

# PERIODIC SAFETY FACTOR ASSESSMENT

**CFR 257.73(e)(1)**

Pond 21, Pond 22, Pond 23, and Waste Water Sludge Pond

Oklaunion Power Station  
Vernon, Texas

October, 2016

Prepared for: Public Service Company of Oklahoma

Prepared by: American Electric Power Service Corporation

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**CCR PONDS AT  
OKLAUNION POWER STATION  
VERNON, TEXAS  
POND 21, POND 22, POND 23, AND WWSP**

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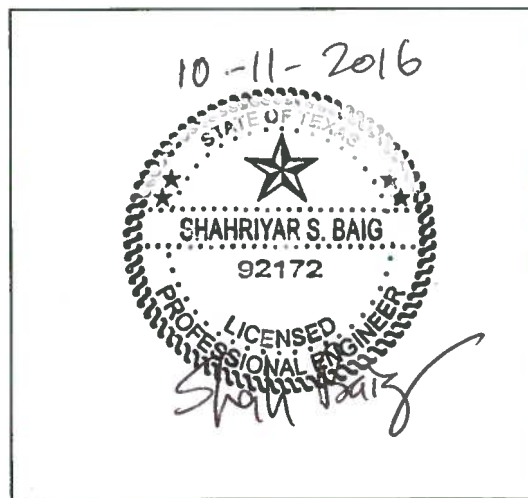
10/5/2016

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10/10/2016



**PROFESSIONAL ENGINEER**

*SEAL & SIGNATURE*

I certify to the best of my knowledge, information, and belief that the information contained in this the safety factor assessment meets the requirements of 40 CFR 257.73(e)

# **POND 21, POND 22, POND 23, AND WWSP INITIAL SAFETY FACTOR ASSESMENT OKLAUNION POWER STATION**

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# INTRODUCTION

In April of 2015, the USEPA formally published national regulations for disposal of coal combustion residuals (CCR) from electric utilities. As part of the rule, the owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the CCR impoundments are in accordance with the rules. This report provides the documentation needed to fulfill the requirements of 40 CFR § 257.73(e), *Periodic Safety Factor Assessments*. AEPSC (American Electric Power Service Corporation) Civil Engineering has performed a slope stability analysis of the dam impounding Pond 21, Pond 22, Pond 23 and WWSP at Oklaunion Power Station.

## PROJECT INFORMATION

The Oklaunion Power Station, located near Vernon, TX, consists of a single 690 MW coal fired scrubbed unit burning PRB coal. (Figure 1 for Location Map). The electric generating unit was commissioned in the early 80's as a Zero Liquid Discharge (ZLD) facility. CCR ponds were constructed and include two 5+ acre ponds for bottom ash storage and dewatering (Pond 21 and Pond 22), a 13+ acre pond for fly ash storage and dewatering (Pond 23), and a 22+ acre pond for Waster Water and Sludge storage and dewatering. (Figure 2 for Pond Location Map).

## SLOPE STABILITY ANALYSIS

Slope stability analyses were performed to document that the existing conditions fulfill the requirements of 40 CFR § 257.73(e), *Periodic Safety Factor Assessments*. The following factors of safety requirements were evaluated.

1. The calculated static factor of safety under long-term, maximum storage pool loading condition must equal or exceed 1.50
2. The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.
3. The calculated seismic factor of safety must equal or exceed 1.00
4. For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20

Existing slope of 3H:1V for inboard and outboard were used in the slope stability analysis. The geometry of the embankment slopes and bottoms of the pond were determined based on the 1987 construction drawings. Soil strength and design parameters were developed based on the results of field and laboratory testing.

Safety factors were determined using SLOPE/W by Geo-Slope International. Mohr-Coulomb failure criterion was assumed for the material and Spencer's Limit Equilibrium Method was used in the program to perform 2-Dimensional limit equilibrium stability analysis to solve minimum factors of safety. Seismic analysis was performed based on the pseudo-static slope stability approach using modified peak horizontal ground accelerations. Figure 3 shows embankment model used to perform slope stability analysis with the computer program Geo Studio Slope/W. The embankment model includes the soil layers, the estimated phreatic surface, and maximum reservoir water levels.

## SOIL PARAMETERS

Soil parameters used were based on the Geotechnical Data Report from borings taken in June 2016, See Appendix A. Due to similar embankment geometry and similar soil characteristics that were revealed within each embankment, one typical cross-section with soil parameters taken for soil boring B-1 was analyzed as a representation of all ponds' upstream and downstream slopes. See Appendix A for soil boring locations.

According to the Geotechnical Data Report, the CCR pond dikes are made of clayey soil material until reaching claystone bedrock at a depth ranging from 15 ft to 25 ft below surface. The embankment clay material is made of medium stiff to stiff lean clays (CL) with trace amounts of gravel. Natural moisture content varied from 11 to 18 percent and the SPT N-values ranged from 6 to 14 blows per foot. For the analysis the claystone bedrock was treated as an impenetrable material as this is where augering refusal was reached. The soil parameters were derived for laboratory tests completed on multiple samples from each soil boring. Laboratory testing consisted of moisture content, Atterberg Limit, grain size distribution, triaxial shear and permeability tests. Table 1 summarizes the soil design parameters used for this analysis.

The original construction drawings show that the inboard slopes were lime stabilized for slope stability. Strength gain from the lime treatment was assumed negligible for long term conditions as the slope is exposed to moisture and freeze/thaw cycles.

**Table 1 – Material Parameters**

Material Layer	Unit Weight (pcf)	Cohesion (psf)	Friction Angle (deg)	Source of Data
Lean Clay (drained)	117	330	28	Soil boring investigation
Lean Clay (undrained)	117	375	20	Soil boring investigation
Claystone Bedrock	IP	IP	IP	N/A

Notes: N/A – Not Applicable, IP- Impenetrable material

## RESERVOIR ELEVATIONS AND PHREATIC SURFACE

Piezometers were installed during the site investigation phase. Piezometers were placed in or near the boring location at each of the embankments. See Geotechnical Data Report for piezometer and boring locations, Appendix A. Ground water was encountered during the site investigation. Soil boring B-1 discovered water at approximately 16.8 ft below surface. Since there was no groundwater encountered within any of the other soil borings, B-1 GW elevation was used for the stability analysis.

The elevation of the reservoir for the long-term storage pool loading was an averaged from the 7 day inspection submitted documents, an elevation of 1213 ft mls was used for both the long term storage pool loading analysis and seismic analysis (Figure 4 and Figure 5).

The surcharge maximum pool level was based on 100-year 24-hour rainfall event, as required by the CCR rules for low hazard dams. This rain event was derived from the Rainfall Frequency Atlas of the United States prepared by the Weather Bureau, 1963. The rainfall event for Vernon, Texas produced approximately 8.3 inches. Since the ponds analyzed within this report do not have outlet structures or

spillways, the maximum pool level was determined by adding the rain fall event to the normal pool elevation. An elevation of 1213.7 ft-msl was used for the maximum surcharge pool loading (Figure 6).

## GROUND ACCELERATION COEFFICIENT

The procedure below describes determination of the ground acceleration coefficient used in the (seismic) analysis. The acceleration coefficient represents earthquake effects on the slope stability.

1. The 2%, 50-year statistical analysis was used to obtain the Peak Ground Acceleration at the rock interface ( $PGA_{rock}$ ). Using the USGS National Hazard Maps, The  $PGA_{rock}$  value for this site was 0.06g, see Figure 7 and 8.
2. The  $PGA_{rock}$  was adjusted to account for earthquake magnitude amplification through the overlying soils/embankment materials. The adjusted PGA ( $PGA_{adjusted}$ ) was determined from Idriss, (1990), "Response of Soft Soil Sites During Earthquakes," see Figure 9. Based on this figure the the  $PGA_{adjusted}$  is 0.14g.
3. The earthquake acceleration "a," is determined based on the  $PGA_{adjusted}$  using the following equation, taken from Earthquake Engineering Handbook:  
$$a = 0.5 * PGA_{adjusted} = 0.5 * 0.14g$$
  
Therefore,  $a = 0.070g$ .

4. The pseudo-static coefficient, "k," is then input into the SLOPE/W Geoslope program to model the effects of seismic loading. The pseudo-static coefficient is represented by the following equation:  
$$k = \frac{a}{g} = \frac{0.070g}{g} = 0.070$$

## LIQUEFACTION ASSESSMENT

Liquefaction of soils occurs when horizontal shearing stresses exceed the strength of existing loose saturated soils. This sudden loss of shear strength and subsequent soil structure is typically associated with earthquake induced horizontal movement. Generally, clean sandy soils below the groundwater level are susceptible to liquefaction conditions during an earthquake. The embankment soils at Oklaunion Power Station are predominantly lean clays (CL) and it is determined that the liquefaction potential at the site is low. No further liquefaction analysis was completed to show that the embankment and foundation materials are not susceptible to liquefaction under the design seismic event.

