Geotechnical Engineering Report

Western Area Power Administration

Gila-Knob T/L Rebuild, Phase 1

Near Yuma, Arizona

March 2, 2016

Terracon Project No. 65155124, Revision No. 1

Prepared for:

Civil Design & Engineering, Inc.
Phoenix, Arizona

Prepared by:

Terracon Consultants, Inc.
Tempe, Arizona

March 2, 2016

Terracon

Civil Design & Engineering, Inc.
340 East Palm Lane, Suite A-138
Phoenix, Arizona 85004

Attn: Christine Laguna, P.E.

Re: **Geotechnical Engineering Report**
Western Area Power Administration
Gila-Knob T/L Rebuild, Phase 1
Near Yuma, Arizona
Terracon Project No. 65155124, Revision No. 1

Dear Ms. Laguna:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the proposed Western Area Power Administration (Western) Gila-Knob T/L Rebuild, Phase 1 project near Yuma, Arizona. These services were performed in general accordance with our Proposal No. P65150718 dated November 6, 2015 and subsequent Task Order No. 189. This geotechnical engineering report presents the results of the subsurface exploration and provides geotechnical engineering recommendations concerning the design and construction of deep foundations for the planned transmission line foundations. This report has been revised to provide additional information regarding caving potential and excavation characteristics.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Registered Professional Engineer (Civil)
CERTIFICATE NO.
47791
JESSE R.
HUSTON
Date Signed 3/2/16
ARIZONA, U.S.A.
Expires 6-30-2016

Jesse R. Huston, P.E.
Senior Project Manager

Donald R. Clark P.E.
Senior Principal

Copies to: Addressee (1 via email)

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EXECUTIVE SUMMARY

A geotechnical engineering exploration has been performed for the proposed Western Area Power Administration's Gila-Knob T/L Rebuild, Phase 1 project located just outside of the North Gila Substation near Yuma, Arizona. Terracon's geotechnical scope of work included the advancement of four (4) test borings to an approximate depth 40 feet below existing site grades, laboratory testing on representative samples of the subsurface materials, engineering analyses and development of engineering recommendations for design and construction of foundations to support the proposed structures.

Based on the information obtained from our engineering analyses of the field and laboratory data, the site appears suitable for the proposed construction based upon geotechnical conditions encountered in the test borings, and provided our recommendations contained in this report are properly implemented in the design and construction. The following geotechnical considerations were identified:

- The subsurface conditions encountered in the test borings generally consists of sand soils with variable amounts of silt and gravel to the maximum depth explored in Borings B-1 and B-2. In Borings B-3 and B-4 to the west of the existing substation, these upper sand soils were underlain with fat clay starting at depths of 19 and 28 feet, respectively. The relative density of the sand soils was generally medium dense to very dense in Borings B-1 and B-2, and loose near the surface in Borings B-3 and B-4 increasing to medium dense below an approximate depth of five (5) feet. The lower fat clay soils were generally very stiff to hard in consistency.

- Groundwater was encountered in Boring B-2 (at Structure 4/8) during drilling at a depth of 32 feet. Groundwater was not encountered in the remaining three (3) borings to the maximum depth explored of approximately 40 feet. Depending upon the final foundation depths, groundwater may be encountered during construction of drilled shaft foundations, particularly for foundations located near Structure 4/8.

- We recommend that pole and truss-mounted equipment be supported on drilled shaft foundation systems. If utilized, fully embedded steel poles should be embedded in accordance with the pole manufacturer's recommendations. Drilling of foundations to design depths should be possible with conventional drilling equipment using single flight power augers. However, considering the sandy and dry nature of the subsurface soils above the level of groundwater, and the presence of relatively shallow groundwater, the caving potential of uncased foundations is considered to be high. Therefore, construction of drilled shaft foundations will likely necessitate the use of temporary casing and/or wet drilling methods.

- Other than drilled shaft foundation excavations, no other types of excavations are anticipated for construction of this transmission line project. In the event that other types of excavations may be required, it is anticipated that the excavations can be accomplished with conventional earthmoving equipment, including backhoe type equipment. It should be noted that very dense materials were encountered below a depth of four feet in Boring B-2 and increased excavation efforts may be necessary for excavations extending into these materials with backhoe type equipment.

- The Yuma area is located in a seismically active zone, and valley areas in and around Yuma are known to be susceptible to seismically induced liquefaction. As part of our engineering evaluation, we have reviewed a liquefaction hazard potential report for Yuma, Arizona. Based on this review, the project site is not located within an area that has been mapped as being susceptible to liquefaction.

- The 2012 International Building Code seismic site classification for this site is Site Class D.

- Other than drilled shaft foundation excavations, no other type of excavation is anticipated for construction of this transmission line project. In the event that other types of excavations may be required, including backhoe type excavations, no particular excavation difficulty is anticipated.

This executive summary should be used in conjunction with the entire report for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled General Comments should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
WESTERN AREA POWER ADMINISTRATION
GILA-KNOB T/L REBUILD, PHASE 1
NEAR YUMA, ARIZONA

Terracon Project No. 65155124, Revision No. 1
March 2, 2016

1.0 INTRODUCTION

This report presents the results of our geotechnical engineering services performed for the proposed Western Area Power Administration's (Western) Gila-Knob Transmission Line Rebuild, Phase 1 located around the North Gila Substation near Yuma, Arizona. The location of the site is shown on a Vicinity Map (Exhibit A-1) included in Appendix A of this report. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- earthwork
- seismic considerations
- groundwater conditions
- foundation design and construction

Our geotechnical engineering scope of work for this project included drilling four (4) borings for subsurface exploration, laboratory testing, geotechnical engineering analysis, and preparation of this report. Logs of the borings along with a Site Plan and Test Locations diagram (Exhibit A-2) are included in Appendix A of this report. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included in Appendix B of this report. Descriptions of the field exploration and laboratory testing are included in their respective appendices.

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site Layout	See Exhibit A-1 in Appendix A.
Structures	Western is designing three (3) 230-kV double-circuit steel monopoles and six (6) single-circuit steel H-frame structures for the Gila-Knob No. 1 230-kV Transmission line to replace and upgade the existing 161-kV single-circuit structures.

2.2 Site Description

ITEM	DESCRIPTION
Location	The project site is located at the northeast corner of E. County 6th Street and S. Avenue 8E near Yuma in Yuma County, Arizona.
Description	The site is generally native desert consisting of sand dunes.
Existing topography	The project site is located on a pediment slightly above the lower lying and relatively flat Gila River Valley floodplain located to the south.
Current ground cover	Bare soil with sparse desert shrubs.

3.0 SUBSURFACE CONDITIONS

3.1 Site Geology

The project area is located in the Basin and Range physiographic province ([1]Cooley, 1967) of the North American Cordillera ([2]Stern, et al, 1979) of the southwestern United States. The southern portion of the Basin and Range province is situated along the southwestern flank of the Colorado Plateau and is bounded by the Sierra Nevada Mountains to the west. Formed during middle and late Tertiary time (100 to 15 m.y. ago), the Basin and Range province is dominated by fault controlled topography. The topography consists of mountain ranges and relatively flat alluviated valleys. These mountain ranges and valleys have evolved from generally complex movements and associated erosional and depositional processes.

Typically, the ranges in this area are of small aerial extent, but protrude significantly above adjacent wide alluviated plains and valleys. The basin rims are formed by the mountain ranges, which consist of sedimentary, igneous, and metamorphic materials that have been subjected to recurrent faulting and tilting, and in some places volcanic and intrusive events. As a result of erosion, the valleys have experienced partial infilling with sedimentary material deposited as alluvial fans. Occasionally, the valleys may become interlocking as a result of coalescing alluvial fans, which are referred to as bajadas.

Surficial geologic conditions mapped in the project vicinity ([3]Richard, et al, 2000) consist of Holocene river alluvium. These materials are described as unconsolidated to weakly consolidated sand and gravel in river channels and sand, silt, and clay on floodplains. This unit also includes young terrace deposits adjacent to floodplains. The soils encountered in the test borings are consistent with the mapped geologic conditions.

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[1] Cooley, M.E., 1967, ***Arizona Highway Geologic Map***, Arizona Geological Society.
[2] Stern, C.W., et al, 1979, ***Geological Evolution of North America***, John Wiley & Sons, Santa Barbara, California.
[3] Richard, S. M., Reynolds, S.J., Spencer, J. E., and Pearthree, P. A., 2000, ***Geologic Map of Arizona***: Arizona Geological Survey Map 35, 1 sheet, scale 1:1,000,000.

3.2 Liquefaction Potential

The Yuma area is located in a seismically active zone, and valley areas in and around Yuma are known to be susceptible to seismically induced liquefaction. As part of our engineering evaluation, we have reviewed a liquefaction hazard potential report for Yuma, Arizona ([4]Stringer, 1997). Based on this review, the project site is not located within an area that has been mapped as being susceptible to liquefaction. Additionally, considering that groundwater was encountered in Boring B-2 only and the soils below the groundwater elevation are dense in relative density, the potential for liquefaction of soils on this site is considered low.

3.3 Subsurface Soil Conditions

Specific conditions encountered at each boring location are indicated on the individual boring logs included in Appendix A of this report. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. Details for each of the borings can be found on the boring logs included in Appendix A of this report.

The subsurface conditions encountered in the test borings generally consists of sand soils with variable amounts of silt and gravel to the maximum depth explored in Borings B-1 and B-2, although an upper layer of silty sandy clay was encountered at the surface in Boring B-2. In Borings B-3 and B-4 to the west of the existing substation, these upper sand soils were underlain with fat clay starting at depths of 19 and 28 feet, respectively. The relative density of the sand soils was generally medium dense to very dense in Borings B-1 and B-2, and loose at the surface in Borings B-3 and B-4 increasing to medium dense below an approximate depth of five (5) feet. The lower fat clay soils were generally very stiff to hard in consistency.

Laboratory tests were conducted on selected soil samples and the test results are presented in Appendix B. The sand and sandy soils exhibit nonplastic to low plasticity characteristics. The deeper fat clay soils encountered in Borings B-3 and B-4 exhibit high plasticity characteristics. The moisture content of the sand soils above the groundwater elevation was generally 1 to 2 percent, and about 20 percent in the fat clay soils. Saturated direct shear testing performed at in-situ dry density indicated a friction angle of 37 and cohesion of 120 psf in the sand soils with gravel, and a friction angle of and 31 degrees and apparent cohesion of 312 psf in the sand soils without gravel. Unconfined compression testing performed on a relatively undisturbed sample of fat clay resulted in an undrained shear strength of 5.6 ksf.

