings are the addition of the following table and notes:

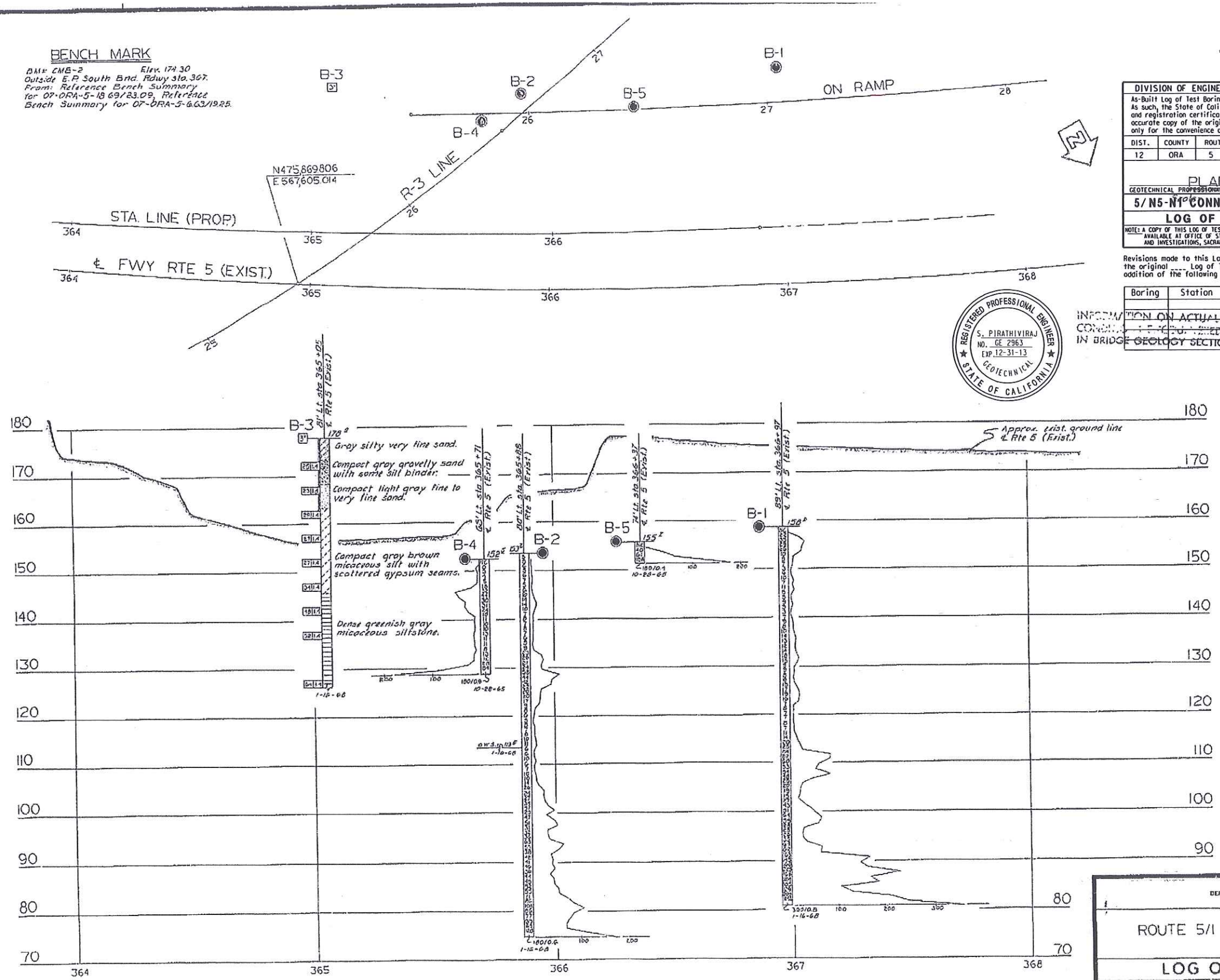
Boring	Station	Offset from C/L Rte. 101

INFORMATION ON ACTUAL FOUNDATION CONDITIONS ENCOUNTERED IS ON FILE IN BRIDGE GEOLOGY SECTION

REGISTERED PROFESSIONAL ENGINEER — S. PIRATHIVIRAJ — NO. GE 2963 — EXP. 12-31-13 — GEOTECHNICAL — STATE OF CALIFORNIA



NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis.



SHEET	OF
171	171

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

ROUTE 5/1 SEPARATION (WIDEN)

LOG OF TEST BORINGS

SCALE As Noted	BRIDGE 55-226	FILE	DRAWING 55226-23

AS BUILT PLANS
Contract No. 2105214

Chg: 07209
WA: 105211

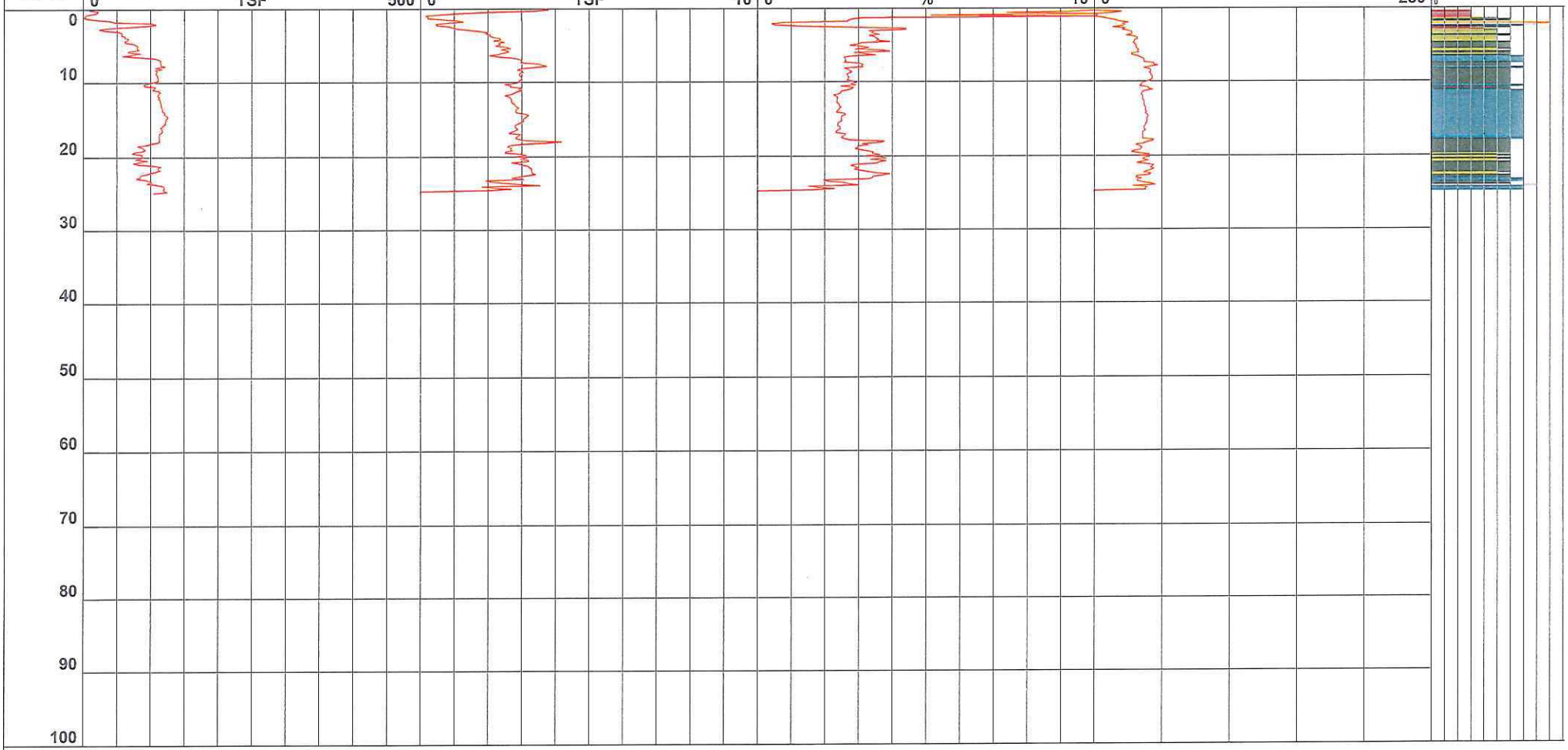
Disregard prints bearing earlier numbers → PREL. DRAWING No. PR-

ENGINEERING GEOLOGY SECTION

Earth Mechanics

Location	I-5 HOV Widening Segment 3	Operator	BH-DM	Filename	SDF(527).cpt
Job Number	11-137	Cone Number	DSG1104	GPS	
Hole Number	CPT-11-318	Date and Time	10/5/2011 12:06:49 AM	Maximum Depth	24.93 ft
Water Table Depth		>24.93 ft			

CPT DATA



1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

I-5 HOV Widening Segment 3

Project ID: Earth Mechanics
Data File: SDF(527).cpt
CPT Date: 10/5/2011 12:06:49 AM
GW During Test: No GW

Sounding ID: CPT-11-318
Project No: 11-137
Cone/Rig: DSG1104

Depth ft	qc PS tsf	qcln PS -	qlncs PS -	Slv Stss tsf	pore prss (psi)	Frct Ratio %	Mat Typ Zon	Material Behavior Description	Unit Wght pcf	Qc to N	SPT R-N	SPT R-N1 60%	Rel Den %	Ftn Ang deg	Und Shr tsf	OCR -	Fin Ic %	Nk -	Vol Strn %	Dry Stlmt 0.00	Liq Stlmt 0.02	Cycl SStn %
0.33	22.3	35.8	-	3.4	0.4	9.9	3	silty CLAY to CLAY	115	1.5	15	24	-	-	1.6	9.9	54	15	N/A	0.00	N/A	N/A
0.49	21.0	33.7	-	2.0	0.4	9.3	3	silty CLAY to CLAY	115	1.5	14	22	-	-	1.5	9.9	54	15	N/A	0.00	N/A	N/A
0.66	16.1	25.9	-	1.2	0.3	7.4	3	silty CLAY to CLAY	115	1.5	11	17	-	-	1.1	9.9	54	15	N/A	0.00	N/A	N/A
0.82	5.0	8.0	-	0.7	0.2	9.9	3	silty CLAY to CLAY	115	1.5	3	5	-	-	0.4	9.9	89	15	N/A	0.00	N/A	N/A
0.98	3.3	5.3	-	0.2	0.0	5.2	3	silty CLAY to CLAY	115	1.5	2	4	-	-	0.2	9.9	87	15	N/A	0.00	N/A	N/A
1.15	1.9	3.0	-	0.2	0.0	9.9	2	Organic SOILS - Peats	100	1.0	2	3	-	-	0.2	9.1	95	10	N/A	0.00	N/A	N/A
1.31	7.2	11.5	-	0.2	0.3	3.2	3	silty CLAY to CLAY	115	1.5	5	8	-	-	0.5	9.9	56	15	N/A	0.00	N/A	N/A
1.48	23.4	37.5	109.3	0.7	0.3	2.8	4	clayy SILT to silty CLAY	115	2.0	12	19	-	-	1.6	9.9	32	15	N/A	0.00	N/A	N/A
1.64	40.9	65.6	136.6	1.1	0.3	2.7	5	silty SAND to sandy SILT	120	4.0	10	16	53	48	-	-	24	16	N/A	0.00	N/A	N/A
1.80	47.5	76.1	145.4	1.3	0.1	2.7	5	silty SAND to sandy SILT	120	4.0	12	19	58	48	-	-	22	16	N/A	0.00	N/A	N/A
1.97	102.4	164.2	167.8	0.8	0.3	0.8	6	clean SAND to silty SAND	125	5.0	20	33	83	48	-	-	6	16	N/A	0.00	N/A	N/A
2.13	107.9	173.1	173.1	0.5	-0.3	0.4	6	clean SAND to silty SAND	125	5.0	22	35	85	48	-	-	5	16	N/A	0.00	N/A	N/A
2.30	94.3	151.2	151.2	0.5	-1.8	0.5	6	clean SAND to silty SAND	125	5.0	19	30	81	48	-	-	5	16	N/A	0.00	N/A	N/A
2.46	65.1	104.3	132.4	0.9	-2.6	1.3	6	clean SAND to silty SAND	125	5.0	13	21	68	48	-	-	12	16	N/A	0.00	N/A	N/A
2.62	36.6	58.6	128.8	1.0	-3.0	2.7	5	silty SAND to sandy SILT	120	4.0	9	15	49	45	-	-	25	16	N/A	0.00	N/A	N/A
2.79	24.4	39.1	-	1.1	-3.0	4.4	4	clayy SILT to silty CLAY	115	2.0	12	20	-	-	1.7	9.9	38	15	N/A	0.00	N/A	N/A
2.95	33.0	53.0	162.7	1.5	-2.9	4.4	4	clayy SILT to silty CLAY	115	2.0	17	26	-	-	2.3	9.9	33	15	N/A	0.00	N/A	N/A
3.12	53.1	85.1	173.4	1.8	-2.9	3.3	5	silty SAND to sandy SILT	120	4.0	13	21	62	46	-	-	24	16	N/A	0.00	N/A	N/A
3.28	57.5	92.3	184.9	2.0	-2.9	3.5	5	silty SAND to sandy SILT	120	4.0	14	23	64	46	-	-	23	16	0.00	-	0.02	0.0
3.45	57.5	92.3	182.8	1.9	-2.9	3.4	5	silty SAND to sandy SILT	120	4.0	14	23	64	46	-	-	23	16	0.00	-	0.02	0.0
3.61	57.5	92.3	189.4	2.1	-2.9	3.6	5	silty SAND to sandy SILT	120	4.0	14	23	64	46	-	-	24	16	0.00	-	0.02	0.0
3.77	62.2	99.8	189.0	2.1	-2.9	3.3	5	silty SAND to sandy SILT	120	4.0	16	25	67	46	-	-	22	16	0.00	-	0.02	0.0
3.94	62.1	99.6	193.3	2.2	-2.9	3.5	5	silty SAND to sandy SILT	120	4.0	16	25	67	46	-	-	22	16	0.00	-	0.02	0.0
4.10	67.5	108.3	203.4	2.4	-2.9	3.5	5	silty SAND to sandy SILT	120	4.0	17	27	70	46	-	-	22	16	0.00	-	0.02	0.0
4.27	66.2	106.1	203.9	2.4	-2.8	3.6	5	silty SAND to sandy SILT	120	4.0	17	27	69	46	-	-	22	16	0.00	-	0.02	0.0
4.43	62.2	99.7	195.2	2.2	-2.8	3.5	5	silty SAND to sandy SILT	120	4.0	16	25	67	46	-	-	23	16	0.00	-	0.02	0.0
4.59	63.6	102.1	209.5	2.5	-2.8	3.9	9	very stiff fine SOIL	120	2.0	32	51	68	46	-	-	24	30	0.00	-	0.02	0.0
4.76	75.4	120.9	202.6	2.3	-2.9	3.1	5	silty SAND to sandy SILT	120	4.0	19	30	73	46	-	-	19	16	0.00	-	0.02	0.0
4.92	79.3	127.1	206.0	2.4	-2.8	3.0	5	silty SAND to sandy SILT	120	4.0	20	32	75	46	-	-	18	16	0.00	-	0.02	0.0
5.09	81.7	131.1	201.8	2.3	-2.9	2.8	5	silty SAND to sandy SILT	120	4.0	20	33	76	46	-	-	17	16	0.00	-	0.02	0.0
5.25	80.8	129.6	213.2	2.5	-2.9	3.2	5	silty SAND to sandy SILT	120	4.0	20	32	76	46	-	-	19	16	0.00	-	0.02	0.0
5.41	80.8	129.5	218.5	2.7	-2.9	3.3	5	silty SAND to sandy SILT	120	4.0	20	32	76	46	-	-	19	16	0.00	-	0.02	0.0
5.58	83.2	133.4	209.2	2.4	-2.9	2.9	5	silty SAND to sandy SILT	120	4.0	21	33	77	46	-	-	18	16	0.00	-	0.02	0.0
5.74	69.3	111.1	212.9	2.6	-2.9	3.7	5	silty SAND to sandy SILT	120	4.0	17	28	70	45	-	-	22	16	0.00	-	0.02	0.0
5.91	66.8	107.2	215.4	2.6	-2.8	3.9	8	stiff SAND to clayy SAND	115	1.0	67	100	-	-	4.4	9.9	23	16	0.00	-	0.02	0.0
6.07	85.5	137.1	211.8	2.5	-2.8	2.9	5	silty SAND to sandy SILT	120	4.0	21	34	77	46	-	-	17	16	0.00	-	0.02	0.0
6.23	74.0	118.3	202.5	2.3	-2.8	3.2	5	silty SAND to sandy SILT	120	4.0	19	30	73	45	-	-	20	16	0.00	-	0.02	0.0
6.40	59.3	93.6	187.7	2.1	-2.8	3.5	5	silty SAND to sandy SILT	120	4.0	15	23	65	44	-	-	23	16	0.00	-	0.02	0.0
6.56	83.4	129.9	201.5	2.3	-2.8	2.8	5	silty SAND to sandy SILT	120	4.0	21	32	76	46	-	-	17	16	0.00	-	0.02	0.0
6.73	106.0	163.0	226.4	2.7	-3.0	2.6	5	silty SAND to sandy SILT	120	4.0	26	41	83	47	-	-	15	16	0.00	-	0.02	0.0
6.89	111.8	169.9	234.2	2.9	-2.9	2.6	5	silty SAND to sandy SILT	120	4.0	28	42	84	47	-	-	14	16	0.00	-	0.02	0.0
7.05	115.3	173.1	237.2	3.0	-2.9	2.6	5	silty SAND to sandy SILT	120	4.0	29	43	85	47	-	-	14	16	0.00	-	0.02	0.0
7.22	114.7	170.3	235.3	3.0	-2.9	2.6	5	silty SAND to sandy SILT	120	4.0	29	43	85	47	-	-	15	16	0.00	-	0.02	0.0
7.38	115.7	169.8	233.3	3.0	-2.9	2.6	5	silty SAND to sandy SILT	120	4.0	29	42	84	47	-	-	14	16	0.00	-	0.02	0.0
7.55	115.9	168.2	247.4	3.5	-2.9	3.0	5	silty SAND to sandy SILT	120	4.0	29	42	84	47	-	-	16	16	0.00	-	0.02	0.0
7.71	115.2	165.3	248.8	3.6	-2.9	3.1	5	silty SAND to sandy SILT	120	4.0	29	41	84	47	-	-	17	16	0.00	-	0.02	0.0
7.87	121.6	172.7	254.3	3.7	-3.0	3.1	5	silty SAND to sandy SILT	120	4.0	30	43	85	47	-	-	16	16	0.00	-	0.02	0.0
8.04	107.8	151.6	235.0	3.4	-3.0	3.1	5	silty SAND to sandy SILT	120	4.0	27	38	81	46	-	-	17	16	0.00	-	0.02	0.0
8.20	116.4	162.0	226.2	3.0	-3.1	2.6	5	silty SAND to sandy SILT	120	4.0	29	40	83	47	-	-	15	16	0.00	-	0.02	0.0
8.37	107.8	148.5	216.4	2.9	-3.0	2.7	5	silty SAND to sandy SILT	120	4.0	27	37	80	46	-	-	16	16	0.00	-	0.02	0.0
8.53	110.1	150.3	219.9	3.0	-3.1	2.7	5	silty SAND to sandy SILT	120	4.0	28	38	80	46	-	-	16	16	0.00	-	0.02	0.0
8.69	109.2	147.6	219.3	3.0	-3.1	2.8	5	silty SAND to sandy SILT	120	4.0	27	37	80	46	-	-	16	16	0.00	-	0.02	0.0
8.86	108.0	144.5	214.8	3.0	-3.1	2.8	5	silty SAND to sandy SILT	120	4.0	27	36	79	46	-	-	16	16	0.00	-	0.02	0.0
9.02	110.5	146.5	213.9	2.9	-3.1	2.7	5	silty SAND to sandy SILT	120	4.0	28	37	80	46	-	-	16	16	0.00	-	0.02	0.0
9.19	110.2	144.8	212.7	3.0	-3.1	2.7	5	silty SAND to sandy SILT	120	4.0	28	36	79	46	-	-	16	16	0.00	-	0.02	0.0
9.35	111.3	145.0	213.7	3.0	-3.1	2.7	5	silty SAND to sandy SILT	120	4.0	28	36	79	46	-	-	16	16	0.00	-	0.02	0.0
9.51	111.2	143.6	212.7	3.0	-3.1	2.7	5	silty SAND to sandy SILT	120	4.0	28	36	79	46	-	-	16	16	0.00	-	0.02	0.0
9.68	111.5	142.7	211.4	3.0	-3.1	2.7	5	silty SAND to sandy SILT	120	4.0	28	36	79	46	-	-	16	16	0.00	-	0.02	0.0
9.84	110.7	140.5	208.0	2.9	-3.1	2.7	5	silty SAND to sandy SILT	120	4.0	28	35	78	46	-	-	16	16	0.00	-	0.02	0.0
10.01	104.4	131.4	204.3	2.9	-3.1	2.8	5	silty SAND to sandy SILT	120	4.0	26	33	76	46	-	-	17	16	0.00	-	0.02	0.0
10.17	96.9	120.9	198.5	2.9	-3.1	3.0	5	silty SAND to sandy SILT	120	4.0	24	30	73	45	-	-	19	16	0.00	-	0.02	0.0
10.34	90.6	112.2	185.0	2.5	-3.1	2.8	5	silty SAND to sandy SILT	120	4.0	23	28	71	45	-	-	19	16	0.00	-	0.02	0.0
10.50	92.1	113.2	189.9	2.7	-3.1	2.9	5	silty SAND to sandy SILT	120	4.0	23	28	71	45	-	-	19	16	0.00	-	0.02	0.0
10.66	107.7	131.3	193.5	2.7	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	27	33	76	45	-	-	16	16	0.00	-	0.02	0.0
10.83	105.7	127.9	201.8	3.0	-3.1	2.9	5	silty SAND to sandy SILT	120	4.0	26	32	75	45	-	-	18	16	0.00	-	0.02	0.0
10.99	103.9	124.8	197.8	2.9	-3.1	2.8	5	silty SAND to sandy SILT	120	4.0	26	31	74	45	-	-	18	16	0.00	-	0.02	0.0
11.16	112.7	134.3	202.2	3.0	-3.2	2.7	5	silty SAND to sandy SILT	120	4.0	28	34	77	45	-	-	17	16	0.00	-	0.02	0.0
11.32	115.0	136.0	197.9	2.9	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	29	34	77	46	-	-	16	16	0.00	-	0.02	0.0
11.48	112.7	132.3	194.4	2.8	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	28	33	76	45	-	-	16	16	0.00	-	0.02	0.0
11.65	111.2	129.7	190.1	2.7	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	28	32	76	45	-	-	16	16	0.00	-	0.02	0.0
11.81	111.1	128.6	183.8	2.5	-3.2	2.3	5	silty SAND to sandy SILT	120	4.0	28	32	75	45	-	-	15	16	0.00	-	0.02	0.0
11.98	113.4	130.4	187.5	2.6	-3.2	2.3	5	silty SAND to sandy SILT	120	4.0	28	33	76	45	-	-	16	16	0.00	-	0.02	0.0
12.14	111.8	127.7	186.7	2.7	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	28	32	75	45	-	-	16	16	0.00	-	0.02	0.0
12.30	114.3	129.6	188.2	2.7	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	29	32	76	45	-	-	16	16	0.00	-	0.02	0.0
12.47	114.3	128.8	187.3	2.7	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	29	32	75	45	-	-	16	16	0.00	-	0.02	0.0
12.63	115.0	128.7	187.0	2.7	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	29	32	75	45	-	-	16	16	0.00	-	0.02	0.0
12.80	115.8	128.7	187.0	2.7	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	29	32	75	45	-	-	16	16	0.00	-	0.02	0.0
12.96	116.4	128.6	188.3	2.8	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	29	32	75	45	-	-	16	16	0.00	-	0.02	0.0
13.12	116.1	127.5	188.1	2.8	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	29	32	75	45	-	-	16	16	0.00	-	0.02	0.0
13.29	116.9	127.6	188.4	2.8	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	29	32	75	45	-	-	16	16	0.00	-	0.02	0.0
13.45	117.7	127.6	190.1	2.9	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	29	32	75	45	-	-	16	16	0.00	-	0.02	0.0
13.62	118.0	127.2	187.8	2.9	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	30	32	75	45	-	-	16	16	0.00	-	0.02	0.0
13.78	117.5	125.9	186.3	2.8	-3.1	2.4	5	silty SAND to sandy SILT	120	4.0	29	31	75	45	-	-	16	16	0.00	-	0.02	0.0
13.94	120.0	127.8	186.1	2.8	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	30	32	75	45	-	-	16	16	0.00	-	0.02	0.0
14.11	121.7	128.9	187.1	2.9	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	30	32	75	45	-	-	16	16	0.00	-	0.02	0.0
14.27	120.5	126.8	192.7	3.1	-3.2	2.6	5	silty SAND to sandy SILT	120	4.0	30	32	75	45	-	-	17	16	0.00	-	0.02	0.0
14.44	123.2	128.9	195.3	3.2	-3.2	2.6	5	silty SAND to sandy SILT	120	4.0	31	32	75	45	-	-	17	16	0.00	-	0.02	0.0
14.60	126.2	131.3	194.3	3.2	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	32	33	76	45	-	-	16	16	0.00	-	0.02	0.0
14.76	125.1	129.4	192.1	3.1	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	31	32	76	45	-	-	16	16	0.00	-	0.02	0.0
14.93	123.0	126.6	189.3	3.1	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	31	32	75	45	-	-	16	16	0.00	-	0.02	0.0
15.09	123.4	126.3	188.8	3.1	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	31	32	75	45	-	-	16	16	0.00	-	0.02	0.0
15.26	122.2	124.4	187.8	3.1	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	31	31	74	45	-	-	17	16	0.00	-	0.02	0.0
15.42	121.9	123.4	185.0	3.0	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	30	31	74	45	-	-	17	16	0.00	-	0.02	0.0

* Indicates the parameter was calculated using the normalized point stress.
The parameters listed above were determined using empirical correlations.
A Professional Engineer must determine their suitability for analysis and design.

Middle Earth Geo Testing

Project ID: Earth Mechanics
Data File: SDF(527).cpt
CPT Date: 10/5/2011 12:06:49 AM
GW During Test: No GW

Sounding ID: CPT-11-318
Project No: 11-137
Cone/Rig: DSG1104

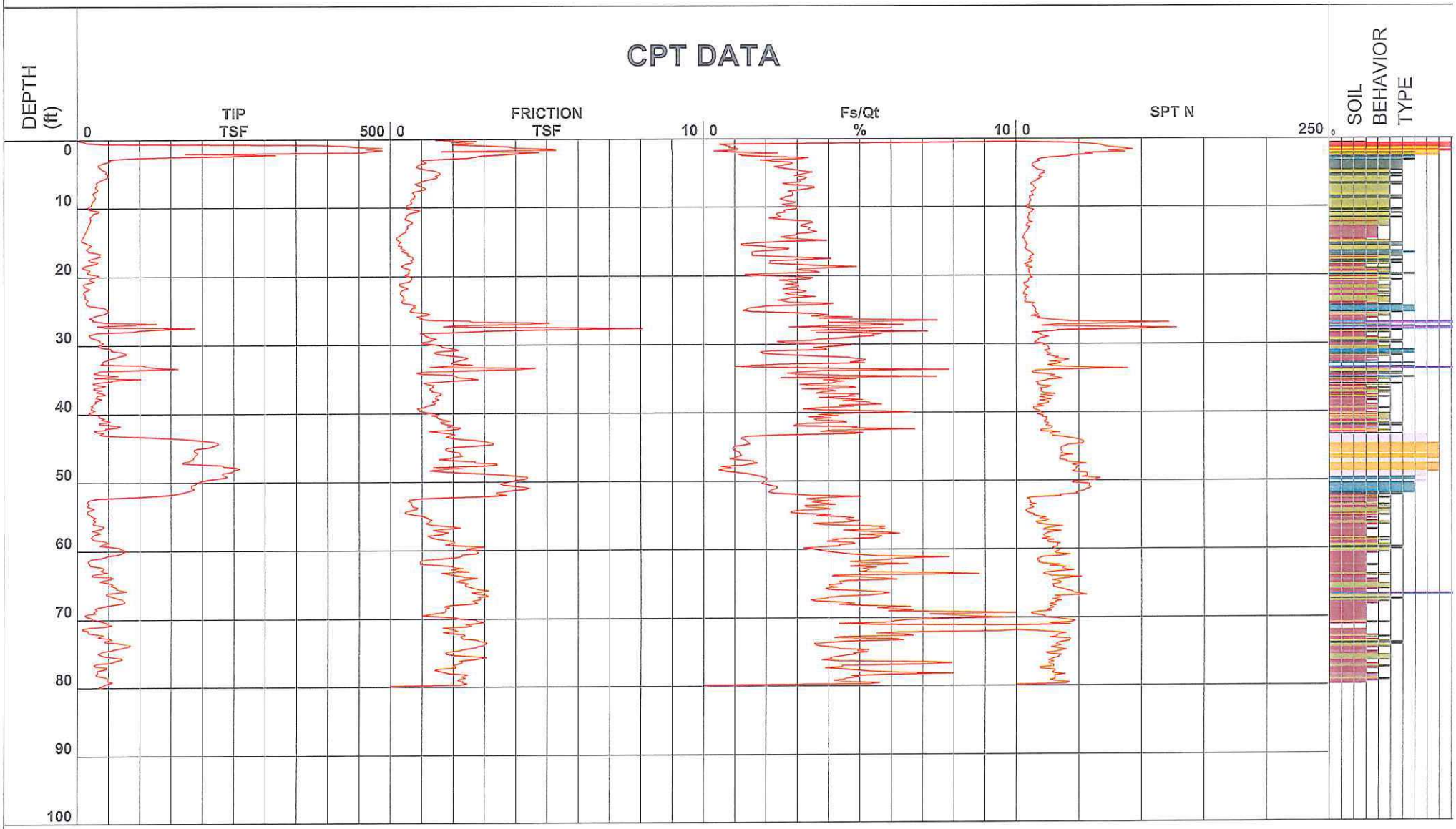
Depth ft	qc PS tsf	qcln PS -	qlncs PS -	Slv Stss tsf	pore prss (psi)	Frct Rato %	Mat Typ Zon	Material Behavior Description	Unit Wght pcf	Qc to N	SPT R-N 60%	SPT R-Nl 60%	Rel Den %	Ftn Ang deg	Und Shr tsf	OCR -	Fin Ic -	Nk -	Vol Strn %	Dry Stlmt 0.00	Liq Stlmt 0.02	Cycl SStn %
15.58	122.2	123.1	183.0	2.9	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	31	31	74	45	-	-	16	16	0.00	-	0.02	0.0
15.75	119.2	119.4	179.3	2.8	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	30	30	73	44	-	-	17	16	0.00	-	0.02	0.0
15.91	118.4	118.0	177.7	2.8	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	30	30	72	44	-	-	17	16	0.00	-	0.02	0.0
16.08	115.0	114.1	176.0	2.8	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	29	29	71	44	-	-	17	16	0.00	-	0.02	0.0
16.24	116.8	115.3	177.4	2.9	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	29	29	72	44	-	-	17	16	0.00	-	0.02	0.0
16.40	117.4	115.2	177.6	2.9	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	29	29	72	44	-	-	17	16	0.00	-	0.02	0.0
16.57	117.8	115.0	175.2	2.8	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	29	29	72	44	-	-	17	16	0.00	-	0.02	0.0
16.73	116.6	113.3	171.8	2.7	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	29	28	71	44	-	-	17	16	0.00	-	0.02	0.0
16.90	113.5	109.8	168.5	2.6	-3.2	2.4	5	silty SAND to sandy SILT	120	4.0	28	27	70	44	-	-	17	16	0.00	-	0.02	0.0
17.06	113.7	109.4	177.0	3.0	-3.2	2.6	5	silty SAND to sandy SILT	120	4.0	28	27	70	44	-	-	18	16	0.00	-	0.02	0.0
17.23	112.6	107.9	175.3	2.9	-3.2	2.6	5	silty SAND to sandy SILT	120	4.0	28	27	70	44	-	-	18	16	0.00	-	0.02	0.0
17.39	112.9	107.6	173.0	2.9	-3.2	2.6	5	silty SAND to sandy SILT	120	4.0	28	27	69	44	-	-	18	16	0.00	-	0.02	0.0
17.55	113.6	107.7	171.8	2.8	-3.2	2.5	5	silty SAND to sandy SILT	120	4.0	28	27	69	44	-	-	18	16	0.00	-	0.02	0.0
17.72	112.7	106.4	174.0	2.9	-3.2	2.6	5	silty SAND to sandy SILT	120	4.0	28	27	69	44	-	-	19	16	0.00	-	0.02	0.0
17.88	114.0	107.1	179.3	3.1	-3.2	2.8	5	silty SAND to sandy SILT	120	4.0	28	27	69	44	-	-	19	16	0.00	-	0.02	0.0
18.05	111.4	104.3	208.0	4.2	-3.2	3.8	5	silty SAND to sandy SILT	120	4.0	28	26	68	44	-	-	23	16	0.00	-	0.02	0.0
18.21	101.9	94.9	195.8	3.8	-3.2	3.7	5	silty SAND to sandy SILT	120	4.0	25	24	65	43	-	-	24	16	0.00	-	0.02	0.0
18.37	95.8	88.8	172.5	3.0	-3.1	3.1	5	silty SAND to sandy SILT	120	4.0	24	22	63	43	-	-	22	16	0.00	-	0.02	0.0
18.54	81.4	75.1	163.6	2.7	-3.2	3.3	4	clayy SILT to silty CLAY	115	2.0	41	38	-	-	5.7	9.9	25	15	0.00	-	0.02	0.0
18.70	87.1	80.0	160.0	2.6	-3.2	3.0	5	silty SAND to sandy SILT	120	4.0	22	20	60	42	-	-	23	16	0.52	-	0.02	3.2
18.87	90.2	82.5	163.2	2.7	-3.2	3.0	5	silty SAND to sandy SILT	120	4.0	23	21	61	42	-	-	23	16	0.00	-	0.02	0.0
19.03	91.9	83.7	161.7	2.7	-3.1	2.9	5	silty SAND to sandy SILT	120	4.0	23	21	61	42	-	-	22	16	0.00	-	0.02	0.0
19.19	88.9	80.6	163.4	2.7	-3.1	3.1	5	silty SAND to sandy SILT	120	4.0	22	20	60	42	-	-	23	16	0.00	-	0.02	0.0
19.36	77.2	69.8	158.1	2.5	-3.1	3.3	4	clayy SILT to silty CLAY	115	2.0	39	35	-	-	5.4	9.9	26	15	0.60	-	0.02	4.2
19.52	73.6	66.2	158.4	2.5	-3.1	3.5	4	clayy SILT to silty CLAY	115	2.0	37	33	-	-	5.2	9.9	27	15	0.60	-	0.02	4.3
19.69	87.9	78.7	170.7	3.0	-3.1	3.4	4	clayy SILT to silty CLAY	115	2.0	44	39	-	-	6.2	9.9	25	15	0.00	-	0.02	0.0
19.85	86.6	77.3	175.6	3.1	-3.2	3.7	4	clayy SILT to silty CLAY	115	2.0	43	39	-	-	6.1	9.9	26	15	0.00	-	0.02	0.0
20.01	89.4	79.4	166.4	2.9	-3.1	3.3	5	silty SAND to sandy SILT	120	4.0	22	20	59	42	-	-	24	16	0.00	-	0.02	0.0
20.18	85.2	75.4	175.2	3.1	-3.0	3.7	4	clayy SILT to silty CLAY	115	2.0	43	38	-	-	6.0	9.9	27	15	0.00	-	0.02	0.0
20.34	78.2	69.0	171.0	3.0	-3.0	3.9	4	clayy SILT to silty CLAY	115	2.0	39	34	-	-	5.5	9.9	28	15	0.00	-	0.02	0.0
20.51	95.3	83.7	174.9	3.2	-3.0	3.4	5	silty SAND to sandy SILT	120	4.0	24	21	61	42	-	-	24	16	0.00	-	0.02	0.0
20.67	84.2	73.7	176.3	3.2	-3.1	3.9	4	clayy SILT to silty CLAY	115	2.0	42	37	-	-	5.9	9.9	27	15	0.00	-	0.02	0.0
20.83	75.5	65.8	162.5	2.7	-3.1	3.7	4	clayy SILT to silty CLAY	115	2.0	38	33	-	-	5.3	9.9	28	15	0.00	-	0.02	0.0
21.00	82.5	71.6	167.1	2.9	-3.1	3.6	4	clayy SILT to silty CLAY	115	2.0	41	36	-	-	5.8	9.9	27	15	0.00	-	0.02	0.0
21.16	104.7	90.5	168.7	3.1	-3.2	3.0	5	silty SAND to sandy SILT	120	4.0	26	23	64	43	-	-	22	16	0.00	-	0.02	0.0
21.33	115.3	99.4	173.2	3.2	-3.2	2.8	5	silty SAND to sandy SILT	120	4.0	29	25	67	43	-	-	20	16	0.00	-	0.02	0.0
21.49	111.2	95.5	173.0	3.2	-3.1	2.9	5	silty SAND to sandy SILT	120	4.0	28	24	65	43	-	-	21	16	0.00	-	0.02	0.0
21.65	111.0	94.9	174.7	3.3	-3.2	3.0	5	silty SAND to sandy SILT	120	4.0	28	24	65	43	-	-	21	16	0.00	-	0.02	0.0
21.82	114.1	97.2	174.2	3.3	-3.2	2.9	5	silty SAND to sandy SILT	120	4.0	29	24	66	43	-	-	21	16	0.00	-	0.02	0.0
21.98	108.6	92.2	174.0	3.3	-3.2	3.1	5	silty SAND to sandy SILT	120	4.0	27	23	64	43	-	-	22	16	0.00	-	0.02	0.0
22.15	101.4	85.7	174.3	3.3	-3.2	3.3	5	silty SAND to sandy SILT	120	4.0	25	21	62	42	-	-	23	16	0.00	-	0.02	0.0
22.31	95.8	80.7	174.9	3.3	-3.1	3.5	4	clayy SILT to silty CLAY	115	2.0	48	40	-	-	6.7	9.9	25	15	0.00	-	0.02	0.0
22.47	87.3	73.3	179.0	3.4	-3.1	4.0	4	clayy SILT to silty CLAY	115	2.0	44	37	-	-	6.1	9.9	28	15	0.00	-	0.02	0.0
22.64	85.1	71.1	171.2	3.2	-3.1	3.8	4	clayy SILT to silty CLAY	115	2.0	43	36	-	-	6.0	9.9	27	15	0.00	-	0.02	0.0
22.80	84.7	70.6	163.2	2.9	-3.1	3.5	4	clayy SILT to silty CLAY	115	2.0	42	35	-	-	5.9	9.9	26	15	0.00	-	0.02	0.0
22.97	79.7	66.2	158.0	2.7	-3.1	3.5	4	clayy SILT to silty CLAY	115	2.0	40	33	-	-	5.6	9.9	27	15	0.74	-	0.02	6.2
23.13	92.6	76.7	166.1	3.1	-3.0	3.4	4	clayy SILT to silty CLAY	115	2.0	46	38	-	-	6.5	9.9	25	15	0.00	-	0.02	0.0
23.30	99.1	81.7	132.8	2.0	-3.0	2.0	5	silty SAND to sandy SILT	120	4.0	25	20	60	42	-	-	18	16	1.83	-	0.02	22.4
23.46	101.7	83.6	137.6	2.1	-3.0	2.1	5	silty SAND to sandy SILT	120	4.0	25	21	61	42	-	-	19	16	1.66	-	0.01	21.4
23.62	95.1	77.9	146.9	2.5	-2.9	2.6	5	silty SAND to sandy SILT	120	4.0	24	19	59	42	-	-	22	16	1.25	-	0.01	13.1
23.79	109.6	89.5	161.4	3.0	-2.9	2.7	5	silty SAND to sandy SILT	120	4.0	27	22	63	42	-	-	21	16	0.00	-	0.01	0.0
23.95	118.5	96.4	176.9	3.6	-2.9	3.0	5	silty SAND to sandy SILT	120	4.0	30	24	66	43	-	-	21	16	0.00	-	0.01	0.0
24.12	120.4	97.6	133.4	1.8	-2.9	1.5	5	silty SAND to sandy SILT	120	4.0	30	24	66	43	-	-	14	16	1.84	-	0.01	17.2
24.28	121.0	97.8	141.1	2.2	-2.9	1.8	5	silty SAND to sandy SILT	120	4.0	30	24	66	43	-	-	16	16	1.55	-	0.01	13.3
24.44	118.5	95.4	153.9	2.7	-2.7	2.3	5	silty SAND to sandy SILT	120	4.0	30	24	65	43	-	-	18	16	0.99	-	0.00	6.5
24.61	120.3	96.5	137.4	2.0	-2.8	1.7	5	silty SAND to sandy SILT	120	4.0	30	24	66	43	-	-	15	16	1.71	-	0.00	16.3

* Indicates the parameter was calculated using the normalized point stress.
The parameters listed above were determined using empirical correlations.
A Professional Engineer must determine their suitability for analysis and design.

Earth Mechanics

Location	I-5 HOV Widening Segment 3	Operator	BH-DM	Filename	SDF(528)-2.cpt
Job Number	11-137	Cone Number	DSG1104	GPS	
Hole Number	CPT-11-321	Date and Time	10/5/2011 1:33:38 AM	Maximum Depth	80.05 ft
Water Table Depth		17.00 ft			

CPT DATA



1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

I-5 HOV Widening Segment 3

Project ID: Earth Mechanics
Data File: SDF(528)-2-17.cpt
CPT Date: 10/5/2011 1:33:38 AM
GW During Test: 17 ft

Sounding ID: CPT-11-321
Project No: 11-137
Cone/Rig: DSG1104

Depth ft	qc PS tsf	qcln PS -	qlncs PS -	Slv Stss tsf	pore prss (psi)	Frct Ratio %	Mat Typ Zon	Material Behavior Description	Unit Wght pcf	Qc to N	SPT R-N 60%	SPT R-N1 60%	Rel Den %	Ftn Ang deg	Und Shr tsf	OCR -	Fin Ic %	Nk -	Vol Strn %	Dry Stlmt 0.00	Liq Stlmt 0.26	Cycl SStn %
0.33	11.2	17.9	-	2.7	0.0	9.9	3	silty CLAY to CLAY	115	1.5	7	12	-	-	0.8	9.9	68	15	N/A	0.00	N/A	N/A
0.49	14.7	23.5	-	2.0	0.5	9.9	3	silty CLAY to CLAY	115	1.5	10	16	-	-	1.0	9.9	62	15	N/A	0.00	N/A	N/A
0.66	45.5	72.9	224.2	2.7	0.6	5.9	9	very stiff fine SOIL	120	2.0	23	36	57	48	-	-	33	30	N/A	0.00	N/A	N/A
0.82	378.4	606.9	606.9	2.0	0.2	0.5	7	grvly SAND to dense SAND	130	6.0	63	100	95	48	-	-	5	16	N/A	0.00	N/A	N/A
0.98	428.8	687.8	687.8	3.1	0.3	0.7	7	grvly SAND to dense SAND	130	6.0	71	100	95	48	-	-	5	16	N/A	0.00	N/A	N/A
1.15	446.2	715.6	715.6	3.8	0.8	0.9	7	grvly SAND to dense SAND	130	6.0	74	100	95	48	-	-	5	16	N/A	0.00	N/A	N/A
1.31	486.4	780.1	780.1	3.9	0.7	0.8	7	grvly SAND to dense SAND	130	6.0	81	100	95	48	-	-	5	16	N/A	0.00	N/A	N/A
1.48	461.3	739.8	739.8	5.1	1.2	1.1	6	clean SAND to silty SAND	125	5.0	92	100	95	48	-	-	5	16	N/A	0.00	N/A	N/A
1.64	486.9	780.9	780.9	5.3	1.3	1.1	6	clean SAND to silty SAND	125	5.0	97	100	95	48	-	-	5	16	N/A	0.00	N/A	N/A
1.80	466.0	747.4	747.4	1.6	1.3	0.4	7	grvly SAND to dense SAND	130	6.0	78	100	95	48	-	-	5	16	N/A	0.00	N/A	N/A
1.97	453.9	728.0	728.0	4.8	2.3	1.0	6	clean SAND to silty SAND	125	5.0	91	100	95	48	-	-	5	16	N/A	0.00	N/A	N/A
2.13	172.8	277.1	329.1	4.1	1.7	2.4	6	clean SAND to silty SAND	125	5.0	35	55	95	48	-	-	10	16	N/A	0.00	N/A	N/A
2.30	317.0	508.5	508.5	3.6	1.5	1.1	6	clean SAND to silty SAND	125	5.0	63	100	95	48	-	-	5	16	N/A	0.00	N/A	N/A
2.46	233.7	374.8	374.8	2.9	1.8	1.2	6	clean SAND to silty SAND	125	5.0	47	75	95	48	-	-	5	16	N/A	0.00	N/A	N/A
2.62	132.5	212.5	255.4	2.7	1.8	2.1	6	clean SAND to silty SAND	125	5.0	27	43	92	48	-	-	11	16	N/A	0.00	N/A	N/A
2.79	74.1	118.8	209.0	2.5	1.9	3.4	5	silty SAND to sandy SILT	120	4.0	19	30	73	47	-	-	20	16	N/A	0.00	N/A	N/A
2.95	51.5	82.7	164.8	1.6	2.0	3.1	5	silty SAND to sandy SILT	120	4.0	13	21	61	46	-	-	23	16	N/A	0.00	N/A	N/A
3.12	54.1	86.8	131.7	1.0	2.0	1.8	5	silty SAND to sandy SILT	120	4.0	14	22	62	46	-	-	17	16	N/A	0.00	N/A	N/A
3.28	48.9	78.4	134.6	1.1	2.1	2.2	5	silty SAND to sandy SILT	120	4.0	12	20	59	45	-	-	20	16	0.38	-	0.28	1.8
3.45	41.4	66.5	139.2	1.1	2.1	2.8	5	silty SAND to sandy SILT	120	4.0	10	17	54	44	-	-	24	16	0.30	-	0.28	1.3
3.61	37.5	60.1	135.0	1.1	2.0	2.9	5	silty SAND to sandy SILT	120	4.0	9	15	50	44	-	-	26	16	0.43	-	0.28	2.1
3.77	33.5	53.8	125.8	0.9	2.0	2.8	5	silty SAND to sandy SILT	120	4.0	8	13	47	43	-	-	27	16	0.97	-	0.28	21.9
3.94	34.2	54.8	121.7	0.9	2.0	2.5	5	silty SAND to sandy SILT	120	4.0	9	14	47	43	-	-	25	16	1.32	-	0.28	22.4
4.10	36.7	58.9	119.2	0.8	1.9	2.3	5	silty SAND to sandy SILT	120	4.0	9	15	50	43	-	-	23	16	1.54	-	0.27	18.0
4.27	39.0	62.5	127.3	1.0	1.8	2.5	5	silty SAND to sandy SILT	120	4.0	10	16	51	43	-	-	24	16	1.05	-	0.27	7.3
4.43	41.0	65.8	137.4	1.1	1.8	2.7	5	silty SAND to sandy SILT	120	4.0	10	16	53	43	-	-	24	16	0.53	-	0.27	2.9
4.59	45.7	73.2	151.9	1.4	1.7	3.0	5	silty SAND to sandy SILT	120	4.0	11	18	57	44	-	-	24	16	0.21	-	0.27	0.9
4.76	47.3	75.8	159.6	1.5	1.7	3.2	5	silty SAND to sandy SILT	120	4.0	12	19	58	44	-	-	24	16	0.16	-	0.27	0.6
4.92	45.1	72.3	164.8	1.6	1.7	3.5	4	clayy SILT to silty CLAY	115	2.0	23	36	-	-	3.2	9.9	26	15	0.00	-	0.27	0.0
5.09	48.6	77.9	165.3	1.6	1.3	3.3	5	silty SAND to sandy SILT	120	4.0	12	19	59	44	-	-	24	16	0.00	-	0.27	0.0
5.25	49.6	79.5	162.5	1.5	1.3	3.1	5	silty SAND to sandy SILT	120	4.0	12	20	59	44	-	-	24	16	0.00	-	0.27	0.0
5.41	49.4	79.3	156.5	1.4	1.3	2.9	5	silty SAND to sandy SILT	120	4.0	12	20	59	44	-	-	23	16	0.20	-	0.27	1.0
5.58	48.1	77.1	160.4	1.5	1.3	3.2	5	silty SAND to sandy SILT	120	4.0	12	19	58	44	-	-	24	16	0.00	-	0.27	0.0
5.74	44.2	71.0	158.7	1.5	1.3	3.3	4	clayy SILT to silty CLAY	115	2.0	22	35	-	-	3.1	9.9	26	15	0.19	-	0.27	0.8
5.91	39.2	62.8	148.5	1.3	1.3	3.3	4	clayy SILT to silty CLAY	115	2.0	20	31	-	-	2.7	9.9	27	15	0.38	-	0.27	1.9
6.07	35.7	57.2	137.8	1.1	1.2	3.1	4	clayy SILT to silty CLAY	115	2.0	18	29	-	-	2.5	9.9	27	15	0.83	-	0.27	12.5
6.23	32.5	51.4	133.2	1.0	1.2	3.2	4	clayy SILT to silty CLAY	115	2.0	16	26	-	-	2.3	9.9	29	15	1.12	-	0.27	30.6
6.40	30.2	47.1	126.9	0.9	1.2	3.1	4	clayy SILT to silty CLAY	115	2.0	15	24	-	-	2.1	9.9	30	15	1.51	-	0.26	44.8
6.56	31.4	48.5	116.6	0.8	1.2	2.6	5	silty SAND to sandy SILT	120	4.0	8	12	43	41	-	-	27	16	2.02	-	0.26	45.9
6.73	32.0	48.8	120.7	0.9	1.2	2.7	4	clayy SILT to silty CLAY	115	2.0	16	24	-	-	2.2	9.9	28	15	1.90	-	0.26	45.5
6.89	29.7	44.7	127.9	1.0	1.2	3.3	4	clayy SILT to silty CLAY	115	2.0	15	22	-	-	2.1	9.9	31	15	1.52	-	0.25	49.9
7.05	29.4	43.7	133.4	1.0	1.2	3.6	4	clayy SILT to silty CLAY	115	2.0	15	22	-	-	2.1	9.9	33	15	1.22	-	0.25	51.2
7.22	31.9	47.0	137.7	1.1	1.2	3.6	4	clayy SILT to silty CLAY	115	2.0	16	23	-	-	2.2	9.9	32	15	1.00	-	0.25	42.5
7.38	33.3	48.5	134.8	1.1	1.2	3.4	4	clayy SILT to silty CLAY	115	2.0	17	24	-	-	2.3	9.9	31	15	1.18	-	0.25	39.1
7.55	31.6	45.6	125.0	1.0	1.2	3.1	4	clayy SILT to silty CLAY	115	2.0	16	23	-	-	2.2	9.9	30	15	1.75	-	0.25	49.3
7.71	28.4	40.5	112.5	0.8	1.2	2.8	4	clayy SILT to silty CLAY	115	2.0	14	20	-	-	2.0	9.9	31	15	2.12	-	0.24	51.2
7.87	25.1	35.5	109.5	0.7	1.2	2.9	4	clayy SILT to silty CLAY	115	2.0	13	18	-	-	1.8	9.9	33	15	2.17	-	0.24	51.2
8.04	26.2	36.6	111.3	0.8	1.2	2.9	4	clayy SILT to silty CLAY	115	2.0	13	18	-	-	1.8	9.9	33	15	2.14	-	0.24	51.2
8.20	27.3	37.8	112.2	0.8	1.1	2.9	4	clayy SILT to silty CLAY	115	2.0	14	19	-	-	1.9	9.9	32	15	2.13	-	0.23	51.2
8.37	28.2	38.7	113.1	0.8	1.2	2.9	4	clayy SILT to silty CLAY	115	2.0	14	19	-	-	2.0	9.9	32	15	2.11	-	0.23	51.2
8.53	29.4	40.0	110.1	0.8	1.2	2.7	4	clayy SILT to silty CLAY	115	2.0	15	20	-	-	2.1	9.9	31	15	2.16	-	0.23	51.2
8.69	28.6	38.5	107.7	0.7	1.2	2.6	4	clayy SILT to silty CLAY	115	2.0	14	19	-	-	2.0	9.9	31	15	2.20	-	0.22	51.2
8.86	27.7	37.0	103.4	0.7	1.2	2.5	4	clayy SILT to silty CLAY	115	2.0	14	19	-	-	1.9	9.9	31	15	2.27	-	0.22	51.2
9.02	25.7	34.0	102.4	0.7	1.2	2.6	4	clayy SILT to silty CLAY	115	2.0	13	17	-	-	1.8	9.9	33	15	2.29	-	0.22	51.2
9.19	24.6	32.3	103.2	0.7	1.2	2.8	4	clayy SILT to silty CLAY	115	2.0	12	16	-	-	1.7	9.9	34	15	2.28	-	0.21	51.2
9.35	23.3	34.4	110.8	0.7	1.2	3.0	4	clayy SILT to silty CLAY	115	2.0	12	17	-	-	1.6	9.9	35	15	2.15	-	0.21	51.2
9.51	23.2	33.9	109.0	0.7	1.2	3.0	4	clayy SILT to silty CLAY	115	2.0	12	17	-	-	1.6	9.9	34	15	2.18	-	0.20	51.2
9.68	22.1	32.0	99.8	0.6	1.2	2.6	4	clayy SILT to silty CLAY	115	2.0	11	16	-	-	1.5	9.9	34	15	2.34	-	0.20	51.2
9.84	19.8	28.3	-	0.5	1.3	2.7	4	clayy SILT to silty CLAY	115	2.0	10	14	-	-	1.4	9.9	36	15	-	-	0.20	-
10.01	17.1	27.4	-	0.5	1.3	3.1	4	clayy SILT to silty CLAY	115	2.0	9	14	-	-	1.2	9.9	39	15	-	-	0.19	-
10.17	17.4	27.9	-	0.5	1.5	3.1	4	clayy SILT to silty CLAY	115	2.0	9	14	-	-	1.2	9.9	39	15	-	-	0.19	-
10.34	22.7	31.4	-	0.7	1.6	3.1	4	clayy SILT to silty CLAY	115	2.0	11	16	-	-	1.6	9.9	36	15	-	-	0.19	-
10.50	35.6	43.8	114.2	0.9	1.5	2.7	4	clayy SILT to silty CLAY	115	2.0	18	22	-	-	2.5	9.9	29	15	2.10	-	0.19	51.2
10.66	34.0	41.5	110.6	0.9	1.5	2.6	4	clayy SILT to silty CLAY	115	2.0	17	21	-	-	2.4	9.9	30	15	2.15	-	0.19	51.2
10.83	26.7	32.4	101.7	0.7	1.5	2.7	4	clayy SILT to silty CLAY	115	2.0	13	16	-	-	1.9	9.9	34	15	2.30	-	0.18	51.2
10.99	24.9	30.0	94.3	0.6	1.5	2.4	4	clayy SILT to silty CLAY	115	2.0	12	15	-	-	1.7	9.9	34	15	2.45	-	0.18	51.2
11.16	23.5	28.1	91.4	0.5	1.5	2.4	4	clayy SILT to silty CLAY	115	2.0	12	14	-	-	1.6	9.9	35	15	2.52	-	0.17	51.2
11.32	21.3	27.7	-	0.5	1.5	2.5	4	clayy SILT to silty CLAY	115	2.0	11	14	-	-	1.5	9.9	36	15	-	-	0.17	-
11.48	20.7	26.6	-	0.5	1.5	2.6	4	clayy SILT to silty CLAY	115	2.0	10	13	-	-	1.4	9.9	37	15	-	-	0.17	-
11.65	22.2	26.0	84.8	0.5	1.5	2.2	4	clayy SILT to silty CLAY	115	2.0	11	13	-	-	1.5	9.9	35	15	2.68	-	0.16	51.2
11.81	21.0	26.6	-	0.5	1.5	2.6	4	clayy SILT to silty CLAY	115	2.0	11	13	-	-	1.5	9.9	37	15	-	-	0.16	-
11.98	21.6	30.5	-	0.6	1.5	3.0	4	clayy SILT to silty CLAY	115	2.0	11	15	-	-	1.5	9.9	37	15	-	-	0.15	-
12.14	20.6	28.7	-	0.7	1.5	3.6	4	clayy SILT to silty CLAY	115	2.0	10	14	-	-	1.4	9.9	40	15	-	-	0.15	-
12.30	20.1	27.6	-	0.7	1.5	3.6	4	clayy SILT to silty CLAY	115	2.0	10	14	-	-	1.4	9.9	41	15	-	-	0.15	-
12.47	18.9	25.6	-	0.6	1.5	3.5	4	clayy SILT to silty CLAY	115	2.0	9	13	-	-	1.3	9.9	42	15	-	-	0.15	-
12.63	17.9	23.9	-	0.6	1.5	3.3	4	clayy SILT to silty CLAY	115	2.0	9	12	-	-	1.2	9.9	42	15	-	-	0.15	-
12.80	16.9	22.3	-	0.5	1.5	3.3	4	clayy SILT to silty CLAY	115	2.0	8	11	-	-	1.2	9.9	43	15	-	-	0.15	-
12.96	16.8	22.0	-	0.6	1.5	3.5	4	clayy SILT to silty CLAY	115	2.0	8	11	-	-	1.2	9.9	45	15	-	-	0.15	-
13.12	15.9	20.5	-	0.5	1.5	3.6	3	silty CLAY to CLAY	115	1.5	11	14	-	-	1.1	9.9	47	15	-	-	0.15	-
13.29	15.0	19.1	-	0.5	1.5	3.5	3	silty CLAY to CLAY	115	1.5	10	13	-	-	1.0	9.9	48	15	-	-	0.15	-
13.45	14.5	18.3	-	0.5	1.5	3.6	3	silty CLAY to CLAY	115	1.5	10	12	-	-	1.0	9.6	49	15	-	-	0.15	-
13.62	13.4	16.7	-	0.5	1.4	3.9	3	silty CLAY to CLAY	115	1.5	9	11	-	-	0.9	8.8	52	15	-	-	0.15	-
13.78	12.0	14.8	-	0.4	1.5	3.7	3	silty CLAY to CLAY	115	1.5	8	10	-	-	0.8	7.7	54	15	-	-	0.15	-
13.94	11.6	14.1	-	0.3	1.5	3.2	3	silty CLAY to CLAY	115	1.5	8	9	-	-	0.8	7.4	53	15	-	-	0.15	-
14.11	11.1	13.4	-	0.3	1.5	3.3	3	silty CLAY to CLAY	115	1.5	7	9	-	-	0.8	7.0	55	15	-	-	0.15	-
14.27	9.7	11.6	-	0.3	1.5	3.0	3	silty CLAY to CLAY	115	1.5	6	8	-	-	0.7	6.0	57	15	-	-	0.15	-
14.44	8.6	10.1	-	0.2	1.5	2.8	3	silty CLAY to CLAY	115	1.5	6	7	-	-	0.6	5.2	59	15	-	-	0.15	-
14.60	7.3	8.5	-	0.2	1.5	3.0	3	silty CLAY to CLAY	115	1.5	5	6	-	-	0.5	4.2	66	15	-	-	0.15	-
14.76	7.4	8.6	-	0.2	1.5	3.6	3	silty CLAY to CLAY	115	1.5	5	6	-	-	0.5	4.3	69	15	-	-	0.15	-
14.93	7.7	8.7	-	0.3	1.5	4.4	3	silty CLAY to CLAY	115	1.5	5	6	-	-	0.5	4.4	72	15	-	-	0.15	-
15.09	14.0	15.7	-	0.3	1.5	2.6	4	clayy SILT to silty CLAY	115	2.0	7	8	-	-	1.0	8.4	48	15	-	-	0.15	-
15.26	16.1	17.9	-	0.3	1.4	1.9	4	clayy SILT to silty CLAY	115	2.0	8	9	-	-	1.1	9.7	40	15	-	-	0.15	-
15.42	22.1	22.6	63.5	0.3	1.4	1.3	5	silty SAND to sandy SILT	120	4.0	6	6	18	36	-	-	31	16	3.39	-	0.15	51.2

* Indicates the parameter was calculated using the normalized point stress.
The parameters listed above were determined using empirical correlations.
A Professional Engineer must determine their suitability for analysis and design.

Middle Earth Geo Testing

Project ID: Earth Mechanics
Data File: SDF(528)-2-17.cpt
CPT Date: 10/5/2011 1:33:38 AM
GW During Test: 17 ft

Sounding ID: CPT-11-321
Project No: 11-137
Cone/Rig: DSG1104

Depth ft	qc PS tsf	qcln PS -	qincs PS -	Slv Stss tsf	pore prss (psi)	Frct Rato %	Mat Typ Zon	Material Behavior Description	Unit Wght pcf	Qc to N	SPT R-N 60%	SPT R-N1 60%	Rel Den %	Ftn Ang deg	Und Shr tsf	OCR -	Fin Ic %	Nk -	Vol Strn %	Dry Stlmt 0.00	Liq Stlmt 0.26	Cycl SStn %
15.58	22.4	22.7	64.1	0.3	1.4	1.3	5	silty SAND to sandy SILT	120	4.0	6	6	18	36	-	-	31	16	3.37	-	0.15	51.2
15.75	20.0	21.6	-	0.4	1.4	2.0	4	clayy SILT to silty CLAY	115	2.0	10	11	-	-	1.4	9.9	38	15	-	-	0.14	-
15.91	17.1	18.3	-	0.3	1.4	2.1	4	clayy SILT to silty CLAY	115	2.0	9	9	-	-	1.2	9.9	41	15	-	-	0.14	-
16.08	14.9	15.7	-	0.4	1.5	2.9	3	silty CLAY to CLAY	115	1.5	10	10	-	-	1.0	8.5	49	15	-	-	0.14	-
16.24	17.6	18.5	-	0.5	1.5	2.8	4	clayy SILT to silty CLAY	115	2.0	9	9	-	-	1.2	9.9	45	15	-	-	0.14	-
16.40	18.4	19.1	-	0.4	1.5	2.2	4	clayy SILT to silty CLAY	115	2.0	9	10	-	-	1.3	9.9	41	15	-	-	0.14	-
16.57	29.6	29.1	77.3	0.5	1.5	1.6	5	silty SAND to sandy SILT	120	4.0	7	7	26	37	-	-	30	16	2.88	-	0.14	51.2
16.73	37.5	36.7	82.8	0.6	1.5	1.6	5	silty SAND to sandy SILT	120	4.0	9	9	34	38	-	-	26	16	2.73	-	0.14	51.2
16.90	34.7	33.8	81.0	0.5	1.5	1.6	5	silty SAND to sandy SILT	120	4.0	9	8	31	38	-	-	27	16	2.78	-	0.13	51.2
17.06	37.1	36.1	83.0	0.6	1.5	1.6	5	silty SAND to sandy SILT	120	4.0	9	9	33	38	-	-	26	16	2.72	-	0.13	51.2
17.23	31.5	30.6	93.0	0.7	1.5	2.3	4	clayy SILT to silty CLAY	115	2.0	16	15	-	-	2.2	9.9	33	15	2.48	-	0.12	51.2
17.39	22.7	22.5	-	0.7	1.5	3.3	4	clayy SILT to silty CLAY	115	2.0	11	11	-	-	1.6	9.9	44	15	-	-	0.12	-
17.55	18.2	18.0	-	0.7	1.5	4.3	3	silty CLAY to CLAY	115	1.5	12	12	-	-	1.2	9.7	53	15	-	-	0.12	-
17.72	21.3	21.0	-	0.7	1.5	3.3	4	clayy SILT to silty CLAY	115	2.0	11	10	-	-	1.5	9.9	45	15	-	-	0.12	-
17.88	33.2	31.9	92.0	0.7	1.5	2.2	4	clayy SILT to silty CLAY	115	2.0	17	16	-	-	2.3	9.9	32	15	2.50	-	0.12	51.2
18.05	31.6	30.3	90.8	0.7	1.5	2.2	4	clayy SILT to silty CLAY	115	2.0	16	15	-	-	2.2	9.9	33	15	2.53	-	0.12	51.2
18.21	23.7	23.1	-	0.5	1.5	2.2	4	clayy SILT to silty CLAY	115	2.0	12	12	-	-	1.6	9.9	37	15	-	-	0.11	-
18.37	15.2	14.8	-	0.4	1.5	3.1	3	silty CLAY to CLAY	115	1.5	10	10	-	-	1.0	7.8	52	15	-	-	0.11	-
18.54	10.1	9.8	-	0.4	1.5	4.0	3	silty CLAY to CLAY	115	1.5	7	7	-	-	0.7	4.9	67	15	-	-	0.11	-
18.70	8.4	8.1	-	0.4	1.5	5.6	3	silty CLAY to CLAY	115	1.5	6	5	-	-	0.5	3.9	80	15	-	-	0.11	-
18.87	13.2	12.6	-	0.5	1.5	4.4	3	silty CLAY to CLAY	115	1.5	9	8	-	-	0.9	6.5	62	15	-	-	0.11	-
19.03	20.4	19.5	-	0.6	1.5	3.3	3	silty CLAY to CLAY	115	1.5	14	13	-	-	1.4	9.9	47	15	-	-	0.11	-
19.19	20.0	19.0	-	0.6	1.5	3.2	4	clayy SILT to silty CLAY	115	2.0	10	9	-	-	1.4	9.9	46	15	-	-	0.11	-
19.36	16.6	15.7	-	0.6	1.5	3.8	3	silty CLAY to CLAY	115	1.5	11	10	-	-	1.1	8.1	54	15	-	-	0.11	-
19.52	16.4	15.4	-	0.6	1.5	4.0	3	silty CLAY to CLAY	115	1.5	11	10	-	-	1.1	7.9	55	15	-	-	0.11	-
19.69	23.3	21.8	-	0.6	1.5	2.6	4	clayy SILT to silty CLAY	115	2.0	12	11	-	-	1.6	9.9	40	15	-	-	0.11	-
19.85	34.9	32.7	75.1	0.5	1.5	1.4	5	silty SAND to sandy SILT	120	4.0	9	8	30	37	-	-	26	16	2.96	-	0.11	51.2
20.01	31.5	29.5	85.9	0.6	1.5	2.0	4	clayy SILT to silty CLAY	115	2.0	16	15	-	-	2.2	9.9	32	15	2.65	-	0.11	51.2
20.18	23.3	21.6	-	0.7	1.5	3.1	4	clayy SILT to silty CLAY	115	2.0	12	11	-	-	1.6	9.9	44	15	-	-	0.10	-
20.34	19.8	18.3	-	0.7	1.5	3.7	3	silty CLAY to CLAY	115	1.5	13	12	-	-	1.4	9.4	50	15	-	-	0.10	-
20.51	19.9	18.3	-	0.7	1.5	3.6	3	silty CLAY to CLAY	115	1.5	13	12	-	-	1.4	9.4	49	15	-	-	0.10	-
20.67	26.8	24.5	-	0.7	1.5	2.5	4	clayy SILT to silty CLAY	115	2.0	13	12	-	-	1.8	9.9	38	15	-	-	0.10	-
20.83	21.6	19.7	-	0.6	1.5	2.9	4	clayy SILT to silty CLAY	115	2.0	11	10	-	-	1.5	9.9	44	15	-	-	0.10	-
21.00	13.5	12.2	-	0.4	1.5	3.2	3	silty CLAY to CLAY	115	1.5	9	8	-	-	0.9	6.0	57	15	-	-	0.10	-
21.16	9.8	8.9	-	0.3	1.5	3.4	3	silty CLAY to CLAY	115	1.5	7	6	-	-	0.6	4.2	67	15	-	-	0.10	-
21.33	11.0	9.9	-	0.3	1.5	3.0	3	silty CLAY to CLAY	115	1.5	7	7	-	-	0.7	4.7	61	15	-	-	0.10	-
21.49	11.5	10.3	-	0.3	1.5	3.4	3	silty CLAY to CLAY	115	1.5	8	7	-	-	0.8	4.9	63	15	-	-	0.10	-
21.65	15.7	14.1	-	0.5	1.5	3.3	3	silty CLAY to CLAY	115	1.5	10	9	-	-	1.1	6.9	54	15	-	-	0.10	-
21.82	20.7	18.4	-	0.6	1.5	2.9	4	clayy SILT to silty CLAY	115	2.0	10	9	-	-	1.4	9.2	46	15	-	-	0.10	-
21.98	17.2	15.2	-	0.4	1.5	2.8	3	silty CLAY to CLAY	115	1.5	11	10	-	-	1.2	7.5	49	15	-	-	0.10	-
22.15	12.1	10.7	-	0.4	1.6	3.4	3	silty CLAY to CLAY	115	1.5	8	7	-	-	0.8	5.1	62	15	-	-	0.10	-
22.31	10.3	9.1	-	0.3	1.5	3.8	3	silty CLAY to CLAY	115	1.5	7	6	-	-	0.7	4.2	68	15	-	-	0.10	-
22.47	10.4	9.1	-	0.3	1.5	3.7	3	silty CLAY to CLAY	115	1.5	7	6	-	-	0.7	4.2	67	15	-	-	0.10	-
22.64	12.4	10.8	-	0.3	1.5	2.9	3	silty CLAY to CLAY	115	1.5	8	7	-	-	0.8	5.1	59	15	-	-	0.10	-
22.80	13.3	11.6	-	0.4	1.5	3.0	3	silty CLAY to CLAY	115	1.5	9	8	-	-	0.9	5.5	58	15	-	-	0.10	-
22.97	13.5	11.7	-	0.4	1.5	3.4	3	silty CLAY to CLAY	115	1.5	9	8	-	-	0.9	5.5	59	15	-	-	0.10	-
23.13	12.5	10.8	-	0.4	1.5	4.0	3	silty CLAY to CLAY	115	1.5	8	7	-	-	0.8	5.1	64	15	-	-	0.10	-
23.30	14.7	12.6	-	0.4	1.5	3.1	3	silty CLAY to CLAY	115	1.5	10	8	-	-	1.0	6.0	55	15	-	-	0.10	-
23.46	17.4	15.0	-	0.5	1.5	2.9	3	silty CLAY to CLAY	115	1.5	12	10	-	-	1.2	7.2	51	15	-	-	0.10	-
23.62	16.4	14.0	-	0.4	1.6	2.6	3	silty CLAY to CLAY	115	1.5	11	9	-	-	1.1	6.7	50	15	-	-	0.10	-
23.79	14.1	12.0	-	0.4	1.5	2.9	3	silty CLAY to CLAY	115	1.5	9	8	-	-	0.9	5.6	56	15	-	-	0.10	-
23.95	14.6	12.4	-	0.4	1.5	3.0	3	silty CLAY to CLAY	115	1.5	10	8	-	-	1.0	5.8	56	15	-	-	0.10	-
24.12	15.6	13.2	-	0.6	1.5	4.5	3	silty CLAY to CLAY	115	1.5	10	9	-	-	1.1	6.2	61	15	-	-	0.10	-
24.28	21.0	17.7	-	0.8	1.5	4.1	3	silty CLAY to CLAY	115	1.5	14	12	-	-	1.4	8.5	52	15	-	-	0.10	-
24.44	34.1	30.3	91.6	0.7	1.5	2.2	4	clayy SILT to silty CLAY	115	2.0	17	15	-	-	2.4	9.9	33	15	2.51	-	0.10	51.2
24.61	44.6	39.6	92.5	0.8	1.5	1.9	5	silty SAND to sandy SILT	120	4.0	11	10	36	37	-	-	27	16	2.49	-	0.10	51.2
24.77	46.3	41.0	85.4	0.7	1.6	1.5	5	silty SAND to sandy SILT	120	4.0	12	10	38	38	-	-	24	16	2.66	-	0.09	51.2
24.94	48.8	43.2	84.8	0.7	1.6	1.4	5	silty SAND to sandy SILT	120	4.0	12	11	39	38	-	-	23	16	2.67	-	0.09	51.2
25.10	50.3	44.4	82.5	0.6	1.6	1.3	5	silty SAND to sandy SILT	120	4.0	13	11	40	38	-	-	21	16	2.74	-	0.09	50.9
25.26	46.8	41.2	87.7	0.7	1.6	1.6	5	silty SAND to sandy SILT	120	4.0	12	10	38	38	-	-	25	16	2.60	-	0.08	51.2
25.43	42.6	37.4	112.1	1.2	1.6	2.9	4	clayy SILT to silty CLAY	115	2.0	21	19	-	-	3.0	9.9	33	15	2.13	-	0.08	51.2
25.59	34.6	28.2	-	1.3	1.6	3.8	4	clayy SILT to silty CLAY	115	2.0	17	14	-	-	2.4	9.9	41	15	-	-	0.07	-
25.76	27.9	22.7	-	1.1	1.6	4.2	3	silty CLAY to CLAY	115	1.5	19	15	-	-	1.9	9.9	47	15	-	-	0.07	-
25.92	24.6	20.0	-	0.9	1.6	3.7	3	silty CLAY to CLAY	115	1.5	16	13	-	-	1.7	9.5	48	15	-	-	0.07	-
26.08	19.9	16.1	-	0.9	1.6	5.2	3	silty CLAY to CLAY	115	1.5	13	11	-	-	1.4	7.5	59	15	-	-	0.07	-
26.25	26.1	21.0	-	1.0	1.6	3.9	3	silty CLAY to CLAY	115	1.5	17	14	-	-	1.8	9.9	48	15	-	-	0.07	-
26.41	24.8	19.9	-	1.3	1.6	5.4	3	silty CLAY to CLAY	115	1.5	17	13	-	-	1.7	9.4	55	15	-	-	0.07	-
26.58	33.8	27.1	-	2.5	1.6	7.8	3	silty CLAY to CLAY	115	1.5	23	18	-	-	2.3	9.9	55	15	-	-	0.07	-
26.74	46.0	36.6	-	2.6	1.7	5.9	3	silty CLAY to CLAY	115	1.5	31	24	-	-	3.2	9.9	44	15	-	-	0.07	-
26.90	127.0	109.9	222.7	5.1	1.0	4.1	9	very stiff fine SOIL	120	2.0	64	55	70	43	-	-	23	30	0.00	-	0.07	0.0
27.07	86.1	74.3	211.8	4.4	1.3	5.2	4	clayy SILT to silty CLAY	115	2.0	43	37	-	-	6.0	9.9	31	15	0.00	-	0.07	0.0
27.23	32.2	25.4	-	2.1	1.2	6.7	3	silty CLAY to CLAY	115	1.5	21	17	-	-	2.2	9.9	53	15	-	-	0.07	-
27.40	43.4	34.1	-	1.7	1.2	4.1	4	clayy SILT to silty CLAY	115	2.0	22	17	-	-	3.0	9.9	39	15	-	-	0.07	-
27.56	188.0	161.6	232.0	5.2	1.1	2.8	5	silty SAND to sandy SILT	120	4.0	47	40	83	45	-	-	15	16	0.00	-	0.07	0.0
27.72	133.6	114.6	292.2	8.0	1.2	6.1	9	very stiff fine SOIL	120	2.0	67	57	72	43	-	-	29	30	0.00	-	0.07	0.0
27.89	99.5	85.2	217.2	4.8	1.4	4.9	4	clayy SILT to silty CLAY	115	2.0	50	43	-	-	7.0	9.9	29	15	0.00	-	0.07	0.0
28.05	89.6	76.6	170.8	3.1	3.3	3.5	4	clayy SILT to silty CLAY	115	2.0	45	38	-	-	6.3	9.9	26	15	0.00	-	0.07	0.0
28.22	32.0	24.7	-	2.3	3.1	7.6	3	silty CLAY to CLAY	115	1.5	21	16	-	-	2.2	9.9	56	15	-	-	0.07	-
28.38	26.7	20.6	-	1.0	3.1	3.9	3	silty CLAY to CLAY	115	1.5	18	14	-	-	1.8	9.5	48	15	-	-	0.07	-
28.54	19.2	14.7	-	1.1	3.0	6.2	3	silty CLAY to CLAY	115	1.5	13	10	-	-	1.3	6.6	65	15	-	-	0.07	-
28.71	20.6	15.7	-	1.1	3.0	5.9	3	silty CLAY to CLAY	115	1.5	14	10	-	-	1.4	7.1	62	15	-	-	0.07	-
28.87	21.9	16.7	-	1.2	3.0	5.9	3	silty CLAY to CLAY	115	1.5	15	11	-	-	1.5	7.6	60	15	-	-	0.07	-
29.04	26.7	20.3	-	1.3	3.0	5.1	3	silty CLAY to CLAY	115	1.5	18	14	-	-	1.8	9.3	53	15	-	-	0.07	-
29.20	33.5	25.4	-	1.5	2.9	4.6	3	silty CLAY to CLAY	115	1.5	22	17	-	-	2.3	9.9	47	15	-	-	0.07	-
29.36	36.6	27.6	-	1.4	2.9	3.9	4	clayy SILT to silty CLAY	115	2.0	18	14	-	-	2.5	9.9	42	15	-	-	0.07	-
29.53	36.8	27.7	-	1.3	2.9	3.6	4	clayy SILT to silty CLAY	115	2.0	18	14	-	-	2.5	9.9	41	15	-	-	0.07	-
29.69	42.5	35.8	102.4	1.0	2.8	2.5	4	clayy SILT to silty CLAY	115	2.0	21	18	-	-	2.9	9.9	32	15	2.29	-	0.07	51.2
29.86	39.8	29.7	-	1.0	2.8	2.8	4	clayy SILT to silty CLAY	115	2.0	20	15	-	-	2.7	9.9	36	15	-	-	0.07	-
30.02	34.4	25.6	-	1.4	2.8	4.4	3	silty CLAY to CLAY	115	1.5	23	17	-	-	2.4	9.9	46	15	-	-	0.07	-
30.19	34.6	25.7	-	1.6	2.6	5.0	3	silty CLAY to CLAY	115	1.5	23	17	-	-	2.4	9.9	48	15	-	-	0.07	-
30.35	39.5	29.2	-	1.7	2.6	4.4	3	silty CLAY to CLAY	115	1.5	26	19	-	-	2.7	9.9	43	15	-	-	0.07	-
30.51	53.6	44.7	137.6	1.9	2.6	3.6	4	clayy SILT to silty CLAY	115	2.0	27	22	-	-	3.7	9.9	33	15	1.65	-	0.07	50.5
30.68	53.9	39.6	-	2.1	2.6	4.0	4	clayy SILT to silty CLAY	115	2.0	27	20	-	-	3.7	9.9	37	15	-	-	0.07	-
30.84	55.4	40.6	-	2.2	2.6	4.1	4	clayy SILT to silty CLAY	115	2.0	28	20	-	-	3.8	9.9	36	15	-	-	0.07	-

* Indicates the parameter was calculated using the normalized point stress.
The parameters listed above were determined using empirical correlations.
A Professional Engineer must determine their suitability for analysis and design.

Project ID: Earth Mechanics
Data File: SDF(528)-2-17.cpt
CPT Date: 10/5/2011 1:33:38 AM
GW During Test: 17 ft

Sounding ID: CPT-11-321
Project No: 11-137
Cone/Rig: DSG1104

Depth ft	qc PS tsf	qcln PS -	qincs PS -	Slv Stss tsf	pore prss (psi)	Frct Rato %	Mat Typ Zon	Material Behavior Description	Unit Wght pcf	Qc to N	SPT R-N 60%	SPT R-N1 60%	Rel Den %	Ftn Ang deg	Und Shr tsf	OCR -	Fin Ic %	Nk -	Vol Strn %	Dry Stlmt 0.00	Liq Stlmt 0.26	Cycl SStn %
31.01	70.8	58.8	118.4	1.5	2.6	2.2	5	silty SAND to sandy SILT	120	4.0	18	15	49	39	-	-	23	16	2.03	-	0.07	35.0
31.17	76.8	63.7	113.6	1.4	2.6	1.9	5	silty SAND to sandy SILT	120	4.0	19	16	52	39	-	-	21	16	2.10	-	0.06	31.7
31.33	78.7	65.1	116.6	1.5	2.6	1.9	5	silty SAND to sandy SILT	120	4.0	20	16	53	39	-	-	21	16	2.06	-	0.06	30.9
31.50	72.1	59.6	124.5	1.7	2.6	2.4	5	silty SAND to sandy SILT	120	4.0	18	15	50	39	-	-	24	16	1.95	-	0.06	34.3
31.66	65.2	53.8	138.1	2.0	2.6	3.2	4	clayy SILT to silty CLAY	115	2.0	33	27	-	-	4.5	9.9	29	15	1.64	-	0.05	40.1
31.83	60.5	49.8	149.9	2.3	2.7	3.9	4	clayy SILT to silty CLAY	115	2.0	30	25	-	-	4.2	9.9	33	15	1.11	-	0.05	37.4
31.99	53.7	38.5	-	2.5	2.7	4.8	3	silty CLAY to CLAY	115	1.5	36	26	-	-	3.7	9.9	40	15	-	-	0.05	-
32.15	49.2	35.1	-	2.4	2.7	5.0	3	silty CLAY to CLAY	115	1.5	33	23	-	-	3.4	9.9	42	15	-	-	0.05	-
32.32	43.4	30.9	-	2.2	2.7	5.4	3	silty CLAY to CLAY	115	1.5	29	21	-	-	3.0	9.9	46	15	-	-	0.05	-
32.48	40.6	28.8	-	2.1	2.7	5.4	3	silty CLAY to CLAY	115	1.5	27	19	-	-	2.8	9.9	47	15	-	-	0.05	-
32.65	42.1	29.8	-	2.0	2.7	4.9	3	silty CLAY to CLAY	115	1.5	28	20	-	-	2.9	9.9	45	15	-	-	0.05	-
32.81	37.9	26.8	-	2.0	2.7	5.4	3	silty CLAY to CLAY	115	1.5	25	18	-	-	2.6	9.9	49	15	-	-	0.05	-
32.97	105.2	85.7	152.5	2.6	2.7	2.5	5	silty SAND to sandy SILT	120	4.0	26	21	62	41	-	-	20	16	1.05	-	0.05	8.1
33.14	110.6	89.9	128.6	1.7	2.7	1.6	5	silty SAND to sandy SILT	120	4.0	28	22	63	41	-	-	15	16	1.90	-	0.05	19.8
33.30	124.7	101.2	122.3	1.3	2.9	1.0	6	clean SAND to silty SAND	125	5.0	25	20	67	42	-	-	11	16	1.98	-	0.04	16.6
33.47	161.0	130.4	206.7	4.6	2.7	2.9	5	silty SAND to sandy SILT	120	4.0	40	33	76	43	-	-	18	16	0.00	-	0.04	0.0
33.63	92.6	74.9	197.2	4.1	2.8	4.6	4	clayy SILT to silty CLAY	115	2.0	46	37	-	-	6.5	9.9	29	15	0.00	-	0.04	0.0
33.79	35.7	24.7	-	2.8	3.0	8.3	3	silty CLAY to CLAY	115	1.5	24	16	-	-	2.5	9.9	58	15	-	-	0.04	-
33.96	32.9	22.7	-	1.2	3.0	3.9	3	silty CLAY to CLAY	115	1.5	22	15	-	-	2.3	9.9	46	15	-	-	0.04	-
34.12	26.8	18.5	-	0.8	3.0	3.4	3	silty CLAY to CLAY	115	1.5	18	12	-	-	1.8	8.0	48	15	-	-	0.04	-
34.29	37.5	25.7	-	1.0	3.1	2.8	4	clayy SILT to silty CLAY	115	2.0	19	13	-	-	2.6	9.9	39	15	-	-	0.04	-
34.45	65.6	52.7	135.8	2.0	2.7	3.1	4	clayy SILT to silty CLAY	115	2.0	33	26	-	-	4.6	9.9	29	15	1.72	-	0.04	41.2
34.61	48.7	33.2	-	2.1	2.9	4.5	3	silty CLAY to CLAY	115	1.5	32	22	-	-	3.4	9.9	41	15	-	-	0.04	-
34.78	28.6	19.4	-	2.1	2.7	8.0	3	silty CLAY to CLAY	115	1.5	19	13	-	-	1.9	8.4	63	15	-	-	0.04	-
34.94	101.8	81.4	148.0	2.5	2.7	2.5	5	silty SAND to sandy SILT	120	4.0	25	20	60	40	-	-	21	16	1.24	-	0.04	11.6
35.11	57.5	38.9	-	2.8	2.8	5.1	3	silty CLAY to CLAY	115	1.5	38	26	-	-	4.0	9.9	41	15	-	-	0.04	-
35.27	55.3	37.2	-	2.1	2.8	4.0	4	clayy SILT to silty CLAY	115	2.0	28	19	-	-	3.8	9.9	37	15	-	-	0.04	-
35.43	35.6	23.9	-	1.6	2.8	4.8	3	silty CLAY to CLAY	115	1.5	24	16	-	-	2.4	9.9	49	15	-	-	0.04	-
35.60	25.5	17.1	-	1.1	2.8	4.6	3	silty CLAY to CLAY	115	1.5	17	11	-	-	1.7	7.3	55	15	-	-	0.04	-
35.76	28.4	18.9	-	1.2	2.9	4.4	3	silty CLAY to CLAY	115	1.5	19	13	-	-	1.9	8.1	52	15	-	-	0.04	-
35.93	45.3	30.1	-	1.4	2.8	3.2	4	clayy SILT to silty CLAY	115	2.0	23	15	-	-	3.1	9.9	38	15	-	-	0.04	-
36.09	39.7	26.4	-	1.3	2.8	3.6	4	clayy SILT to silty CLAY	115	2.0	20	13	-	-	2.7	9.9	42	15	-	-	0.04	-
36.26	28.9	19.1	-	1.4	2.8	5.2	3	silty CLAY to CLAY	115	1.5	19	13	-	-	2.0	8.2	55	15	-	-	0.04	-
36.42	26.2	17.3	-	1.3	2.8	5.3	3	silty CLAY to CLAY	115	1.5	17	12	-	-	1.8	7.3	58	15	-	-	0.04	-
36.58	40.3	26.5	-	1.3	2.8	3.3	4	clayy SILT to silty CLAY	115	2.0	20	13	-	-	2.8	9.9	41	15	-	-	0.04	-
36.75	33.4	21.9	-	1.4	2.8	4.4	3	silty CLAY to CLAY	115	1.5	22	15	-	-	2.3	9.4	49	15	-	-	0.04	-
36.91	31.5	20.6	-	1.3	2.8	4.5	3	silty CLAY to CLAY	115	1.5	21	14	-	-	2.2	8.8	51	15	-	-	0.04	-
37.08	41.3	27.0	-	1.6	2.7	4.0	4	clayy SILT to silty CLAY	115	2.0	21	13	-	-	2.8	9.9	43	15	-	-	0.04	-
37.24	44.9	29.2	-	1.6	2.7	3.8	4	clayy SILT to silty CLAY	115	2.0	22	15	-	-	3.1	9.9	41	15	-	-	0.04	-
37.40	32.4	21.0	-	1.6	2.7	5.3	3	silty CLAY to CLAY	115	1.5	22	14	-	-	2.2	9.0	53	15	-	-	0.04	-
37.57	31.8	20.6	-	1.5	2.7	5.0	3	silty CLAY to CLAY	115	1.5	21	14	-	-	2.2	8.8	53	15	-	-	0.04	-
37.73	30.1	19.4	-	1.5	2.6	5.2	3	silty CLAY to CLAY	115	1.5	20	13	-	-	2.0	8.2	55	15	-	-	0.04	-
37.90	39.2	25.2	-	1.5	2.6	3.9	4	clayy SILT to silty CLAY	115	2.0	20	13	-	-	2.7	9.9	44	15	-	-	0.04	-
38.06	35.5	22.8	-	1.5	2.7	4.6	3	silty CLAY to CLAY	115	1.5	24	15	-	-	2.4	9.7	49	15	-	-	0.04	-
38.22	29.2	18.7	-	1.5	2.7	5.5	3	silty CLAY to CLAY	115	1.5	19	12	-	-	2.0	7.8	57	15	-	-	0.04	-
38.39	30.2	19.3	-	1.3	2.7	4.8	3	silty CLAY to CLAY	115	1.5	20	13	-	-	2.1	8.1	53	15	-	-	0.04	-
38.55	27.3	17.4	-	1.4	2.7	5.8	3	silty CLAY to CLAY	115	1.5	18	12	-	-	1.8	7.2	59	15	-	-	0.04	-
38.72	26.7	16.9	-	1.4	2.8	5.8	3	silty CLAY to CLAY	115	1.5	18	11	-	-	1.8	7.0	60	15	-	-	0.04	-
38.88	22.5	14.3	-	1.3	2.8	6.3	3	silty CLAY to CLAY	115	1.5	15	10	-	-	1.5	5.8	66	15	-	-	0.04	-
39.04	26.1	16.5	-	1.1	2.7	4.8	3	silty CLAY to CLAY	115	1.5	17	11	-	-	1.8	6.8	57	15	-	-	0.04	-
39.21	23.1	14.6	-	1.1	2.7	5.3	3	silty CLAY to CLAY	115	1.5	15	10	-	-	1.6	5.9	62	15	-	-	0.04	-
39.37	22.6	14.2	-	0.9	2.7	4.3	3	silty CLAY to CLAY	115	1.5	15	9	-	-	1.5	5.8	59	15	-	-	0.04	-
39.54	28.9	18.1	-	0.9	2.7	3.5	3	silty CLAY to CLAY	115	1.5	19	12	-	-	2.0	7.5	49	15	-	-	0.04	-
39.70	25.1	15.7	-	1.0	2.6	4.2	3	silty CLAY to CLAY	115	1.5	17	10	-	-	1.7	6.4	56	15	-	-	0.04	-
39.86	19.5	12.1	-	1.1	2.6	6.6	3	silty CLAY to CLAY	115	1.5	13	8	-	-	1.3	4.8	72	15	-	-	0.04	-
40.03	19.5	12.1	-	1.3	2.6	7.6	3	silty CLAY to CLAY	115	1.5	13	8	-	-	1.3	4.8	74	15	-	-	0.04	-
40.19	33.9	21.0	-	1.6	2.7	4.9	3	silty CLAY to CLAY	115	1.5	23	14	-	-	2.3	8.8	52	15	-	-	0.04	-
40.36	36.2	22.4	-	1.3	2.6	3.9	3	silty CLAY to CLAY	115	1.5	24	15	-	-	2.5	9.4	47	15	-	-	0.04	-
40.52	35.2	21.7	-	1.5	2.7	4.6	3	silty CLAY to CLAY	115	1.5	23	14	-	-	2.4	9.1	50	15	-	-	0.04	-
40.68	44.3	27.2	-	1.5	2.6	3.6	4	clayy SILT to silty CLAY	115	2.0	22	14	-	-	3.0	9.9	41	15	-	-	0.04	-
40.85	39.0	23.9	-	1.6	2.6	4.3	3	silty CLAY to CLAY	115	1.5	26	16	-	-	2.7	9.9	47	15	-	-	0.04	-
41.01	49.1	30.0	-	1.7	2.6	3.7	4	clayy SILT to silty CLAY	115	2.0	25	15	-	-	3.4	9.9	40	15	-	-	0.04	-
41.18	53.0	32.3	-	1.9	2.5	3.8	4	clayy SILT to silty CLAY	115	2.0	26	16	-	-	3.7	9.9	39	15	-	-	0.04	-
41.34	36.1	21.9	-	1.6	2.6	4.8	3	silty CLAY to CLAY	115	1.5	24	15	-	-	2.5	9.1	51	15	-	-	0.04	-
41.50	36.2	21.9	-	1.7	2.7	4.9	3	silty CLAY to CLAY	115	1.5	24	15	-	-	2.5	9.1	51	15	-	-	0.04	-
41.67	54.7	33.1	-	1.8	2.7	3.4	4	clayy SILT to silty CLAY	115	2.0	27	17	-	-	3.8	9.9	37	15	-	-	0.04	-
41.83	68.9	52.0	133.6	2.0	2.6	3.1	4	clayy SILT to silty CLAY	115	2.0	34	26	-	-	4.8	9.9	29	15	1.77	-	0.04	41.9
42.00	63.7	48.0	127.8	1.8	2.5	3.0	4	clayy SILT to silty CLAY	115	2.0	32	24	-	-	4.4	9.9	30	15	1.91	-	0.03	46.4
42.16	45.8	27.5	-	2.3	2.6	5.2	3	silty CLAY to CLAY	115	1.5	31	18	-	-	3.1	9.9	47	15	-	-	0.03	-
42.32	45.6	27.3	-	2.2	2.6	5.0	3	silty CLAY to CLAY	115	1.5	30	18	-	-	3.1	9.9	47	15	-	-	0.03	-
42.49	28.3	16.9	-	1.9	2.7	7.4	3	silty CLAY to CLAY	115	1.5	19	11	-	-	1.9	6.9	65	15	-	-	0.03	-
42.65	30.7	18.3	-	1.3	2.9	4.5	3	silty CLAY to CLAY	115	1.5	20	12	-	-	2.1	7.5	53	15	-	-	0.03	-
42.82	42.7	25.3	-	1.6	2.8	4.0	3	silty CLAY to CLAY	115	1.5	28	17	-	-	2.9	9.9	44	15	-	-	0.03	-
42.98	36.9	21.9	-	1.9	2.7	5.5	3	silty CLAY to CLAY	115	1.5	25	15	-	-	2.5	9.0	53	15	-	-	0.03	-
43.15	42.5	25.1	-	2.1	2.7	5.2	3	silty CLAY to CLAY	115	1.5	28	17	-	-	2.9	9.9	49	15	-	-	0.03	-
43.31	76.4	57.0	127.0	1.9	2.6	2.6	5	silty SAND to sandy SILT	120	4.0	19	14	48	38	-	-	26	16	1.92	-	0.03	36.8
43.47	122.3	91.1	126.7	1.8	2.6	1.5	5	silty SAND to sandy SILT	120	4.0	31	23	64	40	-	-	15	16	1.93	-	0.03	19.5
43.64	157.8	117.4	143.2	2.0	2.5	1.3	6	clean SAND to silty SAND	125	5.0	32	23	72	42	-	-	11	16	1.47	-	0.02	8.4
43.80	183.1	136.0	158.5	2.2	2.5	1.2	6	clean SAND to silty SAND	125	5.0	37	27	77	42	-	-	10	16	0.83	-	0.02	4.3
43.97	203.1	150.6	175.0	2.7	2.5	1.3	6	clean SAND to silty SAND	125	5.0	41	30	81	43	-	-	10	16	0.00	-	0.02	0.0
44.13	217.4	160.9	186.2	3.0	2.6	1.4	6	clean SAND to silty SAND	125	5.0	43	32	83	43	-	-	10	16	0.00	-	0.02	0.0
44.29	225.0	166.3	191.8	3.2	2.7	1.4	6	clean SAND to silty SAND	125	5.0	45	33	84	43	-	-	9	16	0.00	-	0.02	0.0
44.46	225.8	166.7	193.8	3.3	2.7	1.5	6	clean SAND to silty SAND	125	5.0	45	33	84	43	-	-	10	16	0.00	-	0.02	0.0
44.62	221.9	163.6	191.5	3.3	2.7	1.5	6	clean SAND to silty SAND	125	5.0	44	33	83	43	-	-	10	16	0.00	-	0.02	0.0
44.79	216.9	159.6	182.0	2.8	2.8	1.3	6	clean SAND to silty SAND	125	5.0	43	32	82	43	-	-	9	16	0.00	-	0.02	0.0
44.95	209.5	154.0	168.9	2.2	2.9	1.0	6	clean SAND to silty SAND	125	5.0	42	31	81	43	-	-	8	16	0.00	-	0.02	0.0
45.11	192.1	141.0	155.4	1.8	3.0	1.0	6	clean SAND to silty SAND	125	5.0	38	28	78	42	-	-	8	16	0.96	-	0.02	4.7
45.28	187.6	137.5	152.1	1.8	3.0	1.0	6	clean SAND to silty SAND	125	5.0	38	27	78	42	-	-	8	16	1.10	-	0.02	5.3
45.44	187.7	137.3	152.4	1.8	2.9	1.0	6	clean SAND to silty SAND	125	5.0	38	27	77	42	-	-	8	16	1.08	-	0.02	5.3
45.61	189.7	138.6	156.2	2.0	3.0	1.1	6	clean SAND to silty SAND	125	5.0	38	28	78	42	-	-	9	16	0.92	-	0.02	4.6
45.77	192.6	140.5	160.8	2.2	3.0	1.2	6	clean SAND to silty SAND	125	5.0	39	28	78	42	-	-	9	16	0.00	-	0.01	0.0
45.93	192.0	139.9	160.6	2.2	3.0	1.2	6	clean SAND to silty SAND	125	5.0	38	28	78	42	-	-	9	16	0.00	-	0.01	0.0
46.10	188.3	137.0	158.9	2.2	3.0	1.2	6	clean SAND to silty SAND	125	5.0	38	27	77	42	-	-	10	16	0.80	-	0.01	4.1
46.26	188.6	137.0	160.0	2.3	3.0	1.2	6	clean SAND to silty SAND	125	5.0	38	27	77	42	-	-	10	16	0.76	-	0.01	4.0

* Indicates the parameter was calculated using the normalized point stress.
The parameters listed above were determined using empirical correlations.
A Professional Engineer must determine their suitability for analysis and design.