## RAPID DRAWDOWN

Although there is no apparent mechanism in place for an uncontrolled drawdown of the water level and it is not required by the CCR rules, to determine a worst case factor of safety calculation, a rapid drawdown analysis was performed. Modeled in SLOPE/W the Multi-Stage Duncan, Wright and Wong method was utilized for the rapid drawdown event. For this case the inboard slopes were analyzed assuming a rapid drawdown of water level of one of CCR Ponds from a water level Elevation of 1213 ft to the bottom of the pond at 1190 ft. See Figure 10.

# SLOPE STABILITY ANALYSIS RESULTS

A summary of the resulting factors of safety, along with the corresponding required minimum values for each of the analyses are presented in Table -2. For each condition there is a correlating Figure produced from SLOPE/W displaying the grid of modeled potential failure arc centers, and the area of potential failure arc tangents, and the final factor of safety.

**Table – 2: Factors of Safety Summary**

<b>Slope Stability Case</b>	<b>Factor of Safety from Analysis</b>	<b>Required Minimum Factor of Safety (257.73e)</b>	<b>Figure</b>
Long-Term, Maximum Storage Pool Loading	4.33	1.50	Figure-4
Seismic	2.97	1.00	Figure-5
Maximum Surcharge Pool Loading	4.35	1.40	Figure-6
Liquefaction	N/A	1.20	N/A
Rapid Drawdown	1.98	N/A	Figure -10

## CONCLUSIONS

Based on the analyses presented within this report, it is concluded that Oklaunion Pond 21, Pond 22, Pond 23, and Waste Water & Sludge Pond impoundment dikes satisfy all minimum slope stability factors of safety values required by the CCR rules.

## FIGURES

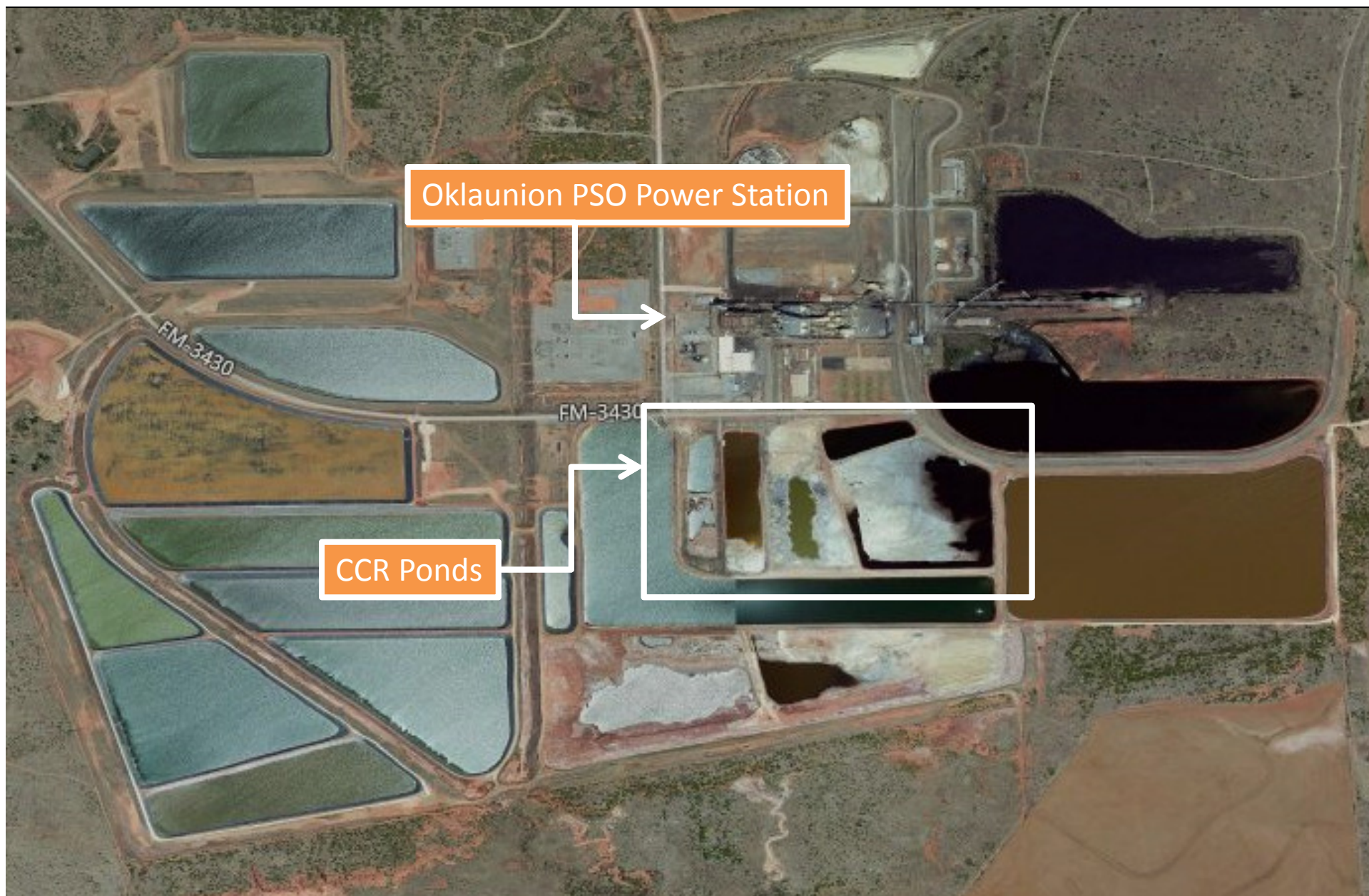


Figure 1 – Oklaunion PSO Power Station Location Map



Figure 2 – Oklaunion Power Station CCR Pond Location Map

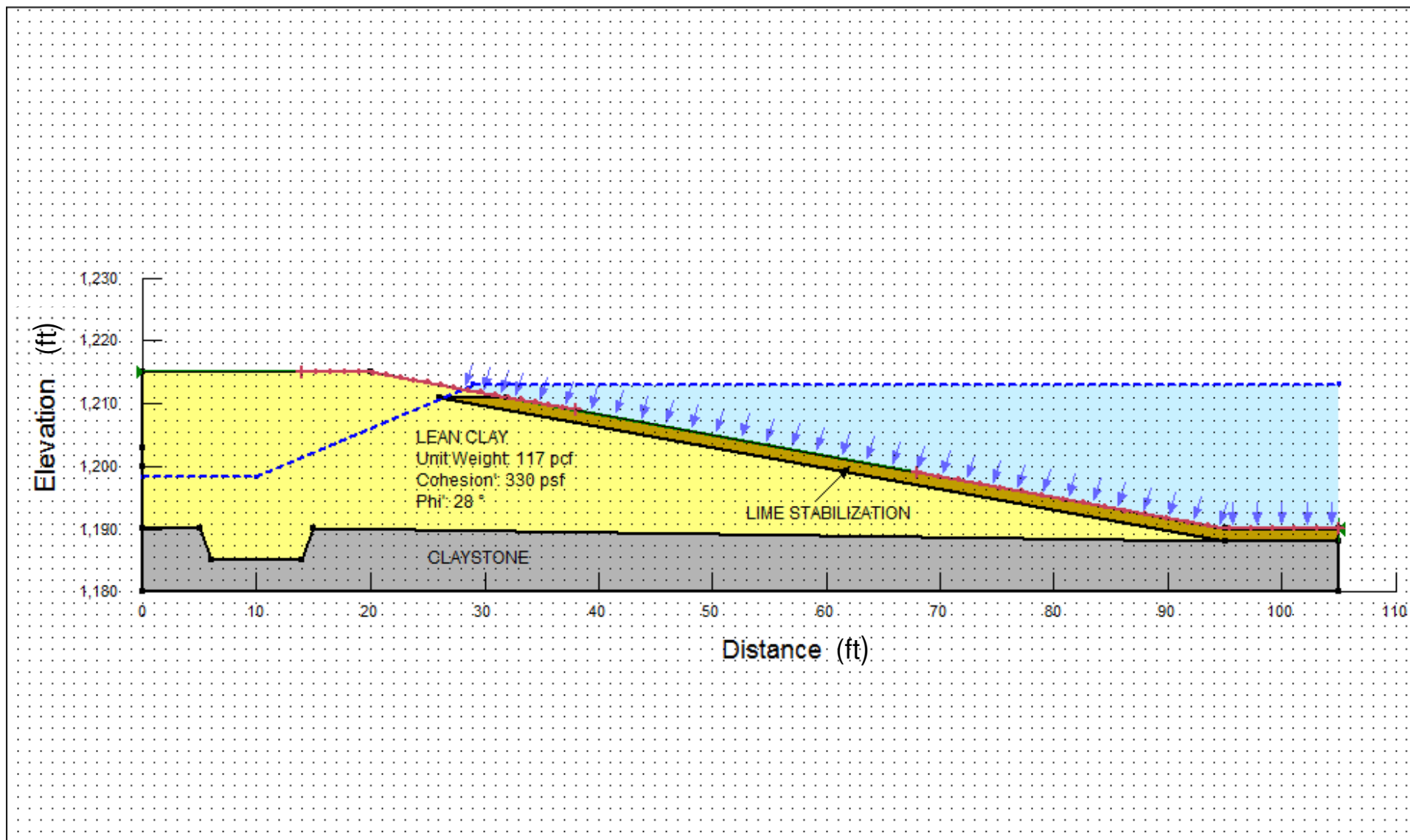


Figure 3 – SLOPE/W Embankment Model.