[4] Stringer, S.L., 1997, **Liquefaction Hazard Evaluation, Yuma Arizona**, Southland Geotechnical, Report No. Y97036.

3.4 Groundwater Conditions

Groundwater was encountered in Boring B-2 (at Structure 4/8) during drilling at a depth of 32 feet. Groundwater was not encountered in the remaining three (3) borings to the maximum depth explored of approximately 40 feet. Depending upon the final foundation depths, groundwater may be encountered during construction of drilled shaft foundations, particularly for foundations located near Structure 4/8. These observations represent groundwater conditions at the time of the field exploration and may not be indicative of other times, or at other locations. Groundwater conditions can change with varying seasonal and weather conditions, and other factors.

Based on information obtained from the Arizona Department of Water Resources – Groundwater Data website (https://gisweb.azwater.gov/waterresourcedata/GWSI.aspx), the depth to regional groundwater was measured in October 2014 to be approximately 24 feet below the ground surface (approximate elevation of 146 feet above mean sea level) at an Arizona Department of Water Resources (ADWR) monitored well site (Local ID C-08-21 21BCA) located approximately four (4) miles east-southeast of the site.

3.5 Seismic Considerations

The following table provides the seismic design criteria in accordance with the 2012 International Building Code at the approximate center of the site, obtained from the USGS Earthquake Hazards website (http://earthquake.usgs.gov/hazards/designmaps/javacalc.php):

Location	Site Class[1]	Site Latitude (ºNorth)	Site Longitude (ºEast)	S_s - Spectral Acceleration for a Short Period	S_1 - Spectral Acceleration for a 1-Second Period	F_a - Site Coefficient for a Short Period	F_v - Site Coefficient for a 1-Second Period
B-2	D	32.74690	-114.48808	0.590g	0.234g	1.33	1.93

[1] Note: In general accordance with the *2012 International Building Code,* Section 1613.3.2, which refers to Chapter 20 of ASCE 7-10. The procedure outlined in Chapter 20 of ASCE 7-10 relies on a site soil profile determination extending to a depth of 100 feet for seismic site classification. The current scope does not include the required 100 foot soil profile determination. Borings extended to a maximum depth of 40 feet. Additional exploration to deeper depths would be required to change the current seismic site classification.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on the geotechnical engineering analyses, subsurface exploration and laboratory test results, we recommend that pole and truss-mounted equipment be supported on drilled shaft foundation systems. If utilized, fully embedded steel poles should be embedded in accordance with the pole manufacturer's recommendations.

Groundwater was encountered in Boring B-2 (at Structure 4/8) during drilling at a depth of 32 feet. Groundwater was not encountered in the remaining three (3) borings to the maximum depth explored of approximately 40 feet. Depending upon the final foundation depths, groundwater may be encountered during construction of drilled shaft foundations, particularly for foundations located near Structure 4/8.

Drilling of foundations to design depths should be possible with conventional drilling equipment using single flight power augers. However, considering the sandy and dry nature of the subsurface soils above the level of groundwater, and the presence of relatively shallow groundwater, the caving potential of uncased foundations is considered to be high. Therefore, construction of drilled shaft foundations will likely necessitate the use of temporary casing and/or wet drilling methods.

Other than drilled shaft foundation excavations, no other types of excavations are anticipated for construction of this transmission line project. In the event that other types of excavations may be required, it is anticipated that the excavations can be accomplished with conventional earthmoving equipment, including backhoe type equipment. It should be noted that very dense materials were encountered below a depth of four feet in Boring B-2 and increased excavation efforts may be necessary for excavations extending into these materials with backhoe type equipment.

We understand that Load and Resistance Factor Design (LRFD) will be used for the design of foundations on this project. All foundation design recommendations are based on nominal (ultimate) resistances. Appropriate LRFD resistance factors should be applied in the design.

Geotechnical engineering recommendations for foundation systems and other earth connected phases of the project are outlined below. The recommendations contained in this report are based upon the results of field and laboratory testing (which are presented in Appendices A and B), engineering analyses, and our current understanding of the proposed project.

4.2 Drilled Shaft Foundations

Drilled shaft foundations drilled to a minimum depth of 10 feet or 4B (where B is the shaft diameter), whichever is greater, into natural soils are recommended for support of the transmission line structures. If utilized, fully embedded steel poles should be embedded in accordance with the pole manufacturer's recommendations.

As requested in the Western RFP, the geotechnical design parameters have been determined for the subsurface profile. Due to the variability of the subsurface conditions, a subsurface profile and related design criteria has been created for each boring. For structure locations in between boring locations, we recommend the more conservative adjacent profile be utilized. Since the borings were drilled to maximum depths of 40 feet, we recommend drilled shaft foundations have a maximum embedment depth of 35 feet unless additional field exploration to deeper depths is completed.

4.2.1 Axial Loading Design Criteria

Structure 4/7 – Axial Design Parameters

Depth to Bottom of Layer (ft)	Effective Unit Weight (pcf)	Soil Type	Friction Angle (ϕ) (degrees)	Undrained Shear Strength (ksf)	Nominal End Bearing Capacity[1] (ksf)	Nominal Skin Friction Compression[2] (ksf)	Nominal Skin Friction Uplift[3] (ksf)	Depth To Water (ft)
7	110	Sand	37	---	---	0.40	0.40	---
15	110	Sand	31	---	24	1.25	1.25	
25	110	Sand	31	---	24	1.75	1.75	
35	110	Sand	31	---	24	2.50	2.50	

Structure 4/8 - Axial Design Parameters

Depth to Bottom of Layer (ft)	Effective Unit Weight (pcf)	Soil Type	Friction Angle (ϕ) (degrees)	Undrained Shear Strength (ksf)	Nominal End Bearing Capacity[1] (ksf)	Nominal Skin Friction Compression[2] (ksf)	Nominal Skin Friction Uplift[3] (ksf)	Depth To Water (ft)
4	100	Sand	31	---	---	0.25	0.25	32
10	110	Sand	37	---	---	0.75	0.75	
20	110	Sand	37	---	60	1.50	1.50	
30	110	Sand	37	---	60	2.25	2.25	
35	47	Sand	37	---	60	2.50	2.50	

Structure 4/10 - Axial Design Parameters								
Depth to Bottom of Layer (ft)	Effective Unit Weight (pcf)	Soil Type	Friction Angle (ϕ) (degrees)	Undrained Shear Strength (ksf)	Nominal End Bearing Capacity[1] (ksf)	Nominal Skin Friction Compression[2] (ksf)	Nominal Skin Friction Uplift[3] (ksf)	Depth To Water (ft)
6	100	Sand	37	---	---	0.05	0.05	---
10	100	Sand	31	---	---	0.30	0.30	
19	110	Sand	37	---	18	1.50	1.50	
35	120	Clay	---	5.6	45	2.50	2.50	

Structure 5/2 - Axial Design Parameters								
Depth to Bottom of Layer (ft)	Effective Unit Weight (pcf)	Soil Type	Friction Angle (ϕ) (degrees)	Undrained Shear Strength (ksf)	Nominal End Bearing Capacity[1] (ksf)	Nominal Skin Friction Compression[2] (ksf)	Nominal Skin Friction Uplift[3] (ksf)	Depth To Water (ft)
5	100	Sand	37	---	---	0.10	0.05	---
15	100	Sand	31	---	18	1.00	0.30	
28	100	Sand	31	---	42	1.75	1.50	
35	110	Clay	---	5.6	45	2.50	2.50	

Table Notes:

1. A strength resistance factor of 0.40 should be applied to the nominal end bearing capacity of sand, and 0.32 for nominal end bearing capacity of clay.
2. A strength resistance factor of 0.44 should be applied to the nominal skin resistance in compression for sand, and 0.36 for nominal skin resistance in compression for clay.
3. A strength resistance factor of 0.36 should be applied to the nominal skin resistance in uplift for sand, and 0.28 for skin resistance in uplift for clay.

Drilled shafts should be considered to work in group action if the horizontal spacing is less than six (6) shaft diameters. A minimum practical horizontal spacing between shafts of at least three (3) diameters should be maintained, and adjacent shafts should bear at the same elevation. The capacity of individual shafts must be reduced when considering the effects of group action. Capacity reduction is a function of shaft spacing and the number of shafts within a group. If group action analyses are necessary, capacity reduction factors can be developed for the analyses.

4.2.2 Lateral Loading Design Criteria

Recommended geotechnical parameters for lateral load analysis of drilled shaft foundations have been developed for use in the computer programs L-PILE or FAD that utilize P-y curve analyses and are presented in the following tables:

Structure 4/7 – Lateral Design Parameters						
Depth to Bottom of Layer (ft)	Effective Unit Weight (pcf)	Soil Type	Friction Angle (ϕ) (degrees)	Undrained Shear Strength (ksf)	Soil Modulus (pci)	Strain at ½ Max Principal Stress ε_{50}
7	110	Sand	37	---	90	---
15	110	Sand	31	---	90	---
25	110	Sand	31	---	90	---
35	110	Sand	31	---	90	---

Structure 4/8 – Lateral Design Parameters						
Depth to Bottom of Layer (ft)	Effective Unit Weight (pcf)	Soil Type	Friction Angle (ϕ) (degrees)	Undrained Shear Strength (ksf)	Soil Modulus (pci)	Strain at ½ Max Principal Stress ε_{50}
4	100	Sand	31	---	90	---
10	110	Sand	37	---	225	---
20	110	Sand	37	---	225	---
30	110	Sand	37	---	225	---
35	47	Sand	37	---	125	---

Structure 4/10 – Lateral Design Parameters						
Depth to Bottom of Layer (ft)	Effective Unit Weight (pcf)	Soil Type	Friction Angle (ϕ) (degrees)	Undrained Shear Strength (ksf)	Soil Modulus (pci)	Strain at ½ Max Principal Stress ε_{50}
6	100	Sand	37	---	25	---
10	100	Sand	31	---	90	---
19	110	Sand	37	---	90	---
35	120	Clay	---	5.6	1,000	0.005

Structure 5/2 – Lateral Design Parameters						
Depth to Bottom of Layer (ft)	Effective Unit Weight (pcf)	Soil Type	Friction Angle (ϕ) (degrees)	Undrained Shear Strength (ksf)	Soil Modulus (pci)	Strain at ½ Max Principal Stress ε_{50}
5	100	Sand	37	---		---
15	100	Sand	31	---		---
28	100	Sand	31	---		---
35	110	Clay	---	5.6	1,000	0.005

All shafts should be reinforced full-depth for the applied axial, lateral and uplift stresses imposed. For this project, use of a minimum shaft diameter of 12 inches is recommended for the foundations.