Project ID: Earth Mechanics
Data File: SDF(528)-2-17.cpt
CPT Date: 10/5/2011 1:33:38 AM
GW During Test: 17 ft

Sounding ID: CPT-11-321
Project No: 11-137
Cone/Rig: DSG1104

Depth ft	qc PS tsf	qcln PS -	qincs PS -	Slv Stss tsf	pore prss (psi)	Frct Ratio %	Mat Typ Zon	Material Behavior Description	Unit Wght pcf	Qc to N	SPT R-N 60%	SPT R-N1 60%	Rel Den %	Ftn Ang deg	Und Shr tsf	OCR -	Fin Ic %	Nk -	Vol Strn %	Dry Stlmt 0.00	Liq Stlmt 0.26	Cycl SStn %
46.43	186.3	135.1	154.9	2.1	3.0	1.1	6	clean SAND to silty SAND	125	5.0	37	27	77	42	-	-	9	16	0.96	-	0.01	4.8
46.59	186.1	134.8	152.2	1.9	3.1	1.0	6	clean SAND to silty SAND	125	5.0	37	27	77	42	-	-	9	16	1.08	-	0.01	5.3
46.75	182.4	132.0	144.6	1.6	3.0	0.9	6	clean SAND to silty SAND	125	5.0	36	26	76	42	-	-	8	16	1.41	-	0.01	7.1
46.92	180.4	130.3	151.2	2.0	3.1	1.1	6	clean SAND to silty SAND	125	5.0	36	26	76	42	-	-	10	16	1.11	-	0.01	5.6
47.08	169.8	122.5	158.4	2.7	3.1	1.6	6	clean SAND to silty SAND	125	5.0	34	24	74	42	-	-	13	16	0.79	-	0.00	4.2
47.25	169.0	121.7	157.5	2.7	3.1	1.6	6	clean SAND to silty SAND	125	5.0	34	24	73	42	-	-	13	16	0.83	-	0.00	4.4
47.41	196.3	141.2	179.2	3.4	3.1	1.8	6	clean SAND to silty SAND	125	5.0	39	28	78	42	-	-	12	16	0.00	-	0.00	0.0
47.57	233.5	167.7	194.9	3.4	3.3	1.5	6	clean SAND to silty SAND	125	5.0	47	34	84	43	-	-	10	16	0.00	-	0.00	0.0
47.74	233.5	167.5	188.2	2.9	3.1	1.3	6	clean SAND to silty SAND	125	5.0	47	33	84	43	-	-	9	16	0.00	-	0.00	0.0
47.90	253.8	181.7	181.7	1.4	2.8	0.6	6	clean SAND to silty SAND	125	5.0	51	36	87	44	-	-	5	16	0.00	-	0.00	0.0
48.07	260.2	186.1	191.0	2.3	2.8	0.9	6	clean SAND to silty SAND	125	5.0	52	37	88	44	-	-	6	16	0.00	-	0.00	0.0
48.23	252.1	180.0	180.0	1.6	3.1	0.7	6	clean SAND to silty SAND	125	5.0	50	36	86	43	-	-	5	16	0.00	-	0.00	0.0
48.39	250.4	178.6	178.6	1.3	3.1	0.5	6	clean SAND to silty SAND	125	5.0	50	36	86	43	-	-	5	16	0.00	-	0.00	0.0
48.56	245.6	174.9	174.9	1.7	3.1	0.7	6	clean SAND to silty SAND	125	5.0	49	35	85	43	-	-	5	16	0.00	-	0.00	0.0
48.72	233.5	166.1	178.5	2.3	3.1	1.0	6	clean SAND to silty SAND	125	5.0	47	33	84	43	-	-	7	16	0.00	-	0.00	0.0
48.89	231.9	164.7	188.5	3.1	3.2	1.4	6	clean SAND to silty SAND	125	5.0	46	33	83	43	-	-	9	16	0.00	-	0.00	0.0
49.05	236.2	167.5	197.6	3.7	3.2	1.6	6	clean SAND to silty SAND	125	5.0	47	34	84	43	-	-	10	16	0.00	-	0.00	0.0
49.22	239.5	169.7	204.1	4.1	3.2	1.7	6	clean SAND to silty SAND	125	5.0	48	34	84	43	-	-	11	16	0.00	-	0.00	0.0
49.38	236.1	167.0	207.0	4.4	3.3	1.9	6	clean SAND to silty SAND	125	5.0	47	33	84	43	-	-	12	16	0.00	-	0.00	0.0
49.54	222.5	157.2	201.6	4.4	3.3	2.0	5	silty SAND to sandy SILT	120	4.0	56	39	82	43	-	-	13	16	0.00	-	0.00	0.0
49.71	209.1	147.5	195.5	4.3	3.3	2.1	5	silty SAND to sandy SILT	120	4.0	52	37	80	42	-	-	13	16	0.00	-	0.00	0.0
49.87	199.4	140.5	187.8	4.0	3.4	2.0	5	silty SAND to sandy SILT	120	4.0	50	35	78	42	-	-	14	16	0.00	-	0.00	0.0
50.04	194.2	136.6	183.8	3.9	3.4	2.0	5	silty SAND to sandy SILT	120	4.0	49	34	77	42	-	-	14	16	0.00	-	0.00	0.0
50.20	190.8	134.1	179.3	3.7	2.9	2.0	5	silty SAND to sandy SILT	120	4.0	48	34	77	42	-	-	14	16	0.00	-	0.00	0.0
50.36	188.3	132.2	175.7	3.5	2.9	1.9	5	silty SAND to sandy SILT	120	4.0	47	33	76	42	-	-	14	16	0.00	-	0.00	0.0
50.53	183.1	128.4	175.5	3.6	2.9	2.0	5	silty SAND to sandy SILT	120	4.0	46	32	75	42	-	-	14	16	0.00	-	0.00	0.0
50.69	183.2	128.3	180.7	3.9	2.9	2.2	5	silty SAND to sandy SILT	120	4.0	46	32	75	42	-	-	15	16	0.00	-	0.00	0.0
50.86	183.0	128.0	186.9	4.3	2.9	2.4	5	silty SAND to sandy SILT	120	4.0	46	32	75	42	-	-	16	16	0.00	-	0.00	0.0
51.02	187.4	130.9	190.6	4.4	2.9	2.4	5	silty SAND to sandy SILT	120	4.0	47	33	76	42	-	-	16	16	0.00	-	0.00	0.0
51.18	183.5	128.1	187.0	4.3	2.9	2.4	5	silty SAND to sandy SILT	120	4.0	46	32	75	42	-	-	16	16	0.00	-	0.00	0.0
51.35	176.4	122.9	177.6	3.9	2.9	2.2	5	silty SAND to sandy SILT	120	4.0	44	31	74	41	-	-	16	16	0.00	-	0.00	0.0
51.51	171.3	119.3	172.3	3.7	3.0	2.2	5	silty SAND to sandy SILT	120	4.0	43	30	73	41	-	-	16	16	0.00	-	0.00	0.0
51.68	161.9	112.6	164.9	3.4	3.0	2.1	5	silty SAND to sandy SILT	120	4.0	40	28	71	41	-	-	16	16	0.00	-	0.00	0.0
51.84	151.4	105.1	163.1	3.4	3.1	2.3	5	silty SAND to sandy SILT	120	4.0	38	26	69	40	-	-	17	16	0.00	-	0.00	0.0
52.00	126.9	88.0	168.5	3.7	3.2	3.0	5	silty SAND to sandy SILT	120	4.0	32	22	63	39	-	-	22	16	0.00	-	0.00	0.0
52.17	91.6	63.5	157.9	3.1	3.4	3.5	4	clayy SILT to silty CLAY	115	2.0	46	32	-	-	6.4	9.9	28	15	0.63	-	0.00	4.7
52.33	37.3	18.9	-	1.9	3.2	5.5	3	silty CLAY to CLAY	115	1.5	25	13	-	-	2.5	7.3	56	15	-	-	0.00	-
52.50	24.0	12.1	-	0.9	3.2	4.5	3	silty CLAY to CLAY	115	1.5	16	8	-	-	1.6	4.5	64	15	-	-	0.00	-
52.66	18.8	9.5	-	0.6	3.2	4.0	3	silty CLAY to CLAY	115	1.5	13	6	-	-	1.2	3.3	69	15	-	-	0.00	-
52.82	16.5	8.3	-	0.6	3.1	4.3	3	silty CLAY to CLAY	115	1.5	11	6	-	-	1.1	2.8	75	15	-	-	0.00	-
52.99	16.8	8.4	-	0.7	3.1	5.0	3	silty CLAY to CLAY	115	1.5	11	6	-	-	1.1	2.9	78	15	-	-	0.00	-
53.15	19.3	9.7	-	0.7	3.0	4.2	3	silty CLAY to CLAY	115	1.5	13	6	-	-	1.3	3.4	69	15	-	-	0.00	-
53.32	17.4	8.7	-	0.7	3.0	4.8	3	silty CLAY to CLAY	115	1.5	12	6	-	-	1.1	3.0	75	15	-	-	0.00	-
53.48	17.0	8.5	-	0.7	2.9	5.2	3	silty CLAY to CLAY	115	1.5	11	6	-	-	1.1	2.9	78	15	-	-	0.00	-
53.64	22.0	11.0	-	0.7	2.9	3.8	3	silty CLAY to CLAY	115	1.5	15	7	-	-	1.4	4.0	64	15	-	-	0.00	-
53.81	27.1	13.5	-	0.9	2.7	3.7	3	silty CLAY to CLAY	115	1.5	18	9	-	-	1.8	5.0	58	15	-	-	0.00	-
53.97	22.5	11.2	-	0.9	2.7	4.4	3	silty CLAY to CLAY	115	1.5	15	7	-	-	1.5	4.0	66	15	-	-	0.00	-
54.14	17.7	8.8	-	0.7	2.7	4.9	3	silty CLAY to CLAY	115	1.5	12	6	-	-	1.1	3.0	76	15	-	-	0.00	-
54.30	16.6	8.2	-	0.5	2.6	4.0	3	silty CLAY to CLAY	115	1.5	11	5	-	-	1.1	2.8	74	15	-	-	0.00	-
54.46	16.7	8.3	-	0.5	2.7	3.5	3	silty CLAY to CLAY	115	1.5	11	6	-	-	1.1	2.8	71	15	-	-	0.00	-
54.63	19.1	9.4	-	0.5	2.6	3.4	3	silty CLAY to CLAY	115	1.5	13	6	-	-	1.2	3.3	66	15	-	-	0.00	-
54.79	22.3	11.0	-	0.7	2.6	3.7	3	silty CLAY to CLAY	115	1.5	15	7	-	-	1.5	3.9	63	15	-	-	0.00	-
54.96	23.4	11.5	-	1.0	2.5	4.7	3	silty CLAY to CLAY	115	1.5	16	8	-	-	1.5	4.1	67	15	-	-	0.00	-
55.12	30.2	14.8	-	1.1	2.5	4.1	3	silty CLAY to CLAY	115	1.5	20	10	-	-	2.0	5.5	57	15	-	-	0.00	-
55.28	27.4	13.4	-	1.2	2.5	5.0	3	silty CLAY to CLAY	115	1.5	18	9	-	-	1.8	4.9	63	15	-	-	0.00	-
55.45	25.3	12.3	-	1.2	2.6	5.5	3	silty CLAY to CLAY	115	1.5	17	8	-	-	1.7	4.5	68	15	-	-	0.00	-
55.61	29.5	14.3	-	1.3	2.6	5.1	3	silty CLAY to CLAY	115	1.5	20	10	-	-	2.0	5.3	62	15	-	-	0.00	-
55.78	27.5	13.3	-	1.3	2.6	5.3	3	silty CLAY to CLAY	115	1.5	18	9	-	-	1.8	4.9	65	15	-	-	0.00	-
55.94	25.0	12.1	-	1.2	2.6	5.7	3	silty CLAY to CLAY	115	1.5	17	8	-	-	1.7	4.4	69	15	-	-	0.00	-
56.11	25.8	12.5	-	1.1	2.6	5.1	3	silty CLAY to CLAY	115	1.5	17	8	-	-	1.7	4.5	66	15	-	-	0.00	-
56.27	36.4	17.6	-	1.3	2.7	3.9	3	silty CLAY to CLAY	115	1.5	24	12	-	-	2.5	6.6	52	15	-	-	0.00	-
56.43	42.8	20.6	-	1.6	2.4	4.1	3	silty CLAY to CLAY	115	1.5	29	14	-	-	2.9	7.9	49	15	-	-	0.00	-
56.60	41.7	20.0	-	2.0	2.4	5.3	3	silty CLAY to CLAY	115	1.5	28	13	-	-	2.8	7.7	54	15	-	-	0.00	-
56.76	38.6	18.5	-	2.2	2.5	6.3	3	silty CLAY to CLAY	115	1.5	26	12	-	-	2.6	7.0	60	15	-	-	0.00	-
56.93	31.0	14.8	-	1.7	2.5	6.3	3	silty CLAY to CLAY	115	1.5	21	10	-	-	2.1	5.5	65	15	-	-	0.00	-
57.09	23.7	11.3	-	1.4	2.7	6.7	3	silty CLAY to CLAY	115	1.5	16	8	-	-	1.6	4.0	74	15	-	-	0.00	-
57.25	34.0	16.2	-	1.5	2.6	5.0	3	silty CLAY to CLAY	115	1.5	23	11	-	-	2.3	6.1	58	15	-	-	0.00	-
57.42	37.3	17.7	-	1.8	2.6	5.4	3	silty CLAY to CLAY	115	1.5	25	12	-	-	2.5	6.7	58	15	-	-	0.00	-
57.58	29.3	13.9	-	1.7	2.5	6.7	3	silty CLAY to CLAY	115	1.5	20	9	-	-	2.0	5.1	68	15	-	-	0.00	-
57.75	25.6	12.1	-	1.6	2.7	7.2	3	silty CLAY to CLAY	115	1.5	17	8	-	-	1.7	4.4	74	15	-	-	0.00	-
57.91	23.6	11.2	-	1.2	2.7	5.9	3	silty CLAY to CLAY	115	1.5	16	7	-	-	1.5	4.0	72	15	-	-	0.00	-
58.07	22.5	10.6	-	1.3	2.6	6.7	3	silty CLAY to CLAY	115	1.5	15	7	-	-	1.5	3.7	76	15	-	-	0.00	-
58.24	24.2	11.4	-	1.4	2.6	6.5	3	silty CLAY to CLAY	115	1.5	16	8	-	-	1.6	4.0	74	15	-	-	0.00	-
58.40	28.1	13.2	-	1.5	2.6	6.2	3	silty CLAY to CLAY	115	1.5	19	9	-	-	1.9	4.8	68	15	-	-	0.00	-
58.57	43.7	20.5	-	1.8	2.7	4.5	3	silty CLAY to CLAY	115	1.5	29	14	-	-	3.0	7.8	51	15	-	-	0.00	-
58.73	47.2	22.1	-	2.0	2.7	4.6	3	silty CLAY to CLAY	115	1.5	31	15	-	-	3.2	8.5	50	15	-	-	0.00	-
58.89	52.0	24.3	-	2.1	2.6	4.2	3	silty CLAY to CLAY	115	1.5	35	16	-	-	3.6	9.4	46	15	-	-	0.00	-
59.06	40.6	18.9	-	1.9	2.5	5.2	3	silty CLAY to CLAY	115	1.5	27	13	-	-	2.7	7.1	56	15	-	-	0.00	-
59.22	36.6	17.0	-	1.8	2.5	5.3	3	silty CLAY to CLAY	115	1.5	24	11	-	-	2.5	6.3	59	15	-	-	0.00	-
59.39	52.1	24.2	-	2.3	2.5	4.7	3	silty CLAY to CLAY	115	1.5	35	16	-	-	3.6	9.3	48	15	-	-	0.00	-
59.55	68.2	31.6	-	3.0	2.4	4.6	3	silty CLAY to CLAY	115	1.5	45	21	-	-	4.7	9.9	43	15	-	-	0.00	-
59.71	69.5	32.1	-	2.6	2.5	4.0	4	clayy SILT to silty CLAY	115	2.0	35	16	-	-	4.8	9.9	40	15	-	-	0.00	-
59.88	76.5	35.3	-	2.4	2.7	3.4	4	clayy SILT to silty CLAY	115	2.0	38	18	-	-	5.3	9.9	36	15	-	-	0.00	-
60.04	78.5	36.1	-	2.8	2.6	3.7	4	clayy SILT to silty CLAY	115	2.0	39	18	-	-	5.4	9.9	37	15	-	-	0.00	-
60.21	73.8	33.9	-	2.8	2.5	3.9	4	clayy SILT to silty CLAY	115	2.0	37	17	-	-	5.1	9.9	39	15	-	-	0.00	-
60.37	71.1	32.6	-	2.8	2.5	4.2	4	clayy SILT to silty CLAY	115	2.0	36	16	-	-	4.9	9.9	41	15	-	-	0.00	-
60.53	64.5	29.5	-	2.8	2.5	4.5	3	silty CLAY to CLAY	115	1.5	43	20	-	-	4.4	9.9	44	15	-	-	0.00	-
60.70	49.8	22.7	-	2.3	2.6	4.9	3	silty CLAY to CLAY	115	1.5	33	15	-	-	3.4	8.7	50	15	-	-	0.00	-
60.86	45.2	20.6	-	2.3	2.7	5.5	3	silty CLAY to CLAY	115	1.5	30	14	-	-	3.1	7.8	55	15	-	-	0.00	-
61.03	38.6	17.6	-	2.2	2.5	6.2	3	silty CLAY to CLAY	115	1.5	26	12	-	-	2.6	6.5	61	15	-	-	0.00	-
61.19	23.4	10.6	-	1.8	2.6	9.3	3	silty CLAY to CLAY	115	1.5	16	7	-	-	1.5	3.7	84	15	-	-	0.00	-
61.35	20.0	9.1	-	1.3	2.6	7.6	3	silty CLAY to CLAY	115	1.5	13	6	-	-	1.3	3.1	85	15	-	-	0.00	-
61.52	17.3	7.8	-	1.0	2.7	7.5	3	silty CLAY to CLAY	115	1.5	12	5	-	-	1.1	2.5	90	15	-	-	0.00	-
61.68	17.7	8.0	-	1.0	2.7	6.8	3	silty CLAY to CLAY	115	1.5	12	5	-	-	1.1	2.6	87	15	-	-	0.00	-

* Indicates the parameter was calculated using the normalized point stress.
The parameters listed above were determined using empirical correlations.
A Professional Engineer must determine their suitability for analysis and design.

Project ID: Earth Mechanics
Data File: SDF(528)-2-17.cpt
CPT Date: 10/5/2011 1:33:38 AM
GW During Test: 17 ft

Sounding ID: CPT-11-321
Project No: 11-137
Cone/Rig: DSG1104

Depth ft	qc PS tsf	*qcln PS -	qlncs PS -	Slv Stss tsf	pore prss (psi)	Frct Rato %	Mat Typ Zon	Material Behavior Description	Unit Wght pcf	Qc to N	SPT R-N 60%	*SPT R-N1 60%	Rel Den %	Ftn Ang deg	Und Shr tsf	OCR -	Fin Ic %	Nk -	Vol Strn %	Dry Stlmt 0.00	Liq Stlmt 0.26	*Cycl SStn %
61.85	20.2	9.1	-	1.0	2.7	5.7	3	silty CLAY to CLAY	115	1.5	13	6	-	-	1.3	3.1	78	15	-	-	0.00	-
62.01	19.0	8.5	-	1.0	2.7	6.3	3	silty CLAY to CLAY	115	1.5	13	6	-	-	1.2	2.8	82	15	-	-	0.00	-
62.17	22.8	10.2	-	1.5	2.7	7.8	3	silty CLAY to CLAY	115	1.5	15	7	-	-	1.5	3.5	81	15	-	-	0.00	-
62.34	37.0	16.6	-	2.0	2.6	5.9	3	silty CLAY to CLAY	115	1.5	25	11	-	-	2.5	6.1	61	15	-	-	0.00	-
62.50	42.7	19.1	-	2.0	2.6	5.1	3	silty CLAY to CLAY	115	1.5	28	13	-	-	2.9	7.1	55	15	-	-	0.00	-
62.67	42.2	18.8	-	2.3	2.6	6.0	3	silty CLAY to CLAY	115	1.5	28	13	-	-	2.9	7.0	58	15	-	-	0.00	-
62.83	38.4	17.1	-	2.0	2.6	5.7	3	silty CLAY to CLAY	115	1.5	26	11	-	-	2.6	6.3	60	15	-	-	0.00	-
63.00	40.1	17.8	-	2.1	2.6	5.8	3	silty CLAY to CLAY	115	1.5	27	12	-	-	2.7	6.6	59	15	-	-	0.00	-
63.16	48.5	21.5	-	2.5	2.6	5.6	3	silty CLAY to CLAY	115	1.5	32	14	-	-	3.3	8.1	54	15	-	-	0.00	-
63.32	32.9	14.6	-	1.6	2.6	5.6	3	silty CLAY to CLAY	115	1.5	22	10	-	-	2.2	5.3	64	15	-	-	0.00	-
63.49	24.0	10.6	-	1.8	2.8	9.1	3	silty CLAY to CLAY	115	1.5	16	7	-	-	1.6	3.7	83	15	-	-	0.00	-
63.65	22.9	10.1	-	2.0	2.8	9.9	3	silty CLAY to CLAY	115	1.5	15	7	-	-	1.5	3.4	87	15	-	-	0.00	-
63.82	54.1	23.8	-	2.3	2.5	4.5	3	silty CLAY to CLAY	115	1.5	36	16	-	-	3.7	9.0	48	15	-	-	0.00	-
63.98	57.6	25.3	-	2.4	2.5	4.4	3	silty CLAY to CLAY	115	1.5	38	17	-	-	3.9	9.6	46	15	-	-	0.00	-
64.14	53.7	23.6	-	2.8	2.6	5.5	3	silty CLAY to CLAY	115	1.5	36	16	-	-	3.7	8.9	52	15	-	-	0.00	-
64.31	42.5	18.6	-	2.4	2.5	6.3	3	silty CLAY to CLAY	115	1.5	28	12	-	-	2.9	6.9	60	15	-	-	0.00	-
64.47	36.5	15.9	-	2.3	2.7	6.9	3	silty CLAY to CLAY	115	1.5	24	11	-	-	2.4	5.8	65	15	-	-	0.00	-
64.64	45.6	19.9	-	2.1	2.8	5.1	3	silty CLAY to CLAY	115	1.5	30	13	-	-	3.1	7.4	54	15	-	-	0.00	-
64.80	53.8	23.4	-	2.3	2.7	4.7	3	silty CLAY to CLAY	115	1.5	36	16	-	-	3.7	8.8	49	15	-	-	0.00	-
64.96	56.9	24.7	-	2.5	2.7	4.7	3	silty CLAY to CLAY	115	1.5	38	16	-	-	3.9	9.4	48	15	-	-	0.00	-
65.13	54.1	23.4	-	2.4	2.6	4.8	3	silty CLAY to CLAY	115	1.5	36	16	-	-	3.7	8.8	49	15	-	-	0.00	-
65.29	60.4	26.1	-	2.4	2.5	4.3	3	silty CLAY to CLAY	115	1.5	40	17	-	-	4.1	9.9	45	15	-	-	0.00	-
65.46	63.6	27.5	-	2.6	2.5	4.3	3	silty CLAY to CLAY	115	1.5	42	18	-	-	4.4	9.9	44	15	-	-	0.00	-
65.62	62.2	26.8	-	2.7	2.6	4.6	3	silty CLAY to CLAY	115	1.5	41	18	-	-	4.3	9.9	46	15	-	-	0.00	-
65.78	71.7	30.8	-	2.8	2.6	4.1	4	clayy SILT to silty CLAY	115	2.0	36	15	-	-	4.9	9.9	41	15	-	-	0.00	-
65.95	79.1	34.0	-	3.1	2.6	4.2	4	clayy SILT to silty CLAY	115	2.0	40	17	-	-	5.5	9.9	40	15	-	-	0.00	-
66.11	62.9	27.0	-	3.0	2.6	5.1	3	silty CLAY to CLAY	115	1.5	42	18	-	-	4.3	9.9	47	15	-	-	0.00	-
66.28	47.2	20.2	-	2.6	2.8	6.0	3	silty CLAY to CLAY	115	1.5	31	13	-	-	3.2	7.5	57	15	-	-	0.00	-
66.44	46.7	19.9	-	2.8	2.8	6.5	3	silty CLAY to CLAY	115	1.5	31	13	-	-	3.2	7.4	58	15	-	-	0.00	-
66.60	53.4	22.8	-	3.1	2.8	6.2	3	silty CLAY to CLAY	115	1.5	36	15	-	-	3.6	8.5	55	15	-	-	0.00	-
66.77	58.8	25.0	-	3.1	2.9	5.7	3	silty CLAY to CLAY	115	1.5	39	17	-	-	4.0	9.4	51	15	-	-	0.00	-
66.93	63.7	27.1	-	2.8	2.9	4.7	3	silty CLAY to CLAY	115	1.5	42	18	-	-	4.4	9.9	46	15	-	-	0.00	-
67.10	72.1	30.6	-	2.9	2.8	4.2	3	silty CLAY to CLAY	115	1.5	48	20	-	-	5.0	9.9	42	15	-	-	0.00	-
67.26	73.9	31.3	-	2.9	2.6	4.1	4	clayy SILT to silty CLAY	115	2.0	37	16	-	-	5.1	9.9	41	15	-	-	0.00	-
67.42	76.3	32.2	-	2.6	2.6	3.6	4	clayy SILT to silty CLAY	115	2.0	38	16	-	-	5.3	9.9	39	15	-	-	0.00	-
67.59	75.2	31.7	-	2.7	2.5	3.8	4	clayy SILT to silty CLAY	115	2.0	38	16	-	-	5.2	9.9	40	15	-	-	0.00	-
67.75	63.7	26.8	-	2.8	2.5	4.7	3	silty CLAY to CLAY	115	1.5	42	18	-	-	4.4	9.9	46	15	-	-	0.00	-
67.92	49.4	20.7	-	2.4	2.5	5.2	3	silty CLAY to CLAY	115	1.5	33	14	-	-	3.4	7.7	54	15	-	-	0.00	-
68.08	42.5	17.8	-	1.8	2.6	4.8	3	silty CLAY to CLAY	115	1.5	28	12	-	-	2.9	6.5	55	15	-	-	0.00	-
68.24	33.8	14.2	-	1.7	2.5	5.8	3	silty CLAY to CLAY	115	1.5	23	9	-	-	2.3	5.0	65	15	-	-	0.00	-
68.41	28.5	11.9	-	1.9	2.6	7.7	3	silty CLAY to CLAY	115	1.5	19	8	-	-	1.9	4.1	76	15	-	-	0.00	-
68.57	31.4	13.1	-	1.8	2.6	6.4	3	silty CLAY to CLAY	115	1.5	21	9	-	-	2.1	4.6	69	15	-	-	0.00	-
68.74	29.1	12.1	-	1.8	2.7	7.1	3	silty CLAY to CLAY	115	1.5	19	8	-	-	1.9	4.2	74	15	-	-	0.00	-
68.90	26.4	11.0	-	1.8	2.7	7.9	3	silty CLAY to CLAY	115	1.5	18	7	-	-	1.7	3.7	79	15	-	-	0.00	-
69.07	29.2	12.1	-	1.7	2.6	6.9	3	silty CLAY to CLAY	115	1.5	19	8	-	-	1.9	4.2	73	15	-	-	0.00	-
69.23	18.3	7.6	-	1.5	2.7	9.9	2	Organic SOILS - Peats	100	1.0	18	8	-	-	1.7	2.4	95	10	-	-	0.00	-
69.39	12.5	5.2	-	1.2	2.8	9.9	2	Organic SOILS - Peats	100	1.0	12	5	-	-	1.1	1.4	95	10	-	-	0.00	-
69.56	14.0	5.8	-	1.0	2.8	9.9	2	Organic SOILS - Peats	100	1.0	14	6	-	-	1.3	1.7	95	10	-	-	0.00	-
69.72	20.7	8.5	-	1.6	2.7	9.9	2	Organic SOILS - Peats	100	1.0	21	9	-	-	2.0	2.8	93	10	-	-	0.00	-
69.89	24.2	10.0	-	2.1	2.7	9.9	3	silty CLAY to CLAY	115	1.5	16	7	-	-	1.6	3.3	88	15	-	-	0.00	-
70.05	23.6	9.7	-	2.3	2.7	9.9	3	silty CLAY to CLAY	115	1.5	16	6	-	-	1.5	3.2	89	15	-	-	0.00	-
70.21	35.9	14.7	-	2.7	2.6	8.6	3	silty CLAY to CLAY	115	1.5	24	10	-	-	2.4	5.2	72	15	-	-	0.00	-
70.38	42.8	17.5	-	2.8	2.6	7.2	3	silty CLAY to CLAY	115	1.5	29	12	-	-	2.9	6.4	64	15	-	-	0.00	-
70.54	49.1	20.1	-	3.0	2.6	6.6	3	silty CLAY to CLAY	115	1.5	33	13	-	-	3.3	7.4	59	15	-	-	0.00	-
70.71	46.1	18.8	-	2.8	2.6	6.6	3	silty CLAY to CLAY	115	1.5	31	13	-	-	3.1	6.9	60	15	-	-	0.00	-
70.87	55.3	22.6	-	2.4	2.6	4.7	3	silty CLAY to CLAY	115	1.5	37	15	-	-	3.8	8.4	50	15	-	-	0.00	-
71.03	45.1	18.4	-	2.6	2.6	6.3	3	silty CLAY to CLAY	115	1.5	30	12	-	-	3.0	6.7	60	15	-	-	0.00	-
71.20	22.9	9.3	-	2.5	2.6	9.9	3	silty CLAY to CLAY	115	1.5	15	6	-	-	1.5	3.0	90	15	-	-	0.00	-
71.36	8.7	3.5	-	1.7	2.6	9.9	2	Organic SOILS - Peats	100	1.0	9	4	-	-	0.7	0.7	95	10	-	-	0.00	-
71.53	8.3	3.4	-	1.9	2.7	9.9	2	Organic SOILS - Peats	100	1.0	8	3	-	-	0.7	0.7	95	10	-	-	0.00	-
71.69	17.4	7.0	-	2.1	2.7	9.9	2	Organic SOILS - Peats	100	1.0	17	7	-	-	1.6	2.1	95	10	-	-	0.00	-
71.85	17.0	6.9	-	2.2	2.7	9.9	2	Organic SOILS - Peats	100	1.0	17	7	-	-	1.6	2.1	95	10	-	-	0.00	-
72.02	17.8	7.2	-	1.7	2.7	9.9	2	Organic SOILS - Peats	100	1.0	18	7	-	-	1.7	2.2	95	10	-	-	0.00	-
72.18	30.4	12.3	-	1.9	2.8	7.2	3	silty CLAY to CLAY	115	1.5	20	8	-	-	2.0	4.2	74	15	-	-	0.00	-
72.35	42.0	16.9	-	2.3	2.6	6.2	3	silty CLAY to CLAY	115	1.5	28	11	-	-	2.8	6.1	62	15	-	-	0.00	-
72.51	36.7	14.7	-	2.4	2.6	7.4	3	silty CLAY to CLAY	115	1.5	24	10	-	-	2.4	5.2	69	15	-	-	0.00	-
72.67	33.6	13.5	-	2.2	2.7	7.7	3	silty CLAY to CLAY	115	1.5	22	9	-	-	2.2	4.7	72	15	-	-	0.00	-
72.84	52.1	20.8	-	2.3	2.6	4.8	3	silty CLAY to CLAY	115	1.5	35	14	-	-	3.5	7.6	52	15	-	-	0.00	-
73.00	55.3	22.1	-	2.3	2.7	4.5	3	silty CLAY to CLAY	115	1.5	37	15	-	-	3.8	8.1	50	15	-	-	0.00	-
73.17	44.9	17.9	-	2.8	2.7	6.8	3	silty CLAY to CLAY	115	1.5	30	12	-	-	3.0	6.5	62	15	-	-	0.00	-
73.33	44.3	17.7	-	2.8	2.8	7.1	3	silty CLAY to CLAY	115	1.5	30	12	-	-	3.0	6.4	63	15	-	-	0.00	-
73.49	65.0	25.8	-	3.0	2.9	5.0	3	silty CLAY to CLAY	115	1.5	43	17	-	-	4.4	9.6	48	15	-	-	0.00	-
73.66	75.0	29.8	-	3.1	2.8	4.4	3	silty CLAY to CLAY	115	1.5	50	20	-	-	5.2	9.9	43	15	-	-	0.00	-
73.82	84.8	33.6	-	3.0	2.7	3.7	4	clayy SILT to silty CLAY	115	2.0	42	17	-	-	5.8	9.9	38	15	-	-	0.00	-
73.99	83.5	33.0	-	3.0	2.7	3.8	4	clayy SILT to silty CLAY	115	2.0	42	17	-	-	5.8	9.9	39	15	-	-	0.00	-
74.15	75.9	30.0	-	2.8	2.7	3.9	4	clayy SILT to silty CLAY	115	2.0	38	15	-	-	5.2	9.9	41	15	-	-	0.00	-
74.31	68.6	27.0	-	2.7	2.7	4.2	3	silty CLAY to CLAY	115	1.5	46	18	-	-	4.7	9.9	44	15	-	-	0.00	-
74.48	58.6	23.0	-	2.5	2.7	4.6	3	silty CLAY to CLAY	115	1.5	39	15	-	-	4.0	8.5	49	15	-	-	0.00	-
74.64	53.1	20.9	-	2.3	2.7	4.7	3	silty CLAY to CLAY	115	1.5	35	14	-	-	3.6	7.6	52	15	-	-	0.00	-
74.81	41.3	16.2	-	2.2	2.7	5.9	3	silty CLAY to CLAY	115	1.5	28	11	-	-	2.8	5.7	62	15	-	-	0.00	-
74.97	37.7	14.7	-	1.9	2.7	5.6	3	silty CLAY to CLAY	115	1.5	25	10	-	-	2.5	5.2	63	15	-	-	0.00	-
75.13	33.8	13.2	-	1.8	2.6	6.0	3	silty CLAY to CLAY	115	1.5	23	9	-	-	2.2	4.6	68	15	-	-	0.00	-
75.30	37.5	14.6	-	1.8	2.6	5.4	3	silty CLAY to CLAY	115	1.5	25	10	-	-	2.5	5.1	63	15	-	-	0.00	-
75.46	41.3	16.1	-	2.0	2.6	5.4	3	silty CLAY to CLAY	115	1.5	28	11	-	-	2.8	5.7	60	15	-	-	0.00	-
75.63	56.0	21.8	-	2.6	2.6	5.0	3	silty CLAY to CLAY	115	1.5	37	15	-	-	3.8	7.9	52	15	-	-	0.00	-
75.79	70.5	27.4	-	3.0	2.7	4.6	3	silty CLAY to CLAY	115	1.5	47	18	-	-	4.8	9.9	46	15	-	-	0.00	-
75.96	71.4	27.7	-	2.9	2.8	4.3	3	silty CLAY to CLAY	115	1.5	48	18	-	-	4.9	9.9	44	15	-	-	0.00	-
76.12	63.3	24.5	-	2.6	2.8	4.4	3	silty CLAY to CLAY	115	1.5	42	16	-	-	4.3	9.0	47	15	-	-	0.00	-
76.28	58.2	22.5	-	2.2	2.8	4.1	3	silty CLAY to CLAY	115	1.5	39	15	-	-	4.0	8.2	48	15	-	-	0.00	-
76.45	53.5	20.6	-	2.3	2.7	4.7	3	silty CLAY to CLAY	115	1.5	36	14	-	-	3.6	7.5	52	15	-	-	0.00	-
76.61	31.7	12.2	-	2.3	2.7	8.3	3	silty CLAY to CLAY	115	1.5	21	8	-	-	2.1	4.1	77	15	-	-	0.00	-
76.78	26.8	10.3	-	2.1	2.8	9.5	3	silty CLAY to CLAY	115	1.5	18	7	-	-	1.7	3.4	86	15	-	-	0.00	-
76.94	28.5	11.0	-	2.0	2.8	8.3	3	silty CLAY to CLAY	115	1.5	19	7	-	-	1.9	3.6	80	15	-	-	0.00	-
77.10	47.0	18.0	-	2.1	2.8	4.9	3	silty CLAY to CLAY	115	1.5	31	12	-	-	3.2	6.4	56	15	-	-	0.00	-

* Indicates the parameter was calculated using the normalized point stress.
The parameters listed above were determined using empirical correlations.
A Professional Engineer must determine their suitability for analysis and design.

Middle Earth Geo Testing

Project ID: Earth Mechanics
Data File: SDF(528)-2-17.cpt
CPT Date: 10/5/2011 1:33:38 AM
GW During Test: 17 ft

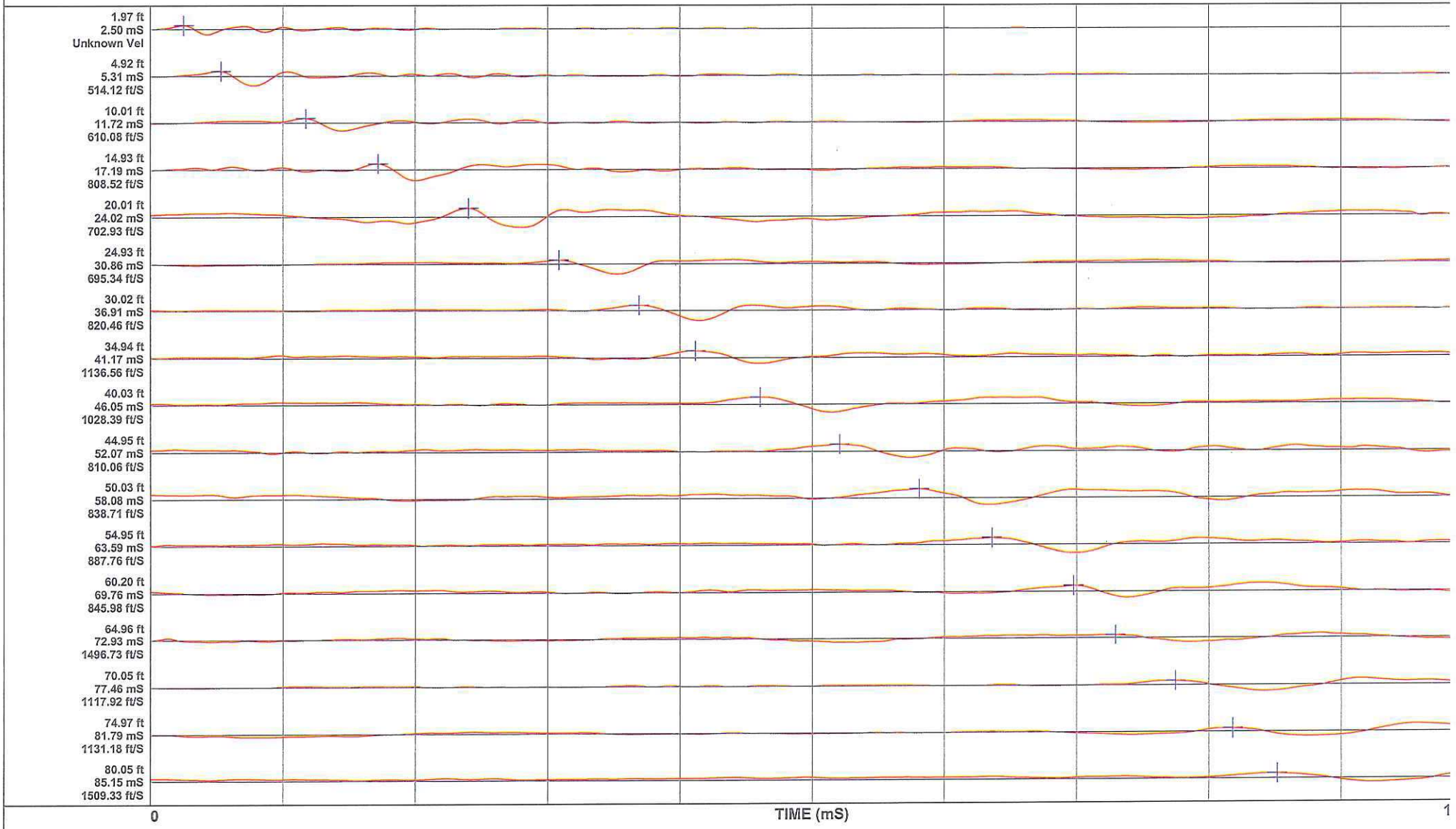
Sounding ID: CPT-11-321
Project No: 11-137
Cone/Rig: DSG1104

Depth ft	qc PS tsf	*qc1n PS -	qlncs PS -	Slv Stss tsf	pore prss (psi)	Frct Rato %	*Mat Typ Zon	*Material Behavior Description	Unit Wght pcf	Qc to N	SPT R-N 60%	*SPT R-N1 60%	Rel Den %	*Ftn Ang deg	Und Shr tsf	OCR -	*Fin Ic %	*Nk -	*Vol Strn %	Dry Stlmt 0.00	Liq Stlmt 0.26	*Cycl SStn %
77.27	47.0	18.0	-	2.1	2.8	4.9	3	silty CLAY to CLAY	115	1.5	31	12	-	-	3.2	6.4	56	15	-	-	0.00	-
77.43	39.8	15.2	-	1.6	2.8	4.4	3	silty CLAY to CLAY	115	1.5	27	10	-	-	2.7	5.3	58	15	-	-	0.00	-
77.60	31.6	12.0	-	1.4	2.7	5.2	3	silty CLAY to CLAY	115	1.5	21	8	-	-	2.1	4.1	68	15	-	-	0.00	-
77.76	32.2	12.2	-	1.6	2.7	5.7	3	silty CLAY to CLAY	115	1.5	21	8	-	-	2.1	4.2	69	15	-	-	0.00	-
77.92	32.7	12.4	-	1.8	2.8	6.2	3	silty CLAY to CLAY	115	1.5	22	8	-	-	2.2	4.2	70	15	-	-	0.00	-
78.09	29.7	11.3	-	1.9	2.8	7.5	3	silty CLAY to CLAY	115	1.5	20	8	-	-	1.9	3.8	77	15	-	-	0.00	-
78.25	30.8	11.7	-	2.5	2.8	9.4	3	silty CLAY to CLAY	115	1.5	21	8	-	-	2.0	3.9	81	15	-	-	0.00	-
78.42	40.3	15.2	-	2.4	2.7	6.6	3	silty CLAY to CLAY	115	1.5	27	10	-	-	2.7	5.3	66	15	-	-	0.00	-
78.58	48.0	18.1	-	2.3	2.7	5.2	3	silty CLAY to CLAY	115	1.5	32	12	-	-	3.2	6.5	57	15	-	-	0.00	-
78.74	48.3	18.2	-	2.4	2.7	5.5	3	silty CLAY to CLAY	115	1.5	32	12	-	-	3.3	6.5	57	15	-	-	0.00	-
78.91	47.9	18.1	-	2.2	2.6	5.1	3	silty CLAY to CLAY	115	1.5	32	12	-	-	3.2	6.4	56	15	-	-	0.00	-
79.07	48.0	18.1	-	2.2	2.6	5.0	3	silty CLAY to CLAY	115	1.5	32	12	-	-	3.2	6.4	56	15	-	-	0.00	-
79.24	55.5	20.9	-	2.3	2.6	4.6	3	silty CLAY to CLAY	115	1.5	37	14	-	-	3.8	7.5	51	15	-	-	0.00	-
79.40	51.6	19.5	-	2.3	2.6	4.9	3	silty CLAY to CLAY	115	1.5	34	13	-	-	3.5	6.9	54	15	-	-	0.00	-
79.56	43.5	16.4	-	2.4	2.7	6.3	3	silty CLAY to CLAY	115	1.5	29	11	-	-	2.9	5.7	63	15	-	-	0.00	-
79.73	42.0	15.9	-	2.2	2.7	6.0	3	silty CLAY to CLAY	115	1.5	28	11	-	-	2.8	5.5	63	15	-	-	0.00	-

* Indicates the parameter was calculated using the normalized point stress.
The parameters listed above were determined using empirical correlations.
A Professional Engineer must determine their suitability for analysis and design.

Earth Mechanics

Location	I-5 HOV Widening Segment 3	Operator	BH-DM	GPS
Job Number	11-137	Cone Number	DSG1104	
Hole Number	CPT-11-321	Date and Time	10/5/2011 1:33:38 AM	



Appendix B

LABORATORY TEST RESULTS

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 11-137 Project Name : I-5 HOV Improvement Project - PCH to San Juan Creek Road

Boring No .	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (tsf)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil-pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-11-316	D-1	5	CL	14.9	129.3	>4.5					310	7.2	5060	1187
A-11-316	S-2	10	CL	19.0				0:22:78						
A-11-316	D-3	15	SP	2.2	101.1									
A-11-316	S-4	20	SP-SM	2.6										
A-11-316	D-5	25	SP-SM	26.7	121.5			0:95:5						
A-11-316	S-6	30	MH	31.1										
A-11-316	D-7	35	MH	25.7	118.9	>4.5				60/33/27				
A-11-316	S-8	40	MH	31.5										
A-11-316	D-9	45	MH	29.8	117.4	>4.5								
A-11-316	S-10	50	MH	29.5										
A-11-316	D-11	55	MH	29.1	116.1	>4.5								
A-11-316	S-12	60	MH	29.8										
A-11-316	D-13	65	MH	30.9	115.0	>4.5								
A-11-316	S-14	70	MH	35.8										
A-11-316	D-15	75	MH	33.5	114.2	>4.5								
A-11-316	S-16	80	MH	22.4										
A-11-316	D-17	85	MH	40.6	110.1	>4.5								
A-11-316	S-18	90	MH	30.9										
A-11-316	D-19	95	CH	32.7	115.8	3.75								
A-11-316	S-20	100	MH	34.9										
A-11-317	S-1	5	CL to SP-SM	10.5							840	7.3	500	296
A-11-317	D-2	10	SP	26.5	114.6			0:96:4						
A-11-317	S-3	15	MH	27.4										
A-11-317	D-4	20	MH	26.6	115.0	>4.5								
A-11-317	S-5	25	MH	30.1						65/38/27				
A-11-317	D-6	30	MH	26.8	121.6	>4.5								
A-11-317	S-7	35	MH	27.8										
A-11-317	D-8	40	MH	26.0	120.3	>4.5								
A-11-317	S-9	45	CH	27.8										
A-11-317	D-10	50	MH	28.2	113.7	>4.5								
A-11-317	S-11	55	MH	30.3										
A-11-317	D-12	60	MH	26.5	117.1	>4.5								
A-11-317	S-13	65	MH	27.5										
A-11-317	D-14	70	MH	25.9	119.9	>4.5								
A-11-317	S-15	75	MH	25.9										
A-11-317	D-16	80	MH	33.2	121.3	>4.5								
A-11-317	S-17	85	MH	24.1										
A-11-317	D-18	90	MH	24.7	121.7	>4.5								
A-11-317	S-19	95	CH	26.4										

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

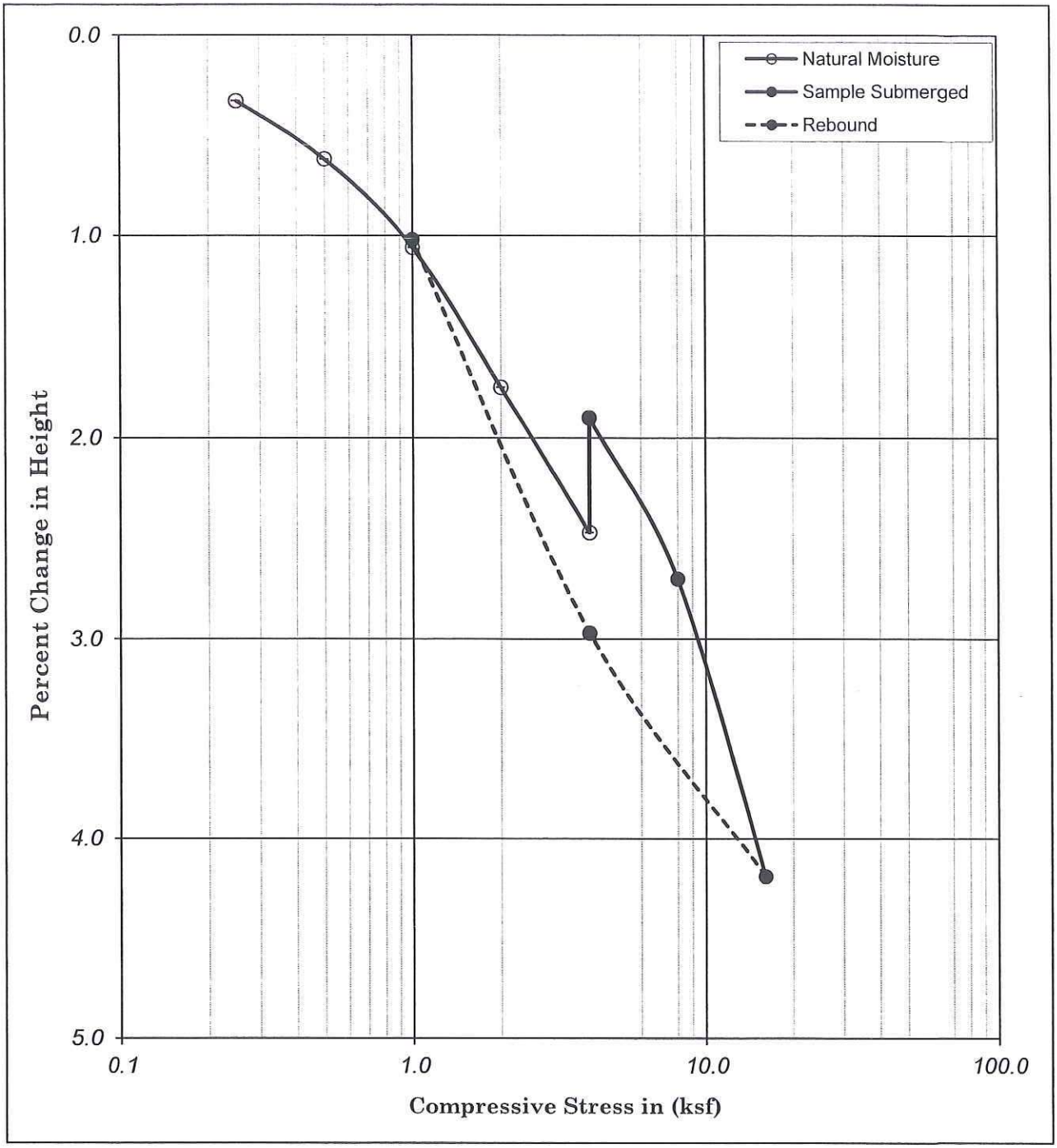
Project No. : 11-137 Project Name : I-5 HOV Improvement Project - PCH to San Juan Creek Road

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (tsf)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil-pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-11-317	S-19	95	CH	26.4										
A-11-317	D-20	100	MH	30.3	114.6	>4.5								
A-11-319	D-1	2.5	SM	8.6	125.1									
A-11-319	S-2	5	CL	25.2										
A-11-319	D-3	10	CL	22.9	119.9	1.75					560	6.7	2600	266
A-11-319	S-4	15	ML	26.0										
A-11-319	D-5	20	CH	26.0	119.9	1.0				51/22/29				
A-11-319	S-6	25	SP-SM	19.0										
A-11-319	D-7	30	SP	17.9	121.5			0:98:2						
A-11-319	S-8	35	CL	24.5										
A-11-319	D-9	40	CL	34.4	115.9	3.75								
A-11-319	S-10	45	CL	32.5										
A-11-319	D-11	50	CH	28.7	115.5	>4.5								
A-11-319	S-12	55	CL	35.9										
A-11-319	D-13	60	MH	33.0	116.1	>4.5								
A-11-319	S-14	65	MH	35.3										
A-11-319	D-15	70	MH	28.0	119.1	4..5								
A-11-319	S-16	75	MH	35.2										
A-11-319	D-17	80	MH	32.7	115.9	>4.5								
A-11-320	S-1	2.5	CL	27.3										
A-11-320	D-2	5	MH	34.1	111.9	>4.5					300	6.8	1160	1699
A-11-320	S-3	10	MH	35.7				0:1:99						
A-11-320	D-4	15	MH	29.0	115.4	>4.5				70/38/32				
A-11-320	S-5	20	MH	31.2										
A-11-320	D-6	25	MH	35.4	113.1	>4.5								
A-11-320	S-7	30	MH	29.5										
A-11-320	D-8	35	MH	26.7	118.2	>4.5								
A-11-320	S-9	40	MH	26.1										
A-11-320	D-10	45	MH	26.0	118.8	>4.5								
A-11-320	S-11	50	MH	29.6										
A-11-320	D-12	55	MH	27.9	119.7	>4.5								
A-11-320	S-13	60	MH	27.3										
A-11-320	D-14	65	MH	26.5	121.1	>4.5								
A-11-320	S-15	70	MH	24.7										
A-11-320	D-16	75	MH	24.1	119.4	>4.5								
A-11-320	S-17	80	MH	26.2										
A-11-322	D-1	5	CL	21.1	118.7	>4.5								
A-11-322	S-2	10	CL	14.1										

TABLE 1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 11-137 Project Name : I-5 HOV Improvement Project - PCH to San Juan Creek Road

Boring No.	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (tsf)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil-pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-11-322	D-3	15	SC	8.7	128.8			21:30:49						
A-11-322	S-4T	20	SM	5.0										
A-11-322	S-4B	21	CL	27.3										
A-11-322	D-5	25	MH	30.8	117.6	>4.5		0:2:98		61/38/23				
A-11-322	S-6	30	MH	27.3										
A-11-322	D-7	35	MH	27.2	120.8	>4.5								
A-11-322	S-8	40	MH	30.6										
A-11-322	D-9	45	MH	25.5	121.0	>4.5								
A-11-322	S-10	50	MH	28.1										
A-11-322	D-11	55	MH	29.3	115.8	>4.5								
A-11-322	S-12	60	MH	27.7										
A-11-322	D-13	65	MH	26.4	122.0	>4.5								
A-11-322	S-14	70	MH	30.8										
A-11-322	D-15	75	MH	37.8	118.9	>4.5								
A-11-322	S-16	80	MH	27.8										
A-11-322	D-17	85	MH	19.7	124.4	>4.5								
A-11-322	S-18	90	MH	25.2										
A-11-322	D-19	95	MH	24.4	120.7	>4.5								
A-11-322	S-20	100	MH	25.5										
A-11-323	S-1	5	SM	9.3							2200	7.7	150	204
A-11-323	D-2	10	CL	12.1	127.8	>4.5								
A-11-323	S-3	15	SM	3.5				13:72:15						
A-11-323	D-4	20	CH	23.5	120.9	>4.5								
A-11-323	S-5	25	CH	25.3										
A-11-323	D-6	30	CH	20.2	122.3	>4.5		0:2:98		68/32/36				
A-11-323	S-7	35	CH	28.9										
A-11-323	D-8	40	CH	30.1	117.4	>4.5								
A-11-323	S-9	45	CH	29.2										
A-11-323	D-10	50	CH	28.1	118.5	>4.5								
A-11-323	S-11	55	MH	30.1										
A-11-323	D-12	60	MH	30.5	116.5	>4.5								
A-11-323	S-13	65	MH	28.2										
A-11-323	D-14	70	MH	27.6	117.2	>4.5								
A-11-323	S-15	75	MH	25.4										
A-11-323	D-16	80	MH	25.2	121.3	>4.5								
A-11-323	S-17	85	MH	25.3										
A-11-323	D-18	90	MH	24.6	121.2	>4.5								
A-11-323	S-19	95	MH	26.0										
A-11-323	D-20	100	MH	27.8	119.6	>4.5								



Boring No. : A-11-316				Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m^3)	Percent Saturation	Void Ratio
Sample No. : D-11				Plastic Limit :	-						
Depth	(ft) :	55.0	56.5	Plastic Index :	-	Initial	29.92	92.63	14.58	98.54	0.82
	(m) :	16.78	17.23	Specific Gravity :	2.70	Final	35.98	93.59	14.73	121.28	0.80

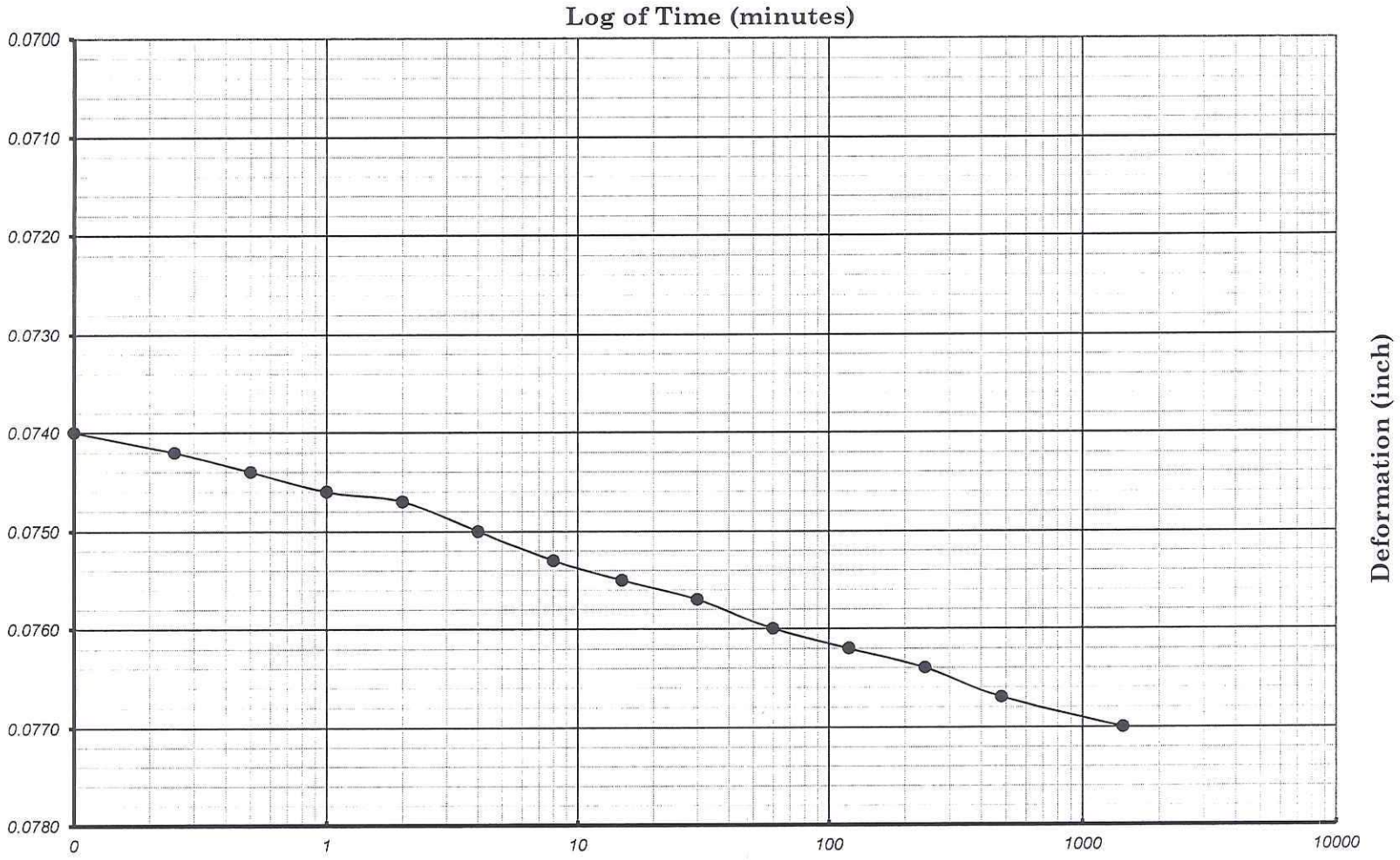
Description : *Very dark gray, Elastic SILT (MH)*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

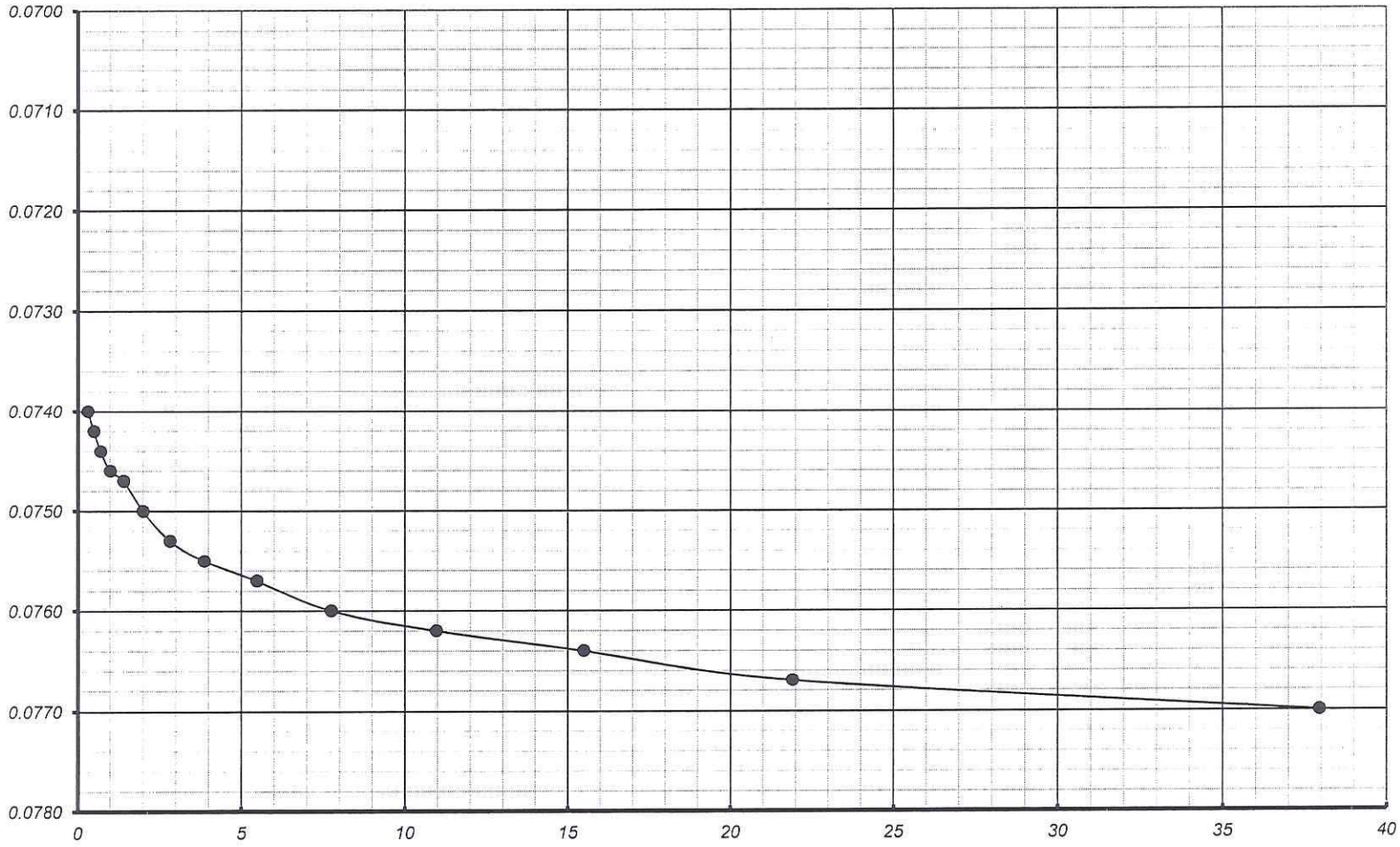
I-5 HOV Improvement Project
PCH to San Juan Creek Road

Project No. : 11-137 12/04/11

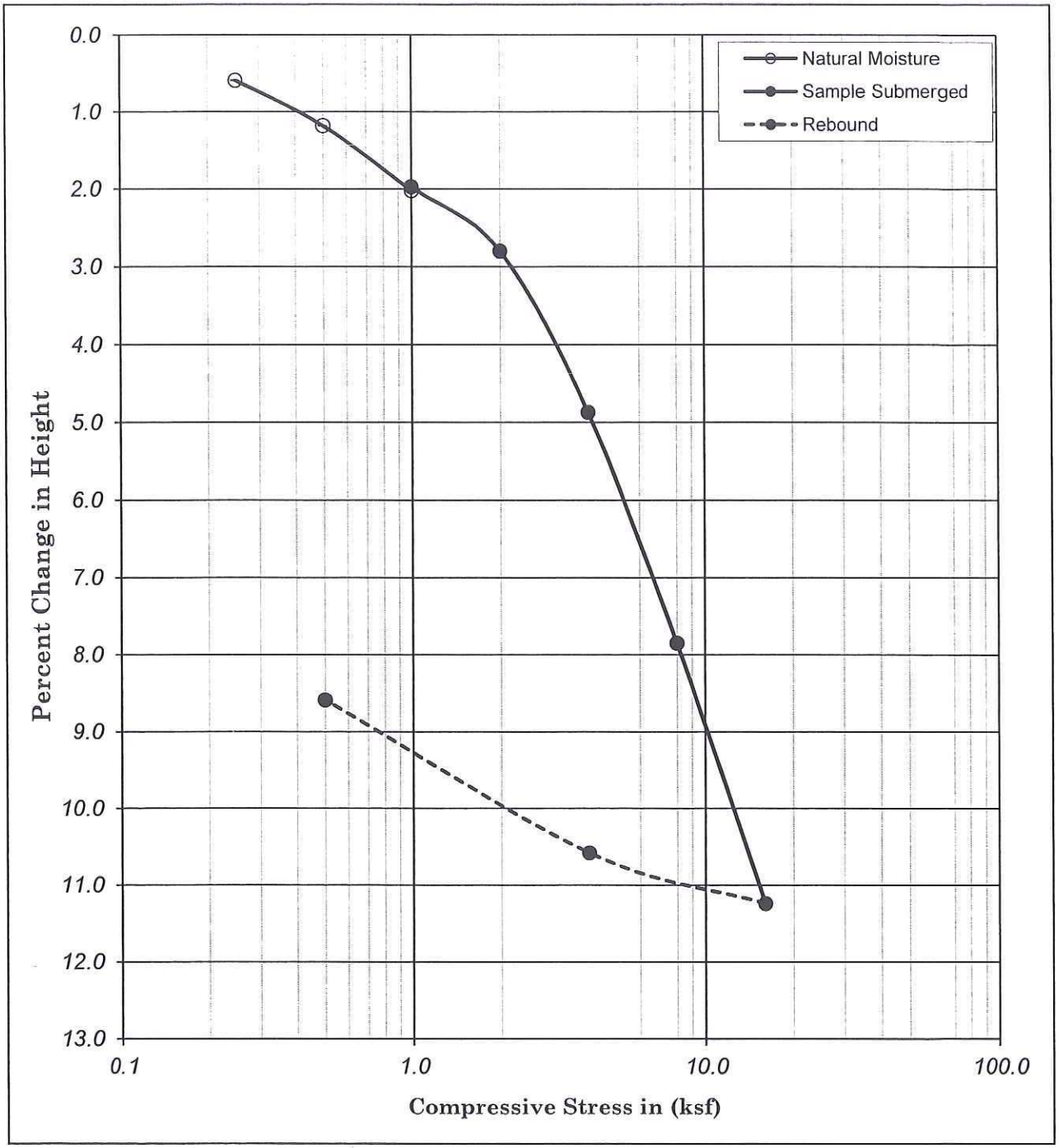
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*I-5 HOV Improvement Project PCH to San Juan Creek Road*	Boring No. : *A-11-316*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-11*	
EMI Project No. : *11-137*		Depth (ft/m) : *55.0* *16.8*	Veritcal Load (ksf/kpa) : *8.00* *383.0*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*I-5 HOV Improvement Project* *PCH to San Juan Creek Road*	Boring No. : *A-11-316*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-11*	
EMI Project No. : *11-137*		Depth (ft/m) : *55.0* *16.8*	Veritcal Load (ksf/kpa) : *8.0* *383.0*



Boring No.	: A-11-319		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No.	: D-3		Plastic Limit :	-						
Depth (ft)	: 15.0	16.5	Plastic Index :	-	Initial	24.03	98.00	15.43	90.11	0.72
Depth (m)	: 4.58	5.03	Specific Gravity :	2.70	Final	21.19	107.25	16.88	100.10	0.57

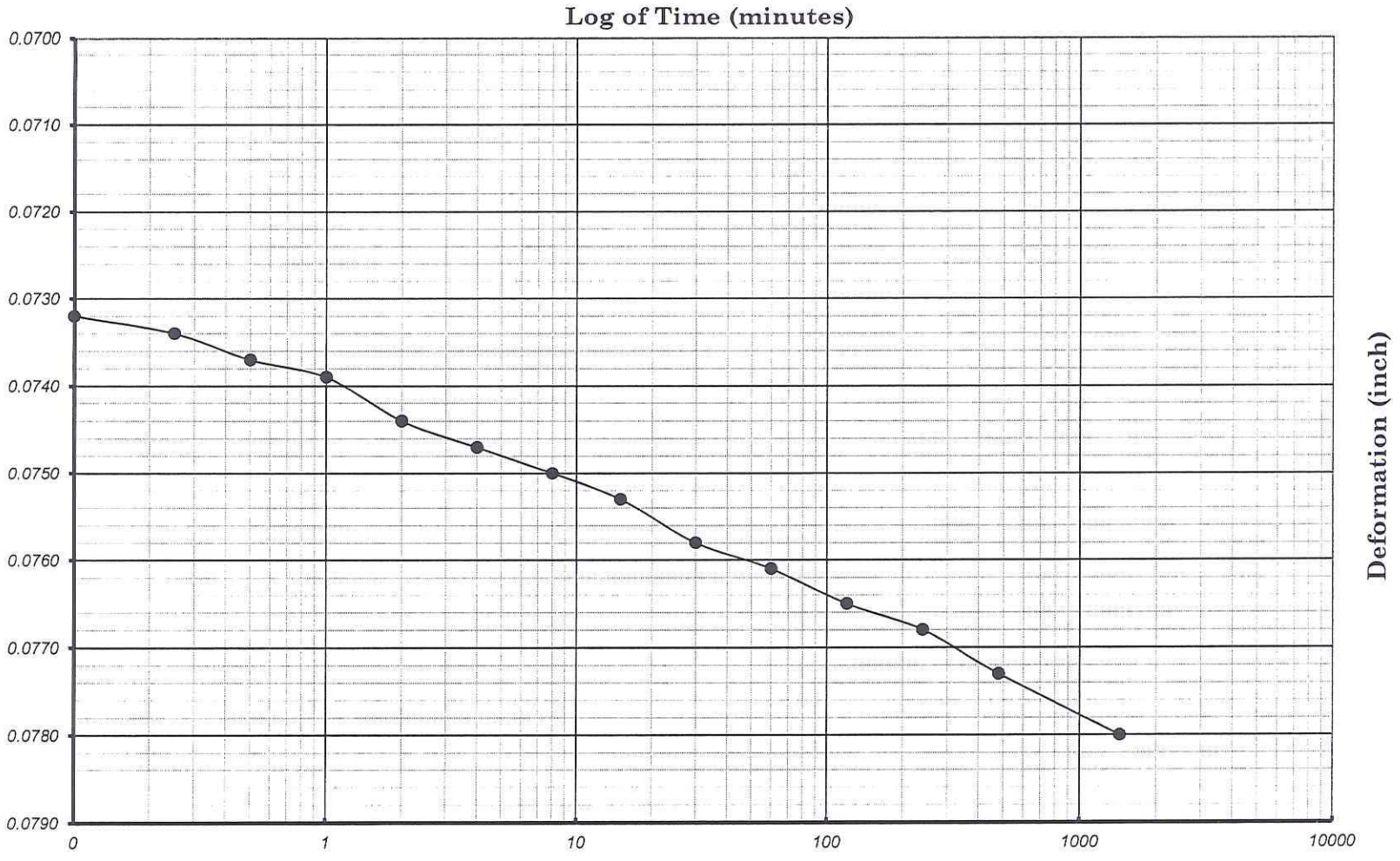
Description : *Olive-gray with yellowish brown , Lean CLAY (CL)*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

I-5 HOV Improvement Project
PCH to San Juan Creek Road

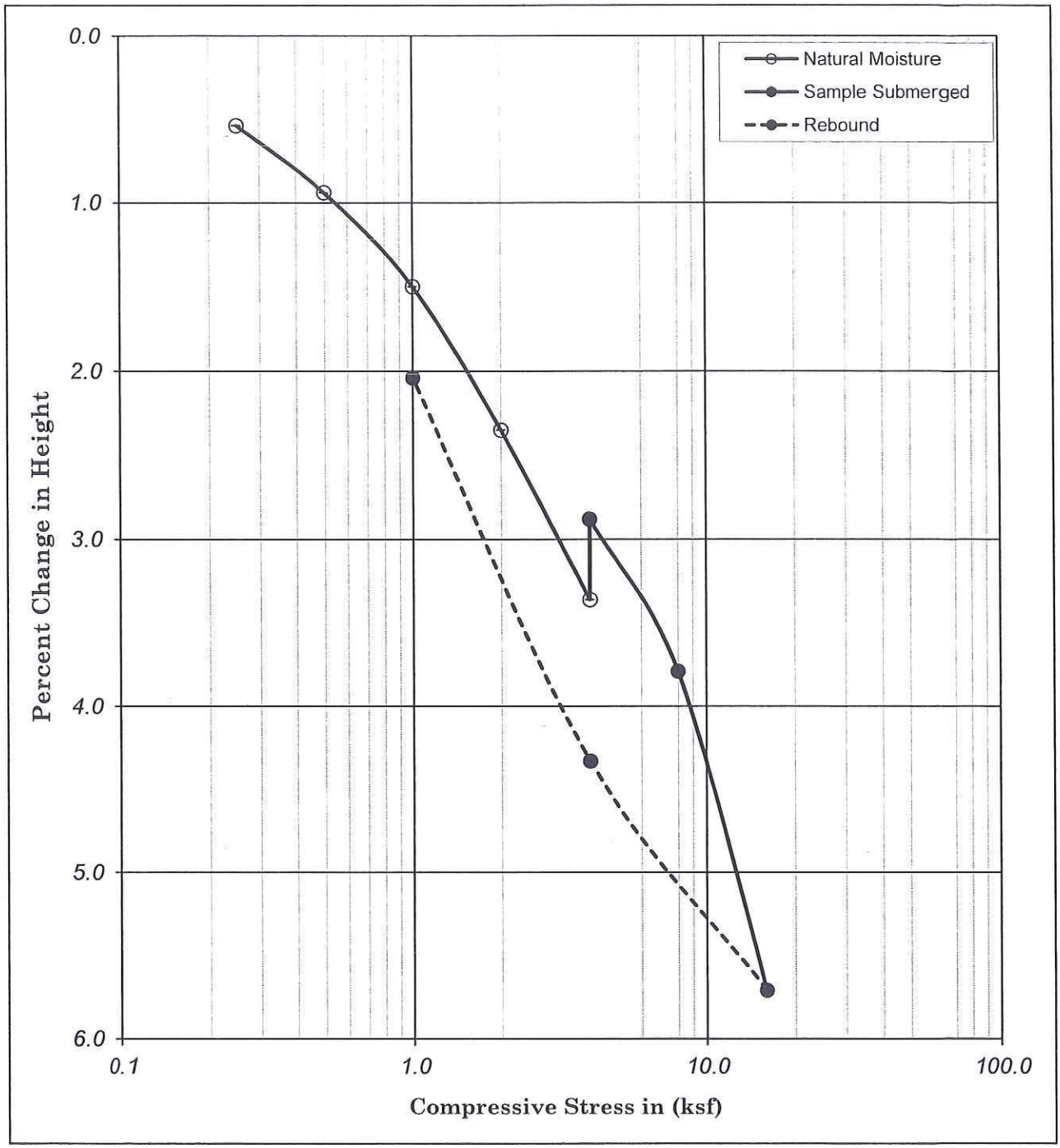
Project No. : *11-137* *12/04/11*

CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*I-5 HOV Improvement Project* *PCH to San Juan Creek Road*	Boring No. : *A-11-319*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-3*	
EMI Project No. : *11-137*		Depth (ft/m) : *15.0* *4.6*	Veritcal Load (ksf/kpa) : *2.00* *95.8*

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*I-5 HOV Improvement Project* *PCH to San Juan Creek Road*	Boring No. : *A-11-319*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-3*	
EMI Project No. : *11-137*		Depth (ft/m) : *15.0* *4.6*	Veritcal Load (ksf/kpa) : *2.0* *95.8*



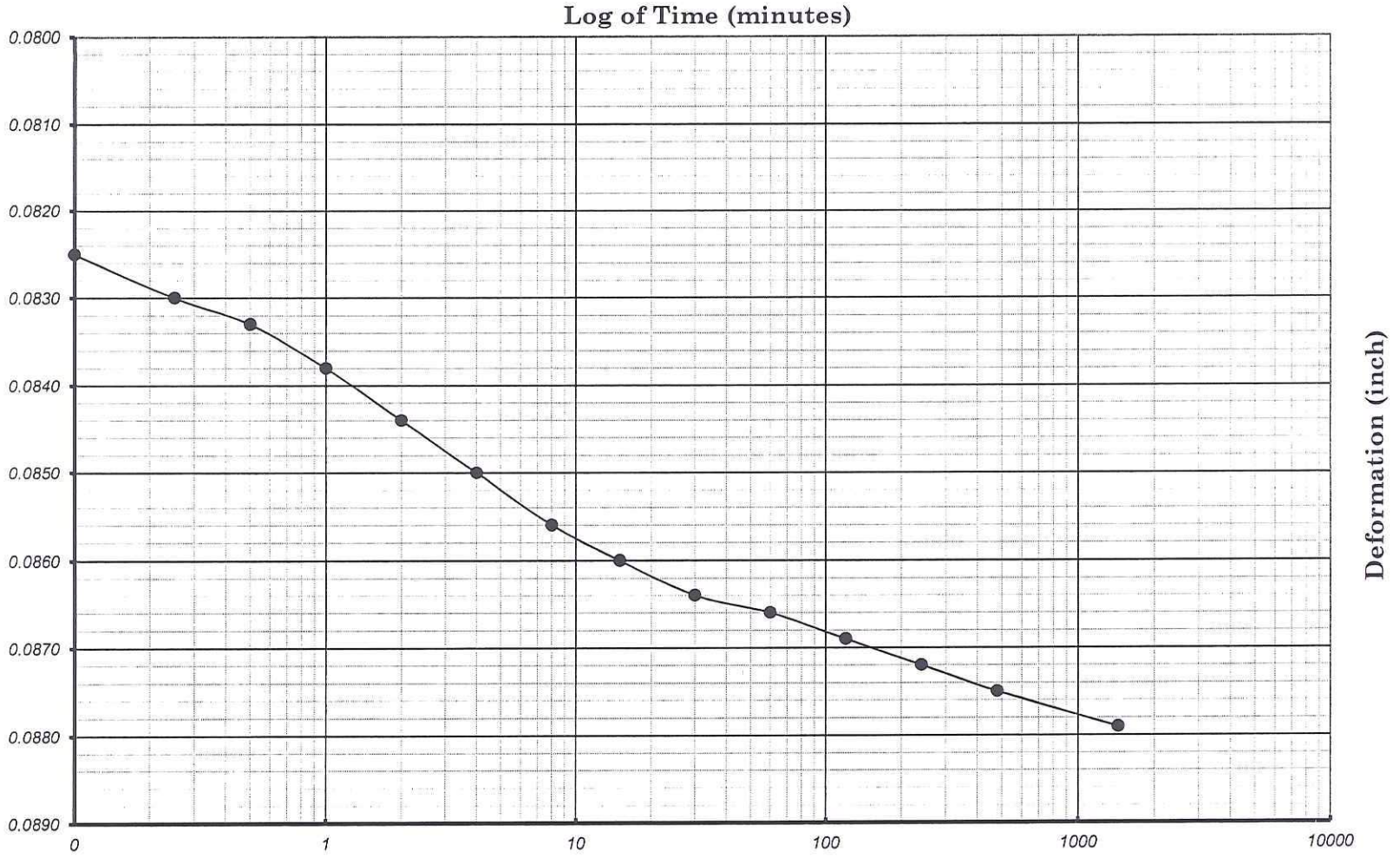
Boring No. : A-11-319				Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m^3)	Percent Saturation	Void Ratio
Sample No. : D-13				Plastic Limit :	-						
Depth	(ft) :	60.0	61.5	Plastic Index :	-	Initial	33.85	84.62	13.32	92.12	0.99
	(m) :	18.30	18.76	Specific Gravity :	2.70	Final	36.30	86.39	13.60	103.05	0.95
Description : Very dark gray, Elastic SILT (MH)											

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

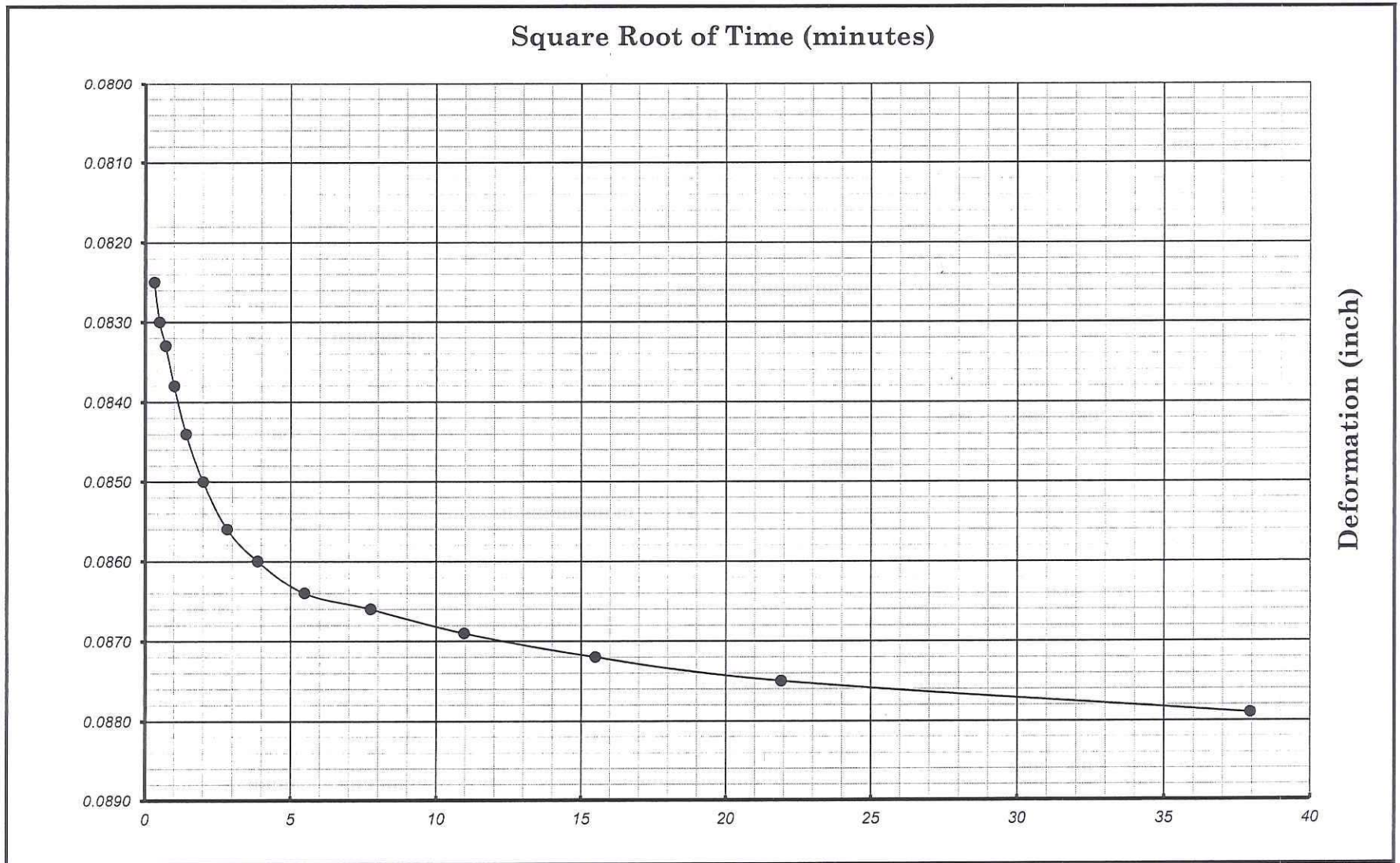
I-5 HOV Improvement Project
PCH to San Juan Creek Road

Project No. : 11-137 12/04/11

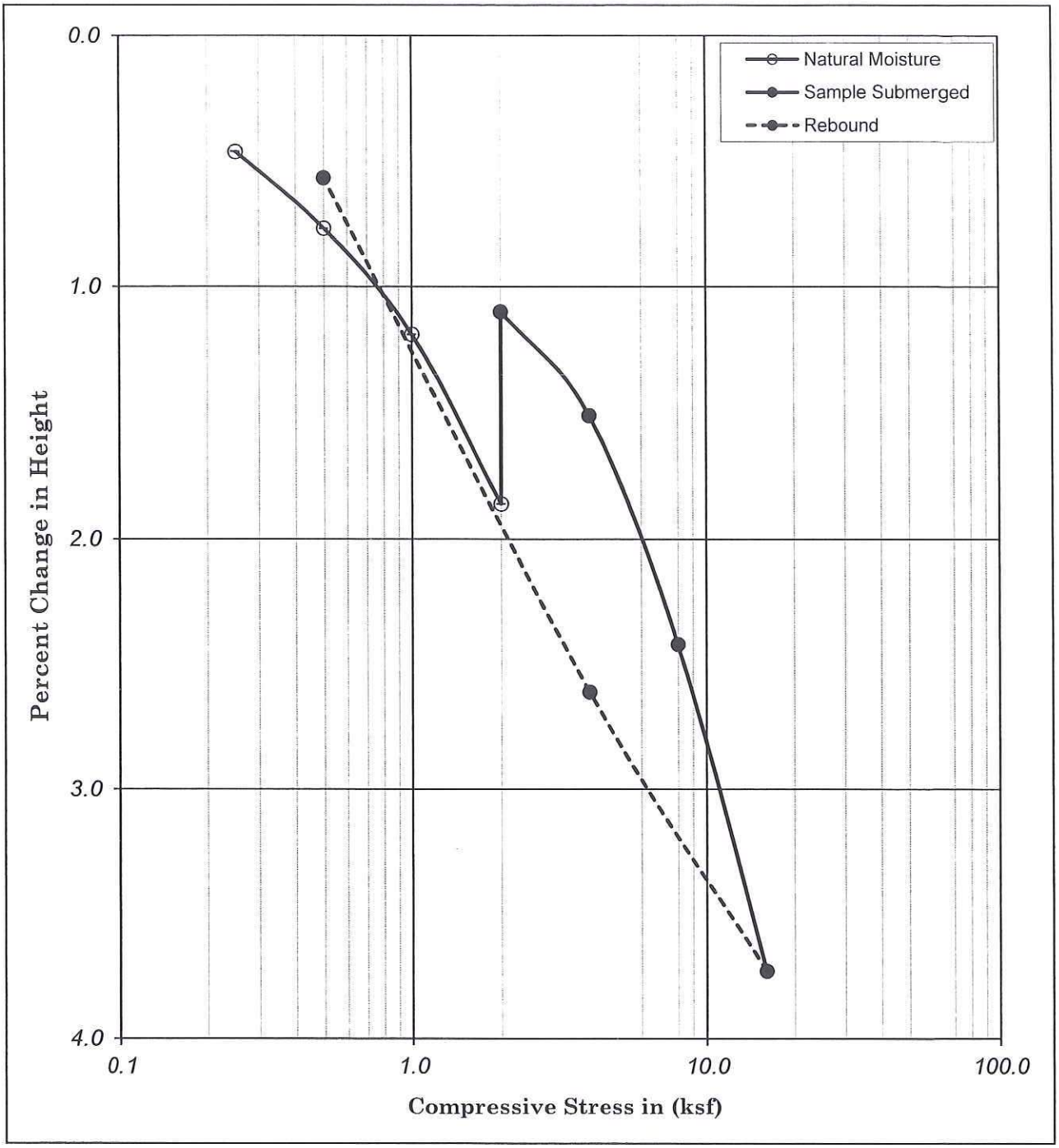
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*I-5 HOV Improvement Project PCH to San Juan Creek Road*	Boring No. : *A-11-319*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-13*	
EMI Project No. : *11-137*		Depth (ft/m) : *60.0* *18.3*	Veritcal Load (ksf/kpa) : *8.00* *383.0*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*I-5 HOV Improvement Project* *PCH to San Juan Creek Road*	Boring No. : *A-11-319*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-13*	
EMI Project No. : *11-137*		Depth (ft/m) : *60.0* *18.3*	Veritcal Load (ksf/kpa) : *8.0* *383.0*



Boring No. : A-11-320				Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No. : D-6				Plastic Limit :	-						
Depth	(ft) :	25.0	26.5	Plastic Index :	-	Initial	34.14	85.74	13.50	95.42	0.97
	(m) :	7.63	8.08	Specific Gravity :	2.70	Final	36.96	86.24	13.57	104.54	0.95

Description : *Very dark gray, Elastic SILT (MH)*

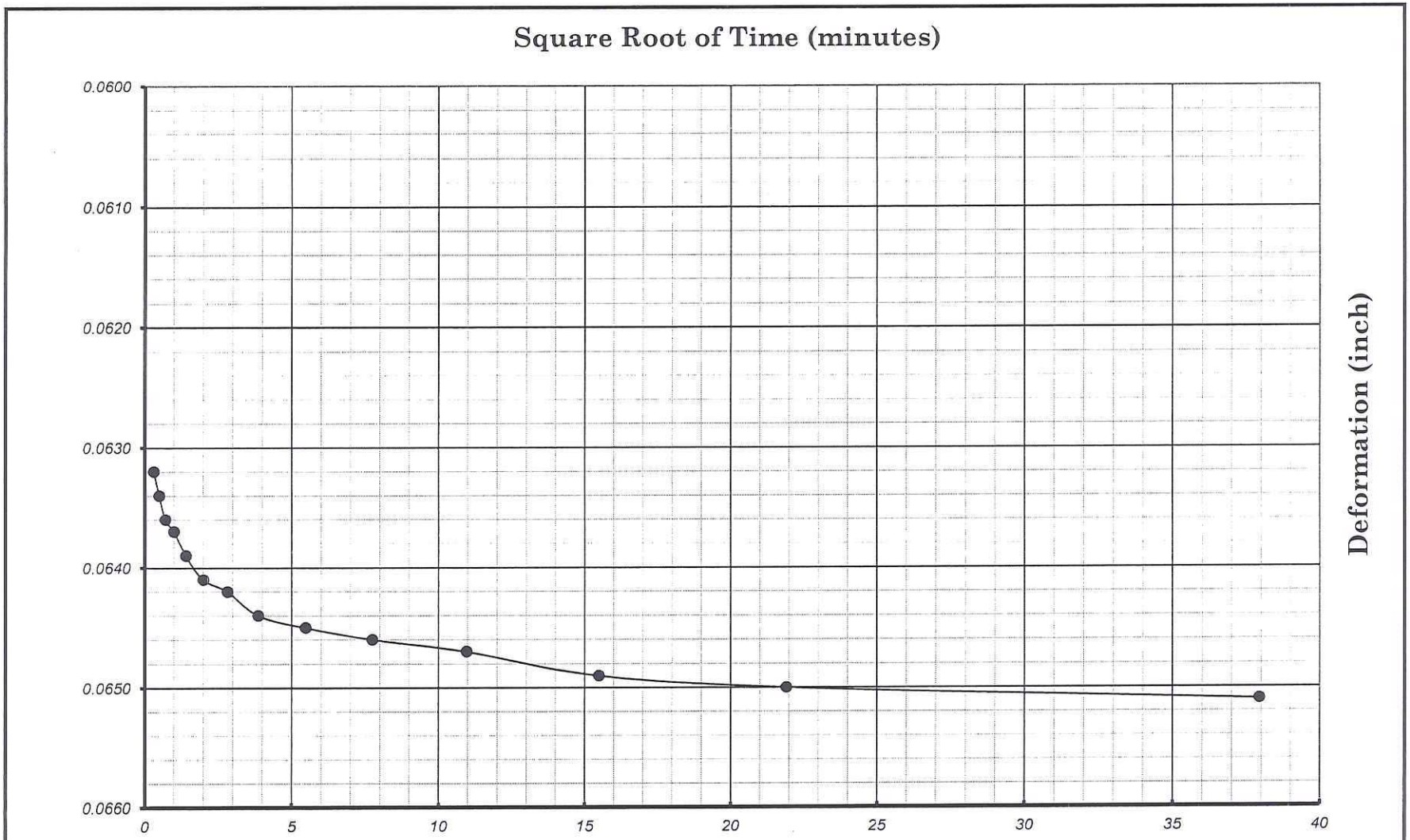
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

I-5 HOV Improvement Project
PCH to San Juan Creek Road

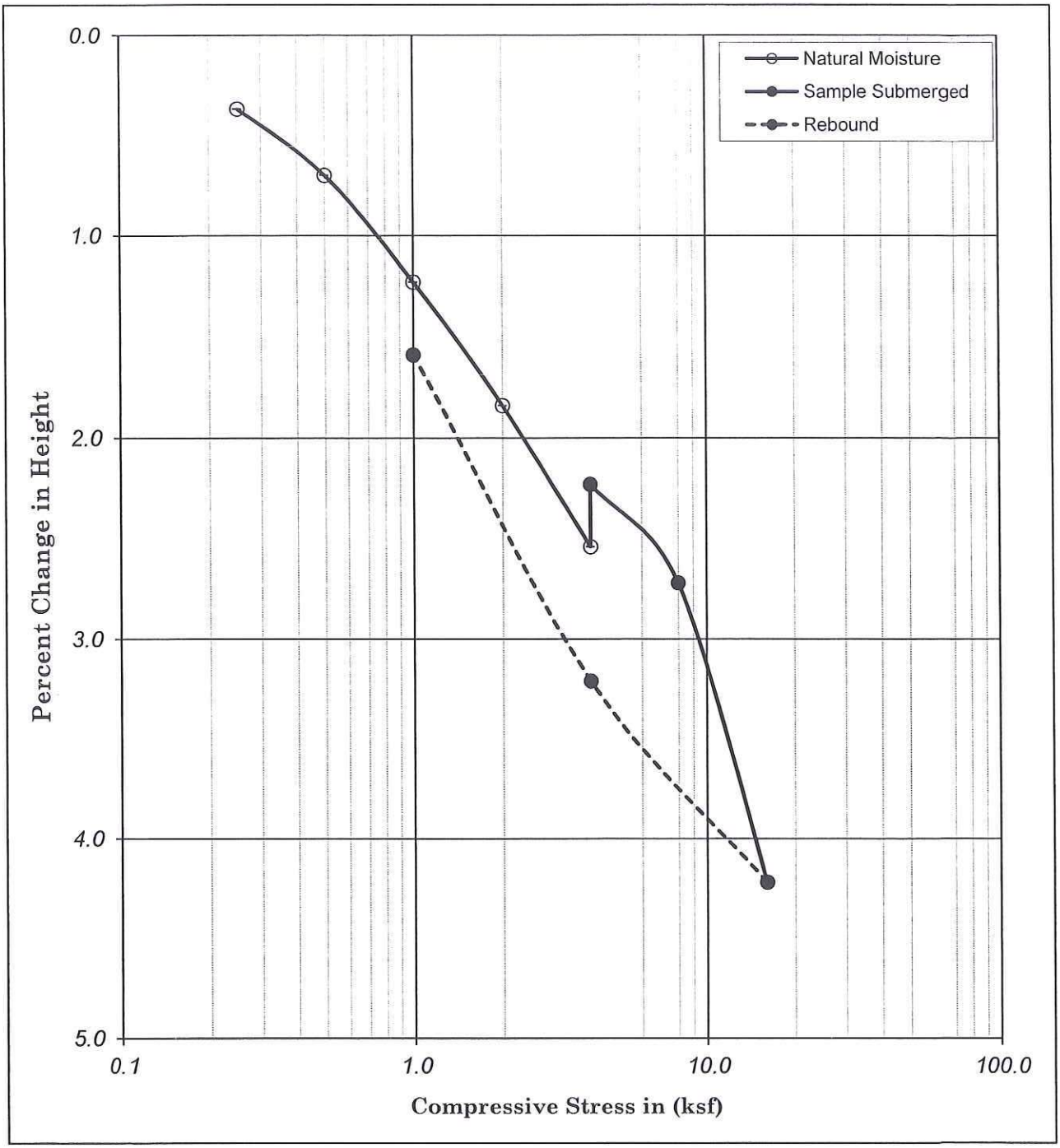
Project No. : 11-137 12/04/11

CONSOLIDATION TEST
(ASTM D-2435 / CT-219)