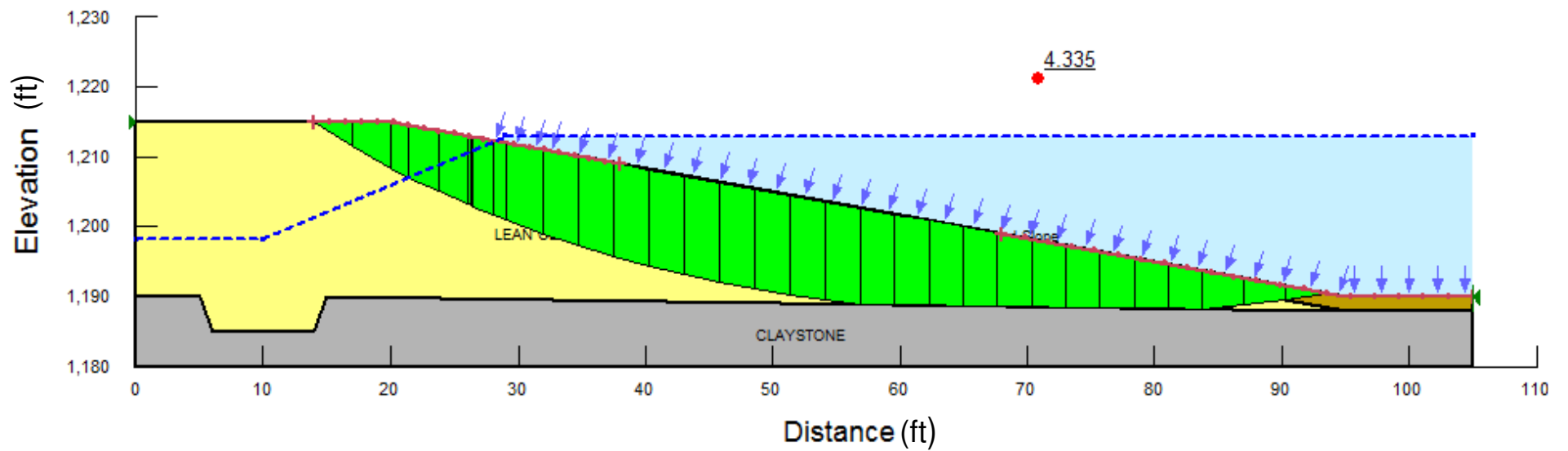


Figure 4 – Cross section embankment model showing simulated critical failure surface with static load and long-term storage pool loading demonstrating a factor of safety of 4.335.

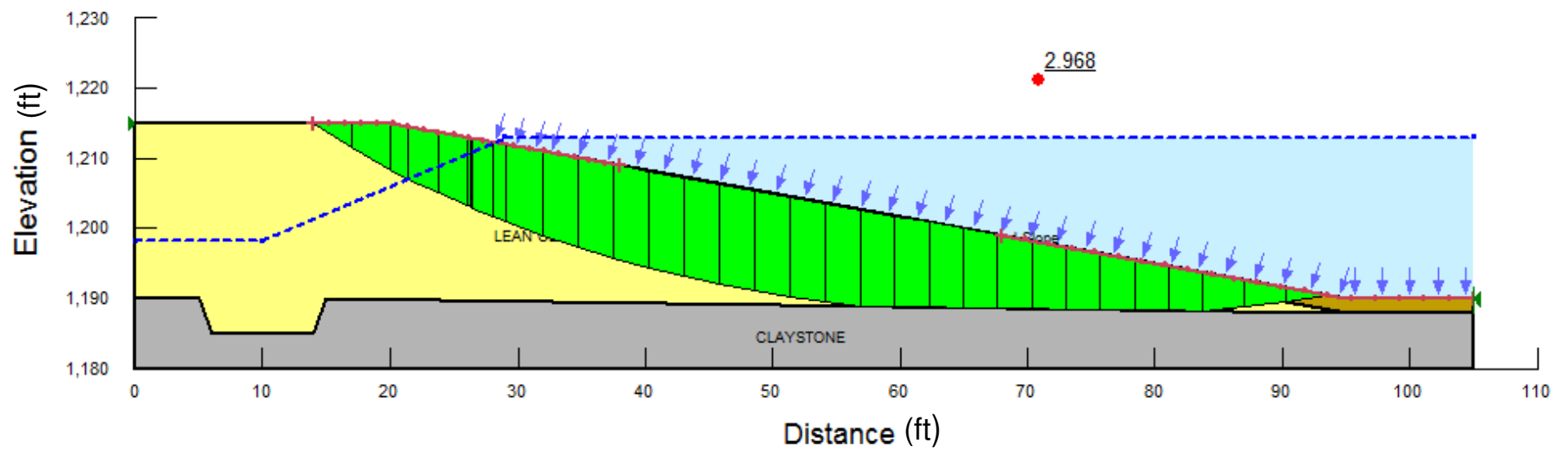


Figure 5 – Cross section embankment model showing simulated critical failure surface with 0.070g seismic load demonstrating a factor of safety of 2.968.

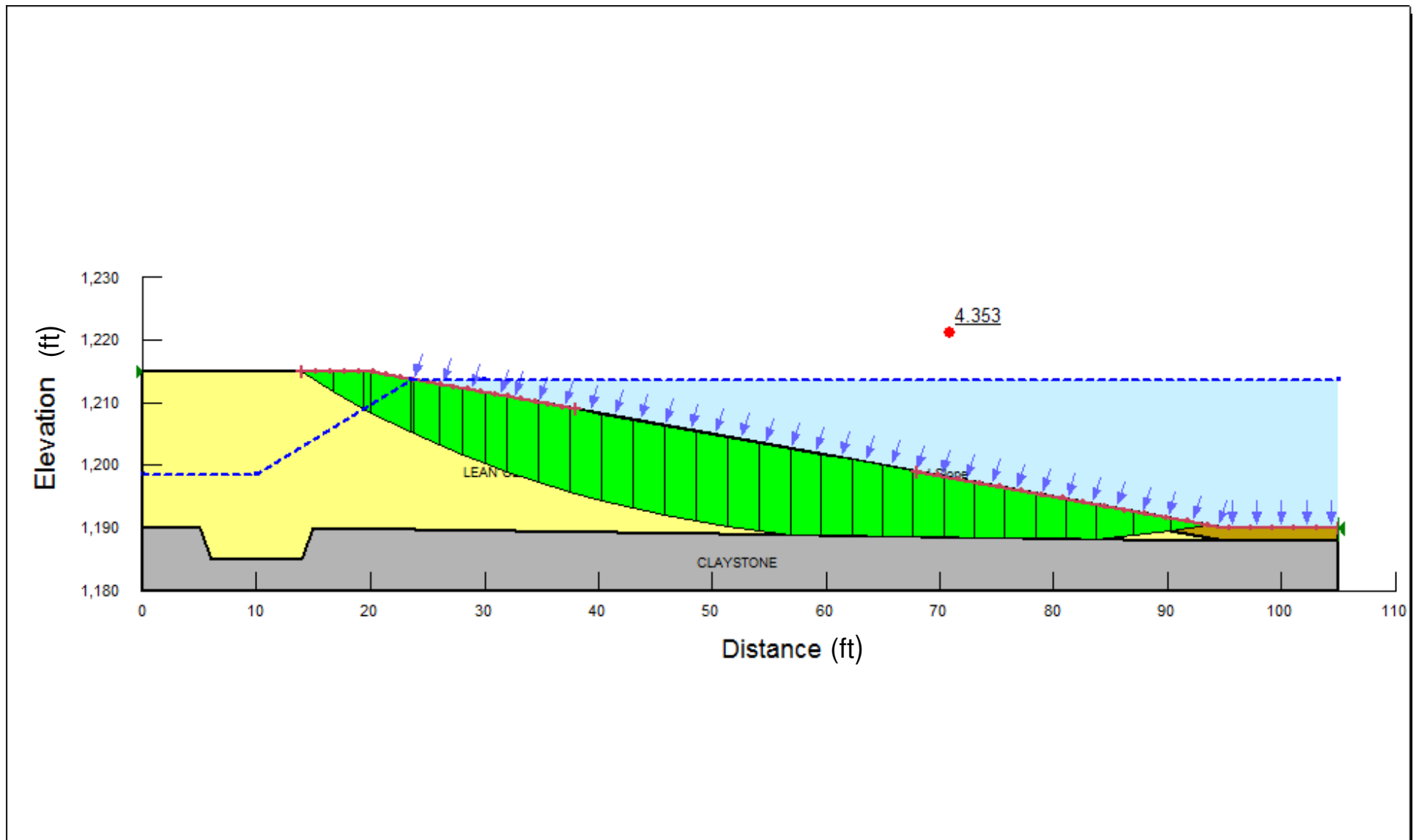


Figure 6 – Cross section embankment model showing simulated critical failure surface with static load and maximum surcharge pool loading demonstrating a factor of safety of 4.353.