4.2.3 Drilled Shaft Construction Considerations

Drilling of foundations to design depths should be possible with conventional drilling equipment using single flight power augers. However, considering the sandy and dry nature of the subsurface soils above the level of groundwater, and the presence of relatively shallow groundwater, the caving potential of uncased foundations is considered to be high. Therefore, construction of drilled shaft foundations will likely necessitate the use of temporary casing and/or wet drilling methods.

Drilled shaft concrete should be placed the same day as drilling and cleaning. Due to potential sloughing and raveling, foundation concrete quantities may exceed calculated geometric volumes.

If casing is used for drilled shaft construction, it should be withdrawn in a slow continuous manner maintaining a sufficient head of concrete to prevent infiltration of water or the creation of voids in pier concrete. Drilled shaft concrete should have a relatively high fluidity when placed in cased pier holes or through a tremie. Concrete with a slump in the range of 6 to 8 inches is recommended.

Free-fall concrete placement in drilled shaft excavations will only be acceptable for shaft excavations without groundwater and if provisions are taken to avoid striking the concrete on the sides of the hole or reinforcing steel. The use of a bottom-dump hopper, or an elephant's trunk discharging near the bottom of the hole where concrete segregation will be minimized, is recommended.

Shaft bearing surfaces must be cleaned prior to concrete placement. A representative of the geotechnical engineer should inspect the bearing surface and shaft configuration. If the soil conditions encountered differ significantly from those presented in this report, supplemental recommendations will be required.

4.3 Corrosion Considerations

Laboratory test results from two (2) samples indicate that the on-site soils have sulfate contents of 602 and 5,928 parts per million. These results indicate a potentially corrosive environment and we recommend that ASTM Type V portland cement be used for all concrete on and below grade. Laboratory test results indicate that on-site soils have pH values ranging from 8.3 to 8.8. These values should be used to determine potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical engineering recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A

FIELD EXPLORATION

LEGEND:

APPROXIMATE BORING LOCATION (STRUCTURE #)

NOTE: SITE IMAGE MAP PROVIDED USGS NATIONAL MAP VIEWER, 2015

Project Mngr:	JRH
Drawn By:	KLJ
Checked By:	JRH
Approved By:	SDN

Project No.	65155124
Scale:	AS SHOWN
File No.	65155124.DWG
Date:	12/16/2015

Terracon
Consulting Engineers and Scientists
4685 South Ash Avenue, Suite H-4 Tempe, AZ 85282
PH. (480) 897-8200 FAX. (480) 897-1133

SITE PLAN AND BORING LOCATIONS

Gila-Knob T/L Rebuild, Phase 1

EAST COUNTY 6th STREET and SOUTH AVENUE 8 ½ E.
YUMA COUNTY, ARIZONA

EXHIBIT

A-1

Field Exploration Description

A total of four (4) test borings were drilled at the site on December 3 and 4, 2015. The borings were drilled to a depth of approximately 40 feet below the existing ground surface at the boring locations. The approximate locations of the borings are shown on the attached Site Plan and Boring Locations diagram, Exhibit A-1.

The borings were located in the field by using the site plan provided by Western showing the existing structure locations. Latitude and longitude coordinates shown on the boring logs were obtained from Google Earth Pro and should be considered approximate.

The test borings were advanced with a truck-mounted CME-55 drill rig utilizing 8-inch diameter hollow-stem augers. Continuous lithologic logs of each boring were recorded by the field geologist during the drilling operations. At selected intervals, samples of the subsurface materials were taken by driving split-spoon (SPT) or ring-lined barrel samplers in general accordance with ASTM Standards. Bulk samples of subsurface materials were also obtained from the auger cuttings.

Penetration resistance measurements were obtained by driving the split-spoon and ring-lined barrel samplers into the subsurface materials with a 140-pound automatic hammer falling 30 inches. The penetration resistance value is a useful index in estimating the consistency or relative density of materials encountered.

Groundwater conditions were evaluated in each boring at the time of site exploration.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Bulk	Shelby Tube	Split Spoon
Rock Core	Macro Core	Modified California Ring Sampler
Grab Sample	No Recovery	Modified Dames & Moore Ring Sampler

WATER LEVEL

- Water Initially Encountered
- Water Level After a Specified Period of Time
- Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
N	N value
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Terracon

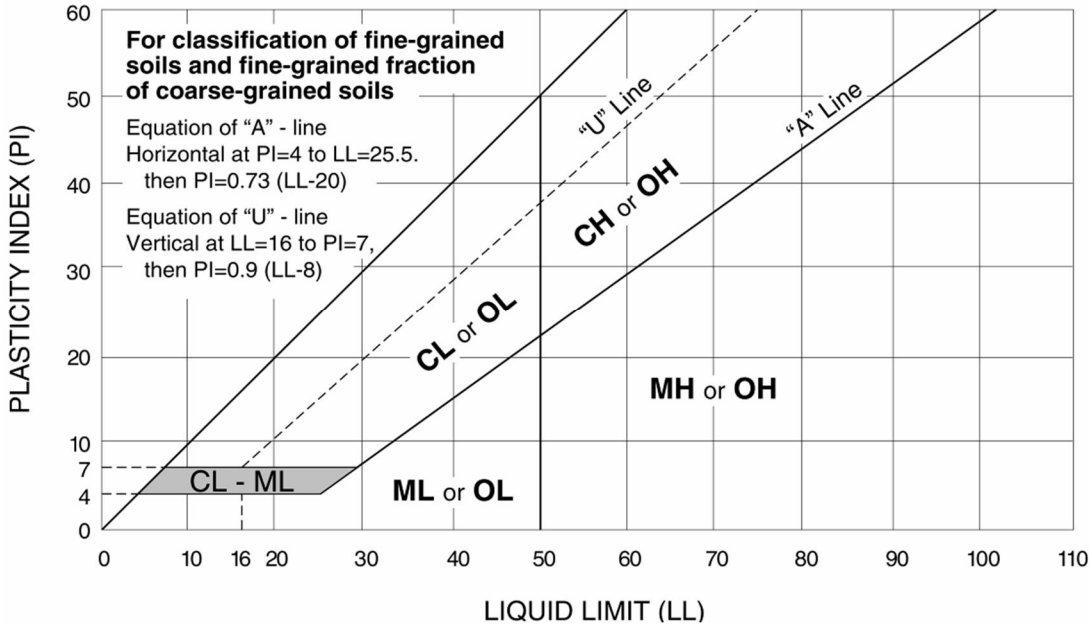
UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



Terracon

Exhibit A-4

BORING LOG NO. B-1

PROJECT: Gila-Knob T/L Rebuild

CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

SITE: North Gila Substation
Near Yuma, Arizona

LOCATION See Exhibit A-1

Latitude: 32.743526° Longitude: -114.488535°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	POORLY GRADED SAND WITH GRAVEL (SP), trace silt, brown, medium dense									
					17-20					
		5			6-17		1	110		
	7.0 **POORLY GRADED SAND WITH SILT (SP-SM)**, trace gravel, brown, medium dense									
		10			12-13-12 N=25		1			
		15			12-13-15 N=28		2		NP	7
		20			12-16		4	92		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
4685 S. Ash Ave., Suite H-4
Tempe, Arizona

Boring Started: 12/4/2015 | Boring Completed: 12/4/2015
Drill Rig: CME-55 | Driller: D&S Drilling
Project No.: 65155124 | Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 65155124.GPJ TERRACON2015.GDT 12/16/15

BORING LOG NO. B-1

PROJECT: Gila-Knob T/L Rebuild

CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

SITE: North Gila Substation
Near Yuma, Arizona

LOCATION See Exhibit A-1

Latitude: 32.743526° Longitude: -114.488535°

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		POORLY GRADED SAND WITH SILT (SP-SM), trace gravel, brown, medium dense *(continued)*									
			25			5-5-6 N=11		3			
			30			6-9-10 N=19		2			
			35			10-12		2	103		
		dense	40			9-13-29 N=42		2			
	40.5	***Boring Terminated at 40.5 Feet***									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
4685 S. Ash Ave., Suite H-4
Tempe, Arizona

Boring Started: 12/4/2015 | Boring Completed: 12/4/2015
Drill Rig: CME-55 | Driller: D&S Drilling
Project No.: 65155124 | Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 65155124.GPJ TERRACON2015.GDT 12/16/15

BORING LOG NO. B-2

PROJECT: Gila-Knob T/L Rebuild

CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

SITE: North Gila Substation
Near Yuma, Arizona

LOCATION See Exhibit A-1

Latitude: 32.746788° Longitude: -114.488083°

DEPTH	GRAPHIC LOG	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SANDY SILTY CLAY (CL-ML), light brown, very stiff, weak cementation									
					6-14		3	98	~~24-17-7~~	~~58~~
4.0	**SILTY SAND WITH GRAVEL (SM)**, light brown, very dense, weak to moderate cementation									
		5			21-50/5"		2			
		10			17-25-30 N=55		1			
		15			12-23-28 N=51		3			
					20-30/3"		4	106		
20.0	**POORLY GRADED SAND WITH GRAVEL (SP)**, trace silt, brown to light brown, very dense, no to weak cementation	20								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Backfilled with cement-bentonite grout upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

While drilling

Terracon
4685 S. Ash Ave., Suite H-4
Tempe, Arizona

Boring Started: 12/3/2015
Boring Completed: 12/3/2015
Drill Rig: CME-55
Driller: D&S Drilling
Project No.: 65155124
Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 65155124.GPJ TERRACON2015.GDT 12/16/15

BORING LOG NO. B-2

PROJECT: Gila-Knob T/L Rebuild

CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

SITE: North Gila Substation
Near Yuma, Arizona

LOCATION See Exhibit A-1

Latitude: 32.746788° Longitude: -114.488083°

DEPTH	GRAPHIC LOG	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
POORLY GRADED SAND WITH GRAVEL (SP), trace silt, brown to light brown, very dense, no to weak cementation *(continued)*										
					50/4"					
		25								
					23-50/6"		2			
		30								
groundwater encountered at approximately 32 feet while drilling			▽							
					19-44-50/3"		13			
		35								
dense					11-15-19 N=34		15			
40.5		40								
Boring Terminated at 40.5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Backfilled with cement-bentonite grout upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
4685 S. Ash Ave., Suite H-4
Tempe, Arizona

Boring Started: 12/3/2015 | Boring Completed: 12/3/2015
Drill Rig: CME-55 | Driller: D&S Drilling
Project No.: 65155124 | Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 65155124.GPJ TERRACON2015.GDT 12/16/15