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*I-5 HOV Improvement Project* *PCH to San Juan Creek Road*	Boring No. : *A-11-320*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Log of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *11-137*		Depth (ft/m) : *25.0* *7.6*	Veritcal Load (ksf/kpa) : *4.00* *191.5*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*I-5 HOV Improvement Project* *PCH to San Juan Creek Road*	Boring No. : *A-11-320*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-6*	
EMI Project No. : *11-137*		Depth (ft/m) : *25.0* *7.6*	Veritcal Load (ksf/kpa) : *4.0* *191.5*



Boring No.	: A-11-323		Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No.	: D-8		Plastic Limit :	-						
Depth (ft)	: 40.0	41.5	Plastic Index :	-	Initial	30.21	88.40	13.91	89.93	0.91
Depth (m)	: 12.20	12.66	Specific Gravity :	2.70	Final	31.75	89.87	14.15	97.91	0.88

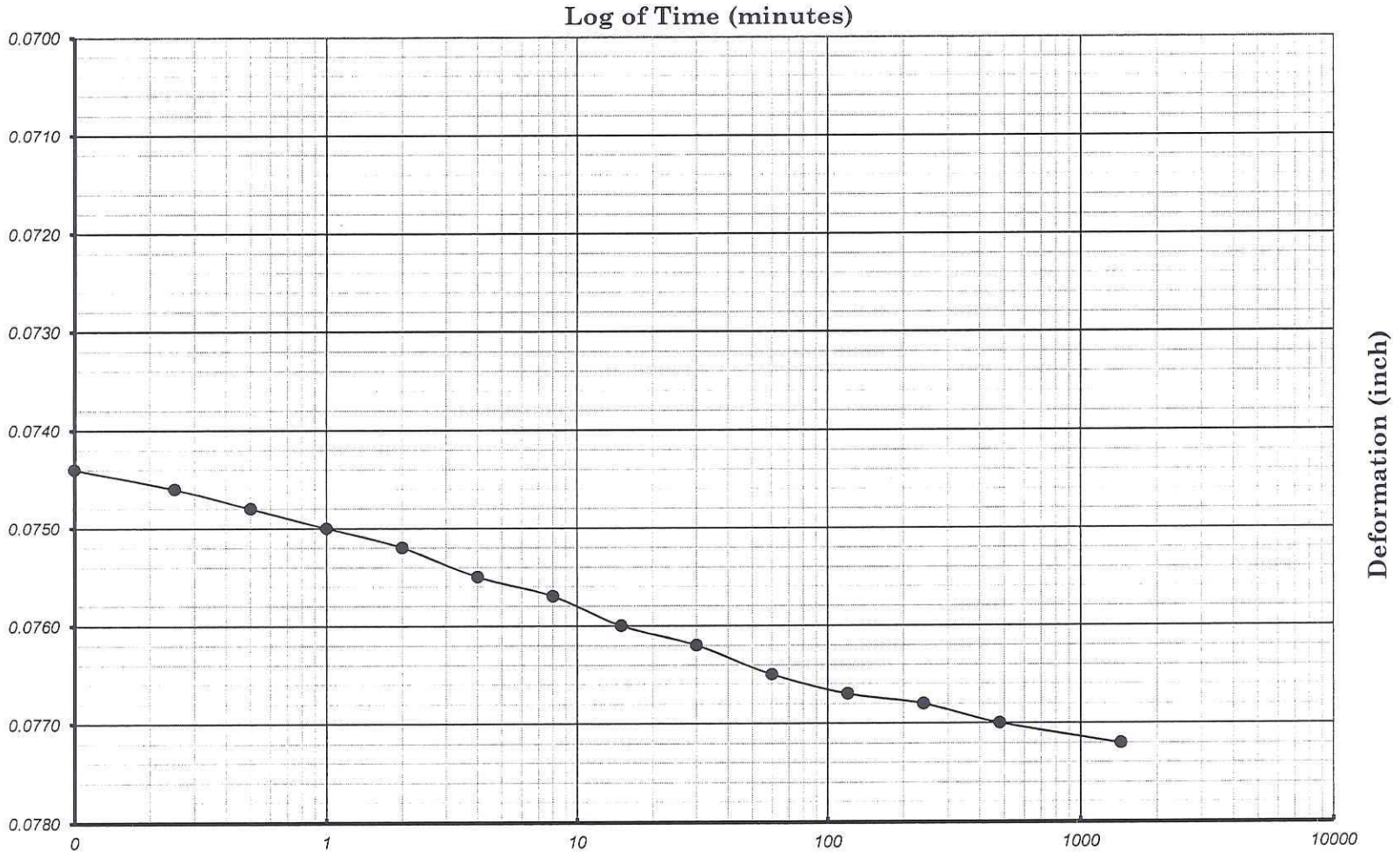
Description : *Very dark grayish brown, Elastic SILT (MH)*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

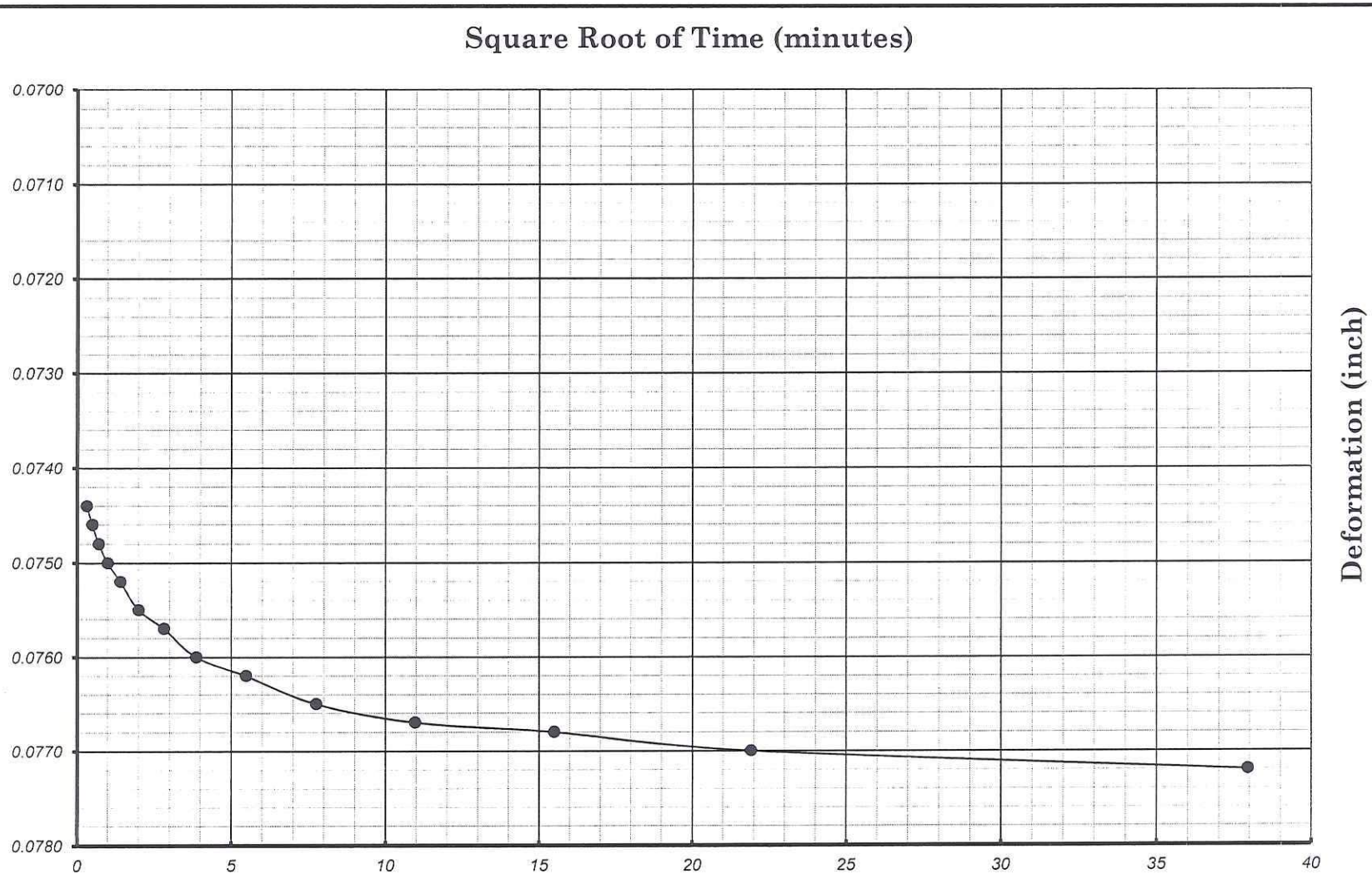
I-5 HOV Improvement Project
PCH to San Juan Creek Road

Project No. : 11-137 12/04/11

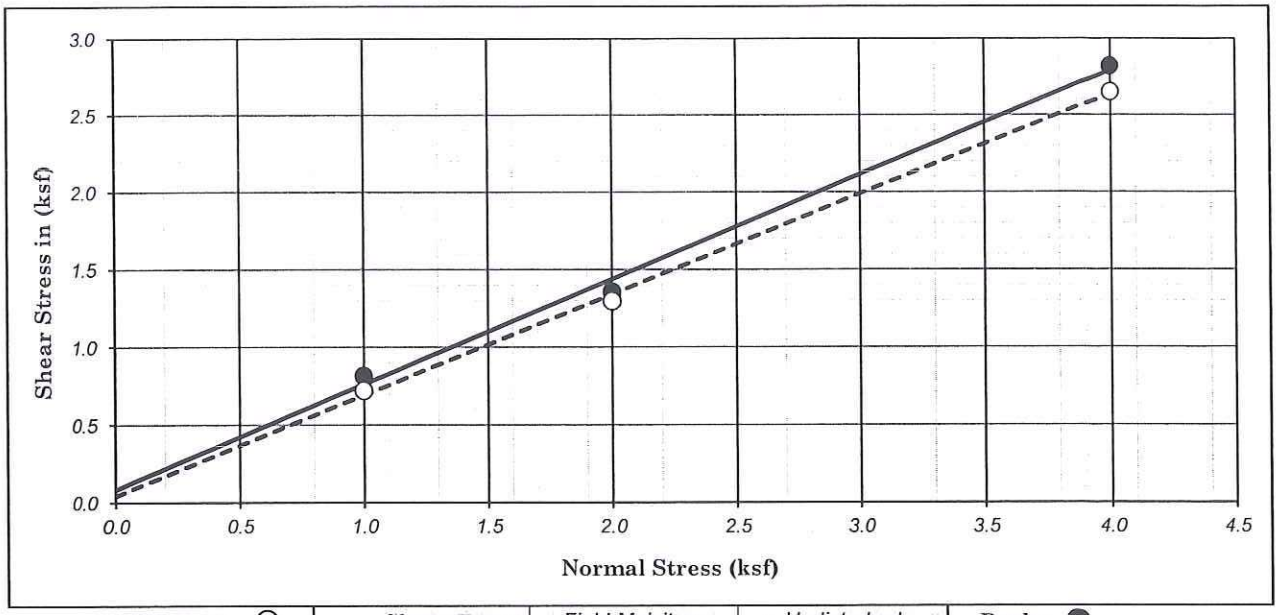
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



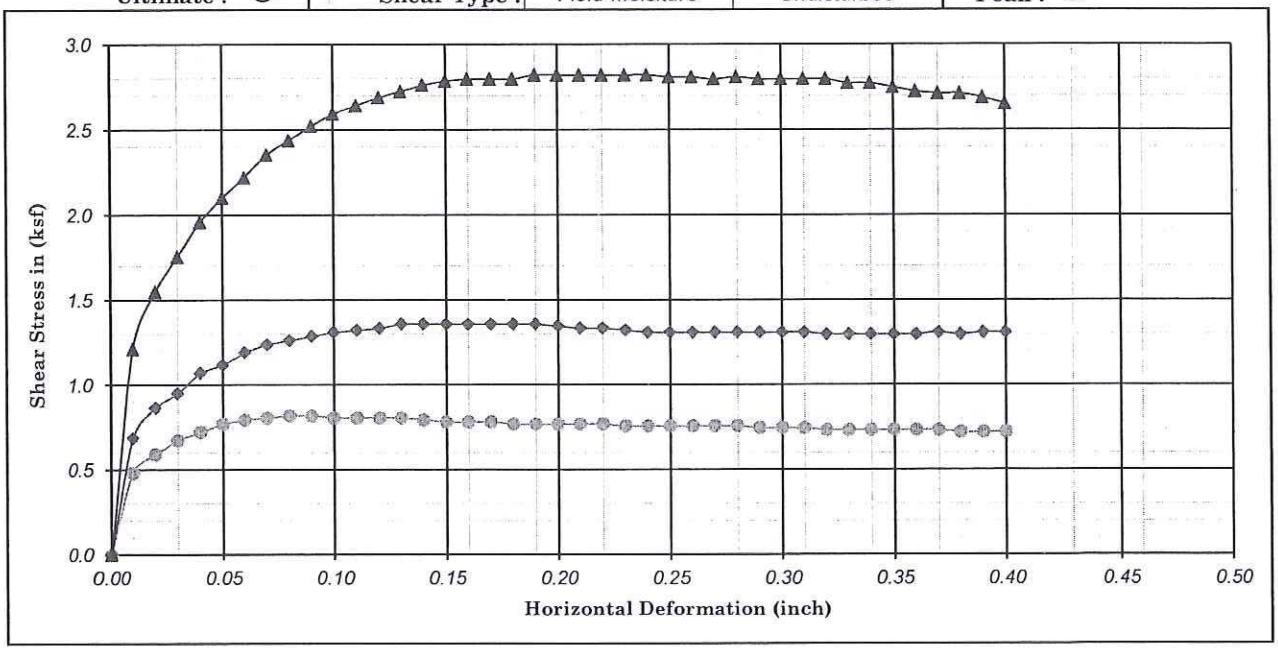
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	***I-5 HOV Improvement Project*** ***PCH to San Juan Creek Road***	**Boring No. :** *A-11-323*	**One-Dimensional Consolidation of Soil** **Time-Deformation Curve (Log of Time Method)**
		Sample No. : *D-8*	
EMI Project No. : *11-137*		**Depth** (ft/m) : *40.0* *12.2*	**Veritcal Load (ksf/kpa) :** *8.00* *383.0*



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	*I-5 HOV Improvement Project PCH to San Juan Creek Road*	Boring No. : *A-11-323*	One-Dimensional Consolidation of Soil Time-Deformation Curve (Square Root of Time Method)
		Sample No. : *D-8*	
EMI Project No. : *11-137*		Depth (ft/m) : *40.0* *12.2*	Veritcal Load (ksf/kpa) : *8.0* *383.0*



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : A-11-316		Strength Intercept (C) :	0.08	(ksf)	Peak	0.04	(ksf)	Ultimate
Sample No. : D-3			4.02	(kPa)		2.01	(kPa)	
Depth (ft/m) : 15.0	0.00	Friction Angle (ϕ) :	34.10	Degree		32.98	Degree	
Description : Olive-brown, Poorly graded SAND (SP)					Shear Rate (inch/minute) :		0.02	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	2.76	100.39	15.80	0.68	1.00	47.88	0.82	39.07	0.72	34.47
◆	2.28	98.75	15.54	0.71	2.00	95.76	1.36	64.93	1.30	62.05
▲	2.90	101.58	15.99	0.66	4.00	191.52	2.82	135.02	2.65	126.98

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

I-5 HOV Improvement Project
PCH to San Juan Creek Road

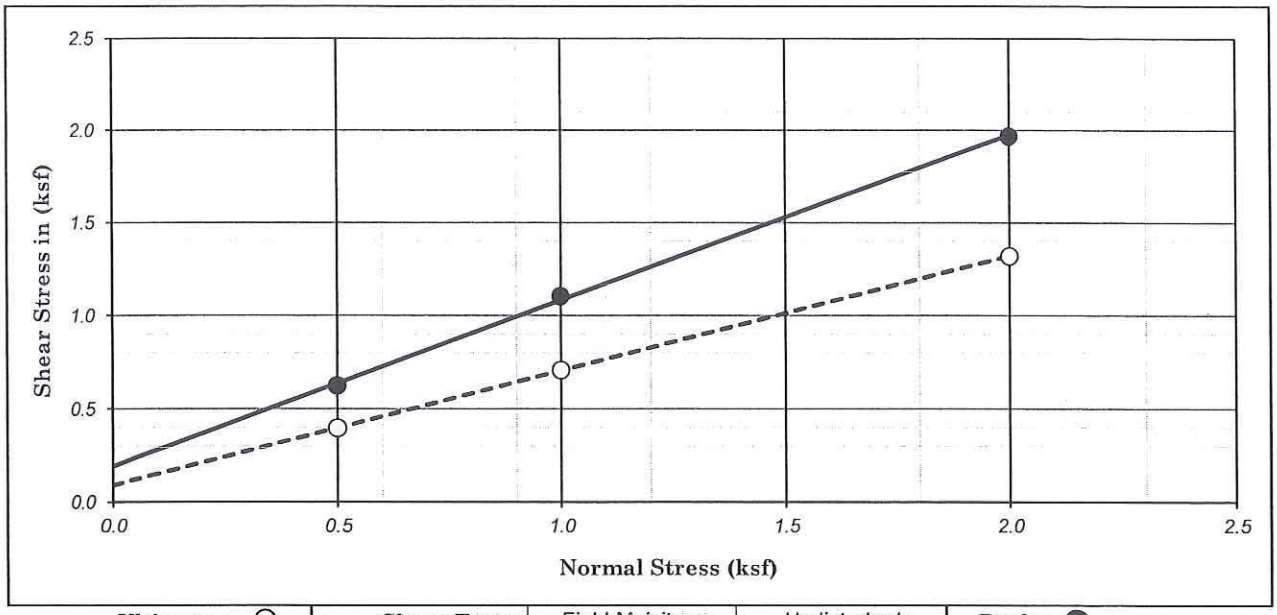
5/N5-N1 Connector Separation

DIRECT SHEAR TEST (ASTM D-3080)

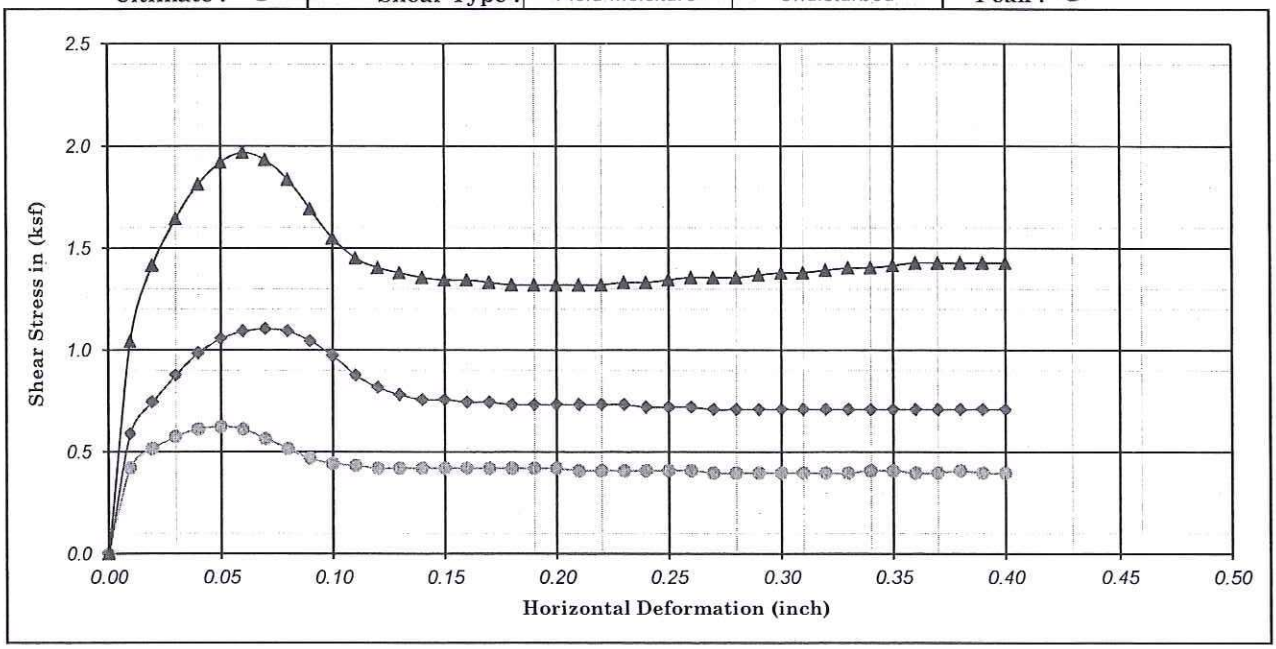
Project No. : 11-137

Date : 11/05/11

Figure No. :



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : A-11-317		Strength Intercept (C) :	0.19	(ksf)	Peak	0.09	(ksf)	Ultimate	
Sample No. : D-2			9.19	(kPa)		4.31	(kPa)		
Depth (ft/m) : 10.0	0.00	Friction Angle (ϕ) :	41.71	Degree		31.61	Degree		
Description : Olive-brown to olive-yellow, Poorly graded SAND with SILT (SP-SM)					Shear Rate (inch/minute) :		0.02		

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	25.93	92.14	14.50	0.83	0.50	23.94	0.62	29.88	0.40	18.96
◆	23.88	94.28	14.84	0.79	1.00	47.88	1.10	52.86	0.71	33.90
▲	24.59	95.10	14.97	0.77	2.00	95.76	1.97	94.23	1.32	63.20

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

I-5 HOV Improvement Project
PCH to San Juan Creek Road

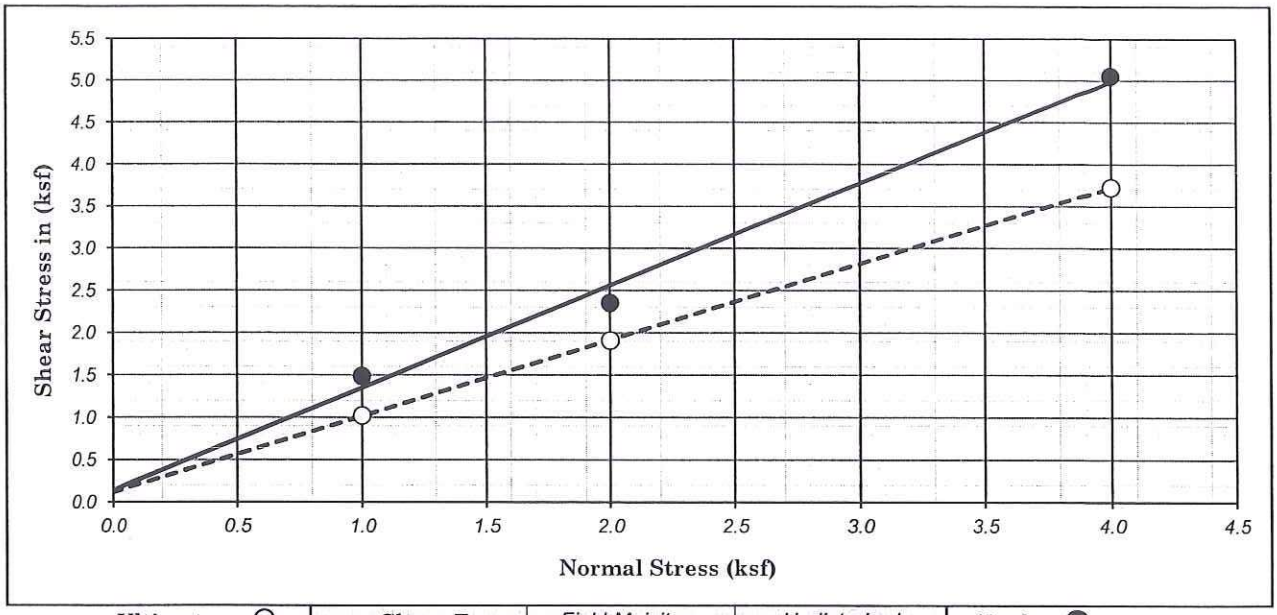
5/N5-N1 Connector Separation

DIRECT SHEAR TEST (ASTM D-3080)

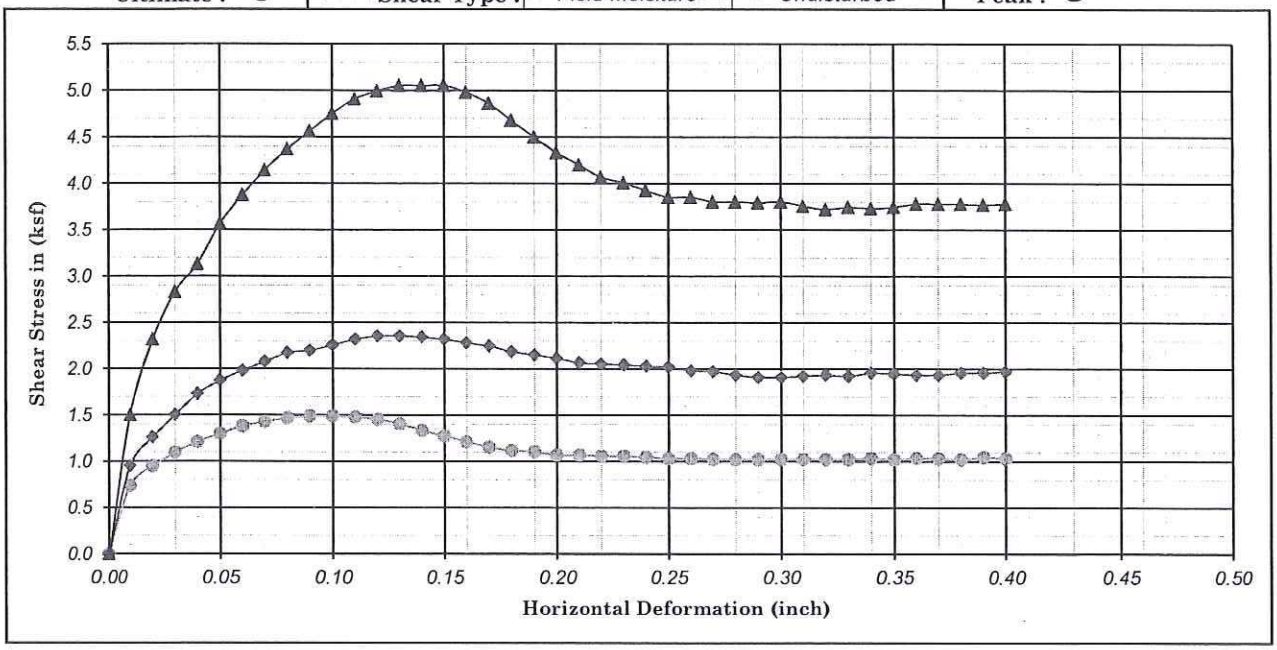
Project No. : 11-137

Date : 11/05/11

Figure No. :



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : A-11-319		Strength Intercept (C) :	0.14	(ksf)	Peak	0.11	(ksf)	Ultimate	
Sample No. : D-7			6.61	(kPa)		5.46	(kPa)		
Depth (ft/m) : 30.0	0.00	Friction Angle (ϕ) :	50.45	Degree		42.01	Degree		
Description : Olive-brown, Poorly graded SAND with SILT (SP-SM)					Shear Rate (inch/minute) :		0.02		

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	19.10	98.09	15.44	0.72	1.00	47.88	1.49	71.25	1.02	48.84
◆	18.94	100.90	15.88	0.67	2.00	95.76	2.35	112.61	1.91	91.36
▲	18.64	104.58	16.46	0.61	4.00	191.52	5.05	241.89	3.72	178.11

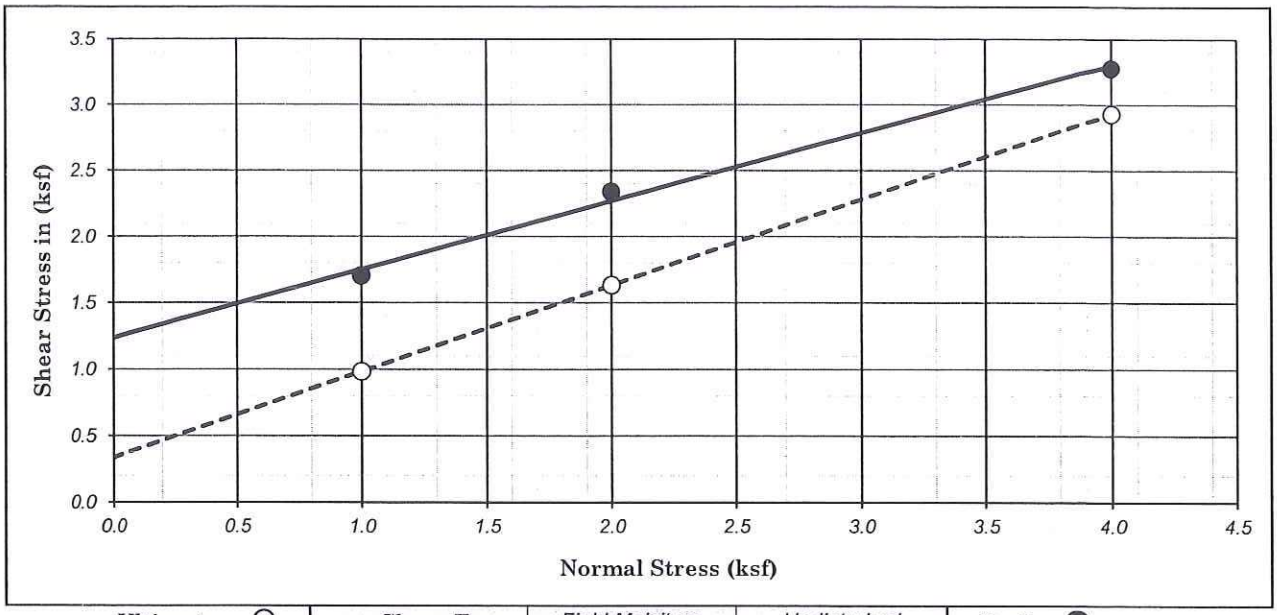
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

I-5 HOV Improvement Project
PCH to San Juan Creek Road

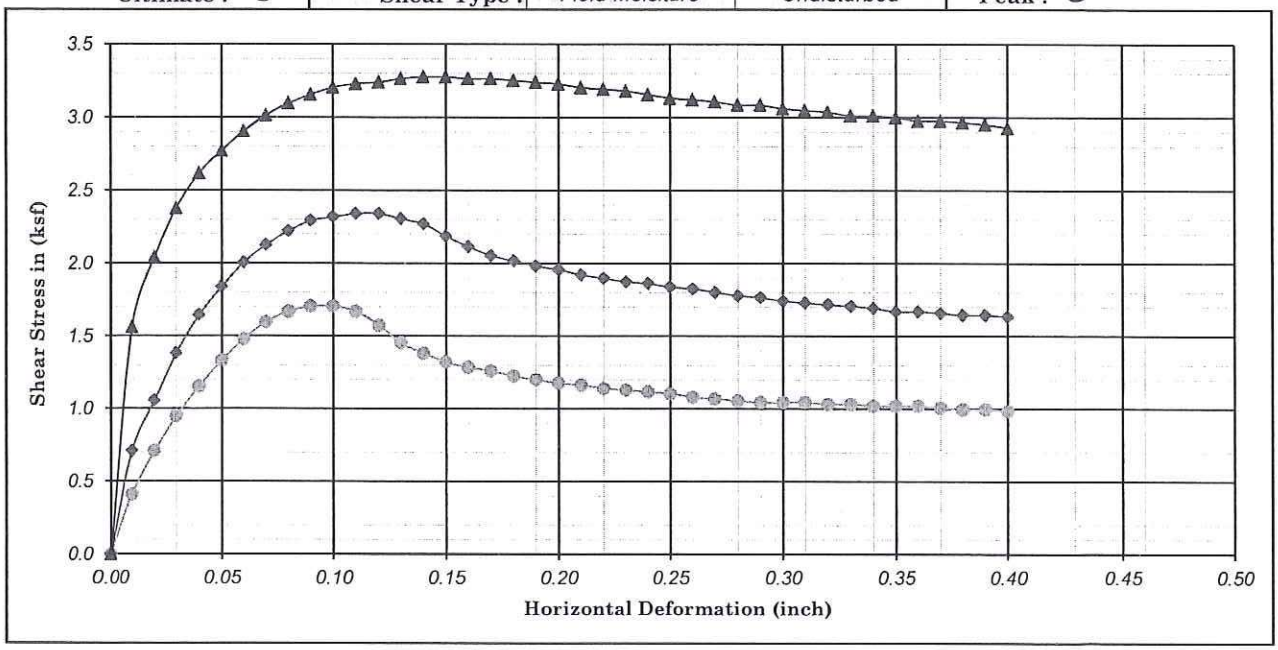
5/N5-N1 Connector Separation

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 11-137 | Date : 11/05/11 | Figure No. :



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : A-11-322		Strength Intercept (C) :	1.24	(ksf)	Peak	0.34	(ksf)	Ultimate	
Sample No. : D-3			59.18	(kPa)		16.09	(kPa)		
Depth (ft/m) : 15.0	0.00	Friction Angle (ϕ) :	27.29	Degree		32.94	Degree		
Description : Olive-brown, CLAYEY SAND with GRAVEL (SC)					Shear Rate (inch/minute) :			0.02	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	16.07	107.99	17.00	0.56	1.00	47.88	1.70	81.59	0.98	47.11
◆	15.09	108.45	17.07	0.55	2.00	95.76	2.34	112.04	1.63	78.14
▲	18.90	106.30	16.73	0.59	4.00	191.52	3.28	156.85	2.93	140.19

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

I-5 HOV Improvement Project
PCH to San Juan Creek Road

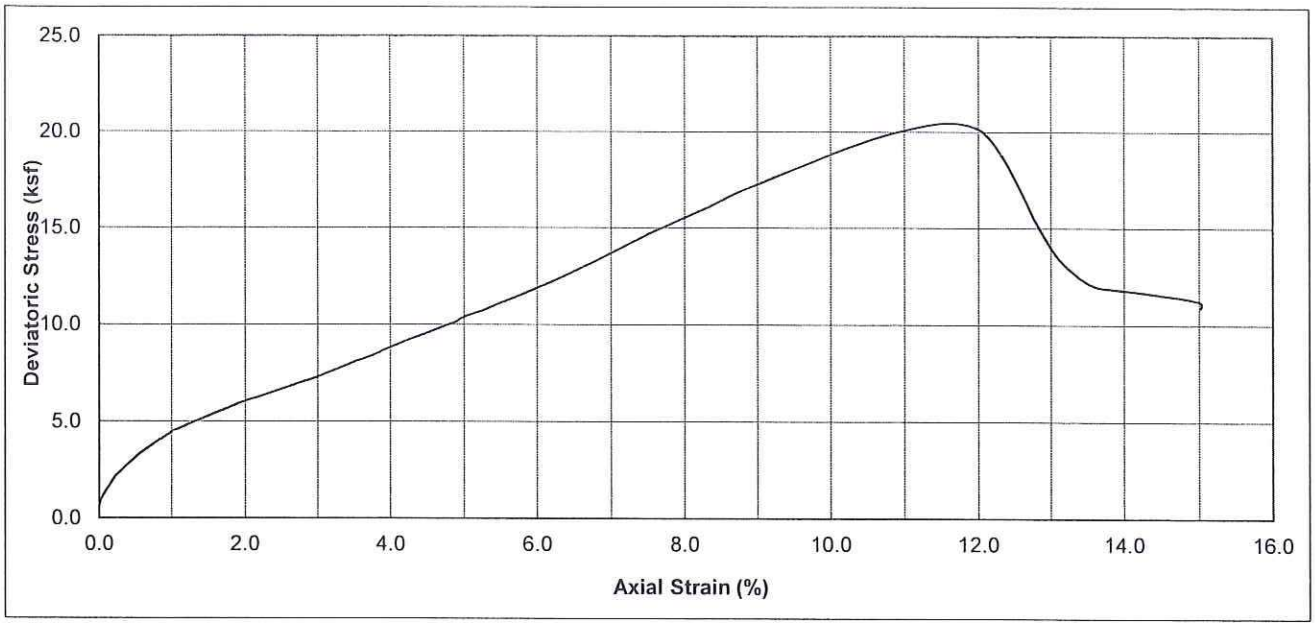
5/N5-N1 Connector Separation

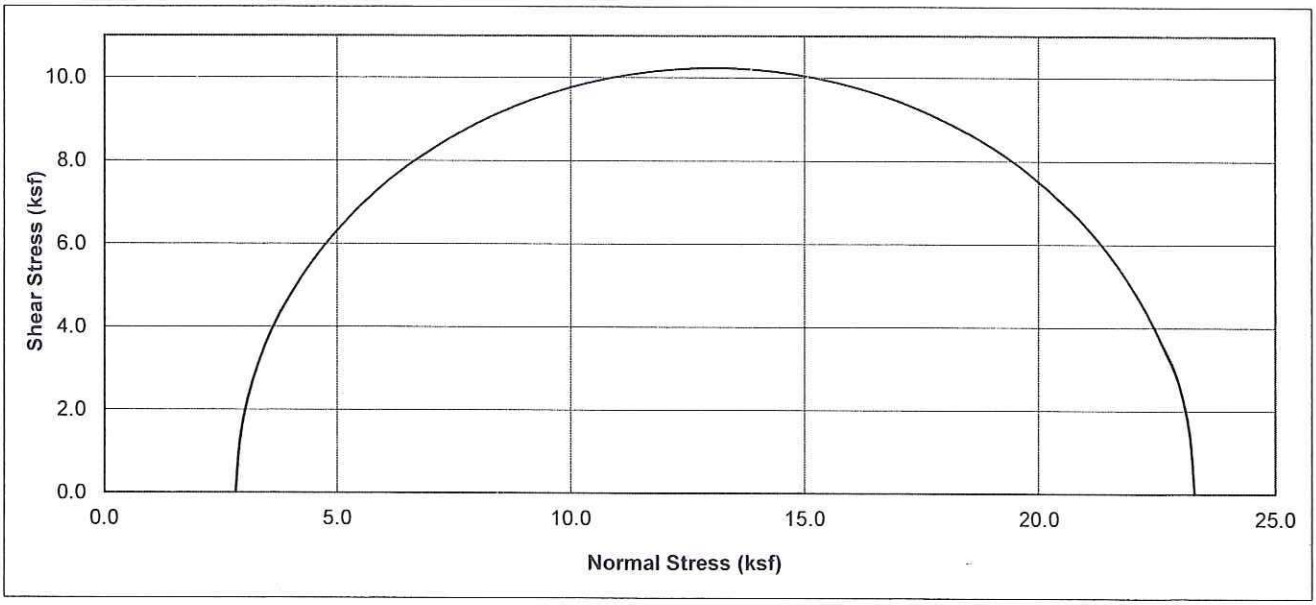
DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 11-137

Date : 11/05/11

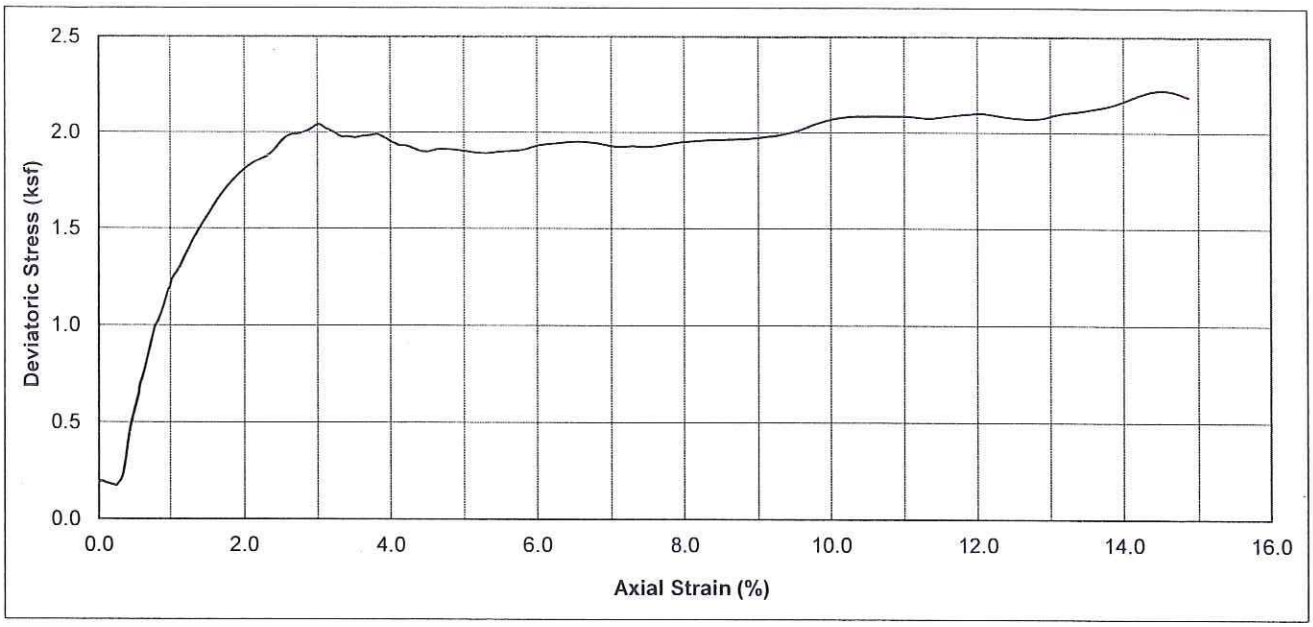
Figure No. :

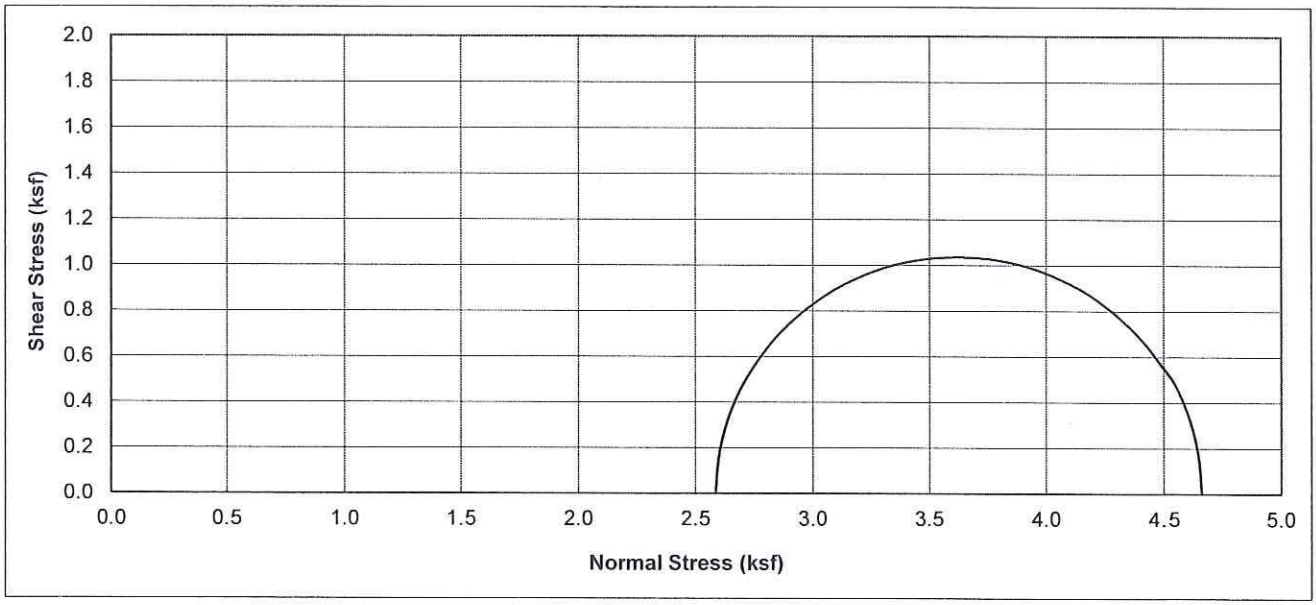




Boring No.	Sample No.	Depth (ft)	Soil Type	Dry Density (pcf)	Moisture Content (%)	Conf. Stress (ksf)	10% Axial Strain Dev. Stress (ksf)	Initial Saturation (%)
A-11-316	D-7	35	Dark olive gray , Elastic SILT (MH)	94.5	26.49	2.82	20.46	91.5

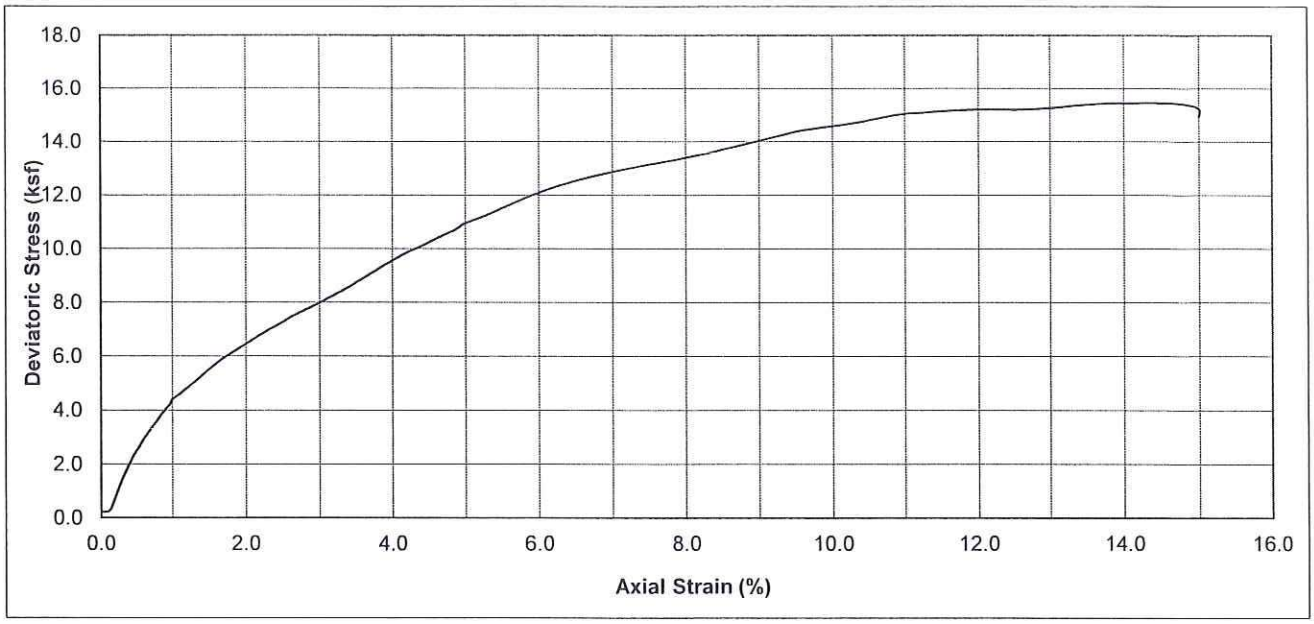
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		I-5 HOV Improvement Project PCH to San Juan Creek Road
		UNCONSOLIDATED UNDRAINED TEST
Project No. : 11-137	Date : 10/28/11	(ASTM D2850) Figure No. :

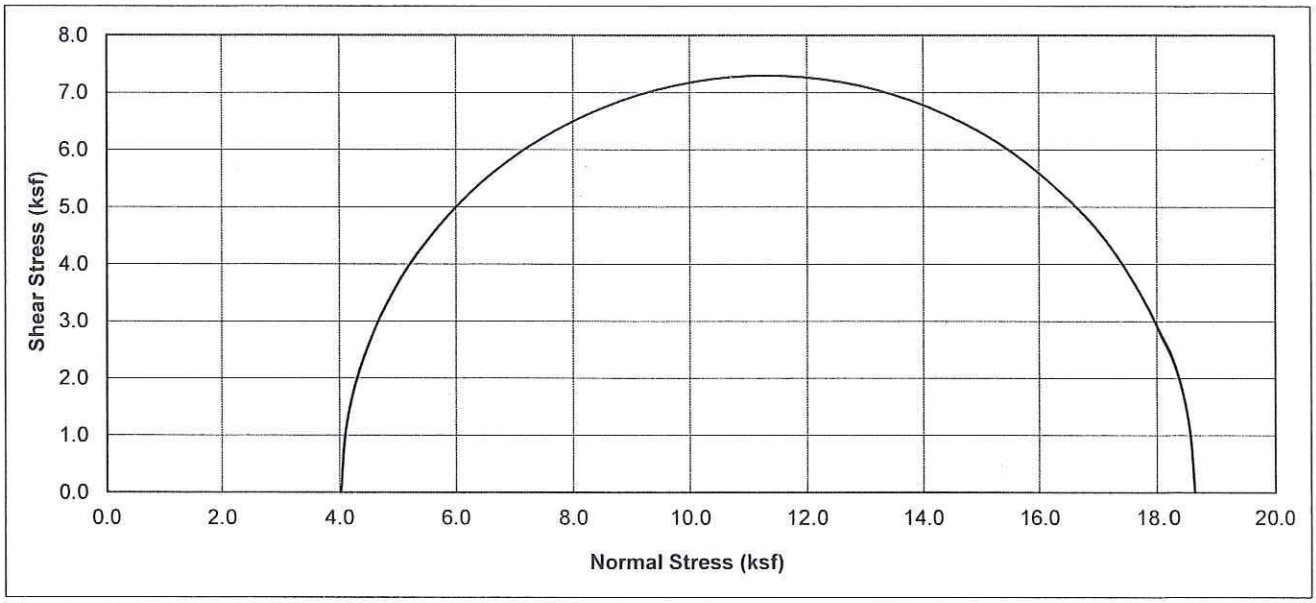




Boring No.	Sample No.	Depth (ft)	Soil Type	Dry Density (pcf)	Moisture Content (%)	Conf. Stress (ksf)	10% Axial Strain Dev. Stress (ksf)	Initial Saturation (%)
A-11-319	D-5	20	Olive brown , SANDY lean CLAY (CH)	95.8	25.96	2.59	2.07	92.4

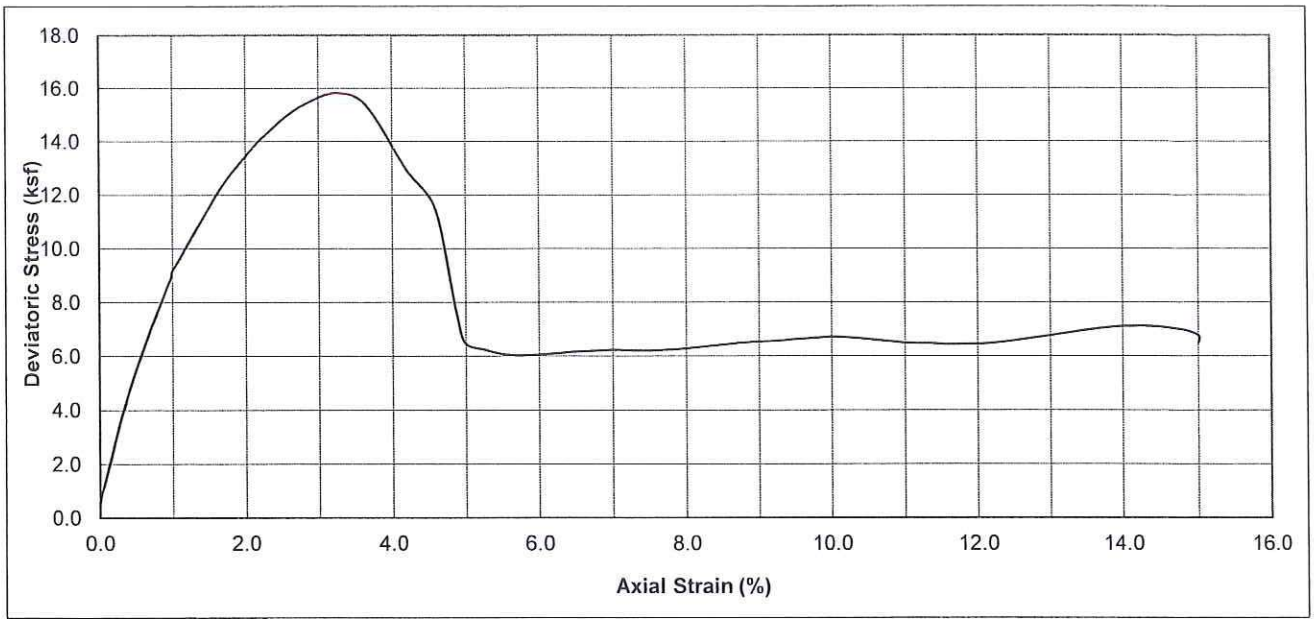
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		I-5 HOV Improvement Project PCH to San Juan Creek Road
		UNCONSOLIDATED UNDRAINED TEST
Project No. : 11-137	Date : 10/28/11	(ASTM D2850) Figure No. :

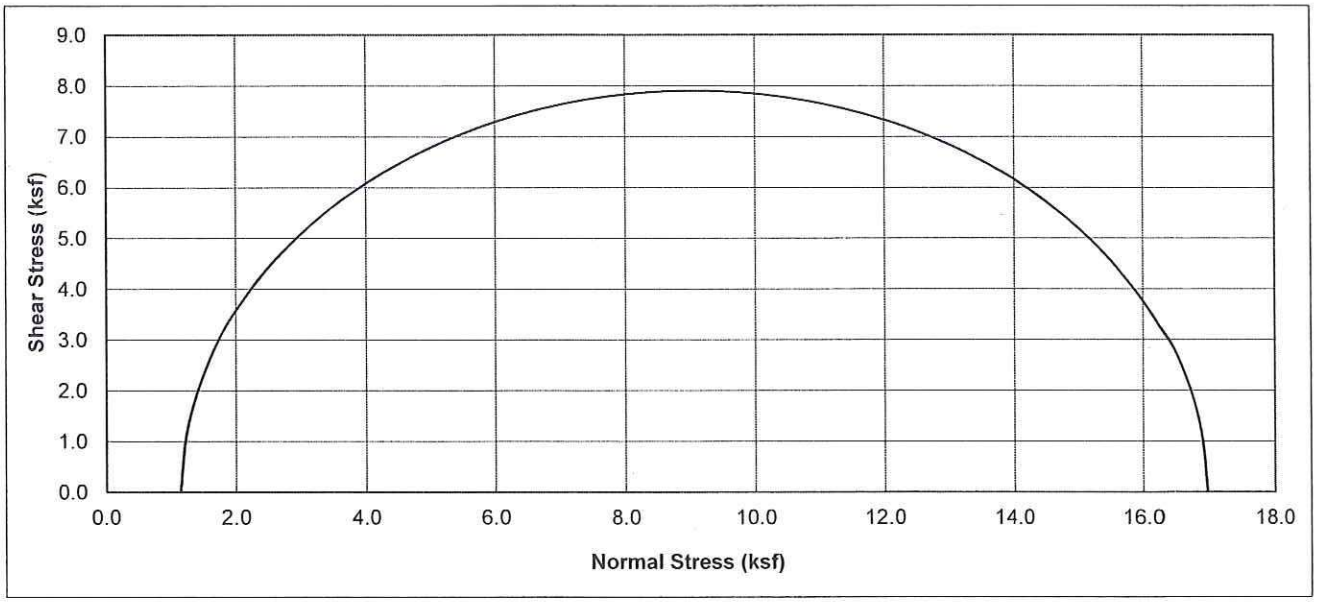




Boring No.	Sample No.	Depth (ft)	Soil Type	Dry Density (pcf)	Moisture Content (%)	Conf. Stress (ksf)	10% Axial Strain Dev. Stress (ksf)	Initial Saturation (%)
A-11-319	D-11	50	Dark brown , Fat CLAY trace gypsum (CH)	91.5	28.68	4.02	14.59	92.0

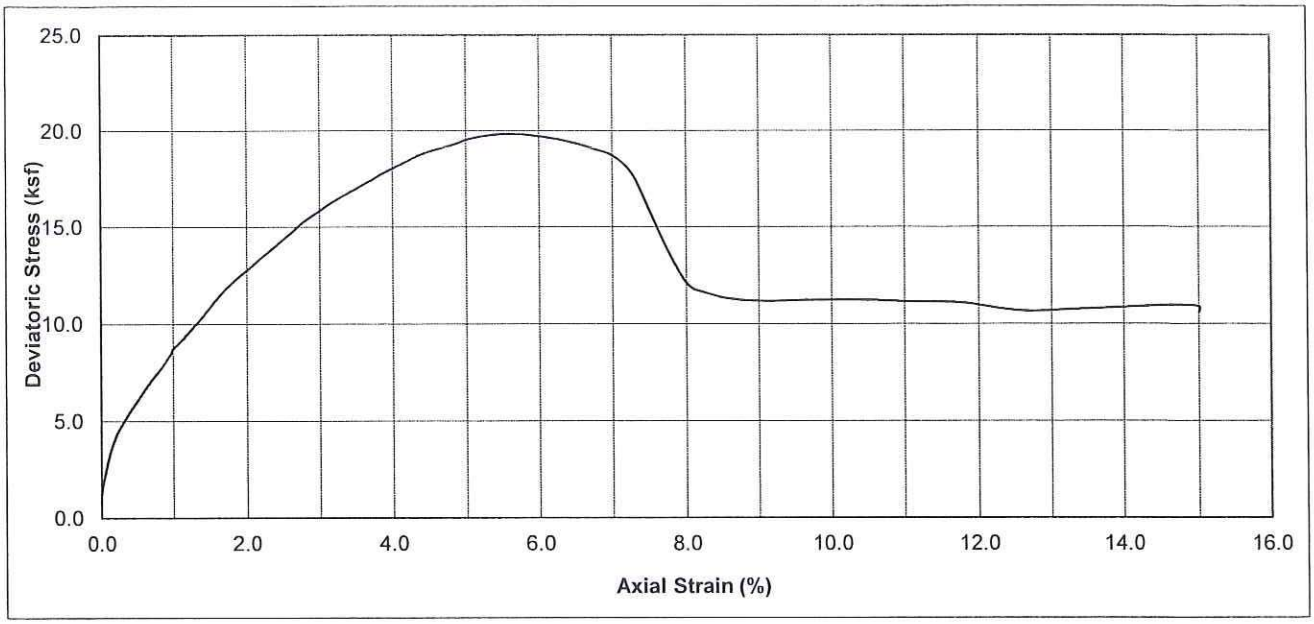
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	**I-5 HOV Improvement Project** **PCH to San Juan Creek Road**
	UNCONSOLIDATED UNDRAINED TEST
Project No. : 11-137 **Date :** 10/28/11	**(ASTM D2850)** **Figure No. :**

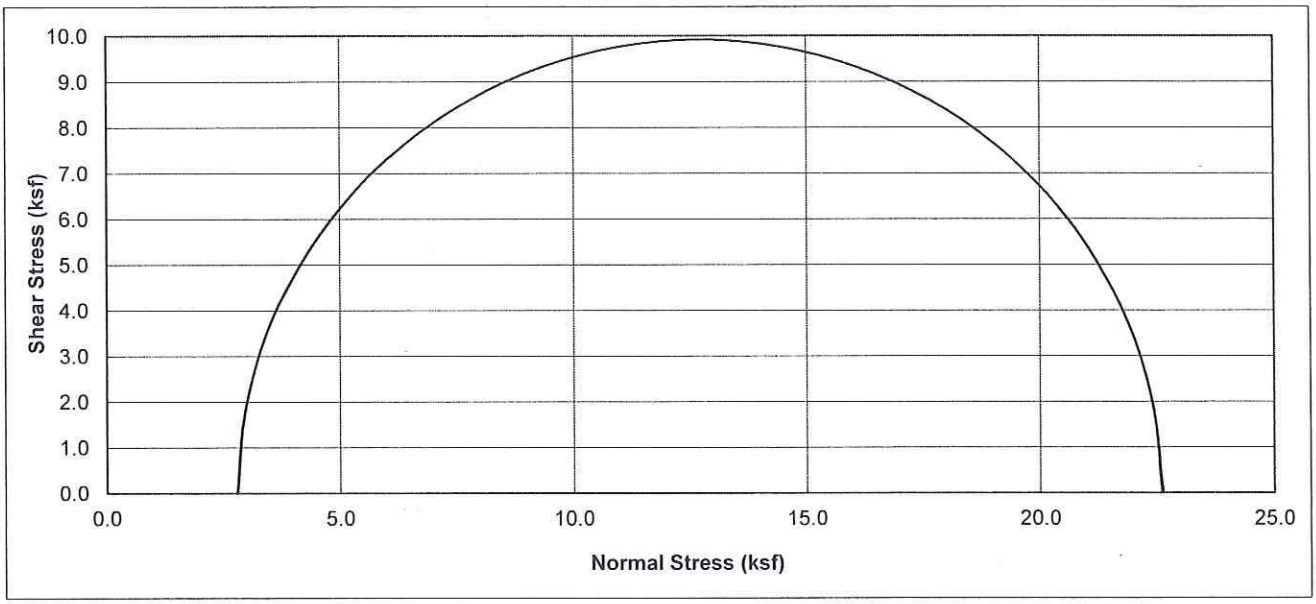




Boring No.	Sample No.	Depth (ft)	Soil Type	Dry Density (pcf)	Moisture Content (%)	Conf. Stress (ksf)	10% Axial Strain Dev. Stress (ksf)	Initial Saturation (%)
A-11-320	D-4	15	Dark olive gray , Elastic SILT (MH)	80.3	28.97	1.15	15.81	71.2

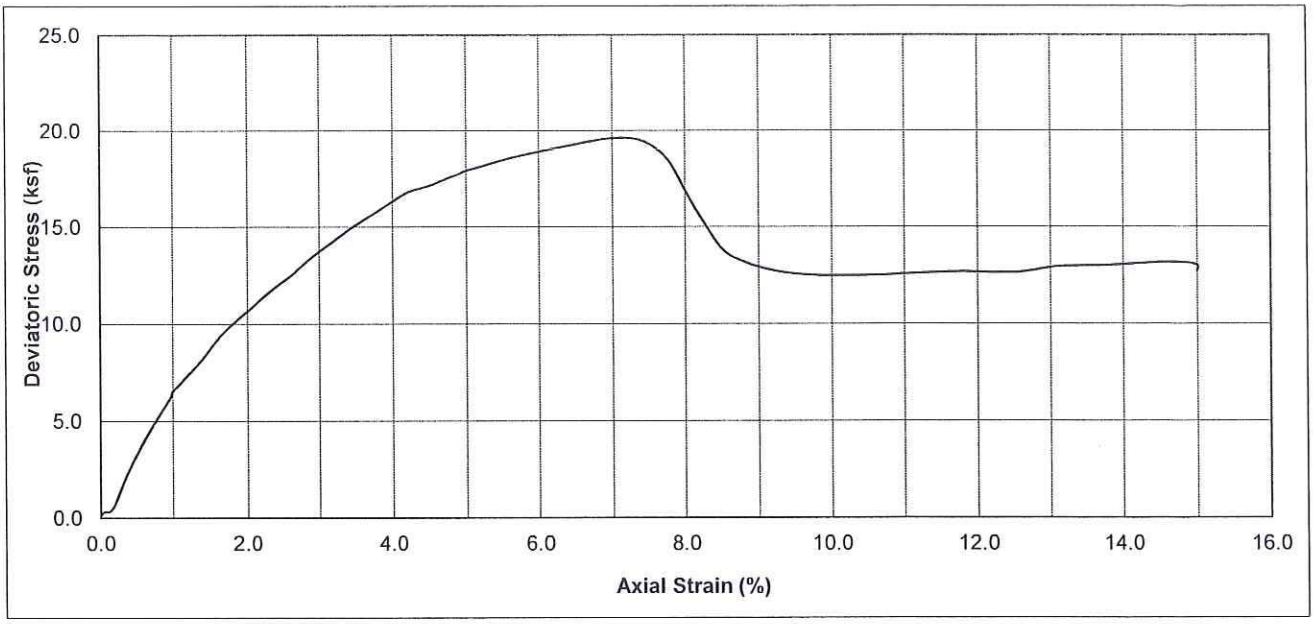
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	I-5 HOV Improvement Project PCH to San Juan Creek Road
	UNCONSOLIDATED UNDRAINED TEST
Project No. : 11-137 Date : 10/28/11	(ASTM D2850) Figure No. :

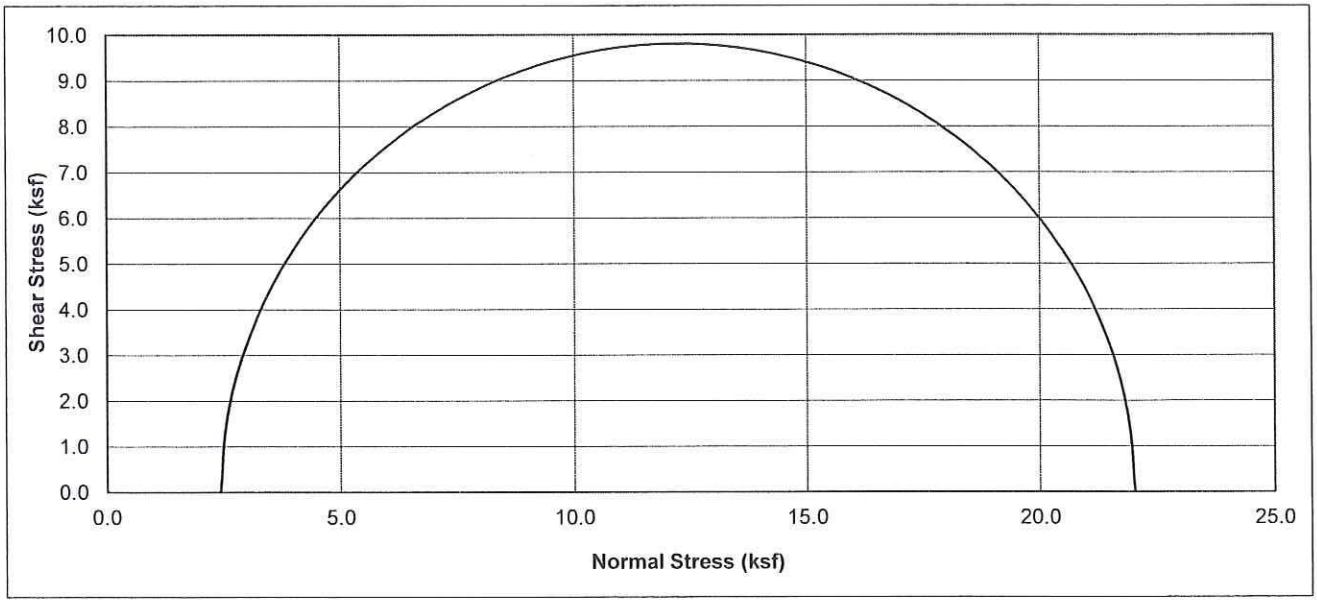




Boring No.	Sample No.	Depth (ft)	Soil Type	Dry Density (pcf)	Moisture Content (%)	Conf. Stress (ksf)	10% Axial Strain Dev. Stress (ksf)	Initial Saturation (%)
A-11-320	D-8	35	Dark olive gray, Elastic SILT (MH)	94.0	26.72	2.80	19.83	91.0

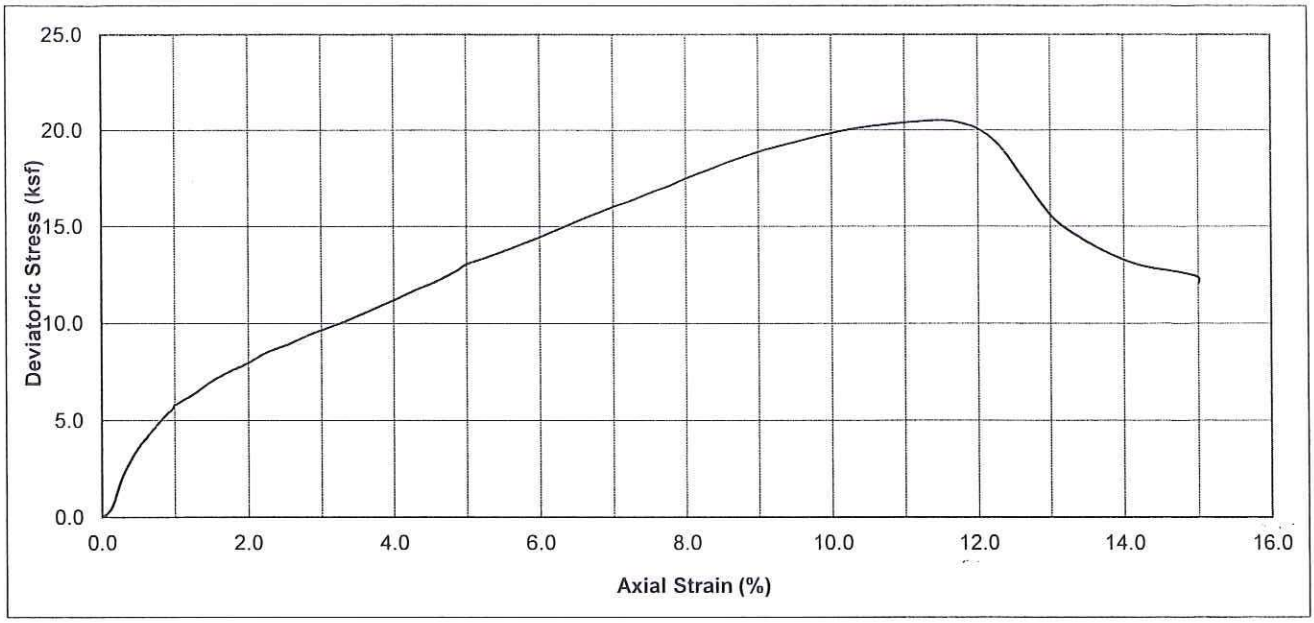
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	I-5 HOV Improvement Project PCH to San Juan Creek Road
	UNCONSOLIDATED UNDRAINED TEST
Project No. : 11-137 / Date : 10/28/11	(ASTM D2850) Figure No. :

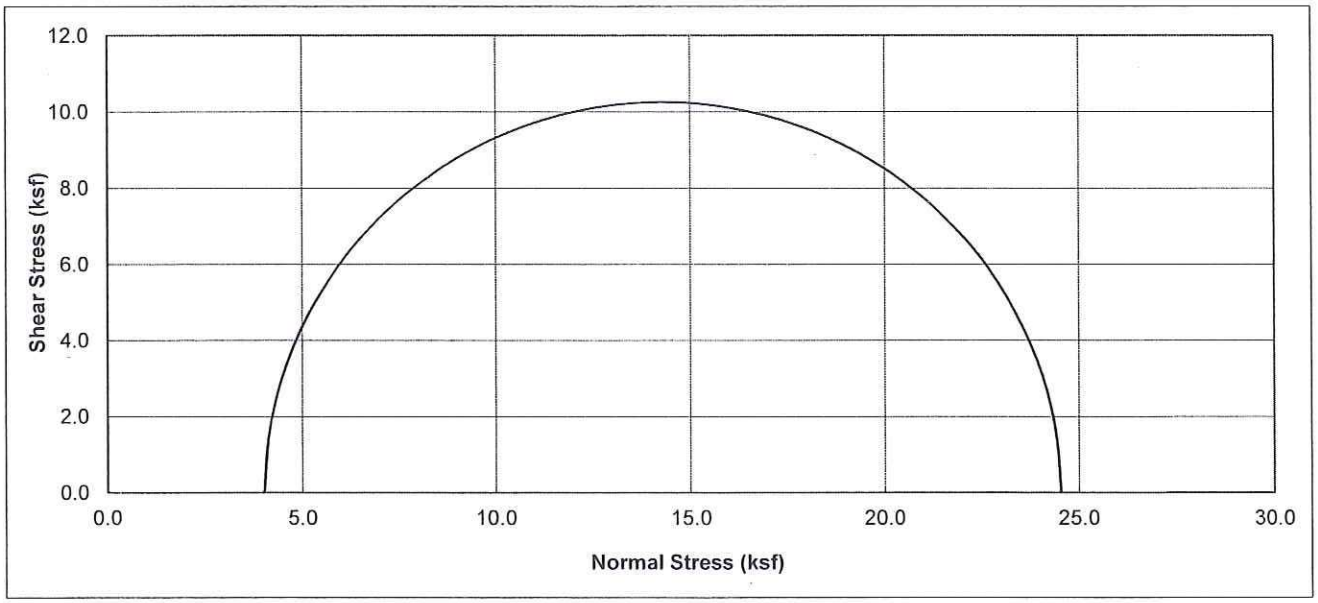




Boring No.	Sample No.	Depth (ft)	Soil Type	Dry Density (pcf)	Moisture Content (%)	Conf. Stress (ksf)	10% Axial Strain Dev. Stress (ksf)	Initial Saturation (%)
A-11-323	D-6	30	Olive brown , Fat CLAY (CH)	102.2	20.22	2.43	19.61	84.2

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	I-5 HOV Improvement Project PCH to San Juan Creek Road
	UNCONSOLIDATED UNDRAINED TEST
Project No. : 11-137 Date : 10/28/11	(ASTM D2850) Figure No. :



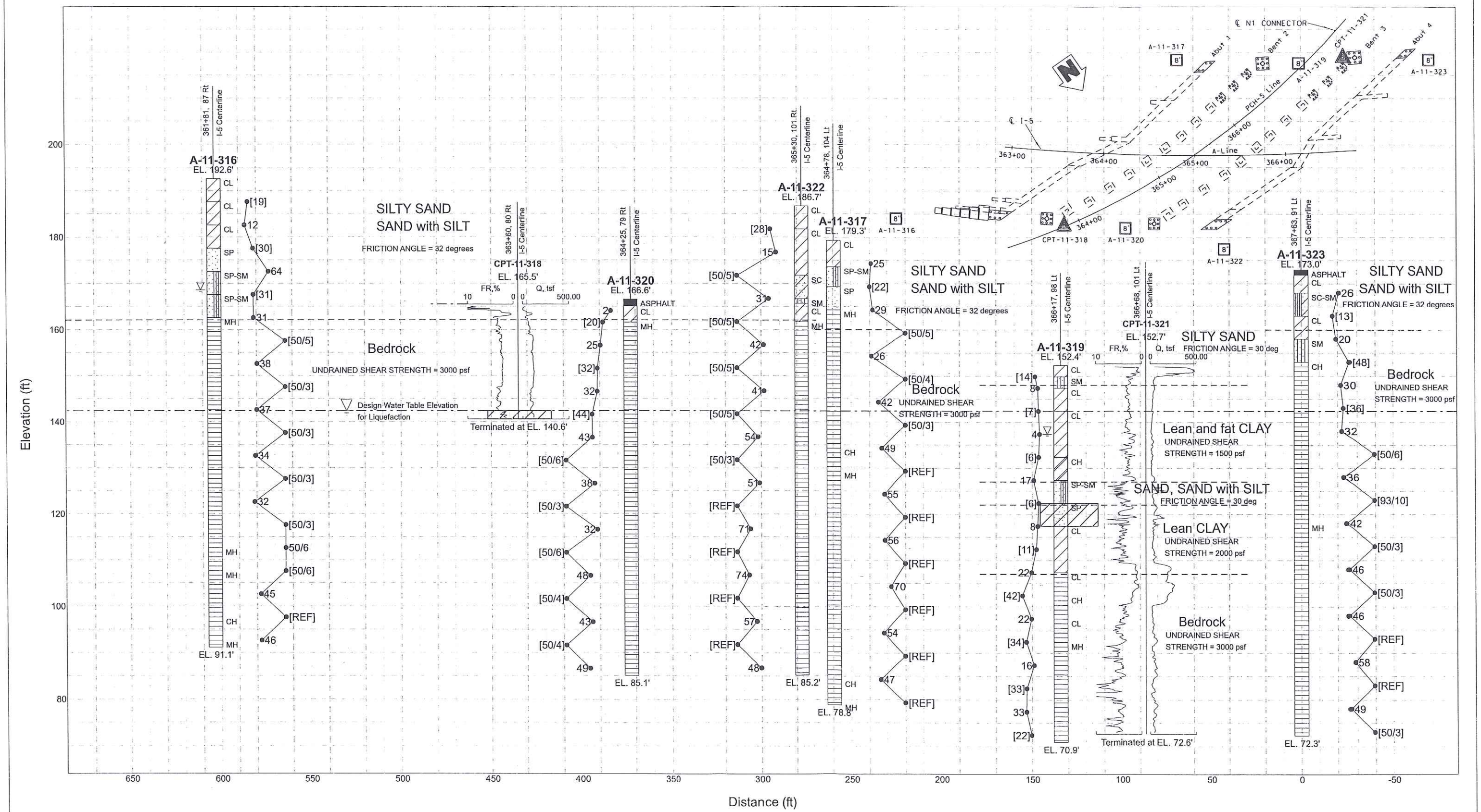


Boring No.	Sample No.	Depth (ft)	Soil Type	Dry Density (pcf)	Moisture Content (%)	Conf. Stress (ksf)	10% Axial Strain Dev. Stress (ksf)	Initial Saturation (%)
A-11-323	D-10	50	Very dark gray, Fat CLAY (CH)	92.5	28.14	4.03	20.52	92.4

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		I-5 HOV Improvement Project PCH to San Juan Creek Road
		UNCONSOLIDATED UNDRAINED TEST
Project No. : 11-137	Date : 10/28/11	(ASTM D2850) Figure No. :

Appendix C

DESIGN CALCULATIONS



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Cross Section Identification				
DIST.	COUNTY **Orange**	ROUTE	POSTMILE	EA **11-137**
PROJECT OR BRIDGE NAME **5/N5-N1 Connector Separation (Widen)**				
BRIDGE NUMBER **55-0226**	PREPARED BY		DATE **6-25-12**	SHEET **1 of 0**

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

17800 Newhope Street, Suite B, Fountain Valley, CA 92708
(714) 751-3826, Fax (714) 751-3928

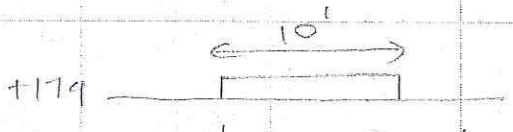
Project 5/N5-N1 conn sep (widen) 55-0226 Project No. 11-137

By SP Date 9/19/12 Checked By LCC Date 10/3/12 Sheet ____ of ____

Abutments settlement calculations considering spread footing

consider as-built bearing pressure = 4 ksf

footing size = 10' x 19' - proposed footing size



▽ +168' - perched water

σ_{vo}	$\Delta\sigma$	settlement
$2 \times 120 = 0.36$	$4 \times 0.9 = 3.6$	$6 \times \frac{1}{40} \log\left(\frac{0.36+3.6}{0.36}\right) = 1.9$
$6 \times 120 + 5 \times 57.6 = 1.0$	$4 \times 0.5 = 2.0$	$10 \times \frac{1}{40} \log\left(\frac{1+2}{1}\right) = 1.4$
$6 \times 120 + 17 \times 57.6 = 1.7$	$4 \times 0.2 = 0.8$	$14 \times \frac{1}{40} \log\left(\frac{1.7+0.8}{1.7}\right) = 0.7$
		4"

with 5 feet of over excavation

σ_{vo}	$\Delta\sigma$	settlement
$5.5 \times 120 = 0.66$	$4 \times 0.8 = 3.2$	$1 \times \frac{1}{40} \log\left(\frac{0.66+3.2}{0.66}\right) = 0.2$
$6 \times 120 + 5 \times 57.6 = 1.6$	$4 \times 0.5 = 2.0$	$10 \times \frac{1}{40} \log\left(\frac{1+2}{1}\right) = 1.4$
$6 \times 120 + 17 \times 57.6 = 1.7$	$4 \times 0.2 = 0.8$	$14 \times \frac{1}{40} \log\left(\frac{1.7+0.8}{1.7}\right) = 0.7$
		2.3"

to get 1-inch settlement bearing pressure has to be 1.3 ksf with 5 feet of over excavation.

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

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(714) 751-3826, Fax (714) 751-3928

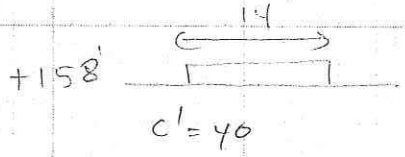
Project 5/NS - N1 conn sep (widen) 55-0226 **Project No.** 11-137

By SP **Date** 9/18/12 **Checked By** LCC **Date** 10/3/12 **Sheet** ____ **of** ____

Bantl settlement calculation considering spread footing

consider as-built bearing pressure = 6 ksf

footing size = 14' x 14' - proposed footing size



▽ +138'

$C_c = 0.1025$

σ_{vo}	$\Delta\sigma$	settlement
$5 \times 120 = 0.6$	$6 \times 0.85 = 5.1$	$10 \times \frac{1}{40} \log\left(\frac{0.6+5.1}{0.6}\right) = 2.9$
$15 \times 120 = 1.8$	$6 \times 0.5 = 3$	$10 \times \frac{1}{40} \log\left(\frac{1.8+3}{1.8}\right) = 1.3$
$20 \times 120 + 10 \times 57.6 = 3$	$6 \times 0.25 = 1.5$	$20 \times 0.025 \log\left(\frac{3+1.5}{3}\right) = 1.1$
		5.3"

with 5 feet of overexcavation

σ_{vo}	$\Delta\sigma$	settlement
$7.5 \times 120 = 0.9$	$6 \times 0.8 = 4.8$	$5 \times \frac{1}{40} \log\left(\frac{0.9+4.8}{0.9}\right) = 1.2$
$15 \times 120 = 1.8$	$6 \times 0.5 = 3$	$10 \times \frac{1}{40} \log\left(\frac{1.8+3}{1.8}\right) = 1.3$
$20 \times 120 + 10 \times 57.6 = 3$	$6 \times 0.25 = 1.5$	$20 \times 0.025 \log\left(\frac{3+1.5}{3}\right) = 1.1$
		3.6"

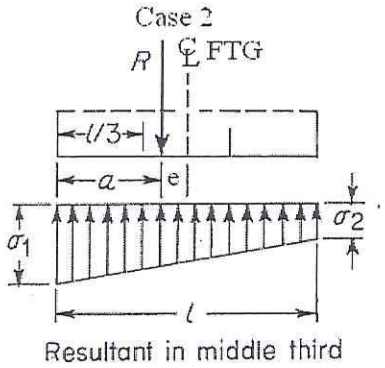
to get 1 inch of settlement bearing pressure has to be 1.1 ksf with 5-feet of overexcavation

SPREAD FOOTING FOUNDATION CALCULATIONS
I-5 Project- Bridge 55-0226

Footing Dimension 14 ft x 14 ft
Allowable Bearing Pressure= 6000.00 psf

Case I (M_{max})
Max Transverse Moment

P_{DL}=	481.2 k
P_{LL}=	203.0 k
M_{DL}=	287.0 k-ft
M_{LL}=	1442.0 k-ft
P_{Total}=	684.2 k
M_{Total}=	1729 k-ft



Bearing Pressure Check
ASD Factored check

e	a	l/3 (ft)	b	σ_1 (plf)	σ_2 (plf)
2.527	4.473	4.667	14.0	101975.7	0.0

Acutal Bearing Pressure q = 7284.0 psf
Bearing Check and Safety Factor = **No Good** 0.8 (≥ 1.0)

Case II (P_{max})
Max Axial load

P_{DL}=	360.2 k
P_{LL}=	405.0 k
M_{DL}=	188.0 k-ft
M_{LL}=	634.0 k-ft
P_{Total}=	765.2 k
M_{Total}=	822 k-ft

Bearing Pressure Check
ASD Factored check

e	a	l/3 (ft)	b	σ_1 (plf)	σ_2 (plf)
1.074	5.926	4.667	14.0	113851.7	29493.9

Acutal Bearing Pressure q = 8132.3 psf
Bearing Check and Safety Factor = **No Good** 0.8 (≥ 1.0)

the depth and horizontal distance at which a subsurface stress acts are expressed in terms of the dimensions of the loaded foundation area. Subsurface stress conditions indicated by Boussinesq and Westergaard equations for commonly occurring foundation loadings are presented in Figures 9-7 and 9-8. The following illustration problems serve to demonstrate the use of these figures.

The stress curves in Figures 9-7 and 9-8 show that the stresses beneath the center of a loaded foundation area will be greater than stresses beneath the edge of the foundation until a depth of about twice the foundation width is reached. Below this level, the stresses beneath the center and edge become practically equal. Consequently, in making determinations of the stresses resulting from a foundation loading, it is suitable to assume a concentrated point loading, if convenient, where the subsurface depth is greater than twice the foundation width.

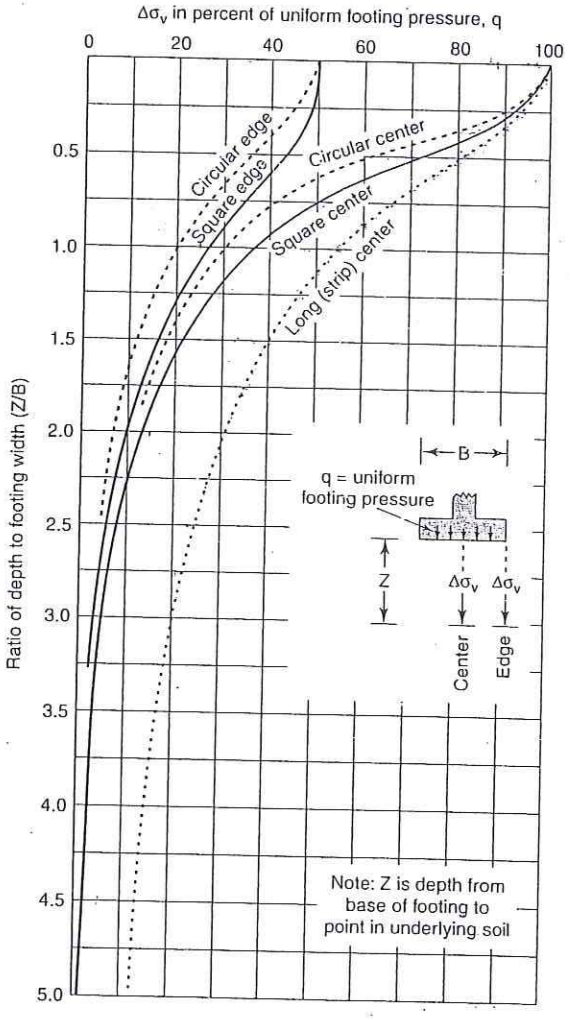


Figure 9-7 Variation of vertical stress beneath a foundation: Boussinesq analysis.

5/N5-N1 Connector Separation (55-0226) Widening SP 11-137

LIQUEFACTION ANALYSIS; ACC. = 0.4 g 16-Feb-12

Liquefaction analysis is performed following Seed's Procedure, outlined by Seed et al (1985), Seed and Harder (1990), updated NCEER (1997)

Emean/E60 = Energy Ratio to correct to standard 60% Energy
Surcharge = Any surcharge on top of the ground (psf)
acc. max = maximum peak acceleration at the ground surface (g's)
[1]C_N = square root of (100 kPa or 1.04427 tsf/effective overburden)
The induced cyclic stress ratio (CSR i) by a given peak ground acceleration (acc. max) is:

CSR i = 0.65 x acc max. x total normal stress x rd / (effective normal stress x g)

where: rd = stress reduction factor (Robertson and Wride (1996), Marcuson (USArmy Eng), per NCEER (1997))
g = acceleration of gravity

The resisting cyclic stress ratio (CSR r) is equal to:

CSR r = CSR x Cm x K sigma

where: Cm = Earthquake Magnitude Correction Factor (Blake, NCEER Table 3, Eq.4)
K sigma = Normalized resistance factor (Fig. 14 from NCEER Liquefaction workshop, Harder Boulanger)
CSR = Resisting Cyclic Stress Ratio. It is a function of the content of fines
(Figure 2, NCEER Workshop, after Seed et al 1985))

Factor of Safety, F sub L is:

F sub L = CSR r / CSR i

A-11-316

Emean (%)	75	Sur.=	psf	192.6	=top of ground el.		Borehole Diamete	8						142.7	=water table El.			acc. max =	0.40	g		Earthq. M=	7.5
C_E	1.25						C_B	1.15														Cm=	1.00

ELEVATION TOP OF LAYER (ft.)	LAYER THICKNESS L (ft.)	TOTAL OVERBUR. PRESS. (tsf)	EFFEC. OVERBUR. PRESS. (tsf)	DEPTH BELOW SURFACE (ft)	C_N	C_R	C_S	C_{ST}	TOTAL UNIT WEIGHT (pcf)	SAMPLER TYPE 1=SPT 2=CA.MOD.	SAMPLER LINED 1=UNLINED 2=LINED	FIELD BLOW COUNT N	STRESS REDUC. COEFF. rd	INDUCED CYCLIC STRESS RATIO	CORRECT BLOW COUNT Nc	EST. PERCENT OF FINES (%)	(N1)60cs	K sigma	RESIST. CYCLIC STRESS RATIO M=7.5	RESIST. CYCLIC STRESS RATIO Overburd Cor Mag Corr	FACTOR OF SAFETY (F sub L)	WILL IT LIQUEFY?
187.6	5	0.29	0.29	5.00	1.91	0.75	1.00	0.50	115	2	2	37	0.99	0.26	39	51.0	52	1.00	high N	high N	LARGE	AboveWT
182.6	5	0.58	0.58	10.00	1.35	0.75	1.20	1.00	115	1	1	12	0.98	0.25	21	78.0	31	1.00	high N	high N	LARGE	AboveWT
177.6	5	0.86	0.86	15.00	1.10	0.85	1.00	0.50	115	2	2	60	0.97	0.25	41	4.0	41	1.00	high N	high N	LARGE	AboveWT
172.6	5	1.15	1.15	20.00	0.95	0.85	1.20	1.00	115	1	1	64	0.95	0.25	90	5.0	90	0.98	high N	high N	LARGE	AboveWT
167.6	5	1.44	1.44	25.00	0.85	0.95	1.00	0.50	115	2	2	61	0.94	0.24	36	5.0	36	0.94	high N	high N	LARGE	AboveWT
162.6	5	1.73	1.73	30.00	0.78	0.95	1.20	1.00	115	1	1	31	0.93	0.24	40	51.0	53	0.90	high N	high N	LARGE	AboveWT
157.6	5	2.01	2.01	35.00	0.72	1.00	1.00	0.50	115	2	2	100	0.89	0.23	52	51.0	68	0.88	high N	high N	LARGE	AboveWT
152.6	5	2.30	2.30	40.00	0.67	1.00	1.20	1.00	115	1	1	38	0.85	0.22	45	51.0	59	0.86	high N	high N	LARGE	AboveWT
147.6	5	2.59	2.59	45.00	0.64	1.00	1.00	0.50	115	2	2	100	0.81	0.21	46	51.0	61	0.83	high N	high N	LARGE	AboveWT
142.6	5	2.88	2.72	50.00	0.62	1.00	1.20	1.00	115	1	1	37	0.77	0.21	40	51.0	53	0.82	high N	high N	LARGE	high N/fines
137.6	5	3.16	2.85	55.00	0.61	1.00	1.00	0.50	115	2	2	100	0.73	0.21	44	51.0	58	0.81	high N	high N	LARGE	high N/fines
132.6	5	3.45	2.98	60.00	0.59	1.00	1.20	1.00	115	1	1	34	0.69	0.21	35	51.0	47	0.80	high N	high N	LARGE	high N/fines
127.6	5	3.74	3.11	65.00	0.58	1.00	1.00	0.50	115	2	2	100	0.64	0.20	42	51.0	56	0.77	high N	high N	LARGE	high N/fines
122.6	5	4.03	3.25	70.00	0.57	1.00	1.20	1.00	115	1	1	32	0.60	0.19	32	51.0	44	0.77	high N	high N	LARGE	high N/fines
117.6	5	4.31	3.38	75.00	0.56	1.00	1.00	0.50	115	2	2	100	0.56	0.19	40	51.0	53	0.76	high N	high N	LARGE	high N/fines
112.6	5	4.60	3.51	80.00	0.55	1.00	1.20	1.00	115	1	1	100	0.55	0.19	95	51.0	119	0.75	high N	high N	LARGE	high N/fines
107.6	5	4.89	3.64	85.00	0.54	1.00	1.00	0.50	115	2	2	100	0.54	0.19	39	51.0	52	0.74	high N	high N	LARGE	high N/fines
102.6	5	5.18	3.77	90.00	0.53	1.00	1.20	1.00	115	1	1	45	0.52	0.19	41	51.0	55	0.74	high N	high N	LARGE	high N/fines
97.6	5	5.46	3.90	95.00	0.52	1.00	1.00	0.50	115	2	2	100	0.51	0.19	38	51.0	51	0.73	high N	high N	LARGE	high N/fines
92.6	5	5.75	4.03	100.00	0.51	1.00	1.20	1.00	115	1	1	46	0.50	0.19	41	51.0	55	0.72	high N	high N	LARGE	high N/fines

5/N5-N1 Connector Separation (55-0226) Widening | SP | 11-137

LIQUEFACTION ANALYSIS; ACC. = 0.4 g | 16-Feb-12

Liquefaction analysis is performed following Seed's Procedure, outlined by Seed et al (1985), Seed and Harder (1990), updated NCEER (1997)

Emean/E60 = Energy Ratio to correct to standard 60% Energy
Surcharge = Any surcharge on top of the ground (psf)
acc. max = maximum peak acceleration at the ground surface (g's)
^1C_N = square root of (100 kPa or 1.04427 tsf/effective overburden)
The induced cyclic stress ratio (CSR i) by a given peak ground acceleration (acc. max) is:

CSR i = 0.65 x acc max. x total normal stress x rd / (effective normal stress x g)

where: rd = stress reduction factor (Robertson and Wride (1996), Marcuson (USArmy Eng), per NCEER (1997))
g = acceleration of gravity

The resisting cyclic stress ratio (CSR r) is equal to:

CSR r = CSR x Cm x K sigma

where: Cm = Earthquake Magnitude Correction Factor (Blake, NCEER Table 3, Eq.4)
K sigma = Normalized resistance factor (Fig. 14 from NCEER Liquefaction workshop, Harder Boulanger)
CSR = Resisting Cyclic Stress Ratio. It is a function of the content of fines
(Figure 2, NCEER Workshop, after Seed et al 1985))

Factor of Safety, F sub L is:

F sub L = CSR r / CSR i

A-11-317

Emean (%)	75	Sur.=	psf	179.3	=top of ground el.	Borehole Diamete	8							142.7	=water table El.		acc. max =	0.40	g	Earthq. M=	7.5		
C_E	1.25					C_B	1.15													Cm=	1.00		

ELEVATION TOP OF LAYER (ft.)	LAYER THICKNESS L (ft.)	TOTAL OVERBUR. PRESS. (tsf)	EFFEC. OVERBUR. PRESS. (tsf)	DEPTH BELOW SURFACE (ft)	C_N	C_R	C_S	C_{ST}	TOTAL UNIT WEIGHT (pcf)	SAMPLER TYPE 1=SPT 2=CA.MOD.	SAMPLER LINED 1=UNLINED 2=LINED	FIELD BLOW COUNT N	STRESS REDUC. COEFF. rd	INDUCED CYCLIC STRESS RATIO	CORRECT BLOW COUNT Nc	EST. PERCENT OF FINES (%)	(N1)60cs	K sigma	RESIST. CYCLIC STRESS RATIO M=7.5	RESIST. CYCLIC STRESS RATIO Overburd Cor Mag Corr	FACTOR OF SAFETY (F sub L)	WILL IT LIQUEFY?
174.3	5	0.29	0.29	5.00	1.91	0.75	1.20	1.00	115	1	1	25	0.99	0.26	62	15.0	68	1.00	high N	high N	LARGE	AboveWT
169.3	5	0.58	0.58	10.00	1.35	0.75	1.00	0.50	115	2	2	43	0.98	0.25	32	4.0	32	1.00	high N	high N	LARGE	AboveWT
164.3	5	0.86	0.86	15.00	1.10	0.85	1.20	1.00	115	1	1	29	0.97	0.25	47	51.0	62	1.00	high N	high N	LARGE	AboveWT
159.3	5	1.15	1.15	20.00	0.95	0.85	1.00	0.50	115	2	2	100	0.95	0.25	59	51.0	76	0.98	high N	high N	LARGE	AboveWT
154.3	5	1.44	1.44	25.00	0.85	0.95	1.20	1.00	115	1	1	26	0.94	0.24	37	51.0	50	0.94	high N	high N	LARGE	AboveWT
149.3	5	1.73	1.73	30.00	0.78	0.95	1.00	0.50	115	2	2	100	0.93	0.24	54	51.0	70	0.90	high N	high N	LARGE	AboveWT
144.3	5	2.01	2.01	35.00	0.72	1.00	1.20	1.00	115	1	1	42	0.89	0.23	53	51.0	69	0.88	high N	high N	LARGE	AboveWT
139.3	5	2.30	2.14	40.00	0.70	1.00	1.00	0.50	115	2	2	100	0.85	0.24	51	51.0	67	0.87	high N	high N	LARGE	high N/fines
134.3	5	2.59	2.28	45.00	0.68	1.00	1.20	1.00	115	1	1	49	0.81	0.24	58	51.0	75	0.86	high N	high N	LARGE	high N/fines
129.3	5	2.88	2.41	50.00	0.66	1.00	1.00	0.50	115	2	2	100	0.77	0.24	48	51.0	63	0.85	high N	high N	LARGE	high N/fines
124.3	5	3.16	2.54	55.00	0.64	1.00	1.20	1.00	115	1	1	55	0.73	0.24	61	51.0	79	0.84	high N	high N	LARGE	high N/fines
119.3	5	3.45	2.67	60.00	0.63	1.00	1.00	0.50	115	2	2	100	0.69	0.23	45	51.0	59	0.83	high N	high N	LARGE	high N/fines
114.3	5	3.74	2.80	65.00	0.61	1.00	1.20	1.00	115	1	1	56	0.64	0.22	59	51.0	76	0.82	high N	high N	LARGE	high N/fines
109.3	5	4.03	2.93	70.00	0.60	1.00	1.00	0.50	115	2	2	100	0.60	0.22	43	51.0	57	0.81	high N	high N	LARGE	high N/fines
104.3	5	4.31	3.06	75.00	0.58	1.00	1.20	1.00	115	1	1	70	0.56	0.21	71	51.0	91	0.78	high N	high N	LARGE	high N/fines
99.3	5	4.60	3.20	80.00	0.57	1.00	1.00	0.50	115	2	2	100	0.55	0.21	42	51.0	56	0.77	high N	high N	LARGE	high N/fines
94.3	5	4.89	3.33	85.00	0.56	1.00	1.20	1.00	115	1	1	54	0.54	0.20	53	51.0	69	0.76	high N	high N	LARGE	high N/fines
89.3	5	5.18	3.46	90.00	0.55	1.00	1.00	0.50	115	2	2	100	0.52	0.20	40	51.0	53	0.75	high N	high N	LARGE	high N/fines
84.3	5	5.46	3.59	95.00	0.54	1.00	1.20	1.00	115	1	1	47	0.51	0.20	44	51.0	58	0.75	high N	high N	LARGE	high N/fines
79.3	5	5.75	3.72	100.00	0.53	1.00	1.00	0.50	115	2	2	100	0.50	0.20	39	51.0	52	0.74	high N	high N	LARGE	high N/fines

Liquefaction Analysis with Cone Penetration Test (CPT) Data

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17800 Newhope Street
Suite B
Fountain Valley, CA 92708

CPT Number: CPT-11-318
Project Name: 5/N5-N1 Connector Separation (Widen)
Project Number: 11-137
Location: Orange County
California

Computed by: SP
Checked by: LEC

Date: 02/16/12
Date: 4/12/12

Figure No.: _____

Reference:

1) Seed, R.B., et al, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*, Keynote Presentation, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, April 30, 2003.
2) Youd, T.L. & Idriss, I.M., et al, *Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils.* ASCE Journal of Geotechnical and Geoenvironmental Engineering, Pp. 817-833, October 2001.
3) Pradel D., *Procedure to Evaluate Earthquake-induced Settlements in Dry Sandy Soils*, ASCE Journal of Geotechnical and Geoenvironmental Engineering, Pp. 364-368, April 1998.
4) Tokimatsu, K. & Seed, H.B., *Evaluation of Settlements in Sands due to Earthquake Shaking*, ASCE Journal of Geotechnical Engineering, Pp. 861-878, August 1987.
5) Jefferies, M.G. & Davies, M.P., *Use of CPT to Estimate Equivalent SPT N_{60}*, ASTM Geotechnical Testing Journal, Vol.17, No. 4, Pp. 458-567, 1993.
6) Robertson, P.K. et al, *Use of Piezometer Cone Data*, Proceedings of the ASCE Specialty Conference In Situ 86: Use of In Situ Tests in Geotechnical Engineering, Blacksburg, Pp. 1263-1280, 1986.