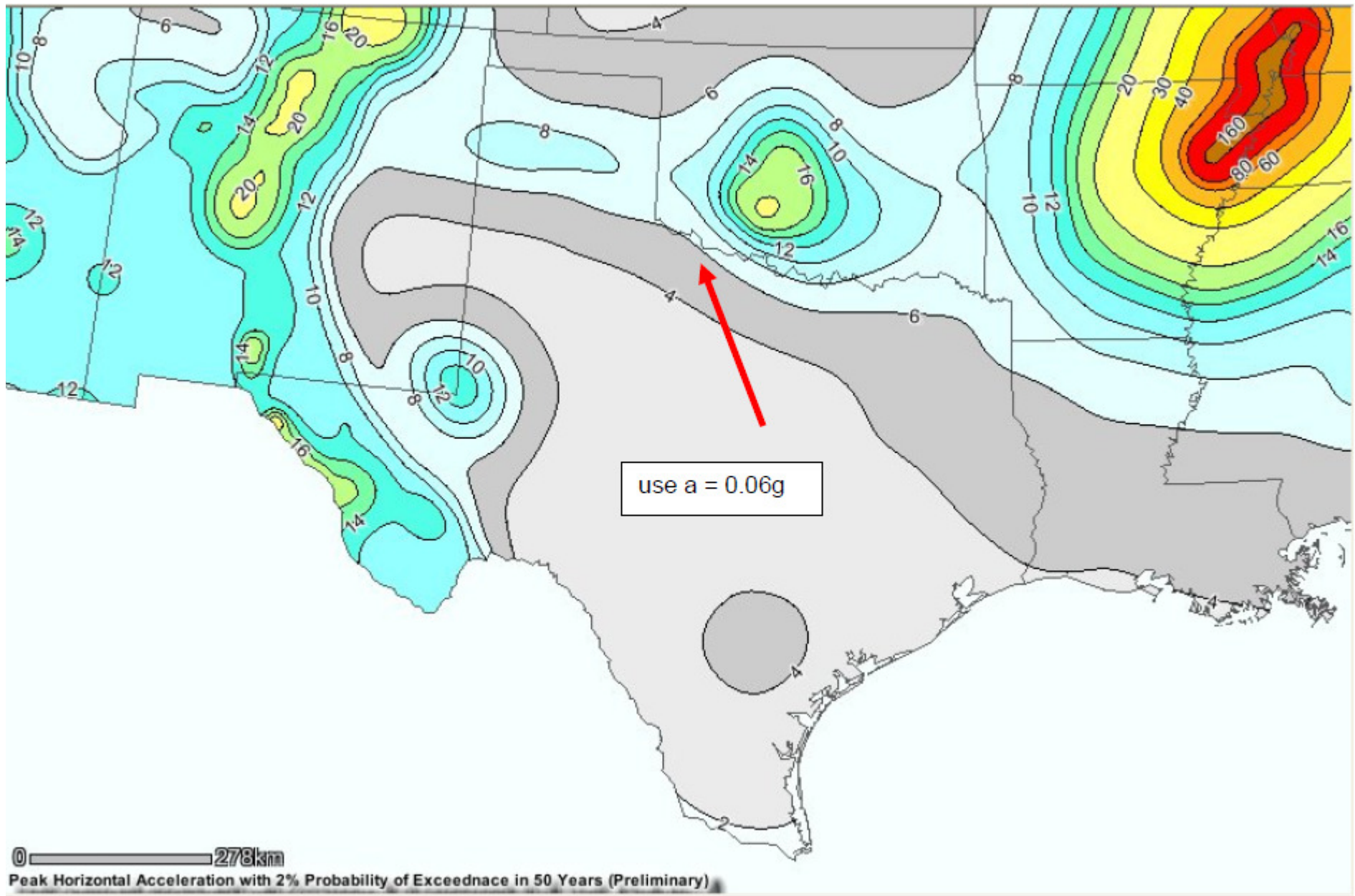
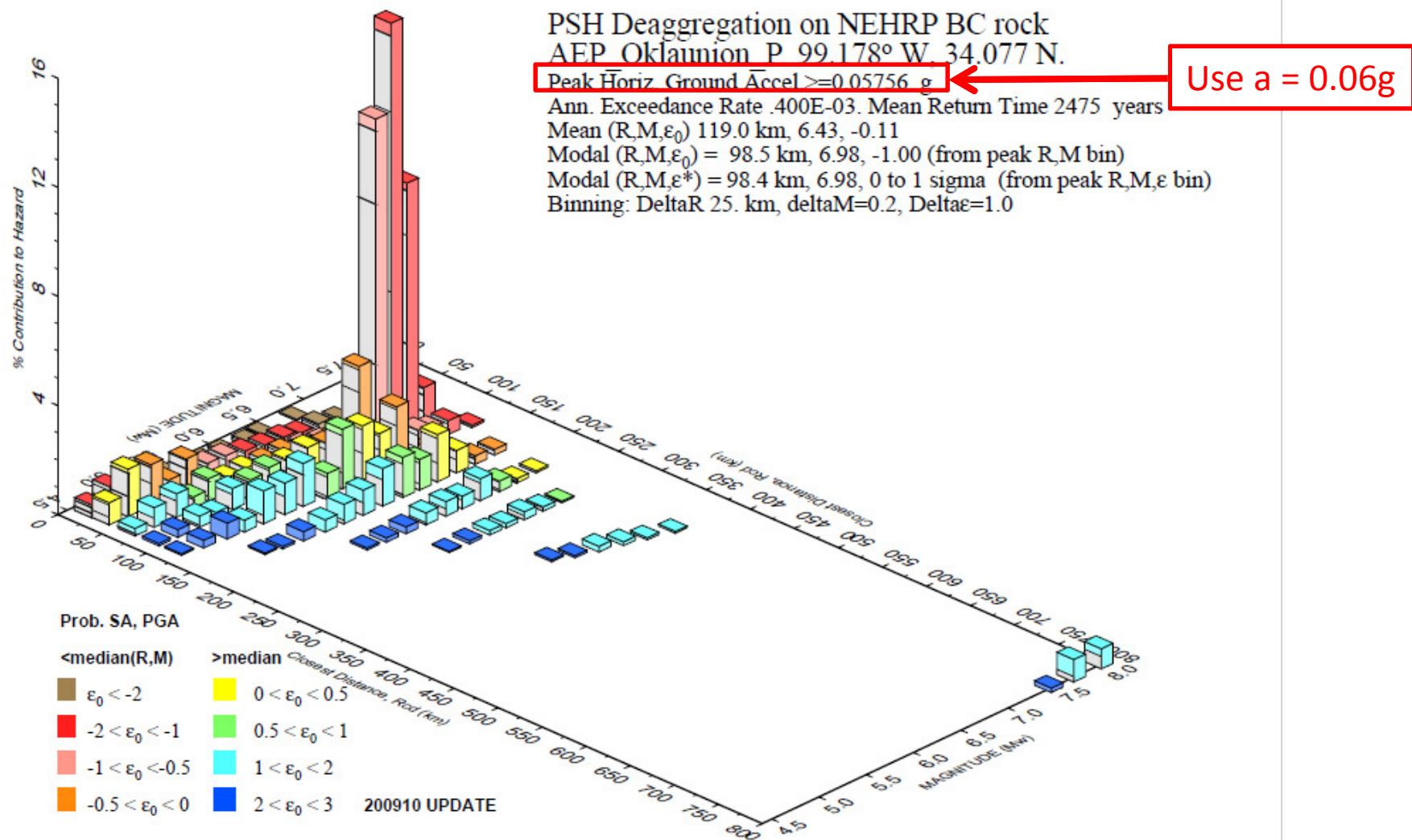