BORING LOG NO. B-3

PROJECT: Gila-Knob T/L Rebuild

CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

SITE: North Gila Substation
Near Yuma, Arizona

LOCATION See Exhibit A-1

Latitude: 32.749149° Longitude: -114.49197°

DEPTH	GRAPHIC LOG	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	POORLY GRADED SAND WITH GRAVEL (SP), trace silt, brown, very loose to loose									
					2-2					
		5			6-7		2	98		
6.0	**POORLY GRADED SAND WITH SILT (SP-SM)**, brown, medium dense									
		10			6-7-7 N=14		1			
11.0	**POORLY GRADED SAND WITH GRAVEL (SP)**, trace silt, brown, medium dense									
		15			12-18		2	108		
19.0	**FAT CLAY (CH)**, brown, very stiff to hard	20			9-13-21 N=34		19		76-25-51	97

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
4685 S. Ash Ave., Suite H-4
Tempe, Arizona

Boring Started: 12/3/2015 | Boring Completed: 12/3/2015
Drill Rig: CME-55 | Driller: D&S Drilling
Project No.: 65155124 | Exhibit: A-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 65155124.GPJ TERRACON2015.GDT 12/16/15

BORING LOG NO. B-3

PROJECT: Gila-Knob T/L Rebuild

CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

SITE: North Gila Substation
Near Yuma, Arizona

LOCATION See Exhibit A-1

Latitude: 32.749149° Longitude: -114.49197°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	FAT CLAY (CH), brown, very stiff to hard *(continued)*									
					14-21	11297	21	98		
		25								
		30			14-19-23 N=42		23			
	very dense				18-32/3"		20	101		
		35								
	37.0 **SILTY SAND WITH GRAVEL (SM)**, light brown, very dense, moderate cementation									
		40			20-35-37 N=72		2			
	40.5 ***Boring Terminated at 40.5 Feet***									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
4685 S. Ash Ave., Suite H-4
Tempe, Arizona

Boring Started: 12/3/2015 | Boring Completed: 12/3/2015
Drill Rig: CME-55 | Driller: D&S Drilling
Project No.: 65155124 | Exhibit: A-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 65155124.GPJ TERRACON2015.GDT 12/16/15

BORING LOG NO. B-4

PROJECT: Gila-Knob T/L Rebuild

CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

SITE: North Gila Substation
Near Yuma, Arizona

LOCATION See Exhibit A-1

Latitude: 32.748832° Longitude: -114.495473°

DEPTH	GRAPHIC LOG	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM), loose									
					5-10					
5.0	**POORLY GRADED SAND WITH SILT (SP-SM)**, trace gravel, medium dense	5			5-7-10 N=17		1		NP	5
					15-22					
11.0	**SILTY SAND (SM)**, trace gravel, dense to very dense, weak to moderate cementation	10								
		15			15-36-34 N=70		5			
		20			12-15-19 N=34		1			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
4685 S. Ash Ave., Suite H-4
Tempe, Arizona

Boring Started: 12/4/2015
Boring Completed: 12/4/2015
Drill Rig: CME-55
Driller: D&S Drilling
Project No.: 65155124
Exhibit: A-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 65155124.GPJ TERRACON2015.GDT 12/16/15

BORING LOG NO. B-4

PROJECT: Gila-Knob T/L Rebuild

CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

SITE: North Gila Substation
Near Yuma, Arizona

LOCATION See Exhibit A-1

Latitude: 32.748832° Longitude: -114.495473°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILTY SAND (SM), trace gravel, dense to very dense, weak to moderate cementation *(continued)*									
	medium dense	25			16-30		2	94		
	28.0 **FAT CLAY (CH)**, brown, hard	30			10-13-17 N=30		20			
		35			15-29		20	92		
	40.5	40			16-20-24 N=44		20			
	Boring Terminated at 40.5 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
4685 S. Ash Ave., Suite H-4
Tempe, Arizona

Boring Started: 12/4/2015 | Boring Completed: 12/4/2015
Drill Rig: CME-55 | Driller: D&S Drilling
Project No.: 65155124 | Exhibit: A-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 65155124.GPJ TERRACON2015.GDT 12/16/15

APPENDIX B

LABORATORY TEST RESULTS

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in Appendix A. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

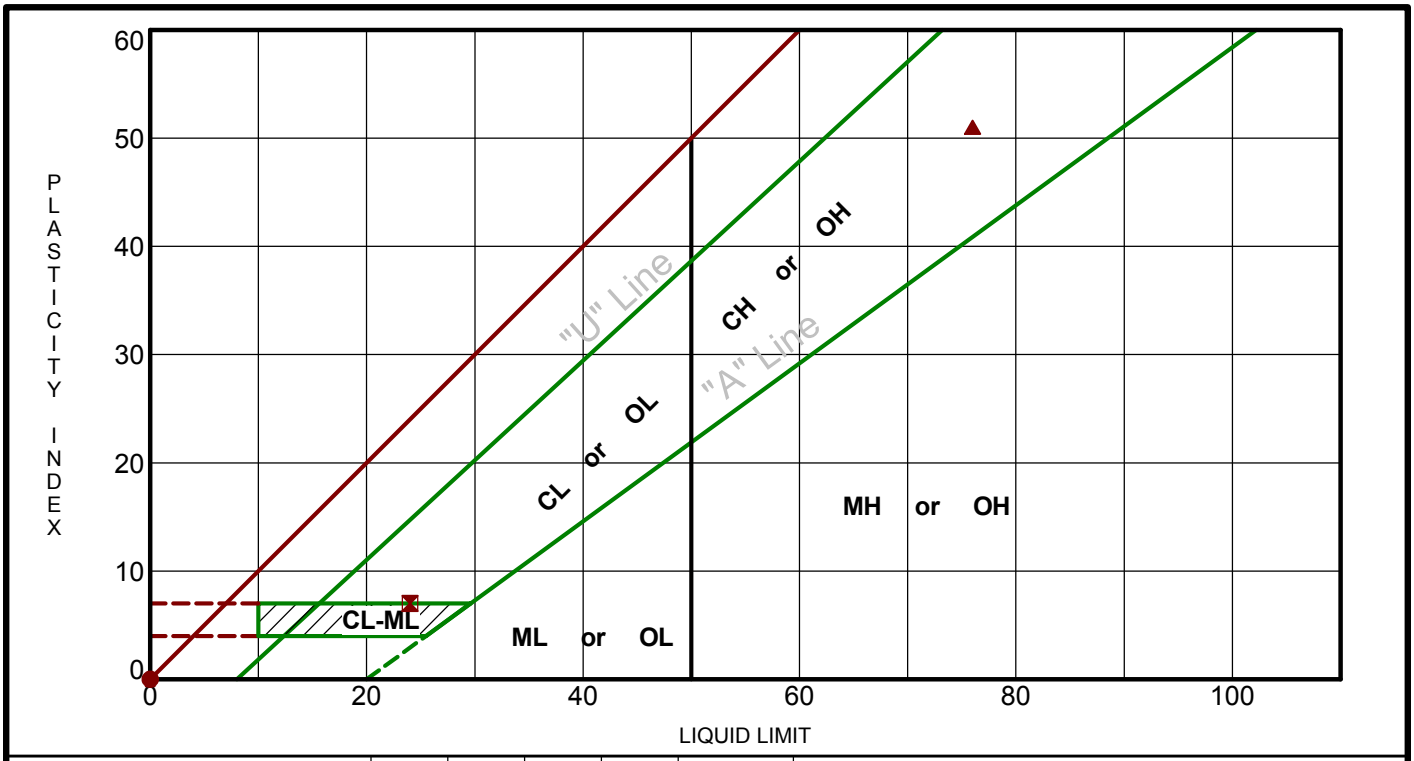
Laboratory tests were conducted on selected soil samples and the test results are presented in this appendix. The laboratory test results were used for the geotechnical engineering analyses, and the development of foundation recommendations. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

Selected soil samples obtained from the site were tested for the following engineering properties:

- Atterberg Limits
- Moisture Content
- Direct Shear
- pH
- Sieve Analysis
- Dry Density
- Unconfined Compression
- Soluble Sulfates

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	B-1	14 - 15.5	NP	NP	NP	7	SP-SM	POORLY GRADED SAND with SILT
⊠	B-2	0 - 4	24	17	7	58	CL-ML	SANDY SILTY CLAY
▲	B-3	19 - 20.5	76	25	51	97	SP	FAT CLAY
★	B-4	5 - 6.5	NP	NP	NP	5	SP-SM	POORLY GRADED SAND with SILT

PROJECT: Gila-Knob T/L Rebuild

SITE: North Gila Substation
Near Yuma, Arizona

Terracon
4685 S. Ash Ave., Suite H-4
Tempe, Arizona

PROJECT NUMBER: 65155124

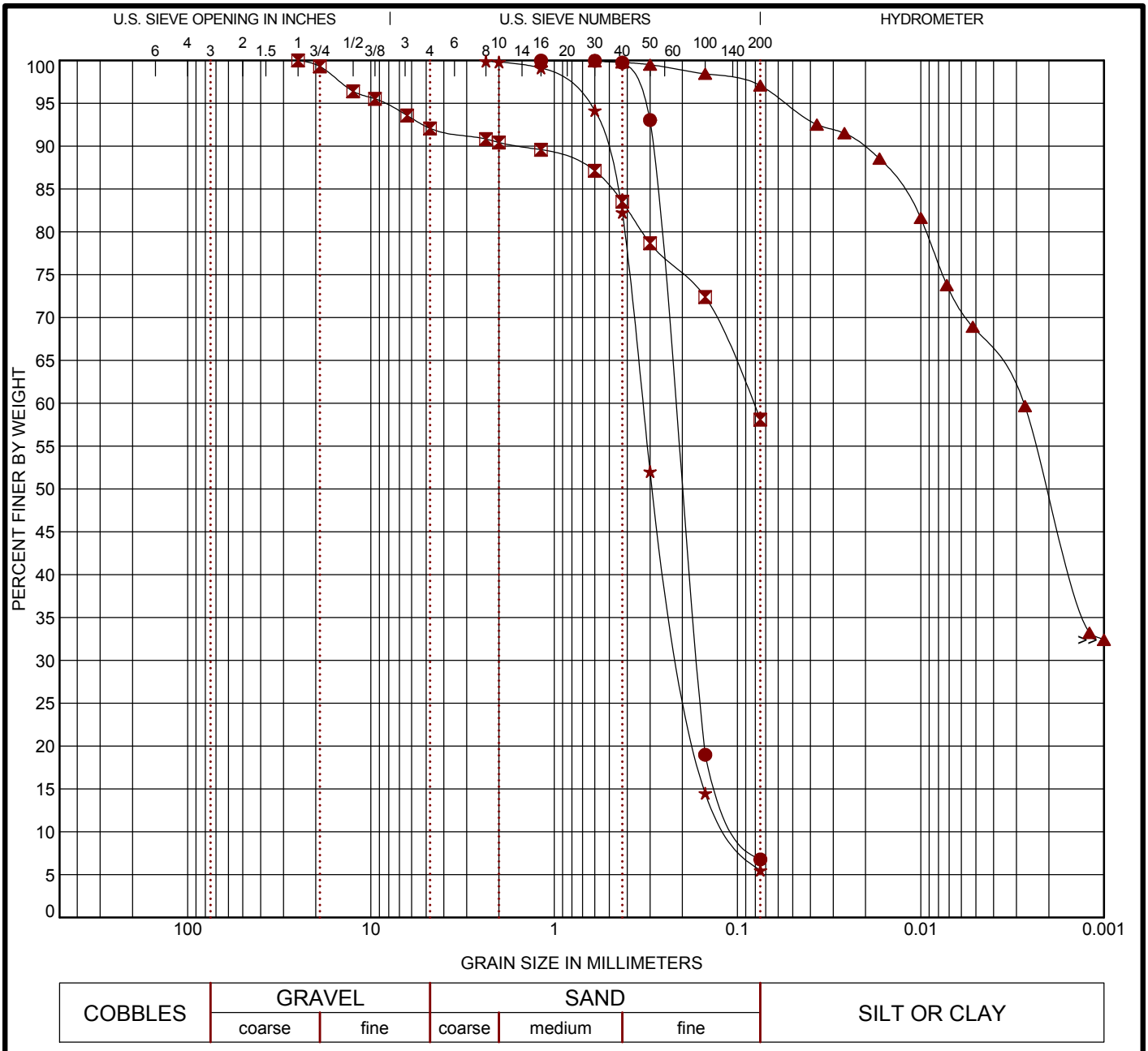
CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