Surface Elevation = 165.5 ft MSL
Design Magnitude, M_w = 7.50
PGA, a_{max} = 0.4 g
Earthquake Scaling Factor, MSF = 1.000 for M_w = 7.5
Design Water Level = 142.7 ft MSL
Water Level at Investigation = 137.4 ft MSL
Req'd Factor of Safety = 1

Summary of Seismically Induced Settlement:

Dry Settlement (in)	0.139
Post-liquefaction Settlement (in)	0.000
Total Settlement (in)	**0.139**

Depth	Elev.	Unit Weight (pcf)		q_c	f_s	Fric. Ratio	% Fines	Equiv. N_{60}	Equiv. $(N_1)_{60}$	α	β	Equiv. $(N_1)_{60CS}$	Stresses at Exploration Water Level		Stresses at Design Water Level		I_c	Soil Type Character (SAND, SILT or non-LIQ CLAY)	Normalization of Tip Resistance			Fines Correction		$CRR_{7.5}$	r_d	CSR_M	$CSR_{7.5}$	FS	a	b	Max Shear Modulus	Cyclic Shear Strain	Norm. Vol. Strain	Dry Settle.	Post-Liq. $(N_1)_{60CS}$	Post-Liq. Vol. Strain	Layer Post-Liq. Settle.
		γ'_{MOIST}	γ'_{SAT}										σ_v	σ'_v	σ_v	σ'_v			n	C_Q	q_{c1N}	Kc	$(q_{c1N})_{cs}$														
(ft)	(ft, MSL)			(tsf)	(tsf)	(%)							(tsf)	(tsf)	(tsf)	(tsf)														(tsf)	(%)	(%)	(in)		(%)	(in)
0.33	165.2	115.0	115.0	22.3	3.4	15.2	34	6	42	4.94	1.19	55	0.019	0.019	0.019	0.019	2.58	SILT	0.7	1.70	35.8	3.18	113.8	0.22	0.999	0.26	0.260	Above Water	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
0.49	165.0	115.0	115.0	21.0	2.0	9.5	35	5	33	5.00	1.20	44	0.026	0.028	0.028	0.028	2.60	SAND	0.5	1.70	33.7	3.32	112.1	0.21	0.999	0.26	0.260	Above Water	0.12	69281	196.8	0.01	0.00	0.000	NA	NA	0.000
0.65	164.8	115.0	115.0	16.1	1.2	7.5	29	4	20	4.61	1.14	28	0.038	0.038	0.038	0.038	2.45	SILT	0.7	1.70	25.9	2.54	65.7	0.11	0.998	0.26	0.260	Above Water	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
0.82	164.7	115.0	115.0	5.0	0.7	14.0	45	1	7	5.00	1.20	13	0.047	0.047	0.047	0.047	2.78	non-LIQ CLAY	1	1.70	NA	4.60	non-LIQ	non-LIQ	0.998	0.26	0.260	Above Water	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
0.98	164.5	115.0	115.0	3.3	0.2	6.1	37	1	4	5.00	1.20	9	0.056	0.056	0.056	0.056	2.64	non-LIQ CLAY	1	1.70	NA	3.57	non-LIQ	non-LIQ	0.998	0.26	0.260	Above Water	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
1.15	164.4	115.0	115.0	1.9	0.2	10.5	61	1	2	5.00	1.20	8	0.066	0.066	0.066	0.066	3.03	non-LIQ CLAY	1	1.70	NA	7.13	non-LIQ	non-LIQ	0.997	0.26	0.260	Above Water	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
1.31	164.2	115.0	115.0	7.2	0.2	2.8	30	2	7	4.70	1.15	12	0.075	0.075	0.075	0.075	2.48	SILT	0.7	1.70	11.6	2.68	31.0	0.08	0.997	0.26	0.260	Above Water	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
1.48	164.0	115.0	115.0	23.4	0.7	3.0	23	5	18	4.09	1.10	24	0.085	0.085	0.085	0.085	2.32	SAND	0.5	1.70	37.6	2.01	75.6	0.12	0.997	0.26	0.260	Above Water	0.13	35693	282.3	0.02	0.02	0.001	NA	NA	0.000
1.64	163.9	115.0	115.0	40.9	1.1	2.7	17	8	28	3.01	1.06	33	0.094	0.094	0.094	0.094	2.14	SAND	0.5	1.70	65.7	1.53	100.4	0.17	0.996	0.26	0.260	Above Water	0.13	33560	343.0	0.02	0.01	0.000	NA	NA	0.000
1.80	163.7	115.0	115.0	47.5	1.3	2.7	16	10	31	2.84	1.06	36	0.104	0.104	0.104	0.104	2.12	SAND	0.5	1.70	76.3	1.48	113.2	0.22	0.996	0.26	0.260	Above Water	0.13	31737	370.8	0.01	0.01	0.000	NA	NA	0.000
1.97	163.5	115.0	115.0	102.4	0.8	0.8	3	17	52	0.00	1.00	52	0.113	0.113	0.113	0.113	1.50	SAND	0.5	1.70	164.5	1.00	164.5	non-LIQ	0.995	0.26	0.260	Above Water	0.13	30065	458.4	0.01	0.00	0.000	NA	NA	0.000
2.13	163.4	115.0	115.0	107.9	0.5	0.5	1	17	50	0.00	1.00	50	0.122	0.122	0.122	0.122	1.33	SAND	0.5	1.70	173.4	1.00	173.4	non-LIQ	0.995	0.26	0.260	Above Water	0.13	28688	470.6	0.01	0.00	0.000	NA	NA	0.000
2.30	163.2	115.0	115.0	94.3	0.5	0.5	2	15	43	0.00	1.00	43	0.132	0.132	0.132	0.132	1.43	SAND	0.5	1.70	151.5	1.00	151.5	0.40	0.995	0.26	0.260	Above Water	0.13	27397	466.1	0.01	0.01	0.000	NA	NA	0.000
2.46	163.0	115.0	115.0	65.1	0.9	1.4	9	12	33	0.59	1.02	34	0.141	0.141	0.141	0.141	1.84	SAND	0.5	1.70	104.6	1.14	119.3	0.24	0.994	0.26	0.260	Above Water	0.13	26313	441.6	0.02	0.01	0.000	NA	NA	0.000
2.62	162.9	115.0	115.0	36.6	1.0	2.7	20	8	21	3.69	1.08	26	0.151	0.151	0.151	0.151	2.24	SAND	0.5	1.70	58.8	1.78	104.5	0.19	0.994	0.26	0.260	Above Water	0.13	25337	392.1	0.02	0.02	0.001	NA	NA	0.000
2.79	162.7	115.0	115.0	24.4	1.1	4.5	32	6	16	4.64	1.17	23	0.160	0.160	0.160	0.160	2.53	SAND	0.5	1.70	39.2	2.94	115.2	0.22	0.993	0.26	0.260	Above Water	0.13	24399	365.4	0.03	0.04	0.002	NA	NA	0.000
2.95	162.6	115.0	115.0	33.0	1.5	4.5	29	8	20	4.62	1.14	27	0.170	0.170	0.170	0.170	2.46	SAND	0.5	1.70	53.0	2.56	135.5	0.31	0.993	0.26	0.260	Above Water	0.13	23596	406.7	0.03	0.03	0.001	NA	NA	0.000
3.12	162.4	115.0	115.0	53.1	1.8	3.4	20	11	26	3.64	1.08	34	0.179	0.179	0.179	0.179	2.23	SAND	0.5	1.70	85.3	1.75	149.5	0.39	0.993	0.26	0.260	Above Water	0.13	22816	469.9	0.02	0.01	0.001	NA	NA	0.000
3.28	162.2	115.0	115.0	57.5	2.0	3.5	20	12	29	3.60	1.08	35	0.189	0.189	0.189	0.189	2.23	SAND	0.5	1.70	92.4	1.74	160.5	non-LIQ	0.992	0.26	0.260	Above Water	0.13	22142	490.2	0.02	0.01	0.000	NA	NA	0.000
3.45	162.1	115.0	115.0	57.5	1.9	3.3	20	12	28	3.54	1.08	34	0.198	0.198	0.198	0.198	2.22	SAND	0.5	1.70	92.4	1.71	157.9	0.45	0.992	0.26	0.260	Above Water	0.13	21480	497.8	0.02	0.01	0.001	NA	NA	0.000
3.61	161.9	115.0	115.0	57.5	2.1	3.7	21	13	28	3.77	1.09	35	0.208	0.208	0.208	0.208	2.26	SAND	0.5	1.70	92.4	1.82	168.0	non-LIQ	0.992	0.26	0.260	Above Water	0.13	20904	508.2	0.02	0.01	0.001	NA	NA	0.000
3.77	161.7	115.0	115.0	62.2	2.1	3.4	20	13	29	3.53	1.08	35	0.217	0.217	0.217	0.217	2.22	SAND	0.5	1.70	99.9	1.70	170.3	non-LIQ	0.991	0.26	0.260	Above Water	0.13	20367	526.2	0.02	0.01	0.000	NA	NA	0.000
3.94	161.6	115.0	115.0	62.1	2.2	3.5	20	13	29	3.66	1.08	35	0.227	0.227	0.227	0.227	2.24	SAND	0.5	1.70	99.8	1.76	176.1	non-LIQ	0.991	0.26	0.260	Above Water	0.13	19835	535.4	0.02	0.01	0.001	NA	NA	0.000
4.10	161.4	115.0	115.0	67.5	2.4	3.6	20	15	31	3.57	1.08	37	0.236	0.236	0.236	0.236	2.22	SAND	0.5	1.70	108.4	1.72	186.9	non-LIQ	0.990	0.26	0.260	Above Water	0.13	19367	556.6	0.02	0.01	0.000	NA	NA	0.000
4.27	161.2	115.0	115.0	66.2	2.4	3.6	20	14	30	3.67	1.08	36	0.246	0.246	0.246	0.246	2.24	SAND	0.5	1.70	106.4	1.77	188.2	non-LIQ	0.990	0.26	0.260	Above Water	0.13	18901	562.0	0.02	0.01	0.001	NA	NA	0.000
4.43	161.1	115.0	115.0	62.2	2.2	3.5	21	14	28	3.75	1.08	34	0.255	0.255	0.255	0.255	2.25	SAND	0.5	1.70	99.9	1.81	180.5	non-LIQ	0.990	0.26	0.260	Above Water	0.13	18488	558.2	0.02	0.02	0.001	NA	NA	0.000
4.59	160.9	115.0	115.0	63.6	2.5	3.9	22	14	28	3.94	1.09	35	0.264	0.264	0.264	0.264	2.29	SAND	0.5	1.70	102.2	1.91	195.2	non-LIQ	0.989	0.26	0.260	Above Water	0.13	18099	571.9	0.02	0.02	0.001	NA	NA	0.000
4.76	160.7	115.0	115.0	75.4	2.3	3.1	18	16	31	3.17	1.06	36	0.274	0.274	0.274	0.274	2.16	SAND	0.5	1.70	121.1	1.57	190.7	non-LIQ	0.989	0.26	0.260	Above Water	0.13	17708	601.8	0.02	0.01	0.001	NA	NA	0.000
4.92	160.6	115.0	115.0	79.3	2.4	3.0	17	17	32	3.08	1.06	37	0.283	0.283	0.283	0.283	2.15	SAND	0.5	1.70	127.4	1.55	197.4	non-LIQ	0.989	0.26	0.260	Above Water	0.13	17360	617.8	0.02	0.01	0.000	NA	NA	0.000
5.09	160.4	115.0	115.0	81.7	2.3	2.8	16	17	32	2.87	1.06	37	0.293	0.293	0.293	0.293	2.12	SAND	0.5	1.70	131.3	1.49	195.9	non-LIQ	0.988	0.26	0.260	Above Water	0.13	17010	628.7	0.02	0.01	0.001	NA	NA	0.000
5.25	160.3	115.0	115.0	80.8	2.5	3.1	18	17	32	3.16	1.06	37	0.302	0.302	0.302	0.302	2.16	SAND	0.5	1.70	129.8	1.57	204.3	non-LIQ	0.988	0.26	0.260	Above Water	0.13	16697	636.3	0.02	0.01	0.000	NA	NA	0.000
5.41	160.1	115.0	115.0	80.8	2.7	3.3	19	17	32	3.37	1.07	37	0.311	0.311	0.311	0.311	2.19	SAND	0.5	1.70	129.8	1.64	213.3	non-LIQ	0.987	0.26	0.260	Above Water	0.13	16399	645.4	0.02	0.01	0.001	NA	NA	0.000
5.58	159.9	115.0	115.0	83.2	2.4	2.9	17	17	31	2.99	1.06	36	0.321	0.321	0.321	0.321	2.14	SAND	0.5	1.70	133.7	1.52	203.7	non-LIQ	0.987	0.26	0.260	Above Water	0.13	16097	653.6	0.02	0.01	0.001	NA	NA	0.000
5.74	159.8	115.0	115.0	69.3	2.6	3.8	22	15	27	3.89	1.09	34	0.330	0.330	0.330	0.330	2.28	SAND	0.5	1.70	111.3	1.88	209.7	non-LIQ	0.987	0.26	0.260	Above Water	0.13	15827	633.3	0.03	0.02	0.001	NA	NA	0.000
5.91	159.6	115.0	115.0	66.8	2.6	3.9	23	15	26	4.02	1.10	33	0.340	0.340	0.340	0.340	2.31	SAND	0.5	1.70	107.3	1.97	211.1	non-LIQ	0.986	0.26	0.260	Above Water	0.13	15552	634.1	0.03	0.02	0.001	NA	NA	0.000
6.07	159.4	115.0	115.0	85.5	2.5	2.9	17	18	31	3.06	1.06	36	0.349	0.349	0.349	0.349	2.14	SAND	0.5	1.70	137.4	1.54	211.8	non-LIQ	0.986	0.26	0.260	Above Water	0.13	15305	679.1	0.02	0.01	0.001	NA	NA	0.000
6.23	159.3	115.0	115.0	74.0	2.3	3.1	19	16	27	3.49	1.07	33	0.358	0.358	0.358	0.358	2.21	SAND	0.5	1.70	118.9	1.69	200.7	non-LIQ	0.985	0.26	0.260	Above Water	0.13	15068	658.6	0.03	0.02	0.001	NA	NA	0.000
6.40	159.1	115.0	115.0	59.3	2.1	3.5	23	13	23	4.08	1.10	29	0.368	0.368	0.368	0.368	2.32	SAND	0.5	1.70	95.0	2.01	190.9	non-LIQ	0.985	0.26	0.260	Above Water	0.13	14826	627.0	0.03	0.03	0.001	NA	NA	0.000
6.56	158.9	115.0	115.0	83.4	2.3	2.8	17	17	29	3.04	1.06	34	0.377	0.377	0.377	0.377	2.14	SAND	0.5	1.67	132.0	1.54	202.9	non-LIQ	0.985	0.26	0.260	Above Water	0.13	14608	691.0	0.03	0.02	0.001	NA	NA	0.000
6.73	158.8	115.0	115.0	106.0	2.7	2.5	14	21	35	2.34	1.04	39	0.387	0.387	0.387	0.387	2.05	SAND	0.5	1.65	165.7	1.36	226.1	non-LIQ	0.984	0.26	0.260	Above Water	0.13	14386	746.0	0.02	0.01	0.000	NA	NA	0.000
6.89	158.6	115.0	115.0	111.8	2.9	2.6	14	22	37	2.30	1.04	41	0.396	0.396	0.396	0.396	2.05	SAND	0.5	1.63	172.7	1.37	236.5	non-LIQ	0.984	0.26	0.260	Above Water	0.13	14184	764.8	0.02	0.01	0.000	NA	NA	0.000
7.05	158.5	115.0	115.0	115.3	3.0	2.6	14	23	37	2.26	1.04	41	0.405	0.405	0.405	0.405	2.04	SAND	0.5	1.62	176.1	1.36	240.0	non-LIQ	0.984	0.26	0.260	Above Water	0.13	13990	776.3	0.02	0.01	0.000	NA	NA	0.000
7.22	158.3	115.0	115.0	114.7	3.0	2.6	14	23	37	2.32	1.04	41	0.415	0.415	0.415	0.415	2.05	SAND	0.5	1.60	173.1	1.37	237.6	non-LIQ	0.983	0.26	0.260	Above Water	0.13	13792	783.8	0.02	0.01	0.000	NA	NA	0.000
7.38	158.1	115.0	115.0	115.7	3.0	2.6	14	23	37	2.30	1.04	41	0.424	0.424	0.424	0.424	2.05	SAND	0.5	1.58	172.7	1.37	236.5	non-LIQ	0.983	0.26	0.260	Above Water	0.14	13611	791.6	0.02	0.01	0.000	NA	NA	0.000
7.55	158.0	115.0	115.0	115.9	3.5	3.0	16	24	37	2.75	1.05	42	0.434	0.434	0.434	0.434	2.10	SAND	0.5	1.56	171.0	1.46	250.2	non-LIQ	0.982	0.26	0.260	Above Water	0.14	13427	803.9	0.02	0.01	0.000	NA	NA	0.000
7.71	157.8	115.0	115.0	115.2	3.6	3.1	16	24	37	2.88	1.06	42	0.443	0.443	0.443	0.443	2.12	SAND	0.5	1.54	168.2	1.49	251.3	non-LIQ	0.982	0.26	0.260	Above Water	0.14	13259	809.7	0.02	0.01	0.000	NA	NA	0.000
7.87	157.6	115.0	115.0	121.6	3.7	3.0	16	25	38	2.72	1.05	43	0.453	0.453	0.453	0.453	2.10	SAND	0.5	1.53	175.7	1.46	255.8	non-LIQ	0.982	0.26	0.260	Above Water	0.14	13096	827.8	0.02	0.01	0.000	NA	NA	0.000
8.04	157.5	115.0	115.0	107.8	3.4	3.2	17	22	34	3.07	1.06	39	0.462	0.462	0.462	0.462	2.15	SAND	0.5	1.51	154.1	1.55	238.4	non-LIQ	0.981	0.26	0.260	Above Water	0.14	12929	806.0	0.03	0.01	0.001	NA	NA	0.000
8.20	157.3	115.0	115.0	116.4	3.0	2.6	15	23	35	2.39	1.05	39	0.472	0.472	0.472	0.472	2.06	SAND	0.5	1.50	164.8	1.39	228.4	non-LIQ	0.981	0.26	0.260	Above Water	0.14	12778	822.6	0.03	0.01	0.000	NA	NA	0.000
8.37	157.1	115.0	115.0	107.8	2.9	2.7	16	22	33	2.70	1.05	37	0.481	0.481	0.481	0.481	2.10	SAND	0.5	1.48	151.1	1.45	219.1	non-LIQ	0.980	0.25	0.250	Above Water	0.14	12621	811.4	0.02	0.01	0.001	NA	NA	0.000
8.53	157.0	115.0	115.0	110.1	3.0	2.7	16	23	33	2.71	1.05	38	0.490	0.490	0.490	0.490	2.10	SAND	0.5	1.47	152.8	1.45	222.0	non-LIQ	0.980	0.25	0.250	Above Water	0.14	12479	822.5	0.02	0.01	0.001	NA	NA	0.000

Liquefaction Analysis with Cone Penetration Test (CPT) Data

Depth	Elev.	Unit Weight (pcf)		q_c	f_s	Frict. Ratio	% Fines	Equiv. N_{60}	Equiv. $(N_1)_{60}$	α	β	Equiv. $(N_1)_{60cs}$	Stresses at Exploration Water Level		Stresses at Design Water Level		I_c	Soil Type Character (SAND, SILT or non-LIQ CLAY)	Normalization of Tip Resistance			Fines Correction		$CRR_{7.5}$	r_d	CSR_M	$CSR_{7.5}$	FS	a	b	Max Shear Modulus	Cyclic Shear Strain	Norm. Vol. Strain	Dry Settle.	Post-Liq. $(N_1)_{60cs}$	Post-Liq. Vol. Strain	Layer Post-Liq. Settle.
(ft)	(ft, MSL)	γ'_{MOIST}	γ'_{SAT}	(tsf)	(tsf)	(%)							σ_v (tsf)	σ_v' (tsf)	σ_v (tsf)	σ_v' (tsf)			n	C_Q	q_{c1N}	Kc	$(q_{c1N})_{cs}$								G_{max} (tsf)	γ (%)	ε_{Nc} (%)	ΔS (in)		ε (%)	ΔS (in)
8.69	156.8	115.0	115.0	109.2	3.0	2.7	16	22	33	2.77	1.05	37	0.500	0.500	0.500	0.500	2.11	SAND	0.5	1.46	150.2	1.47	220.2	non-LIQ	0.980	0.25	0.250	Above Water	0.14	12340	826.2	0.03	0.01	0.001	NA	NA	0.000
8.86	156.6	115.0	115.0	108.0	3.0	2.8	16	22	32	2.84	1.06	37	0.509	0.509	0.509	0.509	2.12	SAND	0.5	1.44	147.1	1.48	218.3	non-LIQ	0.979	0.25	0.250	Above Water	0.14	12198	829.5	0.03	0.01	0.001	NA	NA	0.000
9.02	156.5	115.0	115.0	110.5	2.9	2.6	16	23	32	2.66	1.05	37	0.519	0.519	0.519	0.519	2.09	SAND	0.5	1.43	149.2	1.44	215.0	non-LIQ	0.979	0.25	0.250	Above Water	0.14	12067	838.3	0.03	0.01	0.001	NA	NA	0.000
9.19	156.3	115.0	115.0	110.2	3.0	2.7	16	23	32	2.78	1.05	37	0.528	0.528	0.528	0.528	2.11	SAND	0.5	1.42	147.4	1.47	216.7	non-LIQ	0.979	0.25	0.250	Above Water	0.14	11933	844.5	0.03	0.01	0.001	NA	NA	0.000
9.35	156.2	115.0	115.0	111.3	3.0	2.7	16	23	32	2.75	1.05	36	0.538	0.538	0.538	0.538	2.10	SAND	0.5	1.40	147.6	1.46	215.9	non-LIQ	0.978	0.25	0.250	Above Water	0.14	11810	851.8	0.03	0.01	0.001	NA	NA	0.000
9.51	156.0	115.0	115.0	111.2	3.0	2.7	16	23	32	2.78	1.05	36	0.547	0.547	0.547	0.547	2.11	SAND	0.5	1.39	146.2	1.47	214.7	non-LIQ	0.978	0.25	0.250	Above Water	0.14	11690	856.7	0.03	0.02	0.001	NA	NA	0.000
9.68	155.8	115.0	115.0	111.5	3.0	2.7	16	23	32	2.78	1.05	36	0.557	0.557	0.557	0.557	2.11	SAND	0.5	1.38	145.3	1.47	213.6	non-LIQ	0.977	0.25	0.250	Above Water	0.14	11567	862.6	0.03	0.02	0.001	NA	NA	0.000
9.84	155.7	115.0	115.0	110.7	2.9	2.6	16	23	31	2.75	1.05	35	0.566	0.566	0.566	0.566	2.10	SAND	0.5	1.37	143.1	1.46	209.1	non-LIQ	0.977	0.25	0.250	Above Water	0.14	11453	864.7	0.03	0.02	0.001	NA	NA	0.000
10.01	155.5	115.0	115.0	104.4	2.9	2.8	17	22	29	3.04	1.06	34	0.576	0.576	0.576	0.576	2.14	SAND	0.5	1.36	133.8	1.54	205.5	non-LIQ	0.977	0.25	0.250	Above Water	0.14	11336	857.2	0.03	0.02	0.001	NA	NA	0.000
10.17	155.3	115.0	115.0	96.9	2.9	3.0	19	21	28	3.37	1.07	33	0.585	0.585	0.585	0.585	2.19	SAND	0.5	1.35	123.2	1.64	202.3	non-LIQ	0.976	0.25	0.250	Above Water	0.14	11229	846.2	0.03	0.02	0.001	NA	NA	0.000
10.34	155.2	115.0	115.0	90.6	2.5	2.8	18	19	26	3.33	1.07	31	0.595	0.595	0.595	0.595	2.18	SAND	0.5	1.33	114.2	1.63	186.0	non-LIQ	0.976	0.25	0.250	Above Water	0.14	11118	831.3	0.03	0.02	0.001	NA	NA	0.000
10.50	155.0	115.0	115.0	92.1	2.7	2.9	19	20	26	3.44	1.07	31	0.604	0.604	0.604	0.604	2.20	SAND	0.5	1.32	115.2	1.67	192.6	non-LIQ	0.976	0.25	0.250	Above Water	0.14	11016	842.3	0.03	0.02	0.001	NA	NA	0.000
10.66	154.8	115.0	115.0	107.7	2.7	2.5	16	22	29	2.78	1.05	33	0.613	0.613	0.613	0.613	2.11	SAND	0.5	1.31	133.7	1.47	196.4	non-LIQ	0.975	0.25	0.250	Above Water	0.14	10916	880.5	0.03	0.02	0.001	NA	NA	0.000
10.83	154.7	115.0	115.0	105.7	3.0	2.8	18	22	29	3.14	1.06	34	0.623	0.623	0.623	0.623	2.16	SAND	0.5	1.30	130.2	1.57	204.1	non-LIQ	0.975	0.25	0.250	Above Water	0.14	10813	885.5	0.03	0.02	0.001	NA	NA	0.000
10.99	154.5	115.0	115.0	103.9	2.9	2.8	18	22	28	3.15	1.06	33	0.632	0.632	0.632	0.632	2.16	SAND	0.5	1.29	127.1	1.57	199.5	non-LIQ	0.974	0.25	0.250	Above Water	0.14	10719	884.9	0.03	0.02	0.001	NA	NA	0.000
11.16	154.3	115.0	115.0	112.7	3.0	2.7	16	23	30	2.88	1.06	34	0.642	0.642	0.642	0.642	2.12	SAND	0.5	1.28	136.8	1.50	204.5	non-LIQ	0.974	0.25	0.250	Above Water	0.14	10620	909.3	0.03	0.02	0.001	NA	NA	0.000
11.32	154.2	115.0	115.0	115.0	2.9	2.5	16	24	30	2.72	1.05	34	0.651	0.651	0.651	0.651	2.10	SAND	0.5	1.27	138.6	1.45	201.5	non-LIQ	0.974	0.25	0.250	Above Water	0.14	10530	917.2	0.03	0.02	0.001	NA	NA	0.000
11.48	154.0	115.0	115.0	112.7	2.8	2.5	16	23	29	2.74	1.05	34	0.660	0.660	0.660	0.660	2.10	SAND	0.5	1.27	134.9	1.46	196.8	non-LIQ	0.974	0.25	0.250	Above Water	0.14	10442	915.6	0.03	0.02	0.001	NA	NA	0.000
11.65	153.9	115.0	115.0	111.2	2.7	2.4	16	23	29	2.72	1.05	33	0.670	0.670	0.670	0.670	2.10	SAND	0.5	1.26	132.1	1.46	192.3	non-LIQ	0.973	0.25	0.250	Above Water	0.14	10350	915.8	0.03	0.02	0.001	NA	NA	0.000
11.81	153.7	115.0	115.0	111.1	2.5	2.3	15	23	28	2.54	1.05	32	0.679	0.679	0.679	0.679	2.08	SAND	0.5	1.25	131.1	1.42	185.6	non-LIQ	0.973	0.25	0.250	Above Water	0.14	10266	916.9	0.03	0.02	0.001	NA	NA	0.000
11.98	153.5	115.0	115.0	113.4	2.6	2.3	15	23	29	2.56	1.05	32	0.689	0.689	0.689	0.689	2.08	SAND	0.5	1.24	132.8	1.42	188.6	non-LIQ	0.972	0.25	0.250	Above Water	0.14	10178	927.9	0.03	0.02	0.001	NA	NA	0.000
12.14	153.4	115.0	115.0	111.8	2.7	2.4	16	23	28	2.74	1.05	32	0.698	0.698	0.698	0.698	2.10	SAND	0.5	1.23	130.1	1.46	190.0	non-LIQ	0.972	0.25	0.250	Above Water	0.14	10097	930.4	0.03	0.02	0.001	NA	NA	0.000
12.30	153.2	115.0	115.0	114.3	2.7	2.4	16	23	29	2.65	1.05	33	0.707	0.707	0.707	0.707	2.09	SAND	0.5	1.22	132.1	1.44	190.2	non-LIQ	0.972	0.25	0.250	Above Water	0.14	10018	940.0	0.03	0.02	0.001	NA	NA	0.000
12.47	153.0	115.0	115.0	114.3	2.7	2.4	16	23	28	2.67	1.05	32	0.717	0.717	0.717	0.717	2.09	SAND	0.5	1.21	131.2	1.44	189.4	non-LIQ	0.971	0.25	0.250	Above Water	0.14	9936	944.5	0.03	0.02	0.001	NA	NA	0.000
12.63	152.9	115.0	115.0	115.0	2.7	2.3	16	23	28	2.65	1.05	32	0.726	0.726	0.726	0.726	2.09	SAND	0.5	1.21	131.2	1.44	188.9	non-LIQ	0.971	0.25	0.250	Above Water	0.14	9860	950.2	0.03	0.02	0.001	NA	NA	0.000
12.80	152.7	115.0	115.0	115.8	2.7	2.3	15	24	28	2.63	1.05	32	0.736	0.736	0.736	0.736	2.09	SAND	0.5	1.20	131.2	1.44	188.4	non-LIQ	0.971	0.25	0.250	Above Water	0.14	9782	956.4	0.03	0.02	0.001	NA	NA	0.000
12.96	152.5	115.0	115.0	116.4	2.8	2.4	16	24	28	2.72	1.05	33	0.745	0.745	0.745	0.745	2.10	SAND	0.5	1.19	131.1	1.45	190.7	non-LIQ	0.970	0.25	0.250	Above Water	0.14	9709	963.4	0.03	0.02	0.001	NA	NA	0.000
13.12	152.4	115.0	115.0	116.1	2.8	2.4	16	24	28	2.74	1.05	32	0.754	0.754	0.754	0.754	2.10	SAND	0.5	1.18	129.9	1.46	189.8	non-LIQ	0.970	0.25	0.250	Above Water	0.14	9638	966.9	0.03	0.02	0.001	NA	NA	0.000
13.29	152.2	115.0	115.0	116.9	2.8	2.4	16	24	28	2.72	1.05	32	0.764	0.764	0.764	0.764	2.10	SAND	0.5	1.18	130.0	1.46	189.3	non-LIQ	0.969	0.25	0.250	Above Water	0.14	9564	973.0	0.03	0.02	0.001	NA	NA	0.000
13.45	152.1	115.0	115.0	117.7	2.9	2.5	16	24	28	2.80	1.05	33	0.773	0.773	0.773	0.773	2.11	SAND	0.5	1.17	130.1	1.47	191.7	non-LIQ	0.969	0.25	0.250	Above Water	0.14	9495	980.3	0.03	0.02	0.001	NA	NA	0.000
13.62	151.9	115.0	115.0	118.0	2.9	2.5	16	24	28	2.80	1.05	33	0.783	0.783	0.783	0.783	2.11	SAND	0.5	1.16	129.6	1.47	191.0	non-LIQ	0.969	0.25	0.250	Above Water	0.14	9424	985.3	0.03	0.02	0.001	NA	NA	0.000
13.78	151.7	115.0	115.0	117.5	2.8	2.4	16	24	28	2.74	1.05	32	0.792	0.792	0.792	0.792	2.10	SAND	0.5	1.16	128.3	1.46	187.4	non-LIQ	0.968	0.25	0.250	Above Water	0.14	9358	986.8	0.03	0.02	0.001	NA	NA	0.000
13.94	151.6	115.0	115.0	120.0	2.8	2.3	16	24	28	2.65	1.05	32	0.802	0.802	0.802	0.802	2.09	SAND	0.5	1.15	130.3	1.44	187.6	non-LIQ	0.968	0.25	0.250	Above Water	0.14	9293	996.0	0.03	0.02	0.001	NA	NA	0.000
14.11	151.4	115.0	115.0	121.7	2.9	2.4	16	25	28	2.69	1.05	33	0.811	0.811	0.811	0.811	2.10	SAND	0.5	1.14	131.3	1.45	190.2	non-LIQ	0.967	0.25	0.250	Above Water	0.15	9226	1005.4	0.03	0.02	0.001	NA	NA	0.000
14.27	151.2	115.0	115.0	120.5	3.1	2.6	17	25	28	2.92	1.06	33	0.821	0.821	0.821	0.821	2.13	SAND	0.5	1.14	129.3	1.50	194.5	non-LIQ	0.967	0.25	0.250	Above Water	0.15	9164	1009.9	0.03	0.02	0.001	NA	NA	0.000
14.44	151.1	115.0	115.0	123.2	3.2	2.6	17	25	29	2.91	1.06	33	0.830	0.830	0.830	0.830	2.12	SAND	0.5	1.13	131.4	1.50	197.4	non-LIQ	0.967	0.25	0.250	Above Water	0.15	9099	1021.2	0.03	0.02	0.001	NA	NA	0.000
14.60	150.9	115.0	115.0	126.2	3.2	2.5	16	26	29	2.81	1.05	34	0.839	0.839	0.839	0.839	2.11	SAND	0.5	1.12	133.9	1.48	197.7	non-LIQ	0.966	0.25	0.250	Above Water	0.15	9039	1031.4	0.03	0.02	0.001	NA	NA	0.000
14.76	150.7	115.0	115.0	125.1	3.1	2.5	16	26	29	2.78	1.05	33	0.849	0.849	0.849	0.849	2.11	SAND	0.5	1.12	132.0	1.47	194.0	non-LIQ	0.966	0.25	0.250	Above Water	0.15	8980	1031.6	0.03	0.02	0.001	NA	NA	0.000
14.93	150.6	115.0	115.0	123.0	3.1	2.5	16	25	28	2.87	1.06	33	0.858	0.858	0.858	0.858	2.12	SAND	0.5	1.11	129.1	1.49	192.6	non-LIQ	0.965	0.25	0.250	Above Water	0.15	8919	1031.4	0.04	0.02	0.001	NA	NA	0.000
15.09	150.4	115.0	115.0	123.4	3.1	2.5	16	25	28	2.87	1.06	33	0.868	0.868	0.868	0.868	2.12	SAND	0.5	1.10	128.8	1.49	192.1	non-LIQ	0.965	0.25	0.250	Above Water	0.15	8862	1036.1	0.04	0.02	0.001	NA	NA	0.000
15.26	150.2	115.0	115.0	122.2	3.1	2.5	17	25	28	2.93	1.06	32	0.877	0.877	0.877	0.877	2.13	SAND	0.5	1.10	126.8	1.51	191.0	non-LIQ	0.964	0.25	0.250	Above Water	0.15	8802	1037.7	0.04	0.02	0.001	NA	NA	0.000
15.42	150.1	115.0	115.0	121.9	3.0	2.5	16	25	27	2.87	1.06	32	0.887	0.887	0.887	0.887	2.12	SAND	0.5	1.09	125.9	1.49	187.6	non-LIQ	0.964	0.25	0.250	Above Water	0.15	8747	1039.4	0.04	0.02	0.001	NA	NA	0.000
15.58	149.9	115.0	115.0	122.2	2.9	2.4	16	25	27	2.78	1.05	32	0.896	0.896	0.896	0.896	2.11	SAND	0.5	1.09	125.5	1.47	184.5	non-LIQ	0.964	0.25	0.250	Above Water	0.15	8693	1042.2	0.04	0.03	0.001	NA	NA	0.000
15.75	149.8	115.0	115.0	119.2	2.8	2.3	16	25	27	2.82	1.06	32	0.906	0.906	0.906	0.906	2.11	SAND	0.5	1.08	121.8	1.48	180.2	non-LIQ	0.963	0.25	0.250	Above Water	0.15	8637	1038.1	0.04	0.03	0.001	NA	NA	0.000
15.91	149.6	115.0	115.0	118.4	2.8	2.4	16	24	26	2.87	1.06	31	0.915	0.915	0.915	0.915	2.12	SAND	0.5	1.08	120.3	1.49	179.4	non-LIQ	0.963	0.25	0.250	Above Water	0.15	8585	1040.1	0.04	0.03	0.001	NA	NA	0.000
16.08	149.4	115.0	115.0	115.0	2.8	2.4	17	24	26	3.01	1.06	31	0.925	0.925	0.925	0.925	2.14	SAND	0.5	1.07	116.3	1.53	177.6	non-LIQ	0.963	0.25	0.250	Above Water	0.15	8530	1036.4	0.04	0.03	0.001	NA	NA	0.000
16.24	149.3	115.0	115.0	116.8	2.9	2.5	17	24	26	3.04	1.06	30	0.934	0.934	0.934	0.934	2.14	SAND	0.5	1.06	117.5	1.54	180.5	non-LIQ	0.962	0.25	0.250	Above Water	0.15	8480	1045.7	0.04	0.03	0.001	NA	NA	0.000
16.40	149.1	115.0	115.0	117.4	2.9	2.5	17	24	26	3.03	1.06	30	0.943	0.943	0.943	0.943	2.14	SAND	0.5	1.06	117.5	1.53	180.2	non-LIQ	0.962	0.25	0.250	Above Water	0.15	8430	1050.7	0.04	0.03	0.001	NA	NA	0.000
16.57	148.9	115.0	115.0	117.8	2.8	2.4	17	24	26	2.94	1.06	30	0.953	0.953	0.953	0.953	2.13	SAND	0.5	1.05	117.3	1.51	177.0	non-LIQ	0.961	0.25	0.250	Above Water	0.15	8378	1053.8	0.04	0.03	0.001	NA	NA	0.000
16.73	148.8	115.0	115.0	116.6	2.7	2.3	17	24	25	2.91	1.06	30	0.962	0.962	0.962	0.962	2.12	SAND	0.5	1.05	115.6	1.50	173.4	non-LIQ	0.961	0.25	0.250	Above Water	0.15	8330	1053.0	0.04	0.03	0.001	NA	NA	0.000
16.90	148.6	115.0	115.0	113.5	2.6	2.3	17	24	25	2.95	1.06	29	0.972	0.972	0.972	0.972	2.13	SAND	0.5	1.04	111.9	1.51	169.3	non-LIQ	0.961	0.25	0.250	Above Water	0.15	8279	1047.9	0.04	0.03	0.001	NA	NA	0.000
17.06	148.4	115.0	115.0	113.7	3.0	2.6	18	24	25	3.28	1.07	30	0.981	0.981	0.981	0.981	2.18	SAND	0.5	1.04	111.6	1.61	180.0	non-LIQ	0.960	0.25	0.250	Above Water	0.15	8233	1056.6	0.04	0.03	0.001	NA	NA	0.000
17.23	148.3	115.0	115.0	112.6	2.9	2.6	18	24	25	3.26	1.07	29	0.991	0.991	0.991	0.991	2.17	SAND	0.5	1.03	110.0	1.60	176.4	non-LIQ	0.960	0.25	0.250	Above Water	0.15	8184	1058.1	0.04	0.03	0.001	NA	NA	0.000
17.39	148.1	115.0	115.0	112.9	2.9	2.6	18	24	24	3.26	1.07	29	1.000	1.000	1.000	1.000	2.17	SAND	0.5	1.03	109.8	1.60	176.0	non-LIQ	0.959	0.25	0.250	Above Water	0.15	8139	1062.3	0.04	0.03	0.001	NA	NA	0.000
17.55	148.0	115.0	115.0	113.6	2.8	2.5	18	24	24	3.16	1.06	29	1.009	1.009	1.009	1.009	2.16	SAND	0.5	1.02	109.9	1.57	172.9	non-LIQ	0.959	0.25	0.250	Above Water	0.15	8094	1065.7	0.04	0.03	0.001	NA	NA	0.000
17.72	147.8	115.0	115.0	112.7	2.9	2.6	18	24	24	3.28	1.07	29	1.019	1.019	1.019	1.019	2.18	SAND	0.5	1.02	108.5	1.61	175.0	non-LIQ	0.959	0.25	0.250	Above Water	0.15	8047	1068.9	0.04	0.03	0.001	NA	NA	0.000
17.88	147.6	115.0	115.0	114.0	3.1	2.7	19	24	25	3.39	1.07	30	1.028	1.028	1.028	1.028	2.19	SAND	0.5	1.01	109.3	1.65	180.4	non-LIQ	0.958	0.25	0.250	Above Water	0.15	8004	1078.6	0.04	0.03	0.001	NA	NA	0.000
18.05	147.5	115.0	115.0	111.4	4.2	3.8	23	25	25	4.05	1.10	32	1.038	1.038	1.038	1.038	2.31	SAND	0.5	1.01	106.3	1.98	210.7	non-LIQ	0.958	0.25	0.250	Above Water	0.15	7959	1091.7	0.04	0.03	0.001	NA	NA	0.000
18.21	147.3	115.0	115.0	101.9	3.8	3.7	24	23	23	4.15	1.11	30	1.047	1.047	1.047	1.047	2.33	SAND	0.5	1.01	96.8	2.06	199.3	non-LIQ	0.958	0.25	0.250	Above Water	0.15	7917	1066.4	0.04	0.04	0.001	NA	NA	0.000
18.37	147.1	115.0	115.0	95.8	3.0	3.1	22	21	21	3.97	1.10	27	1.056	1.056	1.056	1.056	2.29	SAND	0.5	1.00	90.6	1.93	174.9	non-LIQ	0.957	0.25	0.250	Above Water	0.15	7875	1041.9	0.05	0.04	0.002	NA	NA	0.000
18.54	147.0	115.0	115.0	81.4	2.7	3.3	25	19	19	4.28	1.11	25	1.066	1.066	1.066	1.066	2.36	SAND	0.5	1.00	76.6	2.17	166.0	non-LIQ	0.957	0.25	0.250	Above Water	0.15	7832	999.8	0.05	0.06	0.002	NA	NA	0.000
18.70	146.8	115.0	115.0	87.1	2.6	3.0	23	19	19	4.04	1.10	25	1.075	1.075	1.075	1.075	2.31	SAND	0.5	0.99	81.7	1.98	161.7	non-LIQ	0.956	0.25	0.250	Above Water	0.15	7792	1017.6	0.05	0.05	0.002	NA	NA	0.000
18.87	146.6	115.0	115.0	90.2	2.7	3.0	23	20	20	4.00	1.10	26	1.085	1.085	1.085	1.085	2.30	SAND	0.5	0.99	84.2	1.95	164.5	non-LIQ	0.956	0.25	0.250	Above Water	0.15	7749	1031.4	0.05	0.05	0.002	NA	NA	0.000
19.03	146.5	115.0	115.0	91.9	2.7	2.9	22	20	20	3.95	1.09	26	1.094	1.094	1.094	1.094	2.29	SAND	0.5	0.98	85.4	1.92	164.1	non-LIQ	0.956	0.25	0.250	Above Water	0.15	7710	1039.3	0.05	0.05	0.002	NA	NA	0.000
19.19	146.3	115.0	115.0	88.9	2.7	3.0	23	20	19	4.06	1.10	25	1.103	1.103	1.103	1.103	2.31	SAND	0.5	0.98	82.3	1.99	163.9	non-LIQ	0.955	0.25	0.250	Above Water	0.15	7672	1034.0	0.05	0.05	0.002	NA	NA	0.000
19.36	146.1	115.0	115.0	77.2	2.5	3.2	26	18	17	4.34	1.12	24	1.113	1.113	1.113	1.113	2.38	SAND	0.5	0.97	71.1	2.22	158.2	0.45	0.955	0.25	0.250	Above Water	0.15	7631	998.9	0.06	0.07	0.003	NA	NA	0.000
19.52	146.0	115.0	115.0	73.6	2.5	3.4	27	17	17	4.46	1.13	23	1.122	1.122	1.122	1.122	2.41	SAND	0.5	0.97	67.5	2.35	158.6	0.45	0.954	0.25	0.250	Above Water	0.15	7594	990.4	0.06	0.07	0.003	NA	NA	0.000
19.69	145.8	115.0	115.0	87.9	3.0	3.4	25	20	19	4.26	1.11	26	1.132	1.132	1.132	1.132	2.35	SAND	0.5	0.97	80.3	2.15	172.6	non-LIQ	0.954	0.25	0.250	Above Water	0.15	7554	1045.8	0.05	0.05	0.002	NA	NA	0.000
19.85	145.7	115.0	115.0	86.6	3.1	3.6	26	20	19	4.35	1.12	26	1.141	1.141	1.141	1.141	2.38	SAND	0.5	0.96	78.8	2.23	175.7	non-LIQ	0.954	0.25	0.250	Above Water	0.15	7518	1046.8	0.05	0.05	0.002	NA	NA	0.000
20.01	145.5	115.0	115.0	89.4	2.9	3.2	24	20	19	4.18	1.11	26	1.151	1.151	1.151	1.151	2.34	SAND	0.5	0.96	81.0	2.06	166.6	non-LIQ	0.953	0.25	0.250	Above Water	0.15	7481	1054.5	0.05	0.05	0.002	NA	NA	0.000
20.18	145.3	115.0	115.0	85.2	3.1	3.6	26	20	19	4.40	1.12	26	1.160	1.160	1.160	1.160	2.39	SAND	0.5	0.95	76.9	2.28	175.3	non-LIQ	0.953	0.25	0.250	Above Water	0.15	7444	1048.8	0.05	0.06	0.002	NA	NA	0.000
20.34	145.2	115.0	115.0	78.2	3.0	3.8	28	18	18	4.55	1.14	25	1.170	1.170	1.170	1.170	2.44	SAND	0.5	0.95	70.3	2.46	173.3	non-LIQ	0.953	0.25	0.250	Above Water	0.15	7408	1028.8	0.06	0.07	0.003	NA	NA	0.000
20.51	145.0	115.0	115.0	95.3	3.2	3.4	24	22	20	4.16	1.11	27	1.179	1.179	1.179	1.179	2.34	SAND	0.5	0.95	85.3	2.07	176.3	non-LIQ	0.952	0.25	0.250	Above Water	0.15	7371	1085.4	0.05	0.05	0.002	NA	NA	0.000
20.67	144.8	115.0	115.0	84.2	3.2	3.8	27	20	19	4.47	1.13	25	1.189	1.189	1.189	1.189	2.41	SAND	0.5	0.94	75.1	2.37	177.7	non-LIQ	0.952	0.25	0.250	Above Water	0.15	7337	1056.5	0.05	0.06	0.002	NA	NA	0.000
20.83	144.7	115.0	115.0	75.5	2.7	3.6	28	18	17	4.53	1.13	23	1.198	1.198	1.198	1.198	2.43	SAND	0.5	0.94	67.1	2.43	162.9	non-LIQ	0.951	0.25	0.250	Above Water	0.16	7303	1023.7	0.06	0.07	0.003	NA	NA	0.000
21.00	144.5	115.0	115.0	82.5	2.9	3.5	26	19	18	4.41	1.12	25	1.208	1.208	1.208	1.208	2.40	SAND	0.5	0.94	73.0	2.30	167.8	non-LIQ	0.951	0.25	0.250	Above Water	0.16	7268	1052.2	0.06	0.06	0.003	NA	NA	0.000
21.16	144.3	115.0	115.0	104.7	3.1	3.0	21	23	21	3.85	1.09	27	1.217	1.217	1.217	1.217	2.27	SAND	0.5	0.93	92.3	1.86	171.6	non-LIQ	0.951	0.25	0.250	Above Water	0.16	7235	1121.2	0.05	0.05	0.002	NA	NA	0.000
21.33	144.2	115.0	115.0	115.3	3.2	2.8	20	25	23	3.57	1.08	28	1.226	1.226	1.226	1.226	2.22	SAND	0.5	0.93	101.2	1.72	174.6	non-LIQ	0.950	0.25	0.250	Above Water	0.16	7200	1153.1	0.05	0.04	0.002	NA	NA	0.000
21.49	144.0	115.0	115.0	111.2	3.2	2.9	21	24	22	3.71	1.08	28	1.236	1.236	1.236	1.236	2.25	SAND	0.5	0.93	97.2	1.79	173.9	non-LIQ	0.950	0.25	0.250	Above Water	0.16	7168	1145.9	0.05	0.04	0.002	NA	NA	0.000
21.65	143.9	115.0	115.0	111.0	3.3	3.0	21	24	22	3.78	1.09	28	1.245	1.245	1.245	1.245	2.26	SAND	0.5	0.92	96.7	1.82	176.3	non-LIQ	0.950	0.25	0.250	Above Water	0.16	7136	1150.0	0.05	0.04	0.002	NA	NA	0.000
21.82	143.7	115.0	115.0	114.1	3.3	2.9	20	25	23	3.69	1.08	28	1.255	1.255	1.255	1.255	2.24	SAND	0.5	0.92	99.0	1.78	176.1	non-LIQ	0.949	0.25	0.250	Above Water	0.16	7103	1161.0	0.05	0.04	0.002	NA	NA	0.000
21.98	143.5	115.0	115.0	108.6	3.3	3.0	22	24	22	3.87	1.09	28	1.264	1.264	1.264	1.264	2.27	SAND	0.5	0.91	93.9	1.87	175.6	non-LIQ	0.949	0.25	0.250	Above Water	0.16	7072	1150.0	0.05	0.04	0.002	NA	NA	0.000
22.15	143.4	115.0	115.0	101.4	3.3	3.3	23	23	21	4.08	1.10	27	1.274	1.274	1.274	1.274	2.32	SAND	0.5	0.91	87.3	2.01	175.5	non-LIQ	0.948	0.25	0.250	Above Water	0.16	7039	1134.1	0.05	0.05	0.002	NA	NA	0.000
22.31	143.2	115.0	115.0	95.8	3.3	3.4	25	22	20	4.25	1.11	26	1.283	1.283	1.283	1.283	2.35	SAND	0.5	0.91	82.2	2.14	175.7	non-LIQ	0.948	0.25	0.250	Above Water	0.16	7009	1121.5	0.05	0.05	0.002	NA	NA	0.000
22.47	143.0	115.0	115.0	87.3	3.4	3.9	27	21	19	4.51	1.13	26	1.292	1.292	1.292	1.292	2.42	SAND	0.5	0.90	74.7	2.41	179.9	non-LIQ	0.948	0.25	0.250	Above Water	0.16	6979	1101.2	0.06	0.06	0.002	NA	NA	0.000
22.64	142.9	115.0	115.0	85.1	3.2	3.8	27	20	18	4.50	1.13	25	1.302	1.302	1.302	1.302	2.42	SAND	0.5	0.90	72.5	2.40	173.9	non-LIQ	0.947	0.25	0.250	Above Water	0.16	6947	1094.2	0.06	0.07	0.003	NA	NA	0.000

Liquefaction Analysis with Cone Penetration Test (CPT) Data

Depth	Elev.	Unit Weight (pcf)		q_c	f_s	Fric. Ratio	% Fines	Equiv. N_{60}	Equiv. $(N_1)_{60}$	α	β	Equiv. $(N_1)_{60cs}$	Stresses at Exploration Water Level		Stresses at Design Water Level		I_c	Soil Type Character (SAND, SILT or non-LIQ CLAY)	Normalization of Tip Resistance			Fines Correction		$CRR_{7.5}$	r_d	CSR_w	$CSR_{7.5}$	FS	a	b	Max Shear Modulus	Cyclic Shear Strain	Norm. Vol. Strain	Dry Settle.	Post-Liq. $(N_1)_{60cs}$	Post-Liq. Vol. Strain	Layer Post-Liq. Settle.
		γ'_{MOIST}	γ'_{SAT}										σ_v	σ_v'	σ_v	σ_v'														G_{max}	γ	ε_{vol}	ΔS			ΔS
(ft)	(ft, MSL)			(tsf)	(tsf)	(%)							(tsf)	(tsf)	(tsf)	(tsf)			n	C_Q	q_{c1N}	Kc	$(q_{c1N})_{cs}$							(tsf)	(%)	(%)	(in)			(in)
22.80	142.7	115.0	115.0	84.7	2.9	3.4	26	20	18	4.40	1.12	24	1.311	1.311	1.311	1.311	2.39	SAND	0.5	0.90	71.9	2.28	164.3	non-LIQ	0.947	0.25	0.250	non-LIQ	0.16	6918	1090.4	0.06	0.07	0.003	NA	NA	0.000
22.97	142.5	115.0	115.0	79.7	2.7	3.4	27	19	17	4.46	1.13	23	1.321	1.321	1.321	1.315	2.41	SAND	0.5	0.90	67.4	2.35	158.5	0.45	0.946	0.25	0.250	1.80	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
23.13	142.4	115.0	115.0	92.6	3.1	3.3	25	21	19	4.27	1.11	25	1.330	1.330	1.330	1.325	2.36	SAND	0.5	0.89	78.1	2.16	168.6	non-LIQ	0.946	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
23.30	142.2	115.0	115.0	99.1	2.0	2.0	18	21	19	3.32	1.07	23	1.340	1.340	1.340	1.334	2.18	SAND	0.5	0.89	83.2	1.63	135.3	0.31	0.946	0.25	0.250	1.24	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
23.46	142.0	115.0	115.0	101.7	2.1	2.1	18	22	19	3.32	1.07	24	1.349	1.349	1.349	1.344	2.18	SAND	0.5	0.89	85.1	1.62	138.3	0.33	0.945	0.25	0.250	1.30	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
23.62	141.9	115.0	115.0	95.1	2.5	2.6	22	21	19	3.89	1.09	24	1.358	1.358	1.358	1.353	2.28	SAND	0.5	0.88	79.3	1.88	149.5	0.39	0.945	0.25	0.250	1.56	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
23.79	141.7	115.0	115.0	109.6	3.0	2.7	21	24	21	3.73	1.08	26	1.368	1.368	1.368	1.363	2.25	SAND	0.5	0.88	91.1	1.80	163.8	non-LIQ	0.945	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
23.95	141.6	115.0	115.0	118.5	3.6	3.0	21	26	23	3.80	1.09	28	1.377	1.377	1.377	1.372	2.26	SAND	0.5	0.88	98.2	1.83	179.8	non-LIQ	0.944	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
24.12	141.4	115.0	115.0	120.4	1.8	1.5	14	24	21	2.16	1.04	24	1.387	1.387	1.387	1.382	2.04	SAND	0.5	0.87	99.4	1.35	134.1	0.30	0.944	0.25	0.250	1.22	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
24.28	141.2	115.0	115.0	121.0	2.2	1.8	16	25	22	2.67	1.05	25	1.396	1.396	1.396	1.391	2.09	SAND	0.5	0.87	99.6	1.44	143.8	0.36	0.943	0.25	0.250	1.43	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
24.44	141.1	115.0	115.0	118.5	2.7	2.3	18	25	22	3.25	1.07	26	1.405	1.405	1.405	1.400	2.17	SAND	0.5	0.87	97.2	1.60	155.6	0.43	0.943	0.25	0.250	1.72	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
24.61	140.9	115.0	115.0	120.3	2.0	1.7	15	24	21	2.48	1.05	25	1.415	1.415	1.415	1.410	2.07	SAND	0.5	0.86	98.3	1.40	136.1	0.32	0.943	0.25	0.250	1.30	NA	NA	NA	NA	NA	0.000	NA	NA	0.000

5/N5-N1 Connector Separation (55-0226) Widening | SP | 11-137

LIQUEFACTION ANALYSIS; ACC. = 0.4 g | 16-Feb-12

Liquefaction analysis is performed following Seed's Procedure, outlined by Seed et al (1985), Seed and Harder (1990), updated NCEER (1997)

Emean/E60 = Energy Ratio to correct to standard 60% Energy
Surcharge = Any surcharge on top of the ground (psf)
acc. max = maximum peak acceleration at the ground surface (g's)
[1]C_N = square root of (100 kPa or 1.04427 tsf/effective overburden)
The induced cyclic stress ratio (CSR i) by a given peak ground acceleration (acc. max) is:

CSR i = 0.65 x acc max. x total normal stress x rd / (effective normal stress x g)

where: rd = stress reduction factor (Robertson and Wride (1996), Marcuson (USArmy Eng), per NCEER (1997))
g = acceleration of gravity

The resisting cyclic stress ratio (CSR r) is equal to:

CSR r = CSR x Cm x K sigma

where: Cm = Earthquake Magnitude Correction Factor (Blake, NCEER Table 3, Eq.4)
K sigma = Normalized resistance factor (Fig. 14 from NCEER Liquefaction workshop, Harder Boulanger)
CSR = Resisting Cyclic Stress Ratio. It is a function of the content of fines
(Figure 2, NCEER Workshop, after Seed et al 1985))

Factor of Safety, F sub L is:

F sub L = CSR r / CSR i

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Emean (%)	75	Sur.=	psf	152.4	=top of ground el.	Borehole Diamete	8							142.7	=water table El.		acc. max =	0.40	g	Earthq. M=	7.5
C_E	1.25					C_B	1.15													Cm=	1.00

ELEVATION TOP OF LAYER (ft.)	LAYER THICKNESS L (ft.)	TOTAL OVERBUR. PRESS. (tsf)	EFFEC. OVERBUR. PRESS. (tsf)	DEPTH BELOW SURFACE (ft)	C_N	C_R	C_S	C_{ST}	TOTAL UNIT WEIGHT (pcf)	SAMPLER TYPE 1=SPT 2=CA.MOD.	SAMPLER LINED 1=UNLINED 2=LINED	FIELD BLOW COUNT N	STRESS REDUC. COEFF. rd	INDUCED CYCLIC STRESS RATIO	CORRECT BLOW COUNT Nc	EST. PERCENT OF FINES (%)	(N1)60cs	K sigma	RESIST. CYCLIC STRESS RATIO M=7.5	RESIST. CYCLIC STRESS RATIO Overburd Cor Mag Corr	FACTOR OF SAFETY (F sub L)	WILL IT LIQUEFY?
149.9	2.5	0.14	0.14	2.50	2.00	0.75	1.00	0.50	115	2	2	28	0.99	0.26	31	15.0	35	1.00	high N	high N	LARGE	AboveWT
147.4	2.5	0.29	0.29	5.00	1.91	0.75	1.20	1.00	115	1	1	8	0.99	0.26	20	51.0	29	1.00	0.41	0.41	1.60	AboveWT
142.4	5	0.58	0.42	10.00	1.58	0.75	1.00	0.50	115	2	2	14	0.98	0.35	12	51.0	20	1.00	0.22	0.22	0.62	fines
137.4	5	0.86	0.55	15.00	1.38	0.85	1.20	1.00	115	1	1	4	0.97	0.39	9	51.0	16	1.00	0.17	0.17	0.43	fines
132.4	5	1.15	0.68	20.00	1.24	0.85	1.00	0.50	115	2	2	12	0.95	0.42	10	51.0	17	1.00	0.18	0.18	0.43	fines
127.4	5	1.44	0.81	25.00	1.13	0.95	1.20	1.00	115	1	1	17	0.94	0.43	32	10.0	34	1.00	high N	high N	LARGE	high N
122.4	5	1.73	0.95	30.00	1.05	0.95	1.00	0.50	115	2	2	12	0.93	0.44	9	2.0	9	1.00	0.10	0.10	0.24	yes
117.4	5	2.01	1.08	35.00	0.98	1.00	1.20	1.00	115	1	1	8	0.89	0.43	14	51.0	22	0.99	0.24	0.24	0.55	fines
112.4	5	2.30	1.21	40.00	0.93	1.00	1.00	0.50	115	2	2	22	0.85	0.42	15	51.0	23	0.97	0.26	0.25	0.59	fines
107.4	5	2.59	1.34	45.00	0.88	1.00	1.20	1.00	115	1	1	22	0.81	0.41	34	51.0	46	0.95	high N	high N	LARGE	high N/fines
102.4	5	2.88	1.47	50.00	0.84	1.00	1.00	0.50	115	2	2	84	0.77	0.39	51	51.0	67	0.93	high N	high N	LARGE	high N/fines
97.4	5	3.16	1.60	55.00	0.81	1.00	1.20	1.00	115	1	1	22	0.73	0.37	31	51.0	43	0.92	high N	high N	LARGE	high N/fines
92.4	5	3.45	1.73	60.00	0.78	1.00	1.00	0.50	115	2	2	67	0.69	0.35	38	51.0	51	0.90	high N	high N	LARGE	high N/fines
87.4	5	3.74	1.87	65.00	0.75	1.00	1.20	1.00	115	1	1	16	0.64	0.34	21	51.0	31	0.88	high N	high N	LARGE	high N/fines
82.4	5	4.03	2.00	70.00	0.72	1.00	1.00	0.50	115	2	2	65	0.60	0.32	34	51.0	46	0.86	high N	high N	LARGE	high N/fines
77.4	5	4.31	2.13	75.00	0.70	1.00	1.20	1.00	115	1	1	33	0.56	0.30	40	51.0	53	0.87	high N	high N	LARGE	high N/fines
72.4	5	4.60	2.26	80.00	0.68	1.00	1.00	0.50	115	2	2	43	0.55	0.29	22	51.0	32	0.86	high N	high N	LARGE	high N/fines

SEISMIC SETTLEMENT CALCULATIONS

5/N5-N1 Connector Separation (55-0226) Widening

EMI Project No. 11-135

UNDER CONDITION,ACC. = 0.4 g

FORMULAE:

Corrected blow count $(N_1)_{60}$ = $C_N * C_s * C_E * C_R * C_B * C_{ST} * N_{field}$

where:

- N_{field} = Uncorrected field blow count
- C_N = Overburden correction factor (See Reference 1)
- C_E = Energy correction (Reference 2) = (Efficiency/60%)
- C_R = Rod Length correction
- C_s = Sampler correction (lined/unlined) (Reference 3)
- C_B = Borehole diameter correction
- C_{ST} = Sampler correction (Sampler diameter)

Efficiency = 75% C_E 1.25

Borehole Dia. (in) = 8.0 C_B 1.15

Soil Unit Weight (pcf) = 120

$K_0 = (1-\sin(\phi))$

$\sigma_m' = (1+2K_0)/3*\sigma_{of}'$

$(K_2)_{max} = 20*(N_1)^{(1/3)}$

$G_{max} = 1000*(K_2)_{max}*(\sigma_m')^{(1/2)}$

$\gamma_{eff}*G_{eff}/G_{max} = 0.65*(a_{max}/g)*(\sigma_{of}'/G_{max})*r_d$

r_d = 1.0 at the ground surface,

= 0.9 at 30 feet below the ground surface

= 0.6 at 70 feet below the ground surface

= 0.5 at 100 feet below the ground surface

$\tau_{av}/\sigma_{of}' = 0.65*(a_{max}/g)*(\sigma_{of}/\sigma_{of}')*r_d$

γ_{eff} for a given $\gamma_{eff}*G_{eff}/G_{max}$ and σ_m' is read from Figure 11 (Tokimatsu and Seed, 19

ε_c for a given γ_{eff} and N_1 is read from Figure 13 (Tokimatsu and Seed, 1987)

CALCULATIONS:

Boring: A-11-319

Water depth (ft bgs): (during drilling) 15.0

Water depth (ft bgs): (design depth) 10.0

Boring Elevation (ft MLLW): 152.4

Groundwater Elevation (ft MLLW): 137.4

Finished Grade Elevn. (ft MLLW): 152.4

Design GW El. (ft MLLW): 142.4

EQ Mag = 7.5

Mag Scale Factor= 1.000

a_{max} = 0.4

Height of Fill (ft): 0.0

Original Depth (ft bgs)	Final Depth (ft bgs)	Elev (ft msl)	Total Stress at Mid depth (psf)	Original Effective Stress at Mid depth (psf)	Sampler SPT = 1 CDS = 2	Uncorrected Blow Count (N)*	Sampler 1=Unlined 2=Lined	Soil Type (1=fine-grained, 2=coarse-grained)	C_N	C_{ST}	C_s	C_r	$(N_1)_{60}$	Estimated Percentage of Fines (%)	(N1)60-CS (NCEER - used if layer does not liquefy)	(N1)60-CS (Seed - used if layer liquefies)	Design Effective Stress at Mid depth (psf)	σ_m' (psf)	$(K_2)_{max}$	G_{max} (psf)	r_d	γ_{eff} G_{eff}/G_{max}	τ_{av}/σ_{of}'	Cyclic Shear Strain, γ_{eff} (%)		Volumetric Strain (Dry Sand) ε_c (%)	Volumetric Strain (Saturated Sand) ε_c (%)	$2*\varepsilon_c$ (dry); ε_c (saturtd.)	Settlement of Each Layer (inches)	Sum.	$CRR_{7.5}$
0			0																													
2.5	2.5	149.9	300	300	2	28	2	2	1.70	0.50	1.00	0.75	25.7	15.0	29.4	-	300	200	6.17E+01	8.73E+05	0.99	8.89E-05	-	1.66E-02	# #	9.91E-03	-	1.98E-02	0.0059	0.0059	0.43
5.0	5.0	147.4	600	600	1	8	1	2	1.70	1.00	1.20	0.75	17.6	49.0	26.1	-	600	400	5.93E+01	1.19E+06	0.99	1.30E-04	-	2.80E-02	# #	2.04E-02	-	4.08E-02	0.0184	0.0243	0.32
10.0	10.0	142.4	1200	1200	2	14	2	1	1.32	0.50	1.00	0.75	-	51.0	-	-	1200	799.996	-	-	0.98	-	0.25	-	- -	-	-	-	-	0.0243	1.00
15.0	15.0	137.4	1800	1800	1	4	1	1	1.08	1.00	1.20	0.85	-	51.0	-	-	1488	991.996	-	-	0.97	-	0.30	-	- -	-	-	-	-	0.0243	1.00
20.0	20.0	132.4	2400	2088	2	12	2	1	1.00	0.50	1.00	0.85	-	51.0	-	-	1776	1184	-	-	0.95	-	0.34	-	- -	-	-	-	-	0.0243	1.00
25.0	25.0	127.4	3000	2376	1	17	1	2	0.94	1.00	1.20	0.95	26.1	10.0	27.5	26.1	2064	1376	5.93E+01	2.20E+06	0.94	2.30E-04	0.36	-	- -			Not Liquefying			
30.0	30.0	122.4	3600	2664	2	12	2	2	0.89	0.50	1.00	0.95	7.3	2.0	7.3	7.3	2352	1568	3.87E+01	1.53E+06	0.93	3.71E-04	0.37	-	- -	-	3.08E+00	3.08E+00	1.8480	1.8480	0.09
35.0	35.0	117.4	4200	2952	1	8	1	1	0.84	1.00	1.20	1.00	-	51.0	-	-	2640	1760	-	-	0.89	-	0.37	-	- -	-	-	-	-	1.8480	1.00
40.0	40.0	112.4	4800	3240	2	22	2	1	0.80	0.50	1.00	1.00	-	51.0	-	-	2928	1952	-	-	0.85	-	0.36	-	- -	-	-	-	-	1.8480	1.00
45.0	45.0	107.4	5400	3528	1	22	1	1	0.77	1.00	1.20	1.00	-	51.0	-	-	3216	2144	-	-	0.81	-	0.35	-	# #	-	-	-	-	1.8480	1.00
50.0	50.0	102.4	6000	3816	2	84	2	1	0.74	0.50	1.00	1.00	-	51.0	-	-	3504	2336	-	-	0.77	-	0.34	-	# #	-	-	-	-	1.8480	1.00
55.0	55.0	97.4	6600	4104	1	22	1	1	0.71	1.00	1.20	1.00	-	51.0	-	-	3792	2528	-	-	0.73	-	0.33	-	# #	-	-	-	-	1.8480	1.00
60.0	60.0	92.4	7200	4392	2	67	2	1	0.69	0.50	1.00	1.00	-	51.0	-	-	4080	2720	-	-	0.69	-	0.31	-	# #	-	-	-	-	1.8480	1.00
65.0	65.0	87.4	7800	4680	1	16	1	1	0.67	1.00	1.20	1.00	-	51.0	-	-	4368	2912	-	-	0.64	-	0.30	-	# #	-	-	-	-	1.8480	1.00
70.0	70.0	82.4	8400	4968	2	65	2	1	0.65	0.50	1.00	1.00	-	51.0	-	-	4656	3104	-	-	0.60	-	0.28	-	# #	-	-	-	-	1.8480	1.00
75.0	75.0	77.4	9000	5256	1	33	1	1	0.63	1.00	1.20	1.00	-	51.0	-	-	4944	3296	-	-	0.56	-	0.27	-	# #	-	-	-	-	1.8480	1.00
80.0	80.0	72.4	9600	5544	2	43	2	1	0.61	0.50	1.00	1.00	-	51.0	-	-	5232	3488	-	-	0.55	-	0.26	-	# #	-	-	-	-	1.8480	1.00
																												Total (in)	1.9		

5/N5-N1 Connector Separation (55-0226) Widening | SP | 11-137

LIQUEFACTION ANALYSIS; ACC. = 0.4 g | 16-Feb-12

Liquefaction analysis is performed following Seed's Procedure, outlined by Seed et al (1985), Seed and Harder (1990), updated NCEER (1997)

Emean/E60 = Energy Ratio to correct to standard 60% Energy
Surcharge = Any surcharge on top of the ground (psf)
acc. max = maximum peak acceleration at the ground surface (g's)
$^{1}C_N$ = square root of (100 kPa or 1.04427 tsf/effective overburden)
The induced cyclic stress ratio (CSR i) by a given peak ground acceleration (acc. max) is:

CSR i = 0.65 x acc max. x total normal stress x rd / (effective normal stress x g)

where: rd = stress reduction factor (Robertson and Wride (1996), Marcuson (USArmy Eng), per NCEER (1997))
g = acceleration of gravity

The resisting cyclic stress ratio (CSR r) is equal to:

CSR r = CSR x Cm x K sigma

where: Cm = Earthquake Magnitude Correction Factor (Blake, NCEER Table 3, Eq.4)
K sigma = Normalized resistance factor (Fig. 14 from NCEER Liquefaction workshop, Harder Boulanger)
CSR = Resisting Cyclic Stress Ratio. It is a function of the content of fines
(Figure 2, NCEER Workshop, after Seed et al 1985))

Factor of Safety, F sub L is:

F sub L = CSR r / CSR i

A-11-320

Emean (%)	75	Sur.=	psf	166.6	=top of ground el.		Borehole Diamete	8						142.7	=water table El.			acc. max =	0.40	g		Earthq. M=	7.5
C_E	1.25						C_B	1.15														Cm=	1.00

ELEVATION TOP OF LAYER (ft.)	LAYER THICKNESS L (ft.)	TOTAL OVERBUR. PRESS. (tsf)	EFFEC. OVERBUR. PRESS. (tsf)	DEPTH BELOW SURFACE (ft)	C_N	C_R	C_S	C_{ST}	TOTAL UNIT WEIGHT (pcf)	SAMPLER TYPE 1=SPT 2=CA.MOD.	SAMPLER LINED 1=UNLINED 2=LINED	FIELD BLOW COUNT N	STRESS REDUC. COEFF. rd	INDUCED CYCLIC STRESS RATIO	CORRECT BLOW COUNT Nc	EST. PERCENT OF FINES (%)	(N1)60cs	K sigma	RESIST. CYCLIC STRESS RATIO M=7.5	RESIST. CYCLIC STRESS RATIO Overburd Cor Mag Corr	FACTOR OF SAFETY (F sub L)	WILL IT LIQUEFY?
164.1	2.5	0.14	0.14	2.50	2.00	0.75	1.20	1.00	115	1	1	2	0.99	0.26	6	51.0	13	1.00	0.14	0.14	0.54	AboveWT
161.6	2.5	0.29	0.29	5.00	1.91	0.75	1.00	0.50	115	2	2	39	0.99	0.26	41	51.0	55	1.00	high N	high N	LARGE	AboveWT
156.6	5	0.58	0.58	10.00	1.35	0.75	1.20	1.00	115	1	1	25	0.98	0.25	44	99.0	58	1.00	high N	high N	LARGE	AboveWT
151.6	5	0.86	0.86	15.00	1.10	0.85	1.00	0.50	115	2	2	63	0.97	0.25	43	51.0	57	1.00	high N	high N	LARGE	AboveWT
146.6	5	1.15	1.15	20.00	0.95	0.85	1.20	1.00	115	1	1	32	0.95	0.25	45	51.0	59	0.98	high N	high N	LARGE	AboveWT
141.6	5	1.44	1.28	25.00	0.90	0.95	1.00	0.50	115	2	2	87	0.94	0.27	54	51.0	70	0.96	high N	high N	LARGE	high N/fines
136.6	5	1.73	1.41	30.00	0.86	0.95	1.20	1.00	115	1	1	43	0.93	0.30	61	51.0	79	0.94	high N	high N	LARGE	high N/fines
131.6	5	2.01	1.54	35.00	0.82	1.00	1.00	0.50	115	2	2	100	0.89	0.30	60	51.0	77	0.92	high N	high N	LARGE	high N/fines
126.6	5	2.30	1.68	40.00	0.79	1.00	1.20	1.00	115	1	1	38	0.85	0.30	52	51.0	68	0.91	high N	high N	LARGE	high N/fines
121.6	5	2.59	1.81	45.00	0.76	1.00	1.00	0.50	115	2	2	100	0.81	0.30	55	51.0	71	0.89	high N	high N	LARGE	high N/fines
116.6	5	2.88	1.94	50.00	0.73	1.00	1.20	1.00	115	1	1	32	0.77	0.30	41	51.0	55	0.87	high N	high N	LARGE	high N/fines
111.6	5	3.16	2.07	55.00	0.71	1.00	1.00	0.50	115	2	2	100	0.73	0.29	52	51.0	68	0.87	high N	high N	LARGE	high N/fines
106.6	5	3.45	2.20	60.00	0.69	1.00	1.20	1.00	115	1	1	48	0.69	0.28	58	51.0	75	0.86	high N	high N	LARGE	high N/fines
101.6	5	3.74	2.33	65.00	0.67	1.00	1.00	0.50	115	2	2	100	0.64	0.27	49	51.0	64	0.85	high N	high N	LARGE	high N/fines
96.6	5	4.03	2.47	70.00	0.65	1.00	1.20	1.00	115	1	1	43	0.60	0.26	49	51.0	64	0.84	high N	high N	LARGE	high N/fines
91.6	5	4.31	2.60	75.00	0.63	1.00	1.00	0.50	115	2	2	100	0.56	0.24	46	51.0	61	0.83	high N	high N	LARGE	high N/fines
86.6	5	4.60	2.73	80.00	0.62	1.00	1.20	1.00	115	1	1	49	0.55	0.24	53	51.0	69	0.82	high N	high N	LARGE	high N/fines

Liquefaction Analysis with Cone Penetration Test (CPT) Data

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17800 Newhope Street
Suite B
Fountain Valley, CA 92708

CPT Number: CPT-11-321
Project Name: 5/N5-N1 Connector Separation (Widen)
Project Number: 11-137
Location: Orange County
California

Computed by: SP
Checked by: [illegible]

Date: 02/16/12
Date: 2/17/12

Figure No.: _____

Reference:

1) Seed, R.B., et al, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework,* Keynote Presentation, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, April 30, 2003.
2) Youd, T.L. & Idriss, I.M., et al, *Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils,* ASCE Journal of Geotechnical and Geoenvironmental Engineering, Pp. 817-833, October 2001.
3) Pradel D., *Procedure to Evaluate Earthquake-induced Settlements in Dry Sandy Soils,* ASCE Journal of Geotechnical and Geoenvironmental Engineering, Pp. 364-368, April 1998.
4) Tokimatsu, K. & Seed, H.B., *Evaluation of Settlements in Sands due to Earthquake Shaking,* ASCE Journal of Geotechnical Engineering, Pp. 861-878, August 1987.
5) Jefferies, M.G. & Davies, M.P., *Use of CPT to Estimate Equivalent SPT N_{60},* ASTM Geotechnical Testing Journal, Vol.17, No. 4, Pp. 458-567, 1993.
6) Robertson, P.K. et al, *Use of Piezometer Cone Data* , Proceedings of the ASCE Specialty Conference In Situ 86: Use of In Situ Tests in Geotechnical Engineering, Blacksburg, Pp. 1263-1280, 1986.

Surface Elevation = 152.7 ft MSL
Design Magnitude, M_w = 7.50
PGA, a_{max} = 0.4 g
Earthquake Scaling Factor, MSF = 1.000 for M_w = 7.5
Design Water Level = 142.7 ft MSL
Water Level at Investigation = 137.4 ft MSL
Req'd Factor of Safety = 1

Summary of Seismically Induced Settlement:

Dry Settlement (in)	0.133
Post-liquefaction Settlement (in)	1.808
Total Settlement (in)	**1.940**

Depth	Elev.	Unit Weight (pcf)		q_c	f_s	Frict. Ratio	% Fines	Equiv. N_{60}	Equiv. $(N_1)_{60}$	α	β	Equiv. $(N_1)_{60cs}$	Stresses at Exploration Water Level		Stresses at Design Water Level		I_c	Soil Type Character (SAND, SILT or non-LIQ CLAY)	Normalization of Tip Resistance			Fines Correction		$CRR_{7.5}$	r_d	CSR_N	$CSR_{7.5}$	FS	a	b	Max Shear Modulus	Cyclic Shear Strain	Norm. Vol. Strain	Dry Settle.	Post-Liq. $(N_1)_{60cs}$	Post-Liq. Vol. Strain	Layer Post-Liq. Settle.
		γ_{MOIST}	γ_{SAT}										σ_v	σ_v'	σ_v	σ_v'			n	C_Q	q_{c1N}	Kc	$(q_{c1N})_{cs}$														
(ft)	(ft, MSL)			(tsf)	(tsf)	(%)							(tsf)	(tsf)	(tsf)	(tsf)														(tsf)	(%)	(%)	(in)		(%)	(in)
0.66	152.0	115.0	115.0	45.5	2.7	5.9	22	10	53	3.89	1.09	62	0.038	0.038	0.038	0.038	2.28	SAND	0.5	1.70	73.1	1.88	137.7	0.32	0.998	0.26	0.260	Above Water	0.12	57944	267.6	0.01	0.00	0.000	NA	NA	0.000
0.82	151.9	115.0	115.0	378.4	2.0	0.5	0	53	253	0.00	1.00	253	0.047	0.047	0.047	0.047	0.98	SAND	0.5	1.70	608.0	1.00	608.0	non-LIQ	0.998	0.26	0.260	Above Water	0.13	50868	502.5	0.00	0.00	0.000	NA	NA	0.000
0.98	151.7	115.0	115.0	428.9	3.1	0.7	0	63	271	0.00	1.00	271	0.056	0.056	0.056	0.056	1.10	SAND	0.5	1.70	689.0	1.00	689.0	non-LIQ	0.998	0.26	0.260	Above Water	0.13	45709	562.3	0.00	0.00	0.000	NA	NA	0.000
1.15	151.6	115.0	115.0	446.2	3.8	0.9	0	67	267	0.00	1.00	267	0.066	0.066	0.066	0.066	1.18	SAND	0.5	1.70	717.0	1.00	717.0	non-LIQ	0.997	0.26	0.260	Above Water	0.13	41526	605.8	0.00	0.00	0.000	NA	NA	0.000
1.31	151.4	115.0	115.0	486.4	3.9	0.8	0	72	270	0.00	1.00	270	0.075	0.075	0.075	0.075	1.15	SAND	0.5	1.70	781.5	1.00	781.5	non-LIQ	0.997	0.26	0.260	Above Water	0.13	38404	649.4	0.00	0.00	0.000	NA	NA	0.000
1.48	151.2	115.0	115.0	461.3	5.1	1.1	0	71	252	0.00	1.00	252	0.085	0.085	0.085	0.085	1.30	SAND	0.5	1.70	741.1	1.00	741.1	non-LIQ	0.997	0.26	0.260	Above Water	0.13	35693	674.2	0.00	0.00	0.000	NA	NA	0.000
1.64	151.1	115.0	115.0	487.0	5.3	1.1	0	75	252	0.00	1.00	252	0.094	0.094	0.094	0.094	1.29	SAND	0.5	1.70	782.4	1.00	782.4	non-LIQ	0.996	0.26	0.260	Above Water	0.13	33560	709.6	0.00	0.00	0.000	NA	NA	0.000
1.80	150.9	115.0	115.0	466.0	1.6	0.4	0	63	202	0.00	1.00	202	0.104	0.104	0.104	0.104	0.83	SAND	0.5	1.70	748.7	1.00	748.7	non-LIQ	0.996	0.26	0.260	Above Water	0.13	31737	691.0	0.00	0.00	0.000	NA	NA	0.000
1.97	150.7	115.0	115.0	454.0	4.8	1.0	0	70	214	0.00	1.00	214	0.113	0.113	0.113	0.113	1.29	SAND	0.5	1.70	729.4	1.00	729.4	non-LIQ	0.995	0.26	0.260	Above Water	0.13	30065	737.0	0.01	0.00	0.000	NA	NA	0.000
2.13	150.6	115.0	115.0	172.8	4.1	2.4	8	31	92	0.24	1.01	93	0.122	0.122	0.122	0.122	1.78	SAND	0.5	1.70	277.7	1.09	303.4	non-LIQ	0.995	0.26	0.260	Above Water	0.13	28688	578.4	0.01	0.00	0.000	NA	NA	0.000
2.30	150.4	115.0	115.0	317.1	3.6	1.1	1	51	143	0.00	1.00	143	0.132	0.132	0.132	0.132	1.39	SAND	0.5	1.70	509.4	1.00	509.4	non-LIQ	0.995	0.26	0.260	Above Water	0.13	27397	695.6	0.01	0.00	0.000	NA	NA	0.000
2.46	150.2	115.0	115.0	233.7	2.9	1.2	3	38	105	0.00	1.00	105	0.141	0.141	0.141	0.141	1.48	SAND	0.5	1.70	375.5	1.00	375.5	non-LIQ	0.994	0.26	0.260	Above Water	0.13	26313	649.0	0.01	0.00	0.000	NA	NA	0.000
2.62	150.1	115.0	115.0	132.5	2.7	2.1	8	24	64	0.35	1.01	65	0.151	0.151	0.151	0.151	1.80	SAND	0.5	1.70	212.9	1.11	236.3	non-LIQ	0.994	0.26	0.260	Above Water	0.13	25337	568.8	0.01	0.00	0.000	NA	NA	0.000
2.79	149.9	115.0	115.0	74.1	2.5	3.4	17	15	39	2.93	1.06	45	0.160	0.160	0.160	0.160	2.13	SAND	0.5	1.70	119.0	1.51	179.4	non-LIQ	0.993	0.26	0.260	Above Water	0.13	24399	498.5	0.01	0.01	0.000	NA	NA	0.000
2.95	149.8	115.0	115.0	51.6	1.6	3.1	19	11	27	3.46	1.07	33	0.170	0.170	0.170	0.170	2.20	SAND	0.5	1.70	82.9	1.68	139.0	0.33	0.993	0.26	0.260	Above Water	0.13	23596	454.8	0.02	0.01	0.001	NA	NA	0.000
3.12	149.6	115.0	115.0	54.2	1.0	1.8	14	11	26	2.07	1.04	29	0.179	0.179	0.179	0.179	2.02	SAND	0.5	1.70	87.0	1.33	115.6	0.22	0.993	0.26	0.260	Above Water	0.13	22816	459.7	0.02	0.02	0.001	NA	NA	0.000
3.28	149.4	115.0	115.0	48.9	1.1	2.2	16	10	24	2.87	1.06	28	0.189	0.189	0.189	0.189	2.12	SAND	0.5	1.70	78.6	1.49	117.1	0.23	0.992	0.26	0.260	Above Water	0.13	22142	457.6	0.02	0.02	0.001	NA	NA	0.000
3.44	149.3	115.0	115.0	41.5	1.1	2.8	21	9	21	3.73	1.08	26	0.198	0.198	0.198	0.198	2.25	SAND	0.5	1.70	66.6	1.80	119.7	0.24	0.992	0.26	0.260	Above Water	0.13	21518	448.0	0.03	0.02	0.001	NA	NA	0.000
3.61	149.1	115.0	115.0	37.5	1.1	2.8	22	8	19	3.98	1.10	25	0.208	0.208	0.208	0.208	2.30	SAND	0.5	1.70	60.2	1.94	116.7	0.23	0.992	0.26	0.260	Above Water	0.13	20904	443.2	0.03	0.03	0.001	NA	NA	0.000
3.77	148.9	115.0	115.0	33.6	0.9	2.7	23	8	17	4.11	1.10	22	0.217	0.217	0.217	0.217	2.32	SAND	0.5	1.70	53.9	2.03	109.4	0.20	0.991	0.26	0.260	Above Water	0.13	20367	435.1	0.03	0.04	0.002	NA	NA	0.000
3.94	148.8	115.0	115.0	34.2	0.9	2.5	23	8	16	4.00	1.10	22	0.227	0.227	0.227	0.227	2.30	SAND	0.5	1.70	55.0	1.95	107.2	0.19	0.991	0.26	0.260	Above Water	0.13	19835	442.9	0.03	0.04	0.002	NA	NA	0.000
4.10	148.6	115.0	115.0	36.7	0.8	2.3	21	8	17	3.75	1.08	22	0.236	0.236	0.236	0.236	2.25	SAND	0.5	1.70	59.0	1.80	106.5	0.19	0.990	0.26	0.260	Above Water	0.13	19367	456.4	0.03	0.04	0.002	NA	NA	0.000
4.27	148.4	115.0	115.0	39.0	1.0	2.5	21	9	18	3.81	1.09	23	0.246	0.246	0.246	0.246	2.26	SAND	0.5	1.70	62.7	1.84	115.1	0.22	0.990	0.26	0.260	Above Water	0.13	18901	472.7	0.03	0.04	0.002	NA	NA	0.000
4.43	148.3	115.0	115.0	41.0	1.1	2.7	22	9	18	3.92	1.09	24	0.255	0.255	0.255	0.255	2.29	SAND	0.5	1.70	65.9	1.90	125.5	0.26	0.990	0.26	0.260	Above Water	0.13	18488	488.2	0.03	0.03	0.001	NA	NA	0.000
4.59	148.1	115.0	115.0	45.7	1.4	3.0	22	10	20	3.94	1.09	26	0.264	0.264	0.264	0.264	2.29	SAND	0.5	1.70	73.4	1.91	140.2	0.34	0.989	0.26	0.260	Above Water	0.13	18099	512.2	0.03	0.03	0.001	NA	NA	0.000
4.76	147.9	115.0	115.0	47.3	1.5	3.2	23	11	21	4.01	1.10	27	0.274	0.274	0.274	0.274	2.30	SAND	0.5	1.70	76.0	1.96	148.7	0.39	0.989	0.26	0.260	Above Water	0.13	17708	525.6	0.03	0.03	0.001	NA	NA	0.000
4.92	147.8	115.0	115.0	45.1	1.6	3.5	25	10	20	4.24	1.11	26	0.283	0.283	0.283	0.283	2.35	SAND	0.5	1.70	72.4	2.13	154.5	0.42	0.989	0.26	0.260	Above Water	0.13	17360	527.0	0.03	0.03	0.001	NA	NA	0.000
5.09	147.6	115.0	115.0	48.6	1.6	3.3	23	11	21	4.08	1.10	27	0.293	0.293	0.293	0.293	2.32	SAND	0.5	1.70	78.1	2.00	156.5	0.44	0.988	0.26	0.260	Above Water	0.13	17010	543.5	0.03	0.03	0.001	NA	NA	0.000
5.25	147.5	115.0	115.0	49.6	1.5	3.1	23	11	21	3.99	1.10	27	0.302	0.302	0.302	0.302	2.30	SAND	0.5	1.70	79.7	1.95	155.1	0.43	0.988	0.26	0.260	Above Water	0.13	16697	551.4	0.03	0.03	0.001	NA	NA	0.000
5.41	147.3	115.0	115.0	49.5	1.4	2.9	22	11	20	3.91	1.09	26	0.311	0.311	0.311	0.311	2.28	SAND	0.5	1.70	79.5	1.89	150.5	0.40	0.987	0.26	0.260	Above Water	0.13	16399	555.2	0.03	0.03	0.001	NA	NA	0.000
5.58	147.1	115.0	115.0	48.1	1.5	3.1	23	11	20	4.09	1.10	26	0.321	0.321	0.321	0.321	2.32	SAND	0.5	1.70	77.3	2.01	155.3	0.43	0.987	0.26	0.260	Above Water	0.13	16097	558.6	0.03	0.03	0.001	NA	NA	0.000
5.74	147.0	115.0	115.0	44.3	1.5	3.3	25	10	18	4.29	1.11	25	0.330	0.330	0.330	0.330	2.36	SAND	0.5	1.70	71.1	2.17	154.6	0.42	0.987	0.26	0.260	Above Water	0.13	15827	552.2	0.04	0.04	0.002	NA	NA	0.000
5.91	146.8	115.0	115.0	39.2	1.3	3.2	26	9	16	4.43	1.13	23	0.340	0.340	0.340	0.340	2.40	SAND	0.5	1.70	63.0	2.31	145.6	0.37	0.986	0.26	0.260	Above Water	0.13	15552	538.3	0.04	0.05	0.002	NA	NA	0.000
6.07	146.6	115.0	115.0	35.8	1.1	3.1	27	8	15	4.48	1.13	21	0.349	0.349	0.349	0.349	2.41	SAND	0.5	1.70	57.5	2.37	136.2	0.31	0.986	0.26	0.260	Above Water	0.13	15305	527.9	0.04	0.06	0.002	NA	NA	0.000
6.23	146.5	115.0	115.0	32.6	1.0	3.1	29	8	13	4.61	1.14	20	0.358	0.358	0.358	0.358	2.45	SAND	0.5	1.70	52.3	2.55	133.2	0.30	0.985	0.26	0.260	Above Water	0.13	15068	519.3	0.05	0.08	0.003	NA	NA	0.000
6.40	146.3	115.0	115.0	30.2	0.9	3.1	30	7	12	4.68	1.15	19	0.368	0.368	0.368	0.368	2.48	SAND	0.5	1.70	48.4	2.65	128.2	0.28	0.985	0.26	0.260	Above Water	0.13	14826	512.8	0.05	0.09	0.004	NA	NA	0.000
6.56	146.1	115.0	115.0	31.5	0.8	2.5	27	7	12	4.47	1.13	18	0.377	0.377	0.377	0.377	2.41	SAND	0.5	1.67	49.8	2.37	117.8	0.23	0.985	0.26	0.260	Above Water	0.13	14608	519.0	0.05	0.09	0.004	NA	NA	0.000
6.73	146.0	115.0	115.0	32.1	0.9	2.7	28	8	12	4.53	1.14	19	0.387	0.387	0.387	0.387	2.43	SAND	0.5	1.65	50.1	2.43	121.9	0.25	0.984	0.26	0.260	Above Water	0.13	14386	528.0	0.05	0.09	0.004	NA	NA	0.000
6.89	145.8	115.0	115.0	29.7	1.0	3.2	31	7	12	4.77	1.16	19	0.396	0.396	0.396	0.396	2.51	SAND	0.5	1.63	45.9	2.81	129.2	0.28	0.984	0.26	0.260	Above Water	0.13	14184	525.5	0.05	0.10	0.004	NA	NA	0.000
7.05	145.7	115.0	115.0	29.4	1.0	3.5	33	7	12	4.87	1.18	19	0.405	0.405	0.405	0.405	2.54	SAND	0.5	1.62	44.9	3.00	134.8	0.31	0.984	0.26	0.260	Above Water	0.13	13990	530.5	0.06	0.10	0.004	NA	NA	0.000
7.22	145.5	115.0	115.0	31.9	1.1	3.5	32	8	13	4.81	1.17	19	0.415	0.415	0.415	0.415	2.52	SAND	0.5	1.60	48.1	2.89	139.0	0.33	0.983	0.26	0.260	Above Water	0.13	13792	547.7	0.05	0.09	0.004	NA	NA	0.000
7.38	145.3	115.0	115.0	33.3	1.1	3.3	30	8	13	4.73	1.16	20	0.424	0.424	0.424	0.424	2.49	SAND	0.5	1.58	49.7	2.74	136.1	0.31	0.983	0.26	0.260	Above Water	0.14	13611	557.2	0.05	0.09	0.003	NA	NA	0.000
7.55	145.2	115.0	115.0	31.7	1.0	3.0	30	8	12	4.71	1.15	19	0.434	0.434	0.434	0.434	2.49	SAND	0.5	1.56	46.7	2.70	126.1	0.27	0.982	0.26	0.260	Above Water	0.14	13427	551.3	0.06	0.10	0.004	NA	NA	0.000
7.71	145.0	115.0	115.0	28.4	0.8	2.7	30	7	11	4.73	1.16	17	0.443	0.443	0.443	0.443	2.49	SAND	0.5	1.54	41.5	2.73	113.4	0.22	0.982	0.26	0.260	Above Water	0.14	13259	536.1	0.06	0.14	0.005	NA	NA	0.000
7.87	144.8	115.0	115.0	25.1	0.7	2.8	33	6	10	4.86	1.18	16	0.453	0.453	0.453	0.453	2.55	SAND	0.5	1.53	36.3	3.04	110.3	0.20	0.982	0.26	0.260	Above Water	0.14	13096	523.0	0.07	0.17	0.007	NA	NA	0.000
8.04	144.7	115.0	115.0	26.2	0.8	2.9	33	7	10	4.86	1.18	16	0.462	0.462	0.462	0.462	2.54	SAND	0.5	1.51	37.4	3.00	112.2	0.21	0.981	0.26	0.260	Above Water	0.14	12929	533.3	0.07	0.16	0.007	NA	NA	0.000
8.20	144.5	115.0	115.0	27.3	0.8	2.8	32	7	10	4.83	1.17	17	0.472	0.472	0.472	0.472	2.53	SAND	0.5	1.50	38.6	2.93	113.0	0.21	0.981	0.26	0.260	Above Water	0.14	12778	543.1	0.07	0.16	0.006	NA	NA	0.000
8.37	144.3	115.0	115.0	28.2	0.8	2.8	32	7	10	4.81	1.17	17	0.481	0.481	0.481	0.481	2.52	SAND	0.5	1.48	39.6	2.88	113.9	0.22	0.980	0.25	0.250	Above Water	0.14	12621	552.3	0.06	0.13	0.005	NA	NA	0.000
8.53	144.2	115.0	115.0	29.5	0.8	2.6	30	7	10	4.72	1.16	17	0.490	0.490	0.490	0.490	2.49	SAND	0.5	1.47	40.9	2.71	110.9	0.21	0.980	0.25	0.250	Above Water	0.14	12479	560.8	0.06	0.13	0.005	NA	NA	0.000
8.69	144.0	115.0	115.0	28.6	0.7	2.6	31	7	10	4.74	1.16	16	0.500	0.500	0.500	0.500	2.50	SAND	0.5	1.46	39.3	2.76	108.4	0.20	0.980	0.25	0.250	Above Water	0.14	12340	559.6	0.06	0.14	0.005	NA	NA	0.000
8.86	143.8	115.0	115.0	27.8	0.7	2.5	31	7	10	4.74	1.16	16	0.509	0.509	0.509	0.509	2.50	SAND	0.5	1.44	37.8	2.76	104.1	0.19	0.979	0.25	0.250	Above Water	0.14	12198	557.5	0.06	0.15	0.006	NA	NA	0.000