Figure 7 – USGS: National Hazard Maps – 2008

Peak Horizontal Acceleration with 2% Probability of Exceedance in 50 Years



GMT 2016 Sep 19 20:49:23 Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average  $v_s = 760$  m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with  $\leq 0.05\%$  contrib. omitted

Figure 8 – Interactive Deaggregations from USGS Geological Hazards Science Center

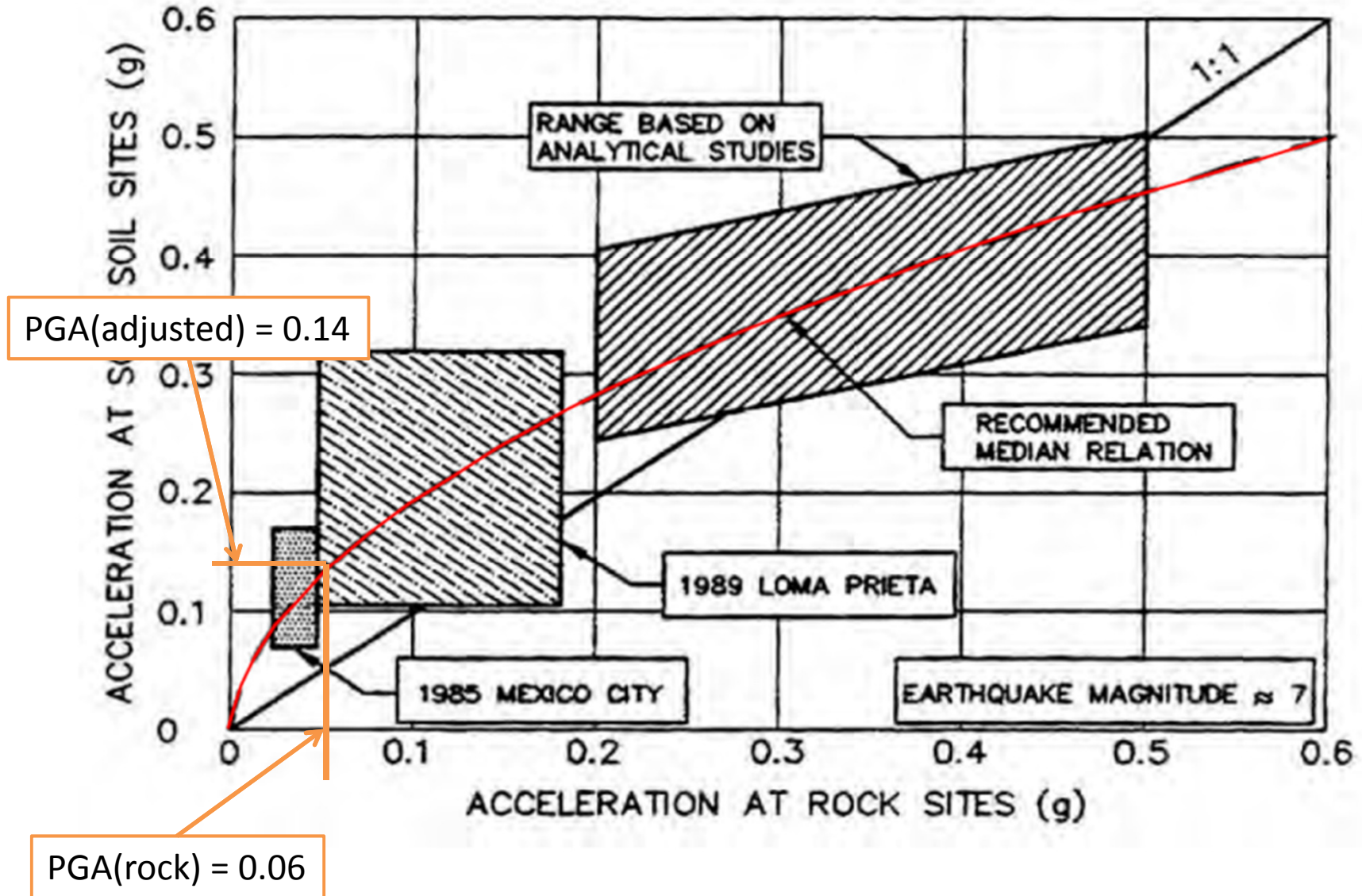


Figure 9 – From Idriss, I.M. (1990), "Response of Soft Soil Sites During Earthquakes,"  
Proc. Memorial Symposium to Honor Professor H.B. Seed, Berkeley, California.

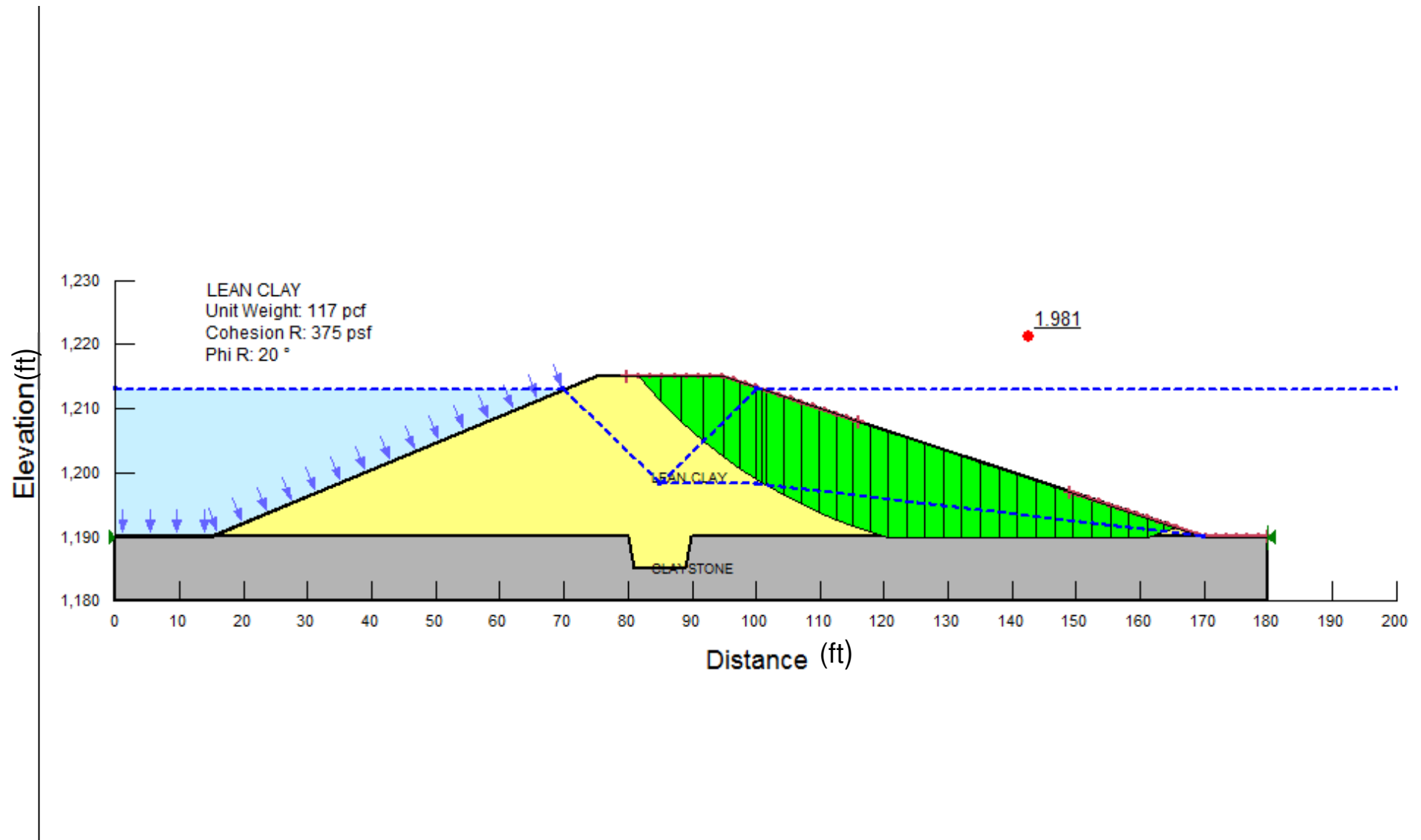


Figure 10 – Cross section embankment model showing simulated critical failure surface in a rapid draw down simulation .  
Factor of Safety of 1.981.