EXHIBIT: B-2

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS 65155124.GPJ TERRACON2015.GDT 12/16/15

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	LL	PL	PI	Cc	Cu
●	B-1	14 - 15.5	POORLY GRADED SAND with SILT (SP-SM)	NP	NP	NP	1.39	2.44
⊠	B-2	0 - 4	SANDY SILTY CLAY (CL-ML)	24	17	7		
▲	B-3	19 - 20.5	FAT CLAY (CH)	76	25	51		
★	B-4	5 - 6.5	POORLY GRADED SAND with SILT (SP-SM)	NP	NP	NP	1.14	3.10

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Fines
●	B-1	14 - 15.5	1.18	0.22	0.166	0.09	0.0	93.2	6.8
⊠	B-2	0 - 4	25	0.082			7.9	34.0	58.1
▲	B-3	19 - 20.5	1.18	0.003			0.0	2.9	28.7 68.4
★	B-4	5 - 6.5	2.36	0.329	0.2	0.106	0.0	94.4	5.5

PROJECT: Gila-Knob T/L Rebuild

SITE: North Gila Substation
Near Yuma, Arizona

Terracon
4685 S. Ash Ave., Suite H-4
Tempe, Arizona

PROJECT NUMBER: 65155124

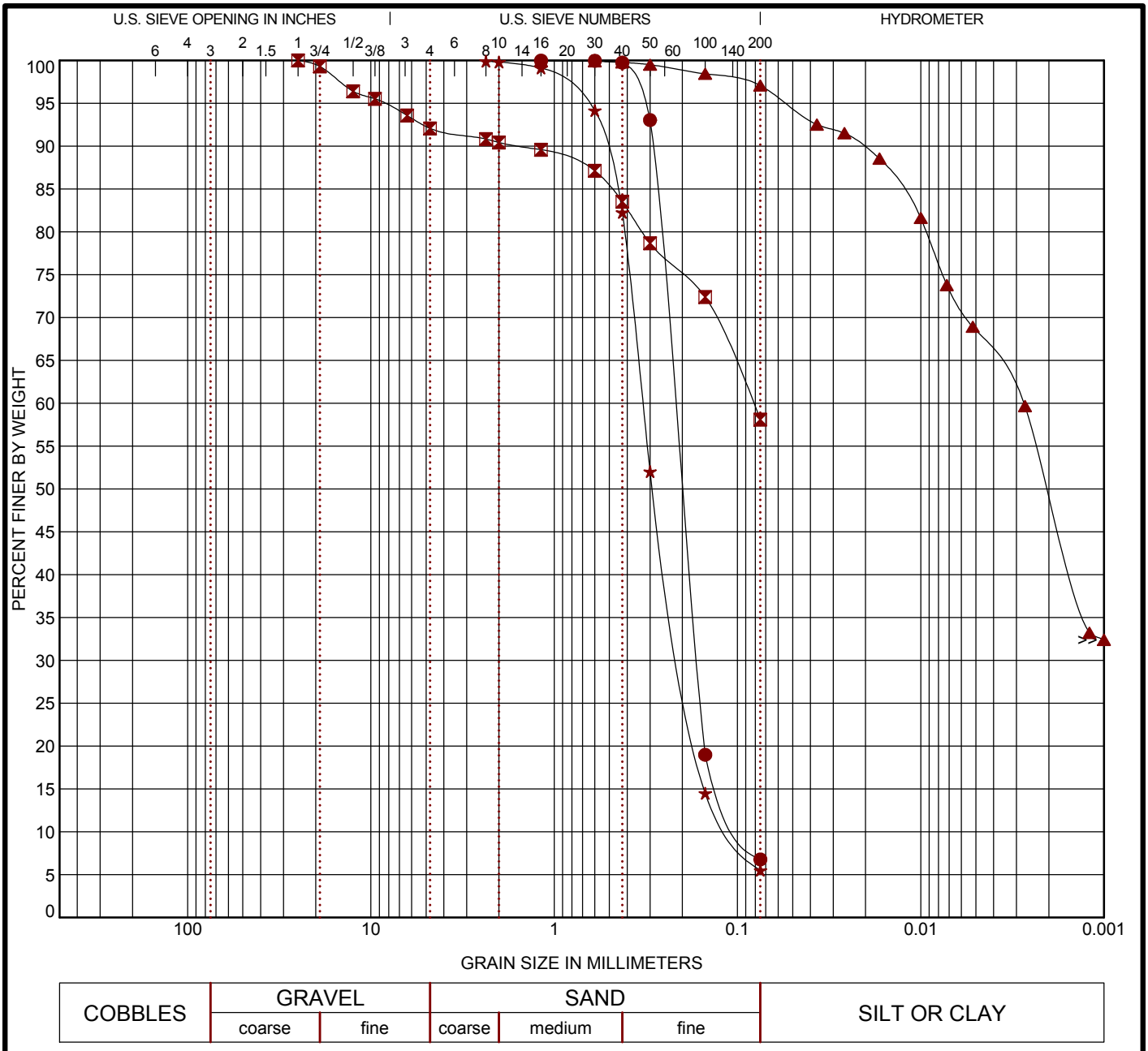
CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

EXHIBIT: B-3

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 65155124.GPJ TERRACON2012.GDT 12/16/15

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	LL	PL	PI	Cc	Cu
●	B-1	14 - 15.5	POORLY GRADED SAND with SILT (SP-SM)	NP	NP	NP	1.39	2.44
⊠	B-2	0 - 4	SANDY SILTY CLAY (CL-ML)	24	17	7		
▲	B-3	19 - 20.5	FAT CLAY (CH)	76	25	51		
★	B-4	5 - 6.5	POORLY GRADED SAND with SILT (SP-SM)	NP	NP	NP	1.14	3.10

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Fines
●	B-1	14 - 15.5	1.18	0.22	0.166	0.09	0.0	93.2	6.8
⊠	B-2	0 - 4	25	0.082			7.9	34.0	58.1
▲	B-3	19 - 20.5	1.18	0.003			0.0	2.9	28.7 68.4
★	B-4	5 - 6.5	2.36	0.329	0.2	0.106	0.0	94.4	5.5

PROJECT: Gila-Knob T/L Rebuild

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Terracon
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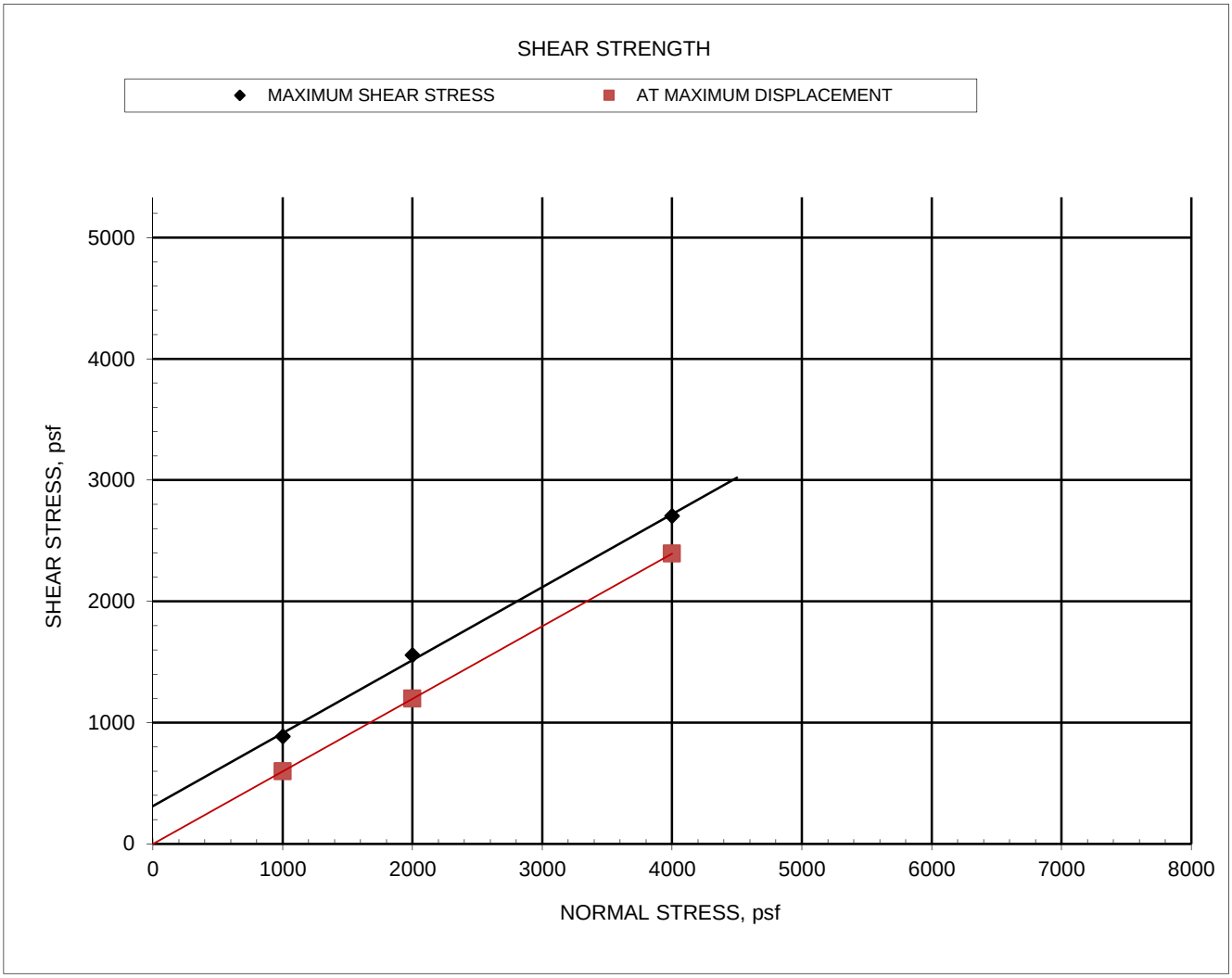
EXHIBIT: B-3