Liquefaction Analysis with Cone Penetration Test (CPT) Data

Depth (ft)	Elev. (ft, MSL)	Unit Weight (pcf) γ'_{MOIST}	Unit Weight (pcf) γ'_{SAT}	q_c (tsf)	f_s (tsf)	Frict. Ratio (%)	% Fines	Equiv. N_{60}	Equiv. $(N_1)_{60}$	α	β	Equiv. $(N_1)_{60cs}$	Stresses at Exploration Water Level σ_v (tsf)	Stresses at Exploration Water Level σ'_v (tsf)	Stresses at Design Water Level σ_v (tsf)	Stresses at Design Water Level σ'_v (tsf)	I_c	Soil Type Character (SAND, SILT or non-LIQ CLAY)	Normalization of Tip Resistance n	C_Q	q_{c1N}	Fines Correction Kc	$(q_{c1N})_{cs}$	$CRR_{7.5}$	r_d	CSR_M	$CSR_{7.5}$	FS	a	b	Max Shear Modulus G_{max} (tsf)	Cyclic Shear Strain γ (%)	Norm. Vol. Strain ε_{Nc} (%)	Dry Settle. ΔS (in)	Post-Liq. $(N_1)_{60cs}$	Post-Liq. Vol. Strain ε (%)	Layer Post-Liq. Settle. ΔS (in)
9.02	143.7	115.0	115.0	25.7	0.7	2.6	32	6	9	4.85	1.17	16	0.519	0.519	0.519	0.519	2.54	SAND	0.5	1.43	34.7	2.97	103.1	0.18	0.979	0.25	0.250	Above Water	0.14	12067	550.1	0.07	0.18	0.007	NA	NA	0.000
9.19	143.5	115.0	115.0	24.7	0.7	2.7	34	6	9	4.93	1.19	15	0.528	0.528	0.528	0.528	2.57	SAND	0.5	1.42	33.0	3.15	103.9	0.18	0.979	0.25	0.250	Above Water	0.14	11933	549.0	0.07	0.20	0.008	NA	NA	0.000
9.35	143.4	115.0	115.0	23.3	0.7	2.9	34	6	8	4.93	1.19	15	0.538	0.538	0.538	0.538	2.57	SILT	0.7	1.61	35.3	3.17	111.9	0.21	0.978	0.25	0.250	Above Water	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
9.51	143.2	115.0	115.0	23.2	0.7	2.9	34	6	8	4.93	1.19	15	0.547	0.547	0.547	0.547	2.57	SILT	0.7	1.59	34.8	3.16	109.9	0.20	0.978	0.25	0.250	Above Water	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
9.68	143.0	115.0	115.0	22.2	0.6	2.5	35	6	8	5.00	1.20	14	0.557	0.557	0.557	0.557	2.60	SAND	0.5	1.38	28.9	3.32	95.8	0.16	0.977	0.25	0.250	Above Water	0.14	11567	541.5	0.08	0.26	0.011	NA	NA	0.000
9.84	142.9	115.0	115.0	19.8	0.5	2.6	36	5	7	5.00	1.20	13	0.566	0.566	0.566	0.566	2.61	SILT	0.7	1.55	29.0	3.39	98.4	0.17	0.977	0.25	0.250	Above Water	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
10.01	142.7	115.0	115.0	17.1	0.5	3.0	38	4	6	5.00	1.20	12	0.576	0.576	0.576	0.575	2.64	non-LIQ CLAY	1	1.70	NA	3.61	non-LIQ	non-LIQ	0.977	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
10.17	142.5	115.0	115.0	17.4	0.5	3.0	37	5	6	5.00	1.20	12	0.585	0.585	0.585	0.580	2.64	non-LIQ CLAY	1	1.70	NA	3.58	non-LIQ	non-LIQ	0.976	0.26	0.260	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
10.33	142.4	115.0	115.0	22.8	0.7	3.0	36	6	8	5.00	1.20	14	0.594	0.594	0.594	0.589	2.61	SILT	0.7	1.50	32.2	3.37	108.7	0.20	0.976	0.26	0.260	0.77	NA	NA	NA	NA	NA	0.000	11	2.460	0.047
10.50	142.2	115.0	115.0	35.6	0.9	2.6	29	9	11	4.63	1.15	18	0.604	0.604	0.604	0.598	2.46	SAND	0.5	1.32	44.6	2.58	114.9	0.22	0.976	0.26	0.260	0.85	NA	NA	NA	NA	NA	0.000	13	2.150	0.044
10.66	142.0	115.0	115.0	34.0	0.9	2.6	29	8	11	4.67	1.15	17	0.613	0.613	0.613	0.608	2.47	SAND	0.5	1.31	42.3	2.63	111.2	0.21	0.975	0.26	0.260	0.80	NA	NA	NA	NA	NA	0.000	13	2.150	0.041
10.83	141.9	115.0	115.0	26.7	0.7	2.6	34	7	9	4.91	1.18	15	0.623	0.623	0.623	0.617	2.56	SAND	0.5	1.30	32.9	3.11	102.3	0.18	0.975	0.26	0.260	0.69	NA	NA	NA	NA	NA	0.000	12	2.310	0.047
10.99	141.7	115.0	115.0	24.9	0.6	2.4	34	6	8	4.91	1.18	15	0.632	0.632	0.632	0.627	2.56	SAND	0.5	1.29	30.5	3.11	94.8	0.16	0.974	0.26	0.260	0.61	NA	NA	NA	NA	NA	0.000	11	2.460	0.047
11.15	141.6	115.0	115.0	23.6	0.5	2.3	34	6	8	4.95	1.19	14	0.641	0.641	0.641	0.636	2.58	SAND	0.5	1.28	28.6	3.21	91.8	0.15	0.974	0.26	0.260	0.58	NA	NA	NA	NA	NA	0.000	11	2.460	0.047
11.32	141.4	115.0	115.0	21.3	0.5	2.4	35	5	7	5.00	1.20	13	0.651	0.651	0.651	0.646	2.59	SILT	0.7	1.41	28.3	3.30	93.3	0.16	0.974	0.25	0.250	0.60	NA	NA	NA	NA	NA	0.000	10	2.620	0.053
11.48	141.2	115.0	115.0	20.7	0.5	2.5	36	5	7	5.00	1.20	13	0.660	0.660	0.660	0.655	2.62	SILT	0.7	1.39	27.2	3.43	93.5	0.16	0.973	0.25	0.250	0.62	NA	NA	NA	NA	NA	0.000	10	2.620	0.050
11.65	141.1	115.0	115.0	22.2	0.5	2.1	35	6	7	4.96	1.19	13	0.670	0.670	0.670	0.665	2.58	SAND	0.5	1.26	26.4	3.22	85.1	0.14	0.973	0.25	0.250	0.55	NA	NA	NA	NA	NA	0.000	10	2.620	0.053
11.81	140.9	115.0	115.0	21.1	0.5	2.5	36	5	7	5.00	1.20	13	0.679	0.679	0.679	0.674	2.62	SILT	0.7	1.36	27.2	3.44	93.5	0.16	0.972	0.25	0.250	0.62	NA	NA	NA	NA	NA	0.000	10	2.620	0.050
11.98	140.7	115.0	115.0	21.6	0.6	2.9	36	6	7	5.00	1.20	13	0.689	0.689	0.689	0.684	2.61	non-LIQ CLAY	1	1.54	NA	3.41	non-LIQ	non-LIQ	0.972	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
12.14	140.6	115.0	115.0	20.6	0.7	3.5	40	6	7	5.00	1.20	13	0.698	0.698	0.698	0.693	2.68	non-LIQ CLAY	1	1.52	NA	3.88	non-LIQ	non-LIQ	0.972	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
12.30	140.4	115.0	115.0	20.1	0.7	3.5	40	5	7	5.00	1.20	13	0.707	0.707	0.707	0.702	2.70	non-LIQ CLAY	1	1.50	NA	4.00	non-LIQ	non-LIQ	0.971	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
12.47	140.2	115.0	115.0	18.9	0.6	3.3	41	5	6	5.00	1.20	12	0.717	0.717	0.717	0.712	2.71	non-LIQ CLAY	1	1.48	NA	4.09	non-LIQ	non-LIQ	0.971	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
12.63	140.1	115.0	115.0	17.9	0.6	3.2	42	5	6	5.00	1.20	12	0.726	0.726	0.726	0.721	2.72	non-LIQ CLAY	1	1.46	NA	4.17	non-LIQ	non-LIQ	0.971	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
12.80	139.9	115.0	115.0	16.9	0.5	3.1	43	5	6	5.00	1.20	12	0.736	0.736	0.736	0.731	2.75	non-LIQ CLAY	1	1.44	NA	4.34	non-LIQ	non-LIQ	0.970	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
12.96	139.7	115.0	115.0	16.8	0.6	3.3	44	5	6	5.00	1.20	12	0.745	0.745	0.745	0.740	2.77	non-LIQ CLAY	1	1.42	NA	4.53	non-LIQ	non-LIQ	0.970	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
13.12	139.6	115.0	115.0	15.9	0.5	3.4	46	5	5	5.00	1.20	11	0.754	0.754	0.754	0.749	2.80	non-LIQ CLAY	1	1.40	NA	4.79	non-LIQ	non-LIQ	0.969	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
13.29	139.4	115.0	115.0	15.0	0.5	3.3	47	4	5	5.00	1.20	11	0.764	0.764	0.764	0.759	2.82	non-LIQ CLAY	1	1.38	NA	4.97	non-LIQ	non-LIQ	0.969	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
13.45	139.3	115.0	115.0	14.5	0.5	3.4	49	4	5	5.00	1.20	11	0.773	0.773	0.773	0.768	2.85	non-LIQ CLAY	1	1.37	NA	5.19	non-LIQ	non-LIQ	0.969	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
13.62	139.1	115.0	115.0	13.4	0.5	3.6	52	4	5	5.00	1.20	11	0.783	0.783	0.783	0.778	2.89	non-LIQ CLAY	1	1.35	NA	5.64	non-LIQ	non-LIQ	0.968	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
13.78	138.9	115.0	115.0	12.0	0.4	3.4	54	4	5	5.00	1.20	10	0.792	0.792	0.792	0.787	2.93	non-LIQ CLAY	1	1.34	NA	5.95	non-LIQ	non-LIQ	0.968	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
13.94	138.8	115.0	115.0	11.6	0.3	3.0	52	4	4	5.00	1.20	10	0.802	0.802	0.802	0.797	2.90	non-LIQ CLAY	1	1.32	NA	5.75	non-LIQ	non-LIQ	0.967	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
14.11	138.6	115.0	115.0	11.1	0.3	3.0	54	3	4	5.00	1.20	10	0.811	0.811	0.811	0.806	2.93	non-LIQ CLAY	1	1.30	NA	6.00	non-LIQ	non-LIQ	0.967	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
14.27	138.4	115.0	115.0	9.8	0.3	2.7	56	3	3	5.00	1.20	9	0.821	0.821	0.821	0.816	2.97	non-LIQ CLAY	1	1.29	NA	6.37	non-LIQ	non-LIQ	0.967	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
14.44	138.3	115.0	115.0	8.6	0.2	2.5	58	3	3	5.00	1.20	9	0.830	0.830	0.830	0.825	3.00	non-LIQ CLAY	1	1.27	NA	6.72	non-LIQ	non-LIQ	0.966	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
14.60	138.1	115.0	115.0	7.3	0.2	2.6	65	2	3	5.00	1.20	8	0.839	0.839	0.839	0.835	3.09	non-LIQ CLAY	1	1.26	NA	7.82	non-LIQ	non-LIQ	0.966	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
14.76	137.9	115.0	115.0	7.5	0.2	3.2	68	3	3	5.00	1.20	8	0.849	0.849	0.849	0.844	3.13	non-LIQ CLAY	1	1.25	NA	8.35	non-LIQ	non-LIQ	0.966	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
14.93	137.8	115.0	115.0	7.7	0.3	3.9	71	3	3	5.00	1.20	9	0.858	0.858	0.858	0.853	3.17	non-LIQ CLAY	1	1.23	NA	8.90	non-LIQ	non-LIQ	0.965	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
15.09	137.6	115.0	115.0	14.0	0.3	2.5	47	4	4	5.00	1.20	10	0.868	0.868	0.868	0.863	2.82	non-LIQ CLAY	1	1.22	NA	4.93	non-LIQ	non-LIQ	0.965	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
15.26	137.4	115.0	115.0	16.1	0.3	1.8	40	4	5	5.00	1.20	11	0.877	0.877	0.877	0.872	2.69	non-LIQ CLAY	1	1.21	NA	3.90	non-LIQ	non-LIQ	0.964	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
15.42	137.3	115.0	115.0	22.1	0.3	1.2	31	5	6	4.76	1.16	12	0.887	0.883	0.887	0.882	2.50	SAND	0.5	1.09	22.9	2.78	63.7	0.10	0.964	0.25	0.250	0.42	NA	NA	NA	NA	NA	0.000	8	2.920	0.056
15.58	137.1	115.0	115.0	22.4	0.3	1.2	31	5	6	4.76	1.16	12	0.896	0.887	0.896	0.887	2.50	SAND	0.5	1.09	23.1	2.79	64.4	0.10	0.964	0.25	0.250	0.42	NA	NA	NA	NA	NA	0.000	8	2.920	0.056
15.75	137.0	115.0	115.0	20.1	0.4	1.9	37	5	6	5.00	1.20	12	0.906	0.892	0.906	0.892	2.63	non-LIQ CLAY	1	1.19	NA	3.51	non-LIQ	non-LIQ	0.963	0.25	0.250	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
15.91	136.8	115.0	115.0	17.1	0.3	2.0	40	5	5	5.00	1.20	11	0.915	0.896	0.915	0.896	2.69	non-LIQ CLAY	1	1.18	NA	3.96	non-LIQ	non-LIQ	0.963	0.26	0.260	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
16.08	136.6	115.0	115.0	14.9	0.4	2.7	48	4	5	5.00	1.20	11	0.925	0.900	0.925	0.900	2.83	non-LIQ CLAY	1	1.18	NA	5.08	non-LIQ	non-LIQ	0.963	0.26	0.260	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
16.24	136.5	115.0	115.0	17.7	0.5	2.7	44	5	5	5.00	1.20	11	0.934	0.904	0.934	0.904	2.77	non-LIQ CLAY	1	1.17	NA	4.51	non-LIQ	non-LIQ	0.962	0.26	0.260	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
16.40	136.3	115.0	115.0	18.4	0.4	2.0	39	5	5	5.00	1.20	11	0.943	0.909	0.943	0.909	2.68	non-LIQ CLAY	1	1.16	NA	3.86	non-LIQ	non-LIQ	0.962	0.26	0.260	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
16.57	136.1	115.0	115.0	29.6	0.5	1.6	29	7	8	4.64	1.15	13	0.953	0.913	0.953	0.913	2.46	SAND	0.5	1.08	30.1	2.59	78.2	0.12	0.961	0.26	0.260	0.48	NA	NA	NA	NA	NA	0.000	10	2.620	0.053
16.73	136.0	115.0	115.0	37.5	0.6	1.5	25	9	9	4.32	1.12	15	0.962	0.917	0.962	0.917	2.37	SAND	0.5	1.07	38.1	2.20	83.9	0.14	0.961	0.26	0.260	0.52	NA	NA	NA	NA	NA	0.000	11	2.460	0.047
16.90	135.8	115.0	115.0	34.7	0.5	1.6	27	8	9	4.45	1.13	14	0.972	0.922	0.972	0.922	2.41	SAND	0.5	1.07	35.2	2.34	82.1	0.13	0.961	0.26	0.260	0.51	NA	NA	NA	NA	NA	0.000	11	2.460	0.050
17.06	135.6	115.0	115.0	37.2	0.6	1.6	26	9	9	4.36	1.12	15	0.981	0.926	0.981	0.925	2.38	SAND	0.5	1.07	37.6	2.24	84.1	0.14	0.960	0.26	0.260	0.52	NA	NA	NA	NA	NA	0.000	11	2.460	0.047
17.22	135.5	115.0	115.0	31.6	0.7	2.2	32	8	8	4.85	1.17	15	0.990	0.930	0.990	0.930	2.54	SAND	0.5	1.07	31.8	2.96	94.3	0.16	0.960	0.27	0.270	0.58	NA	NA	NA	NA	NA	0.000	11	2.460	0.047
17.39	135.3	115.0	115.0	22.7	0.7	3.2	42	6	7	5.00	1.20	13	1.000	0.935	1.000	0.935	2.73	non-LIQ CLAY	1	1.13	NA	4.24	non-LIQ	non-LIQ	0.959	0.27	0.270	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
17.55	135.2	115.0	115.0	18.2	0.7	4.1	51	5	6	5.00	1.20	12	1.009	0.939	1.009	0.939	2.88	non-LIQ CLAY	1	1.13	NA	5.53	non-LIQ	non-LIQ	0.959	0.27	0.270	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
17.72	135.0	115.0	115.0	21.3	0.7	3.1	43	6	6	5.00	1.20	12	1.019	0.943	1.019	0.943	2.75	non-LIQ CLAY	1	1.12	NA	4.40	non-LIQ	non-LIQ	0.959	0.27	0.270	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
17.88	134.8	115.0	115.0	33.2	0.7	2.1	31	8	9	4.77	1.16	15	1.028	0.948	1.028	0.948	2.51	SAND	0.5	1.06	33.1	2.81	93.2	0.16	0.958	0.27	0.270	0.58	NA	NA	NA	NA	NA	0.000	11	2.460	0.047
18.04	134.7	115.0	115.0	31.6	0.7	2.1	32	8	8	4.83	1.17	14	1.037	0.952	1.037	0.952	2.53	SAND	0.5	1.05	31.5	2.92	92.0	0.15	0.958	0.27	0.270	0.56	NA	NA	NA	NA	NA	0.000	11	2.460	0.047
18.21	134.5	115.0	115.0	23.8	0.5	2.1	36	6	6	5.00	1.20	13	1.047	0.956	1.047	0.956	2.61	non-LIQ CLAY	1	1.11	NA	3.40	non-LIQ	non-LIQ	0.958	0.27	0.270	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
18.37	134.3	115.0	115.0	15.3	0.4	2.9	50	4	5	5.00	1.20	11	1.056	0.960	1.056	0.960	2.87	non-LIQ CLAY	1	1.10	NA	5.37	non-LIQ	non-LIQ	0.957	0.27	0.270	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
18.54	134.2	115.0	115.0	10.2	0.4	3.6	65	3	4	5.00	1.20	9	1.066	0.965	1.066	0.965	3.09	non-LIQ CLAY	1	1.10	NA	7.80	non-LIQ	non-LIQ	0.957	0.27	0.270	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
18.70	134.0	115.0	115.0	8.4	0.4	4.9	77	3	3	5.00	1.20	9	1.075	0.969	1.075	0.969	3.25	non-LIQ CLAY	1	1.09	NA	10.01	non-LIQ	non-LIQ	0.956	0.28	0.280	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
18.86	133.8	115.0	115.0	13.2	0.5	4.0	60	4	4	5.00	1.20	10	1.084	0.973	1.084	0.973	3.02	non-LIQ CLAY	1	1.09	NA	6.95	non-LIQ	non-LIQ	0.956	0.28	0.280	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
19.03	133.7	115.0	115.0	20.5	0.6	3.1	45	6	6	5.00	1.20	12	1.094	0.978	1.094	0.978	2.78	non-LIQ CLAY	1	1.08	NA	4.64	non-LIQ	non-LIQ	0.956	0.28	0.280	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
19.19	133.5	115.0	115.0	20.0	0.6	3.0	45	6	6	5.00	1.20	12	1.103	0.982	1.103	0.982	2.78	non-LIQ CLAY	1	1.08	NA	4.63	non-LIQ	non-LIQ	0.955	0.28	0.280	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
19.36	133.3	115.0	115.0	16.7	0.6	3.6	52	5	5	5.00	1.20	11	1.113	0.987	1.113	0.987	2.90	non-LIQ CLAY	1	1.07	NA	5.71	non-LIQ	non-LIQ	0.955	0.28	0.280	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
19.52	133.2	115.0	115.0	16.4	0.6	3.7	53	5	5	5.00	1.20	11	1.122	0.991	1.122	0.991	2.92	non-LIQ CLAY	1	1.07	NA	5.88	non-LIQ	non-LIQ	0.954	0.28	0.280	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
19.69	133.0	115.0	115.0	23.3	0.6	2.4	39	6	6	5.00	1.20	13	1.132	0.995	1.132	0.995	2.67	non-LIQ CLAY	1	1.06	NA	3.82	non-LIQ	non-LIQ	0.954	0.28	0.280	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
19.85	132.9	115.0	115.0	34.9	0.5	1.3	26	8	8	4.36	1.12	14	1.141	0.999	1.141	0.999	2.38	SAND	0.5	1.03	33.9	2.24	76.0	0.12	0.954	0.28	0.280	0.43	NA	NA	NA	NA	NA	0.000	10	2.620	0.050
20.01	132.7	115.0	115.0	31.5	0.6	1.9	31	8	8	4.79	1.17	14	1.151	1.004	1.151	1.004	2.51	SAND	0.5	1.03	30.6	2.84	87.0	0.14	0.953	0.28	0.280	0.50	NA	NA	NA	NA	NA	0.000	11	2.460	0.047
20.18	132.5	115.0	115.0	23.3	0.7	3.0	42	6	7	5.00	1.20	13	1.160	1.008	1.160	1.008	2.73	non-LIQ CLAY	1	1.05	NA	4.24	non-LIQ	non-LIQ	0.953	0.29	0.290	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
20.34	132.4	115.0	115.0	19.8	0.7	3.5	48	6	6	5.00	1.20	12	1.170	1.012	1.170	1.012	2.84	non-LIQ CLAY	1	1.05	NA	5.12	non-LIQ	non-LIQ	0.953	0.29	0.290	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
20.51	132.2	115.0	115.0	20.0	0.7	3.4	48	6	6	5.00	1.20	12	1.179	1.017	1.179	1.017	2.83	non-LIQ CLAY	1	1.04	NA	5.05	non-LIQ	non-LIQ	0.952	0.29	0.290	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
20.67	132.0	115.0	115.0	26.9	0.7	2.4	37	7	7	5.00	1.20	14	1.189	1.021	1.189	1.021	2.63	non-LIQ CLAY	1	1.04	NA	3.53	non-LIQ	non-LIQ	0.952	0.29	0.290	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
20.83	131.9	115.0	115.0	21.6	0.6	2.7	43	6	6	5.00	1.20	12	1.198	1.025	1.198	1.025	2.75	non-LIQ CLAY	1	1.03	NA	4.34	non-LIQ	non-LIQ	0.951	0.29	0.290	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
21.00	131.7	115.0	115.0	13.5	0.4	2.9	55	4	4	5.00	1.20	10	1.208	1.030	1.208	1.030	2.95	non-LIQ CLAY	1	1.03	NA	6.23	non-LIQ	non-LIQ	0.951	0.29	0.290	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
21.16	131.5	115.0	115.0	9.9	0.3	3.0	65	3	3	5.00	1.20	9	1.217	1.034	1.217	1.034	3.09	non-LIQ CLAY	1	1.02	NA	7.85	non-LIQ	non-LIQ	0.951	0.29	0.290	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
21.33	131.4	115.0	115.0	11.1	0.3	2.6	59	4	4	5.00	1.20	9	1.226	1.038	1.226	1.038	3.01	non-LIQ CLAY	1	1.02	NA	6.88	non-LIQ	non-LIQ	0.950	0.29	0.290	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
21.49	131.2	115.0	115.0	11.5	0.3	3.0	61	4	4	5.00	1.20	10	1.236	1.043	1.236	1.043	3.03	non-LIQ CLAY	1	1.01	NA	7.13	non-LIQ	non-LIQ	0.950	0.29	0.290	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
21.65	131.1	115.0	115.0	15.8	0.5	3.0	52	5	5	5.00	1.20	11	1.245	1.047	1.245	1.047	2.91	non-LIQ CLAY	1	1.01	NA	5.76	non-LIQ	non-LIQ	0.950	0.29	0.290	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
21.82	130.9	115.0	115.0	20.7	0.6	2.7	44	6	6	5.00	1.20	12	1.255	1.051	1.255	1.051	2.77	non-LIQ CLAY	1	1.01	NA	4.56	non-LIQ	non-LIQ	0.949	0.29	0.290	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
21.98	130.7	115.0	115.0	17.2	0.4	2.6	48	5	5	5.00	1.20	11	1.264	1.055	1.264	1.055	2.83	non-LIQ CLAY	1	1.00	NA	5.04	non-LIQ	non-LIQ	0.949	0.30	0.300	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
22.15	130.6	115.0	115.0	12.2	0.4	3.1	60	4	4	5.00	1.20	10	1.274	1.060	1.274	1.060	3.02	non-LIQ CLAY	1	1.00	NA	6.97	non-LIQ	non-LIQ	0.948	0.30	0.300	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
22.31	130.4	115.0	115.0	10.3	0.3	3.3	66	4	4	5.00	1.20	9	1.283	1.064	1.283	1.064	3.11	non-LIQ CLAY	1	0.99	NA	8.05	non-LIQ	non-LIQ	0.948	0.30	0.300	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
22.47	130.2	115.0	115.0	10.4	0.3	3.2	65	4	4	5.00	1.20	9	1.292	1.068	1.292	1.068	3.10	non-LIQ CLAY	1	0.99	NA	7.93	non-LIQ	non-LIQ	0.948	0.30	0.300	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
22.64	130.1	115.0	115.0	12.4	0.3	2.6	57	4	4	5.00	1.20	10	1.302	1.073	1.302	1.073	2.98	non-LIQ CLAY	1	0.99	NA	6.51	non-LIQ	non-LIQ	0.947	0.30	0.300	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000

Liquefaction Analysis with Cone Penetration Test (CPT) Data

Depth	Elev.	Unit Weight (pcf)		q_c	f_s	Frict. Ratio	% Fines	Equiv. N_{60}	Equiv. $(N_1)_{60}$	α	β	Equiv. $(N_1)_{60cs}$	Stresses at Exploration Water Level		Stresses at Design Water Level		I_c	Soil Type Character (SAND, SILT or non-LIQ CLAY)	Normalization of Tip Resistance			Fines Correction		$CRR_{7.5}$	r_d	CSR_M	$CSR_{7.5}$	FS	a	b	Max Shear Modulus	Cyclic Shear Strain	Norm. Vol. Strain	Dry Settle.	Post-Liq. $(N_1)_{60cs}$	Post-Liq. Vol. Strain	Layer Post-Liq. Settle.
(ft)	(ft, MSL)	γ'_{MOIST}	γ'_{SAT}	(tsf)	(tsf)	(%)							σ_v (tsf)	σ'_v (tsf)	σ_v (tsf)	σ'_v (tsf)			n	C_Q	q_{c1N}	Kc	$(q_{c1N})_{cs}$								G_{max} (tsf)	γ (%)	ε_{Nc} (%)	ΔS (in)		ε (%)	ΔS (in)
22.80	129.9	115.0	115.0	13.3	0.4	2.7	56	4	4	5.00	1.20	10	1.311	1.077	1.311	1.077	2.96	non-LIQ CLAY	1	0.98	NA	6.32	non-LIQ	non-LIQ	0.947	0.30	0.300	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
22.97	129.7	115.0	115.0	13.5	0.4	3.1	58	4	4	5.00	1.20	10	1.321	1.081	1.321	1.081	2.99	non-LIQ CLAY	1	0.98	NA	6.59	non-LIQ	non-LIQ	0.946	0.30	0.300	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
23.13	129.6	115.0	115.0	12.5	0.4	3.6	62	4	4	5.00	1.20	10	1.330	1.086	1.330	1.086	3.06	non-LIQ CLAY	1	0.97	NA	7.41	non-LIQ	non-LIQ	0.946	0.30	0.300	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
23.29	129.4	115.0	115.0	14.7	0.4	2.8	54	5	4	5.00	1.20	10	1.339	1.090	1.339	1.090	2.93	non-LIQ CLAY	1	0.97	NA	5.99	non-LIQ	non-LIQ	0.946	0.30	0.300	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
23.46	129.2	115.0	115.0	17.5	0.5	2.7	49	5	5	5.00	1.20	11	1.349	1.094	1.349	1.094	2.85	non-LIQ CLAY	1	0.97	NA	5.24	non-LIQ	non-LIQ	0.945	0.30	0.300	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
23.62	129.1	115.0	115.0	16.5	0.4	2.4	49	5	5	5.00	1.20	11	1.358	1.099	1.358	1.099	2.85	non-LIQ CLAY	1	0.96	NA	5.21	non-LIQ	non-LIQ	0.945	0.30	0.300	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
23.79	128.9	115.0	115.0	14.1	0.4	2.6	54	4	4	5.00	1.20	10	1.368	1.103	1.368	1.103	2.93	non-LIQ CLAY	1	0.96	NA	6.05	non-LIQ	non-LIQ	0.945	0.30	0.300	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
23.95	128.8	115.0	115.0	14.6	0.4	2.7	54	4	4	5.00	1.20	10	1.377	1.107	1.377	1.107	2.93	non-LIQ CLAY	1	0.96	NA	6.04	non-LIQ	non-LIQ	0.944	0.31	0.310	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
24.11	128.6	115.0	115.0	15.7	0.6	4.1	60	5	5	5.00	1.20	11	1.386	1.111	1.386	1.111	3.02	non-LIQ CLAY	1	0.95	NA	6.92	non-LIQ	non-LIQ	0.944	0.31	0.310	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
24.28	128.4	115.0	115.0	21.0	0.8	3.8	51	6	6	5.00	1.20	12	1.396	1.116	1.396	1.116	2.88	non-LIQ CLAY	1	0.95	NA	5.53	non-LIQ	non-LIQ	0.943	0.31	0.310	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
24.44	128.3	115.0	115.0	34.1	0.7	2.1	32	8	8	4.85	1.17	14	1.405	1.120	1.405	1.120	2.54	SAND	0.5	0.97	31.3	2.96	92.6	0.15	0.943	0.31	0.310	0.50	NA	NA	NA	NA	NA	0.000	11	2.460	0.047
24.61	128.1	115.0	115.0	44.7	0.8	1.8	26	10	10	4.40	1.12	16	1.415	1.125	1.415	1.125	2.39	SAND	0.5	0.97	40.9	2.29	93.6	0.16	0.943	0.31	0.310	0.50	NA	NA	NA	NA	NA	0.000	12	2.310	0.047
24.77	127.9	115.0	115.0	46.3	0.7	1.5	24	10	10	4.13	1.10	15	1.424	1.129	1.424	1.129	2.33	SAND	0.5	0.97	42.4	2.04	86.5	0.14	0.942	0.31	0.310	0.45	NA	NA	NA	NA	NA	0.000	12	2.310	0.044
24.93	127.8	115.0	115.0	48.9	0.7	1.4	22	11	10	3.96	1.10	15	1.433	1.133	1.433	1.133	2.29	SAND	0.5	0.97	44.6	1.93	86.0	0.14	0.942	0.31	0.310	0.45	NA	NA	NA	NA	NA	0.000	12	2.310	0.044
25.10	127.6	115.0	115.0	50.3	0.6	1.3	21	11	11	3.79	1.09	15	1.443	1.137	1.443	1.137	2.26	SAND	0.5	0.96	45.8	1.83	83.7	0.13	0.941	0.31	0.310	0.43	NA	NA	NA	NA	NA	0.000	13	2.150	0.044
25.26	127.4	115.0	115.0	46.8	0.7	1.6	24	11	10	4.18	1.11	15	1.452	1.142	1.452	1.142	2.34	SAND	0.5	0.96	42.6	2.08	88.8	0.15	0.941	0.31	0.310	0.47	NA	NA	NA	NA	NA	0.000	12	2.310	0.044
25.43	127.3	115.0	115.0	42.6	1.2	2.8	32	11	10	4.83	1.17	17	1.462	1.146	1.462	1.146	2.53	SAND	0.5	0.96	38.7	2.93	113.5	0.22	0.941	0.31	0.310	0.70	NA	NA	NA	NA	NA	0.000	13	2.150	0.044
25.59	127.1	115.0	115.0	34.6	1.3	3.6	40	9	9	5.00	1.20	16	1.471	1.150	1.471	1.150	2.70	non-LIQ CLAY	1	0.92	NA	3.98	non-LIQ	non-LIQ	0.940	0.31	0.310	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
25.75	127.0	115.0	115.0	27.9	1.1	4.0	46	8	8	5.00	1.20	14	1.481	1.155	1.481	1.155	2.80	non-LIQ CLAY	1	0.92	NA	4.79	non-LIQ	non-LIQ	0.940	0.31	0.310	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
25.92	126.8	115.0	115.0	24.6	0.9	3.5	47	7	7	5.00	1.20	13	1.490	1.159	1.490	1.159	2.81	non-LIQ CLAY	1	0.91	NA	4.88	non-LIQ	non-LIQ	0.940	0.31	0.310	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
26.08	126.6	115.0	115.0	19.9	0.9	4.8	57	6	6	5.00	1.20	12	1.500	1.163	1.500	1.163	2.98	non-LIQ CLAY	1	0.91	NA	6.52	non-LIQ	non-LIQ	0.939	0.31	0.310	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
26.25	126.5	115.0	115.0	26.2	1.0	3.7	47	7	7	5.00	1.20	14	1.509	1.168	1.509	1.168	2.81	non-LIQ CLAY	1	0.91	NA	4.88	non-LIQ	non-LIQ	0.939	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
26.41	126.3	115.0	115.0	24.8	1.3	5.0	53	8	7	5.00	1.20	14	1.519	1.172	1.519	1.172	2.92	non-LIQ CLAY	1	0.90	NA	5.89	non-LIQ	non-LIQ	0.938	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
26.57	126.1	115.0	115.0	33.9	2.5	7.5	54	10	10	5.00	1.20	17	1.528	1.176	1.528	1.176	2.93	non-LIQ CLAY	1	0.90	NA	6.01	non-LIQ	non-LIQ	0.938	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
26.74	126.0	115.0	115.0	46.0	2.6	5.7	43	13	12	5.00	1.20	19	1.538	1.181	1.538	1.181	2.75	non-LIQ CLAY	1	0.90	NA	4.37	non-LIQ	non-LIQ	0.938	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
26.90	125.8	115.0	115.0	127.0	5.1	4.0	23	28	27	4.07	1.10	34	1.547	1.185	1.547	1.185	2.31	SAND	0.5	0.95	113.5	2.00	226.5	non-LIQ	0.937	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
27.07	125.6	115.0	115.0	86.1	4.4	5.1	31	21	20	4.77	1.16	28	1.557	1.189	1.557	1.189	2.51	SAND	0.5	0.94	76.7	2.80	215.0	non-LIQ	0.937	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
27.23	125.5	115.0	115.0	32.3	2.1	6.4	52	10	9	5.00	1.20	16	1.566	1.194	1.566	1.194	2.90	non-LIQ CLAY	1	0.89	NA	5.73	non-LIQ	non-LIQ	0.937	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
27.40	125.3	115.0	115.0	43.4	1.7	3.9	38	11	11	5.00	1.20	18	1.576	1.198	1.576	1.198	2.66	non-LIQ CLAY	1	0.88	NA	3.70	non-LIQ	non-LIQ	0.936	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
27.56	125.1	115.0	115.0	188.0	5.2	2.7	15	38	36	2.57	1.05	40	1.585	1.202	1.585	1.202	2.08	SAND	0.5	0.94	166.7	1.42	237.0	non-LIQ	0.936	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
27.72	125.0	115.0	115.0	133.6	8.0	6.0	28	32	30	4.59	1.14	39	1.594	1.206	1.594	1.206	2.45	SAND	0.5	0.94	118.3	2.51	297.2	non-LIQ	0.935	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
27.89	124.8	115.0	115.0	99.6	4.8	4.8	28	24	22	4.59	1.14	30	1.604	1.211	1.604	1.211	2.45	SAND	0.5	0.93	87.9	2.51	220.6	non-LIQ	0.935	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
28.05	124.7	115.0	115.0	89.6	3.1	3.5	25	21	19	4.31	1.12	26	1.613	1.215	1.613	1.215	2.37	SAND	0.5	0.93	79.0	2.19	173.4	non-LIQ	0.935	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
28.22	124.5	115.0	115.0	32.1	2.3	7.2	55	10	9	5.00	1.20	16	1.623	1.220	1.623	1.220	2.95	non-LIQ CLAY	1	0.87	NA	6.19	non-LIQ	non-LIQ	0.934	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
28.38	124.3	115.0	115.0	26.8	1.0	3.6	47	8	7	5.00	1.20	14	1.632	1.224	1.632	1.224	2.81	non-LIQ CLAY	1	0.86	NA	4.90	non-LIQ	non-LIQ	0.934	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
28.54	124.2	115.0	115.0	19.2	1.1	5.7	63	6	6	5.00	1.20	12	1.641	1.228	1.641	1.228	3.07	non-LIQ CLAY	1	0.86	NA	7.53	non-LIQ	non-LIQ	0.933	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
28.71	124.0	115.0	115.0	20.6	1.1	5.4	60	7	6	5.00	1.20	12	1.651	1.232	1.651	1.232	3.03	non-LIQ CLAY	1	0.86	NA	7.06	non-LIQ	non-LIQ	0.933	0.32	0.320	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
28.87	123.8	115.0	115.0	21.9	1.2	5.4	59	7	7	5.00	1.20	13	1.660	1.237	1.660	1.237	3.01	non-LIQ CLAY	1	0.86	NA	6.83	non-LIQ	non-LIQ	0.933	0.33	0.330	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
29.04	123.7	115.0	115.0	26.8	1.3	4.8	52	8	7	5.00	1.20	14	1.670	1.241	1.670	1.241	2.90	non-LIQ CLAY	1	0.85	NA	5.68	non-LIQ	non-LIQ	0.932	0.33	0.330	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
29.20	123.5	115.0	115.0	33.5	1.5	4.4	46	9	9	5.00	1.20	16	1.679	1.245	1.679	1.245	2.79	non-LIQ CLAY	1	0.85	NA	4.74	non-LIQ	non-LIQ	0.932	0.33	0.330	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
29.36	123.3	115.0	115.0	36.7	1.4	3.7	41	10	9	5.00	1.20	16	1.688	1.250	1.688	1.250	2.71	non-LIQ CLAY	1	0.85	NA	4.10	non-LIQ	non-LIQ	0.932	0.33	0.330	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
29.53	123.2	115.0	115.0	36.9	1.3	3.5	40	10	9	5.00	1.20	16	1.698	1.254	1.698	1.254	2.69	non-LIQ CLAY	1	0.84	NA	3.95	non-LIQ	non-LIQ	0.931	0.33	0.330	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
29.69	123.0	115.0	115.0	42.6	1.0	2.4	31	10	10	4.77	1.16	16	1.707	1.258	1.707	1.258	2.51	SAND	0.5	0.92	36.9	2.81	103.5	0.18	0.931	0.33	0.330	0.56	NA	NA	NA	NA	NA	0.000	12	2.310	0.044
29.86	122.8	115.0	115.0	39.8	1.0	2.6	34	10	9	4.91	1.18	16	1.717	1.263	1.717	1.263	2.56	SAND	0.5	0.92	34.5	3.10	106.9	0.19	0.930	0.33	0.330	0.59	NA	NA	NA	NA	NA	0.000	12	2.310	0.047
30.02	122.7	115.0	115.0	34.4	1.4	4.2	45	10	9	5.00	1.20	16	1.726	1.267	1.726	1.267	2.78	non-LIQ CLAY	1	0.84	NA	4.59	non-LIQ	non-LIQ	0.930	0.33	0.330	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
30.18	122.5	115.0	115.0	34.6	1.6	4.7	47	10	9	5.00	1.20	16	1.735	1.271	1.735	1.271	2.81	non-LIQ CLAY	1	0.83	NA	4.87	non-LIQ	non-LIQ	0.928	0.33	0.330	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
30.35	122.4	115.0	115.0	39.5	1.7	4.2	42	11	10	5.00	1.20	17	1.745	1.276	1.745	1.276	2.73	non-LIQ CLAY	1	0.83	NA	4.25	non-LIQ	non-LIQ	0.927	0.33	0.330	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
30.51	122.2	115.0	115.0	53.6	1.9	3.5	33	13	12	4.87	1.18	19	1.754	1.280	1.754	1.280	2.55	SAND	0.5	0.91	46.1	3.02	139.2	0.33	0.926	0.33	0.330	1.00	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
30.68	122.0	115.0	115.0	54.0	2.1	3.9	36	14	13	5.00	1.20	20	1.764	1.284	1.764	1.284	2.61	non-LIQ CLAY	1	0.82	NA	3.37	non-LIQ	non-LIQ	0.924	0.33	0.330	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
30.84	121.9	115.0	115.0	55.4	2.2	3.9	35	14	13	5.00	1.20	20	1.773	1.288	1.773	1.288	2.60	non-LIQ CLAY	1	0.82	NA	3.34	non-LIQ	non-LIQ	0.923	0.33	0.330	non-LIQ	NA	NA	NA	NA	NA	0.000	NA	NA	0.000
31.00	121.7	115.0	115.0	70.9	1.5	2.2	23	16	14	4.04	1.10	20	1.783	1.293	1.783	1.293	2.31	SAND	0.5	0.90	60.6	1.98	120.0	0.24	0.922	0.33	0.330	0.73	NA	NA	NA	NA	NA	0.000	16	1.840	0.035
31.17	121.5	115.0	115.0	76.8	1.4	1.8	20	17	15	3.65	1.08	20	1.792	1.297	1.792	1.297	2.24	SAND	0.5	0.90	65.6	1.76	115.3	0.22	0.920	0.33	0.330	0.67	NA	NA	NA	NA	NA	0.000	17	1.740	0.035
31.33	121.4	115.0	115.0	78.7	1.5	1.9	20	17	15	3.66	1.08	20	1.801	1.301	1.801	1.301	2.24	SAND	0.5	0.90	67.1	1.76	118.3	0.23	0.919	0.33	0.330	0.71	NA	NA	NA	NA	NA	0.000	17	1.740	0.033
31.50	121.2	115.0	115.0	72.2	1.7	2.4	23.7	16.3	14.6	4.1	1.1	20.0	1.81	1.31	1.81	1.31	2.33	SAND	0.5	0.90	61	2.05	126	0.267	0.918	0.330	0.330	0.81	NA	NA	NA	NA	NA	0.00	17.00	1.74	0.04
31.66	121.0	115.0	115.0	65.2	2.0	3.1	28.5	15.5	13.9	4.6	1.1	21.0	1.82	1.31	1.82	1.31	2.45	SAND	0.5	0.90	55	2.52	140	0.334	0.916	0.330	0.330	1.01	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
31.82	120.9	115.0	115.0	60.5	2.3	3.8	32.3	15.0	13.5	4.8	1.2	21.0	1.83	1.31	1.83	1.31	2.54	SAND	0.5	0.90	51	2.96	152	0.405	0.915	0.330	0.330	1.23	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
31.99	120.7	115.0	115.0	53.7	2.5	4.6	38.8	14.2	12.8	5.0	1.2	20.0	1.84	1.32	1.84	1.32	2.67	non-LIQ CLAY	1	0.80	NA	3.78	non-LIQ	non-LIQ	0.914	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
32.15	120.6	115.0	115.0	49.2	2.4	4.9	41.2	13.3	11.9	5.0	1.2	19.0	1.85	1.32	1.85	1.32	2.71	non-LIQ CLAY	1	0.80	NA	4.10	non-LIQ	non-LIQ	0.912	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
32.32	120.4	115.0	115.0	43.4	2.2	5.2	44.7	12.2	10.9	5.0	1.2	18.0	1.86	1.33	1.86	1.33	2.78	non-LIQ CLAY	1	0.80	NA	4.59	non-LIQ	non-LIQ	0.911	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
32.48	120.2	115.0	115.0	40.6	2.1	5.1	45.8	11.5	10.3	5.0	1.2	17.0	1.87	1.33	1.87	1.33	2.80	non-LIQ CLAY	1	0.79	NA	4.76	non-LIQ	non-LIQ	0.910	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
32.64	120.1	115.0	115.0	42.1	2.0	4.7	43.8	11.7	10.4	5.0	1.2	18.0	1.88	1.34	1.88	1.34	2.76	non-LIQ CLAY	1	0.79	NA	4.46	non-LIQ	non-LIQ	0.908	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
32.81	119.9	115.0	115.0	38.0	2.0	5.1	47.4	10.9	9.7	5.0	1.2	17.0	1.89	1.34	1.89	1.34	2.82	non-LIQ CLAY	1	0.79	NA	4.99	non-LIQ	non-LIQ	0.907	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
32.97	119.7	115.0	115.0	105.3	2.6	2.5	20.2	22.8	20.2	3.6	1.1	25.0	1.90	1.34	1.90	1.34	2.23	SAND	0.5	0.89	88	1.75	155	0.426	0.906	0.330	0.330	1.29	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
33.14	119.6	115.0	115.0	110.6	1.7	1.6	15.1	22.4	19.9	2.5	1.0	23.0	1.91	1.35	1.91	1.35	2.08	SAND	0.5	0.89	93	1.41	131	0.289	0.904	0.330	0.330	0.87	NA	NA	NA	NA	NA	0.00	21.00	1.42	0.03
33.30	119.4	115.0	115.0	124.7	1.3	1.0	10.6	23.7	21.0	1.1	1.0	23.0	1.91	1.35	1.91	1.35	1.91	SAND	0.5	0.88	104	1.20	125	0.261	0.903	0.330	0.330	0.79	NA	NA	NA	NA	NA	0.00	22.00	1.35	0.03
33.46	119.2	115.0	115.0	161.0	4.6	2.9	17.6	33.7	29.8	3.1	1.1	35.0	1.92	1.36	1.92	1.36	2.16	SAND	0.5	0.88	134	1.57	210	non-LIQ	0.902	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
33.63	119.1	115.0	115.0	92.6	4.1	4.5	29.1	22.2	19.5	4.6	1.1	27.0	1.93	1.36	1.93	1.36	2.46	SAND	0.5	0.88	77	2.59	200	non-LIQ	0.900	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
33.79	118.9	115.0	115.0	35.8	2.8	7.8	57.2	11.3	9.9	5.0	1.2	17.0	1.94	1.37	1.94	1.37	2.98	non-LIQ CLAY	1	0.77	NA	6.53	non-LIQ	non-LIQ	0.899	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
33.96	118.7	115.0	115.0	32.9	1.2	3.7	45.3	9.3	8.2	5.0	1.2	15.0	1.95	1.37	1.95	1.37	2.79	non-LIQ CLAY	1	0.77	NA	4.68	non-LIQ	non-LIQ	0.898	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
34.12	118.6	115.0	115.0	26.9	0.8	3.1	47.0	7.7	6.8	5.0	1.2	13.0	1.96	1.37	1.96	1.37	2.82	non-LIQ CLAY	1	0.77	NA	4.94	non-LIQ	non-LIQ	0.896	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
34.28	118.4	115.0	115.0	37.5	1.0	2.7	38.0	9.9	8.6	5.0	1.2	15.0	1.97	1.38	1.97	1.38	2.65	non-LIQ CLAY	1	0.77	NA	3.66	non-LIQ	non-LIQ	0.895	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
34.45	118.3	115.0	115.0	65.7	2.0	3.0	28.5	15.6	13.7	4.6	1.1	20.0	1.98	1.38	1.98	1.38	2.45	SAND	0.5	0.87	54	2.53	137	0.322	0.894	0.330	0.330	0.97	NA	NA	NA	NA	NA	0.00	16.00	1.84	0.04
34.61	118.1	115.0	115.0	48.7	2.1	4.3	40.5	13.1	11.5	5.0	1.2	19.0	1.99	1.39	1.99	1.39	2.70	non-LIQ CLAY	1	0.76	NA	4.00	non-LIQ	non-LIQ	0.892	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
34.78	117.9	115.0	115.0	28.6	2.1	7.4	61.8	9.4	8.2	5.0	1.2	15.0	2.00	1.39	2.00	1.39	3.05	non-LIQ CLAY	1	0.76	NA	7.30	non-LIQ	non-LIQ	0.891	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
34.94	117.8	115.0	115.0	101.8	2.5	2.5	20.6	22.1	19.3	3.7	1.1	25.0	2.01	1.40	2.01	1.40	2.25	SAND	0.5	0.87	84	1.79	150	0.395	0.890	0.330	0.330	1.20	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
35.10	117.6	115.0	115.0	57.6	2.8	4.9	39.6	15.4	13.4	5.0	1.2	21.0	2.02	1.40	2.02	1.40	2.68	non-LIQ CLAY	1	0.76	NA	3.88	non-LIQ	non-LIQ	0.888	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
35.27	117.4	115.0	115.0	55.3	2.1	3.8	36.6	14.3	12.4	5.0	1.2	20.0	2.03	1.40	2.03	1.40	2.62	non-LIQ CLAY	1	0.75	NA	3.48	non-LIQ	non-LIQ	0.887	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
35.43	117.3	115.0	115.0	35.6	1.6	4.5	47.5	10.3	8.9	5.0	1.2	16.0	2.04	1.41	2.04	1.41	2.83	non-LIQ CLAY	1	0.75	NA	5.01	non-LIQ	non-LIQ	0.886	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
35.60	117.1	115.0	115.0	25.5	1.1	4.2	53.9	7.8	6.8	5.0	1.2	13.0	2.05	1.41	2.05	1.41	2.93	non-LIQ CLAY	1	0.75	NA	6.00	non-LIQ	non-LIQ	0.884	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
35.76	116.9	115.0	115.0	28.4	1.2	4.1	51.1	8.5	7.3	5.0	1.2	14.0	2.06	1.42	2.06	1.42	2.89	non-LIQ CLAY	1	0.75	NA	5.56	non-LIQ	non-LIQ	0.883	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
35.93	116.8	115.0	115.0	45.3	1.4	3.1	37.1	11.8	10.2	5.0	1.2	17.0	2.07	1.42	2.07	1.42	2.64	non-LIQ CLAY	1	0.74	NA	3.55	non-LIQ	non-LIQ	0.882	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
36.09	116.6	115.0	115.0	39.8	1.3	3.4	40.9	10.8	9.3	5.0	1.2	16.0	2.08	1.43	2.08	1.43	2.71	non-LIQ CLAY	1	0.74	NA	4.06	non-LIQ	non-LIQ	0.880	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
36.25	116.5	115.0	115.0	28.9	1.4	4.8	53.7	8.8	7.6	5.0	1.2	14.0	2.08	1.43	2.08	1.43	2.93	non-LIQ CLAY	1	0.74	NA	5.96	non-LIQ	non-LIQ	0.879	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
36.42	116.3	115.0	115.0	26.3	1.3	4.9	56.3	8.2	7.1	5.0	1.2	13.0	2.09	1.44	2.09	1.44	2.97	non-LIQ CLAY	1	0.74	NA	6.39	non-LIQ	non-LIQ	0.878	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
36.58	116.1	115.0	115.0	40.3	1.3	3.2	39.8	10.8	9.2	5.0	1.2	16.0	2.10	1.44	2.10	1.44	2.69	non-LIQ CLAY	1	0.74	NA	3.91	non-LIQ	non-LIQ	0.876	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
36.75	116.0	115.0	115.0	33.4	1.4	4.1	47.7	9.7	8.3	5.0	1.2	15.0	2.11	1.44	2.11	1.44	2.83	non-LIQ CLAY	1	0.73	NA	5.04	non-LIQ	non-LIQ	0.875	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
36.91	115.8	115.0	115.0	31.6	1.3	4.2	49.6	9.3	7.9	5.0	1.2	15.0	2.12	1.45	2.12	1.45	2.86	non-LIQ CLAY	1	0.73	NA	5.33	non-LIQ	non-LIQ	0.874	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00

Liquefaction Analysis with Cone Penetration Test (CPT) Data

Depth (ft)	Elev. (ft, MSL)	Unit Weight (pcf) γ'_{MOIST}	Unit Weight (pcf) γ'_{SAT}	q_c (tsf)	f_s (tsf)	Frict. Ratio (%)	% Fines	Equiv. N_{60}	Equiv. $(N_1)_{60}$	α	β	Equiv. $(N_1)_{60CS}$	Stresses at Exploration Water Level σ_v (tsf)	Stresses at Exploration Water Level σ'_v (tsf)	Stresses at Design Water Level σ_v (tsf)	Stresses at Design Water Level σ'_v (tsf)	I_c	Soil Type Character (SAND, SILT or non-LIQ CLAY)	Normalization of Tip Resistance n	C_Q	q_{c1N}	Fines Correction Kc	Fines Correction $(q_{c1N})_{cs}$	$CRR_{7.5}$	r_d	CSR_M	$CSR_{7.5}$	FS	a	b	Max Shear Modulus G_{max} (tsf)	Cyclic Shear Strain γ (%)	Norm. Vol. Strain ε_{Nc} (%)	Dry Settle. ΔS (in)	Post-Liq. $(N_1)_{60CS}$	Post-Liq. Vol. Strain ε (%)	Layer Post-Liq. Settle. ΔS (in)
37.07	115.6	115.0	115.0	41.4	1.6	3.8	42.3	11.3	9.7	5.0	1.2	17.0	2.13	1.45	2.13	1.45	2.73	non-LIQ CLAY	1	0.73	NA	4.25	non-LIQ	non-LIQ	0.872	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
37.24	115.5	115.0	115.0	44.9	1.6	3.6	40.0	12.0	10.3	5.0	1.2	17.0	2.14	1.46	2.14	1.46	2.69	non-LIQ CLAY	1	0.73	NA	3.94	non-LIQ	non-LIQ	0.871	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
37.40	115.3	115.0	115.0	32.4	1.6	5.0	52.1	9.8	8.3	5.0	1.2	15.0	2.15	1.46	2.15	1.46	2.90	non-LIQ CLAY	1	0.72	NA	5.72	non-LIQ	non-LIQ	0.870	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
37.57	115.1	115.0	115.0	31.8	1.5	4.6	51.4	9.5	8.1	5.0	1.2	15.0	2.16	1.47	2.16	1.47	2.89	non-LIQ CLAY	1	0.72	NA	5.61	non-LIQ	non-LIQ	0.868	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
37.73	115.0	115.0	115.0	30.1	1.5	4.9	53.6	9.2	7.8	5.0	1.2	14.0	2.17	1.47	2.17	1.47	2.93	non-LIQ CLAY	1	0.72	NA	5.95	non-LIQ	non-LIQ	0.867	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
37.89	114.8	115.0	115.0	39.2	1.5	3.7	43.3	10.8	9.2	5.0	1.2	16.0	2.18	1.47	2.18	1.47	2.75	non-LIQ CLAY	1	0.72	NA	4.39	non-LIQ	non-LIQ	0.866	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
38.06	114.6	115.0	115.0	35.6	1.5	4.3	48.0	10.3	8.7	5.0	1.2	15.0	2.19	1.48	2.19	1.48	2.83	non-LIQ CLAY	1	0.72	NA	5.08	non-LIQ	non-LIQ	0.864	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
38.22	114.5	115.0	115.0	29.2	1.5	5.1	55.4	9.1	7.7	5.0	1.2	14.0	2.20	1.48	2.20	1.48	2.95	non-LIQ CLAY	1	0.71	NA	6.24	non-LIQ	non-LIQ	0.863	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
38.39	114.3	115.0	115.0	30.2	1.3	4.5	52.3	9.1	7.7	5.0	1.2	14.0	2.21	1.49	2.21	1.49	2.90	non-LIQ CLAY	1	0.71	NA	5.74	non-LIQ	non-LIQ	0.862	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
38.55	114.2	115.0	115.0	27.4	1.4	5.3	57.9	8.7	7.3	5.0	1.2	14.0	2.22	1.49	2.22	1.49	2.99	non-LIQ CLAY	1	0.71	NA	6.65	non-LIQ	non-LIQ	0.860	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
38.71	114.0	115.0	115.0	26.7	1.4	5.3	58.7	8.6	7.2	5.0	1.2	14.0	2.23	1.50	2.23	1.50	3.00	non-LIQ CLAY	1	0.71	NA	6.79	non-LIQ	non-LIQ	0.859	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
38.88	113.8	115.0	115.0	22.6	1.3	5.7	64.7	7.6	6.4	5.0	1.2	13.0	2.24	1.50	2.24	1.50	3.09	non-LIQ CLAY	1	0.71	NA	7.80	non-LIQ	non-LIQ	0.858	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
39.04	113.7	115.0	115.0	26.2	1.1	4.3	55.6	8.1	6.8	5.0	1.2	13.0	2.24	1.50	2.24	1.50	2.96	non-LIQ CLAY	1	0.70	NA	6.28	non-LIQ	non-LIQ	0.856	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
39.21	113.5	115.0	115.0	23.2	1.1	4.8	60.8	7.6	6.3	5.0	1.2	13.0	2.25	1.51	2.25	1.51	3.03	non-LIQ CLAY	1	0.70	NA	7.13	non-LIQ	non-LIQ	0.855	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
39.37	113.3	115.0	115.0	22.6	0.9	3.8	57.3	7.2	6.0	5.0	1.2	12.0	2.26	1.51	2.26	1.51	2.98	non-LIQ CLAY	1	0.70	NA	6.55	non-LIQ	non-LIQ	0.854	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
39.53	113.2	115.0	115.0	28.9	0.9	3.2	48.2	8.4	7.0	5.0	1.2	13.0	2.27	1.52	2.27	1.52	2.84	non-LIQ CLAY	1	0.70	NA	5.12	non-LIQ	non-LIQ	0.852	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
39.70	113.0	115.0	115.0	25.1	1.0	3.8	54.6	7.7	6.5	5.0	1.2	13.0	2.28	1.52	2.28	1.52	2.94	non-LIQ CLAY	1	0.70	NA	6.11	non-LIQ	non-LIQ	0.851	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
39.86	112.8	115.0	115.0	19.5	1.1	5.8	70.2	6.9	5.8	5.0	1.2	12.0	2.29	1.53	2.29	1.53	3.16	non-LIQ CLAY	1	0.69	NA	8.74	non-LIQ	non-LIQ	0.850	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
40.03	112.7	115.0	115.0	19.6	1.3	6.6	73.0	7.1	5.9	5.0	1.2	12.0	2.30	1.53	2.30	1.53	3.20	non-LIQ CLAY	1	0.69	NA	9.25	non-LIQ	non-LIQ	0.848	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
40.19	112.5	115.0	115.0	34.0	1.6	4.6	50.8	10.1	8.4	5.0	1.2	15.0	2.31	1.53	2.31	1.53	2.88	non-LIQ CLAY	1	0.69	NA	5.51	non-LIQ	non-LIQ	0.847	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
40.35	112.4	115.0	115.0	36.3	1.3	3.7	45.7	10.3	8.5	5.0	1.2	15.0	2.32	1.54	2.32	1.54	2.79	non-LIQ CLAY	1	0.69	NA	4.74	non-LIQ	non-LIQ	0.846	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
40.52	112.2	115.0	115.0	35.2	1.5	4.3	49.0	10.3	8.5	5.0	1.2	15.0	2.33	1.54	2.33	1.54	2.85	non-LIQ CLAY	1	0.69	NA	5.24	non-LIQ	non-LIQ	0.844	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
40.68	112.0	115.0	115.0	44.3	1.5	3.4	40.5	11.9	9.9	5.0	1.2	17.0	2.34	1.55	2.34	1.55	2.70	non-LIQ CLAY	1	0.68	NA	4.00	non-LIQ	non-LIQ	0.843	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
40.85	111.9	115.0	115.0	39.0	1.6	4.1	46.1	11.1	9.2	5.0	1.2	16.0	2.35	1.55	2.35	1.55	2.80	non-LIQ CLAY	1	0.68	NA	4.79	non-LIQ	non-LIQ	0.842	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
41.01	111.7	115.0	115.0	49.1	1.7	3.5	39.4	13.1	10.8	5.0	1.2	18.0	2.36	1.56	2.36	1.56	2.68	non-LIQ CLAY	1	0.68	NA	3.85	non-LIQ	non-LIQ	0.840	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
41.17	111.5	115.0	115.0	53.0	1.9	3.6	38.3	14.0	11.5	5.0	1.2	19.0	2.37	1.56	2.37	1.56	2.66	non-LIQ CLAY	1	0.68	NA	3.70	non-LIQ	non-LIQ	0.839	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
41.34	111.4	115.0	115.0	36.1	1.6	4.5	49.5	10.6	8.7	5.0	1.2	15.0	2.38	1.56	2.38	1.56	2.86	non-LIQ CLAY	1	0.68	NA	5.31	non-LIQ	non-LIQ	0.838	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
41.50	111.2	115.0	115.0	36.2	1.7	4.6	49.9	10.7	8.8	5.0	1.2	16.0	2.39	1.57	2.39	1.57	2.87	non-LIQ CLAY	1	0.67	NA	5.37	non-LIQ	non-LIQ	0.836	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
41.67	111.0	115.0	115.0	54.8	1.8	3.3	36.5	14.2	11.6	5.0	1.2	19.0	2.40	1.57	2.40	1.57	2.62	non-LIQ CLAY	1	0.67	NA	3.47	non-LIQ	non-LIQ	0.835	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
41.83	110.9	115.0	115.0	69.0	2.0	3.0	28.5	16.4	13.4	4.6	1.1	20.0	2.41	1.58	2.41	1.58	2.45	SAND	0.5	0.82	53	2.53	135	0.309	0.834	0.330	0.330	0.94	NA	NA	NA	NA	NA	0.00	15.00	1.91	0.04
41.99	110.7	115.0	115.0	63.8	1.8	2.9	29.3	15.3	12.5	4.7	1.1	19.0	2.41	1.58	2.41	1.58	2.47	SAND	0.5	0.82	49	2.62	129	0.280	0.832	0.330	0.330	0.85	NA	NA	NA	NA	NA	0.00	15.00	1.91	0.04
42.16	110.5	115.0	115.0	45.9	2.3	4.9	46.4	13.1	10.7	5.0	1.2	18.0	2.42	1.59	2.42	1.59	2.81	non-LIQ CLAY	1	0.67	NA	4.84	non-LIQ	non-LIQ	0.831	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
42.32	110.4	115.0	115.0	45.7	2.2	4.8	46.0	13.0	10.6	5.0	1.2	18.0	2.43	1.59	2.43	1.59	2.80	non-LIQ CLAY	1	0.67	NA	4.78	non-LIQ	non-LIQ	0.830	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
42.49	110.2	115.0	115.0	28.4	1.9	6.7	63.8	9.5	7.8	5.0	1.2	14.0	2.44	1.59	2.44	1.59	3.08	non-LIQ CLAY	1	0.66	NA	7.64	non-LIQ	non-LIQ	0.828	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
42.65	110.1	115.0	115.0	30.7	1.3	4.1	52.2	9.3	7.5	5.0	1.2	14.0	2.45	1.60	2.45	1.60	2.90	non-LIQ CLAY	1	0.66	NA	5.73	non-LIQ	non-LIQ	0.827	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
42.81	109.9	115.0	115.0	42.7	1.6	3.8	43.5	11.8	9.6	5.0	1.2	17.0	2.46	1.60	2.46	1.60	2.76	non-LIQ CLAY	1	0.66	NA	4.43	non-LIQ	non-LIQ	0.826	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
42.98	109.7	115.0	115.0	37.0	1.9	5.1	51.9	11.1	9.0	5.0	1.2	16.0	2.47	1.61	2.47	1.61	2.90	non-LIQ CLAY	1	0.66	NA	5.68	non-LIQ	non-LIQ	0.824	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
43.14	109.6	115.0	115.0	42.6	2.1	4.8	48.0	12.3	10.0	5.0	1.2	17.0	2.48	1.61	2.48	1.61	2.83	non-LIQ CLAY	1	0.66	NA	5.08	non-LIQ	non-LIQ	0.823	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
43.31	109.4	115.0	115.0	76.5	1.9	2.5	25.2	17.5	14.2	4.3	1.1	20.0	2.49	1.62	2.49	1.62	2.37	SAND	0.5	0.81	58	2.19	128	0.277	0.822	0.330	0.330	0.84	NA	NA	NA	NA	NA	0.00	16.00	1.84	0.04
43.47	109.2	115.0	115.0	122.4	1.8	1.5	14.5	24.6	19.9	2.3	1.0	23.0	2.50	1.62	2.50	1.62	2.05	SAND	0.5	0.81	93	1.38	129	0.278	0.820	0.330	0.330	0.84	NA	NA	NA	NA	NA	0.00	21.00	1.42	0.03
43.64	109.1	115.0	115.0	157.8	2.0	1.2	11.0	30.2	24.3	1.2	1.0	26.0	2.51	1.63	2.51	1.63	1.92	SAND	0.5	0.81	120	1.21	146	0.368	0.819	0.330	0.330	1.12	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
43.80	108.9	115.0	115.0	183.2	2.2	1.2	9.6	34.3	27.6	0.7	1.0	29.0	2.52	1.63	2.52	1.63	1.87	SAND	0.5	0.81	139	1.16	162	non-LIQ	0.818	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
43.96	108.7	115.0	115.0	203.1	2.7	1.3	9.5	38.0	30.5	0.7	1.0	32.0	2.53	1.63	2.53	1.63	1.86	SAND	0.5	0.80	155	1.16	179	non-LIQ	0.816	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
44.13	108.6	115.0	115.0	217.4	3.0	1.4	9.4	40.5	32.6	0.7	1.0	34.0	2.54	1.64	2.54	1.64	1.86	SAND	0.5	0.80	165	1.15	190	non-LIQ	0.815	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
44.29	108.4	115.0	115.0	225.0	3.2	1.4	9.3	41.9	33.6	0.6	1.0	35.0	2.55	1.64	2.55	1.64	1.85	SAND	0.5	0.80	171	1.15	196	non-LIQ	0.814	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
44.46	108.2	115.0	115.0	225.8	3.3	1.5	9.5	42.2	33.8	0.7	1.0	35.0	2.56	1.65	2.56	1.65	1.86	SAND	0.5	0.80	171	1.16	198	non-LIQ	0.812	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
44.62	108.1	115.0	115.0	221.9	3.3	1.5	9.7	41.6	33.3	0.8	1.0	35.0	2.57	1.65	2.57	1.65	1.87	SAND	0.5	0.80	168	1.16	195	non-LIQ	0.811	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
44.78	107.9	115.0	115.0	216.9	2.8	1.3	8.9	40.1	32.1	0.5	1.0	33.0	2.57	1.66	2.57	1.66	1.84	SAND	0.5	0.80	164	1.13	186	non-LIQ	0.810	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
44.95	107.8	115.0	115.0	209.6	2.2	1.0	7.6	38.0	30.3	0.2	1.0	31.0	2.58	1.66	2.58	1.66	1.78	SAND	0.5	0.80	158	1.09	173	non-LIQ	0.808	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
45.11	107.6	115.0	115.0	192.2	1.8	1.0	7.8	34.9	27.8	0.3	1.0	28.0	2.59	1.66	2.59	1.66	1.78	SAND	0.5	0.80	145	1.10	159	0.452	0.807	0.330	0.330	1.37	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
45.28	107.4	115.0	115.0	187.6	1.8	0.9	7.9	34.2	27.2	0.3	1.0	28.0	2.60	1.67	2.60	1.67	1.79	SAND	0.5	0.80	141	1.10	155	0.428	0.806	0.330	0.330	1.30	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
45.44	107.3	115.0	115.0	187.8	1.8	1.0	8.0	34.2	27.2	0.3	1.0	28.0	2.61	1.67	2.61	1.67	1.80	SAND	0.5	0.80	141	1.10	156	0.431	0.804	0.330	0.330	1.31	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
45.60	107.1	115.0	115.0	189.8	2.0	1.1	8.5	34.9	27.7	0.4	1.0	29.0	2.62	1.68	2.62	1.68	1.82	SAND	0.5	0.79	142	1.12	160	0.458	0.803	0.330	0.330	1.39	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
45.77	106.9	115.0	115.0	192.7	2.2	1.1	9.0	35.7	28.3	0.6	1.0	29.0	2.63	1.68	2.63	1.68	1.84	SAND	0.5	0.79	144	1.14	164	non-LIQ	0.802	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
45.93	106.8	115.0	115.0	192.1	2.2	1.2	9.1	35.7	28.3	0.6	1.0	29.0	2.64	1.69	2.64	1.69	1.84	SAND	0.5	0.79	144	1.14	164	non-LIQ	0.800	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
46.10	106.6	115.0	115.0	188.4	2.2	1.2	9.4	35.1	27.8	0.7	1.0	29.0	2.65	1.69	2.65	1.69	1.86	SAND	0.5	0.79	141	1.15	162	non-LIQ	0.799	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
46.26	106.4	115.0	115.0	188.6	2.3	1.2	9.6	35.3	27.9	0.8	1.0	29.0	2.66	1.69	2.66	1.69	1.87	SAND	0.5	0.79	141	1.16	163	non-LIQ	0.798	0.330	0.330	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
46.42	106.3	115.0	115.0	186.3	2.1	1.1	9.1	34.6	27.3	0.6	1.0	28.0	2.67	1.70	2.67	1.70	1.84	SAND	0.5	0.79	139	1.14	158	0.449	0.796	0.330	0.330	1.36	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
46.59	106.1	115.0	115.0	186.1	1.9	1.0	8.6	34.3	27.0	0.4	1.0	28.0	2.68	1.70	2.68	1.70	1.82	SAND	0.5	0.79	139	1.12	156	0.431	0.795	0.330	0.330	1.30	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
46.75	106.0	115.0	115.0	182.5	1.6	0.9	7.6	33.0	26.0	0.2	1.0	27.0	2.69	1.71	2.69	1.71	1.78	SAND	0.5	0.79	136	1.09	148	0.381	0.794	0.320	0.320	1.19	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
46.92	105.8	115.0	115.0	180.4	2.0	1.1	9.4	33.7	26.5	0.7	1.0	28.0	2.70	1.71	2.70	1.71	1.86	SAND	0.5	0.79	134	1.15	154	0.423	0.792	0.320	0.320	1.32	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
47.08	105.6	115.0	115.0	169.9	2.7	1.6	12.6	33.2	26.1	1.7	1.0	29.0	2.71	1.72	2.71	1.72	1.99	SAND	0.5	0.79	126	1.28	162	non-LIQ	0.791	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
47.24	105.5	115.0	115.0	169.1	2.7	1.6	12.6	33.1	25.9	1.7	1.0	29.0	2.72	1.72	2.72	1.72	1.99	SAND	0.5	0.78	125	1.28	161	non-LIQ	0.790	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
47.41	105.3	115.0	115.0	196.4	3.4	1.7	12.1	38.1	29.9	1.6	1.0	32.0	2.73	1.72	2.73	1.72	1.97	SAND	0.5	0.78	145	1.26	183	non-LIQ	0.788	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
47.57	105.1	115.0	115.0	233.6	3.4	1.5	9.5	43.6	34.1	0.7	1.0	35.0	2.74	1.73	2.74	1.73	1.86	SAND	0.5	0.78	173	1.15	199	non-LIQ	0.787	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
47.74	105.0	115.0	115.0	233.6	2.9	1.3	8.4	42.9	33.5	0.4	1.0	34.0	2.75	1.73	2.75	1.73	1.81	SAND	0.5	0.78	172	1.12	193	non-LIQ	0.785	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
47.90	104.8	115.0	115.0	253.8	1.4	0.6	3.5	42.5	33.1	0.0	1.0	33.0	2.75	1.74	2.75	1.74	1.54	SAND	0.5	0.78	187	1.00	187	non-LIQ	0.784	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
48.06	104.6	115.0	115.0	260.3	2.3	0.9	5.6	45.5	35.5	0.0	1.0	36.0	2.76	1.74	2.76	1.74	1.67	SAND	0.5	0.78	192	1.02	196	non-LIQ	0.783	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
48.23	104.5	115.0	115.0	252.1	1.6	0.6	4.2	42.8	33.3	0.0	1.0	33.0	2.77	1.75	2.77	1.75	1.59	SAND	0.5	0.78	185	1.00	185	non-LIQ	0.781	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
48.39	104.3	115.0	115.0	250.5	1.3	0.5	3.2	41.7	32.4	0.0	1.0	32.0	2.78	1.75	2.78	1.75	1.53	SAND	0.5	0.78	184	1.00	184	non-LIQ	0.780	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
48.56	104.1	115.0	115.0	245.7	1.7	0.7	4.8	42.2	32.8	0.0	1.0	33.0	2.79	1.75	2.79	1.75	1.62	SAND	0.5	0.78	180	1.00	180	non-LIQ	0.779	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
48.72	104.0	115.0	115.0	233.6	2.3	1.0	7.0	41.8	32.5	0.1	1.0	33.0	2.80	1.76	2.80	1.76	1.74	SAND	0.5	0.78	171	1.07	183	non-LIQ	0.778	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
48.88	103.8	115.0	115.0	231.9	3.1	1.3	9.0	43.0	33.3	0.6	1.0	34.0	2.81	1.76	2.81	1.76	1.84	SAND	0.5	0.77	170	1.14	193	non-LIQ	0.776	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
49.05	103.7	115.0	115.0	236.2	3.7	1.6	9.9	44.4	34.4	0.9	1.0	36.0	2.82	1.77	2.82	1.77	1.88	SAND	0.5	0.77	173	1.17	202	non-LIQ	0.775	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
49.21	103.5	115.0	115.0	239.6	4.1	1.7	10.5	45.5	35.1	1.0	1.0	37.0	2.83	1.77	2.83	1.77	1.91	SAND	0.5	0.77	175	1.19	209	non-LIQ	0.774	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
49.38	103.3	115.0	115.0	236.2	4.4	1.9	11.4	45.4	35.1	1.3	1.0	37.0	2.84	1.78	2.84	1.78	1.94	SAND	0.5	0.77	172	1.23	212	non-LIQ	0.772	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
49.54	103.2	115.0	115.0	222.5	4.4	2.0	12.3	43.4	33.5	1.7	1.0	36.0	2.85	1.78	2.85	1.78	1.98	SAND	0.5	0.77	162	1.27	206	non-LIQ	0.771	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
49.70	103.0	115.0	115.0	209.1	4.3	2.1	13.2	41.3	31.8	2.0	1.0	35.0	2.86	1.78	2.86	1.78	2.01	SAND	0.5	0.77	152	1.31	200	non-LIQ	0.770	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
49.87	102.8	115.0	115.0	199.5	4.0	2.0	13.4	39.5	30.4	2.0	1.0	34.0	2.87	1.79	2.87	1.79	2.02	SAND	0.5	0.77	145	1.32	192	non-LIQ	0.768	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
50.03	102.7	115.0	115.0	194.2	3.9	2.0	13.6	38.5	29.6	2.1	1.0	33.0	2.88	1.79	2.88	1.79	2.02	SAND	0.5	0.77	141	1.33	188	non-LIQ	0.767	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
50.20	102.5	115.0	115.0	190.9	3.7	1.9	13.4	37.8	29.0	2.0	1.0	32.0	2.89	1.80	2.89	1.80	2.02	SAND	0.5	0.77	138	1.32	183	non-LIQ	0.765	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
50.36	102.3	115.0	115.0	188.4	3.5	1.9	13.3	37.2	28.5	2.0	1.0	32.0	2.90	1.80	2.90	1.80	2.01	SAND	0.5	0.77	136	1.32	179	non-LIQ	0.764	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
50.52	102.2	115.0	115.0	183.2	3.6	2.0	14.0	36.6	28.0	2.2	1.0	31.0	2.90	1.81	2.90	1.81	2.04	SAND	0.5	0.77	133	1.35	179	non-LIQ	0.763	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
50.69	102.0	115.0	115.0	183.2	3.9	2.1	14.8	37.0	28.3	2.4	1.0	32.0	2.91	1.81	2.91	1.81	2.06	SAND	0.5	0.76	132	1.39	184	non-LIQ	0.761	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
50.85	101.9	115.0	115.0	183.0	4.3	2.3	15.6	37.4	28.5	2.7	1.1	33.0	2.92	1.81	2.92	1.81	2.09	SAND	0.5	0.76	132	1.44	191	non-LIQ	0.760	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
51.02	101.7	115.0	115.0	187.4	4.4	2.4	15.6	38.2	29.1	2.7	1.1	33.0	2.93	1.82	2.93	1.82	2.09	SAND	0.5	0.76	135	1.44	194	non-LIQ	0.759	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
51.18	101.5	115.0	115.0	183.6	4.3	2.3	15.6	37.5	28.5	2.7	1.1	33.0	2.94	1.82	2.94	1.82	2.09	SAND	0.5	0.76	132	1.44	191	non-LIQ	0.757	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00

Liquefaction Analysis with Cone Penetration Test (CPT) Data

Depth (ft)	Elev. (ft, MSL)	Unit Weight (pcf) γ'_{MOIST}	Unit Weight (pcf) γ'_{SAT}	q_c (tsf)	f_s (tsf)	Frict. Ratio (%)	% Fines	Equiv. N_{60}	Equiv. $(N_1)_{60}$	α	β	Equiv. $(N_1)_{60cs}$	Stresses at Exploration Water Level σ_v (tsf)	Stresses at Exploration Water Level σ'_v (tsf)	Stresses at Design Water Level σ_v (tsf)	Stresses at Design Water Level σ'_v (tsf)	I_c	Soil Type Character (SAND, SILT or non-LIQ CLAY)	Normalization of Tip Resistance n	C_Q	q_{c1N}	Fines Correction Kc	$(q_{c1n})_{cs}$	$CRR_{7.5}$	r_d	CSR_M	$CSR_{7.5}$	FS	a	b	Max Shear Modulus G_{max} (tsf)	Cyclic Shear Strain γ (%)	Norm. Vol. Strain ε_{Nc} (%)	Dry Settle. ΔS (in)	Post-Liq. $(N_1)_{60cs}$	Post-Liq. Vol. Strain ε (%)	Layer Post-Liq. Settle. ΔS (in)
51.35	101.4	115.0	115.0	176.4	3.9	2.2	15.4	35.9	27.3	2.6	1.1	31.0	2.95	1.83	2.95	1.83	2.08	SAND	0.5	0.76	127	1.43	181	non-LIQ	0.756	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
51.51	101.2	115.0	115.0	171.4	3.7	2.1	15.4	34.8	26.5	2.6	1.1	30.0	2.96	1.83	2.96	1.83	2.08	SAND	0.5	0.76	123	1.43	176	non-LIQ	0.755	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
51.67	101.0	115.0	115.0	162.0	3.4	2.1	15.7	33.1	25.1	2.7	1.1	29.0	2.97	1.84	2.97	1.84	2.10	SAND	0.5	0.76	116	1.45	168	non-LIQ	0.754	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
51.84	100.9	115.0	115.0	151.5	3.4	2.2	17.0	31.5	23.9	3.0	1.1	28.0	2.98	1.84	2.98	1.84	2.14	SAND	0.5	0.76	109	1.53	166	non-LIQ	0.752	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
52.00	100.7	115.0	115.0	126.9	3.7	2.9	21.8	28.0	21.2	3.9	1.1	27.0	2.99	1.84	2.99	1.84	2.28	SAND	0.5	0.76	91	1.88	171	non-LIQ	0.751	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
52.17	100.5	115.0	115.0	91.7	3.1	3.4	27.7	21.6	16.3	4.5	1.1	23.0	3.00	1.85	3.00	1.85	2.43	SAND	0.5	0.76	66	2.44	160	non-LIQ	0.749	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
52.33	100.4	115.0	115.0	37.4	1.9	5.0	54.9	11.6	8.7	5.0	1.2	15.0	3.01	1.85	3.01	1.85	2.95	non-LIQ CLAY	1	0.57	NA	6.16	non-LIQ	non-LIQ	0.748	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
52.49	100.2	115.0	115.0	24.0	0.9	3.9	62.3	7.9	6.0	5.0	1.2	12.0	3.02	1.86	3.02	1.86	3.06	non-LIQ CLAY	1	0.57	NA	7.39	non-LIQ	non-LIQ	0.747	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
52.66	100.0	115.0	115.0	18.8	0.6	3.3	67.2	6.5	4.9	5.0	1.2	11.0	3.03	1.86	3.03	1.86	3.12	non-LIQ CLAY	1	0.57	NA	8.23	non-LIQ	non-LIQ	0.745	0.320	0.320	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
52.82	99.9	115.0	115.0	16.5	0.6	3.5	73.2	6.1	4.6	5.0	1.2	10.0	3.04	1.87	3.04	1.87	3.20	non-LIQ CLAY	1	0.57	NA	9.28	non-LIQ	non-LIQ	0.744	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
52.99	99.7	115.0	115.0	16.8	0.7	4.0	75.4	6.3	4.7	5.0	1.2	11.0	3.05	1.87	3.05	1.87	3.23	non-LIQ CLAY	1	0.57	NA	9.69	non-LIQ	non-LIQ	0.743	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
53.15	99.6	115.0	115.0	19.4	0.7	3.5	67.5	6.7	5.0	5.0	1.2	11.0	3.06	1.88	3.06	1.88	3.13	non-LIQ CLAY	1	0.56	NA	8.28	non-LIQ	non-LIQ	0.741	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
53.31	99.4	115.0	115.0	17.4	0.7	3.9	73.4	6.4	4.8	5.0	1.2	11.0	3.07	1.88	3.07	1.88	3.21	non-LIQ CLAY	1	0.56	NA	9.33	non-LIQ	non-LIQ	0.740	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
53.48	99.2	115.0	115.0	17.0	0.7	4.2	76.1	6.4	4.8	5.0	1.2	11.0	3.08	1.88	3.08	1.88	3.24	non-LIQ CLAY	1	0.56	NA	9.80	non-LIQ	non-LIQ	0.739	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
53.64	99.1	115.0	115.0	22.1	0.7	3.3	62.1	7.3	5.5	5.0	1.2	12.0	3.08	1.89	3.08	1.89	3.05	non-LIQ CLAY	1	0.56	NA	7.35	non-LIQ	non-LIQ	0.737	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
53.81	98.9	115.0	115.0	27.1	0.9	3.3	56.1	8.5	6.3	5.0	1.2	13.0	3.09	1.89	3.09	1.89	2.96	non-LIQ CLAY	1	0.56	NA	6.35	non-LIQ	non-LIQ	0.736	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
53.97	98.7	115.0	115.0	22.6	0.9	3.8	64.5	7.6	5.7	5.0	1.2	12.0	3.10	1.90	3.10	1.90	3.09	non-LIQ CLAY	1	0.56	NA	7.75	non-LIQ	non-LIQ	0.735	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
54.13	98.6	115.0	115.0	17.7	0.7	4.0	74.1	6.5	4.9	5.0	1.2	11.0	3.11	1.90	3.11	1.90	3.21	non-LIQ CLAY	1	0.56	NA	9.44	non-LIQ	non-LIQ	0.733	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
54.30	98.4	115.0	115.0	16.6	0.5	3.2	72.0	6.0	4.5	5.0	1.2	10.0	3.12	1.91	3.12	1.91	3.19	non-LIQ CLAY	1	0.56	NA	9.08	non-LIQ	non-LIQ	0.732	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
54.46	98.2	115.0	115.0	16.8	0.5	2.8	69.3	5.9	4.4	5.0	1.2	10.0	3.13	1.91	3.13	1.91	3.15	non-LIQ CLAY	1	0.55	NA	8.59	non-LIQ	non-LIQ	0.731	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
54.63	98.1	115.0	115.0	19.1	0.5	2.8	64.5	6.5	4.8	5.0	1.2	11.0	3.14	1.91	3.14	1.91	3.09	non-LIQ CLAY	1	0.55	NA	7.77	non-LIQ	non-LIQ	0.729	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
54.79	97.9	115.0	115.0	22.3	0.7	3.1	61.7	7.3	5.5	5.0	1.2	12.0	3.15	1.92	3.15	1.92	3.05	non-LIQ CLAY	1	0.55	NA	7.27	non-LIQ	non-LIQ	0.728	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
54.95	97.8	115.0	115.0	23.4	1.0	4.1	65.1	8.0	5.9	5.0	1.2	12.0	3.16	1.92	3.16	1.92	3.09	non-LIQ CLAY	1	0.55	NA	7.86	non-LIQ	non-LIQ	0.727	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
55.12	97.6	115.0	115.0	30.2	1.1	3.6	55.5	9.4	7.0	5.0	1.2	13.0	3.17	1.93	3.17	1.93	2.95	non-LIQ CLAY	1	0.55	NA	6.25	non-LIQ	non-LIQ	0.725	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
55.28	97.4	115.0	115.0	27.5	1.2	4.4	61.8	9.0	6.7	5.0	1.2	13.0	3.18	1.93	3.18	1.93	3.05	non-LIQ CLAY	1	0.55	NA	7.30	non-LIQ	non-LIQ	0.724	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
55.45	97.3	115.0	115.0	25.4	1.2	4.8	65.9	8.7	6.4	5.0	1.2	13.0	3.19	1.94	3.19	1.94	3.11	non-LIQ CLAY	1	0.55	NA	8.01	non-LIQ	non-LIQ	0.723	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
55.61	97.1	115.0	115.0	29.5	1.3	4.5	60.5	9.6	7.1	5.0	1.2	14.0	3.20	1.94	3.20	1.94	3.03	non-LIQ CLAY	1	0.55	NA	7.08	non-LIQ	non-LIQ	0.721	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
55.77	96.9	115.0	115.0	27.5	1.3	4.6	62.9	9.2	6.8	5.0	1.2	13.0	3.21	1.94	3.21	1.94	3.06	non-LIQ CLAY	1	0.54	NA	7.49	non-LIQ	non-LIQ	0.720	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
55.94	96.8	115.0	115.0	25.1	1.2	5.0	67.3	8.7	6.4	5.0	1.2	13.0	3.22	1.95	3.22	1.95	3.13	non-LIQ CLAY	1	0.54	NA	8.25	non-LIQ	non-LIQ	0.719	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
56.10	96.6	115.0	115.0	25.8	1.1	4.4	64.2	8.7	6.4	5.0	1.2	13.0	3.23	1.95	3.23	1.95	3.08	non-LIQ CLAY	1	0.54	NA	7.70	non-LIQ	non-LIQ	0.717	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
56.27	96.4	115.0	115.0	36.5	1.3	3.5	50.7	10.8	8.0	5.0	1.2	15.0	3.24	1.96	3.24	1.96	2.88	non-LIQ CLAY	1	0.54	NA	5.49	non-LIQ	non-LIQ	0.716	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
56.43	96.3	115.0	115.0	42.8	1.6	3.8	48.0	12.4	9.1	5.0	1.2	16.0	3.24	1.96	3.24	1.96	2.83	non-LIQ CLAY	1	0.54	NA	5.09	non-LIQ	non-LIQ	0.715	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
56.59	96.1	115.0	115.0	41.8	2.0	4.9	53.1	12.7	9.3	5.0	1.2	16.0	3.25	1.97	3.25	1.97	2.92	non-LIQ CLAY	1	0.54	NA	5.87	non-LIQ	non-LIQ	0.713	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
56.76	95.9	115.0	115.0	38.7	2.2	5.8	58.4	12.4	9.1	5.0	1.2	16.0	3.26	1.97	3.26	1.97	3.00	non-LIQ CLAY	1	0.54	NA	6.73	non-LIQ	non-LIQ	0.712	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
56.92	95.8	115.0	115.0	31.1	1.7	5.6	63.7	10.4	7.6	5.0	1.2	14.0	3.27	1.97	3.27	1.97	3.08	non-LIQ CLAY	1	0.54	NA	7.63	non-LIQ	non-LIQ	0.711	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
57.09	95.6	115.0	115.0	23.8	1.4	5.8	72.7	8.7	6.3	5.0	1.2	13.0	3.28	1.98	3.28	1.98	3.20	non-LIQ CLAY	1	0.53	NA	9.19	non-LIQ	non-LIQ	0.709	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
57.25	95.5	115.0	115.0	34.0	1.5	4.5	57.0	10.7	7.8	5.0	1.2	14.0	3.29	1.98	3.29	1.98	2.98	non-LIQ CLAY	1	0.53	NA	6.50	non-LIQ	non-LIQ	0.708	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
57.41	95.3	115.0	115.0	37.3	1.8	5.0	56.5	11.7	8.5	5.0	1.2	15.0	3.30	1.99	3.30	1.99	2.97	non-LIQ CLAY	1	0.53	NA	6.42	non-LIQ	non-LIQ	0.707	0.310	0.310	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
57.58	95.1	115.0	115.0	29.4	1.7	5.9	66.7	10.1	7.4	5.0	1.2	14.0	3.31	1.99	3.31	1.99	3.12	non-LIQ CLAY	1	0.53	NA	8.14	non-LIQ	non-LIQ	0.705	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
57.74	95.0	115.0	115.0	25.7	1.6	6.3	72.2	9.3	6.8	5.0	1.2	13.0	3.32	2.00	3.32	2.00	3.19	non-LIQ CLAY	1	0.53	NA	9.10	non-LIQ	non-LIQ	0.704	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
57.91	94.8	115.0	115.0	23.7	1.2	5.0	70.3	8.4	6.1	5.0	1.2	12.0	3.33	2.00	3.33	2.00	3.16	non-LIQ CLAY	1	0.53	NA	8.77	non-LIQ	non-LIQ	0.703	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
58.07	94.6	115.0	115.0	22.5	1.3	5.7	74.6	8.4	6.1	5.0	1.2	12.0	3.34	2.00	3.34	2.00	3.22	non-LIQ CLAY	1	0.53	NA	9.54	non-LIQ	non-LIQ	0.701	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
58.23	94.5	115.0	115.0	24.3	1.4	5.6	71.9	8.8	6.4	5.0	1.2	13.0	3.35	2.01	3.35	2.01	3.19	non-LIQ CLAY	1	0.53	NA	9.06	non-LIQ	non-LIQ	0.700	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
58.40	94.3	115.0	115.0	28.1	1.5	5.5	66.7	9.7	7.0	5.0	1.2	13.0	3.36	2.01	3.36	2.01	3.12	non-LIQ CLAY	1	0.53	NA	8.14	non-LIQ	non-LIQ	0.699	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
58.56	94.1	115.0	115.0	43.7	1.8	4.1	49.7	12.9	9.3	5.0	1.2	16.0	3.37	2.02	3.37	2.02	2.86	non-LIQ CLAY	1	0.52	NA	5.35	non-LIQ	non-LIQ	0.697	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
58.73	94.0	115.0	115.0	47.3	2.0	4.3	48.7	13.8	10.0	5.0	1.2	17.0	3.38	2.02	3.38	2.02	2.85	non-LIQ CLAY	1	0.52	NA	5.19	non-LIQ	non-LIQ	0.696	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
58.89	93.8	115.0	115.0	52.0	2.1	4.0	45.3	14.7	10.6	5.0	1.2	18.0	3.39	2.03	3.39	2.03	2.79	non-LIQ CLAY	1	0.52	NA	4.69	non-LIQ	non-LIQ	0.695	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
59.06	93.6	115.0	115.0	40.6	1.9	4.8	54.2	12.5	9.0	5.0	1.2	16.0	3.40	2.03	3.40	2.03	2.94	non-LIQ CLAY	1	0.52	NA	6.05	non-LIQ	non-LIQ	0.693	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
59.22	93.5	115.0	115.0	36.6	1.8	4.8	57.2	11.6	8.3	5.0	1.2	15.0	3.41	2.03	3.41	2.03	2.98	non-LIQ CLAY	1	0.52	NA	6.53	non-LIQ	non-LIQ	0.692	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
59.38	93.3	115.0	115.0	52.1	2.3	4.3	47.0	14.9	10.8	5.0	1.2	18.0	3.41	2.04	3.41	2.04	2.82	non-LIQ CLAY	1	0.52	NA	4.93	non-LIQ	non-LIQ	0.691	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
59.55	93.2	115.0	115.0	68.3	3.0	4.4	41.7	18.6	13.4	5.0	1.2	21.0	3.42	2.04	3.42	2.04	2.72	non-LIQ CLAY	1	0.52	NA	4.17	non-LIQ	non-LIQ	0.689	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
59.71	93.0	115.0	115.0	69.6	2.6	3.8	39.2	18.5	13.3	5.0	1.2	21.0	3.43	2.05	3.43	2.05	2.68	non-LIQ CLAY	1	0.52	NA	3.82	non-LIQ	non-LIQ	0.688	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
59.88	92.8	115.0	115.0	76.5	2.4	3.2	30.2	18.5	13.3	4.7	1.2	20.0	3.44	2.05	3.44	2.05	2.49	SAND	0.5	0.72	52	2.71	141	0.340	0.687	0.300	0.300	1.13	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
60.04	92.7	115.0	115.0	78.5	2.8	3.5	36.1	20.2	14.5	5.0	1.2	22.0	3.45	2.06	3.45	2.06	2.61	non-LIQ CLAY	1	0.51	NA	3.42	non-LIQ	non-LIQ	0.685	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
60.20	92.5	115.0	115.0	73.8	2.8	3.7	38.0	19.4	13.9	5.0	1.2	22.0	3.46	2.06	3.46	2.06	2.65	non-LIQ CLAY	1	0.51	NA	3.66	non-LIQ	non-LIQ	0.684	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
60.37	92.3	115.0	115.0	71.1	2.8	4.0	39.6	19.0	13.6	5.0	1.2	21.0	3.47	2.07	3.47	2.07	2.68	non-LIQ CLAY	1	0.51	NA	3.88	non-LIQ	non-LIQ	0.683	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
60.53	92.2	115.0	115.0	64.6	2.8	4.3	42.6	17.8	12.7	5.0	1.2	20.0	3.48	2.07	3.48	2.07	2.74	non-LIQ CLAY	1	0.51	NA	4.30	non-LIQ	non-LIQ	0.681	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
60.70	92.0	115.0	115.0	49.8	2.3	4.6	49.3	14.6	10.4	5.0	1.2	18.0	3.49	2.07	3.49	2.07	2.86	non-LIQ CLAY	1	0.51	NA	5.28	non-LIQ	non-LIQ	0.680	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
60.86	91.8	115.0	115.0	45.2	2.3	5.1	53.4	13.8	9.8	5.0	1.2	17.0	3.50	2.08	3.50	2.08	2.92	non-LIQ CLAY	1	0.51	NA	5.92	non-LIQ	non-LIQ	0.679	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
61.02	91.7	115.0	115.0	38.7	2.2	5.6	59.3	12.5	8.9	5.0	1.2	16.0	3.51	2.08	3.51	2.08	3.01	non-LIQ CLAY	1	0.51	NA	6.87	non-LIQ	non-LIQ	0.677	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
61.19	91.5	115.0	115.0	23.4	1.8	7.8	82.1	9.3	6.6	5.0	1.2	13.0	3.52	2.09	3.52	2.09	3.31	non-LIQ CLAY	1	0.51	NA	10.91	non-LIQ	non-LIQ	0.676	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
61.35	91.4	115.0	115.0	20.1	1.3	6.2	82.7	8.0	5.7	5.0	1.2	12.0	3.53	2.09	3.53	2.09	3.32	non-LIQ CLAY	1	0.51	NA	11.02	non-LIQ	non-LIQ	0.675	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
61.52	91.2	115.0	115.0	17.4	1.0	6.0	87.8	7.3	5.2	5.0	1.2	11.0	3.54	2.10	3.54	2.10	3.38	non-LIQ CLAY	1	0.50	NA	11.96	non-LIQ	non-LIQ	0.673	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
61.68	91.0	115.0	115.0	17.7	1.0	5.4	84.5	7.2	5.1	5.0	1.2	11.0	3.55	2.10	3.55	2.10	3.34	non-LIQ CLAY	1	0.50	NA	11.36	non-LIQ	non-LIQ	0.672	0.300	0.300	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
61.84	90.9	115.0	115.0	20.3	1.0	4.7	76.2	7.6	5.4	5.0	1.2	11.0	3.56	2.10	3.56	2.10	3.24	non-LIQ CLAY	1	0.50	NA	9.83	non-LIQ	non-LIQ	0.671	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
62.01	90.7	115.0	115.0	19.0	1.0	5.1	80.4	7.4	5.3	5.0	1.2	11.0	3.57	2.11	3.57	2.11	3.29	non-LIQ CLAY	1	0.50	NA	10.60	non-LIQ	non-LIQ	0.669	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
62.17	90.5	115.0	115.0	22.9	1.5	6.5	79.2	8.8	6.3	5.0	1.2	13.0	3.57	2.11	3.57	2.11	3.28	non-LIQ CLAY	1	0.50	NA	10.37	non-LIQ	non-LIQ	0.668	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
62.34	90.4	115.0	115.0	37.1	2.0	5.3	59.8	12.0	8.5	5.0	1.2	15.0	3.58	2.12	3.58	2.12	3.02	non-LIQ CLAY	1	0.50	NA	6.97	non-LIQ	non-LIQ	0.667	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
62.50	90.2	115.0	115.0	42.7	2.0	4.7	53.9	13.1	9.2	5.0	1.2	16.0	3.59	2.12	3.59	2.12	2.93	non-LIQ CLAY	1	0.50	NA	5.99	non-LIQ	non-LIQ	0.665	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
62.66	90.0	115.0	115.0	42.2	2.3	5.5	57.2	13.3	9.4	5.0	1.2	16.0	3.60	2.13	3.60	2.13	2.98	non-LIQ CLAY	1	0.50	NA	6.54	non-LIQ	non-LIQ	0.664	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
62.83	89.9	115.0	115.0	38.4	2.0	5.1	58.2	12.3	8.6	5.0	1.2	15.0	3.61	2.13	3.61	2.13	3.00	non-LIQ CLAY	1	0.50	NA	6.70	non-LIQ	non-LIQ	0.663	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
62.99	89.7	115.0	115.0	40.1	2.1	5.3	57.9	12.8	9.0	5.0	1.2	16.0	3.62	2.13	3.62	2.13	2.99	non-LIQ CLAY	1	0.50	NA	6.64	non-LIQ	non-LIQ	0.661	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
63.16	89.5	115.0	115.0	48.5	2.5	5.2	52.9	14.7	10.4	5.0	1.2	17.0	3.63	2.14	3.63	2.14	2.91	non-LIQ CLAY	1	0.49	NA	5.85	non-LIQ	non-LIQ	0.660	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
63.32	89.4	115.0	115.0	32.9	1.6	5.0	62.2	10.9	7.7	5.0	1.2	14.0	3.64	2.14	3.64	2.14	3.05	non-LIQ CLAY	1	0.49	NA	7.37	non-LIQ	non-LIQ	0.659	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
63.48	89.2	115.0	115.0	24.1	1.8	7.6	81.7	9.5	6.7	5.0	1.2	13.0	3.65	2.15	3.65	2.15	3.31	non-LIQ CLAY	1	0.49	NA	10.83	non-LIQ	non-LIQ	0.657	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
63.65	89.1	115.0	115.0	23.0	2.0	8.8	87.0	9.5	6.7	5.0	1.2	13.0	3.66	2.15	3.66	2.15	3.37	non-LIQ CLAY	1	0.49	NA	11.82	non-LIQ	non-LIQ	0.656	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
63.81	88.9	115.0	115.0	54.2	2.3	4.2	46.8	15.5	10.9	5.0	1.2	18.0	3.67	2.16	3.67	2.16	2.81	non-LIQ CLAY	1	0.49	NA	4.90	non-LIQ	non-LIQ	0.655	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
63.98	88.7	115.0	115.0	57.6	2.4	4.1	45.3	16.3	11.4	5.0	1.2	19.0	3.68	2.16	3.68	2.16	2.79	non-LIQ CLAY	1	0.49	NA	4.68	non-LIQ	non-LIQ	0.653	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
64.14	88.6	115.0	115.0	53.8	2.8	5.2	50.7	16.0	11.2	5.0	1.2	18.0	3.69	2.16	3.69	2.16	2.88	non-LIQ CLAY	1	0.49	NA	5.49	non-LIQ	non-LIQ	0.652	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
64.30	88.4	115.0	115.0	42.5	2.4	5.7	58.4	13.6	9.5	5.0	1.2	16.0	3.70	2.17	3.70	2.17	3.00	non-LIQ CLAY	1	0.49	NA	6.73	non-LIQ	non-LIQ	0.651	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
64.47	88.2	115.0	115.0	36.5	2.3	6.2	64.0	12.3	8.6	5.0	1.2	15.0	3.71	2.17	3.71	2.17	3.08	non-LIQ CLAY	1	0.49	NA	7.67	non-LIQ	non-LIQ	0.649	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00
64.63	88.1	115.0	115.0	45.6	2.1	4.6	52.7	13.8	9.6	5.0	1.2	17.0	3.72	2.18	3.72	2.18	2.91	non-LIQ CLAY	1	0.49	NA	5.81	non-LIQ	non-LIQ	0.648	0.290	0.290	non-LIQ	NA	NA	NA	NA	NA	0.00	NA	NA	0.00