# **APPENDIX A**

## Geotechnical Data Report

# Geotechnical Data Report

**Oklaunion Ponds Area Dikes  
AEP Oklaunion Power Station  
Vernon, Texas**

September 8, 2016

Terracon Project No. N4165227

**Prepared for:**

American Electric Power  
Columbus, Ohio

**Prepared by:**

Terracon Consultants, Inc.  
Columbus, Ohio

Offices Nationwide  
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**Terracon**

Geotechnical ■ Environmental ■ Construction Materials ■ Facilities

September 8, 2016



American Electric Power  
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Attn: Ms. Leilah Saadi  
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Re: Geotechnical Data Report  
Oklaunion Ponds Area Dikes  
AEP Oklaunion Power Station  
Vernon, Texas  
Terracon Project No. N4165227

Dear Ms. Saadi:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. These services were performed in general accordance with our proposal PN4165227 dated May 18, 2016 and our supplemental proposal PN4165283 dated June 14, 2016, under Blanket Contract No. 787002X103 dated October 21, 2013 and American Electric Power (AEP) Letter of Authorization (LoA) for Release 0480 dated May 24, 2016, and Amendment 01 to the LoA dated June 24, 2016.

This report presents the results of our field and laboratory testing programs and includes logs of test borings, piezometer installation records and laboratory testing data sheets. Performing geotechnical engineering analyses and developing geotechnical engineering recommendations associated with the field and laboratory testing programs was not requested by AEP as part of our scope of services.

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.**

A blue ink signature of Mark Evener, written in a cursive style.

for  
Mark Evener  
Staff Geologist

A blue ink signature of Kevin M. Ernst, written in a cursive style.

Kevin M. Ernst, P.E.  
Senior Associate

Reviewed by: Tim G. Abrams, P.E. (Texas), Senior Geotechnical Engineer



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**GEOTECHNICAL DATA REPORT  
OKLAUNION PONDS AREA DIKES  
AEP OKLAUNION POWER STATION  
VERNON, TEXAS**

**Terracon Project No. N4165227  
September 8, 2016**

## **1.0 INTRODUCTION**

This report presents the results of geotechnical field and laboratory services performed for American Electric Power (AEP) for slope stability analyses of pond dikes at the AEP Oklaunion Power Station located in Vernon, Texas. Terracon's scope of work for this project included the advancement of six (6) geotechnical test borings, identified as Borings B-1 to B-6 to a depth range of about 20.5 to 40.3 feet below existing site grades.

Additionally, a total of five (5) piezometers were installed at the site. Borings B-5A and B-6A were advanced at locations offset from Borings B-5 and B-6 and piezometers were installed in each of these borings. Piezometers were also installed in borings B-1, B-3, and B-4. A drawing of showing the locations of the borings and piezometers, logs of the borings and piezometer installation records are included in Appendix A. Results of testing of soil samples from the borings are included in Appendix B.

The following sections present information about the project and provides a summary of the field exploration and laboratory testing results.

## **2.0 PROJECT INFORMATION**

### **2.1 Site Location**

The Oklaunion Power Station is located at 12567 FM Rd 3430, Vernon, Texas 76384, approximately three miles south-southeast of the intersection of the intersection of Farm to Market Road 433 and Farm to Market Road 3430 in Wilbarger Count Texas. The approximate coordinates of the site are Latitude 34.08425, Longitude -99.17869444.

The plant is operated by American Power Service Corporation and is a coal fired facility which features 17 waste evaporation ponds with a total area of 335.9 acres: six (6) of the wastewater ponds contain some byproducts of the coal combustion process while the 11 other ponds contain cooling tower blowdown. The six ponds containing Coal Combustion Residue (CCR) are primarily located in the south central portion of the plant site.

## 2.2 Project Description

We understand that AEP is planning to perform slope stability analyses related to compliance of pond dikes with CCR Rules. Slope stability analyses will be performed on the dikes around Pond 21, Pond 22, Pond 23 and the Wastewater and Sludge Pond. Exhibit A-1, Site Location Plan shows the approximate location of these ponds. Terracon was requested to perform geotechnical test borings, install piezometers for groundwater observations, and perform geotechnical laboratory testing on soil samples recovered from the soil borings. Performing slope stability analyses and developing geotechnical engineering recommendations associated with the field and laboratory testing programs were not requested by AEP as part of Terracon's scope of services.

## 3.0 FIELD EXPLORATION

### 3.1 Geotechnical Test Borings

To develop subsurface information for AEP's slope stability analyses, Terracon performed a total of six (6) geotechnical test borings identified as Borings B-1 to B-6 to a depth range of about 20.5 to 40.3 feet below existing site grades. The locations of the test borings are shown on Exhibit A-2, Boring Location Plan. The following table provides a summary of the location and completion depth for each boring.

Boring No.	Location	Boring Completion Depth (feet)
B-1	Along south side of Pond 23	24.5
B-2	East side dike of Wastewater & Sludge Pond	27.4
B-3	Dike between Pond 23 and Wastewater & Sludge Pond	20.5
B-4	Dike between Pond 22 and Pond 23	20.5
B-5	Dike between Pond 21 and 22	40.3
B-6	Along west side of Pond 21	39.4

The test borings were located in field by the Terracon field geologist using coordinates developed from a site map provided by AEP. A handheld GPS unit was used to locate the borings in the field. Terracon coordinated with site personnel to check the boring locations with underground utilities, and adjusted them as necessary to avoid underground interference. The approximate Latitude and Longitude of the test borings as determined by the field geologist are shown on borings logs. Terracon's scope of services did not include survey of the boring locations. We understand AEP intends to provide Terracon the coordinates of the borings (Latitude and Longitude, or plant coordinates) and ground surface elevation upon completion of a survey scheduled for the fall of

2016. Once available, Terracon will issue updated boring logs with the as drilled coordinates included.

A track-mounted drilling rig was be utilized to perform the borings. The borings were drilled with a rotary drill rig using continuous flight hollow-stem augers to advance the boreholes. Samples of the soil and bedrock encountered in the borings were obtained using the split barrel sampling procedure.

In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound auto-hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in-situ relative density of cohesionless soils and consistency of cohesive soils.

An automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT-N value. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

In addition to split-barrel samples, thin-walled steel (Shelby) tubes were hydraulically pushed into the undisturbed soils in advance of the hollow stem augers to collect soil samples for triaxial shear and permeability laboratory tests. The locations of the Shelby tube samples were determined in coordination with AEP's project geotechnical engineer.

Field logs of the borings were prepared by the field geologist. These logs included visual classifications of the materials encountered during drilling, as well as the driller's interpretation of the subsurface conditions between samples.

The samples were marked for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. The borings not completed as piezometers were backfilled with bentonite grout prior to the drill crew leaving the site. Additional information concerning piezometer installation is summarized in Section 3.2 below.

Information provided on the boring logs attached to this report includes soil and bedrock descriptions, consistency evaluations, boring depth, sampling intervals, and observed groundwater conditions. The final boring logs included with this report represent the Terracon project geotechnical engineer's interpretation of the field logs and includes modifications based on laboratory observation and tests of the samples.

### 3.2 Piezometer Installation

A total of five (5) piezometers were installed at the site. Borings B-5A and B-6A were advanced at locations offset from Borings B-5 and B-6 and piezometers were installed in each of these borings. Piezometers were also installed in boreholes of geotechnical test borings B-1, B-3, and B-4. Exhibit A-2 shows the locations of the piezometers.

In general, the piezometers were open standpipe type constructed using 2-inch diameter, flush mount PVC riser casing and slotted PVC well screen installed within an 8-1/4 inch diameter borehole. The slot size of the well screen was 0.010 inches and filter pack material consisted of 12/20 sand. The screened interval of each piezometer was determined by the Terracon field geologist in consultation with the AEP project geotechnical engineer. A 2 foot thick bentonite seal placed above the top of the filter sand and the borehole was grouted to the surface. A flush mounted protective steel manhole casing was installed at the surface within a concrete well pad. Details of piezometer installation records are included in Appendix A as Exhibits A-11 to A-20.

The following table provides a summary of the initial water level reading in each of the piezometer boreholes taken at completion of drilling and the water levels readings taken when the installed piezometers were developed by the field geologist.

Piezometer No.	Initial Reading Date/Time	Initial Water Level Reading (feet) <sup>1</sup>	Development Date/Time	Water Level Reading at Development (feet) <sup>1</sup>
B-1	7/12/16 14:30	16.8	7/14/16 13:15	7.6
B-3	7/13/16 09:00	None (Dry)	7/14/16 12:30	9.1
B-4	7/12/16 14:45	None (Dry)	7/14/16 11:30	3.5
B-5A	7/12/16 09:00	None (Dry)	7/14/16 11:15	None (Dry)
B-6A	7/12/16 10:30	None (Dry)	7/14/16 10:30	6.6

Notes: (1) Depth below existing ground surface

Well development was performed by Terracon field geologist on July 14, 2016. An inline electric water pump and 3/4 inch poly-flow line was used to purge the piezometers of at least three well volumes of water. This method is implemented in order to flush all fine sediment from the screens of these piezometers, conditioning the screen and allowing groundwater to flow more readily through it. A minimum of three well volumes were removed from each of the piezometers, with two exceptions. Piezometer B-5A had no water, therefore no development was performed. Piezometer B-6A was pumped dry at 2.5 well volumes, with very slow recharge, so development was terminated at that point. It was also noted that Piezometer B-1 contained a large amount of silt in the pump discharge, so a total of eight well volumes were pumped from the piezometer.