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 65155124.GPJ TERRACON2012.GDT 12/16/15

DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS
ASTM D3080



		FRICTION ANGLE	COHESION	NORMAL	NORMAL	NORMAL
AT MAXIMUM SHEAR STRESS		**31.0 deg**	**312 psf**	STRESS, psf	STRESS, psf	STRESS, psf
AT MAXIMUM DISPLACEMENT		**30.9 deg**	**0 psf**	1000	2000	4000
INITIAL AREA, in2	4.596	INITIAL MOISTURE, %		5.0	5.0	5.0
INITIAL LENGTH, in	1.000	INITIAL DRY DENSITY, pcf		86.3	88.3	87.0
SPECIFIC GRAVITY	2.65	INITIAL SATURATION, %		14	15	15
SG ASSUMED	X	INITIAL VOID RATIO		0.92	0.87	0.90
SG TESTED		FINAL MOISTURE, %		33.2	30.8	30.8
LIQUID LIMIT		FINAL SATURATION, %		100	100	100
PLASTIC LIMIT		FINAL VOID RATIO		0.88	0.82	0.82
PLASTICITY INDEX		MAXIMUM SHEAR STRESS, psf		886	1556	2705
		DISPLACEMENT AT MAXIMUM SHEAR, in		0.093	0.095	0.153
		SHEAR STRESS AT MAX DISPLACEMENT, psf		598	1197	2394
		MAXIMUM DISPLAEMENT, in		0.451	0.451	0.451
SAMPLE TYPE	UNDISTURBED	RATE OF LOADING, in/min		0.0160	0.0160	0.0160
DESCRIPTION	Poorly Graded Sand w/ Silt (SP-SM)					

PROJECT NAME: Gila-Knob T/L Rebuild

BORING NO. B-1

LOCATION: Near Yuma

DEPTH, feet 19.0' TO 20.0'

JOB NO.: 65155124

SHEAR: INUNDATED

DATE: 12/15/2015

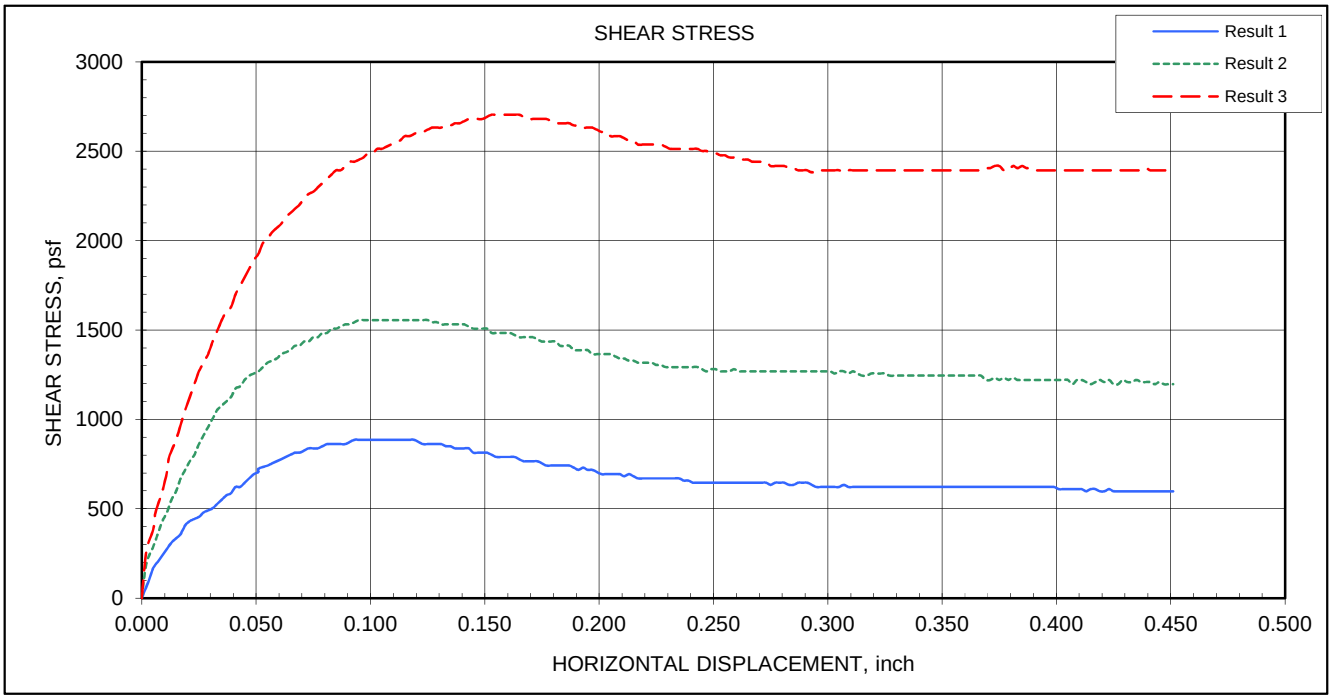
C:\Users\jrhuston\Desktop\65155124 Gila-Knob\[65155124 B-1 @ 19 4000 Direct Shear.xls]Sample Data