5/N5-N1 Connector Separation (55-0226) Widening | SP | 11-137

LIQUEFACTION ANALYSIS; ACC. = 0.4 g | 16-Feb-12

Liquefaction analysis is performed following Seed's Procedure, outlined by Seed et al (1985), Seed and Harder (1990), updated NCEER (1997)

Emean/E60 = Energy Ratio to correct to standard 60% Energy
Surcharge = Any surcharge on top of the ground (psf)
acc. max = maximum peak acceleration at the ground surface (g's)
^1C_N = square root of (100 kPa or 1.04427 tsf/effective overburden)
The induced cyclic stress ratio (CSR i) by a given peak ground acceleration (acc. max) is:

CSR i = 0.65 x acc max. x total normal stress x rd / (effective normal stress x g)

where: rd = stress reduction factor (Robertson and Wride (1996), Marcuson (USArmy Eng), per NCEER (1997))
g = acceleration of gravity

The resisting cyclic stress ratio (CSR r) is equal to:

CSR r = CSR x Cm x K sigma

where: Cm = Earthquake Magnitude Correction Factor (Blake, NCEER Table 3, Eq.4)
K sigma = Normalized resistance factor (Fig. 14 from NCEER Liquefaction workshop, Harder Boulanger)
CSR = Resisting Cyclic Stress Ratio. It is a function of the content of fines
(Figure 2, NCEER Workshop, after Seed et al 1985))

Factor of Safety, F sub L is:

F sub L = CSR r / CSR i

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Emean (%) 75 Sur.= psf 186.7 =top of ground el. Borehole Diamete 8 142.7 =water table El. acc. max = 0.40 g Earthq. M= 7.5
C_E 1.25 C_B 1.15 Cm= 1.00

ELEVATION TOP OF LAYER (ft.)	LAYER THICKNESS L (ft.)	TOTAL OVERBUR. PRESS. (tsf)	EFFEC. OVERBUR. PRESS. (tsf)	DEPTH BELOW SURFACE (ft)	C_N	C_R	C_S	C_{ST}	TOTAL UNIT WEIGHT (pcf)	SAMPLER TYPE 1=SPT 2=CA.MOD.	SAMPLER LINED 1=UNLINED 2=LINED	FIELD BLOW COUNT N	STRESS REDUC. COEFF. rd	INDUCED CYCLIC STRESS RATIO	CORRECT BLOW COUNT Nc	EST. PERCENT OF FINES (%)	(N1)60cs	K sigma	RESIST. CYCLIC STRESS RATIO M=7.5	RESIST. CYCLIC STRESS RATIO Overburd Cor Mag Corr	FACTOR OF SAFETY (F sub L)	WILL IT LIQUEFY?
181.7	5	0.29	0.29	5.00	1.91	0.75	1.00	0.50	115	2	2	55	0.99	0.26	57	51.0	74	1.00	high N	high N	LARGE	AboveWT
176.7	5	0.58	0.58	10.00	1.35	0.75	1.20	1.00	115	1	1	15	0.98	0.25	27	51.0	38	1.00	high N	high N	LARGE	AboveWT
171.7	5	0.86	0.86	15.00	1.10	0.85	1.00	0.50	115	2	2	100	0.97	0.25	68	49.0	87	1.00	high N	high N	LARGE	AboveWT
166.7	5	1.15	1.15	20.00	0.95	0.85	1.20	1.00	115	1	1	31	0.95	0.25	44	15.0	49	0.98	high N	high N	LARGE	AboveWT
161.7	5	1.44	1.44	25.00	0.85	0.95	1.00	0.50	115	2	2	100	0.94	0.24	59	98.0	76	0.94	high N	high N	LARGE	AboveWT
156.7	5	1.73	1.73	30.00	0.78	0.95	1.20	1.00	115	1	1	42	0.93	0.24	54	51.0	70	0.90	high N	high N	LARGE	AboveWT
151.7	5	2.01	2.01	35.00	0.72	1.00	1.00	0.50	115	2	2	100	0.89	0.23	52	51.0	68	0.88	high N	high N	LARGE	AboveWT
146.7	5	2.30	2.30	40.00	0.67	1.00	1.20	1.00	115	1	1	41	0.85	0.22	48	51.0	63	0.86	high N	high N	LARGE	AboveWT
141.7	5	2.59	2.43	45.00	0.66	1.00	1.00	0.50	115	2	2	100	0.81	0.22	48	51.0	63	0.85	high N	high N	LARGE	high N/fines
136.7	5	2.88	2.56	50.00	0.64	1.00	1.20	1.00	115	1	1	54	0.77	0.22	60	51.0	77	0.83	high N	high N	LARGE	high N/fines
131.7	5	3.16	2.69	55.00	0.62	1.00	1.00	0.50	115	2	2	100	0.73	0.22	45	51.0	59	0.82	high N	high N	LARGE	high N/fines
126.7	5	3.45	2.83	60.00	0.61	1.00	1.20	1.00	115	1	1	51	0.69	0.22	54	51.0	70	0.81	high N	high N	LARGE	high N/fines
121.7	5	3.74	2.96	65.00	0.59	1.00	1.00	0.50	115	2	2	100	0.64	0.21	43	51.0	57	0.80	high N	high N	LARGE	high N/fines
116.7	5	4.03	3.09	70.00	0.58	1.00	1.20	1.00	115	1	1	71	0.60	0.20	72	51.0	92	0.78	high N	high N	LARGE	high N/fines
111.7	5	4.31	3.22	75.00	0.57	1.00	1.00	0.50	115	2	2	100	0.56	0.20	41	51.0	55	0.77	high N	high N	LARGE	high N/fines
106.7	5	4.60	3.35	80.00	0.56	1.00	1.20	1.00	115	1	1	74	0.55	0.20	72	51.0	92	0.76	high N	high N	LARGE	high N/fines
101.7	5	4.89	3.48	85.00	0.55	1.00	1.00	0.50	115	2	2	100	0.54	0.20	40	51.0	53	0.75	high N	high N	LARGE	high N/fines
96.7	5	5.18	3.62	90.00	0.54	1.00	1.20	1.00	115	1	1	57	0.52	0.20	53	51.0	69	0.75	high N	high N	LARGE	high N/fines
91.7	5	5.46	3.75	95.00	0.53	1.00	1.00	0.50	115	2	2	100	0.51	0.19	38	51.0	51	0.74	high N	high N	LARGE	high N/fines
86.7	5	5.75	3.88	100.00	0.52	1.00	1.20	1.00	115	1	1	48	0.50	0.19	43	51.0	57	0.73	high N	high N	LARGE	high N/fines

5/N5-N1 Connector Separation (55-0226) Widening
LIQUEFACTION ANALYSIS; ACC. = 0.4 g

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16-Feb-12

Liquefaction analysis is performed following Seed's Procedure, outlined by Seed et al (1985), Seed and Harder (1990), updated NCEER (1997)

Emean/E60 = Energy Ratio to correct to standard 60% Energy
Surcharge = Any surcharge on top of the ground (psf)
acc. max = maximum peak acceleration at the ground surface (g's)
^1C_N = square root of (100 kPa or 1.04427 tsf/effective overburden)
The induced cyclic stress ratio (CSR i) by a given peak ground acceleration (acc. max) is:

CSR i = 0.65 x acc max. x total normal stress x rd / (effective normal stress x g)

where: rd = stress reduction factor (Robertson and Wride (1996), Marcuson (USArmy Eng), per NCEER (1997))
g = acceleration of gravity

The resisting cyclic stress ratio (CSR r) is equal to:

CSR r = CSR x Cm x K sigma

where: Cm = Earthquake Magnitude Correction Factor (Blake, NCEER Table 3, Eq.4)
K sigma = Normalized resistance factor (Fig. 14 from NCEER Liquefaction workshop, Harder Boulanger)
CSR = Resisting Cyclic Stress Ratio. It is a function of the content of fines
(Figure 2, NCEER Workshop, after Seed et al 1985))

Factor of Safety, F sub L is:

F sub L = CSR r / CSR i

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Emean (%) 75 Sur.= psf 173 =top of ground el. Borehole Diamete 8 142.7 =water table El. acc. max = 0.40 g Earthq. M= 7.5
C_E 1.25 C_B 1.15 Cm= 1.00

ELEVATION TOP OF LAYER (ft.)	LAYER THICKNESS L (ft.)	TOTAL OVERBUR. PRESS. (tsf)	EFFEC. OVERBUR. PRESS. (tsf)	DEPTH BELOW SURFACE (ft)	C_N	C_R	C_S	C_{ST}	TOTAL UNIT WEIGHT (pcf)	SAMPLER TYPE 1=SPT 2=CA.MOD.	SAMPLER LINED 1=UNLINED 2=LINED	FIELD BLOW COUNT N	STRESS REDUC. COEFF. rd	INDUCED CYCLIC STRESS RATIO	CORRECT BLOW COUNT Nc	EST. PERCENT OF FINES (%)	(N1)60cs	K sigma	RESIST. CYCLIC STRESS RATIO M=7.5	RESIST. CYCLIC STRESS RATIO Overburd Cor Mag Corr	FACTOR OF SAFETY (F sub L)	WILL IT LIQUEFY?
168	5	0.29	0.29	5.00	1.91	0.75	1.20	1.00	115	1	1	26	0.99	0.26	65	15.0	71	1.00	high N	high N	LARGE	AboveWT
163	5	0.58	0.58	10.00	1.35	0.75	1.00	0.50	115	2	2	25	0.98	0.25	19	51.0	28	1.00	0.37	0.37	1.45	AboveWT
158	5	0.86	0.86	15.00	1.10	0.85	1.20	1.00	115	1	1	20	0.97	0.25	33	15.0	38	1.00	high N	high N	LARGE	AboveWT
153	5	1.15	1.15	20.00	0.95	0.85	1.00	0.50	115	2	2	95	0.95	0.25	56	51.0	73	0.98	high N	high N	LARGE	AboveWT
148	5	1.44	1.44	25.00	0.85	0.95	1.20	1.00	115	1	1	30	0.94	0.24	42	51.0	56	0.94	high N	high N	LARGE	AboveWT
143	5	1.73	1.73	30.00	0.78	0.95	1.00	0.50	115	2	2	71	0.93	0.24	38	98.0	51	0.90	high N	high N	LARGE	AboveWT
138	5	2.01	1.86	35.00	0.75	1.00	1.20	1.00	115	1	1	32	0.89	0.25	42	51.0	56	0.88	high N	high N	LARGE	high N/fines
133	5	2.30	1.99	40.00	0.72	1.00	1.00	0.50	115	2	2	100	0.85	0.26	53	51.0	69	0.86	high N	high N	LARGE	high N/fines
128	5	2.59	2.12	45.00	0.70	1.00	1.20	1.00	115	1	1	36	0.81	0.26	44	51.0	58	0.87	high N	high N	LARGE	high N/fines
123	5	2.88	2.25	50.00	0.68	1.00	1.00	0.50	115	2	2	100	0.77	0.25	49	51.0	64	0.86	high N	high N	LARGE	high N/fines
118	5	3.16	2.38	55.00	0.66	1.00	1.20	1.00	115	1	1	42	0.73	0.25	48	51.0	63	0.85	high N	high N	LARGE	high N/fines
113	5	3.45	2.51	60.00	0.64	1.00	1.00	0.50	115	2	2	100	0.69	0.24	47	51.0	62	0.84	high N	high N	LARGE	high N/fines
108	5	3.74	2.65	65.00	0.63	1.00	1.20	1.00	115	1	1	46	0.64	0.24	50	51.0	65	0.83	high N	high N	LARGE	high N/fines
103	5	4.03	2.78	70.00	0.61	1.00	1.00	0.50	115	2	2	100	0.60	0.23	45	51.0	59	0.82	high N	high N	LARGE	high N/fines
98	5	4.31	2.91	75.00	0.60	1.00	1.20	1.00	115	1	1	46	0.56	0.22	48	51.0	63	0.81	high N	high N	LARGE	high N/fines
93	5	4.60	3.04	80.00	0.59	1.00	1.00	0.50	115	2	2	100	0.55	0.22	43	51.0	57	0.78	high N	high N	LARGE	high N/fines
88	5	4.89	3.17	85.00	0.57	1.00	1.20	1.00	115	1	1	58	0.54	0.22	58	51.0	75	0.77	high N	high N	LARGE	high N/fines
83	5	5.18	3.30	90.00	0.56	1.00	1.00	0.50	115	2	2	100	0.52	0.21	41	51.0	55	0.76	high N	high N	LARGE	high N/fines
78	5	5.46	3.43	95.00	0.55	1.00	1.20	1.00	115	1	1	49	0.51	0.21	47	51.0	62	0.76	high N	high N	LARGE	high N/fines
73	5	5.75	3.57	100.00	0.54	1.00	1.00	0.50	115	2	2	100	0.50	0.21	39	51.0	52	0.75	high N	high N	LARGE	high N/fines

RIGHT BRIDGE (I-5 Northbound)

5/N5-N1 CONNECTOR SEPARATION (55-0226)

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

17800 Newhope Street, Suite B, Fountain Valley, CA 92708
(714) 751-3826, Fax (714) 751-3928

Project 5/N5-N1 connector separation (55-0226) **Project No.** 11-137

By SP **Date** 02/22/12 **Checked By** LLC **Date** 3/20/12 **Sheet** ____ **of** ____

Right Bridge

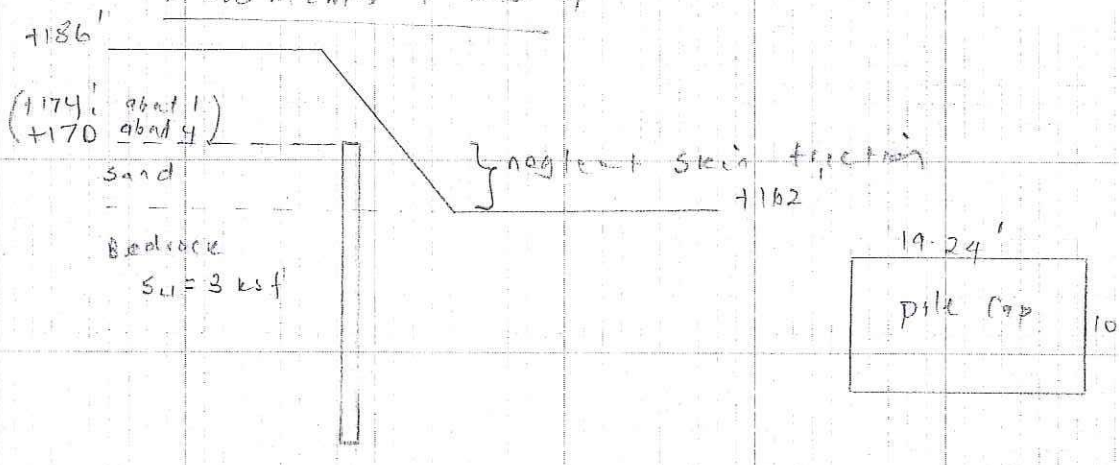
24-inch CIDH pile

$P = \pi D = \pi \times 2 = 6.283$ ft

$A = \frac{\pi}{4} D^2 = \frac{\pi}{4} \times 24^2 = 452.4$ in^2 $= 3.142$ ft^2

$I = \frac{\pi}{64} 24^4 = 16286$ in^4 ; $I_{crack} = 8143$ in^4

Abutments 1 and 4



Abutment 1

Maximum load per pile = 183 kips

Nominal Resistance = 183 x 2 = 366 kips ; Consider 370 kips

Nominal Resistance per support = 660 x 2 = 1320 kips

Abutment 4

Maximum load per pile = 127 kips

Nominal Resistance = 127 x 2 = 254 kips

consider 260 kips

Nominal Resistance per support = 616 x 2 = 1232 kips

consider 1240 kips

average pile spacing = 3d

Group reduction factor = 0.75

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

17800 Newhope Street, Suite B, Fountain Valley, CA 92708
(714) 751-3826, Fax (714) 751-3928

Project SJNS-N1 connector separation C55-02261 **Project No.** 11-137

By SP **Date** 02/23/12 **Checked By** LSC **Date** 3/20/12 **Sheet** ____ **of** ____

from analyses

Abutment 1 - cut off elevation +174 feet.

at depth of 49 feet, pile capacity = 373 kips > 370 kips

pile tip elevation for compression = 174 - 49 = +125 feet

Available group nominal resistance at pile tip elevation of +125 ft = 6 x 373 x 0.75 = 1678 kips

Required group nominal resistance = 1320 kips < 1678 kips

Available group nominal resistance exceeds required group nominal resistant.

Abutment 1 pile tip elevation for compression = +125 feet.

Nominal resistance = 370 kips

Abutment 4 - cut off elevation +171 feet

at depth of 35 feet

pile capacity = 269 kips

pile tip elevation for compression = 170 - 35

= +135 feet

Available group nominal resistance at pile tip elevation of +135 ft = 6 x 269 x 0.75

= 1210 kips

Required nominal resistance = 1240 kips > 1210 kips

compression capacity needed per pile = $\frac{1240}{6 \times 0.75}$ = 276 kips

consider 280 kips

at depth of 37 feet

pile capacity = 290 kips > 280 kips

Abutment 4 pile tip elevation for compression = +170 - 37

= +133 feet

nominal resistance = 280 kips

SKIN FRICTION FOR DRILLED SHAFT IN BOTH COHESIONLESS AND COHESIVE SOILS USING REESE AND O'NEILL'S METHOD (1999)

PROJECT: 5/N5-N1 Connector Separation (55-0226) ITEM: 24-inch Diameter CIDH Pile
PROJECT NO.: 11-137 Abutment 1 (Right Bridge)
DONE BY: SP DATE: 02/23/12
CHECKED BY: DATE:

D_s => 2.00 ft Hw => 5.0 ft Hg => 0.0 ft
p = 6.28 ft Ho => 0.0 ft Hf => 0.0 ft

Hw is the depth to water table.
Hg is the depth to ground surface used in calculation.
Ho is the depth to location starting initial overburden pressure
Hf is the depth to location starting accumulation of skin frictio
bottom of footing = 174 ft

Soil Layer =>	from Top	to Bottom =>	γ (pcf)=>	γ' (pcf)=	c' (ksf) =>	ϕ' =>	
(1)	0	13	120	57.6	0.00	32	SM
(2)	13	50	120	57.6	3.00	0	Bedrock

Sublayer No.	Depth, z (ft)	z_i (ft)	New Depth (ft)	Soil Unit Weight (pcf)	Overburden Pressure (psf)	c' (ksf)	β	f_i^s (ksf)	ΔQ_s^s (kips)	Q_s^s (kips)	f_i^c (ksf)	ΔQ_s^c (kips)	Q_s^c (kips)	Q_s (kips)
0	0.0	0.0	0.0	120.0	0									
1	0.0	0.0	0.0	120.0	0	0.0				0.0			0.0	0.0
2	1.0	0.5	0.5	120.0	60	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
3	2.0	1.5	1.5	120.0	180	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
4	3.0	2.5	2.5	120.0	300	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
5	4.0	3.5	3.5	120.0	420	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
6	5.0	4.5	4.5	120.0	540	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
7	6.0	5.5	5.5	57.6	598	0.0	1.18	0.00	0.0	0.0	0.00	0.0	0.0	0.0
8	7.0	6.5	6.5	57.6	655	0.0	1.16	0.00	0.0	0.0	0.00	0.0	0.0	0.0
9	8.0	7.5	7.5	57.6	713	0.0	1.13	0.00	0.0	0.0	0.00	0.0	0.0	0.0
10	9.0	8.5	8.5	57.6	770	0.0	1.11	0.00	0.0	0.0	0.00	0.0	0.0	0.0
11	10.0	9.5	9.5	57.6	828	0.0	1.08	0.00	0.0	0.0	0.00	0.0	0.0	0.0
12	11.0	10.5	10.5	57.6	886	0.0	1.06	0.00	0.0	0.0	0.00	0.0	0.0	0.0
13	12.0	11.5	11.5	57.6	943	0.0	1.04	0.00	0.0	0.0	0.00	0.0	0.0	0.0
14	13.0	12.5	12.5	57.6	1001	0.0	1.02	0.00	0.0	0.0	0.00	0.0	0.0	0.0
15	14.0	13.5	13.5	57.6	1058	3.0	1.00	0.00	0.0	0.0	1.65	10.4	10.4	10.4
16	15.0	14.5	14.5	57.6	1116	3.0	0.99	0.00	0.0	0.0	1.65	10.4	20.8	20.8
17	16.0	15.5	15.5	57.6	1174	3.0	0.97	0.00	0.0	0.0	1.65	10.4	31.1	31.1
18	17.0	16.5	16.5	57.6	1231	3.0	0.95	0.00	0.0	0.0	1.65	10.4	41.5	41.5
19	18.0	17.5	17.5	57.6	1289	3.0	0.94	0.00	0.0	0.0	1.65	10.4	51.9	51.9
20	19.0	18.5	18.5	57.6	1346	3.0	0.92	0.00	0.0	0.0	1.65	10.4	62.2	62.2
21	20.0	19.5	19.5	57.6	1404	3.0	0.90	0.00	0.0	0.0	1.65	10.4	72.6	72.6
22	21.0	20.5	20.5	57.6	1462	3.0	0.89	0.00	0.0	0.0	1.65	10.4	83.0	83.0
23	22.0	21.5	21.5	57.6	1519	3.0	0.87	0.00	0.0	0.0	1.65	10.4	93.3	93.3
24	23.0	22.5	22.5	57.6	1577	3.0	0.86	0.00	0.0	0.0	1.65	10.4	103.7	103.7
25	24.0	23.5	23.5	57.6	1634	3.0	0.85	0.00	0.0	0.0	1.65	10.4	114.1	114.1
26	25.0	24.5	24.5	57.6	1692	3.0	0.83	0.00	0.0	0.0	1.65	10.4	124.4	124.4
27	26.0	25.5	25.5	57.6	1750	3.0	0.82	0.00	0.0	0.0	1.65	10.4	134.8	134.8
28	27.0	26.5	26.5	57.6	1807	3.0	0.81	0.00	0.0	0.0	1.65	10.4	145.2	145.2
29	28.0	27.5	27.5	57.6	1865	3.0	0.79	0.00	0.0	0.0	1.65	10.4	155.5	155.5
30	29.0	28.5	28.5	57.6	1922	3.0	0.78	0.00	0.0	0.0	1.65	10.4	165.9	165.9
31	30.0	29.5	29.5	57.6	1980	3.0	0.77	0.00	0.0	0.0	1.65	10.4	176.3	176.3
32	31.0	30.5	30.5	57.6	2038	3.0	0.75	0.00	0.0	0.0	1.65	10.4	186.6	186.6
33	32.0	31.5	31.5	57.6	2095	3.0	0.74	0.00	0.0	0.0	1.65	10.4	197.0	197.0
34	33.0	32.5	32.5	57.6	2153	3.0	0.73	0.00	0.0	0.0	1.65	10.4	207.4	207.4
35	34.0	33.5	33.5	57.6	2210	3.0	0.72	0.00	0.0	0.0	1.65	10.4	217.7	217.7
36	35.0	34.5	34.5	57.6	2268	3.0	0.71	0.00	0.0	0.0	1.65	10.4	228.1	228.1
37	36.0	35.5	35.5	57.6	2326	3.0	0.70	0.00	0.0	0.0	1.65	10.4	238.5	238.5
38	37.0	36.5	36.5	57.6	2383	3.0	0.68	0.00	0.0	0.0	1.65	10.4	248.8	248.8
39	38.0	37.5	37.5	57.6	2441	3.0	0.67	0.00	0.0	0.0	1.65	10.4	259.2	259.2
40	39.0	38.5	38.5	57.6	2498	3.0	0.66	0.00	0.0	0.0	1.65	10.4	269.6	269.6
41	40.0	39.5	39.5	57.6	2556	3.0	0.65	0.00	0.0	0.0	1.65	10.4	279.9	279.9
42	41.0	40.5	40.5	57.6	2614	3.0	0.64	0.00	0.0	0.0	1.65	10.4	290.3	290.3
43	42.0	41.5	41.5	57.6	2671	3.0	0.63	0.00	0.0	0.0	1.65	10.4	300.7	300.7
44	43.0	42.5	42.5	57.6	2729	3.0	0.62	0.00	0.0	0.0	1.65	10.4	311.0	311.0
45	44.0	43.5	43.5	57.6	2786	3.0	0.61	0.00	0.0	0.0	1.65	10.4	321.4	321.4
46	45.0	44.5	44.5	57.6	2844	3.0	0.60	0.00	0.0	0.0	1.65	10.4	331.8	331.8
47	46.0	45.5	45.5	57.6	2902	3.0	0.59	0.00	0.0	0.0	1.65	10.4	342.1	342.1
48	47.0	46.5	46.5	57.6	2959	3.0	0.58	0.00	0.0	0.0	1.65	10.4	352.5	352.5
49	48.0	47.5	47.5	57.6	3017	3.0	0.57	0.00	0.0	0.0	1.65	10.4	362.9	362.9
50	49.0	48.5	48.5	57.6	3074	3.0	0.56	0.00	0.0	0.0	1.65	10.4	373.2	373.2
51	50.0	49.5	49.5	57.6	3132	3.0	0.55	0.00	0.0	0.0	1.65	10.4	383.6	383.6

SKIN FRICTION FOR DRILLED SHAFT IN BOTH COHESIONLESS AND COHESIVE SOILS USING REESE AND O'NEILL'S METHOD (1999)

PROJECT: 5/N5-N1 Connector Separation (55-0226) ITEM: 24-inch Diameter CIDH Pile
PROJECT NO.: 11-137 Abutment 4 (Right Bridge)
DONE BY: SP DATE: 02/23/12
CHECKED BY: DATE:

D_s => 2.00 ft Hw => 5.0 ft Hg => 0.0 ft
p = 6.28 ft Ho => 0.0 ft Hf => 0.0 ft

Hw is the depth to water table.
Hg is the depth to ground surface used in calculation.
Ho is the depth to location starting initial overburden pressure
Hf is the depth to location starting accumulation of skin frictio
bottom of footing = 171 ft

Soil Layer =>	from Top	to Bottom =>	γ (pcf)=>	γ' (pcf)=	c' (ksf) =>	φ' =>	
(1)	0	9	120	57.6	0.00	32	SM
(2)	9	50	120	57.6	3.00	0	Bedrock

Sublayer No.	Depth, z (ft)	z_i (ft)	New Depth (ft)	Soil Unit Weight (pcf)	Overburden Pressure (psf)	c' (ksf)	β	f_i^s (ksf)	ΔQ_s^s (kips)	Q_s^s (kips)	f_i^c (ksf)	ΔQ_s^c (kips)	Q_s^c (kips)	Q_s (kips)
0	0.0	0.0	0.0	120.0	0									
1	0.0	0.0	0.0	120.0	0	0.0				0.0			0.0	0.0
2	1.0	0.5	0.5	120.0	60	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
3	2.0	1.5	1.5	120.0	180	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
4	3.0	2.5	2.5	120.0	300	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
5	4.0	3.5	3.5	120.0	420	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
6	5.0	4.5	4.5	120.0	540	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
7	6.0	5.5	5.5	57.6	598	0.0	1.18	0.00	0.0	0.0	0.00	0.0	0.0	0.0
8	7.0	6.5	6.5	57.6	655	0.0	1.16	0.00	0.0	0.0	0.00	0.0	0.0	0.0
9	8.0	7.5	7.5	57.6	713	0.0	1.13	0.00	0.0	0.0	0.00	0.0	0.0	0.0
10	9.0	8.5	8.5	57.6	770	0.0	1.11	0.00	0.0	0.0	0.00	0.0	0.0	0.0
11	10.0	9.5	9.5	57.6	828	3.0	1.08	0.00	0.0	0.0	1.65	10.4	10.4	10.4
12	11.0	10.5	10.5	57.6	886	3.0	1.06	0.00	0.0	0.0	1.65	10.4	20.7	20.7
13	12.0	11.5	11.5	57.6	943	3.0	1.04	0.00	0.0	0.0	1.65	10.4	31.1	31.1
14	13.0	12.5	12.5	57.6	1001	3.0	1.02	0.00	0.0	0.0	1.65	10.4	41.5	41.5
15	14.0	13.5	13.5	57.6	1058	3.0	1.00	0.00	0.0	0.0	1.65	10.4	51.9	51.9
16	15.0	14.5	14.5	57.6	1116	3.0	0.99	0.00	0.0	0.0	1.65	10.4	62.2	62.2
17	16.0	15.5	15.5	57.6	1174	3.0	0.97	0.00	0.0	0.0	1.65	10.4	72.6	72.6
18	17.0	16.5	16.5	57.6	1231	3.0	0.95	0.00	0.0	0.0	1.65	10.4	83.0	83.0
19	18.0	17.5	17.5	57.6	1289	3.0	0.94	0.00	0.0	0.0	1.65	10.4	93.3	93.3
20	19.0	18.5	18.5	57.6	1346	3.0	0.92	0.00	0.0	0.0	1.65	10.4	103.7	103.7
21	20.0	19.5	19.5	57.6	1404	3.0	0.90	0.00	0.0	0.0	1.65	10.4	114.1	114.1
22	21.0	20.5	20.5	57.6	1462	3.0	0.89	0.00	0.0	0.0	1.65	10.4	124.4	124.4
23	22.0	21.5	21.5	57.6	1519	3.0	0.87	0.00	0.0	0.0	1.65	10.4	134.8	134.8
24	23.0	22.5	22.5	57.6	1577	3.0	0.86	0.00	0.0	0.0	1.65	10.4	145.2	145.2
25	24.0	23.5	23.5	57.6	1634	3.0	0.85	0.00	0.0	0.0	1.65	10.4	155.5	155.5
26	25.0	24.5	24.5	57.6	1692	3.0	0.83	0.00	0.0	0.0	1.65	10.4	165.9	165.9
27	26.0	25.5	25.5	57.6	1750	3.0	0.82	0.00	0.0	0.0	1.65	10.4	176.3	176.3
28	27.0	26.5	26.5	57.6	1807	3.0	0.81	0.00	0.0	0.0	1.65	10.4	186.6	186.6
29	28.0	27.5	27.5	57.6	1865	3.0	0.79	0.00	0.0	0.0	1.65	10.4	197.0	197.0
30	29.0	28.5	28.5	57.6	1922	3.0	0.78	0.00	0.0	0.0	1.65	10.4	207.4	207.4
31	30.0	29.5	29.5	57.6	1980	3.0	0.77	0.00	0.0	0.0	1.65	10.4	217.7	217.7
32	31.0	30.5	30.5	57.6	2038	3.0	0.75	0.00	0.0	0.0	1.65	10.4	228.1	228.1
33	32.0	31.5	31.5	57.6	2095	3.0	0.74	0.00	0.0	0.0	1.65	10.4	238.5	238.5
34	33.0	32.5	32.5	57.6	2153	3.0	0.73	0.00	0.0	0.0	1.65	10.4	248.8	248.8
35	34.0	33.5	33.5	57.6	2210	3.0	0.72	0.00	0.0	0.0	1.65	10.4	259.2	259.2
36	35.0	34.5	34.5	57.6	2268	3.0	0.71	0.00	0.0	0.0	1.65	10.4	269.6	269.6
37	36.0	35.5	35.5	57.6	2326	3.0	0.70	0.00	0.0	0.0	1.65	10.4	279.9	279.9
38	37.0	36.5	36.5	57.6	2383	3.0	0.68	0.00	0.0	0.0	1.65	10.4	290.3	290.3
39	38.0	37.5	37.5	57.6	2441	3.0	0.67	0.00	0.0	0.0	1.65	10.4	300.7	300.7
40	39.0	38.5	38.5	57.6	2498	3.0	0.66	0.00	0.0	0.0	1.65	10.4	311.0	311.0
41	40.0	39.5	39.5	57.6	2556	3.0	0.65	0.00	0.0	0.0	1.65	10.4	321.4	321.4
42	41.0	40.5	40.5	57.6	2614	3.0	0.64	0.00	0.0	0.0	1.65	10.4	331.8	331.8
43	42.0	41.5	41.5	57.6	2671	3.0	0.63	0.00	0.0	0.0	1.65	10.4	342.1	342.1
44	43.0	42.5	42.5	57.6	2729	3.0	0.62	0.00	0.0	0.0	1.65	10.4	352.5	352.5
45	44.0	43.5	43.5	57.6	2786	3.0	0.61	0.00	0.0	0.0	1.65	10.4	362.9	362.9
46	45.0	44.5	44.5	57.6	2844	3.0	0.60	0.00	0.0	0.0	1.65	10.4	373.2	373.2
47	46.0	45.5	45.5	57.6	2902	3.0	0.59	0.00	0.0	0.0	1.65	10.4	383.6	383.6
48	47.0	46.5	46.5	57.6	2959	3.0	0.58	0.00	0.0	0.0	1.65	10.4	394.0	394.0
49	48.0	47.5	47.5	57.6	3017	3.0	0.57	0.00	0.0	0.0	1.65	10.4	404.3	404.3
50	49.0	48.5	48.5	57.6	3074	3.0	0.56	0.00	0.0	0.0	1.65	10.4	414.7	414.7
51	50.0	49.5	49.5	57.6	3132	3.0	0.55	0.00	0.0	0.0	1.65	10.4	425.1	425.1

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

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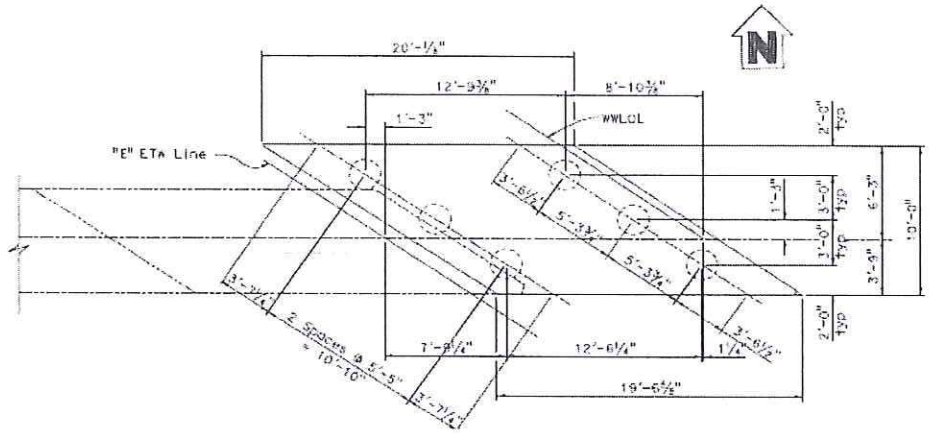
phone: (714)751-3826, Fax (714)751-3928

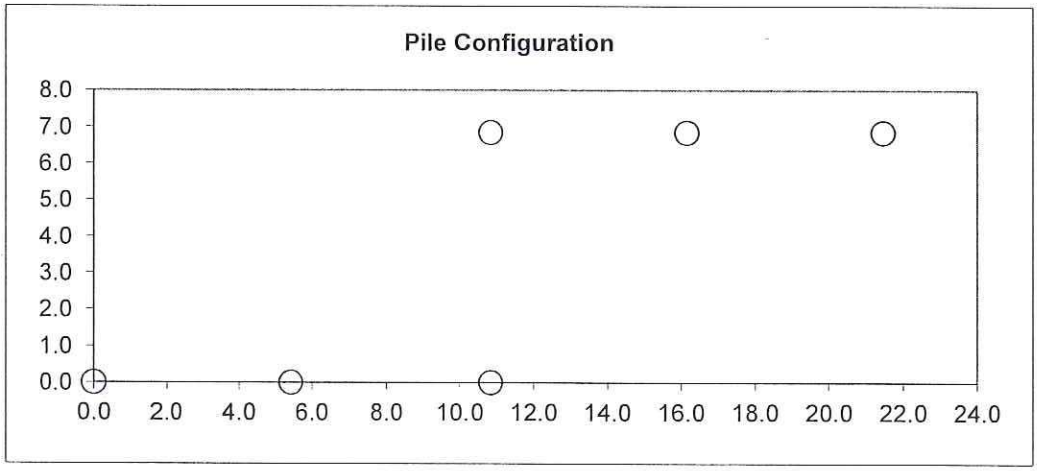
Project: 5/N5-N1 Connector Separation (55-0226) Project No. 11-137
By SP Date 02/22/12 Check by Date Sheet

Proposed Abutment 4 (Right Bridge) Pile Layout



Calculation of Pile Group Efficiency for Lateral Load Capacity

(using formula in Group 7.0 Technical Manual)



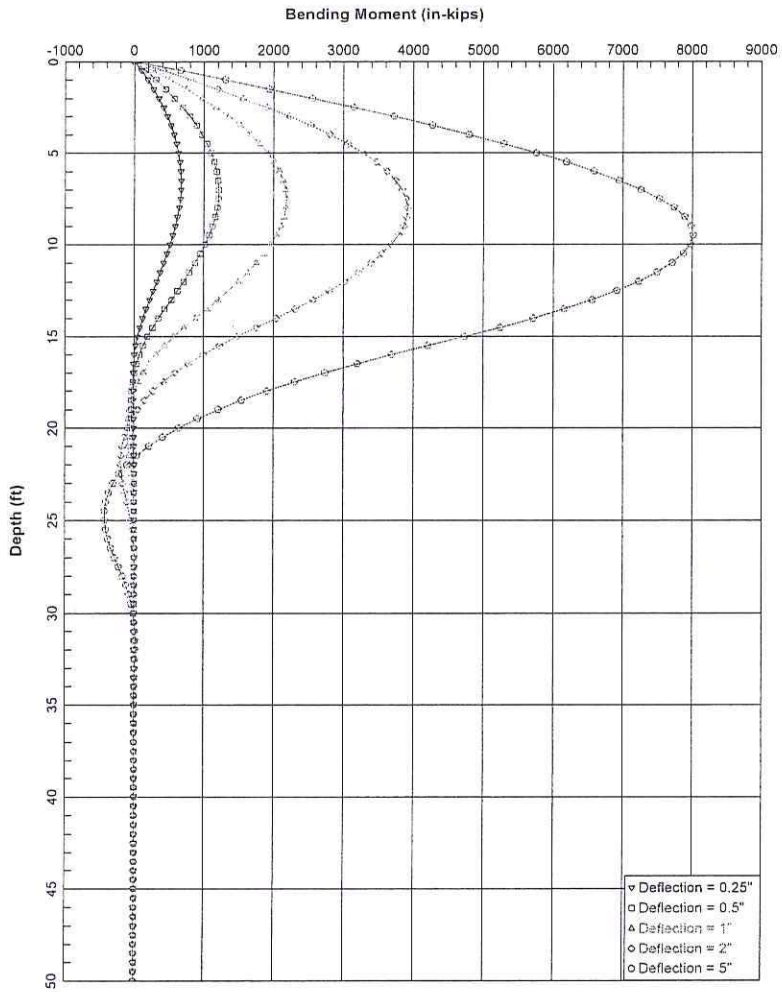
Pile Dia. (feet): 2
No. of Piles: 6

Group Efficiency	X-Dir	Y-Dir
	0.69	0.80

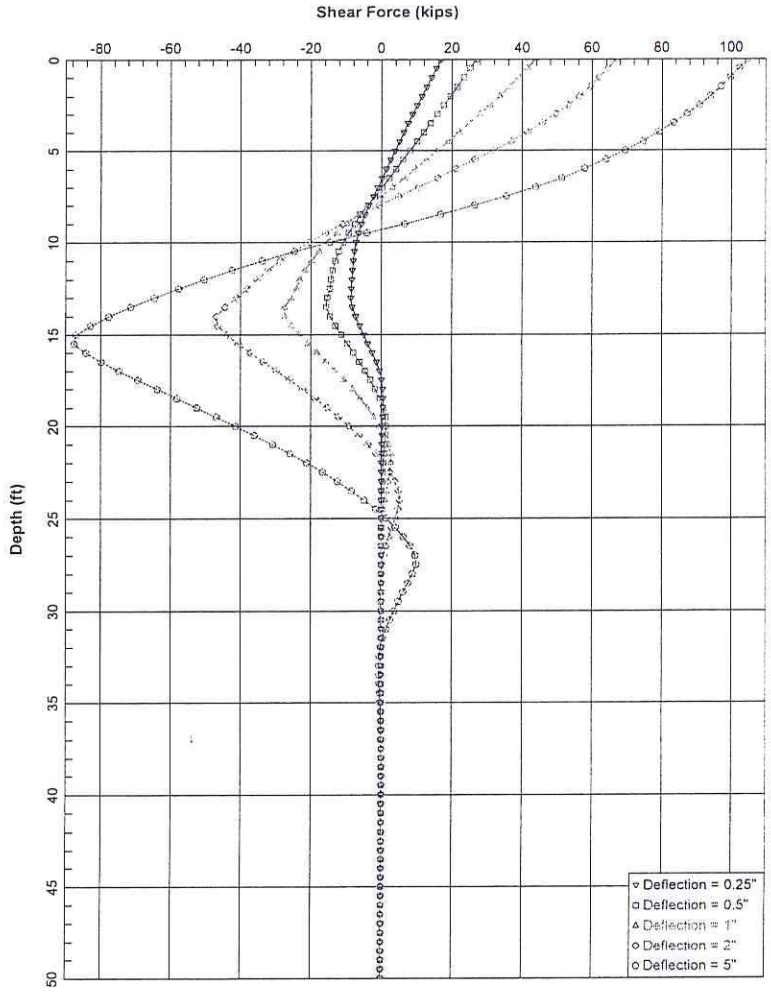
Coordinates

Pile No.	X	Y
1	0.0	0.0
2	5.4	0.0
3	10.8	0.0
4	10.8	6.8
5	16.1	6.8
6	21.5	6.8

Reduction Factors in X-dir	Reduction Factors in Y-dir
0.627	0.891
0.586	0.724
0.812	0.615
0.612	0.860
0.628	0.796
0.902	0.892



I-5 HOV Improvement, PCH to San Juan Creek Road - 24-inch CIDH Piles at Abutments 1 and 4 (Right Bridge)



I-5 HOV Improvement, PCH to San Juan Creek Road - 24-inch CIDH Piles at Abutments 1 and 4 (Right Bridge)

```
================================================================================

                    LPile Plus for Windows, Version 6.0 (6.0.09)

                  Analysis of Individual Piles and Drilled Shafts
                 Subjected to Lateral Loading Using the p-y Method

                            (c) 1985-2010 by Ensoft, Inc.
                                All Rights Reserved

================================================================================

This program is licensed to:

Earth Mechanics, Inc.
Earth Mechanics, Inc.

--------------------------------------------------------------------------------
                              Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:      X:\Projects\2011\11-137 - TRC, I-5 HOV Widening - Segment 3\Reports\02 5_N5-N1 Conn Sep (55-0226)\Analysis\Lateral Capacity\
Name of input data file:     5_N5_N1 Conn Sep 24-inch CIDH (Abutments 1 and 4-Right Bridge).lp6d
Name of output file:         5_N5_N1 Conn Sep 24-inch CIDH (Abutments 1 and 4-Right Bridge).lp6o
Name of plot output file:    5_N5_N1 Conn Sep 24-inch CIDH (Abutments 1 and 4-Right Bridge).lp6p
Name of runtime file:        5_N5_N1 Conn Sep 24-inch CIDH (Abutments 1 and 4-Right Bridge).lp6r

--------------------------------------------------------------------------------
                            Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  February 24, 2012      Time:  13:59:47

--------------------------------------------------------------------------------
                                 Problem Title
--------------------------------------------------------------------------------

Project Name:
Job Number:
Client:
Engineer:
Description:


--------------------------------------------------------------------------------
                                 Program Options
--------------------------------------------------------------------------------

Units Used - US Customary Units: pounds, inches, feet

Basic Program Options:

This analysis computes nonlinear bending stiffness and nominal Moment
  Capacity with Pile Response Computed Using Nonlinear EI

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis uses p-y multipliers for group action
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix elements
- Output summary table of values for pile-head deflection, maximum
  bending moment, and shear force only
- Analysis assumes no soil movements acting on pile
- No p-y curves to be computed and output for user-specified depths

Solution Control Parameters:
- Number of pile increments                     =          100
- Maximum number of iterations allowed          =          100
- Deflection tolerance for convergence          =   1.0000E-05  in
- Maximum allowable deflection                  =     100.0000  in

Pile Response Output Options:
- Only summary tables of pile-head deflection, maximum bending moment,
  and maximum shear force are to be written to output report file.

--------------------------------------------------------------------------------
                      Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Total Number of Sections                       =          1

Total Pile Length                              =      50.00 ft

Depth of ground surface below top of pile      =      -5.00 ft
```

Slope angle of ground surface = 0.00 deg.

Pile dimensions used for p-y curve computations defined using 2 points.
p-y curves are computed using values of pile diameter interpolated over
the length of the pile.

Point	Depth X ft	Pile Diameter in
1	0.00000	24.0000000
2	50.000000	24.0000000

Input Structural Properties:

Section No. 1:

Section Type	=	Elastic Pile
Cross-sectional Shape	=	Circular
Section Length	=	50.000 in
Top Width	=	24.000 in
Bottom Width	=	24.000 in
Top Area	=	452.000000 sq. in
Bottom Area	=	452.000000 sq. in
Moment of Inertia at Top	=	8.143E+03 in^4
Moment of Inertia at Bottom	=	8.143E+03 in^4
Elastic Modulus	=	3200000.000 lbs/in

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = -5.000 ft
Distance from top of pile to bottom of layer = 7.000 ft
p-y subgrade modulus k for top of soil layer = 90.000 lbs/in**3
p-y subgrade modulus k for bottom of layer = 90.000 lbs/in**3

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 7.000 ft
Distance from top of pile to bottom of layer = 13.000 ft
p-y subgrade modulus k for top of soil layer = 60.000 lbs/in**3
p-y subgrade modulus k for bottom of layer = 60.000 lbs/in**3

Layer 3 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer = 13.000 ft
Distance from top of pile to bottom of layer = 60.000 ft

(Depth of lowest layer extends 10.00 ft below pile tip)

Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 6 points

Point No.	Depth X ft	Eff. Unit Weight pcf
1	-5.00	60.00000
2	7.00	60.00000
3	7.00	57.60000
4	13.00	57.60000
5	13.00	57.60000
6	60.00	57.60000

Summary of Soil Properties

Layer Num.	Soil Type (p-y Curve Criteria)	Depth ft	Eff. Unit Wt., pcf	Cohesion psf	Friction Ang., deg.	qu psi	RQD percent	Epsilon 50	kpy pci	Rock Emass psi	krm	Test Type	Test Prop.	Elas. Subgr. pci
1	Sand (Reese, et al.)	-5.000	60.000	--	32.000	--	--	--	90.000	--	--	--	--	--
		7.000	60.000	--	32.000	--	--	--	90.000	--	--	--	--	--
2	Sand (Reese, et al.)	7.000	57.600	--	32.000	--	--	--	60.000	--	--	--	--	--
		13.000	57.600	--	32.000	--	--	--	60.000	--	--	--	--	--
3	Soft Clay	13.000	57.600	3000.000	--	--	--	0.00500	--	--	--	--	--	--
		60.000	57.600	3000.000	--	--	--	0.00500	--	--	--	--	--	--

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.7000	1.0000
2	50.000	0.7000	1.0000

Loading Type

p-y criteria for static loading was used for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 5

Load No.	Load Type	Condition 1		Condition 2		Axial Thrust Force, lbs
1	4	y =	0.250 in	M =	0.000 in-lbs	150000.000
2	4	y =	0.500 in	M =	0.000 in-lbs	150000.000
3	4	y =	1.000 in	M =	0.000 in-lbs	150000.000
4	4	y =	2.000 in	M =	0.000 in-lbs	150000.000
5	4	y =	5.000 in	M =	0.000 in-lbs	150000.000

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust values were determined from pile-head loading conditions

Number of Sections = 1

Section No. 1:

Moment-Curvature properties derived from elastic section properties

Summary of Pile Response(s)

Definitions of Pile-Head Loading Conditions:

Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

Load Case No.	Load Type No.	Condition 1 V(lbs) or y(inches)	Condition 2 in-lb, rad., or in-lb/rad.	Axial Load lbs	Pile-Head Deflection inches	Maximum Moment in-lbs	Maximum Shear lbs	Pile-Head Rotation radians

1	4	y =	0.2500	M =	0.000	150000.	0.25000000	674448.	16887.	0.00000000
2	4	y =	0.5000	M =	0.000	150000.	0.50000000	1212980.	26820.	0.00000000
3	4	y =	1.0000	M =	0.000	150000.	1.00000000	2183299.	43756.	0.00000000
4	4	y =	2.0000	M =	0.000	150000.	2.00000000	3913106.	66908.	0.00000000
5	4	y =	5.0000	M =	0.000	150000.	5.00000000	8013742.	104697.	0.00000000

Summary of Warning Messages

The following warning was reported 1184 times

**** Warning ****

An unreasonable input value for shear strength has been specified for a soil defined using the soft clay criteria. The input value is greater than 8.68 psi (1,250 psf). You should check your input data for correctness.

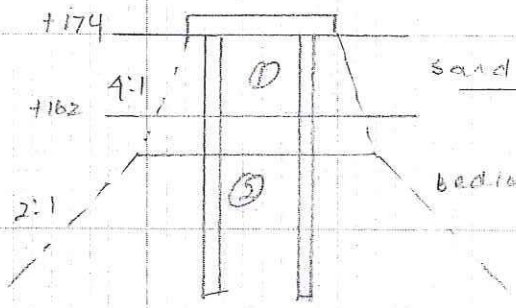
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

17800 Newhope Street, Suite B, Fountain Valley, CA 92708
(714) 751-3826, Fax (714) 751-3928

Project 5/405-N1 connector separation (55-0226) **Project No.** 11-197

By SP **Date** 02-24-12 **Checked By** LCC **Date** 2/29/12 **Sheet** ____ **of** ____

Settlement



Total load per support = 660 kip
permanent load per support = 590 k
pile cap = 19' x 10'

consider pile length D = 18

$\frac{2}{3}B = 12$

Equivalent footing = $(19 + \frac{12}{4} \times 2) \times (10 + \frac{12}{6} \times 2)$
= 25' x 16'

$q = \frac{660}{25 \times 16} = 1.65$ ksf for immediate settlement

$q = \frac{590}{25 \times 16} = 1.48$ ksf for consolidation settlement

	σ_{vo}	$\Delta\sigma$	Settlement
②	$7 \times 120 + 15 \times 57.6 = 1.76$	$\frac{590}{(25+10)(16+10)} = 0.65$	$20 \times \frac{1}{40} \log\left(\frac{1.76+0.65}{1.76}\right) = 0.8$
	$7 \times 120 + 35 \times 57.6 = 2.91$	$\frac{590}{(25+30)(16+30)} = 0.24$	$20 \times \frac{1}{40} \log\left(\frac{2.91+0.24}{2.91}\right) = 0.2$
	$7 \times 120 + 50 \times 57.6 = 3.72$	$\frac{590}{(25+45)(16+45)} = 0.13$	$10 \times \frac{1}{40} \log\left(\frac{3.72+0.13}{3.72}\right) = 0.04$
			1.04"

pile length for settlement = 15 ft
pile tip elevation for settlement = 174 - 18 = +156 for Abut 1
= 170 - 18 = +152 for Abut 4

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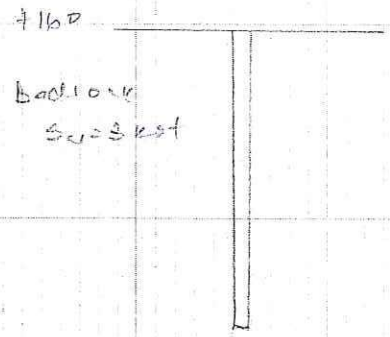
Project 5/405-N1 connector separation (53-0226) **Project No.** 11-137

By SD **Date** 02-24-12 **Checked By** LCC **Date** 3/20/12 **Sheet** ____ **of** ____

Bents 2 and 3



pile spacing = 4.5' = 2.25 d

group efficiency factor = 0.6

pile cap = 13'x13'

bottom of footing elevation = +158 feet

Nominal resistance per pile

Strength limit state = 188/0.7 = 268 kips
consider 270 kips for bent 2

= 193/0.7 = 275 kips
consider 280 kips for Bent 3

Extreme Event limit State = 332/1.0 = 332 kips
Consider 340 kips for Bent 2

= 342/1.0 = 342 kips
Consider 350 kips for Bent 3

Tension = 176 kips Bent 2
= 184 kips Bent 3
consider 190 kips for Bent 2 & Bent 3

Nominal resistance per Support

Strength limit state = 1157/0.7 = 1596 kips
consider 1600 kips for Bent 2
= 1218/0.7 = 1740 kips for Bent 3

Extreme event limit state = 622 & 631 kips
consider 640 kips for Bents 2 & 3

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Project 5/N5-N1 connector separation (55-0226) **Project No.** 11-157

By SP **Date** 02-24-12 **Checked By** LLC **Date** 2/29/12 **Sheet** ____ **of** ____

from the Analysis

Strength limit state

at depth at 33 feet pile capacity = 290.3 > 270 kips for Bent 2
> 280 kips for Bent 3

pile tip elevation = 158 - 33 = +125 feet for Bent 2 & 3

Available group nominal resistance at pile tip elevation of +125 ft = 8 x 290.3 x 0.6 = 1393.4 kips

required group nominal resistance = 1600 > 1393 kips for Bent 2
= 1740 > 1393 kips for Bent 3

compression capacity needed per pile = $\frac{1600}{0.6 \times 8}$ = 333 kips

consider 340 kips for Bent 2

= $\frac{1740}{0.6 \times 8}$ = 362 kips

consider 370 kips for Bent 3

at 38 ft pile capacity = 342 kips > 340 kips for Bent 2

at 41 ft, pile capacity = 373 kips > 370 kips for Bent 3

pile tip elevation for compression = 157 - 38 = +119 ft for Bent 2
= 158 - 41 = +117 ft for Bent 3

Nominal resistance per pile = 340 kips for Bent 2

Nominal resistance per pile = 370 kips for Bent 3

Extreme Event Limit State

at 38 feet, pile capacity = 342 kips > 340 kips for Bent 2

at 39 feet, pile capacity = 352 kips > 350 kips for Bent 3

consider pile length = 40 feet; Nominal resistance = 360 kips

pile tip elevation = 157 - 40 = +117 ft - Bent 2; 158 - 40 = +118 - Bent 3

Available group nominal resistance at pile tip elevation at +118 ft = 8 x 342 x 0.6 = 1642 kips

required group nominal resistance = 640 kips < 1642 kips for Bent 2 to Bent 3

pile tip elevation for compression (extreme event) = +117 - Bent 2
+118 - Bent 3

Nominal resistance at +118 ft = 340 kips for Bent 2
350 kips for Bent 3

at 33 ft, tension capacity = 2/3 x 290 = 193. kips > 190 kips

pile tip elevation for tension (Extreme event) = +124 ft for Bent 2
+125 ft for Bent 3

SKIN FRICTION FOR DRILLED SHAFT IN BOTH COHESIONLESS AND COHESIVE SOILS USING REESE AND O'NEILL'S METHOD (1999)

PROJECT: 5/N5-N1 Connector Separation (55-0226) ITEM: 24-inch Diameter CIDH Pile
PROJECT NO.: 11-137 Bents 2 and 3 (Right Bridge)
DONE BY: SP DATE: 02/24/12
CHECKED BY: DATE:

D_s => 2.00 ft Hw => 5.0 ft Hg => 0.0 ft
p = 6.28 ft Ho => 0.0 ft Hf => 0.0 ft

Hw is the depth to water table.
Hg is the depth to ground surface used in calculation.
Ho is the depth to location starting initial overburden pressure
Hf is the depth to location starting accumulation of skin friction
bottom of footing = 158 ft

Soil Layer =>	from Top	to Bottom =>	γ (pcf)=>	γ' (pcf)=	c' (ksf) =>	ϕ' =>	
(1)	0	50	120	57.6	3.00	0	Bedrock

Sublayer No.	Depth, z (ft)	z_i (ft)	New Depth (ft)	Soil Unit Weight (pcf)	Overburden Pressure (psf)	c' (ksf)	β	f_i^s (ksf)	ΔQ_s^s (kips)	Q_s^s (kips)	f_i^c (ksf)	ΔQ_s^c (kips)	Q_s^c (kips)	Q_s (kips)
0	0.0	0.0	0.0	120.0	0									
1	0.0	0.0	0.0	120.0	0	3.0				0.0			0.0	0.0
2	1.0	0.5	0.5	120.0	60	3.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
3	2.0	1.5	1.5	120.0	180	3.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
4	3.0	2.5	2.5	120.0	300	3.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
5	4.0	3.5	3.5	120.0	420	3.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
6	5.0	4.5	4.5	120.0	540	3.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
7	6.0	5.5	5.5	57.6	598	3.0	1.18	0.00	0.0	0.0	1.65	10.4	10.4	10.4
8	7.0	6.5	6.5	57.6	655	3.0	1.16	0.00	0.0	0.0	1.65	10.4	20.7	20.7
9	8.0	7.5	7.5	57.6	713	3.0	1.13	0.00	0.0	0.0	1.65	10.4	31.1	31.1
10	9.0	8.5	8.5	57.6	770	3.0	1.11	0.00	0.0	0.0	1.65	10.4	41.5	41.5
11	10.0	9.5	9.5	57.6	828	3.0	1.08	0.00	0.0	0.0	1.65	10.4	51.8	51.8
12	11.0	10.5	10.5	57.6	886	3.0	1.06	0.00	0.0	0.0	1.65	10.4	62.2	62.2
13	12.0	11.5	11.5	57.6	943	3.0	1.04	0.00	0.0	0.0	1.65	10.4	72.6	72.6
14	13.0	12.5	12.5	57.6	1001	3.0	1.02	0.00	0.0	0.0	1.65	10.4	82.9	82.9
15	14.0	13.5	13.5	57.6	1058	3.0	1.00	0.00	0.0	0.0	1.65	10.4	93.3	93.3
16	15.0	14.5	14.5	57.6	1116	3.0	0.99	0.00	0.0	0.0	1.65	10.4	103.7	103.7
17	16.0	15.5	15.5	57.6	1174	3.0	0.97	0.00	0.0	0.0	1.65	10.4	114.0	114.0
18	17.0	16.5	16.5	57.6	1231	3.0	0.95	0.00	0.0	0.0	1.65	10.4	124.4	124.4
19	18.0	17.5	17.5	57.6	1289	3.0	0.94	0.00	0.0	0.0	1.65	10.4	134.8	134.8
20	19.0	18.5	18.5	57.6	1346	3.0	0.92	0.00	0.0	0.0	1.65	10.4	145.1	145.1
21	20.0	19.5	19.5	57.6	1404	3.0	0.90	0.00	0.0	0.0	1.65	10.4	155.5	155.5
22	21.0	20.5	20.5	57.6	1462	3.0	0.89	0.00	0.0	0.0	1.65	10.4	165.9	165.9
23	22.0	21.5	21.5	57.6	1519	3.0	0.87	0.00	0.0	0.0	1.65	10.4	176.2	176.2
24	23.0	22.5	22.5	57.6	1577	3.0	0.86	0.00	0.0	0.0	1.65	10.4	186.6	186.6
25	24.0	23.5	23.5	57.6	1634	3.0	0.85	0.00	0.0	0.0	1.65	10.4	197.0	197.0
26	25.0	24.5	24.5	57.6	1692	3.0	0.83	0.00	0.0	0.0	1.65	10.4	207.3	207.3
27	26.0	25.5	25.5	57.6	1750	3.0	0.82	0.00	0.0	0.0	1.65	10.4	217.7	217.7
28	27.0	26.5	26.5	57.6	1807	3.0	0.81	0.00	0.0	0.0	1.65	10.4	228.1	228.1
29	28.0	27.5	27.5	57.6	1865	3.0	0.79	0.00	0.0	0.0	1.65	10.4	238.4	238.4
30	29.0	28.5	28.5	57.6	1922	3.0	0.78	0.00	0.0	0.0	1.65	10.4	248.8	248.8
31	30.0	29.5	29.5	57.6	1980	3.0	0.77	0.00	0.0	0.0	1.65	10.4	259.2	259.2
32	31.0	30.5	30.5	57.6	2038	3.0	0.75	0.00	0.0	0.0	1.65	10.4	269.5	269.5
33	32.0	31.5	31.5	57.6	2095	3.0	0.74	0.00	0.0	0.0	1.65	10.4	279.9	279.9
34	33.0	32.5	32.5	57.6	2153	3.0	0.73	0.00	0.0	0.0	1.65	10.4	290.3	290.3
35	34.0	33.5	33.5	57.6	2210	3.0	0.72	0.00	0.0	0.0	1.65	10.4	300.7	300.7
36	35.0	34.5	34.5	57.6	2268	3.0	0.71	0.00	0.0	0.0	1.65	10.4	311.0	311.0
37	36.0	35.5	35.5	57.6	2326	3.0	0.70	0.00	0.0	0.0	1.65	10.4	321.4	321.4
38	37.0	36.5	36.5	57.6	2383	3.0	0.68	0.00	0.0	0.0	1.65	10.4	331.8	331.8
39	38.0	37.5	37.5	57.6	2441	3.0	0.67	0.00	0.0	0.0	1.65	10.4	342.1	342.1
40	39.0	38.5	38.5	57.6	2498	3.0	0.66	0.00	0.0	0.0	1.65	10.4	352.5	352.5
41	40.0	39.5	39.5	57.6	2556	3.0	0.65	0.00	0.0	0.0	1.65	10.4	362.9	362.9
42	41.0	40.5	40.5	57.6	2614	3.0	0.64	0.00	0.0	0.0	1.65	10.4	373.2	373.2
43	42.0	41.5	41.5	57.6	2671	3.0	0.63	0.00	0.0	0.0	1.65	10.4	383.6	383.6
44	43.0	42.5	42.5	57.6	2729	3.0	0.62	0.00	0.0	0.0	1.65	10.4	394.0	394.0
45	44.0	43.5	43.5	57.6	2786	3.0	0.61	0.00	0.0	0.0	1.65	10.4	404.3	404.3
46	45.0	44.5	44.5	57.6	2844	3.0	0.60	0.00	0.0	0.0	1.65	10.4	414.7	414.7
47	46.0	45.5	45.5	57.6	2902	3.0	0.59	0.00	0.0	0.0	1.65	10.4	425.1	425.1
48	47.0	46.5	46.5	57.6	2959	3.0	0.58	0.00	0.0	0.0	1.65	10.4	435.4	435.4
49	48.0	47.5	47.5	57.6	3017	3.0	0.57	0.00	0.0	0.0	1.65	10.4	445.8	445.8
50	49.0	48.5	48.5	57.6	3074	3.0	0.56	0.00	0.0	0.0	1.65	10.4	456.2	456.2
51	50.0	49.5	49.5	57.6	3132	3.0	0.55	0.00	0.0	0.0	1.65	10.4	466.5	466.5

Earth Mechanics, Inc.
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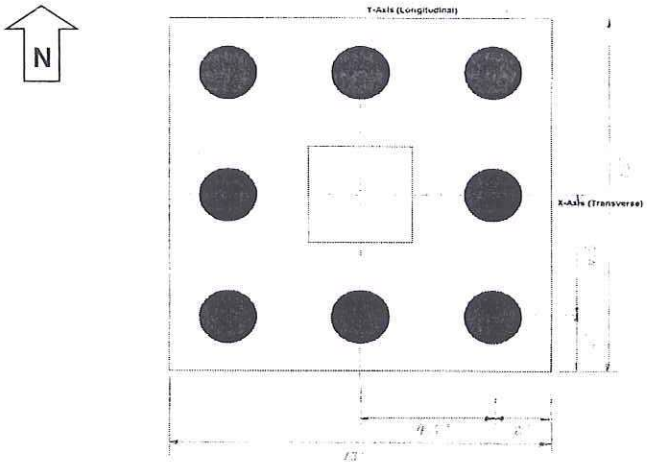
phone: (714)751-3826, Fax (714)751-3928

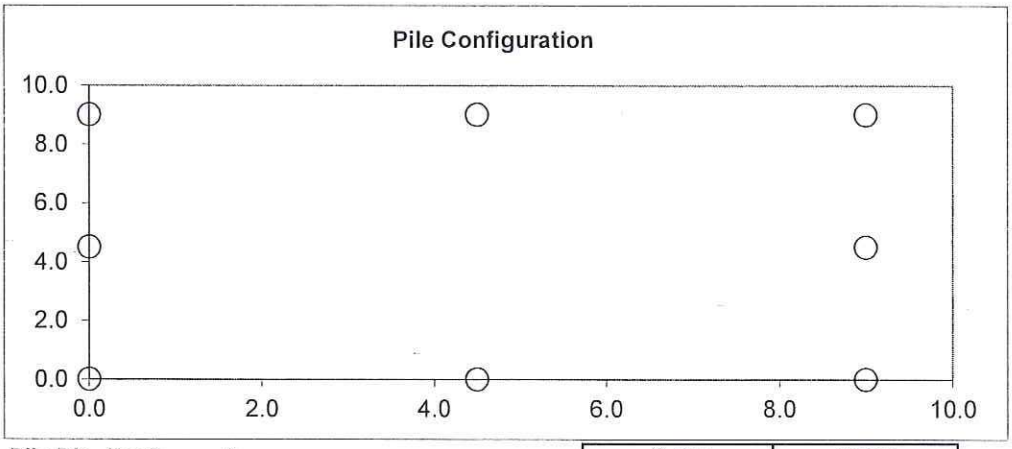
Project: 5/N5-N1 Connector Separation (55-0226) Project No. 11-137
By SP Date 02/22/12 Check by Date Sheet

Proposed Bent 2 Pile Layout



Calculation of Pile Group Efficiency for Lateral Load Capacity

(using formula in Group 7.0 Technical Manual)



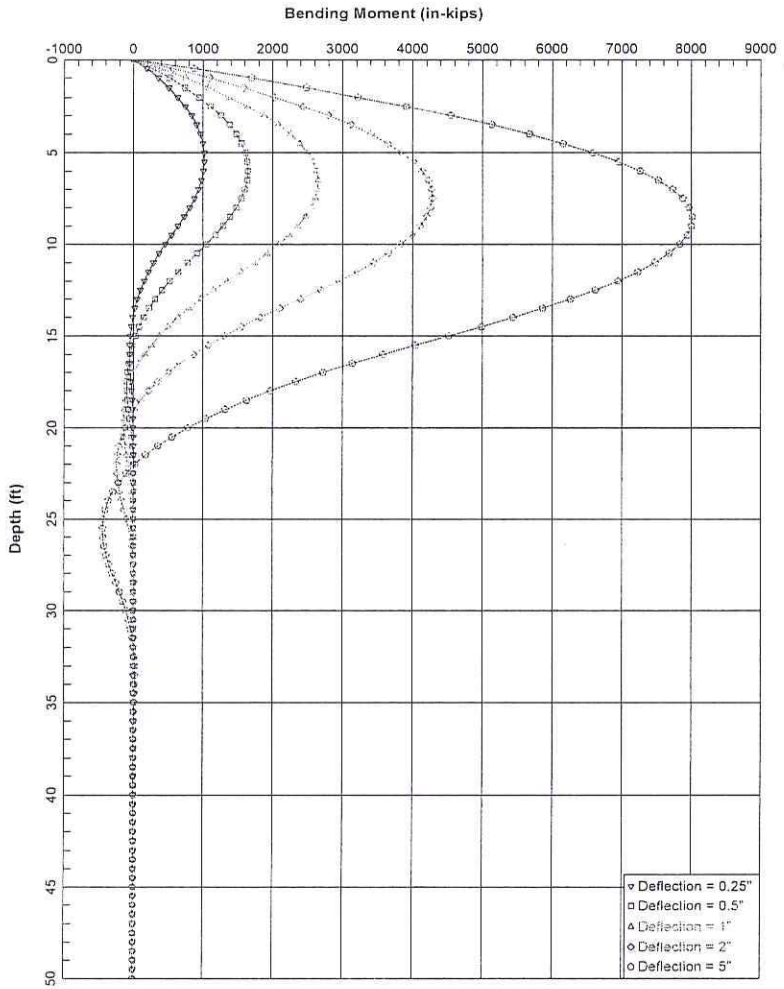
Pile Dia. (feet): 2
No. of Piles: 8

Group Efficiency	X-Dir	Y-Dir
	0.522	0.522

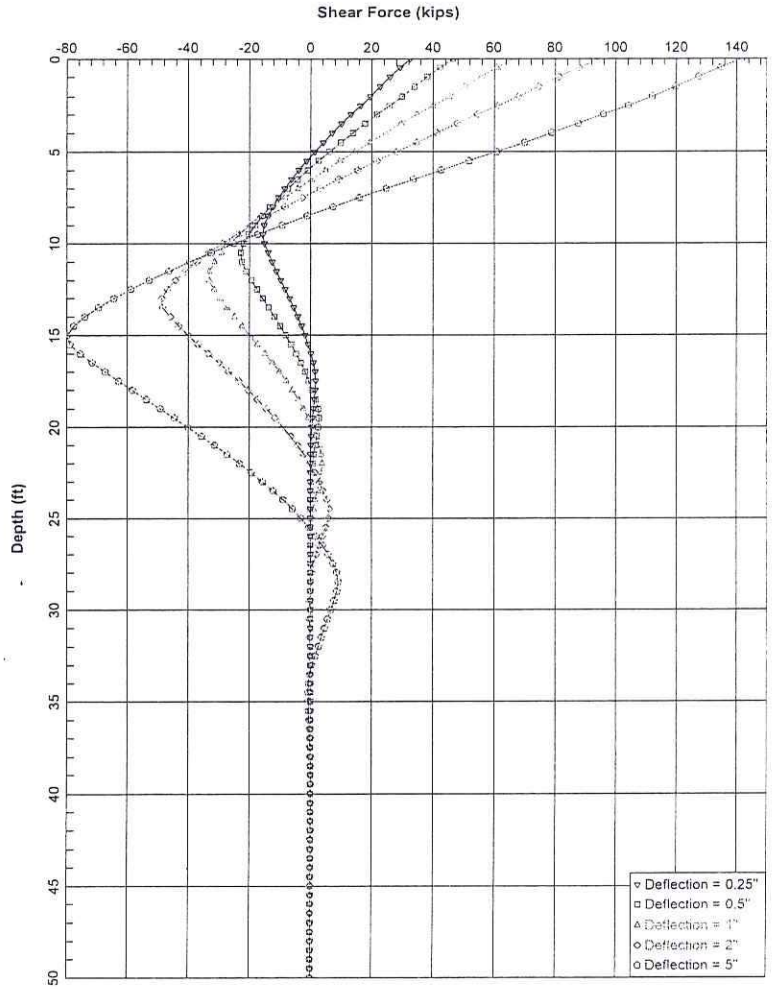
Coordinates

Pile No.	X	Y
1	0.0	0.0
2	4.5	0.0
3	9.0	0.0
4	0.0	4.5
5	9.0	4.5
6	0.0	9.0
7	4.5	9.0
8	9.0	9.0

Reduction Factors in X-dir	Reduction Factors in Y-dir
0.411	0.411
0.446	0.365
0.729	0.411
0.365	0.446
0.638	0.446
0.411	0.729
0.446	0.638
0.729	0.729



I-5 HOV Improvement, PCH to San Juan Creek Road - 24-inch CIDH Piles at Bents 2 and 3 (Right Bridge)



I-5 HOV Improvement, PCH to San Juan Creek Road - 24-inch CIDH Piles at Bents 2 and 3 (Right Bridge)

LPile Plus for Windows, Version 6.0 (6.0.09)

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

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Earth Mechanics, Inc.
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Files Used for Analysis

Path to file locations: X:\Projects\2011\11-137 - TRC, I-5 HOV Widening - Segment 3\Reports\02 5_N5-N1 Conn Sep (55-0226)\Analysis\Lateral Capacity\
Name of input data file: 5_N5_N1 Conn Sep 24-inch CIDH (Bents 2 and 3-Right Bridge).lp6d
Name of output file: 5_N5_N1 Conn Sep 24-inch CIDH (Bents 2 and 3-Right Bridge).lp6o
Name of plot output file: 5_N5_N1 Conn Sep 24-inch CIDH (Bents 2 and 3-Right Bridge).lp6p
Name of runtime file: 5_N5_N1 Conn Sep 24-inch CIDH (Bents 2 and 3-Right Bridge).lp6r

Date and Time of Analysis

Date: February 24, 2012 Time: 15:15:19

Problem Title

Project Name:
Job Number:
Client:
Engineer:
Description:

Program Options

Units Used - US Customary Units: pounds, inches, feet

Basic Program Options:

This analysis computes nonlinear bending stiffness and nominal Moment
Capacity with Pile Response Computed Using Nonlinear EI

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis uses p-y multipliers for group action
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix elements
- Output summary table of values for pile-head deflection, maximum bending moment, and shear force only
- Analysis assumes no soil movements acting on pile
- No p-y curves to be computed and output for user-specified depths

Solution Control Parameters:
- Number of pile increments = 100
- Maximum number of iterations allowed = 100
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in

Pile Response Output Options:
- Only summary tables of pile-head deflection, maximum bending moment, and maximum shear force are to be written to output report file.

Pile Structural Properties and Geometry

Total Number of Sections = 1

Total Pile Length = 50.00 ft

Depth of ground surface below top of pile = -5.00 ft

Slope angle of ground surface = 0.00 deg.

Pile dimensions used for p-y curve computations defined using 2 points.
p-y curves are computed using values of pile diameter interpolated over

the length of the pile.

Point	Depth X ft	Pile Diameter in
1	0.00000	24.0000000
2	50.000000	24.0000000

Input Structural Properties:

Section No. 1:

Section Type	=	Elastic Pile
Cross-sectional Shape	=	Circular
Section Length	=	50.000 in
Top Width	=	24.000 in
Bottom Width	=	24.000 in
Top Area	=	452.000000 sq. in
Bottom Area	=	452.000000 sq. in
Moment of Inertia at Top	=	8.143E+03 in^4
Moment of Inertia at Bottom	=	8.143E+03 in^4
Elastic Modulus	=	3200000.000 lbs/in

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000 degrees
	=	0.000 radians
Pile Batter Angle	=	0.000 degrees
	=	0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 2 layers

Layer 1 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer	=	-5.000 ft
Distance from top of pile to bottom of layer	=	22.000 ft

Layer 2 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer	=	22.000 ft
Distance from top of pile to bottom of layer	=	60.000 ft

(Depth of lowest layer extends 10.00 ft below pile tip)

Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 4 points

Point No.	Depth X ft	Eff. Unit Weight pcf
1	-5.00	120.00000
2	22.00	120.00000
3	22.00	57.60000
4	60.00	57.60000

Summary of Soil Properties

Layer Num.	Soil Type (p-y Curve Criteria)	Depth ft	Eff. Unit Wt., pcf	Cohesion psf	Friction Ang., deg.	qu psi	RQD percent	Epsilon 50	kpy pci	Rock Emass psi	krm	Test Type	Test Prop.	Elas. Subgr. pci
1	Soft Clay	-5.000	120.000	3000.000	--	--	--	0.00500	--	--	--	--	--	--
		22.000	120.000	3000.000	--	--	--	0.00500	--	--	--	--	--	--
2	Soft Clay	22.000	57.600	3000.000	--	--	--	0.00500	--	--	--	--	--	--
		60.000	57.600	3000.000	--	--	--	0.00500	--	--	--	--	--	--

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.5200	1.0000
2	50.000	0.5200	1.0000

Loading Type

---

p-y criteria for static loading was used for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 5

Load No.	Load Type	Condition 1		Condition 2		Axial Thrust Force, lbs
1	4	y =	0.250 in	M =	0.000 in-lbs	150000.000
2	4	y =	0.500 in	M =	0.000 in-lbs	150000.000
3	4	y =	1.000 in	M =	0.000 in-lbs	150000.000
4	4	y =	2.000 in	M =	0.000 in-lbs	150000.000
5	4	y =	5.000 in	M =	0.000 in-lbs	150000.000

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust values were determined from pile-head loading conditions

Number of Sections = 1

Section No. 1:

Moment-Curvature properties derived from elastic section properties

---

Summary of Pile Response(s)

Definitions of Pile-Head Loading Conditions:

Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

Load Case No.	Load Type No.	Condition 1 V(lbs) or y(inches)		Condition 2 in-lb, rad., or in-lb/rad.		Axial Load lbs	Pile-Head Deflection inches	Maximum Moment in-lbs	Maximum Shear lbs	Pile-Head Rotation radians
1	4	y =	0.2500	M =	0.000	150000.	0.25000000	1018806.	32469.	0.00000000
2	4	y =	0.5000	M =	0.000	150000.	0.50000000	1644316.	46351.	0.00000000
3	4	y =	1.0000	M =	0.000	150000.	1.00000000	2648615.	66138.	0.00000000
4	4	y =	2.0000	M =	0.000	150000.	2.00000000	4280344.	94440.	0.00000000
5	4	y =	5.0000	M =	0.000	150000.	5.00000000	8012325.	141676.	0.00000000

Summary of Warning Messages

The following warning was reported 1600 times

**** Warning ****

An unreasonable input value for shear strength has been specified for a soil defined using the soft clay criteria. The input value is greater than 8.68 psi (1,250 psf). You should check your input data for correctness.

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

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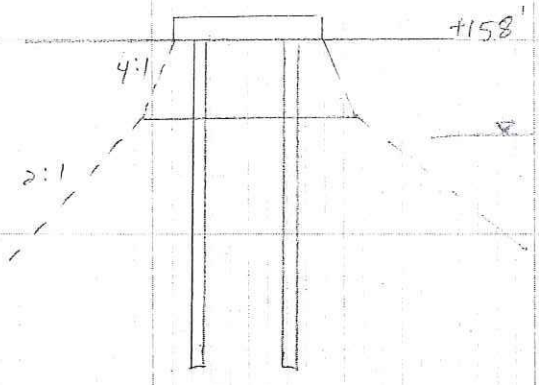
Project 5/N5-N1 connector separation (3E-0026) **Project No.** 11-137

By SP **Date** 02-24-12 **Checked By** KC **Date** 3/20/12 **Sheet** ____ **of** ____

Settlement for Bents 2 & 3



Total load per support = 797 kips
permanent load per support = 620 kips
pile cap = 13' x 13'

consider pile length D = 20 ft.
$2D/3 = 13.3$ ft

Equivalent footing = $(13 + \frac{13.3}{4}\times 2) \times (13 + \frac{13.3}{4}\times 2)$
$= 19.7' \times 19.7'$

$q = \frac{797}{19.7\times 19.7} = 2.0$ ksf for immediate settlement

$q = \frac{620}{19.7\times 19.7} = 1.6$ ksf for consolidation settlement

σ_{vo}	$\Delta\sigma$	Settlement
$16.5\times 1.20 = 1.98$	$\frac{797}{(19.7+8.5)(19.7+8.5)} = 1.5$	$17\times\frac{1}{40}\log\left(\frac{1.98+1.5}{1.98}\right) = 0.53$
$20\times 120 + 10\times 57.6 = 3.0$	$\frac{620}{(19.7+17)(19.7+17)} = 0.46$	$20\times\frac{1}{40}\log\left(\frac{3+0.46}{3}\right) = 0.36$
$20\times 120 + 30\times 57.6 = 4.13$	$\frac{620}{(19.7+37)(19.7+37)} = 0.19$	$20\times\frac{1}{40}\log\left(\frac{4.13+0.19}{4.13}\right) = 0.12$
		1.01 ft

pile length for settlement = 20 ft

pile tip elevation for settlement = 157 − 20 = +137 Bent 2
= 158 − 20 = +138 Bents 3

LEFT BRIDGE (I-5 Southbound)

5/N5-N1 CONNECTOR SEPARATION (55-0226)

Earth Mechanics, Inc.
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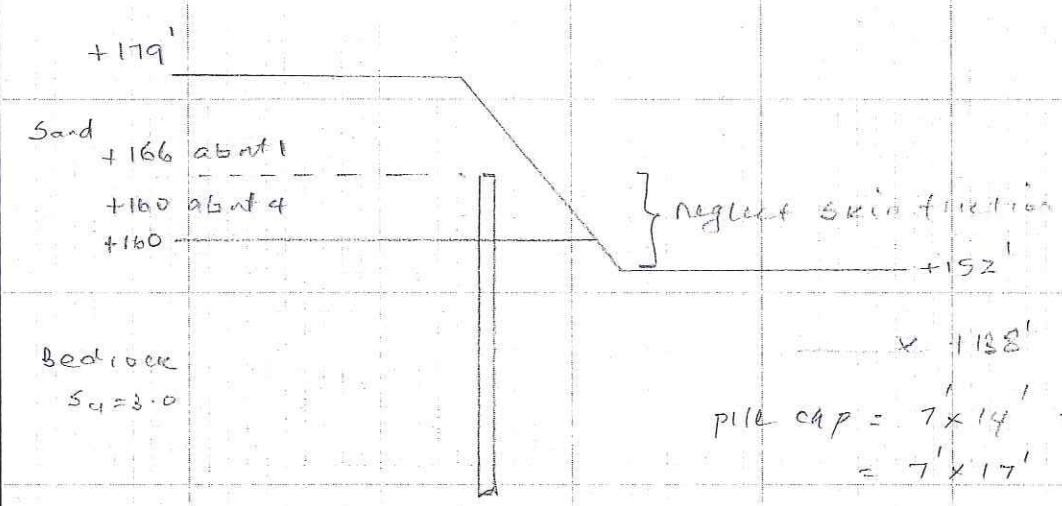
Project 5/N5-N1 connector separation (55-0226) **Project No.** 11-137

By SP **Date** 02-24-12 **Checked By** LCC **Date** 3/21/12 **Sheet** ____ **of** ____

Lett Bridge

24-inch diameter C104 piles

Abutments 1 and 4



pile cap = 7' x 14' for abut 4
= 7' x 17' for abut 1

Abutment 1

Maximum load per pile = 152 kips

Nominal resistance per pile = 152 x 2 = 304 kips
consider 310 kips

Nominal resistance per support = 394 x 2 = 788 kips
consider 790 kips

Abutment 4

Maximum load per pile = 134 kips

Nominal resistance per pile = 134 x 2 = 268 kips
consider 270 kips

Nominal resistance per support = 334 x 2 = 668 kips
consider 670 kips

pile spacing = 2.9d

Group efficiency factor = 0.75

Earth Mechanics, Inc.
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(714) 751-3826, Fax (714) 751-3928

Project 5|N5-N1 connector separation (55-0224) **Project No.** 11-187

By SP **Date** 02-24-12 **Checked By** KCL **Date** 3/2/12 **Sheet** ____ **of** ____

tion analysis

Abutment 1 - cut-off elevation +166 ft
at depth of 44 ft, pile capacity = 311 kips > 310 kips
pile tip elevation for compression = 166-44 = +122 feet

Available group nominal resistance at pile
tip elevation of +122 ft = 4 x 311 x 0.75
= 871 kips

Required group nominal resistance = 790 kips > 871 kips

Abut 1 pile tip elevation for compression = +122 feet

Abutment-4 cut-off elevation = +160 ft
at depth of 41 feet, pile capacity = 279.9 kips > 270 kips
pile tip elevation for compression = 160-41 = +119 feet

Available group nominal resistance at pile
tip elevation of +119 feet = 4 x 279.9 x 0.75
= 839.7 kips

Required group nominal resistance = 670 kips > 839.7 kips

Abut 4 pile tip elevation for compression = +119 feet

SKIN FRICTION FOR DRILLED SHAFT IN BOTH COHESIONLESS AND COHESIVE SOILS USING REESE AND O'NEILL'S METHOD (1999)

PROJECT: 5/N5-N1 Connector Separation (55-0226) ITEM: 24-inch Diameter CIDH Pile
PROJECT NO.: 11-137 Abutments 1 and 4 (Left Bridge)
DONE BY: SP DATE: 02/23/12
CHECKED BY: DATE:

D_s => 2.00 ft Hw => 5.0 ft Hg => 0.0 ft
p = 6.28 ft Ho => 0.0 ft Hf => 0.0 ft

Hw is the depth to water table.
Hg is the depth to ground surface used in calculation.
Ho is the depth to location starting initial overburden pressure
Hf is the depth to location starting accumulation of skin frictio
bottom of footing = 166 ft

Soil Layer =>	from Top	to Bottom =>	γ (pcf)=>	γ' (pcf)=	c' (ksf) =>	ϕ' =>	
(1)	0	14	120	57.6	0.00	32	SM
(2)	14	50	120	57.6	3.00	0	Bedrock

Sublayer No.	Depth, z (ft)	z_i (ft)	New Depth (ft)	Soil Unit Weight (pcf)	Overburden Pressure (psf)	c' (ksf)	β	f_i^s (ksf)	ΔQ_s^s (kips)	Q_s^s (kips)	f_i^c (ksf)	ΔQ_s^c (kips)	Q_s^c (kips)	Q_s (kips)
0	0.0	0.0	0.0	120.0	0									
1	0.0	0.0	0.0	120.0	0	0.0				0.0			0.0	0.0
2	1.0	0.5	0.5	120.0	60	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
3	2.0	1.5	1.5	120.0	180	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
4	3.0	2.5	2.5	120.0	300	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
5	4.0	3.5	3.5	120.0	420	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
6	5.0	4.5	4.5	120.0	540	0.0	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
7	6.0	5.5	5.5	57.6	598	0.0	1.18	0.00	0.0	0.0	0.00	0.0	0.0	0.0
8	7.0	6.5	6.5	57.6	655	0.0	1.16	0.00	0.0	0.0	0.00	0.0	0.0	0.0
9	8.0	7.5	7.5	57.6	713	0.0	1.13	0.00	0.0	0.0	0.00	0.0	0.0	0.0
10	9.0	8.5	8.5	57.6	770	0.0	1.11	0.00	0.0	0.0	0.00	0.0	0.0	0.0
11	10.0	9.5	9.5	57.6	828	0.0	1.08	0.00	0.0	0.0	0.00	0.0	0.0	0.0
12	11.0	10.5	10.5	57.6	886	0.0	1.06	0.00	0.0	0.0	0.00	0.0	0.0	0.0
13	12.0	11.5	11.5	57.6	943	0.0	1.04	0.00	0.0	0.0	0.00	0.0	0.0	0.0
14	13.0	12.5	12.5	57.6	1001	0.0	1.02	0.00	0.0	0.0	0.00	0.0	0.0	0.0
15	14.0	13.5	13.5	57.6	1058	0.0	1.00	0.00	0.0	0.0	0.00	0.0	0.0	0.0
16	15.0	14.5	14.5	57.6	1116	3.0	0.99	0.00	0.0	0.0	1.65	10.4	10.4	10.4
17	16.0	15.5	15.5	57.6	1174	3.0	0.97	0.00	0.0	0.0	1.65	10.4	20.8	20.8
18	17.0	16.5	16.5	57.6	1231	3.0	0.95	0.00	0.0	0.0	1.65	10.4	31.1	31.1
19	18.0	17.5	17.5	57.6	1289	3.0	0.94	0.00	0.0	0.0	1.65	10.4	41.5	41.5
20	19.0	18.5	18.5	57.6	1346	3.0	0.92	0.00	0.0	0.0	1.65	10.4	51.9	51.9
21	20.0	19.5	19.5	57.6	1404	3.0	0.90	0.00	0.0	0.0	1.65	10.4	62.2	62.2
22	21.0	20.5	20.5	57.6	1462	3.0	0.89	0.00	0.0	0.0	1.65	10.4	72.6	72.6
23	22.0	21.5	21.5	57.6	1519	3.0	0.87	0.00	0.0	0.0	1.65	10.4	83.0	83.0
24	23.0	22.5	22.5	57.6	1577	3.0	0.86	0.00	0.0	0.0	1.65	10.4	93.3	93.3
25	24.0	23.5	23.5	57.6	1634	3.0	0.85	0.00	0.0	0.0	1.65	10.4	103.7	103.7
26	25.0	24.5	24.5	57.6	1692	3.0	0.83	0.00	0.0	0.0	1.65	10.4	114.1	114.1
27	26.0	25.5	25.5	57.6	1750	3.0	0.82	0.00	0.0	0.0	1.65	10.4	124.4	124.4
28	27.0	26.5	26.5	57.6	1807	3.0	0.81	0.00	0.0	0.0	1.65	10.4	134.8	134.8
29	28.0	27.5	27.5	57.6	1865	3.0	0.79	0.00	0.0	0.0	1.65	10.4	145.2	145.2
30	29.0	28.5	28.5	57.6	1922	3.0	0.78	0.00	0.0	0.0	1.65	10.4	155.5	155.5
31	30.0	29.5	29.5	57.6	1980	3.0	0.77	0.00	0.0	0.0	1.65	10.4	165.9	165.9
32	31.0	30.5	30.5	57.6	2038	3.0	0.75	0.00	0.0	0.0	1.65	10.4	176.3	176.3
33	32.0	31.5	31.5	57.6	2095	3.0	0.74	0.00	0.0	0.0	1.65	10.4	186.6	186.6
34	33.0	32.5	32.5	57.6	2153	3.0	0.73	0.00	0.0	0.0	1.65	10.4	197.0	197.0
35	34.0	33.5	33.5	57.6	2210	3.0	0.72	0.00	0.0	0.0	1.65	10.4	207.4	207.4
36	35.0	34.5	34.5	57.6	2268	3.0	0.71	0.00	0.0	0.0	1.65	10.4	217.7	217.7
37	36.0	35.5	35.5	57.6	2326	3.0	0.70	0.00	0.0	0.0	1.65	10.4	228.1	228.1
38	37.0	36.5	36.5	57.6	2383	3.0	0.68	0.00	0.0	0.0	1.65	10.4	238.5	238.5
39	38.0	37.5	37.5	57.6	2441	3.0	0.67	0.00	0.0	0.0	1.65	10.4	248.8	248.8
40	39.0	38.5	38.5	57.6	2498	3.0	0.66	0.00	0.0	0.0	1.65	10.4	259.2	259.2
41	40.0	39.5	39.5	57.6	2556	3.0	0.65	0.00	0.0	0.0	1.65	10.4	269.6	269.6
42	41.0	40.5	40.5	57.6	2614	3.0	0.64	0.00	0.0	0.0	1.65	10.4	279.9	279.9
43	42.0	41.5	41.5	57.6	2671	3.0	0.63	0.00	0.0	0.0	1.65	10.4	290.3	290.3
44	43.0	42.5	42.5	57.6	2729	3.0	0.62	0.00	0.0	0.0	1.65	10.4	300.7	300.7
45	44.0	43.5	43.5	57.6	2786	3.0	0.61	0.00	0.0	0.0	1.65	10.4	311.0	311.0
46	45.0	44.5	44.5	57.6	2844	3.0	0.60	0.00	0.0	0.0	1.65	10.4	321.4	321.4
47	46.0	45.5	45.5	57.6	2902	3.0	0.59	0.00	0.0	0.0	1.65	10.4	331.8	331.8
48	47.0	46.5	46.5	57.6	2959	3.0	0.58	0.00	0.0	0.0	1.65	10.4	342.2	342.2
49	48.0	47.5	47.5	57.6	3017	3.0	0.57	0.00	0.0	0.0	1.65	10.4	352.5	352.5
50	49.0	48.5	48.5	57.6	3074	3.0	0.56	0.00	0.0	0.0	1.65	10.4	362.9	362.9
51	50.0	49.5	49.5	57.6	3132	3.0	0.55	0.00	0.0	0.0	1.65	10.4	373.3	373.3

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

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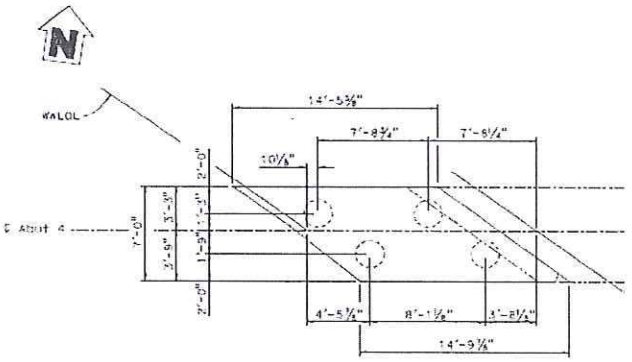
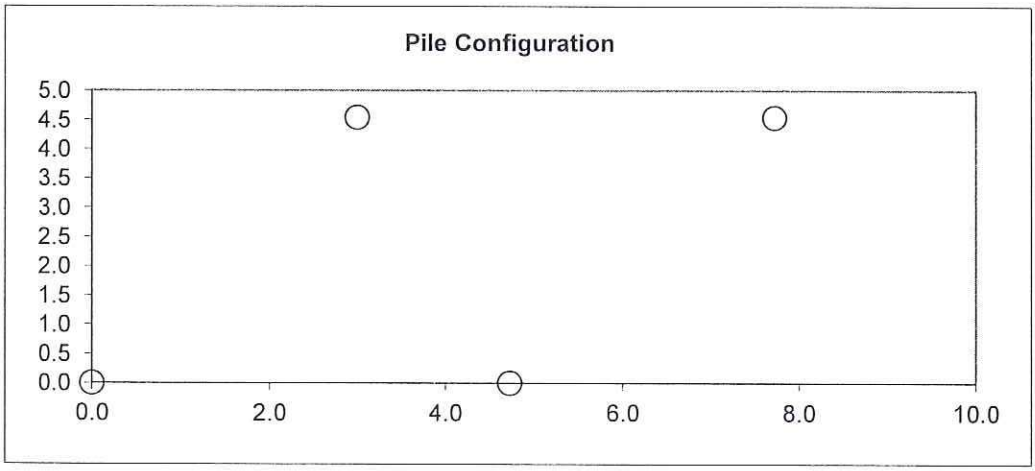
Project: 5/N5-N1 Connector Separation (55-0226) Project No. 11-137
By SP Date 02/22/12 Check by Date Sheet

Proposed Abutment 4 (Left Bridge) Pile Layout



Calculation of Pile Group Efficiency for Lateral Load Capacity

(using formula in Group 7.0 Technical Manual)



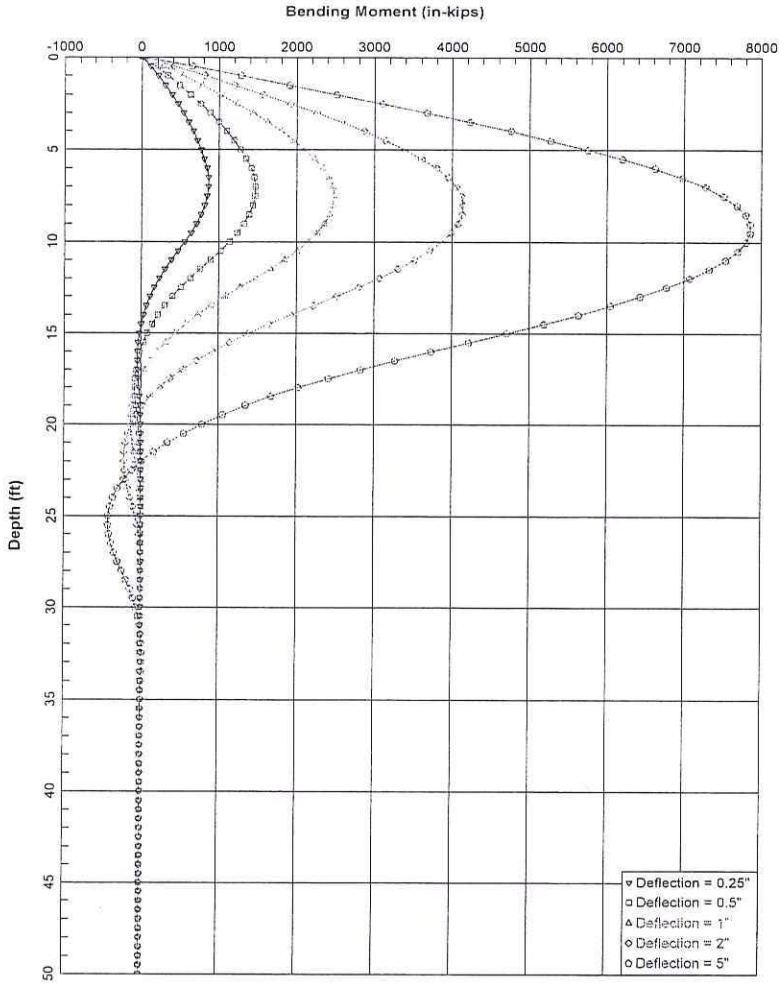
Pile Dia. (feet): 2
No. of Piles: 4

Group Efficiency	X-Dir	Y-Dir
	0.61	0.64

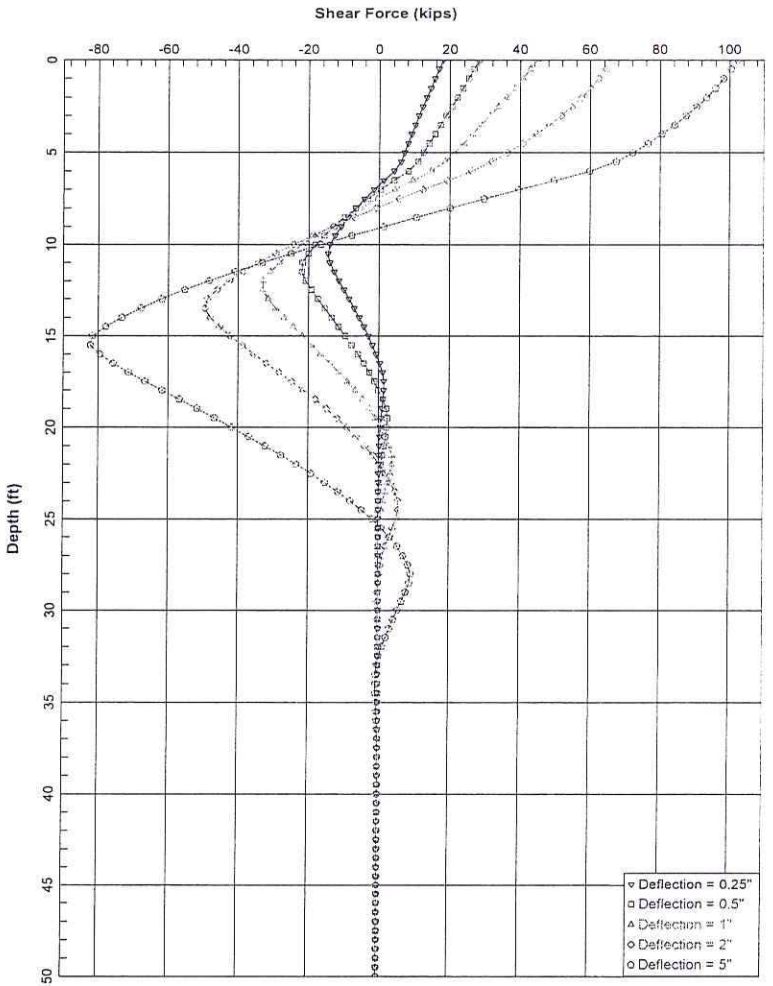
Coordinates

Pile No.	X	Y
1	0.0	0.0
2	4.7	0.0
3	3.0	4.5
4	7.7	4.5

Reduction Factors in X-dir	Reduction Factors in Y-dir
0.500	0.634
0.641	0.460
0.506	0.682
0.789	0.776



I-5 HOV Improvement, PCH to San Juan Creek Road - 24-inch CIDH Piles at Abutments 1 and 4 (Left Bridge)



I-5 HOV Improvement, PCH to San Juan Creek Road - 24-inch CIDH Piles at Abutments 1 and 4 (Left Bridge)

```
================================================================================

                  LPile Plus for Windows, Version 6.0 (6.0.09)

               Analysis of Individual Piles and Drilled Shafts
              Subjected to Lateral Loading Using the p-y Method

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                            All Rights Reserved

================================================================================

This program is licensed to:

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Earth Mechanics, Inc.

--------------------------------------------------------------------------------
                              Files Used for Analysis
--------------------------------------------------------------------------------


Path to file locations:      X:\Projects\2011\11-137 - TRC, I-5 HOV Widening - Segment 3\Reports\02 5_N5-N1 Conn Sep (55-0226)\Analysis\Lateral Capacity\
Name of input data file:     5_N5_N1 Conn Sep 24-inch CIDH (Abutments 1 and 4-Left Bridge).lp6d
Name of output file:         5_N5_N1 Conn Sep 24-inch CIDH (Abutments 1 and 4-Left Bridge).lp6o
Name of plot output file:    5_N5_N1 Conn Sep 24-inch CIDH (Abutments 1 and 4-Left Bridge).lp6p
Name of runtime file:        5_N5_N1 Conn Sep 24-inch CIDH (Abutments 1 and 4-Left Bridge).lp6r

--------------------------------------------------------------------------------
                            Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  February 24, 2012      Time:  17:27:29

--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name:
Job Number:
Client:
Engineer:
Description:


--------------------------------------------------------------------------------
                                Program Options
--------------------------------------------------------------------------------

Units Used - US Customary Units: pounds, inches, feet

Basic Program Options:

This analysis computes nonlinear bending stiffness and nominal Moment
  Capacity with Pile Response Computed Using Nonlinear EI

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis uses p-y multipliers for group action
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix elements
- Output summary table of values for pile-head deflection, maximum
  bending moment, and shear force only
- Analysis assumes no soil movements acting on pile
- No p-y curves to be computed and output for user-specified depths

Solution Control Parameters:
- Number of pile increments                      =         100
- Maximum number of iterations allowed           =         100
- Deflection tolerance for convergence           =  1.0000E-05  in
- Maximum allowable deflection                   =    100.0000  in

Pile Response Output Options:
- Only summary tables of pile-head deflection, maximum bending moment,
  and maximum shear force are to be written to output report file.

--------------------------------------------------------------------------------
                      Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Total Number of Sections                        =         1

Total Pile Length                               =      50.00 ft

Depth of ground surface below top of pile       =      -5.00 ft
```

Slope angle of ground surface = 0.00 deg.