### **3.3 Summary of Subsurface Conditions**

In general, the test borings encountered cohesive fill above native cohesive soils underlain by bedrock. In general, the fill consisted of lean clay with varying amounts of sand; and trace amounts gravel. The native soils underlying the fill generally consisted of lean clay with varying amounts of sand; and trace amounts of gravel. The bedrock consisted predominantly of claystone, and to less extent siltstone.

Subsurface conditions encountered at the boring locations are indicated on the individual test boring logs presented as Exhibit A-1 to A-10 in Appendix A. 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 of soils and bedrock conditions for the test borings can be found on the test boring logs in Appendix A of this report. An explanation of terminology found on the boring logs is presents in Appendix C, Exhibit C-1: General Notes. The Unified Soil Classification System (USCS) was used to classify soil samples from the recovered from the borings. Exhibit C-2 provides as summary of the USCS. Terminology used to describe the bedrock encountered the borings is presented in Exhibit C-3: Description of Bedrock Properties.

Groundwater was recorded by the field geologist when encountered in the borings during the time of drilling and sampling prior to grouting the borehole or installing a piezometer. These water level observations are shown on the boring logs reflect the water levels at completion of the short period of drilling and may not reflect long term groundwater levels. Due to the low permeability of the fine-grained cohesive soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole in these materials.

Long term observations or the piezometers which are sealed from the influence of surface water are often required to define groundwater levels in materials of this type. Additional readings of the piezometers installed at the site should be used to establish groundwater levels. It was not within Terracon's scope of services to provide for groundwater readings of the piezometers installed for this project. Groundwater level fluctuations occur due to fluctuation in the pond water levels, and due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings and development of the piezometers were performed.

## **4.0 LABORATORY TESTING**

### **4.1 Laboratory Testing Description**

Laboratory testing consisting of moisture content tests, Atterberg Limits tests, grain size distribution tests, Consolidated Undrained (CU) triaxial shear (compression) tests (with pore pressure measurements) and hydraulic conductivity (permeability) tests performed on selected samples obtained from the test borings. The samples to be tested were selected by AEP's

project geotechnical engineer prior to commencing the testing. The testing was performed under the supervision of Terracon's laboratory supervisor. The following tables summarizes the American Society for Testing and Material (ASTM) test methods used for this project.

<b>Test</b>	<b>Test Method</b>
Moisture Content	ASTM D2216-10 - <i>Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass</i>
Atterberg Limits	ASTM D4318-10e1 - <i>Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils</i>
Grain Size Distribution	ASTM D422 - 63(2007) - <i>Standard Test Method for Particle-Size Analysis of Soils</i>
CU Triaxial Shear	ASTM D4767-11 - <i>Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils</i>
Hydraulic Conductivity	ASTM D5084-16 - <i>Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i>

## **4.2 Summary of Laboratory Testing Results**

The results of the laboratory testing are presented in Appendix B. Exhibit B-1 provides a tabular summary of moisture content, Atterberg Limits, and grain size distribution test results. The laboratory data sheets for the Atterberg Limits and grain size distribution testing are included as Exhibits B-2 to B-20. Results of the triaxial CU compression (with pore pressure measurements) tests are presented in Exhibits B-21 to B-31. Results of hydraulic conductivity (permeability) test results are presented in Exhibits B-32 to B-42.

## **5.0 GENERAL COMMENTS**

The test data 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 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.

**Geotechnical Data Report**

Oklaunion Ponds Area Dikes ■ AEP Oklaunion Power Station, Vernon, Texas  
September 8, 2016 ■ Terracon Project No. N4165227



This data 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.

**APPENDIX A**  
**FIELD EXPLORATION**

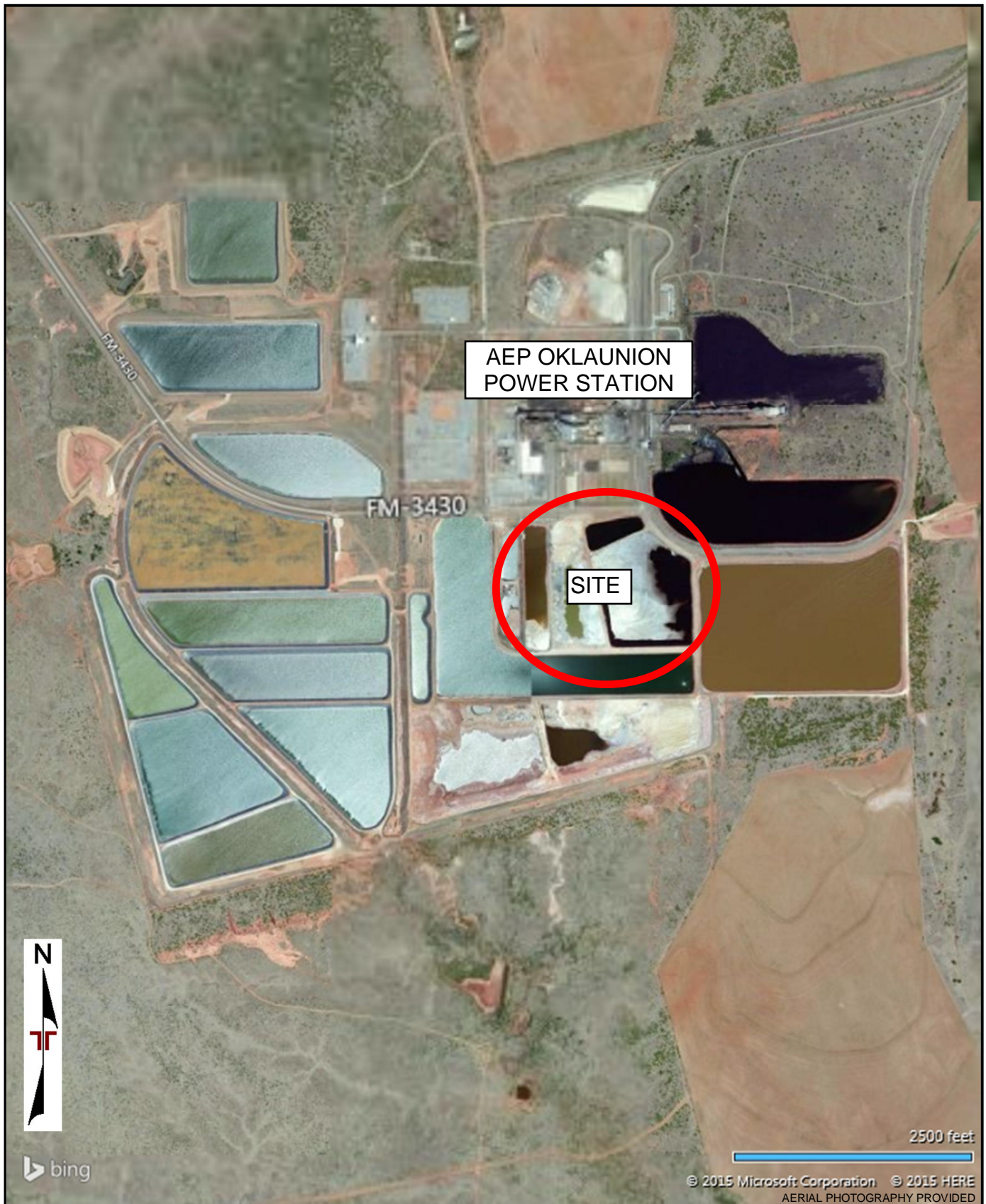



DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager: KME	Project No. N4165227	 <p>800 MORRISON ROAD COLUMBUS, OHIO 43230</p>	<p><b>SITE LOCATION PLAN</b></p> <p>OKLAUNION PONDS AREA DIKES AMERICAN ELECTRIC POWER OKLAUNION POWER STATION 12567 FM ROAD 3430</p>	<p>Exhibit</p> <p><b>A-1</b></p>
Drawn by: DAB	Scale: AS SHOWN			
Checked by: KME	File Name: reportloc			
Approved by: KME	Date: 8/25/16			



# BORING LOG NO. B-1

Page 1 of 1

**PROJECT:** Oklaunion Ponds Area Dikes

**CLIENT:** American Electric Power

**SITE:** AEP Oklaunion Power Station  
Vernon, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2  Latitude: 34.07618° Longitude: -99.17544°  DEPTH	DEPTH (FL)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
								TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)			LL-PL-PI
<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div></div>	0.3	5   											