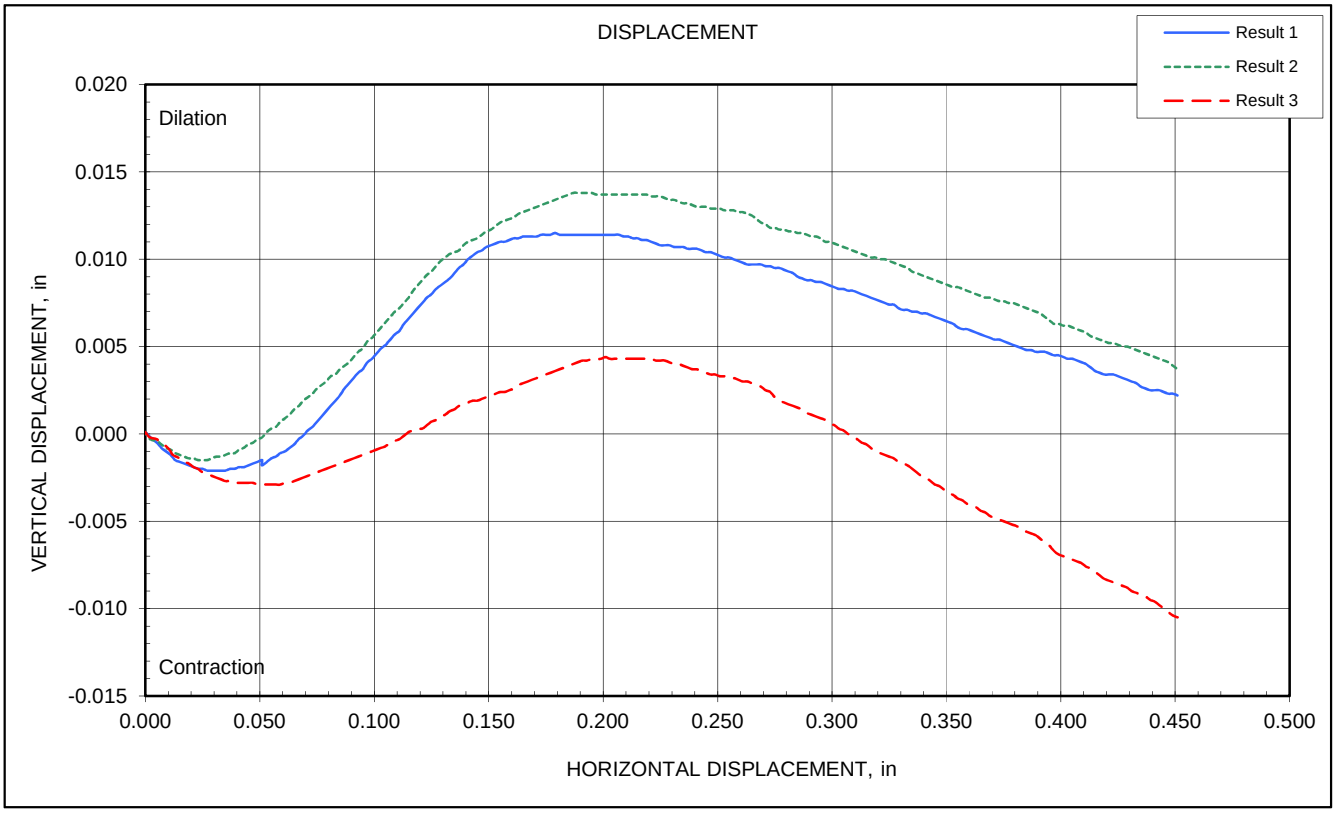
Terracon

EXHIBIT: B-4

Gila-Knob T/L Rebuild
Near Yuma
65155124
12/15/2015

BORING NO.	B-1
DEPTH, feet	19.0' TO 20.0'
SHEAR:	INUNDATED





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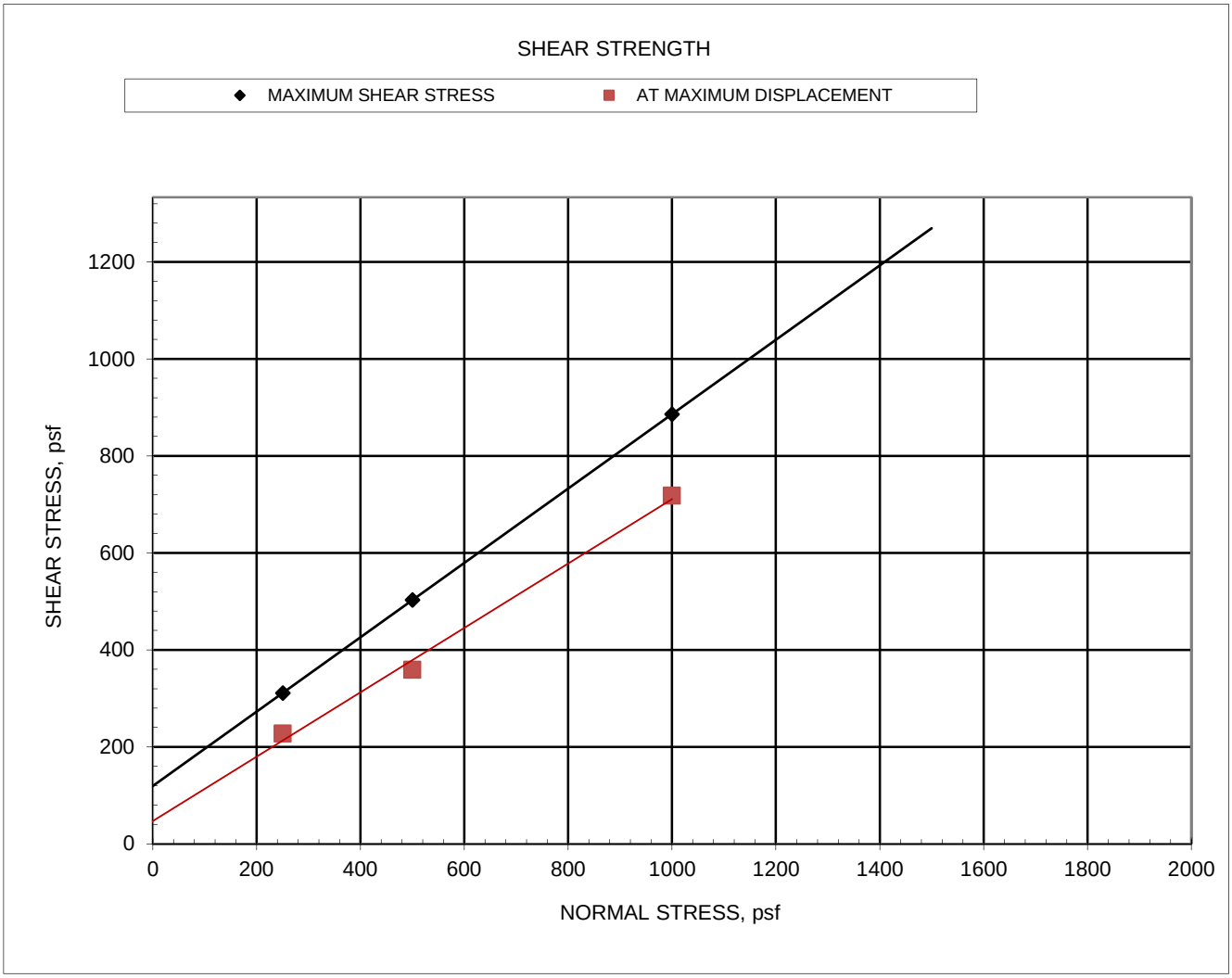
Terracon

EXHIBIT: B-5

DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS
ASTM D3080



		FRICTION ANGLE	COHESION	NORMAL	NORMAL	NORMAL
AT MAXIMUM SHEAR STRESS		**37.5 deg**	**120 psf**	STRESS, psf	STRESS, psf	STRESS, psf
AT MAXIMUM DISPLACEMENT		**33.6 deg**	**48 psf**	250	500	1000
INITIAL AREA, in2	4.596	INITIAL MOISTURE, %		2.2	2.2	2.7
INITIAL LENGTH, in	1.000	INITIAL DRY DENSITY, pcf		98.0	98.5	96.0
SPECIFIC GRAVITY	2.65	INITIAL SATURATION, %		8	9	10
SG ASSUMED	X	INITIAL VOID RATIO		0.69	0.68	0.72
SG TESTED		FINAL MOISTURE, %		2.2	2.2	2.6
LIQUID LIMIT		FINAL SATURATION, %		9	9	10
PLASTIC LIMIT		FINAL VOID RATIO		0.68	0.66	0.69
PLASTICITY INDEX		MAXIMUM SHEAR STRESS, psf		311	503	886
		DISPLACEMENT AT MAXIMUM SHEAR, in		0.085	0.073	0.111
		SHEAR STRESS AT MAX DISPLACEMENT, psf		227	359	718
		MAXIMUM DISPLAEMENT, in		0.451	0.451	0.451
SAMPLE TYPE	UNDISTURBED	RATE OF LOADING, in/min		0.0160	0.0160	0.0160
DESCRIPTION	Poorly Graded Sand (SP)					

PROJECT NAME: Gila-Knob T/L Rebuild

BORING NO. B-3

LOCATION: Near Yuma

DEPTH, feet 5.0' TO 6.0'

JOB NO.: 65155124

SHEAR: INUNDATED

DATE: 12/15/2015

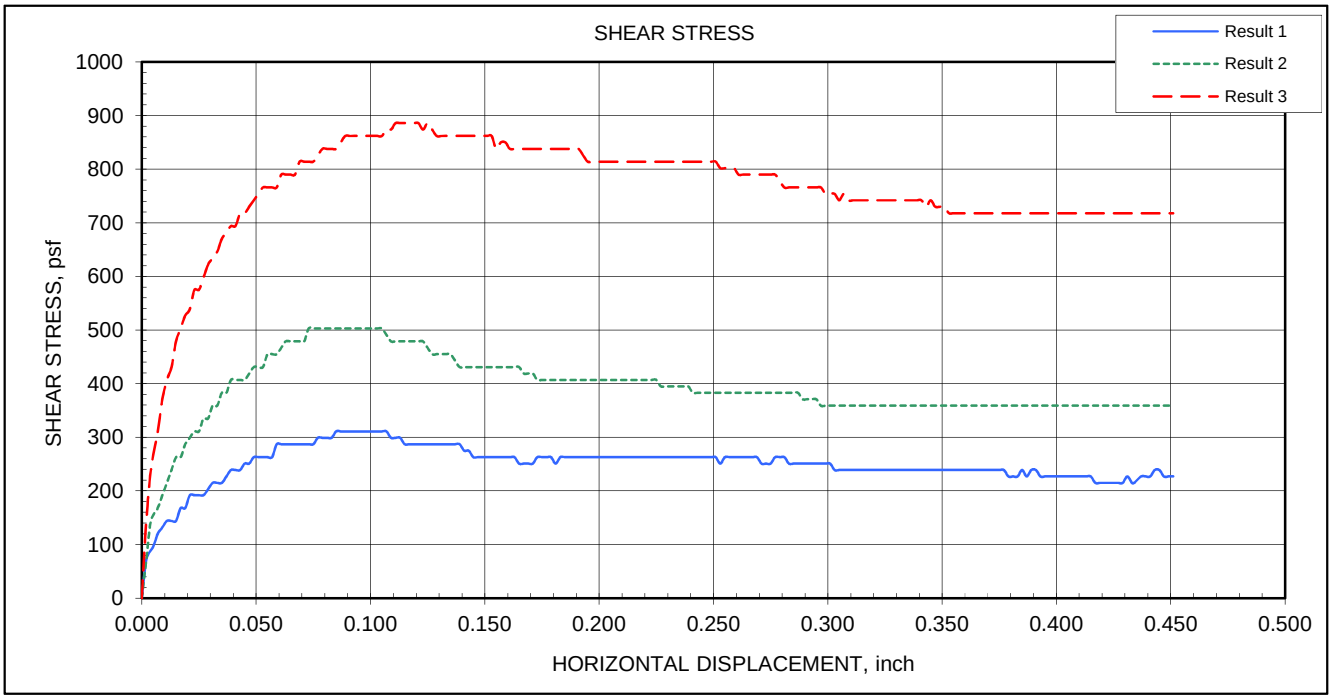
C:\Users\jrhuston\Desktop\65155124 Gila-Knob\[65155124 B-3 @ 5 1000 Direct Shear.xls]Sample Data