Pile dimensions used for p-y curve computations defined using 2 points.
p-y curves are computed using values of pile diameter interpolated over
the length of the pile.

Point	Depth X ft	Pile Diameter in
1	0.00000	24.0000000
2	50.000000	24.0000000

Input Structural Properties:

Section No. 1:

Section Type	=	Elastic Pile
Cross-sectional Shape	=	Circular
Section Length	=	50.000 in
Top Width	=	24.000 in
Bottom Width	=	24.000 in
Top Area	=	452.000000 sq. in
Bottom Area	=	452.000000 sq. in
Moment of Inertia at Top	=	8.143E+03 in^4
Moment of Inertia at Bottom	=	8.143E+03 in^4
Elastic Modulus	=	3200000.000 lbs/in

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000 degrees
	=	0.000 radians
Pile Batter Angle	=	0.000 degrees
	=	0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 4 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	-5.000 ft
Distance from top of pile to bottom of layer	=	6.000 ft
p-y subgrade modulus k for top of soil layer	=	90.000 lbs/in**3
p-y subgrade modulus k for bottom of layer	=	90.000 lbs/in**3

Layer 2 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer	=	6.000 ft
Distance from top of pile to bottom of layer	=	14.000 ft

Layer 3 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer	=	14.000 ft
Distance from top of pile to bottom of layer	=	28.000 ft

Layer 4 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer	=	28.000 ft
Distance from top of pile to bottom of layer	=	60.000 ft

(Depth of lowest layer extends 10.00 ft below pile tip)

Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 8 points

Point No.	Depth X ft	Eff. Unit Weight pcf
1	-5.00	60.00000
2	6.00	60.00000
3	6.00	60.00000

4	14.00	60.00000
5	14.00	120.00000
6	28.00	120.00000
7	28.00	57.60000
8	60.00	57.60000

Summary of Soil Properties

Layer Num.	Soil Type (p-y Curve Criteria)	Depth ft	Eff. Unit Wt., pcf	Cohesion psf	Friction Ang., deg.	qu psi	RQD percent	Epsilon 50	kpy pci	Rock Emass psi	krm	Test Type	Test Prop.	Elas. Subgr. pci
1	Sand (Reese, et al.)	-5.000	60.000	--	32.000	--	--	--	90.000	--	--	--	--	--
		6.000	60.000	--	32.000	--	--	--	90.000	--	--	--	--	--
2	Soft Clay	6.000	60.000	3000.000	--	--	--	0.00500	--	--	--	--	--	--
		14.000	60.000	3000.000	--	--	--	0.00500	--	--	--	--	--	--
3	Soft Clay	14.000	120.000	3000.000	--	--	--	0.00500	--	--	--	--	--	--
		28.000	120.000	3000.000	--	--	--	0.00500	--	--	--	--	--	--
4	Soft Clay	28.000	57.600	3000.000	--	--	--	0.00500	--	--	--	--	--	--
		60.000	57.600	3000.000	--	--	--	0.00500	--	--	--	--	--	--

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.6000	1.0000
2	50.000	0.6000	1.0000

Loading Type

p-y criteria for static loading was used for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 5

Load No.	Load Type	Condition 1		Condition 2		Axial Thrust Force, lbs
1	4	y =	0.250 in	M =	0.000 in-lbs	150000.000
2	4	y =	0.500 in	M =	0.000 in-lbs	150000.000
3	4	y =	1.000 in	M =	0.000 in-lbs	150000.000
4	4	y =	2.000 in	M =	0.000 in-lbs	150000.000
5	4	y =	5.000 in	M =	0.000 in-lbs	150000.000

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust values were determined from pile-head loading conditions

Number of Sections = 1

Section No. 1:

Moment-Curvature properties derived from elastic section properties

Summary of Pile Response(s)

Definitions of Pile-Head Loading Conditions:

Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian

Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

Load Case No.	Load Type No.	Condition 1 V(lbs) or y(inches)	Condition 2 in-lb, rad., or in-lb/rad.	Axial Load lbs	Pile-Head Deflection inches	Maximum Moment in-lbs	Maximum Shear lbs	Pile-Head Rotation radians
1	4	y = 0.2500	M = 0.000	150000.	0.25000000	863729.	18027.	0.00000000
2	4	y = 0.5000	M = 0.000	150000.	0.50000000	1470790.	28259.	0.00000000
3	4	y = 1.0000	M = 0.000	150000.	1.00000000	2482689.	44817.	0.00000000
4	4	y = 2.0000	M = 0.000	150000.	2.00000000	4142749.	66562.	0.00000000
5	4	y = 5.0000	M = 0.000	150000.	5.00000000	7857940.	102434.	0.00000000

Summary of Warning Messages

The following warning was reported 1720 times

**** Warning ****

An unreasonable input value for shear strength has been specified for a soil defined using the soft clay criteria. The input value is greater than 8.68 psi (1,250 psf). You should check your input data for correctness.

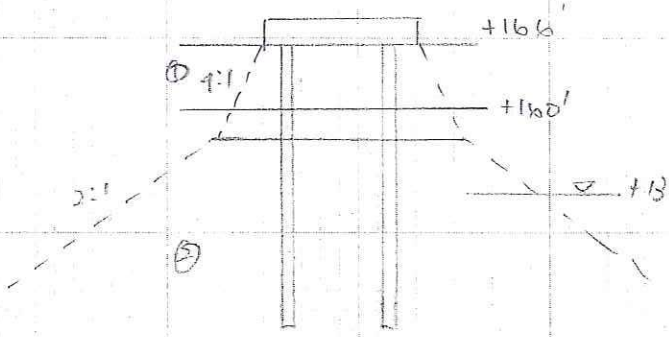
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

17800 Newhope Street, Suite B, Fountain Valley, CA 92708
(714) 751-3826, Fax (714) 751-3928

Project 51N5-N1 Connector separation (55-0226) **Project No.** 11-137

By SA **Date** 02-24-12 **Checked By** LCC **Date** 2/21/12 **Sheet** ____ **of** ____

Settlement - Abutments 1 & 4



Total load per support = 385 kips

permanent load per support = 308 kips

Pile cap = 7' x 14'

consider pile length D = 12

$2D/3 = 8$

Equivalent footing $= \left(7 + \frac{8}{4} \times 2\right) \times \left(14 + \frac{8}{4} \times 2\right)$

$= 11' \times 18''$

$q = \frac{385}{11 \times 18} = 1.94$ ksf for immediate settlement

$q = \frac{308}{11 \times 18} = 1.55$ ksf for consolidation settlement

σ_{vo}	$\Delta\sigma$	settlement
② $18 \times 120 = 2.2$	$\frac{385}{(11+10)(18+10)} = 0.65$	$20 \times \frac{1}{40} \log\left(\frac{2.2+0.65}{2.2}\right) = 0.67$
$28 \times 120 + 10 \times 57.6 = 3.94$	$\frac{308}{(11+30)(18+30)} = 0.16$	$20 \times \frac{1}{40} \log\left(\frac{3.94+0.16}{3.94}\right) = 0.11$
$28 \times 120 + 30 \times 57.6 = 5.1$	$\frac{308}{(11+50)(18+50)} = 0.1$	$20 \times \frac{1}{40} \log\left(\frac{5.1+0.1}{5.1}\right) = 0.1$
		0.88

pile length is less than 12 feet and settlement is less than 1"

no applicable pile length for Abutments 1 & 4 (Cafe bridge)

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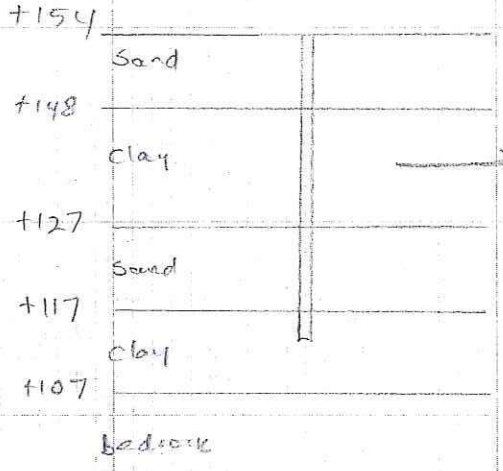
Project 5/N5-N1 connector separation (55-0226) **Project No.** 11-137

By SP **Date** 02-24-12 **Checked By** LCC **Date** 3/2/12 **Sheet** ____ **of** ____

Bents 2 and 4



pile spacing = 2.5d
Group efficiency factor = 0.65
pile cap = 14' x 14'

bottom of footing elevation = +150 ft at Bent 2
= +145 ft at Bent 3

Nominal resistance per pile
strength limit state = 194/0.7 = 277 kips
consider 280 kips at Bent 2
= 188/0.7 = 268 kips
consider 270 kips at Bent 3
Extreme event limit state = 349/1.0 = 340 kips for Bent 2

= 320/1.0 = 320 kips for Bent 3

Tension = 192/1.0 = 192 kips
consider 200 kips at Bent 2
= 180/1.0 = 180 kips at Bent 3

Nominal resistance per support
strength limit state = 1216/0.7 = 1737 kips; consider 1740 kips Bent 2
= 1115/0.7 = 1593 kips; consider 1600 kips Bent 3
Extreme event limit state = 589 & 557 kips at Bents 2 & 3
consider 590 kips at Bent 2; 560 kips at Bent 3

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Project 5/N5-N1 connector separation (55-0226) **Project No.** 11-137

By SP **Date** 02-24-12 **Checked By** LCC **Date** 2/21/12 **Sheet** ____ **of** ____

from analysis
Strength limit state

Bent 2

at depth of 46 ft, pile capacity = 282 kips > 280 kips Bent 2

piletip elevation for compression = 150 - 46 = +104 feet

Available group nominal resistance at pile
pile tip elevation of +104 ft = 8 x 282 x 0.65
= 1466 kips

Required group nominal resistance = 1740 kips > 1483 kips
compression capacity needed per pile = $\frac{1740}{0.65 \times 8}$ = 334 kips

consider 340 kips

at 52 feet, pile capacity = 344 kips > 340 kips

pile tip elevation for compression = 150 - 52
= +98 feet Bent 2

nominal resistance = 340 kips Bent 2

Bent 3

at depth of 44 ft, pile capacity = 276 kips > 270 kips
pile tip elevation for compression = 145 - 44
= +101 feet Bent 3

available group nominal resistance at pile
tip elevation of +101 ft = 8 x 276 x 0.65
= 1435 kips

Required group nominal resistance = 1600 kips > 1433 kips
compression capacity needed per pile = $\frac{1600}{0.65 \times 8}$ = 307 kips

consider 310 kips for Bent 3

at 48 ft, pile capacity = 317 kips > 310 kips
pile tip elevation for compression = 145 - 48
= +97 feet Bent 3

Nominal resistance = 310 kips Bent 3

Earth Mechanics, Inc.
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Project SJN5-N1 connector separation (59-0226) **Project No.** 11-157

By SP **Date** 02-24-12 **Checked By** WCC **Date** 3/2/12 **Sheet** ____ **of** ____

Extreme event limit state

Bent 2
at 52 ft, pile capacity = 349 kips > 340 kips Bent 2
pile tip elevation for compression = +98 feet Bent 2
Available group nominal resistance at pile tip elevation of +98 ft = 8 x 349 x 0.65 = 1788 kips
required group nominal resistance = 580 kips < 1788 kips
pile tip elevation for compression (Extreme event)
= +98 feet for Bent 2

Bent 3
at 49 ft, pile capacity = 327.8 kips > 326 Bent 3
pile tip elevation for compression = 145 - 49
= +96 feet Bent 3
Available group nominal resistance at pile tip elevation of +96 ft = 8 x 327.8 x 0.65 = 1704 kips
Required group nominal resistance = 550 kips < 1704 kips
pile tip elevation for compression (Extreme event)
= +96 feet for Bent 3

Bent 2 - Tension
at 48 feet, tension capacity = $\frac{2}{3}$ x 302
= 201 kips > 200 kips
pile tip elevation for tension (Extreme event)
= 150 - 48
= +102 feet for Bent 2

Bent 3 - Tension
at 44 feet, tension capacity = 2/3 x 276 = 184 kips > 180 kips
pile tip elevation for tension (Extreme event)
= 145 - 44
= +101 feet for Bent 3

SKIN FRICTION FOR DRILLED SHAFT IN BOTH COHESIONLESS AND COHESIVE SOILS USING REESE AND O'NEILL'S METHOD (1999)

PROJECT: 5/N5-N1 Connector Separation (55-0226) ITEM: 24-inch Diameter CIDH Pile
PROJECT NO.: 11-137 Bent 2 (Left Bridge)
DONE BY: SP DATE: 02/24/12
CHECKED BY: DATE:

D_s => 2.00 ft Hw => 5.0 ft Hg => 0.0 ft
p = 6.28 ft Ho => 0.0 ft Hf => 0.0 ft

Hw is the depth to water table.
Hg is the depth to ground surface used in calculation.
Ho is the depth to location starting initial overburden pressure
Hf is the depth to location starting accumulation of skin frictio
bottom of footing = 151 ft

Soil Layer =>	from Top	to Bottom =>	γ (pcf)=>	γ' (pcf)=	c' (ksf) =>	ϕ' =>	
(1)	0	3	120	57.6	0.00	32	SM
(2)	3	24	115	52.6	1.50	0	CL
(3)	24	34	120	57.6	0.00	32	SP/SP-SM
(4)	34	44	115	52.6	2.00	0	CL
(5)	44	60	120	57.6	3.00	0	Bedrock

Sublayer No.	Depth, z (ft)	z_i (ft)	New Depth (ft)	Soil Unit Weight (pcf)	Overburden Pressure (psf)	c' (ksf)	β	f_i^s (ksf)	ΔQ_s^s (kips)	Q_s^s (kips)	f_i^c (ksf)	ΔQ_s^c (kips)	Q_s^c (kips)	Q_s (kips)
0	0.0	0.0	0.0	120.0	0									
1	0.0	0.0	0.0	120.0	0	0.0				0.0			0.0	0.0
2	1.0	0.5	0.5	120.0	60	0.0	1.20	0.07	0.5	0.5	0.00	0.0	0.0	0.5
3	2.0	1.5	1.5	120.0	180	0.0	1.20	0.22	1.4	1.8	0.00	0.0	0.0	1.8
4	3.0	2.5	2.5	120.0	300	0.0	1.20	0.36	2.3	4.1	0.00	0.0	0.0	4.1
5	4.0	3.5	3.5	115.0	415	1.5	1.20	0.00	0.0	4.1	0.00	0.0	0.0	4.1
6	5.0	4.5	4.5	115.0	530	1.5	1.20	0.00	0.0	4.1	0.00	0.0	0.0	4.1
7	6.0	5.5	5.5	52.6	583	1.5	1.18	0.00	0.0	4.1	0.83	5.2	5.2	9.3
8	7.0	6.5	6.5	52.6	635	1.5	1.16	0.00	0.0	4.1	0.83	5.2	10.4	14.4
9	8.0	7.5	7.5	52.6	688	1.5	1.13	0.00	0.0	4.1	0.83	5.2	15.6	19.6
10	9.0	8.5	8.5	52.6	740	1.5	1.11	0.00	0.0	4.1	0.83	5.2	20.7	24.8
11	10.0	9.5	9.5	52.6	793	1.5	1.08	0.00	0.0	4.1	0.83	5.2	25.9	30.0
12	11.0	10.5	10.5	52.6	846	1.5	1.06	0.00	0.0	4.1	0.83	5.2	31.1	35.2
13	12.0	11.5	11.5	52.6	898	1.5	1.04	0.00	0.0	4.1	0.83	5.2	36.3	40.4
14	13.0	12.5	12.5	52.6	951	1.5	1.02	0.00	0.0	4.1	0.83	5.2	41.5	45.5
15	14.0	13.5	13.5	52.6	1003	1.5	1.00	0.00	0.0	4.1	0.83	5.2	46.7	50.7
16	15.0	14.5	14.5	52.6	1056	1.5	0.99	0.00	0.0	4.1	0.83	5.2	51.8	55.9
17	16.0	15.5	15.5	52.6	1109	1.5	0.97	0.00	0.0	4.1	0.83	5.2	57.0	61.1
18	17.0	16.5	16.5	52.6	1161	1.5	0.95	0.00	0.0	4.1	0.83	5.2	62.2	66.3
19	18.0	17.5	17.5	52.6	1214	1.5	0.94	0.00	0.0	4.1	0.83	5.2	67.4	71.5
20	19.0	18.5	18.5	52.6	1266	1.5	0.92	0.00	0.0	4.1	0.83	5.2	72.6	76.6
21	20.0	19.5	19.5	52.6	1319	1.5	0.90	0.00	0.0	4.1	0.83	5.2	77.8	81.8
22	21.0	20.5	20.5	52.6	1372	1.5	0.89	0.00	0.0	4.1	0.83	5.2	82.9	87.0
23	22.0	21.5	21.5	52.6	1424	1.5	0.87	0.00	0.0	4.1	0.83	5.2	88.1	92.2
24	23.0	22.5	22.5	52.6	1477	1.5	0.86	0.00	0.0	4.1	0.83	5.2	93.3	97.4
25	24.0	23.5	23.5	52.6	1529	1.5	0.85	0.00	0.0	4.1	0.83	5.2	98.5	102.6
26	25.0	24.5	24.5	57.6	1587	0.0	0.83	1.32	8.3	12.4	0.00	0.0	98.5	110.9
27	26.0	25.5	25.5	57.6	1645	0.0	0.82	1.35	8.5	20.8	0.00	0.0	98.5	119.3
28	27.0	26.5	26.5	57.6	1702	0.0	0.81	1.37	8.6	29.4	0.00	0.0	98.5	127.9
29	28.0	27.5	27.5	57.6	1760	0.0	0.79	1.39	8.8	38.2	0.00	0.0	98.5	136.7
30	29.0	28.5	28.5	57.6	1817	0.0	0.78	1.42	8.9	47.1	0.00	0.0	98.5	145.6
31	30.0	29.5	29.5	57.6	1875	0.0	0.77	1.44	9.0	56.1	0.00	0.0	98.5	154.6
32	31.0	30.5	30.5	57.6	1933	0.0	0.75	1.46	9.2	65.3	0.00	0.0	98.5	163.8
33	32.0	31.5	31.5	57.6	1990	0.0	0.74	1.48	9.3	74.6	0.00	0.0	98.5	173.1
34	33.0	32.5	32.5	57.6	2048	0.0	0.73	1.50	9.4	84.0	0.00	0.0	98.5	182.5
35	34.0	33.5	33.5	57.6	2105	0.0	0.72	1.51	9.5	93.5	0.00	0.0	98.5	192.0
36	35.0	34.5	34.5	52.6	2158	2.0	0.71	0.00	0.0	93.5	1.10	6.9	105.4	198.9
37	36.0	35.5	35.5	52.6	2211	2.0	0.70	0.00	0.0	93.5	1.10	6.9	112.3	205.8
38	37.0	36.5	36.5	52.6	2263	2.0	0.68	0.00	0.0	93.5	1.10	6.9	119.2	212.7
39	38.0	37.5	37.5	52.6	2316	2.0	0.67	0.00	0.0	93.5	1.10	6.9	126.1	219.6
40	39.0	38.5	38.5	52.6	2368	2.0	0.66	0.00	0.0	93.5	1.10	6.9	133.0	226.5
41	40.0	39.5	39.5	52.6	2421	2.0	0.65	0.00	0.0	93.5	1.10	6.9	140.0	233.4
42	41.0	40.5	40.5	52.6	2474	2.0	0.64	0.00	0.0	93.5	1.10	6.9	146.9	240.3

Sublayer No.	Depth, z (ft)	z_i (ft)	New Depth (ft)	Soil Unit Weight (pcf)	Overburden Pressure (psf)	c' (ksf)	β	f_i^s (ksf)	ΔQ_s^s (kips)	Q_s^s (kips)	f_i^c (ksf)	ΔQ_s^c (kips)	Q_s^c (kips)	Q_s (kips)
43	42.0	41.5	41.5	52.6	2526	2.0	0.63	0.00	0.0	93.5	1.10	6.9	153.8	247.2
44	43.0	42.5	42.5	52.6	2579	2.0	0.62	0.00	0.0	93.5	1.10	6.9	160.7	254.2
45	44.0	43.5	43.5	52.6	2631	2.0	0.61	0.00	0.0	93.5	1.10	6.9	167.6	261.1
46	45.0	44.5	44.5	57.6	2689	3.0	0.60	0.00	0.0	93.5	1.65	10.4	178.0	271.4
47	46.0	45.5	45.5	57.6	2747	3.0	0.59	0.00	0.0	93.5	1.65	10.4	188.3	281.8
48	47.0	46.5	46.5	57.6	2804	3.0	0.58	0.00	0.0	93.5	1.65	10.4	198.7	292.2
49	48.0	47.5	47.5	57.6	2862	3.0	0.57	0.00	0.0	93.5	1.65	10.4	209.1	302.5
50	49.0	48.5	48.5	57.6	2919	3.0	0.56	0.00	0.0	93.5	1.65	10.4	219.4	312.9
51	50.0	49.5	49.5	57.6	2977	3.0	0.55	0.00	0.0	93.5	1.65	10.4	229.8	323.3
52	51.0	50.5	50.5	57.6	3035	3.0	0.54	0.00	0.0	93.5	1.65	10.4	240.2	333.6
53	52.0	51.5	51.5	57.6	3092	3.0	0.53	0.00	0.0	93.5	1.65	10.4	250.5	344.0
54	53.0	52.5	52.5	57.6	3150	3.0	0.52	0.00	0.0	93.5	1.65	10.4	260.9	354.4
55	54.0	53.5	53.5	57.6	3207	3.0	0.51	0.00	0.0	93.5	1.65	10.4	271.3	364.7
56	55.0	54.5	54.5	57.6	3265	3.0	0.50	0.00	0.0	93.5	1.65	10.4	281.6	375.1
57	56.0	55.5	55.5	57.6	3323	3.0	0.49	0.00	0.0	93.5	1.65	10.4	292.0	385.5
58	57.0	56.5	56.5	57.6	3380	3.0	0.49	0.00	0.0	93.5	1.65	10.4	302.4	395.8
59	58.0	57.5	57.5	57.6	3438	3.0	0.48	0.00	0.0	93.5	1.65	10.4	312.7	406.2
60	59.0	58.5	58.5	57.6	3495	3.0	0.47	0.00	0.0	93.5	1.65	10.4	323.1	416.6
61	60.0	59.5	59.5	57.6	3553	3.0	0.46	0.00	0.0	93.5	1.65	10.4	333.5	426.9

SKIN FRICTION FOR DRILLED SHAFT IN BOTH COHESIONLESS AND COHESIVE SOILS USING REESE AND O'NEILL'S METHOD (1999)

PROJECT: 5/N5-N1 Connector Separation (55-0226) ITEM: 24-inch Diameter CIDH Pile
PROJECT NO.: 11-137 Bent 3 (Left Bridge)
DONE BY: SP DATE: 02/24/12
CHECKED BY: DATE:

D_s => 2.00 ft Hw => 5.0 ft Hg => 0.0 ft
p = 6.28 ft Ho => 0.0 ft Hf => 0.0 ft

Hw is the depth to water table.
Hg is the depth to ground surface used in calculation.
Ho is the depth to location starting initial overburden pressure
Hf is the depth to location starting accumulation of skin frictio
bottom of footing = 146 ft

Soil Layer =>	from Top	to Bottom =>	γ (pcf)=>	γ' (pcf)=	c' (ksf) =>	φ' =>	
(1)	0	19	115	52.6	1.50	0	CL
(2)	19	29	120	57.6	0.00	32	SP/SP-SM
(3)	29	39	115	52.6	2.00	0	CL
(4)	39	60	120	57.6	3.00	0	Bedrock

Sublayer No.	Depth, z (ft)	z_i (ft)	New Depth (ft)	Soil Unit Weight (pcf)	Overburden Pressure (psf)	c' (ksf)	β	f_i^s (ksf)	ΔQ_s^s (kips)	Q_s^s (kips)	f_i^c (ksf)	ΔQ_s^c (kips)	Q_s^c (kips)	Q_s (kips)
0	0.0	0.0	0.0	115.0	0									
1	0.0	0.0	0.0	115.0	0	1.5				0.0			0.0	0.0
2	1.0	0.5	0.5	115.0	58	1.5	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
3	2.0	1.5	1.5	115.0	173	1.5	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
4	3.0	2.5	2.5	115.0	288	1.5	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
5	4.0	3.5	3.5	115.0	403	1.5	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
6	5.0	4.5	4.5	115.0	518	1.5	1.20	0.00	0.0	0.0	0.00	0.0	0.0	0.0
7	6.0	5.5	5.5	52.6	570	1.5	1.18	0.00	0.0	0.0	0.83	5.2	5.2	5.2
8	7.0	6.5	6.5	52.6	623	1.5	1.16	0.00	0.0	0.0	0.83	5.2	10.4	10.4
9	8.0	7.5	7.5	52.6	675	1.5	1.13	0.00	0.0	0.0	0.83	5.2	15.6	15.6
10	9.0	8.5	8.5	52.6	728	1.5	1.11	0.00	0.0	0.0	0.83	5.2	20.7	20.7
11	10.0	9.5	9.5	52.6	781	1.5	1.08	0.00	0.0	0.0	0.83	5.2	25.9	25.9
12	11.0	10.5	10.5	52.6	833	1.5	1.06	0.00	0.0	0.0	0.83	5.2	31.1	31.1
13	12.0	11.5	11.5	52.6	886	1.5	1.04	0.00	0.0	0.0	0.83	5.2	36.3	36.3
14	13.0	12.5	12.5	52.6	938	1.5	1.02	0.00	0.0	0.0	0.83	5.2	41.5	41.5
15	14.0	13.5	13.5	52.6	991	1.5	1.00	0.00	0.0	0.0	0.83	5.2	46.7	46.7
16	15.0	14.5	14.5	52.6	1044	1.5	0.99	0.00	0.0	0.0	0.83	5.2	51.8	51.8
17	16.0	15.5	15.5	52.6	1096	1.5	0.97	0.00	0.0	0.0	0.83	5.2	57.0	57.0
18	17.0	16.5	16.5	52.6	1149	1.5	0.95	0.00	0.0	0.0	0.83	5.2	62.2	62.2
19	18.0	17.5	17.5	52.6	1201	1.5	0.94	0.00	0.0	0.0	0.83	5.2	67.4	67.4
20	19.0	18.5	18.5	52.6	1254	1.5	0.92	0.00	0.0	0.0	0.83	5.2	72.6	72.6
21	20.0	19.5	19.5	57.6	1312	0.0	0.90	1.19	7.4	7.4	0.00	0.0	72.6	80.0
22	21.0	20.5	20.5	57.6	1369	0.0	0.89	1.22	7.6	15.1	0.00	0.0	72.6	87.7
23	22.0	21.5	21.5	57.6	1427	0.0	0.87	1.25	7.8	22.9	0.00	0.0	72.6	95.5
24	23.0	22.5	22.5	57.6	1484	0.0	0.86	1.28	8.0	30.9	0.00	0.0	72.6	103.5
25	24.0	23.5	23.5	57.6	1542	0.0	0.85	1.30	8.2	39.1	0.00	0.0	72.6	111.7
26	25.0	24.5	24.5	57.6	1600	0.0	0.83	1.33	8.4	47.5	0.00	0.0	72.6	120.1
27	26.0	25.5	25.5	57.6	1657	0.0	0.82	1.36	8.5	56.0	0.00	0.0	72.6	128.6
28	27.0	26.5	26.5	57.6	1715	0.0	0.81	1.38	8.7	64.7	0.00	0.0	72.6	137.3
29	28.0	27.5	27.5	57.6	1772	0.0	0.79	1.40	8.8	73.5	0.00	0.0	72.6	146.1
30	29.0	28.5	28.5	57.6	1830	0.0	0.78	1.43	9.0	82.5	0.00	0.0	72.6	155.0
31	30.0	29.5	29.5	52.6	1883	2.0	0.77	0.00	0.0	82.5	1.10	6.9	79.5	162.0
32	31.0	30.5	30.5	52.6	1935	2.0	0.75	0.00	0.0	82.5	1.10	6.9	86.4	168.9
33	32.0	31.5	31.5	52.6	1988	2.0	0.74	0.00	0.0	82.5	1.10	6.9	93.3	175.8
34	33.0	32.5	32.5	52.6	2040	2.0	0.73	0.00	0.0	82.5	1.10	6.9	100.2	182.7
35	34.0	33.5	33.5	52.6	2093	2.0	0.72	0.00	0.0	82.5	1.10	6.9	107.1	189.6
36	35.0	34.5	34.5	52.6	2146	2.0	0.71	0.00	0.0	82.5	1.10	6.9	114.0	196.5
37	36.0	35.5	35.5	52.6	2198	2.0	0.70	0.00	0.0	82.5	1.10	6.9	121.0	203.4
38	37.0	36.5	36.5	52.6	2251	2.0	0.68	0.00	0.0	82.5	1.10	6.9	127.9	210.3
39	38.0	37.5	37.5	52.6	2303	2.0	0.67	0.00	0.0	82.5	1.10	6.9	134.8	217.2
40	39.0	38.5	38.5	52.6	2356	2.0	0.66	0.00	0.0	82.5	1.10	6.9	141.7	224.2
41	40.0	39.5	39.5	57.6	2414	3.0	0.65	0.00	0.0	82.5	1.65	10.4	152.1	234.5
42	41.0	40.5	40.5	57.6	2471	3.0	0.64	0.00	0.0	82.5	1.65	10.4	162.4	244.9
43	42.0	41.5	41.5	57.6	2529	3.0	0.63	0.00	0.0	82.5	1.65	10.4	172.8	255.3

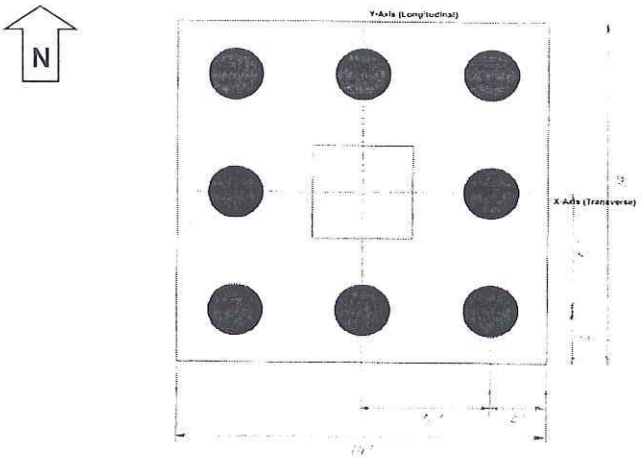
Sublayer No.	Depth, z (ft)	z_i (ft)	New Depth (ft)	Soil Unit Weight (pcf)	Overburden Pressure (psf)	c' (ksf)	β	f_i^s (ksf)	ΔQ_s^s (kips)	Q_s^s (kips)	f_i^c (ksf)	ΔQ_s^c (kips)	Q_s^c (kips)	Q_s (kips)
44	43.0	42.5	42.5	57.6	2586	3.0	0.62	0.00	0.0	82.5	1.65	10.4	183.2	265.6
45	44.0	43.5	43.5	57.6	2644	3.0	0.61	0.00	0.0	82.5	1.65	10.4	193.5	276.0
46	45.0	44.5	44.5	57.6	2702	3.0	0.60	0.00	0.0	82.5	1.65	10.4	203.9	286.4
47	46.0	45.5	45.5	57.6	2759	3.0	0.59	0.00	0.0	82.5	1.65	10.4	214.3	296.7
48	47.0	46.5	46.5	57.6	2817	3.0	0.58	0.00	0.0	82.5	1.65	10.4	224.6	307.1
49	48.0	47.5	47.5	57.6	2874	3.0	0.57	0.00	0.0	82.5	1.65	10.4	235.0	317.5
50	49.0	48.5	48.5	57.6	2932	3.0	0.56	0.00	0.0	82.5	1.65	10.4	245.4	327.8
51	50.0	49.5	49.5	57.6	2990	3.0	0.55	0.00	0.0	82.5	1.65	10.4	255.7	338.2
52	51.0	50.5	50.5	57.6	3047	3.0	0.54	0.00	0.0	82.5	1.65	10.4	266.1	348.6
53	52.0	51.5	51.5	57.6	3105	3.0	0.53	0.00	0.0	82.5	1.65	10.4	276.5	358.9
54	53.0	52.5	52.5	57.6	3162	3.0	0.52	0.00	0.0	82.5	1.65	10.4	286.8	369.3
55	54.0	53.5	53.5	57.6	3220	3.0	0.51	0.00	0.0	82.5	1.65	10.4	297.2	379.7
56	55.0	54.5	54.5	57.6	3278	3.0	0.50	0.00	0.0	82.5	1.65	10.4	307.6	390.0
57	56.0	55.5	55.5	57.6	3335	3.0	0.49	0.00	0.0	82.5	1.65	10.4	317.9	400.4
58	57.0	56.5	56.5	57.6	3393	3.0	0.49	0.00	0.0	82.5	1.65	10.4	328.3	410.8
59	58.0	57.5	57.5	57.6	3450	3.0	0.48	0.00	0.0	82.5	1.65	10.4	338.7	421.1
60	59.0	58.5	58.5	57.6	3508	3.0	0.47	0.00	0.0	82.5	1.65	10.4	349.0	431.5
61	60.0	59.5	59.5	57.6	3566	3.0	0.46	0.00	0.0	82.5	1.65	10.4	359.4	441.9

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

17800 Newhope Street, Suite B, Fountain Valley, CA 92708
phone: (714)751-3826, Fax (714)751-3928

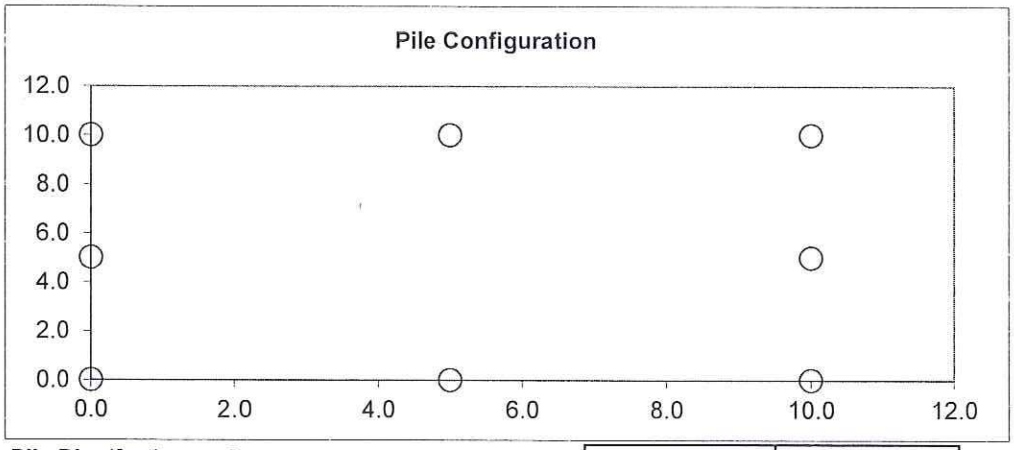
Project: 5/N5-N1 Connector Separation (55-0226) Project No. 11-137
By SP Date 02/22/12 Check by Date Sheet

Proposed Bent 2 Pile Layout (Left Bridge)



Calculation of Pile Group Efficiency for Lateral Load Capacity

(using formula in Group 7.0 Technical Manual)



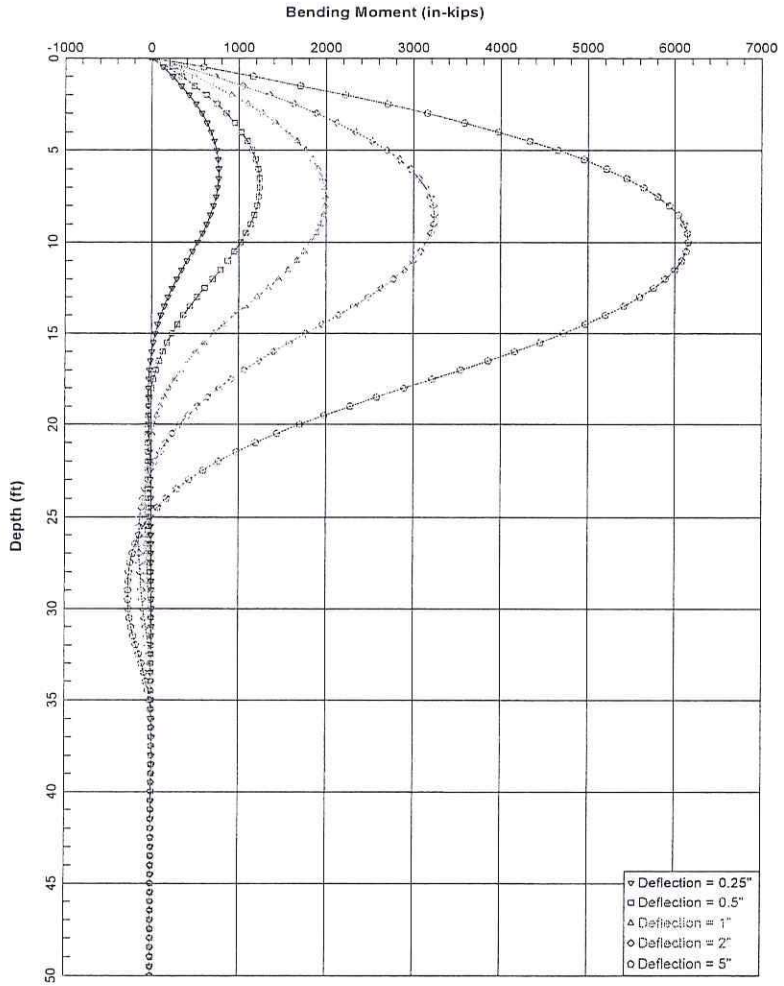
Pile Dia. (feet):	2
No. of Piles:	8

Group Efficiency	X-Dir	Y-Dir
	0.594	0.594

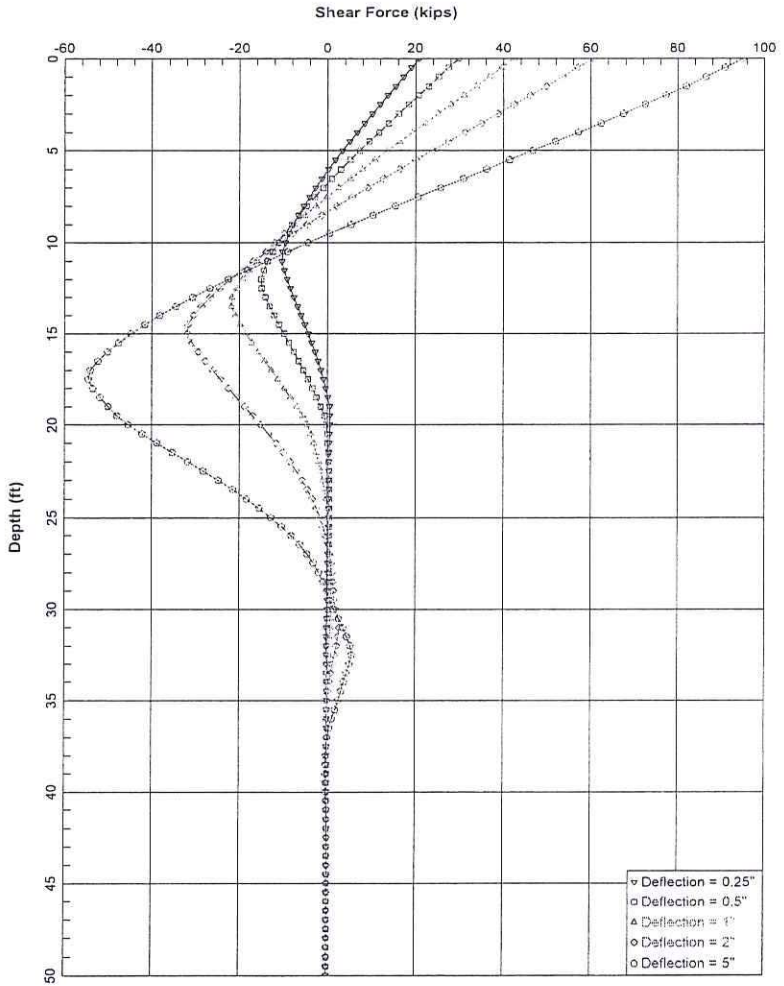
Coordinates

Pile No.	X	Y
1	0.0	0.0
2	5.0	0.0
3	10.0	0.0
4	0.0	5.0
5	10.0	5.0
6	0.0	10.0
7	5.0	10.0
8	10.0	10.0

Reduction Factors in X-dir	Reduction Factors in Y-dir
0.486	0.486
0.515	0.467
0.776	0.486
0.467	0.515
0.730	0.515
0.486	0.776
0.515	0.730
0.776	0.776



I-5 HOV Improvement, PCH to San Juan Creek Road - 24-inch CIDH Piles at Bents 2 and 3 (Left Bridge)



I-5 HOV Improvement, PCH to San Juan Creek Road - 24-inch CIDH Piles at Bents 2 and 3 (Left Bridge)

LPile Plus for Windows, Version 6.0 (6.0.09)

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

(c) 1985-2010 by Ensoft, Inc.
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This program is licensed to:

Earth Mechanics, Inc.
Earth Mechanics, Inc.

Files Used for Analysis

Path to file locations: X:\Projects\2011\11-137 - TRC, I-5 HOV Widening - Segment 3\Reports\02 5_N5-N1 Conn Sep (55-0226)\Analysis\Lateral Capacity\
Name of input data file: 5_N5_N1 Conn Sep 24-inch CIDH (Bents 2 and 3-Left Bridge).lp6d
Name of output file: 5_N5_N1 Conn Sep 24-inch CIDH (Bents 2 and 3-Left Bridge).lp6o
Name of plot output file: 5_N5_N1 Conn Sep 24-inch CIDH (Bents 2 and 3-Left Bridge).lp6p
Name of runtime file: 5_N5_N1 Conn Sep 24-inch CIDH (Bents 2 and 3-Left Bridge).lp6r

Date and Time of Analysis

Date: February 24, 2012 Time: 20:07:16

Problem Title

Project Name:
Job Number:
Client:
Engineer:
Description:

Program Options

Units Used - US Customary Units: pounds, inches, feet

Basic Program Options:

This analysis computes nonlinear bending stiffness and nominal Moment
Capacity with Pile Response Computed Using Nonlinear EI

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis uses p-y multipliers for group action
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix elements
- Output summary table of values for pile-head deflection, maximum bending moment, and shear force only
- Analysis assumes no soil movements acting on pile
- No p-y curves to be computed and output for user-specified depths

Solution Control Parameters:

- Number of pile increments	=	100	
- Maximum number of iterations allowed	=	100	
- Deflection tolerance for convergence	=	1.0000E-05	in
- Maximum allowable deflection	=	100.0000	in

Pile Response Output Options:
- Only summary tables of pile-head deflection, maximum bending moment, and maximum shear force are to be written to output report file.

Pile Structural Properties and Geometry

Total Number of Sections	=	1
Total Pile Length	=	50.00 ft
Depth of ground surface below top of pile	=	-5.00 ft

Slope angle of ground surface = 0.00 deg.

Pile dimensions used for p-y curve computations defined using 2 points.
p-y curves are computed using values of pile diameter interpolated over
the length of the pile.

Point	Depth X ft	Pile Diameter in
1	0.00000	24.0000000
2	50.000000	24.0000000

Input Structural Properties:

Section No. 1:

Section Type	=	Elastic Pile
Cross-sectional Shape	=	Circular
Section Length	=	50.000 in
Top Width	=	24.000 in
Bottom Width	=	24.000 in
Top Area	=	452.000000 sq. in
Bottom Area	=	452.000000 sq. in
Moment of Inertia at Top	=	8.143E+03 in^4
Moment of Inertia at Bottom	=	8.143E+03 in^4
Elastic Modulus	=	3200000.000 lbs/in

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 5 layers

Layer 1 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer = -5.000 ft
Distance from top of pile to bottom of layer = 9.000 ft

Layer 2 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer = 9.000 ft
Distance from top of pile to bottom of layer = 20.000 ft

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 20.000 ft
Distance from top of pile to bottom of layer = 30.000 ft
p-y subgrade modulus k for top of soil layer = 60.000 lbs/in**3
p-y subgrade modulus k for bottom of layer = 60.000 lbs/in**3

Layer 4 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer = 30.000 ft
Distance from top of pile to bottom of layer = 40.000 ft

Layer 5 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer = 40.000 ft
Distance from top of pile to bottom of layer = 60.000 ft

(Depth of lowest layer extends 10.00 ft below pile tip)

Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 10 points

Point	Depth X	Eff. Unit Weight

No.	ft	pcf
1	-5.00	115.00000
2	9.00	115.00000
3	9.00	52.60000
4	20.00	52.60000
5	20.00	57.60000
6	30.00	57.60000
7	30.00	52.60000
8	40.00	52.60000
9	40.00	57.60000
10	60.00	57.60000

Summary of Soil Properties

Layer Num.	Soil Type (p-y Curve Criteria)	Depth ft	Eff. Unit Wt., pcf	Cohesion psf	Friction Ang., deg.	qu psi	RQD percent	Epsilon 50	kpy pci	Rock Emass psi	krm	Test Type	Test Prop.	Elas. Subgr. pci
1	Soft Clay	-5.000	115.000	1500.000	--	--	--	0.00700	--	--	--	--	--	--
		9.000	115.000	1500.000	--	--	--	0.00700	--	--	--	--	--	--
2	Soft Clay	9.000	52.600	1500.000	--	--	--	0.00700	--	--	--	--	--	--
		20.000	52.600	1500.000	--	--	--	0.00700	--	--	--	--	--	--
3	Sand (Reese, et al.)	20.000	57.600	--	32.000	--	--	--	60.000	--	--	--	--	--
		30.000	57.600	--	32.000	--	--	--	60.000	--	--	--	--	--
4	Soft Clay	30.000	52.600	2000.000	--	--	--	0.00700	--	--	--	--	--	--
		40.000	52.600	2000.000	--	--	--	0.00700	--	--	--	--	--	--
5	Soft Clay	40.000	57.600	3000.000	--	--	--	0.00500	--	--	--	--	--	--
		60.000	57.600	3000.000	--	--	--	0.00500	--	--	--	--	--	--

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.6000	1.0000
2	50.000	0.6000	1.0000

Loading Type

p-y criteria for static loading was used for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 5

Load No.	Load Type	Condition 1		Condition 2		Axial Thrust Force, lbs
1	4	y =	0.250 in	M =	0.000 in-lbs	150000.000
2	4	y =	0.500 in	M =	0.000 in-lbs	150000.000
3	4	y =	1.000 in	M =	0.000 in-lbs	150000.000
4	4	y =	2.000 in	M =	0.000 in-lbs	150000.000
5	4	y =	5.000 in	M =	0.000 in-lbs	150000.000

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust values were determined from pile-head loading conditions

Number of Sections = 1

Section No. 1:

Moment-Curvature properties derived from elastic section properties

Summary of Pile Response(s)

Definitions of Pile-Head Loading Conditions:

Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

Load Case No.	Load Type No.	Condition 1 V(lbs) or y(inches)	Condition 2 in-lb, rad., or in-lb/rad.	Axial Load lbs	Pile-Head Deflection inches	Maximum Moment in-lbs	Maximum Shear lbs	Pile-Head Rotation radians
1	4	y = 0.2500	M = 0.000	150000.	0.25000000	768519.	20793.	0.00000000
2	4	y = 0.5000	M = 0.000	150000.	0.50000000	1236976.	29680.	0.00000000
3	4	y = 1.0000	M = 0.000	150000.	1.00000000	1994584.	42322.	0.00000000
4	4	y = 2.0000	M = 0.000	150000.	2.00000000	3236038.	60521.	0.00000000
5	4	y = 5.0000	M = 0.000	150000.	5.00000000	6152334.	95132.	0.00000000

Summary of Warning Messages

The following warning was reported 1404 times

**** Warning ****

An unreasonable input value for shear strength has been specified for a soil defined using the soft clay criteria. The input value is greater than 8.68 psi (1,250 psf). You should check your input data for correctness.

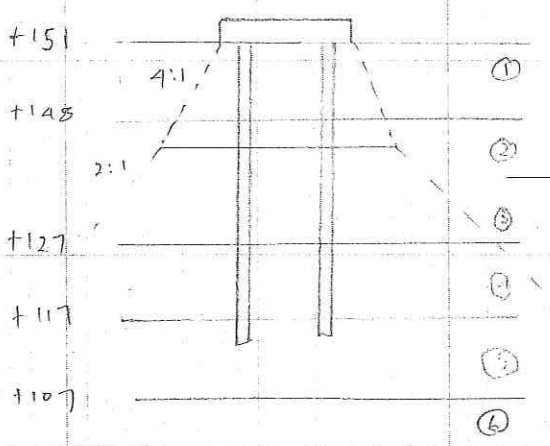
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

17800 Newhope Street, Suite B, Fountain Valley, CA 92708
(714) 751-3826, Fax (714) 751-3928

Project SINS-N1 connector separation (99-0226) **Project No.** 11-137

By SP **Date** 02-27-12 **Checked By** LSC **Date** 3/21/12 **Sheet** ____ **of** ____

Settlement - Bents 2 & 3



Total load per support = 774 kips
permanent load per support = 592 kips
pile cap = 14' x 14'

Consider pile length D = 24 feet
2D/3 = 18 feet

Equivalent footing = $(14 + \frac{18}{4} \times 2) \times (14 + \frac{18}{4} \times 2)$
= 23' x 23'

$q = \frac{774}{21 \times 21} = 1.76$ ksf for immediate settlement

$q = \frac{592}{21 \times 21} = 1.34$ ksf for consolidation settlement

	σ_{vo}	$\Delta\sigma$	settlement
③	$3 \times 120 + 10 \times 115 + 8 \times 52.6 = 1.93$	$\frac{592}{(23+3)(23+3)} = 0.88$	$6 \times \frac{1}{30} \log\left(\frac{1.93 + 0.88}{1.93}\right) = 0.38$
④	$3 \times 120 + 10 \times 115 + 11 \times 52.6 + 5 \times 57.6 = 2.38$	$\frac{774}{(23+11)(23+11)} = 0.66$	$10 \times \frac{1}{40} \log\left(\frac{2.38 + 0.66}{2.38}\right) = 0.32$
⑤	$3 \times 120 + 10 \times 115 + 16 \times 52.6 + 10 \times 57.6 = 2.93$	$\frac{592}{(23+21)(23+21)} = 0.3$	$10 \times \frac{1}{40} \log\left(\frac{2.93 + 0.3}{2.93}\right) = 0.13$
⑥	$3 \times 120 + 10 \times 115 + 21 \times 52.6 + 20 \times 57.6 = 3.76$	$\frac{592}{(23+36)(23+36)} = 0.17$	$20 \times \frac{1}{40} \log\left(\frac{3.76 + 0.17}{3.76}\right) = 0.13$
			0.96

pile length for settlement = 24 ft
pile tip elevation for settlement = 150 - 24 = +126 feet for Bent 2
Similarly, pile tip elevation for settlement = 145 - 24 = +121 feet for Bent 3

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

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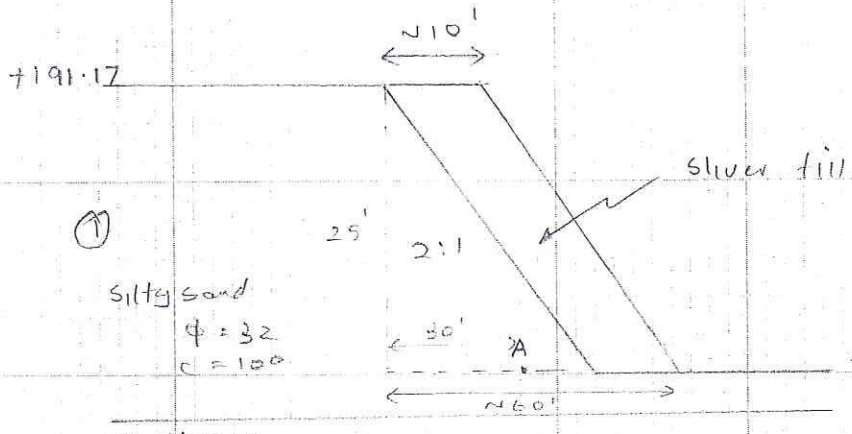
(714) 751-3826, Fax (714) 751-3928

Project SR55-I1 Connector Separation (55-0226) **Project No.** 11-157

By SP **Date** 3/19/12 **Checked By** LLC **Date** 3/21/12 **Sheet** ____ **of** ____

Approach Embankment

Abutment 1 @ at Right bridge (I-5 NB)

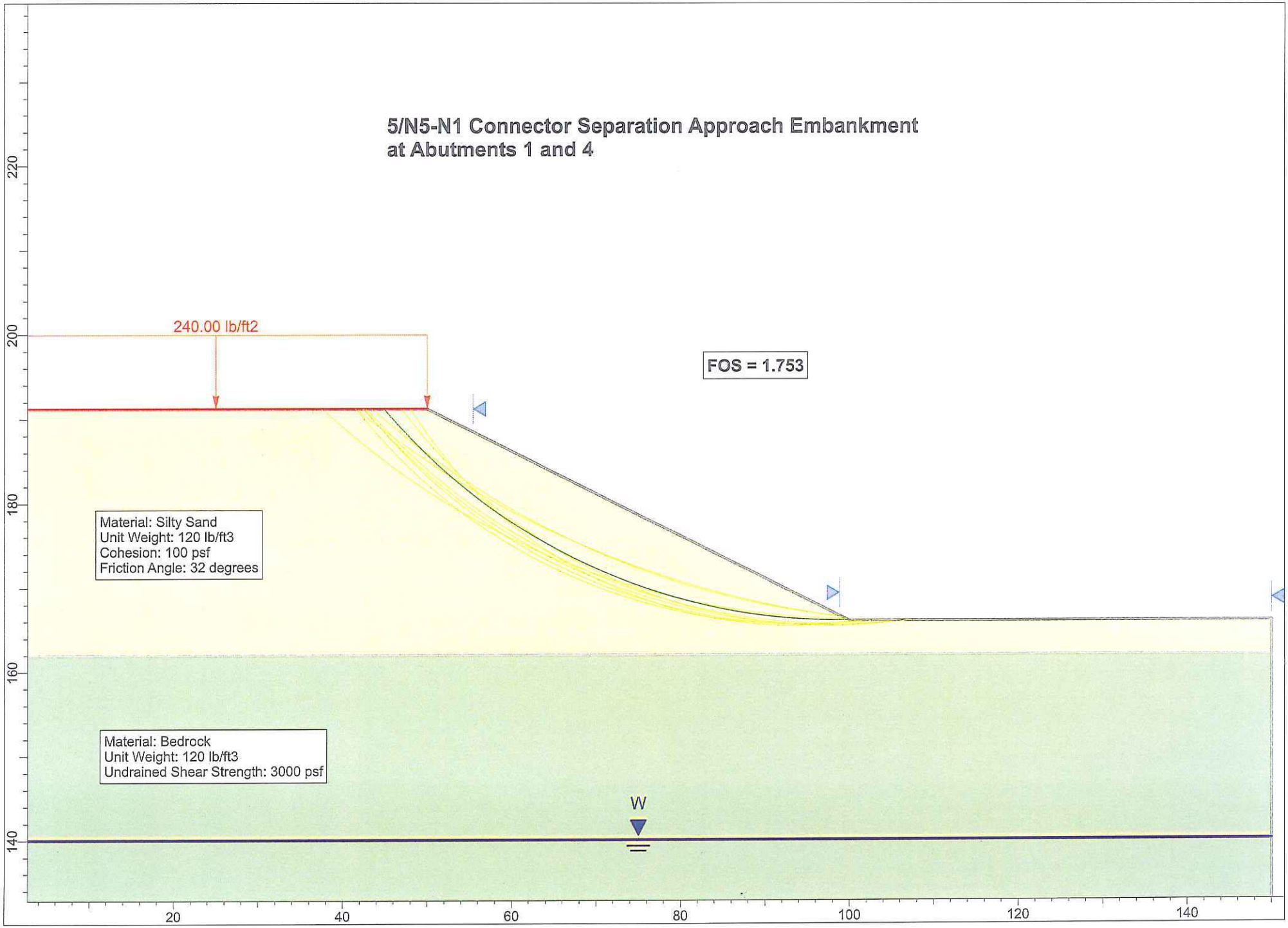


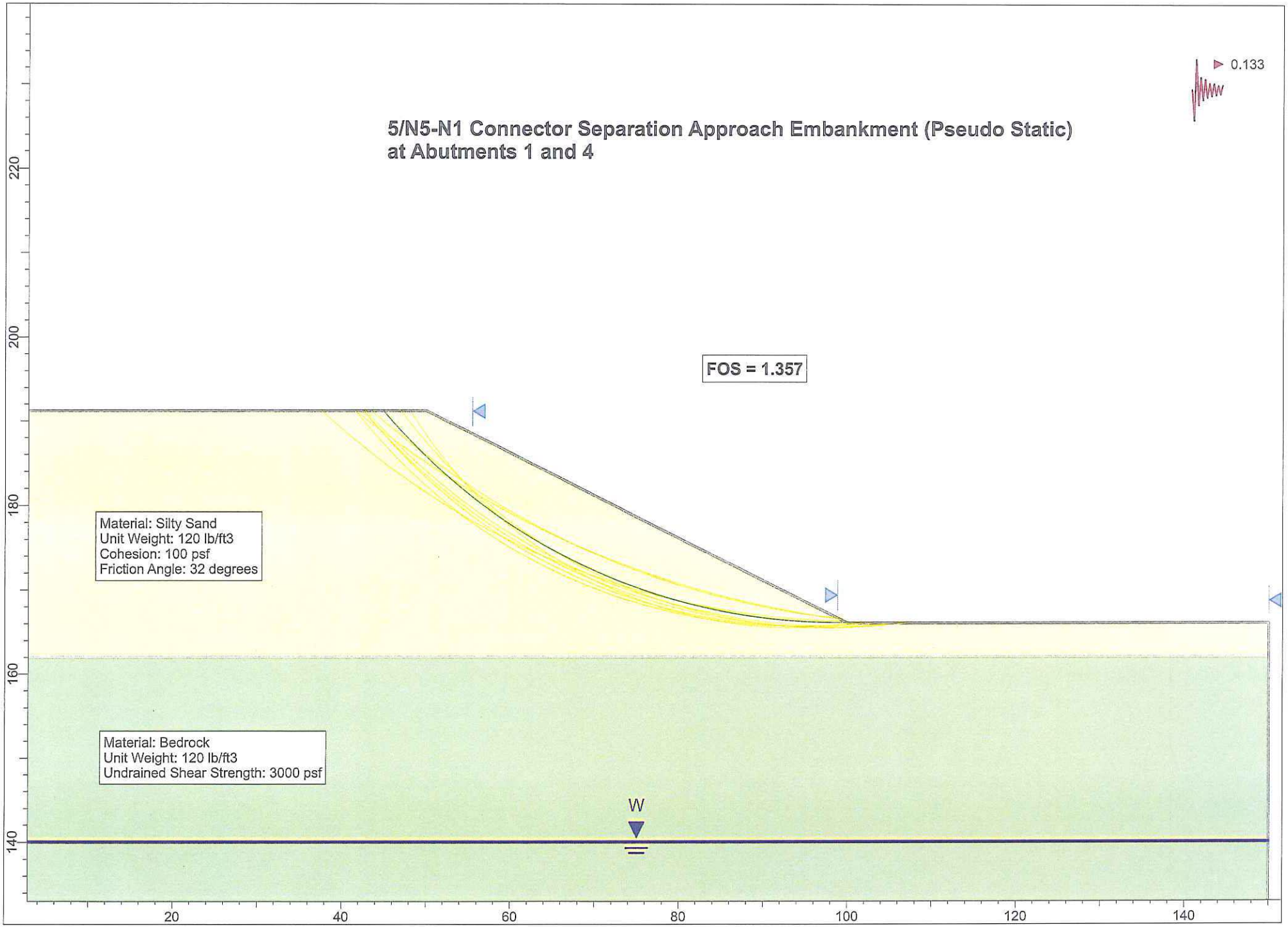
Settlement

due to new fill

$\Delta\sigma$ = stress increase due to new embankment − stress increase due to existing embankment

	σ_v	$\Delta\sigma$ at point A (New Embankment)	$\Delta\sigma$ at point A (Existing Embankment)	$\Delta\sigma$ at point A	Settlement
①	15 × 120 = 1.8	1.8	1.2	= 0.6	$4 \times \frac{1}{40} \log\left(\frac{1.8+0.6}{1.8}\right)$ = 0.15
②	27 × 120 = 3.2	1.78	1.22	= 0.56	$20 \times \frac{1}{40} \log\left(\frac{3.2+0.56}{3.2}\right)$ = 0.42
	39 × 120 + 8 × 57.6 = 5.14	1.7	1.28	= 0.42	$20 \times \frac{1}{40} \log\left(\frac{5.14+0.42}{5.14}\right)$ = 0.2
	39 × 120 + 28 × 57.6 = 6.3	1.62	1.31	= 0.31	$20 \times \frac{1}{40} \log\left(\frac{6.3+0.31}{6.3}\right)$ = 0.13
					0.91


5/N5-N1 Connector Separation Approach Embankment
at Abutments 1 and 4
240.00 lb/ft2
FOS = 1.753
Material: Silty Sand
Unit Weight: 120 lb/ft3
Cohesion: 100 psf
Friction Angle: 32 degrees
Material: Bedrock
Unit Weight: 120 lb/ft3
Undrained Shear Strength: 3000 psf
W
220
200
180
160
140
20
40
60
80
100
120
140


0.133
5/N5-N1 Connector Separation Approach Embankment (Pseudo Static)
at Abutments 1 and 4
FOS = 1.357
Material: Silty Sand
Unit Weight: 120 lb/ft3
Cohesion: 100 psf
Friction Angle: 32 degrees
Material: Bedrock
Unit Weight: 120 lb/ft3
Undrained Shear Strength: 3000 psf
W
220
200
180
160
140
20
40
60
80
100
120
140

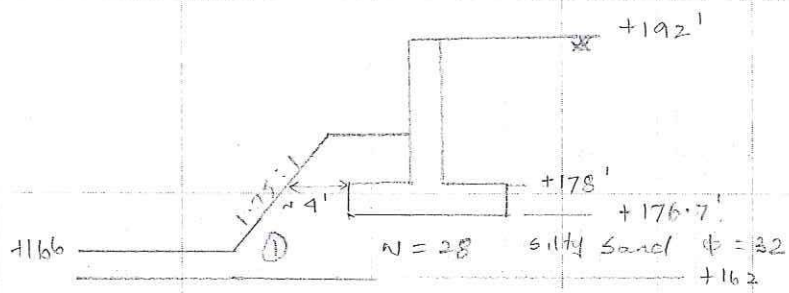
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

17800 Newhope Street, Suite B, Fountain Valley, CA 92708
(714) 751-3826, Fax (714) 751-3928

Project 5/N5-N1 connector separation (SS-0226) **Project No.** 11-187

By SP **Date** 03/20/12 **Checked By** LSC **Date** 3/21/12 **Sheet** ____ **of** ____

Caltrans Standard Type 1 wall



② $i = \tan^{-1}\left(\frac{1}{1.75}\right) = 29.7°$

wall ht = 14'

width = 12'-6" per 2010 standard plan

for strength limit B' = 11.5'

Bearing Capacity

$q_{ult} = cN_{cm} + \gamma D N_{qm} + \frac{1}{2}\gamma B N_{\gamma m}$

for footing on a slope

$N_q = 0$

$N_c = 35.5$ for $\phi = 32$

$D_f = \frac{4}{1.75} + 1.7 = 4'$

$D_f/B = 0.35$

$N_q = 17.3$

$q_{ult} = 100 \times 35.5 + \frac{1}{2} \times 120 \times 11.5 \times 17.3 = 15.5$ ksf

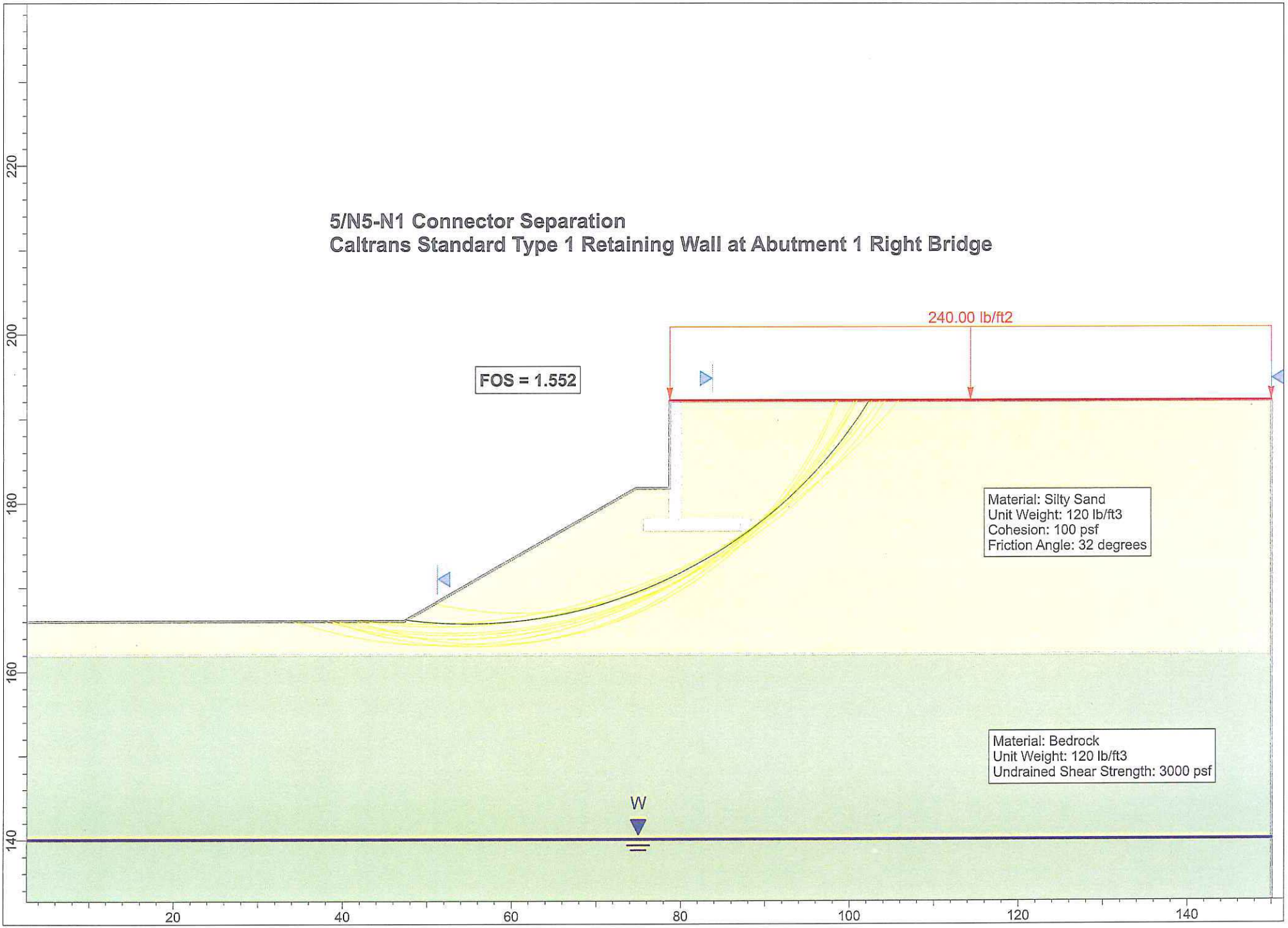
nominal $q = 0.45 \times 15.5 = 7$ ksf for strength limit

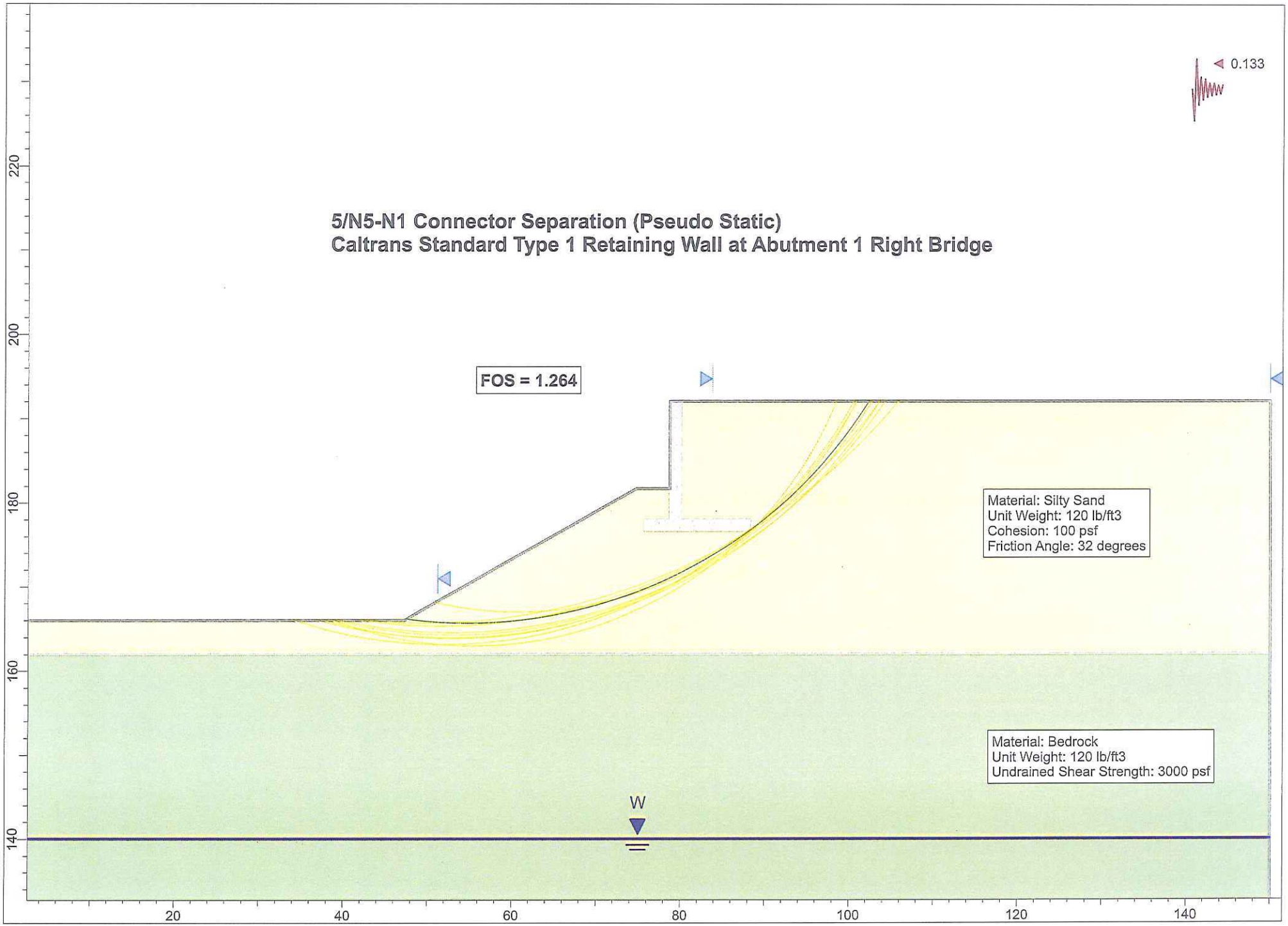
Settlement

for bearing pressure of 2.1 ksf, 3 ft over excavation

	σ_{vo}	$\Delta\sigma$	settlement
①	$13 \times 120 = 1.56$	$2.1 \times 0.6 = 1.3$	$12 \times \frac{1}{50} \log\left(\frac{1.56+1.3}{1.56}\right) = 0.76$
②	$22.5 \times 120 = 2.7$	$2.1 \times 0.35 = 0.74$	$7 \times \frac{1}{40} \log\left(\frac{2.7+0.74}{2.7}\right) = 0.22$
			0.98

perform 3 feet of overexcavation


5/N5-N1 Connector Separation
Caltrans Standard Type 1 Retaining Wall at Abutment 1 Right Bridge
240.00 lb/ft2
FOS = 1.552
Material: Silty Sand
Unit Weight: 120 lb/ft3
Cohesion: 100 psf
Friction Angle: 32 degrees
Material: Bedrock
Unit Weight: 120 lb/ft3
Undrained Shear Strength: 3000 psf
W
220
200
180
160
140
20
40
60
80
100
120
140


0.133
5/N5-N1 Connector Separation (Pseudo Static)
Caltrans Standard Type 1 Retaining Wall at Abutment 1 Right Bridge
FOS = 1.264
Material: Silty Sand
Unit Weight: 120 lb/ft3
Cohesion: 100 psf
Friction Angle: 32 degrees
Material: Bedrock
Unit Weight: 120 lb/ft3
Undrained Shear Strength: 3000 psf
W
220
200
180
160
140
20
40
60
80
100
120
140

Appendix D

CALTRANS REVIEW COMMENTS AND EMI RESPONSES

DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES

TO: MR. JEFF DEFEVERE
Office of Special Funded Projects (OSFP)
Attention: Ms. LUQI YANG
Fax: (916) 227-8683

DATE: January 22, 2013

FILE: 12 ORA 05 6.7
District County Route Post mile

FDN REPORT BY: Earth Mechanics, Inc DATED: Jan. 19, 2013 5/N5-N1 Connector Separation (Widen)
Structure Name

GENERAL PLAN DATED: Nov. 12, 2012 FDN PLAN DATED: Nov. 12, 2012 12-0F96E4 55-0226
EA Number Bridge Number

Submittal (*Check One*): [ ] 1st [ ] 2nd [X] 3rd [ ] 4th [ ] Other:

The Office of Geotechnical Design South 1 (OGDS-1) has reviewed the submittal titled "Revised Final Foundation Report for 5/N5-N1 Connector Separation (Widen), Bridge No. 55-0226, Orange County, California, 12-ORA-05, PM 6.7, Caltrans Project No. 1200020279, EA No 12-0F96E4", prepared by Earth Mechanics, Inc, dated January 19, 2013.

During our review we made reference to the following:

- OGDS-1 review comment memorandum dated January 4, 2013.
- Responses to OGDS-1 review comment memorandum, prepared by Earth Mechanics, Inc., dated January 11, 2013.

The consultants have adequately responded to our review comments and incorporated the revisions in the subject report. Include this memorandum in the report, where appropriate.

.

Please call Sharid Amiri at (949)724-2599, if you have any questions.

Approval:

Reviewed By: Sharid Amiri, PhD, P.E.
Geotechnical Design South-1

(C1) Approved
Office of Special Funded projects

Cc: OGDS (Sacramento) DES Office of Specifications and Estimates (All Reviews) OSC R.E Pending File

Raja Pirathiviraj

From: Sharid Amiri <sharid.amiri@dot.ca.gov>
Sent: Saturday, January 19, 2013 5:34 PM
To: Raja Pirathiviraj; Salama, Ayman
Cc: Ahmed Abou-Abdou; Salama, Ayman; Kamran Mazhar; Luqi Yang (luqi.yang@dot.ca.gov); Lino Cheang
Subject: RE: EFIS 1200020279, FR (Bridge Structures Foundation Report) "Over the shoulder" review: Review of January 11th, Consultant response memo
Attachments: EMI Response Calculations.pdf

Your response is adequate, please revise the subject reports and submit them (pdf) for our review.

Thank you

Sharid K. Amiri (PhD, PE)

Senior Transportation Engineer
D-12 Oversight
Geotechnical Design South-1
3347 Michelson Drive, Suite 100
Irvine, Ca. 92612
Tel. (949) 724-2599

Raja Pirathiviraj <raja@earthmech.com>

Raja Pirathiviraj <raja@earthmech.com>

01/19/2013 03:00 PM

To: Sharid Amiri <sharid.amiri@dot.ca.gov>

cc: Lino Cheang <L.Cheang@earthmech.com>, Kamran Mazhar <kamran.mazhar@dot.ca.gov>, Ahmed Abou-Abdou <ahmed.abou-abdou@dot.ca.gov>, "Luqi Yang (luqi.yang@dot.ca.gov)" <luqi.yang@dot.ca.gov>, "Salama, Ayman" <ASalama@trcsolutions.com>

Subject: RE: EFIS 1200020279, FR (Bridge Structures Foundation Report) "Over the shoulder" review: Review of January 11th, Consultant response memo

Sharid,

Thank you for reviewing our responses. Please see below our responses to your comments in your email for Bridge No. 55-0226, Bridge No. 55-0510 and Bridge No. 55-0227. Please let us know if you accept it.

For convenience, your email comments are provided in ***bold and italics*** followed by EMI responses in square parenthesis.

- *The Foundation Reports were submitted to Caltrans on November 28th, 2012. Include the latter and revise the response memo accordingly.*

[EMI Response: We will revise our response memo as "Earth Mechanics, Inc. (EMI) submitted the Final Foundation Report, dated October 5, 2012, to Caltrans for Review and Caltrans Office of Geotechnical Design South 1 (OGDS-1) has received it on November 28, 2012" and will include in Appendix D of the report.]

- *Expand on the response to comment No.16: "...Sufficient data does not exist to modify the Nk value for local conditions"..*

In retrospect, what engineering tasks should have been performed so that sufficient data exist to evaluate site specific Nk? explain.

[EMI Response: Based on the CPT interpretation files provided in Appendix A of the report, an Nk value of 15 was used in estimating the undrained shear strength values using CPT correlation, which is the mid value of typical Nk values that range between 10 and 20 indicated in the CPT guidelines by Robertson (2009). In addition, based on our laboratory test results, over consolidation ratio (OCR) is slightly higher than 1.0. The OCR of 1 or slightly higher indicates that the soil is normally consolidated or slightly over consolidated (calculation sheets are attached). Based on these data, we believe that using Nk value of 15 is appropriate for the design. Based on Nk value of 15 and cone tip resistances, the estimated undrained shear strength values are higher than the undrained shear strength values used in our design; therefore, the design is appropriately conservative.
In retrospect, the cone factor Nk, which varies mainly between 10 and 20 should preferably have been obtained from empirical correlation with the strength test used in that area (Robertson, 2009). As a minimum, we believe that one boring and two to five CPT soundings should be performed for a site, depending on the number of supports and width of the bridge. This boring used for sampling and testing should be performed next to one of the CPT soundings to check the local CPT correlations and soil behavior type. The boring should be extended to the same depth as he CPT sounding. Soil samples should be taken at least every 2.5 or 3 feet using SPT, Modified California Drive, or other appropriate samplers, or at changes in soil stratigraphy. Additional confirmation borings and CPT soundings should be necessary if the site is large or the subsurface conditions vary significantly within the site. The need for and the number of the additional borings should be determined by the project geotechnical consultant, subject to the review of the appropriate regulatory agencies.]

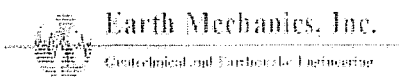
- ***Robertson (2009) is cited as a reference in the response to comment No.16. Include it in the list of references in the subject Foundation Reports and revise accordingly.***

[EMI Responses:
Robertson, P.K., 2009, Interpretation of Cone Penetration Tests – A Unified Approach, Canadian Geotechnical Journal Volume 46: 1337-1355. We will include this reference in the report.]

- ***Include all Caltrans geotechnical review comments and the over the shoulder review comments (i.e.email correspondence) in the appendix.***

[EMI Response: We will include all the email correspondences in the Appendix D of the report.]

Thanks
regards
Raja



"Raja" Sivasubramaniam Pirathiviraj, P.E., G.E.
Earth Mechanics Inc | Senior Staff Engineer | 17800 Newhope Street, Suite B, Fountain Valley CA 92708 | Office 714.751-3826 Ext. 123 | Fax 714.751-3928

From: Sharid Amiri [mailto:sharid.amiri@dot.ca.gov]
Sent: Friday, January 18, 2013 3:34 PM
To: Salama, Ayman; Luqi Yang
Cc: Lino Cheang; Raja Pirathiviraj; Kamran Mazhar; Ahmed Abou-Abdou
Subject: EFIS 1200020279, FR (Bridge Structures Foundation Report) "Over the shoulder" review: Review of January 11th, Consultant response memo

Bridge No.55-0226, Bridge No.55-0510, Bridge No.55-0227

- The Foundation Reports were submitted to Caltrans on November 28th, 2012. Include the latter and revise the response memo accordingly.
- Expand on the response to comment No.16: "...Sufficient data does not exist to modify the Nk value for local conditions"..

In retrospect, what engineering tasks should have been performed so that sufficient data exist to evaluate site specific Nk? explain.

- Robertson (2009) is cited as a reference in the response to comment No.16. Include it in the list of references in the subject Foundation Reports and revise accordingly.
- Include all Caltrans geotechnical review comments and the over the shoulder review comments (i.e.email correspondence) in the appendix.

Our office will review the revised foundation reports, once we receive them and submit the review memorandum accordingly.

Sharid K. Amiri (PhD, PE)

Senior Transportation Engineer
D-12 Oversight
Geotechnical Design South-1
3347 Michelson Drive, Suite 100
Irvine, Ca. 92612
Tel. (949) 724-2599

"Salama, Ayman" <ASalama@trcsolutions.com>

"Salama, Ayman" <ASalama@trcsolutions.com>	To	Sharid Amiri <sharid.amiri@dot.ca.gov>
	cc	"Ahmed Abou-Abdou (ahmed.abou-abdou@dot.ca.gov)" <ahmed.abou-abdou@dot.ca.gov>, Bob Bazargan <bob.bazargan@dot.ca.gov>, Kamran Mazhar <kamran.mazhar@dot.ca.gov>, Luqi Yang <luqi.yang@dot.ca.gov>, "L.Cheang@earthmech.com" <L.Cheang@earthmech.com>, "raja@earthmech.com" <raja@earthmech.com>
01/16/2013 01:42 PM	Subject	Re: EFIS 1200020279, FR (Bridge Structures Foundation Report) Review (2nd)

I understand Sharid.
Thank you for working with us to meet the tight schedule for HQ-OE.
Best regards,

Ayman Salama
TRC
T: 949 789 4413
C: 949 798 9385

On Jan 16, 2013, at 11:08 AM, "Sharid Amiri" <sharid.amiri@dot.ca.gov> wrote:

Hi Ayman

I am in receipt of your email. I will submit my review comments for the response for the three bridge structures by Friday. Keep in mind that some of these comments had to do with the quality of the calcs that have not been reviewed in its entirety.

We will review the revised reports once these comments are incorporated.

Sharid K. Amiri (PhD, PE)

Senior Transportation Engineer
D-12 Oversight
Geotechnical Design South-1
3347 Michelson Drive, Suite 100
Irvine, Ca. 92612
Tel. (949) 724-2599
<graycol.gif>"Salama, Ayman" <ASalama@trcsolutions.com>

"Salama, Ayman" <ecblank.gif><ecblank.gif>
<ASalama@trcsolutions.com> To Sharid Amiri <sharid.amiri@dot.ca.gov>
<ecblank.gif><ecblank.gif>
01/16/2013 10:02 AM cc Kamran Mazhar <kamran.mazhar@dot.ca.gov>, Luqi Yang <luqi.yang@dot.ca.gov>, "Ahmed Abou-Abdou (ahmed.abou-abdou@dot.ca.gov)" <ahmed.abou-abdou@dot.ca.gov>, Bob Bazargan <bob.bazargan@dot.ca.gov>, "L.Cheang@earthmech.com" <L.Cheang@earthmech.com>, "raja@earthmech.com" <raja@earthmech.com>
<ecblank.gif><ecblank.gif>
Subject RE: EFIS 1200020279, FR (Bridge Structures Foundation Report) Review (2nd)

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Hi Sharid,
It was nice talking with you today to follow up on the status on the Foundation Reports for Bridge Nos. 55-0510, 55-0226, and 55-0227L.
It is my understanding that EMI met with you last week and submitted a response to your comments on the three FRs on Saturday 01/12/13 and if you agreed with their responses they will revise the foundation reports for the three bridges and

submit the final foundation reports.

Due to the project schedule we need to submit the Final PSE package to HQ-OE on Tuesday next week (01/22) and I would really appreciate it if you can review and respond to EMI responses for to your comments on the reports and provide them with your comments for each report as soon as you complete your review and hopefully will get all the reviews complete by this Friday 01/18 as EMI will need 3 days to revise the three reports and submit them to us on Monday COB or Tuesday morning the latest.

I truly appreciate your continuous support and cooperation to prioritize the review of these three bridges and to provide EMI with your review comments bridge by bridge so they can work in parallel while you are reviewing the other reports.

Best Regards,
Ayman

From: Sharid Amiri [mailto:sharid.amiri@dot.ca.gov]
Sent: Sunday, January 06, 2013 7:28 PM
To: Luqi Yang
Cc: Bob Bazargan; Kamran Mazhar; L.Cheang@earthmech.com; Salama, Ayman
Subject: EFIS 1200020279, FR (Bridge Structures Foundation Report) Review (2nd)

Luqi

Please find attached

(See attached file: Route 5_1 Separation _widen__ Bridge No. 55-0510_FR Review_2__ 100512_ EMI.pdf)(See attached file: 5_N5-N1 Connector Separation _widen__ Bridge No. 55-0226_FR Review_2__ 100512_ EMI.pdf)(See attached file: Camino Capistrano UC_ Bridge No. 55-0227L_FR Review_2__ 100512_ EMI.pdf)

Sharid K. Amiri (PhD, PE)

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Tel. (949) 724-2599

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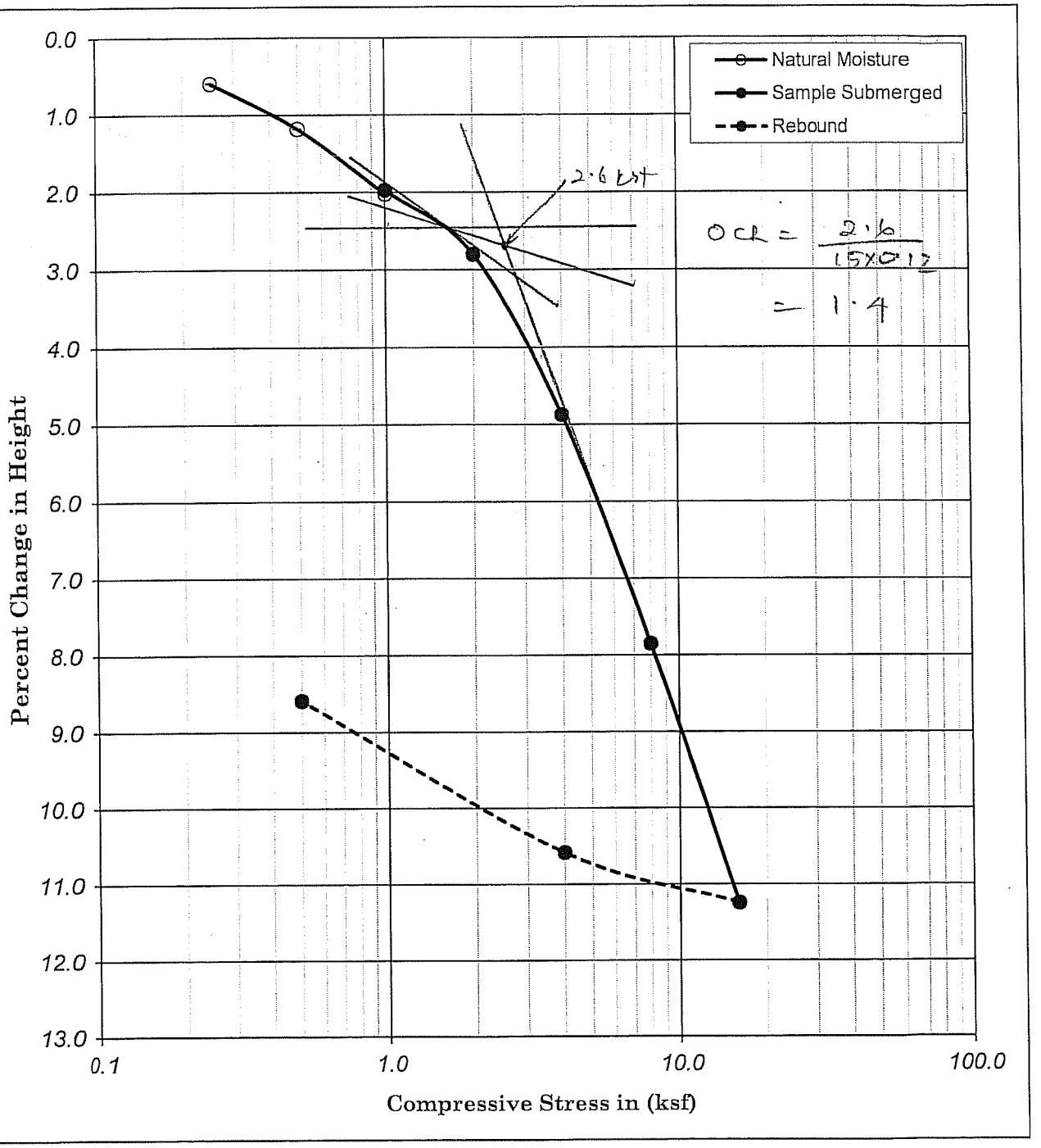


Boring No. : A-11-319			Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No. : D-3			Plastic Limit :	-						
Depth	(ft) : 15.0	16.5	Plastic Index :	-	Initial	24.03	98.00	15.43	90.11	0.72
	(m) : 4.58	5.03	Specific Gravity :	2.70	Final	21.19	107.25	16.88	100.10	0.57

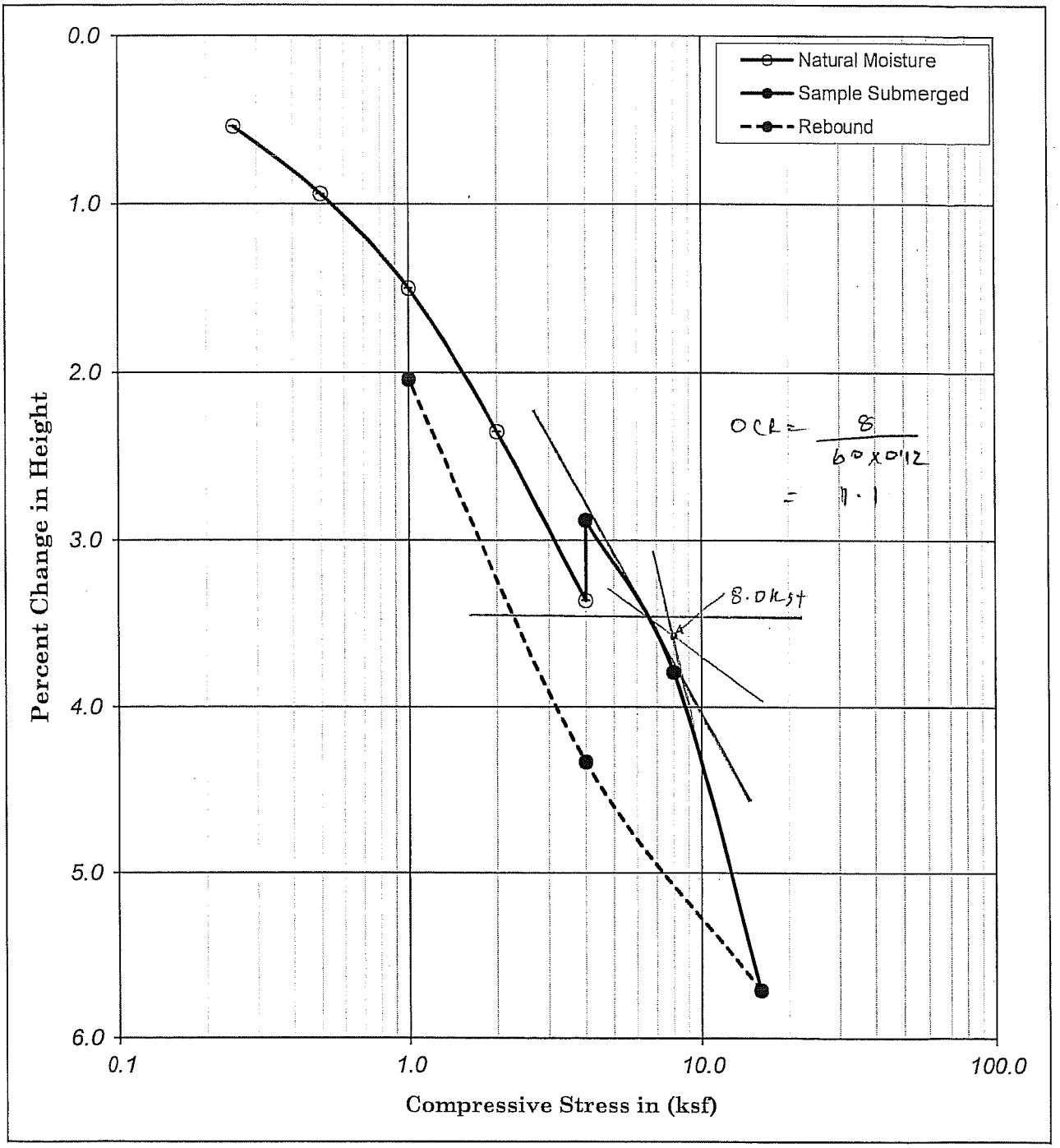
Description : *Olive-gray with yellowish brown , Lean CLAY (CL)*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

I-5 HOV Improvement Project
PCH to San Juan Creek Road

Project No.: *11-137* *12/04/11*

CONSOLIDATION TEST
(ASTM D-2435 / CT-219)



Boring No. : A-11-319				Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No. : D-13				Plastic Limit :	-						
Depth	(ft) :	60.0	61.5	Plastic Index :	-	Initial	33.85	84.62	13.32	92.12	0.99
	(m) :	18.30	18.76	Specific Gravity :	2.70	Final	36.30	86.39	13.60	103.05	0.95

Description : *Very dark gray, Elastic SILT (MH)*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

I-5 HOV Improvement Project
PCH to San Juan Creek Road

Project No.: 11-137 12/04/11

CONSOLIDATION TEST
(ASTM D-2435 / CT-219)

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

MEMORANDUM

EMI PROJECT NO: 11-137

DATE: January 19, 2013

PREPARED FOR: Dr. Ayman Salama / TRC Solutions, Inc. (TRC)

PREPARED BY: (Raja) S. Pirathiviraj and Lino Cheang / Earth Mechanics, Inc. (EMI)

SUBJECT: Responses to Caltrans 2nd Review Comments
Final Foundation Report for 5/N5-N1 Connector Separation (Widen)
Bridge No. 55-0226
Orange County, California
12-ORA-5, PM 6.7
Caltrans Project No. 1200020279 (EA 12-0F96E4)

Earth Mechanics, Inc. (EMI) submitted the Final Foundation Report, dated October 5, 2012, to Caltrans for review and Caltrans Office of Geotechnical Design South 1 (OGDS-1) has received the report on November 28, 2012. OGDS-1 has reviewed the report and provided their comments in a memorandum dated January 04, 2013. A copy of the memorandum is provided in Attachment 1.

This memorandum provides our responses to Caltrans OGDS-1 comments. For convenience, Caltrans comments are provided in italics followed by EMI responses.

1. Title Sheet addressed to TRC: Include the date of the meeting where over the shoulder meeting was conducted and the name of the oversight geo-professional.

The second paragraph of the title sheet (letter) will be revised as follows:

"Earlier versions of this report dated April 23, 2012 and October 5, 2012 were submitted to Caltrans for review. Office of Geotechnical Design South 1 (OGDS-1) provided their comments in memorandums dated August 31, 2012 and January 4, 2013. EMI prepared responses to the OGDS-1 review comments, which were reviewed by the Caltrans Oversight Geo-Professional Dr. Sharid Amiri at the over-the-shoulder review meeting conducted at the EMI office on September 20, 2012 and January 9, 2013. The EMI oversight engineers, Mr. Lino Cheang and Mr. Raja Pirathiviraj on September 20, 2012, and Mr. Andrew Korkos, Mr. Mike Kapuskar and Mr. Raja Pirathiviraj on January 9, 2013, were the attendees of the meeting. Responses to Caltrans comments have been incorporated into this Revised Final Foundation Report. Caltrans review comments and EMI responses are provided in Appendix D."

2. Existing geotechnical information was reviewed and collected to prepare the subject report. Revise Section 1.2 of the subject report accordingly.

This task is listed in Section 1.1 of the report as a first bullet item.

3. The site investigation must be site specific and stated as such in the report. Revise Section 1.2 of the subject report accordingly.

The second bullet item in Section 1.1 of the report will be revised as follows:.

" • Site-specific field exploration consisting of drilling and logging exploratory borings and cone penetration test (CPT) soundings;"

4. Project description does not make any reference to the other bridge structures that are part of the subject project. Revise Section 1.3 accordingly.

The first paragraph in Section 1.2, Project Description, will include reference to the other bridge structures as follows:

"The proposed improvement project includes widening of three bridge structures; 5/N5-N1 Connector Separation (Bridge No. 55-0226), Route 5/1 Separation (Bridge No. 55-0510) and Camino Capistrano Undercrossing (Bridge No. 55-0227)"

5. Revise Section 1.0 to include a table for "As-Built Foundation Data" with the relevant information.

A "Section 1.3. As-Built Foundation Data" will be included in Section 1.0 of the report as follows.

"1.3 As-Built Foundation Data

This existing bridge was originally named "Route 5/1 Separation", and was constructed in 1960 as separate left and right bridges. The median was closed in a 1969 widening. In 1973, the connector separation was again widened at both sides. The existing structure is a three-span structure with a variable length of about 229 feet and a variable width of about 162 feet. The abutments and bents are supported on spread footings except for the left bridge bent footings in the 1973 widening; Bents 2 and 3 of the left bridge in the 1973 widening are supported on 16-inch diameter Cast-In-Drilled-Hole (CIDH) concrete piles. Pertinent foundation data as shown on the as-built plans is summarized in Table 1-1.

Table 1-1. As-Built Foundation Data

Bridge		Support	Foundation Type	Bottom of Footing Elevation (feet)	Design Load
Original Bridge in 1960	Right Bridge (I-5 NB)	Abutment 1	Shallow Footing	+176.5 and +177.5	4 ksf
		Bents 2 and 3	Shallow Footing	+155.0	6 ksf
		Abutment 4	Shallow Footing	+171.0 and +172.0	4 ksf
	Left Bridge (I-5 SB)	Abutment 1	Shallow Footing	+171.0 and +172.0	4 ksf
		Bents 2 and 3	Shallow Footing	+155.0	6 ksf
		Abutment 4	Shallow Footing	+166.0 and +167.5	4 ksf

Bridge		Support	Foundation Type	Bottom of Footing Elevation (feet)	Design Load
1969 Median Widening	Right and Left Bridges (I-5 NB and SB)	Abutment 1	Shallow Footing	+172.0 and +175.0	4 ksf
		Bents 2 and 3	Shallow Footing	+152.0 and +155.0	6 ksf
		Abutment 4	Shallow Footing	+167.5 and +169.5	4 ksf
1973 Widening	Right Bridge (I-5 NB)	Abutment 1	Shallow Footing	+177.5	4 ksf
		Bents 2 and 3	Shallow Footing	+155.0	6 ksf
		Abutment 4	Shallow Footing	+172.0	4 ksf
	Left Bridge (I-5 SB)	Abutment 1	Shallow Footing	+167.5	4 ksf
		Bents 2 and 3[1]	16-inch CIDH	+150.0 to +157.0	90 kips
		Abutment 4	Shallow Footing	+161.5	4 ksf

Note:
1. The specified pile tip elevation is +120.0 feet

6. Revise the notes in Table 2.1, to include the appropriate Survey Datum.

We will include the survey datum in the notes in Table 2-1 as follows:

"Exploration locations were field surveyed using California Coordinate System (CCS) 83 (1991.35) Zone 6 and vertical datum NAVD 1988."

7. Revise Section 2 to include survey conducted for each boring and CPT.

We will revise the second paragraph in Section 2.1 of the report as follows:

"To supplement the existing subsurface information, six soil borings and two cone penetration test (CPT) soundings were performed between September 27 and October 6, 2011. The exploration locations were field surveyed using California Coordinate System (CCS) 83 (1991.35) Zone 6 and vertical datum NAVD 1988 to obtain coordinates and elevations and establish stations and offsets. Boring information, including surveyed locations and elevations, are summarized in Table 2-1. Locations of the borings and CPTs are shown on the LOTB sheets provided in Appendix A."

8. Revise Section 2.0 of the subject report to include a narrative as to how the hammer efficiency is assessed per Caltrans Guidelines.

The fourth paragraph in Section 2.1 of the report will include a narrative as to how the hammer efficiency is assessed as follows:

"The SPT hammer energy measurements for this drill rig were performed by SPT CAL under subcontract with 2R Drilling on April 14, 2011. The SPT hammer energy report is provided in Appendix A."

9. Revise Section 2.2 to include a Table for the laboratory tests performed with type of test, applicable test method (i.e. ASTM, CT designation) and purpose of the test.

Section 2.2 of the foundation report will be revised to include the table below.

Table 2-2. Explanation of Laboratory Tests Performed

Type of Test	Applicable Test Method	Purpose
Unit Weight	ASTM D 4767	Estimate in-situ unit soil weight
Moisture Content	ASTM D 2216	Estimate in-situ soil moisture content
Percent Passing No. 200 Sieve	ASTM D 1140	Determine the percentage of fine grained particles of soil
Consolidation	ASTM D 2435	Determine compressibility of fine-grained soil
Direct Shear	ASTM D 3080	Determine strength parameters of coarse-grained soil
Unconsolidated Undrained Triaxial	ASTM D 2850	Estimate strength parameters of fine-grained soil
Soil pH	CT 532/643	Determine corrosion potential of soil
Minimum Resistivity	CT 532/643	Determine corrosion potential of soil
Sulfate Content	CT 417	Determine corrosion potential of soil
Chloride Content	CT 422	Determine corrosion potential of soil

Notes:
1. ASTM = American Society for Testing and Materials; 2. CT = California Test Method.

10. Revise Section 4.0 to include a separate subsection (i.e. 4.3) for Idealized Soil Profile along with the Table 2 and the corresponding narrative.

"Section 4.2 Idealized Soil Profile" will be added to the Foundation Report along with "Table 4-1 Idealized Soil Profile and Strength Parameters".

11. Insert the Idealized Soil Profile in the main report where appropriate.

"Figure 4-1 Idealized Soil Profile" will be added to the Section 4.2 of the report.

12. Revise the Idealized Soil Profile to include station line.

Figure 4-1 showing the station line, will be added to Section 4.2 of the report.

13. Designate where the supports are located on the Idealized Soil Profile.

Figure 4-1 showing the support locations, will be added to Section 4.2 of the report.

14. Revise the Table of Contents accordingly.

The table of contents will be revised to reflect the format changes discussed herein.

15. Was the CPT calibrated against the borings performed at the site? Explain and provide justification.

CPT-11-321 was calibrated against the nearby boring A-11-319 performed at the site. Based on the boring, stratigraphy consists of about 50 feet of lean and fat clay with layers of sand and sand with silt underlain by sedimentary bedrock of the Capistrano formation. The soil behavior type shown on the CPT sounding log is consistent with the observations from the nearby boring.

The CPT output data file with the estimated undrained shear strength using CPT correlations is provided in Appendix A of the report. Unconsolidated-undtained triaxial test results are presented in Appendix B of the report. The undrained shear strength values obtained from unconsolidated-undrained triaxial tests falls within the lower bound shear strength values that were estimated using CPT correlations. The design strength parameters were conservatively selected based on the average lower bound shear strength values.

In addition, the small-strain shear wave velocity (Vs30) measured by the seismic cone penetrometer used in Sounding CPT-11-321 was used to normalize the Vs30 values calculated using correlations with SPT blowcounts obtained from other borings drilled for this bridge.

16. How was the cone factor Nk as it relates to the subject CPT investigation evaluated? Explain and provide justification.

Based on the CPT interpretation files provided in Appendix A of the report, an Nk value of 15 was used in estimating the undrained shear strength values using CPT correlation, which is the mid value of typical Nk values that range between 10 and 20 indicated in the CPT guidelines by Robertson (2009). In addition, based on our laboratory test results, over consolidation ratio (OCR) is slightly higher than 1.0. The OCR of 1 or slightly higher indicates that the soil is normally consolidated or slightly over consolidated (calculation sheets are attached). Based on these data, we believe that using Nk value of 15 is appropriate for the design. Based on Nk value of 15 and cone tip resistances, the estimated undrained shear strength values are higher than the undrained shear strength values used in our design; therefore, the design is appropriately conservative.

In retrospect, the cone factor Nk, which varies mainly between 10 and 20 should preferably have been obtained from empirical correlation with the strength test used in that area (Robertson, 2009). As a minimum, we believe that one boring and two to five CPT soundings should be performed for a site, depending on the number of supports and width of the bridge. This boring used for sampling and testing should be performed next to one of the CPT soundings to check the local CPT correlations and soil behavior type. The boring should be extended to the same depth as he CPT sounding. Soil samples should be taken at least every 2.5 or 3 feet using SPT, Modified California Drive, or other appropriate samplers, or at changes in soil stratigraphy. Additional confirmation borings and CPT soundings should be necessary if the site is large or the subsurface conditions vary significantly within the site. The need for and the number of the additional borings should be determined by the project geotechnical consultant, subject to the review of the appropriate regulatory agencies.

17. Refer to the CPT data and calculate the bearing capacity and the consolidation settlement magnitude when spread footing is considered. Explain why spread footing cannot be considered based on the engineering calculation derived from the CPT.

The CPT data shows that the lower-bound undrained shear strength is similar to the strength obtained from laboratory tests, which was used in the analysis to determine bearing capacity. Since there are 8 borings and 2 CPTs were performed for this bridge, consolidation settlements were performed based on the soil boring data and the laboratory testing. The CPT data was not used to evaluate consolidation settlement. The primary purpose of the CPT soundings, conducted for the bridge, was to estimate shear wave velocity and assess liquefaction potential.

Spread footing is not recommended as a suitable foundation option for the widening of 5/N5-N1 Connector Separation due to excessive settlement. Spread footing settlement is estimated using the AASHTO LRFD Equation 10.6.2.4.2-3. Using the footing pressures presented in the as-built plans for abutments and bents, the settlement of the spread footing is estimated to be about 4 inches and 5.3 inches at abutments and bents, respectively. A 5-foot deep overexcavation will only lower the settlement to about 2.3 inches and 3.6 inches at abutments and bents, respectively. The settlement calculations are included in Appendix C of the report.

18. Why CPT data was not used in part for evaluation of the design parameters?

CPT data was used in assessing the in-situ shear strength and subsurface conditions. Although the CPT data shows that there are layers with higher shear strengths, the CPT data also shows soil layers with lower strengths that are equivalent to the strengths selected for the idealized soil profile. Our rationale was to use lower-bound strengths from the CPT data as well as strength data from the UU triaxial and direct shear tests.

19. Compare the in-situ data interpreted by CPT with the laboratory tests values and come up with idealized strength parameters.

Please see response to Comment No. 18.

20. Why idealized soil profile soil strength characterization in Table 4.1 is based only on the SPT, when CPT was also conducted to characterize the subsurface soil?

Please see response to Comment No. 18.

21. Provide SAP input files corresponding to the seismic analysis of the bridge pile foundation.

EMI did not perform SAP analyses for the subject project and does not have the SAP files. JACOBS should be contacted regarding the SAP analysis.

22. Revise the subject report to include Section 3.0 for only "Geology".

Section 3.0 will be retitled as requested.

23. Take out Seismicity from Section 3.0.

Section 3.0 will be retitled as requested and the seismicity will be included in Section 5.0 as requested in Comment No. 24.

24. Revise the subject report to include Section 5 as "Seismicity and Geo-Seismic Hazards" to have subsections 5-1 for "Seismic Study", 5-2 for "Ground Rupture", 5-3 for "Caltrans ARS Curve", 5-3-1 for "Development of Vs30", 5-3-2 for "Development of Caltrans ARS Curve", 5-4 for "Liquefaction", 5-5 for "Lateral Spread", 5-6 for "Seismic Settlement".

Section 5.0 and its subsections will be formatted as requested.

25. Revise the subject report to include Section 6 for "Soil Corrosion".

Section 6.0 will be retitled as requested.

26. Revise the subject report to include Section 7 for "Scour".

Section 7.0 will be retitled as requested.

27. Revise the subject report to include Section 8.0 for "Foundation Recommendations".

Section 8.0 will be retitled as requested.

Attachments:

Attachment 1 – Second Review Comments by Caltrans Office of Geotechnical Design South 1 (OGDS-1), Dated January 4, 2013, on the Final Foundation Report for 5/N5-N1 Connector Separation (Widen), Bridge No. 55-0226, Orange County, California, 12-ORA-05, PM 6.7, Caltrans Project No. 1200020279, EA No. 12-0F96E4, Prepared by Earth Mechanics, Inc., Dated October 5, 2012.

Reference:

Earth Mechanics, Inc., 2012, Final Foundation Report for 5/N5-N1 Connector Separation (Widen), Bridge No. 55-0226, Orange County, California, 12-ORA-05, PM 6.7, Caltrans Project No. 1200020279, EA No. 12-0F96E4, October 5.

ATTACHMENT 1

Caltrans Review Comments, Dated January 4, 2013

DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES

TO: MR. JEFF DEFEVERE
Office of Special Funded Projects (OSFP)
Attention: Ms. LUQI YANG
Fax: (916) 227-8683

DATE: January 04, 2013

FILE: 12 ORA 05 6.7
District County Route Post mile

FDN REPORT BY: Earth Mechanics, Inc DATED: Oct. 05, 2012 5/N5-N1 Connector Separation (Widen)
Structure Name

GENERAL PLAN DATED: Nov. 12, 2012 FDN PLAN DATED: Nov. 12, 2012 12-0F96E4 55-0226
EA Number Bridge Number

Submittal (*Check One*): [ ] 1st [X] 2nd [ ] 3rd [ ] 4th [ ] Other:

The Office of Geotechnical Design South 1 (OGDS-1) has reviewed the submittal titled "Final Foundation Report for 5/N5-N1 Connector Separation (Widen), Bridge No. 55-0226, Orange County, California, 12-ORA-05, PM 6.7, Caltrans Project No. 1200020279, EA No 12-0F96E4", prepared by Earth Mechanics, Inc, dated October 05, 2012 and received by our office on November 28, 2012.

We have the following comments:

1. Title Sheet addressed to TRC: Include the date of the meeting where over the shoulder meeting was conducted and the name of the oversight geo-professional.
2. Existing geotechnical information was reviewed and collected to prepare the subject report. Revise Section 1.2 of the subject report accordingly.
3. The site investigation must be site specific and stated as such in the report. Revise Section 1.2 of the subject report accordingly.
4. Project description does not make any reference to the other bridge structures that are part of the subject project. Revise Section 1.3 accordingly.
5. Revise Section 1.0 to include a table for "As-Built Foundation Data" with the relevant information.
6. Revise the notes in Table 2.1, to include the appropriate Survey Datum.
7. Revise Section 2 to include survey conducted for each boring and CPT.
8. Revise Section 2.0 of the subject report to include a narrative as to how the hammer efficiency is assessed per Caltrans Guidelines.
9. Revise Section 2.2 to include a Table for the laboratory tests performed with type of test, applicable test method (i.e. ASTM, CT designation) and purpose of the test.
10. Revise Section 4.0 to include a separate subsection (i.e. 4.3) for Idealized Soil Profile along with the Table 2 and the corresponding narrative.
11. Insert the Idealized Soil Profile in the main report where appropriate.
12. Revise the Idealized Soil Profile to include station line.
13. Designate where the supports are located on the Idealized Soil Profile.
14. Revise the Table of Contents accordingly.
15. Was the CPT calibrated against the borings performed at the site? Explain and provide justification.

16. How was the cone factor Nk as it relates to the subject CPT investigation evaluated? Explain and provide justification.
17. Refer to the CPT data and calculate the bearing capacity and the consolidation settlement magnitude when spread footing is considered. Explain why spread footing cannot be considered based on the engineering calculation derived from the CPT.
18. Why CPT data was not used in part for evaluation of the design parameters?
19. Compare the in-situ data interpreted by CPT with the laboratory tests values and come up with idealized strength parameters.
20. Why idealized soil profile soil strength characterization in Table 4.1 is based only on the SPT, when CPT was also conducted to characterize the subsurface soil?
21. Provide SAP input files corresponding to the seismic analysis of the bridge pile foundation.
22. Revise the subject report to include Section 3.0 for only “Geology”.
23. Take out Seismicity from Section 3.0.
24. Revise the subject report to include Section 5 as “Seismicity and Geo-Seismic Hazards” to have subsections 5-1 for “Seismic Study”, 5-2 for “Ground Rupture”, 5-3 for “Caltrans ARS Curve”, 5-3-1 for “Development of Vs30”, 5-3-2 for “Development of Caltrans ARS Curve”, 5-4 for “Liquefaction”, 5-5 for “Lateral Spread”, 5-6 for “Seismic Settlement”.
25. Revise the subject report to include Section 6 for “Soil Corrosion”.
26. Revise the subject report to include Section 7 for “Scour”.
27. Revise the subject report to include Section 8.0 for “Foundation Recommendations” .

Please call Sharid Amiri at (949)724-2599, if you have any questions.

Approval: Reviewed By: Sharid Amiri, PhD, P.E.
Geotechnical Design South-1

(C3) Not Approved
Office of Special Funded projects

Cc: OGDS (Sacramento) DES Office of Specifications and Estimates (All Reviews) OSC R.E Pending File

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

MEMORANDUM

EMI PROJECT NO: 11-137

DATE: September 27, 2012

PREPARED FOR: Dr. Ayman Salama / TRC Solutions, Inc. (TRC)

PREPARED BY: (Raja) S. Pirathiviraj and Lino Cheang / Earth Mechanics, Inc. (EMI)

SUBJECT: Responses to Caltrans Review Comments
Foundation Report for 5/N5-N1 Connector Separation (Widen)
Bridge No. 55-0226
Orange County, California
12-ORA-5, PM 6.7
Caltrans Project No. 1200020279 (EA 12-0F96E4)

Earth Mechanics, Inc. (EMI) submitted the subject structure foundation report, dated April 23, 2012, to Caltrans for review. Caltrans Office of Geotechnical Design South 1 (OGDS-1) has reviewed the report and provided their comments in a memorandum dated August 31, 2012. A copy of the memorandum is provided in Attachment 1.

This memorandum provides our responses to Caltrans OGDS-1 comments. For convenience, Caltrans comments are provided in italics followed by EMI responses.

1. *Provide all input software files and actual spread sheets (not PDF) in a CD for our review.*

We comply. We will provide a CD containing all input software files and actual spread sheets of our analyses.

2. *Provide backup information for the development of the Design ARS curve.*

We comply. All the backup information for the development of the design ARS curve is provided in Attachment 2.

3. *The existing structure is supported by spread footing. It is not clear why spread footing is not selected as a suitable foundation for the proposed structure. Provide justification and engineering calculation.*

Spread footing is not recommended as a suitable foundation option for the widening of 5/N5-N1 Connector Separation due to excessive settlement. Using the footing pressures presented in the as-built plans for abutments and bents, the settlement of the spread footing is estimated to be about 4 inches and 5.3 inches at abutments and bents, respectively. A 5-foot deep overexcavation will only lower the settlement to about 2.3 inches and 3.6 inches at abutments and bents,

respectively. The settlement calculations will be included in Appendix C of the Final Foundation Report. Further, calculations performed by the structural engineers show that the required bearing capacity for the bents is larger than the 6 ksf used in our settlement estimates. The required bearing capacity calculations for the bent footings by structural engineers are presented in Appendix C.

4. Provide Idealized soil profile that includes CPT/Boring information, stations, along with the water table elevation information (measured and design), liquefiable zone and other relevant information.

We comply. A cross section, showing the idealized soil profile with CPT/Boring information, field and design groundwater table elevations, design soil strength parameters, and liquefiable zone is included in Appendix C of the Final Foundation Report. The cross section will also show the proposed foundation plan and the CPT/Boring locations.

Attachments

Attachment 1 – Caltrans Review Comments, Dated August 31, 2012.

Attachment 2 – Backup Information for Development of Design ARS Curve.

ATTACHMENT 1

Caltrans Review Comments, Dated August 31, 2012

DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES

TO: MR. JEFF DEFEVERE
Office of Special Funded Projects (OSFP)
Attention: Ms. LUQI YANG
Fax: (916) 227-8683

DATE: August 31, 2012

FILE: 12 ORA 05 6.7
District County Route Post mile

FDN REPORT BY: Earth Mechanics, Inc DATED: April 23, 2012 5/N5-N1 Connector Separation (Widen)
Structure Name

GENERAL PLAN DATED: April 23, 2012 FDN PLAN DATED: April 23, 2012 12-0F96E4 55-0226
EA Number Bridge Number

Submittal (*Check One*): [x] 1st [ ] 2nd [ ] 3rd [ ] 4th [ ] Other:

The Office of Geotechnical Design South 1 (OGDS-1) has reviewed the submittal titled "Foundation Report for 5/N5-N1 Connector Separation (Widen), Bridge No. 55-0226, Orange County, California, 12-ORA-05, PM 6.7, Caltrans Project No. 1200020279, EA No 12-0F96E4", prepared by Earth Mechanics, Inc, dated April 23, 2012.

We have the following comments:

1. Provide all input software files and actual spread sheets (not PDF) in a CD for our review.

2. Provide backup information for the development of the design ARS curve.

3. The existing structure is supported by spread footing. It is not clear why spread footing is not selected as a suitable foundation for the proposed structure. Provide justification and engineering calculation.

4. Provide Idealized soil profile that includes CPT/Boring information, stations, along with the water table elevation information (measured and design), liquefiable zone and other relevant information.

Please call Sharid Amiri at (949)724-2599, if you have any questions.

Approval:

Reviewed By: Sharid Amiri, PhD, P.E.
Geotechnical Design South-1

(C3) Not Approved
Office of Special Funded projects

Cc: OGDS (Sacramento) DES Office of Specifications and Estimates (All Reviews) OSC R.E Pending File

ATTACHMENT 2

Backup Information for Development of Design ARS Curve

Shear Wave Velocity V_s^{30} Calculations

Boring	A-11-316
Depth	100 feet
ER_i	75 %
V_{s30}	368 m/s

Depth	Soil Type	Blow count N	N_{60}	Vs (m/s)	Thickness of Layer d (feet)	d/Vs
5	Clay	19	24	250	7.5	0.030057
10	Clay	12	15	214	5	0.023351
15	Sand	30	38	287	5	0.017391
20	Sand	64	80	358	5	0.013961
25	Sand	31	39	290	5	0.017227
30	Clay	31	39	294	5	0.017024
35	Rock	100	125	509	5	0.009832
40	Rock	38	48	374	5	0.013387
45	Rock	100	125	509	5	0.009832
50	Rock	37	46	370	5	0.013501
55	Rock	100	125	509	5	0.009832
60	Rock	34	43	360	5	0.01387
65	Rock	100	125	509	5	0.009832
70	Rock	32	40	354	5	0.014141
75	Rock	100	125	509	5	0.009832
80	Rock	100	125	509	5	0.009832
85	Rock	100	125	509	5	0.009832
90	Rock	45	56	394	5	0.012684
95	Rock	100	125	509	5	0.009832
100	Rock	46	58	397	2.5	0.006298

Boring	A-11-317
Depth	100 feet
ER_i	75 %
V_{s30}	409 m/s

Depth	Soil Type	Blow count N	N_{60}	Vs (m/s)	Thickness of Layer d (feet)	d/Vs
5	Sand	25	31	273	7.5	0.027504
10	Sand	22	28	263	5	0.019028
15	Rock	29	36	343	5	0.014592
20	Rock	100	125	509	5	0.009832
25	Rock	26	33	331	5	0.01511
30	Rock	100	125	509	5	0.009832
35	Rock	42	53	386	5	0.012966
40	Rock	100	125	509	5	0.009832
45	Rock	49	61	405	5	0.012344
50	Rock	100	125	509	5	0.009832
55	Rock	55	69	420	5	0.011897
60	Rock	100	125	509	5	0.009832
65	Rock	56	70	423	5	0.011829
70	Rock	100	125	509	5	0.009832
75	Rock	70	88	454	5	0.011016
80	Rock	100	125	509	5	0.009832
85	Rock	54	68	418	5	0.011967
90	Rock	100	125	509	5	0.009832
95	Rock	47	59	400	5	0.012509
100	Rock	100	125	509	2.5	0.004916

Boring	A-11-319
Depth	81.5 feet
ER_i	75 %
V_{s30}	258 m/s

Depth	Soil Type	Blow count N	N_{60}	Vs (m/s)	Thickness of Layer d (feet)	d/Vs
2.5	Clay	14	18	225	3.75	0.016637
5	Clay	8	10	187	3.75	0.020045
10	Clay	7	9	179	5	0.027942
15	Clay	4	5	149	5	0.033666
20	Clay	6	8	170	5	0.029414
25	Sand	17	21	244	5	0.020505
30	Sand	6	8	180	5	0.027736
35	Sand	8	10	196	5	0.025515
40	Clay	11	14	208	5	0.024038
45	Rock	22	28	314	5	0.015937
50	Rock	42	53	386	5	0.012966
55	Rock	22	28	314	5	0.015937
60	Rock	34	43	360	5	0.01387
65	Rock	16	20	283	5	0.017641
70	Rock	33	41	357	5	0.014003
75	Rock	33	41	357	5	0.014003
80	Rock	22	28	314	3.25	0.010359
81.5						

Boring	A-11-320
Depth	81.5 feet
ER_i	75 %
V_{s30}	393 m/s

Depth	Soil Type	Blow count N	N_{60}	Vs (m/s)	Thickness of Layer d (feet)	d/Vs
2.5	Clay	2	3	118	3.75	0.031805
5	Rock	20	25	304	3.75	0.012321
10	Rock	25	31	327	5	0.0153
15	Rock	32	40	354	5	0.014141
20	Rock	32	40	354	5	0.014141
25	Rock	44	55	391	5	0.012775
30	Rock	43	54	389	5	0.012869
35	Rock	100	125	509	5	0.009832
40	Rock	38	48	374	5	0.013387
45	Rock	100	125	509	5	0.009832
50	Rock	32	40	354	5	0.014141
55	Rock	100	125	509	5	0.009832
60	Rock	48	60	402	5	0.012425
65	Rock	100	125	509	5	0.009832
70	Rock	43	54	389	5	0.012869
75	Rock	100	125	509	5	0.009832
80	Rock	49	61	405	3.25	0.008024
81.5						

Boring	CPT-11-321
Depth	80.8
V_{s30}	275 m/s

Depth		Vs (ft/s)	Vs (m/s)	Thickness of Layer d (feet)	d/Vs
4.92		514	157	7.465	0.047638
10.01		610	186	5.005	0.026915
14.93		809	246	5	0.020289
20.01		703	214	5	0.023337
24.93		695	212	5.005	0.023615
30.02		820	250	5.005	0.020014
34.94		1137	346	5.005	0.014448
40.03		1028	313	5.005	0.015967
44.95		810	247	5	0.020251
50.03		839	256	5	0.019559
54.95		888	271	5.085	0.018792
60.2		846	258	5.005	0.01941
64.96		1497	456	4.925	0.010796
70.05		1118	341	5.005	0.014689
74.97		1131	345	5.375	0.015589
80.8		1509	460	2.915	0.006336

Boring	A-11-322
Depth	100 feet
ER_i	75 %
V_{s30}	405 m/s

Depth	Soil Type	Blow count N	N_{60}	Vs (m/s)	Thickness of Layer d (feet)	d/Vs
5	Clay	28	35	284	7.5	0.026416
10	Clay	15	19	231	5	0.021679
15	Sand	100	125	380	5	0.013158
20	Sand	31	39	290	5	0.017227
25	Rock	100	125	509	5	0.009832
30	Rock	42	53	386	5	0.012966
35	Rock	100	125	509	5	0.009832
40	Rock	41	51	383	5	0.013066
45	Rock	100	125	509	5	0.009832
50	Rock	54	68	418	5	0.011967
55	Rock	100	125	509	5	0.009832
60	Rock	51	64	410	5	0.012187
65	Rock	100	125	509	5	0.009832
70	Rock	71	89	456	5	0.010967
75	Rock	100	125	509	5	0.009832
80	Rock	74	93	462	5	0.010823
85	Rock	100	125	509	5	0.009832
90	Rock	57	71	425	5	0.011763
95	Rock	100	125	509	5	0.009832
100	Rock	48	60	402	2.5	0.006213

Boring	A-11-323
Depth	100 feet
ER_i	75 %
V_{s30}	379 m/s

Depth	Soil Type	Blow count N	N_{60}	Vs (m/s)	Thickness of Layer d (feet)	d/Vs
5	Sand	26	33	276	7.5	0.027192
10	Clay	13	16	220	5	0.022737
15	Sand	20	25	256	5	0.019561
20	Rock	48	60	402	5	0.012425
25	Rock	30	38	346	5	0.014435
30	Rock	36	45	367	5	0.01362
35	Rock	32	40	354	5	0.014141
40	Rock	100	125	509	5	0.009832
45	Rock	36	45	367	5	0.01362
50	Rock	100	125	509	5	0.009832
55	Rock	42	53	386	5	0.012966
60	Rock	100	125	509	5	0.009832
65	Rock	46	58	397	5	0.012595
70	Rock	100	125	509	5	0.009832
75	Rock	46	58	397	5	0.012595
80	Rock	100	125	509	5	0.009832
85	Rock	58	73	427	5	0.011698
90	Rock	100	125	509	5	0.009832
95	Rock	49	61	405	5	0.012344
100	Rock	100	125	509	2.5	0.004916

Boring	A-11-324
Depth	100 feet
ER_i	75 %
V_{s30}	243 m/s

Depth	Soil Type	Blow count N	N_{60}	Vs (m/s)	Thickness of Layer d (feet)	d/Vs
5	Clay	16	20	236	7.5	0.031827
10	Clay	40	50	310	5	0.016129
15	Clay	13	16	220	5	0.022737
20	Clay	18	23	245	5	0.020402
25	Clay	11	14	208	5	0.024038
30	Clay	20	25	254	5	0.019699
35	Clay	13	16	220	5	0.022737
40	Clay	11	14	208	5	0.024038
45	Clay	13	16	220	5	0.022737
50	Clay	20	25	254	5	0.019699
55	Clay	18	23	245	5	0.020402
60	Clay	13	16	220	5	0.022737
65	Clay	13	16	220	5	0.022737
70	Clay	15	19	231	5	0.021679
75	Clay	10	13	202	5	0.024813
80	Clay	7	9	179	5	0.027942
85	Rock	31	39	350	5	0.014285
90	Rock	100	125	509	5	0.009832
95	Rock	22	28	314	5	0.015937
100	Rock	26	33	331	2.5	0.007555

Boring	A-11-326
Depth	81.5 feet
ER_i	75 %
V_{s30}	362 m/s

Depth	Soil Type	Blow count N	N_{60}	Vs (m/s)	Thickness of Layer d (feet)	d/Vs
3	Clay	6	8	170	4	0.023531
5	Clay	4	5	149	3.5	0.023566
10	Clay	4	5	149	5	0.033666
15	Rock	29	36	343	5	0.014592
20	Rock	28	35	339	5	0.014757
25	Rock	100	125	509	5	0.009832
30	Rock	29	36	343	5	0.014592
35	Rock	100	125	509	5	0.009832
40	Rock	44	55	391	5	0.012775
45	Rock	100	125	509	5	0.009832
50	Rock	44	55	391	5	0.012775
55	Rock	100	125	509	5	0.009832
60	Rock	45	56	394	5	0.012684
65	Rock	100	125	509	5	0.009832
70	Rock	46	58	397	5	0.012595
75	Rock	100	125	509	5	0.009832
80	Rock	52	65	413	3.25	0.007873
81.5						

Boring	A-11-327
Depth	100 feet
ER_i	75 %
V_{s30}	230 m/s

Depth	Soil Type	Blow count N	N_{60}	Vs (m/s)	Thickness of Layer d (feet)	d/Vs
5	Clay	14	18	225	7.5	0.033274
10	Clay	14	18	225	5	0.022183
15	Clay	12	15	214	5	0.023351
20	Clay	13	16	220	5	0.022737
25	Clay	6	8	170	5	0.029414
30	Clay	22	28	262	5	0.019083
35	Clay	10	13	202	5	0.024813
40	Clay	37	46	310	5	0.016129
45	Clay	12	15	214	5	0.023351
50	Clay	22	28	262	5	0.019083
55	Clay	10	13	202	5	0.024813
60	Clay	20	25	254	5	0.019699
65	Clay	13	16	220	5	0.022737
70	Clay	21	26	258	5	0.019381
75	Clay	14	18	225	5	0.022183
80	Sand	14	18	230	5	0.021693
85	Clay	19	24	250	5	0.020038
90	Clay	21	26	258	5	0.019381
95	Clay	15	19	231	5	0.021679
100	Clay	23	29	266	2.5	0.009401

Boring	A-11-328
Depth	100 feet
ER_i	75 %
V_{s30}	356 m/s

Depth	Soil Type	Blow count N	N_{60}	Vs (m/s)	Thickness of Layer d (feet)	d/Vs
5	Clay	23	29	266	7.5	0.028204
10	clay	21	26	258	5	0.019381
15	sand	23	29	266	5	0.018784
20	sand	24	30	269	5	0.018554
25	clay	11	14	208	5	0.024038
30	Rock	24	30	323	5	0.0155
35	Rock	42	53	386	5	0.012966
40	Rock	31	39	350	5	0.014285
45	Rock	100	125	509	5	0.009832
50	Rock	44	55	391	5	0.012775
55	Rock	100	125	509	5	0.009832
60	Rock	35	44	364	5	0.013743
65	Rock	100	125	509	5	0.009832
70	Rock	51	64	410	5	0.012187
75	Rock	100	125	509	5	0.009832
80	Rock	49	61	405	5	0.012344
85	Rock	100	125	509	5	0.009832
90	Rock	40	50	380	5	0.01317
95	Rock	100	125	509	5	0.009832
100	Rock	54	68	418	2.5	0.005984

Fault & Site Data Input Sheet

Fault & Site Data Input Sheet

The input sheet is to help the user organize the site data for developing the design response spectrum. Beta-Testers: If you fill out the fault and site information for each location, please provide this document and the *checker* to facilitate the QC/QA procedures listed in the 2009 Deterministic Fault Information & Seismic Procedures QC/QA checklist.

Project Information

Dist – EA: 12 - 0F 96E County: Orange Route: I-5 PM: 6.76

Bridge/Facility Name: Route 5/1 separation Bridge/Facility No.: 55-0510

Latitude: 33° 28 ' 11" N = 33.4697 Longitude: 117° 40' 11.6" W = -117.6699

probabilistic R_{mean} = 7.3 km

Fault Information (#1)

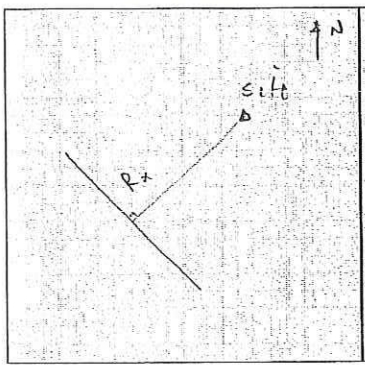
Fault Name: Newport-Inglewood Rose Canyon fault Zone (offshore or Dana point section) Fault ID#: 222

MMax: 7.5 Fault Type: RLSS

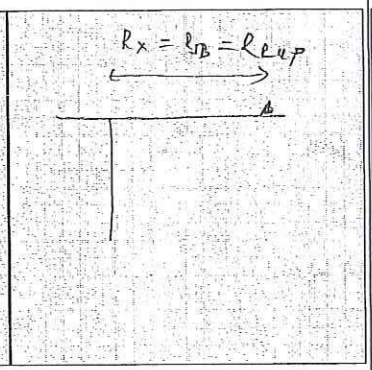
Fault Dip: 90 Dip Direction: V

Top of Rupture: 0 Bottom of Rupture: 13

Plan View



Elevation View



Calculated or Measure Distances

R_{RUP}: 6.15 km

R_{JB}: 6.15 km

R_X: 6.15 km

Determination of V_{S30}

V_{S30} (m/s): 275

Determination of Z1.0 and Z2.5

$Z_{1.0}$ (m/s): 0

$Z_{2.5}$ (km/s): 0

Notes:

Similar calculations for other V_{S30}

V_{S30} = 245, 259, 379, 392, 404, 419, 432, 439

Fault Information (#2)

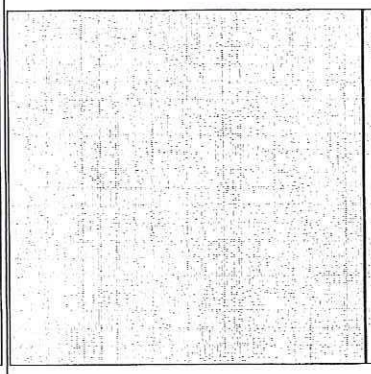
Fault Name: _____ Fault ID#: _____

MMax: _____ Fault Type: _____

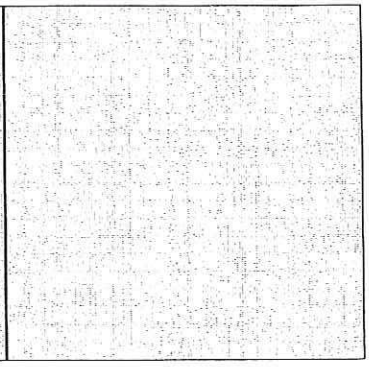
Fault Dip: _____ Dip Direction: _____

Top of Rupture: _____ Bottom of Rupture: _____

Plan View



Elevation View



Calculated or Measure Distances

R_{RUP}: _____

R_{JB}: _____

R_X: _____

Determination of V_{S30}

V_{S30} (m/s): _____

Determination of Z1.0 and Z2.5

$Z_{1.0}$ (m/s): _____

$Z_{2.5}$ (km/s): _____

Notes:

ARS Online Output, Fault Map and Basin Map

SITE DATA

Shear Wave Velocity, V_{S30}:	275 m/s
Latitude:	33.467000
Longitude:	-117.669900
Depth to Vs = 1.0 km/s:	326 m
Depth to Vs = 2.5 km/s:	2.00 km

DETERMINISTIC

Newport Inglewood-Rose Canyon fault zone (Offshore or Dana Point section)

Fault ID:	222
Maximum Magnitude (MMax):	7.5
Fault Type:	RLSS
Fault Dip:	90 Deg
Dip Direction:	V
Bottom of Rupture Plane:	13.00 km
Top of Rupture Plane(Ztor):	0.00 km
Rrup	6.15 km
Rjb:	6.15 km
Rx:	6.15 km
Fnorm:	0
Frev:	0

Period	SA(Base Spectrum)	Basin Factor	Near Fault Factor (Applied)	SA(Final Spectrum)
0.01	0.384	1.000	1.000	0.384
0.02	0.390	1.000	1.000	0.390
0.022	0.394	1.000	1.000	0.394
0.025	0.399	1.000	1.000	0.399
0.029	0.405	1.000	1.000	0.405
0.03	0.407	1.000	1.000	0.407
0.032	0.412	1.000	1.000	0.412
0.035	0.419	1.000	1.000	0.419
0.036	0.422	1.000	1.000	0.422
0.04	0.431	1.000	1.000	0.431
0.042	0.435	1.000	1.000	0.435
0.044	0.440	1.000	1.000	0.440
0.045	0.443	1.000	1.000	0.443
0.046	0.445	1.000	1.000	0.445
0.048	0.450	1.000	1.000	0.450

0.05	0.455	1.000	1.000	0.455
0.055	0.469	1.000	1.000	0.469
0.06	0.484	1.000	1.000	0.484
0.065	0.498	1.000	1.000	0.498
0.067	0.504	1.000	1.000	0.504
0.07	0.513	1.000	1.000	0.513
0.075	0.527	1.000	1.000	0.527
0.08	0.542	1.000	1.000	0.542
0.085	0.558	1.000	1.000	0.558
0.09	0.573	1.000	1.000	0.573
0.095	0.588	1.000	1.000	0.588
0.1	0.602	1.000	1.000	0.602
0.11	0.628	1.000	1.000	0.628
0.12	0.652	1.000	1.000	0.652
0.13	0.673	1.000	1.000	0.673
0.133	0.679	1.000	1.000	0.679
0.14	0.692	1.000	1.000	0.692
0.15	0.709	1.000	1.000	0.709
0.16	0.724	1.000	1.000	0.724
0.17	0.737	1.000	1.000	0.737
0.18	0.749	1.000	1.000	0.749
0.19	0.760	1.000	1.000	0.760
0.2	0.770	1.000	1.000	0.770
0.22	0.781	1.000	1.000	0.781
0.24	0.789	1.000	1.000	0.789
0.25	0.792	1.000	1.000	0.792
0.26	0.793	1.000	1.000	0.793
0.28	0.795	1.000	1.000	0.795
0.29	0.795	1.000	1.000	0.795
0.3	0.796	1.000	1.000	0.796
0.32	0.794	1.000	1.000	0.794
0.34	0.791	1.000	1.000	0.791
0.35	0.789	1.000	1.000	0.789
0.36	0.787	1.000	1.000	0.787
0.38	0.782	1.000	1.000	0.782
0.4	0.777	1.000	1.000	0.777
0.42	0.773	1.000	1.000	0.773
0.44	0.769	1.000	1.000	0.769
0.45	0.767	1.000	1.000	0.767
0.46	0.765	1.000	1.000	0.765
0.48	0.760	1.000	1.000	0.760
0.5	0.756	1.000	1.000	0.756
0.55	0.731	1.000	1.020	0.745
0.6	0.708	1.000	1.040	0.736
0.65	0.687	1.000	1.060	0.728
0.667	0.680	1.000	1.067	0.726
0.7	0.668	1.000	1.080	0.721
0.75	0.650	1.000	1.100	0.715
0.8	0.630	1.000	1.120	0.705
0.85	0.611	1.000	1.140	0.696

0.9	0.593	1.000	1.160	0.688
0.95	0.577	1.000	1.180	0.680
1	0.561	1.000	1.200	0.673
1.1	0.529	1.000	1.200	0.634
1.2	0.500	1.000	1.200	0.600
1.3	0.474	1.000	1.200	0.568
1.4	0.450	1.000	1.200	0.540
1.5	0.427	1.000	1.200	0.513
1.6	0.405	1.000	1.200	0.486
1.7	0.384	1.000	1.200	0.461
1.8	0.365	1.000	1.200	0.438
1.9	0.348	1.000	1.200	0.417
2	0.333	1.000	1.200	0.399
2.2	0.301	1.000	1.200	0.362
2.4	0.275	1.000	1.200	0.330
2.5	0.263	1.000	1.200	0.316
2.6	0.252	1.000	1.200	0.303
2.8	0.233	1.000	1.200	0.279
3	0.216	1.000	1.200	0.259
3.2	0.201	1.000	1.200	0.241
3.4	0.187	1.000	1.200	0.224
3.5	0.181	1.000	1.200	0.217
3.6	0.175	1.000	1.200	0.210
3.8	0.164	1.000	1.200	0.197
4	0.155	1.000	1.200	0.186
4.2	0.147	1.000	1.200	0.176
4.4	0.139	1.000	1.200	0.167
4.6	0.132	1.000	1.200	0.158
4.8	0.126	1.000	1.200	0.151
5	0.120	1.000	1.200	0.144

To use above data in Excel, copy/paste:

```
0.01    0.384    1.000    1.000    0.384
0.02    0.390    1.000    1.000    0.390
```

PROBABILISTIC

Probabilistic Model
USGS Seismic Hazard Map(2008) 975 Year Return Period

Period	SA(Base Spectrum)	Basin Factor	Near Fault Factor (Applied)	SA(Final Spectrum)
0.01	0.387	1.000	1.000	0.387
0.02	0.451	1.000	1.000	0.451
0.022	0.461	1.000	1.000	0.461
0.025	0.474	1.000	1.000	0.474
0.029	0.490	1.000	1.000	0.490
0.03	0.493	1.000	1.000	0.493
0.032	0.501	1.000	1.000	0.501
0.035	0.511	1.000	1.000	0.511
0.036	0.514	1.000	1.000	0.514
0.04	0.526	1.000	1.000	0.526

0.042	0.531	1.000	1.000	0.531
0.044	0.537	1.000	1.000	0.537
0.045	0.540	1.000	1.000	0.540
0.046	0.542	1.000	1.000	0.542
0.048	0.547	1.000	1.000	0.547
0.05	0.552	1.000	1.000	0.552
0.055	0.564	1.000	1.000	0.564
0.06	0.575	1.000	1.000	0.575
0.065	0.585	1.000	1.000	0.585
0.067	0.589	1.000	1.000	0.589
0.07	0.595	1.000	1.000	0.595
0.075	0.604	1.000	1.000	0.604
0.08	0.613	1.000	1.000	0.613
0.085	0.621	1.000	1.000	0.621
0.09	0.629	1.000	1.000	0.629
0.095	0.636	1.000	1.000	0.636
0.1	0.643	1.000	1.000	0.643
0.11	0.663	1.000	1.000	0.663
0.12	0.681	1.000	1.000	0.681
0.13	0.698	1.000	1.000	0.698
0.133	0.703	1.000	1.000	0.703
0.14	0.714	1.000	1.000	0.714
0.15	0.730	1.000	1.000	0.730
0.16	0.744	1.000	1.000	0.744
0.17	0.758	1.000	1.000	0.758
0.18	0.772	1.000	1.000	0.772
0.19	0.785	1.000	1.000	0.785
0.2	0.798	1.000	1.000	0.798
0.22	0.800	1.000	1.000	0.800
0.24	0.802	1.000	1.000	0.802
0.25	0.803	1.000	1.000	0.803
0.26	0.803	1.000	1.000	0.803
0.28	0.805	1.000	1.000	0.805
0.29	0.806	1.000	1.000	0.806
0.3	0.807	1.000	1.000	0.807
0.32	0.796	1.000	1.000	0.796
0.34	0.786	1.000	1.000	0.786
0.35	0.782	1.000	1.000	0.782
0.36	0.777	1.000	1.000	0.777
0.38	0.769	1.000	1.000	0.769
0.4	0.761	1.000	1.000	0.761
0.42	0.754	1.000	1.000	0.754
0.44	0.747	1.000	1.000	0.747
0.45	0.743	1.000	1.000	0.743
0.46	0.740	1.000	1.000	0.740
0.48	0.734	1.000	1.000	0.734
0.5	0.727	1.000	1.000	0.727
0.55	0.697	1.000	1.020	0.711
0.6	0.671	1.000	1.040	0.698
0.65	0.647	1.000	1.060	0.686

0.667	0.640	1.000	1.067		0.683
0.7	0.626	1.000	1.080		0.677
0.75	0.608	1.000	1.100		0.668
0.8	0.581	1.000	1.120		0.651
0.85	0.557	1.000	1.140		0.635
0.9	0.536	1.000	1.160		0.622
0.95	0.516	1.000	1.180		0.609
1	0.498	1.000	1.200		0.598
1.1	0.462	1.000	1.200		0.554
1.2	0.431	1.000	1.200		0.517
1.3	0.404	1.000	1.200		0.485
1.4	0.381	1.000	1.200		0.457
1.5	0.361	1.000	1.200		0.433
1.6	0.343	1.000	1.200		0.411
1.7	0.326	1.000	1.200		0.392
1.8	0.312	1.000	1.200		0.374
1.9	0.299	1.000	1.200		0.358
2	0.287	1.000	1.200		0.344
2.2	0.260	1.000	1.200		0.312
2.4	0.237	1.000	1.200		0.285
2.5	0.227	1.000	1.200		0.273
2.6	0.218	1.000	1.200		0.262
2.8	0.202	1.000	1.200		0.242
3	0.188	1.000	1.200		0.226
3.2	0.175	1.000	1.200		0.210
3.4	0.163	1.000	1.200		0.195
3.5	0.158	1.000	1.200		0.189
3.6	0.153	1.000	1.200		0.183
3.8	0.143	1.000	1.200		0.172
4	0.135	1.000	1.200		0.162
4.2	0.130	1.000	1.200		0.155
4.4	0.124	1.000	1.200		0.149
4.6	0.120	1.000	1.200		0.144
4.8	0.115	1.000	1.200		0.138
5	0.111	1.000	1.200		0.134

To use above data in Excel, copy/paste:

```
0.01    0.387    1.000    1.000    0.387
0.02    0.451    1.000    1.000    0.451
```

Envelope Data

Period	SA
0.01	0.387
0.02	0.451
0.022	0.461
0.025	0.474
0.029	0.490
0.03	0.493
0.032	0.501

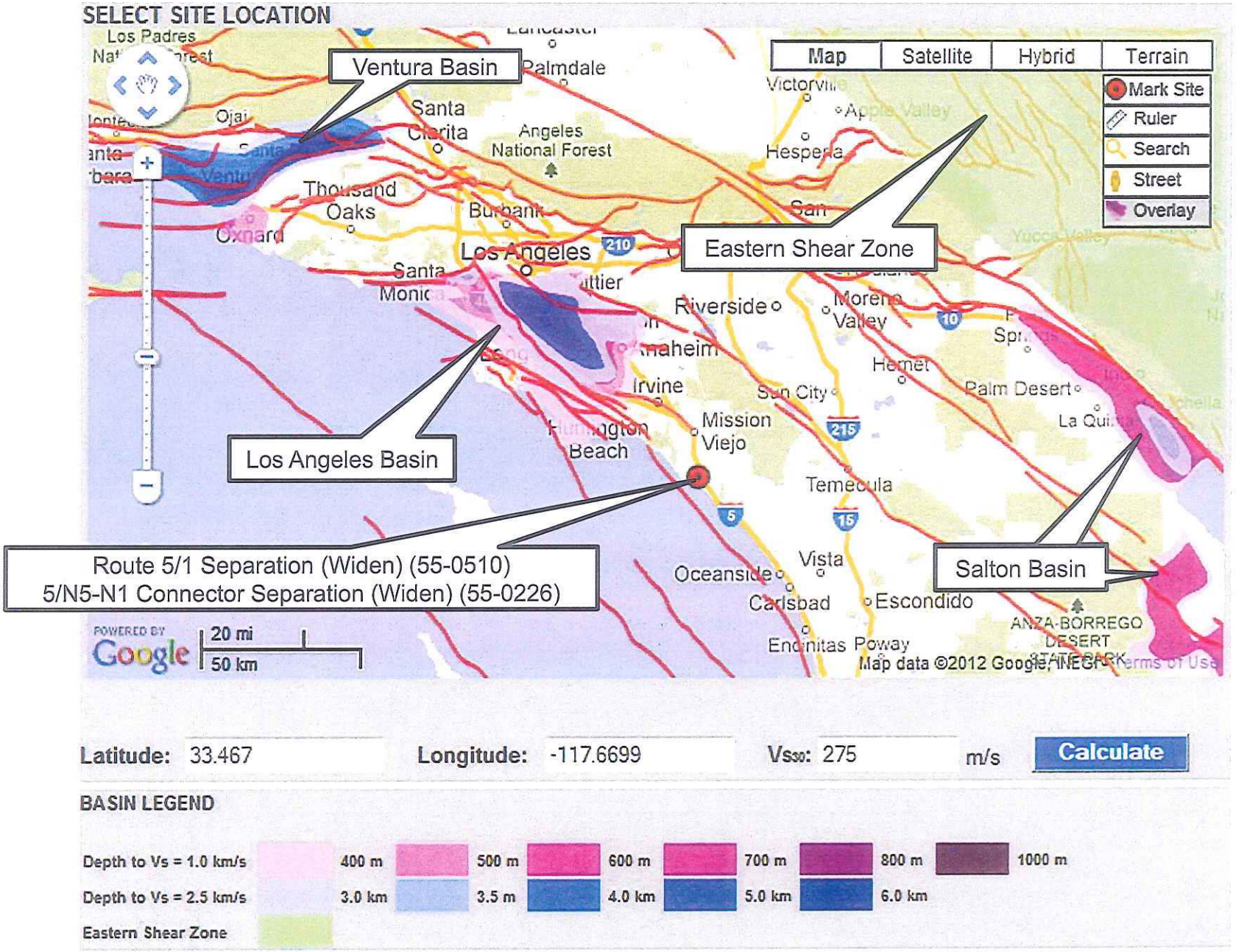
0.035	0.511
0.036	0.514
0.04	0.526
0.042	0.531
0.044	0.537
0.045	0.540
0.046	0.542
0.048	0.547
0.05	0.552
0.055	0.564
0.06	0.575
0.065	0.585
0.067	0.589
0.07	0.595
0.075	0.604
0.08	0.613
0.085	0.621
0.09	0.629
0.095	0.636
0.1	0.643
0.11	0.663
0.12	0.681
0.13	0.698
0.133	0.703
0.14	0.714
0.15	0.730
0.16	0.744
0.17	0.758
0.18	0.772
0.19	0.785
0.2	0.798
0.22	0.800
0.24	0.802
0.25	0.803
0.26	0.803
0.28	0.805
0.29	0.806
0.3	0.807
0.32	0.796
0.34	0.791
0.35	0.789
0.36	0.787
0.38	0.782
0.4	0.777
0.42	0.773
0.44	0.769
0.45	0.767
0.46	0.765
0.48	0.760
0.5	0.756

0.55	0.745
0.6	0.736
0.65	0.728
0.667	0.726
0.7	0.721
0.75	0.715
0.8	0.705
0.85	0.696
0.9	0.688
0.95	0.680
1	0.673
1.1	0.634
1.2	0.600
1.3	0.568
1.4	0.540
1.5	0.513
1.6	0.486
1.7	0.461
1.8	0.438
1.9	0.417
2	0.399
2.2	0.362
2.4	0.330
2.5	0.316
2.6	0.303
2.8	0.279
3	0.259
3.2	0.241
3.4	0.224
3.5	0.217
3.6	0.210
3.8	0.197
4	0.186
4.2	0.176
4.4	0.167
4.6	0.158
4.8	0.151
5	0.144

To use above data in Excel, copy/paste:

```
0.01    0.387
0.02    0.451
```

Route 5/1 Separation (Widen) (55-0510) 5/N5-N1 Connector Separation (Widen) (55-0226)	ARS Online Fault Map
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 09-25-12



Latitude: 33.467 **Longitude:** -117.6699 **Vs_{30}:** 275 m/s **Calculate**

BASIN LEGEND

Depth to Vs = 1.0 km/s	400 m	500 m	600 m	700 m	800 m	1000 m			
Depth to Vs = 2.5 km/s	3.0 km	3.5 m	4.0 km	5.0 km	6.0 km				
Eastern Shear Zone									

Route 5/1 Separation (Widen) (55-0510) 5/N5-N1 Connector Separation (Widen) (55-0226)	ARS Online Basin Map
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 09-25-12

Caltrans Deterministic ARS Spreadsheet

Newport Inglewood-Ross Canyon Fault (Fault ID# 222)

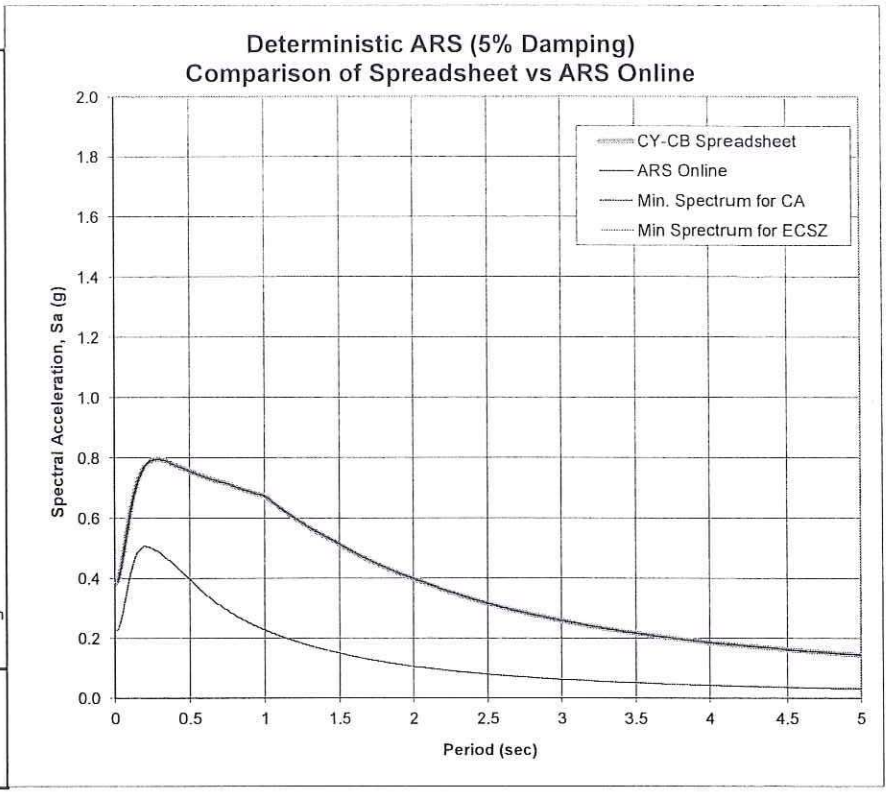
Comparison of ARS Curves
(unlock sheet with "shmi")

Model Inputs

Fault		
Magnitude	7.5	(5 to 8.5)
F_{RV}	0	(input 1 = Rev)
F_{NM}	0	(input 1 = Normal)
Dip (degree)	90	(0 to 90)
Z_{TOR} (km)	0	
Distance		
R_{RUP} (km)	6.2	
R_{JB} (km)	6.2	
R_X (km)	6.2	
Hanging Wall?	☐ Yes?	
Near-Field Factor?	☑ Yes?	
Site		
V_{S30} (m/sec)	275	(270 to 1500 m/s)
$Z_{1.0}$ (m)	0	(0 - No Basin)
$Z_{2.5}$ (km)	0	(0 - No Basin)
No. Cal. Basin?	☐ Yes ?	(Check only for sites located within a Basin)
So. Cal. Basin?	☐ Yes ?	

Analysis

ARS Online vs CY-CB Spreadsheet Results
MAX. % Diff. = 0%



CY-CB Spreadsheet Results	
T (sec)	CB-CY S(a)
0.010	0.38392
0.020	0.38963
0.022	0.39354
0.025	0.39888
0.029	0.40521
0.030	0.40713
0.032	0.41207
0.035	0.41921
0.036	0.42155
0.040	0.43053
0.042	0.43542
0.044	0.44027
0.045	0.44287
0.046	0.44541
0.048	0.45030
0.050	0.45519
0.055	0.46934
0.060	0.48373
0.065	0.49802
0.067	0.50395
0.070	0.51260
0.075	0.52709
0.080	0.54242
0.085	0.55766
0.090	0.57267
0.095	0.58756
0.100	0.60205
0.110	0.62791
0.120	0.65177
0.130	0.67328
0.133	0.67905
0.140	0.69187
0.150	0.70874
0.160	0.72383
0.170	0.73708
0.180	0.74937

Place ARS Online Deterministic Data Here "Paste"					
T (sec)	Base S(a)	Basin Factor	Near Fault Factor	Final Adj. S(a)	Diff. (%)
0.01	0.384	1	1	0.384	0%
0.02	0.39	1	1	0.39	0%
0.022	0.394	1	1	0.394	0%
0.025	0.399	1	1	0.399	0%
0.029	0.405	1	1	0.405	0%
0.03	0.407	1	1	0.407	0%
0.032	0.412	1	1	0.412	0%
0.035	0.419	1	1	0.419	0%
0.036	0.422	1	1	0.422	0%
0.04	0.431	1	1	0.431	0%
0.042	0.435	1	1	0.435	0%
0.044	0.44	1	1	0.44	0%
0.045	0.443	1	1	0.443	0%
0.046	0.445	1	1	0.445	0%
0.048	0.45	1	1	0.45	0%
0.05	0.455	1	1	0.455	0%
0.055	0.469	1	1	0.469	0%
0.06	0.484	1	1	0.484	0%
0.065	0.498	1	1	0.498	0%
0.067	0.504	1	1	0.504	0%
0.07	0.513	1	1	0.513	0%
0.075	0.527	1	1	0.527	0%
0.08	0.542	1	1	0.542	0%
0.085	0.558	1	1	0.558	0%
0.09	0.573	1	1	0.573	0%
0.095	0.588	1	1	0.588	0%
0.1	0.602	1	1	0.602	0%
0.11	0.628	1	1	0.628	0%
0.12	0.652	1	1	0.652	0%
0.13	0.673	1	1	0.673	0%
0.133	0.679	1	1	0.679	0%
0.14	0.692	1	1	0.692	0%
0.15	0.709	1	1	0.709	0%
0.16	0.724	1	1	0.724	0%
0.17	0.737	1	1	0.737	0%
0.18	0.749	1	1	0.749	0%

For Comparsion Plots of Min. Sprectra, Paste Special into Cells			
Min. Spectrum for CA		Min Sprectrum for ECSZ	
T (sec)	S (a)	T (sec)	S (a)
0.01	0.2264355		
0.02	0.2292964		
0.022	0.231658		
0.025	0.2349626		
0.029	0.2390608		
0.03	0.2402334		
0.032	0.2437408		
0.035	0.2488898		
0.036	0.250641		
0.04	0.2573834		
0.042	0.2609625		
0.044	0.264548		
0.045	0.2664015		
0.046	0.2682612		
0.048	0.2718729		
0.05	0.2755171		
0.055	0.2881796		
0.06	0.300911		
0.065	0.3135281		
0.067	0.3186195		
0.07	0.3261491		
0.075	0.3386376		
0.08	0.3516198		
0.085	0.364458		
0.09	0.377045		
0.095	0.3894007		
0.1	0.40142		
0.11	0.4212307		
0.12	0.4393672		
0.13	0.455667		
0.133	0.4600472		
0.14	0.4698226		
0.15	0.4826171		
0.16	0.4894972		
0.17	0.4951001		
0.18	0.4999218		

0.190	0.76040
0.200	0.77038
0.220	0.78065
0.240	0.78864
0.250	0.79163
0.260	0.79287
0.280	0.79542
0.290	0.79547
0.300	0.79559
0.320	0.79397
0.340	0.79108
0.350	0.78915
0.360	0.78717
0.380	0.78234
0.400	0.77710
0.420	0.77343
0.440	0.76909
0.450	0.76716
0.460	0.76499
0.480	0.76046
0.500	0.75624
0.550	0.74551
0.600	0.73652
0.650	0.72839
0.660	0.72504
0.700	0.72113
0.750	0.71466
0.800	0.70517
0.850	0.69644
0.900	0.68794
0.950	0.68028
1.000	0.67267
1.100	0.63397
1.200	0.59933
1.300	0.56777
1.400	0.53902
1.500	0.51221
1.600	0.48484
1.700	0.45984
1.800	0.43722
1.900	0.41678
2.000	0.39826
2.200	0.36100
2.400	0.32948
2.500	0.31543
2.600	0.30239
2.800	0.27892
3.000	0.25852
3.200	0.24031
3.400	0.22419
3.500	0.21682
3.600	0.20985
3.800	0.19700
4.000	0.18549
4.200	0.17567
4.400	0.16658
4.600	0.15827
4.800	0.15065
5.000	0.14360

0.19	0.76	1	1	0.76	0%
0.2	0.77	1	1	0.77	0%
0.22	0.781	1	1	0.781	0%
0.24	0.789	1	1	0.789	0%
0.25	0.792	1	1	0.792	0%
0.26	0.793	1	1	0.793	0%
0.28	0.795	1	1	0.795	0%
0.29	0.795	1	1	0.795	0%
0.3	0.796	1	1	0.796	0%
0.32	0.794	1	1	0.794	0%
0.34	0.791	1	1	0.791	0%
0.35	0.789	1	1	0.789	0%
0.36	0.787	1	1	0.787	0%
0.38	0.782	1	1	0.782	0%
0.4	0.777	1	1	0.777	0%
0.42	0.773	1	1	0.773	0%
0.44	0.769	1	1	0.769	0%
0.45	0.767	1	1	0.767	0%
0.46	0.765	1	1	0.765	0%
0.48	0.76	1	1	0.76	0%
0.5	0.756	1	1	0.756	0%
0.55	0.731	1	1.02	0.745	0%
0.6	0.708	1	1.04	0.736	0%
0.65	0.687	1	1.06	0.728	0%
0.667	0.68	1	1.067	0.726	0%
0.7	0.668	1	1.08	0.721	0%
0.75	0.65	1	1.1	0.715	0%
0.8	0.63	1	1.12	0.705	0%
0.85	0.611	1	1.14	0.696	0%
0.9	0.593	1	1.16	0.688	0%
0.95	0.577	1	1.18	0.68	0%
1	0.561	1	1.2	0.673	0%
1.1	0.529	1	1.2	0.634	0%
1.2	0.5	1	1.2	0.6	0%
1.3	0.474	1	1.2	0.568	0%
1.4	0.45	1	1.2	0.54	0%
1.5	0.427	1	1.2	0.513	0%
1.6	0.405	1	1.2	0.486	0%
1.7	0.384	1	1.2	0.461	0%
1.8	0.365	1	1.2	0.438	0%
1.9	0.348	1	1.2	0.417	0%
2	0.333	1	1.2	0.399	0%
2.2	0.301	1	1.2	0.362	0%
2.4	0.275	1	1.2	0.33	0%
2.5	0.263	1	1.2	0.316	0%
2.6	0.252	1	1.2	0.303	0%
2.8	0.233	1	1.2	0.279	0%
3	0.216	1	1.2	0.259	0%
3.2	0.201	1	1.2	0.241	0%
3.4	0.187	1	1.2	0.224	0%
3.5	0.181	1	1.2	0.217	0%
3.6	0.175	1	1.2	0.21	0%
3.8	0.164	1	1.2	0.197	0%
4	0.155	1	1.2	0.186	0%
4.2	0.147	1	1.2	0.176	0%
4.4	0.139	1	1.2	0.167	0%
4.6	0.132	1	1.2	0.158	0%
4.8	0.126	1	1.2	0.151	0%
5	0.12	1	1.2	0.144	0%

0.19	0.5038624		
0.2	0.5071486		
0.22	0.5051218		
0.24	0.5019929		
0.25	0.4999847		
0.26	0.4974264		
0.28	0.492425		
0.29	0.4894468		
0.3	0.4864857		
0.32	0.4785065		
0.34	0.4703153		
0.35	0.4661365		
0.36	0.462032		
0.38	0.4537277		
0.4	0.4455931		
0.42	0.4354395		
0.44	0.4255349		
0.45	0.4208331		
0.46	0.416142		
0.48	0.4070979		
0.5	0.398482		
0.55	0.3714942		
0.6	0.3481843		
0.65	0.3276675		
0.66	0.3226963		
0.7	0.3095329		
0.75	0.2933302		
0.8	0.2775914		
0.85	0.2633633		
0.9	0.2503797		
0.95	0.2385802		
1	0.227672		
1.1	0.2073013		
1.2	0.189936		
1.3	0.1748603		
1.4	0.1616204		
1.5	0.1498311		
1.6	0.1388055		
1.7	0.1290039		
1.8	0.1202979		
1.9	0.1125479		
2	0.1056704		
2.2	0.0936335		
2.4	0.0837312		
2.5	0.0794161		
2.6	0.0754627		
2.8	0.0684596		
3	0.0624777		
3.2	0.0573919		
3.4	0.0529504		
3.5	0.0509403		
3.6	0.0490488		
3.8	0.0455794		
4	0.0424971		
4.2	0.0398817		
4.4	0.0375063		
4.6	0.0353489		
4.8	0.033374		
5	0.0315646		

2009 Deterministic Fault Information & Seismic Procedure QC/QA Checklist

This document is to be filled out by *checker* to evaluate the fault parameters and design response spectrum used for seismic design recommendations for bridge structures. To facilitate the quality check, the designer shall provide the checker all pertinent project information, geologic information and approved exceptions (if applicable) needed to complete this form. The *checker* must be familiar with the Seismic Design Criteria (Appendix B), Deterministic PGA Map and ARS Online Report, and Geotechnical Services Design Manual in order to successfully perform a quality check. Tools available to checkers include the Deterministic Response Spectrum Spreadsheet, Probabilistic Response Spectrum Spreadsheet (after USGS), 2008 USGS National Seismic Hazard Map and the ARS Online web tool. The above documents and tools are available at http://dap3.dot.ca.gov/shake_stable/technical.php.

Project Information

Dist – EA: 12 - 0F96 E County: ORA Route: 5 PM: 6.76

Bridge/Facility Name: Route 5/1 separation Bridge/Facility No.: 55 - 0510

Latitude: 33.4670 Longitude: -117.6699

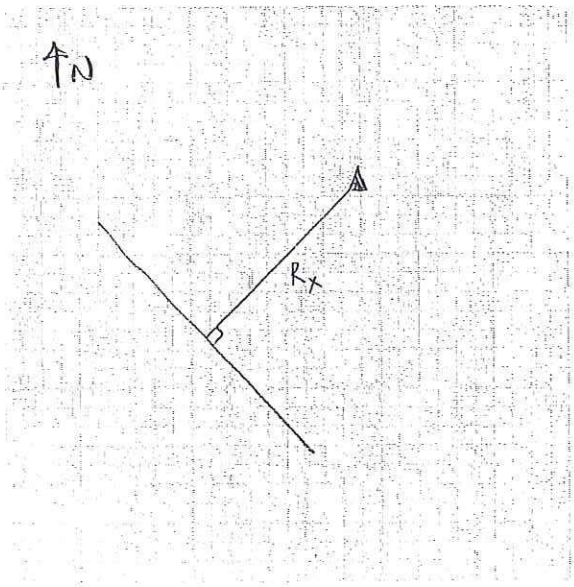
Deterministic Fault Information

Fault Name: Newport Inglewood Rose canyon Fault ID#: 222 M_{MAX}: 7.5 Fault Type: RLSS

Fault Dip: 90 Dip Direction: V Top of Rupture: 0 Bottom of Rupture: 13

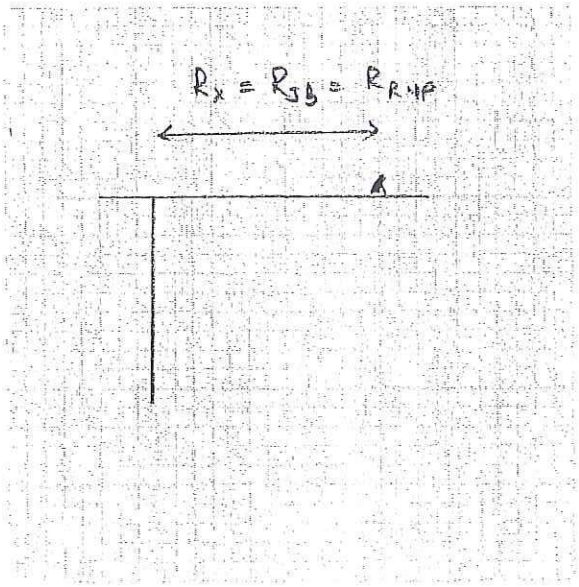
Plan View

(rough sketch; show dimensions)



Elevation View

(rough sketch; show dimensions)



Calculated or Measured Distances

R_{RUP}:	6.15 km	☒	Calculated / graphically	☒	Same as Rx (by definition)
R_{JB}:	6.15 km	☒	Calculated / graphically	☒	Same as Rx (by definition)
R_X:	6.15 km	☒	"Ruler" function on ARS Online	☐	Deterministic PGA Map

2009 Deterministic Fault Information & Seismic Procedure QC/QA Checklist

Determination of V_{S30}

V_{S30} (m/s): 275

Method of Determining V_{S30}: SPT correlation (e.g. P-S logging, Geophysics, SPT correlations, etc)

Additional Explanation (if needed): Calibrated with CPT data

Determination of Z1.0 and Z2.5 (if site located in designated California deep basin)

$Z_{1.0}$ (m/s): 0 $Z_{2.5}$ (km/s): 0

Method of Determining $Z_{1.0}$ & $Z_{2.5}$: ARS Online (e.g. ARS Online, SDC figure, other)

Additional Explanation (if needed): _____

Deterministic - Special Conditions

Yes	No	N/A	
☒	☐		Was the Errata Deterministic Fault Database Spreadsheet reviewed to ensure that the correct fault parameters used in the analysis.
☒	☐	☐	Were the Near-Fault Factors applied correctly? *Applies to sites with a R_{RUP} distance of 25 km or less, as defined in the SDC.*
☒	☐	☐	Were deep basin depths ($Z_{1.0}$ & $Z_{2.5}$) estimated correctly? *Applies to sites located in deep basins as shown in Figures B.5 - B.11 of the SDC or ARS Online.*
☐	☐	☒	If the site is located within the Eastern California Shear Zone (ECSZ), was the design ARS larger than the minimum spectrum for the ECSZ (as defined in the SDC, Appendix B, Figure B.2)?
☐	☐	☒	If the controlling fault is the Cascadia Subduction Zone, was the alternate seismic procedure applied correctly (as defined in the SDC, Appendix B)?
☐	☐	☒	If the deterministic ARS falls below the Minimum Deterministic Spectra (as defined in the SDC), did the Minimum Deterministic Spectra control the deterministic design spectrum?
☒	☐		Did the ARS Online deterministic spectrum correspond within 10% of the calculated deterministic spectrum? If not, note it in the comments section of this document and email a copy to the ARS Online development team, ARS_Online@dot.ca.gov, so that they may address the potential bug.

Probabilistic - Special Conditions

Yes	No	N/A	
☒	☐	☐	Were Near-Fault Factors applied correctly (as defined by SDC)? *Applies to sites with a deaggregation R distance of 25 km or less.*
☒	☐	☐	Were deep basin depths ($Z_{1.0}$ & $Z_{2.5}$) estimated correctly? *Applies to sites located in deep basins as shown in Figures B.5 - B.11 of the SDC or ARS Online.*
☒	☐	☐	If the site has a V_{S30} of less than 300 m/s, was the resulting ARS curve checked against spectral acceleration from USGS Interactive Deaggregation tool?
☒	☐	☐	If the USGS Interactive Deaggregation tool and spectral acceleration data were used, were the appropriate near-fault and basin correction factors applied?

2009 Deterministic Fault Information & Seismic Procedure QC/QA Checklist

Yes	No	N/A	
☐	☐	☒	If the probabilistic ARS falls below the Minimum Deterministic Spectra (as defined in the SDC), did the Minimum Deterministic Spectra control the design spectrum?
☒	☐		Did the ARS Online design spectrum correspond within 10% of the USGS spectral acceleration data from the verification spreadsheet? If not, note it in the comments section of this document and email a copy to the ARS Online development team, ARS_Online@dot.ca.gov, so that they may address the potential bug.

Comments / Observations Encountered during QC/QA process:

ARS curves were generated for other V_{S30} = 295, 259, 379, 392, 404, 419, 432 & 439. Design ARS curve is average of all the ARS curves

I certify that I have performed a quality check of the referenced fault information and design response spectrum provided by the geotechnical designer. The quality check is based on Seismic Design Criteria (Appendix B), Deterministic PGA Map and ARS Online Report, and the Geotechnical Services Design Manual.

LING CHEANG — PRINCIPAL

Checker (Print) — Title

[signature] — 1/12/2012

Checker (Signature) — Date

I certify that the referenced project complies with Geotechnical Service's Quality Control/Quality Assurance procedures, as described in the memorandum, "Quality Control/Quality Assurance for the 2009 Seismic Design Procedures", dated August 12, 2009.

LING CHEANG — PRINCIPAL

Functional Supervisor (Print) — Title

[signature] — 1/12/2012

Functional Supervisor (Signature) — Date

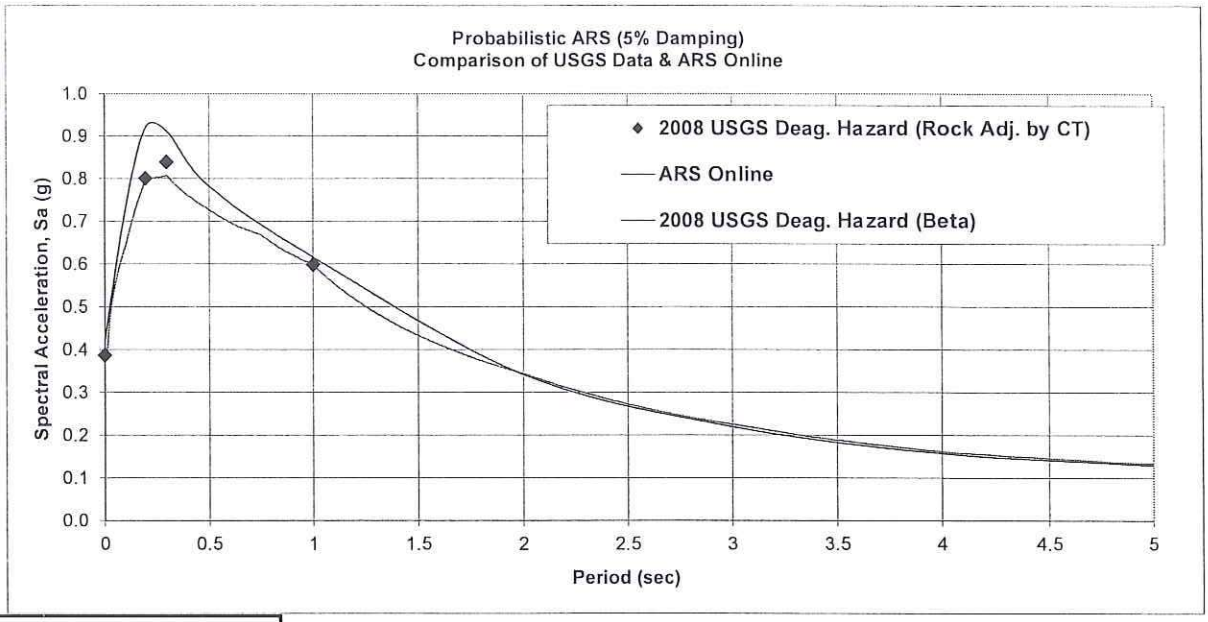
(This original checklist and signature sheet shall be placed in the geotechnical project file, and a copy sent to the Mark Willian of the Geotechnical Services Corporate Unit).

Caltrans Probabilistic Spreadsheet

Comparison spreadsheet of the 2008 USGS Probabilistic Seismic Hazard Data and ARS Online Probabilistic Data (unlock spreadsheet "shmi")
Spectral Accelerations Points from USGS Website at http://earthquake.usgs.gov/research/hazmaps/products_data/2008/data/

* Note: This spreadsheet uses the given latitude and longitude data provided by the user to estimate spectral acceleration values with a probability of exceedence 5% in 50 yrs (or 975 yr return period). The four spectral acceleration data points plotted on the graph are from the USGS website and are based on a 0.05 degree grid. Basic interpolation is used to estimate intermediate values inside each grid. Raw Data points are provided in the tabs of this spreadsheet. Corner grid spectral acceleration data are shown in the "calculation" tab.

Input Site Information	
Latitude	Longitude
33.4670	-117.6699
V_{S30} (m/s) =	275
Near Fault Factor, Derived from USGS Deagg. Dist (km) =	7.3
$Z_{1.0}$ (m) =	0
$Z_{2.5}$ (km) =	0



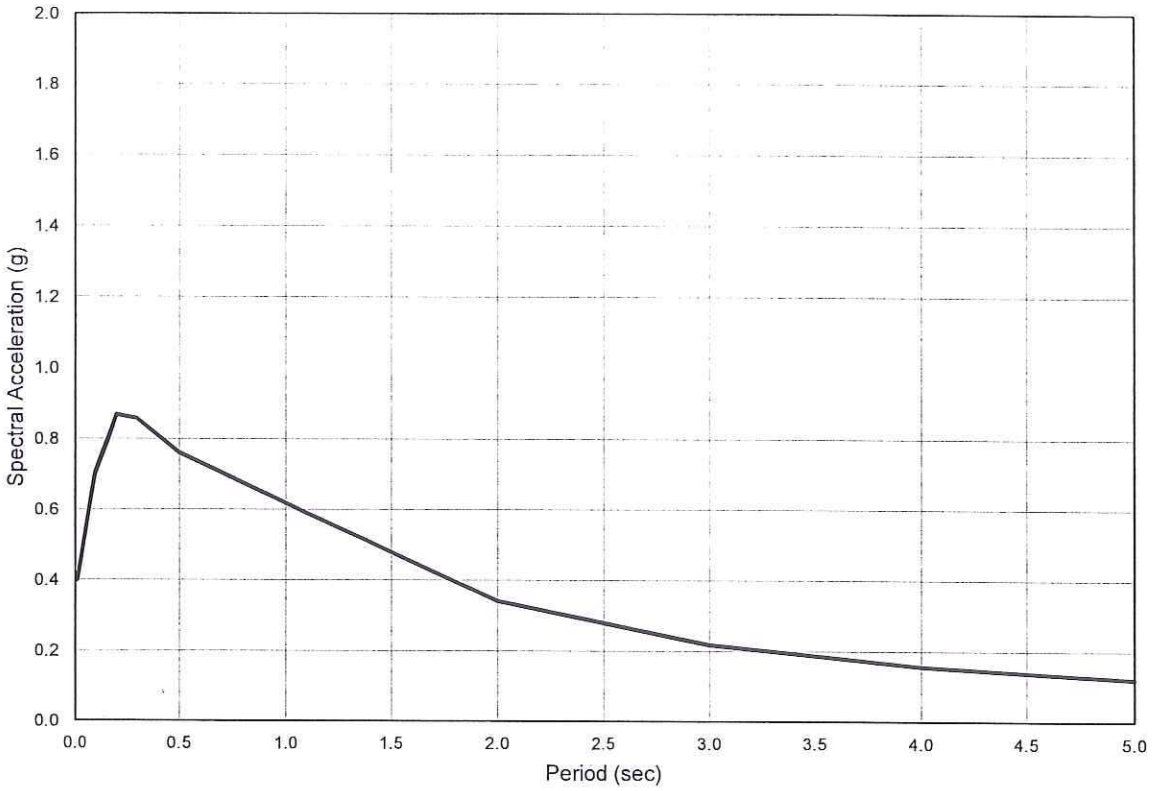
Place ARS Online Probabilistic Data Here "Paste"				
T (sec)	Base Spectrum S(a)	Basin Factor	Near Fault Factor	Final Adj. Spectrum S(a)
0.01	0.387	1	1	0.387
0.02	0.451	1	1	0.451
0.022	0.461	1	1	0.461
0.025	0.474	1	1	0.474
0.029	0.49	1	1	0.49
0.03	0.493	1	1	0.493
0.032	0.501	1	1	0.501
0.035	0.511	1	1	0.511
0.036	0.514	1	1	0.514
0.04	0.526	1	1	0.526
0.042	0.531	1	1	0.531
0.044	0.537	1	1	0.537
0.045	0.54	1	1	0.54
0.046	0.542	1	1	0.542
0.048	0.547	1	1	0.547
0.05	0.552	1	1	0.552
0.055	0.564	1	1	0.564
0.06	0.575	1	1	0.575
0.065	0.585	1	1	0.585
0.067	0.589	1	1	0.589
0.07	0.595	1	1	0.595
0.075	0.604	1	1	0.604
0.08	0.613	1	1	0.613
0.085	0.621	1	1	0.621
0.09	0.629	1	1	0.629
0.095	0.636	1	1	0.636
0.1	0.643	1	1	0.643
0.11	0.663	1	1	0.663
0.12	0.681	1	1	0.681
0.13	0.698	1	1	0.698
0.133	0.703	1	1	0.703
0.14	0.714	1	1	0.714
0.15	0.73	1	1	0.73
0.16	0.744	1	1	0.744
0.17	0.758	1	1	0.758
0.18	0.772	1	1	0.772
0.19	0.785	1	1	0.785
0.2	0.798	1	1	0.798
0.22	0.8	1	1	0.8
0.24	0.802	1	1	0.802
0.25	0.803	1	1	0.803
0.26	0.803	1	1	0.803

Analysis of ARS Online Results vs USGS Deaggregation Hazard (Adj. By CT)							
Period (sec)	USGS Interpolated Spectral Accel.	Adj. for Near Fault Effect	Adj. for Soil Amplification	Adj. For Basin Effect	Final Adj. USGS Spec Accel	ARS Online Final Adj. Spect. Accel.	% Difference (bet. USGS & ARS Online)
0	0.368	1.000	1.051	1.000	0.387	0.387	0.0%
0.2	0.880	1.000	0.910	1.000	0.801	0.798	0.3%
0.3	0.725	1.000	1.157	1.000	0.839	0.807	3.8%
1	0.273	1.200	1.826	1.000	0.599	0.598	0.1%
					Max % Difference =		3.8%

USGS Deaggregation Hazard (Beta) with Near Field and Basin Factors						
Period (sec)	INPUT USGS Deagg. Spec Accel	Adj. for Near Fault Effect	Adj. For Basin Effect	Final Adj. USGS Deagg Spec Accel	ARS Online Final Adj. Spect. Accel.	% Difference (bet. USGS & ARS Online)
0	0.4246	1.000	1.000	0.425	0.387	*8.9%*
0.1	0.7333	1.000	1.000	0.733	0.643	*12.3%*
0.2	0.9208	1.000	1.000	0.921	0.798	*13.3%*
0.3	0.9125	1.000	1.000	0.913	0.807	*11.6%*
0.5	0.7823	1.000	1.000	0.782	0.727	7.1%
1	0.5137	1.200	1.000	0.616	0.598	3.0%
2	0.2846	1.200	1.000	0.342	0.344	0.7%
3	0.1833	1.200	1.000	0.220	0.226	2.7%
4	0.13129	1.200	1.000	0.158	0.162	2.8%
5	0.10803	1.200	1.000	0.130	0.134	3.4%
				Max % Difference =		7.1%

0.28	0.805	1	1	0.805
0.29	0.806	1	1	0.806
0.3	0.807	1	1	0.807
0.32	0.796	1	1	0.796
0.34	0.786	1	1	0.786
0.35	0.782	1	1	0.782
0.36	0.777	1	1	0.777
0.38	0.769	1	1	0.769
0.4	0.761	1	1	0.761
0.42	0.754	1	1	0.754
0.44	0.747	1	1	0.747
0.45	0.743	1	1	0.743
0.46	0.74	1	1	0.74
0.48	0.734	1	1	0.734
0.5	0.727	1	1	0.727
0.55	0.697	1	1.02	0.711
0.6	0.671	1	1.04	0.698
0.65	0.647	1	1.06	0.686
0.667	0.64	1	1.067	0.683
0.7	0.626	1	1.08	0.677
0.75	0.608	1	1.1	0.668
0.8	0.581	1	1.12	0.651
0.85	0.557	1	1.14	0.635
0.9	0.536	1	1.16	0.622
0.95	0.516	1	1.18	0.609
1	0.498	1	1.2	0.598
1.1	0.462	1	1.2	0.554
1.2	0.431	1	1.2	0.517
1.3	0.404	1	1.2	0.485
1.4	0.381	1	1.2	0.457
1.5	0.361	1	1.2	0.433
1.6	0.343	1	1.2	0.411
1.7	0.326	1	1.2	0.392
1.8	0.312	1	1.2	0.374
1.9	0.299	1	1.2	0.358
2	0.287	1	1.2	0.344
2.2	0.26	1	1.2	0.312
2.4	0.237	1	1.2	0.285
2.5	0.227	1	1.2	0.273
2.6	0.218	1	1.2	0.262
2.8	0.202	1	1.2	0.242
3	0.188	1	1.2	0.226
3.2	0.175	1	1.2	0.21
3.4	0.163	1	1.2	0.195
3.5	0.158	1	1.2	0.189
3.6	0.153	1	1.2	0.183
3.8	0.143	1	1.2	0.172
4	0.135	1	1.2	0.162
4.2	0.13	1	1.2	0.155
4.4	0.124	1	1.2	0.149
4.6	0.12	1	1.2	0.144
4.8	0.115	1	1.2	0.138
5	0.111	1	1.2	0.134

ARS Curve



Latitude = 33.4670 °
Longitude = -117.6699 °
Damping Ratio = 5%

Spectral Coordinates	
	Acc. (g)
Period (sec)	Design
0.010	0.400
0.100	0.701
0.200	0.869
0.300	0.857
0.500	0.760
1.000	0.618
2.000	0.342
3.000	0.218
4.000	0.156
5.000	0.121

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Route 5/1 Separation 5/N5-N1 Connector Separation	Design ARS Curve
	Project: 11-137 Date: 01/12/12	Figure 2