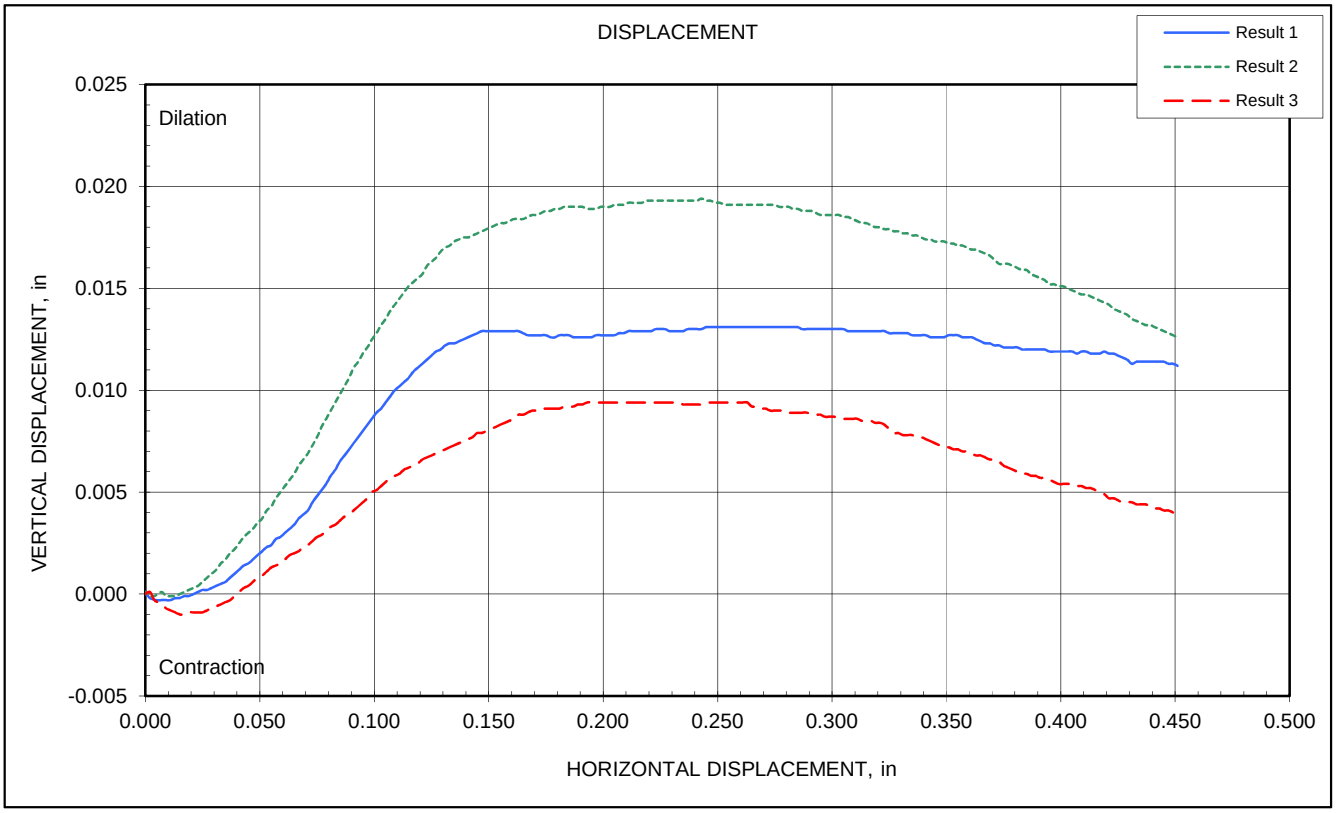
Terracon

EXHIBIT: B-6

Gila-Knob T/L Rebuild
Near Yuma
65155124
12/15/2015

BORING NO.	B-3
DEPTH, feet	5.0' TO 6.0'
SHEAR:	INUNDATED





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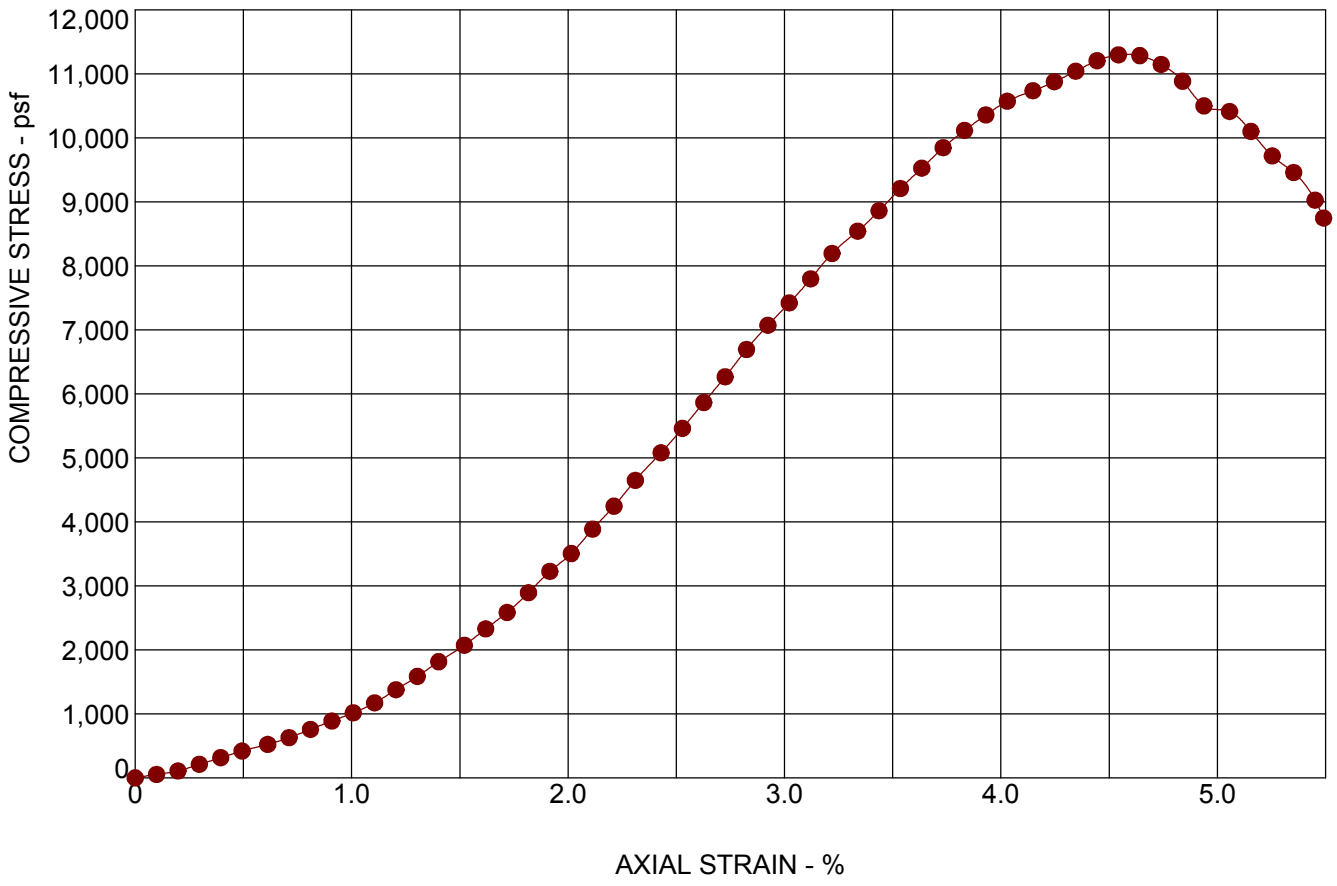
Terracon

EXHIBIT: B-7

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH

SPECIMEN TEST DATA

Moisture Content:	%	21
Dry Density:	pcf	99
Diameter:	in.	2.41
Height:	in.	5.06
Height / Diameter Ratio:		2.10
Calculated Saturation:	%	81.51
Calculated Void Ratio:		0.68
Assumed Specific Gravity:		2.65
Failure Strain:	%	4.54
Unconfined Compressive Strength	(psf)	11297
Undrained Shear Strength:	(psf)	5648
Strain Rate:	in/min	0.0200
Remarks:		

SAMPLE TYPE: RING

SAMPLE LOCATION: B-3 @ 24 - 25 feet

SAMPLE DESCRIPTION: FAT CLAY (CH)

LL	PL	PI	Percent < #200 Sieve

PROJECT: Gila-Knob T/L Rebuild

SITE: North Gila Substation
Near Yuma, Arizona

Terracon
4685 S. Ash Ave., Suite H-4
Tempe, Arizona

PROJECT NUMBER: 65155124

CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

EXHIBIT: B-8

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. UNCONFINED WITH PHOTOS 65155124.GPJ TERRACON2012.GDT 12/16/15

SUMMARY OF LABORATORY RESULTS

Borehole No.	Depth (ft.)	USCS Soil Class.	In-Situ Properties		Classification				Expansion Testing					Corrosivity				Remarks
			Dry Density (pcf)	Water Content (%)	Passing #200 Sieve (%)	Atterberg Limits LL	PL	PI	Dry Density (pcf)	Water Content (%)	Surcharge (psf)	Expansion (%)	Expansion Index EI_{50}	pH	Resistivity (ohm-cm)	Sulfates (ppm)	Chlorides (ppm)	
B-1	5.0 - 6.0	SP	110	1														1, 2
B-1	9.0 - 10.5	SP-SM		1														2
B-1	14.0 - 15.5	SP-SM		2	7	NP	NP	NP										
B-1	19.0 - 20.0	SP-SM	92	4														1, 2
B-1	24.0 - 25.5	SP-SM		3														2
B-1	29.0 - 30.5	SP-SM		2														2
B-1	34.0 - 35.0	SP-SM	103	2														1, 2
B-1	39.0 - 40.5	SP-SM		2														2
B-2	0.0 - 4.0	CL-ML			58	24	17	7						8.3		5928		
B-2	2.0 - 3.0	CL-ML	98	3														1, 2
B-2	5.0 - 5.9	SM		2														2
B-2	9.0 - 10.5	SM		1														2
B-2	14.0 - 15.5	SM		3														2
B-2	19.0 - 19.8	SM	106	4														1, 2
B-2	29.0 - 29.5	SP		2														2
B-2	34.0 - 35.3	SP		13														2
B-2	39.0 - 40.5	SP		15														2
B-3	5.0 - 6.0	SP	98	2														1, 2
B-3	9.0 - 10.5	SP-SM		1														2
B-3	14.0 - 15.0	SP	108	2														1, 2
B-3	19.0 - 20.5	SP		19	97	76	25	51										
B-3	24.0 - 25.0	CH	98	21														1, 2
B-3	29.0 - 30.5	CH		23										8.0		602		2
B-3	34.0 - 34.8	CH	101	20														1, 2
B-3	39.0 - 40.5	SM		2														2

REMARKS

1. Dry Density and/or moisture determined from one or more rings of a multi-ring sample.
2. Visual Classification.
3. Submerged to approximate saturation.
4. Expansion Index in accordance with ASTM D4829-95.
5. Air-Dried Sample

PROJECT: Gila-Knob T/L Rebuild

SITE: North Gila Substation
Near Yuma, Arizona

Terracon
4685 S. Ash Ave., Suite H-4
Tempe, Arizona
PH. 480-897-8200 FAX. 480-897-1133

PROJECT NUMBER: 65155124

CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

EXHIBIT: B-9

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SOIL PROPERTIES 2 65155124.GPJ TERRACON2012.GDT 12/16/15

SUMMARY OF LABORATORY RESULTS

Borehole No.	Depth (ft.)	USCS Soil Class.	In-Situ Properties		Classification				Expansion Testing					Corrosivity				Remarks
			Dry Density (pcf)	Water Content (%)	Passing #200 Sieve (%)	Atterberg Limits			Dry Density (pcf)	Water Content (%)	Surcharge (psf)	Expansion (%)	Expansion Index EI_{50}	pH	Resistivity (ohm-cm)	Sulfates (ppm)	Chlorides (ppm)	
						LL	PL	PI										
B-4	5.0 - 6.5	SP-SM		1	5	NP	NP	NP										
B-4	14.0 - 15.5	SM		5														2
B-4	19.0 - 20.5	SM		1														2
B-4	24.0 - 25.0	SM	94	2														1, 2
B-4	29.0 - 30.5	CH		20														2
B-4	34.0 - 35.0	CH	92	20														1, 2
B-4	39.0 - 40.5	CH		20														2

REMARKS

1. Dry Density and/or moisture determined from one or more rings of a multi-ring sample.
2. Visual Classification.
3. Submerged to approximate saturation.
4. Expansion Index in accordance with ASTM D4829-95.
5. Air-Dried Sample

PROJECT: Gila-Knob T/L Rebuild

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PH. 480-897-8200 FAX. 480-897-1133

PROJECT NUMBER: 65155124

CLIENT: Civil Design & Engineering, Inc.
Phoenix, Arizona

EXHIBIT: B-10

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