# BORING LOG NO. B-2

Page 1 of 2

**PROJECT:** Oklaunion Ponds Area Dikes

**CLIENT:** American Electric Power

**SITE:** AEP Oklaunion Power Station  
Vernon, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 34.07736° Longitude: -99.17196°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS  LL-PL-PI
								TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)			
	DEPTH												
	0.2' <b>GRAVEL (2")</b>				18	19-21-25 N=46							
	0.9' <b>FILL - SILTY SAND WITH GRAVEL (SM)</b> , brown, dense				5	13-17-8 N=25					11		NP
	3.0' <b>FILL - SILTY SAND (SM)</b> , trace gravel, reddish-brown, very stiff to hard				18	3-5-8 N=13	2.0 (HP)				17		
	<b>FILL - LEAN CLAY WITH SAND (CL)</b> , trace gravel, reddish-brown, stiff to medium stiff												
		5			16						16		33-17-16
					18	3-5-9 N=14	4.5+ (HP)				13		
	8.5' <b>FILL - LEAN CLAY (CL)</b> , reddish-brown, medium stiff				11	2-2-5 N=7	1.75 (HP)				15		
		10			10	2-2-3 N=5	4.25 (HP)				15		33-13-20
	11.5' <b>FILL - LEAN CLAY WITH SAND (CL)</b> , trace gravel, reddish-brown, stiff to very stiff				16						14		28-14-14
					18	3-8-8 N=16	4.5+ (HP)				14		
		15			18	5-8-10 N=18	4.0 (HP)				12		
	18.0' <b>FILL - LEAN CLAY WITH SAND (CL)</b> , reddish-brown, stiff to very stiff				18	4-8-12 N=20	1.0 (HP)				15		33-9-24
					18	4-6-7 N=13	3.25 (HP)				18		
	20.5' <b>FILL - LEAN CLAY WITH SAND (CL)</b> , trace gravel, reddish-brown, stiff to very stiff				18	3-4-6 N=10	4.5+ (HP)				16		37-9-28
					18	2-7-7 N=14	2.5 (HP)				14		
	24.5'				18	3-7-8 N=15	1.0 (HP)				16		33-11-22
		25			18								

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

Hammer Type: Automatic

Advancement Method:  
4.25" Hollow Stem Auger

Abandonment Method:  
Boring backfilled with cement/bentonite grout.

See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

- Offset 15' W to avoid utility conflict
- Shelby tube 5-7': 600 psi down pressure
- Shelby tube 12-14': 350 psi down pressure

## WATER LEVEL OBSERVATIONS

No water encountered while sampling

**Terracon**  
800 Morrison Rd  
Gahanna, OH

Boring Started: 7/14/2016

Drill Rig: CME 850X, Rig #884

Project No.: N4165227

Boring Completed: 7/14/2016

Driller: D. Bowles

Exhibit: A-4

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL N4165227 OKLAUNION POWER STATION NEW GPJ TERRACON2015.GDT 8/30/16




# BORING LOG NO. B-2

Page 2 of 2

**PROJECT:** Oklaunion Ponds Area Dikes

**CLIENT:** American Electric Power

**SITE:** AEP Oklaunion Power Station  
Vernon, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2  Latitude: 34.07736°    Longitude: -99.17196°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
								TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)			LL-PL-PI
	<b>CLAYSTONE</b> , severely weathered, soft, reddish-brown to gray <i>(continued)</i>				18	3-7-19 N=26	4.5+ (HP)				16		
					17	21-28-50/5"				11			
	<b>Boring Terminated at 27.4 Feet</b>												

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

Hammer Type: Automatic

Advancement Method:  
4.25" Hollow Stem Auger

Abandonment Method:  
Boring backfilled with cement/bentonite grout.

See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

## WATER LEVEL OBSERVATIONS

No water encountered while sampling

**Terracon**  
800 Morrison Rd  
Gahanna, OH

Boring Started: 7/14/2016

Drill Rig: CME 850X, Rig #884

Project No.: N4165227

Boring Completed: 7/14/2016

Driller: D. Bowles

Exhibit: A-4

# BORING LOG NO. B-3

Page 1 of 1

**PROJECT:** Oklaunion Ponds Area Dikes

**CLIENT:** American Electric Power

**SITE:** AEP Oklaunion Power Station  
Vernon, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 34.07786° Longitude: -99.17542°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS  LL-PL-PI
								TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)			
	DEPTH												
	0.2 <b>GRAVEL (2")</b>												
	1.5 <b>FILL - SILTY SAND (SM)</b> , trace gravel, brown, medium dense				10	2-2-11 N=13							
	3.0 <b>FILL - CLAYEY SAND (SC)</b> , trace gravel, reddish-brown, medium dense				10	8-8-11 N=19	1.5 (HP)				12		28-17-11
	<b>FILL - LEAN CLAY (CL)</b> , trace gravel, reddish-brown, stiff				14	8-5-5 N=10	2.5 (HP)				16		
		5			13						13		32-16-16
	7.5 <b>FILL - LEAN CLAY (CL)</b> , reddish-brown, medium stiff				7	2-2-5 N=7	3.0 (HP)				15		
		10			14	3-3-3 N=6	3.25 (HP)				13		31-12-19
					16	3-3-5 N=8	3.5 (HP)				13		
	12.0 <b>FILL - LEAN CLAY (CL)</b> , trace gravel, reddish-brown, medium stiff to stiff				18						18		34-15-19
	14.8 <b>LEAN CLAY (CL)</b> , reddish-brown to gray, stiff	15			18	2-5-8 N=13	1.25 (HP)				15		38-13-25
					18	4-6-8 N=14	2.75 (HP)				15		32-11-21
	<b>CLAYSTONE</b> , severely weathered, soft, reddish-brown to gray				18	3-8-17 N=25					14		
		20			18	13-25-31 N=56					9		
	<b>Boring Terminated at 20.5 Feet</b>												

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

Hammer Type: Automatic

Advancement Method:  
4.25" Hollow Stem Auger

Abandonment Method:  
Boring completed as a piezometer.

See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:  
- Shelby tube 12-14': 200 psi down pressure

## WATER LEVEL OBSERVATIONS

No water encountered while sampling

**Terracon**  
800 Morrison Rd  
Gahanna, OH

Boring Started: 7/13/2016

Drill Rig: CME 850X, Rig #884

Project No.: N4165227

Boring Completed: 7/13/2016

Driller: D. Bowles

Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL N4165227 OKLAUNION POWER STATION NEW GPJ TERRACON2015.GDT 8/30/16

# BORING LOG NO. B-4

Page 1 of 1

**PROJECT:** Oklaunion Ponds Area Dikes

**CLIENT:** American Electric Power

**SITE:** AEP Oklaunion Power Station  
Vernon, Texas

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL N4165227 OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/30/16

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 34.07856° Longitude: -99.17702°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
								TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)			
	DEPTH												
	0.7 <b>GRAVEL (8")</b>				12	22-11-20 N=31	3.0 (HP)				6		23-11-12
	1.5 <b>FILL - CLAYEY SAND (SC)</b> , trace gravel, reddish-brown, hard				6	5-5-6 N=11	4.5+ (HP)				19		
	<b>FILL - LEAN CLAY WITH SAND (CL)</b> , reddish-brown, stiff				13	3-5-6 N=11	3.25 (HP)				16		32-13-19
	5.0 <b>FILL - LEAN CLAY WITH SAND (CL)</b> , trace gravel, reddish-brown, medium stiff	5			15								
					10	2-2-5 N=7	4.25 (HP)				16		34-12-22
					17						17		32-10-22
	10.5 <b>LEAN CLAY WITH SAND (CL)</b> , trace gravel, reddish-brown to gray, soft to medium stiff	10			14	2-2-2 N=4	1.0 (HP)				17		37-11-26
					16								
	15.5 <b>CLAYSTONE</b> , severely weathered, soft, reddish-brown to gray	15			15	2-3-3 N=6	2.0 (HP)				13		
					15	5-9-15 N=24					13		
	Wet split spoon @ 17.0 - 18.5'				18	10-24-36 N=60					10		
					11	17-50/5"							
	20.5 <b>Boring Terminated at 20.5 Feet</b>	20											

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

Hammer Type: Automatic

Advancement Method:  
4.25" Hollow Stem Auger

Abandonment Method:  
Boring completed as a piezometer.

See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

- Shelby tube 5-7': 350 psi down pressure
- Shelby tube 8.5-10.5': 400 psi down pressure
- Shelby tube 12-14': 400 psi down pressure

## WATER LEVEL OBSERVATIONS

No water encountered while sampling

**Terracon**  
800 Morrison Rd  
Gahanna, OH

Boring Started: 7/12/2016

Drill Rig: CME 850X, Rig #884

Project No.: N4165227

Boring Completed: 7/12/2016

Driller: D. Bowles

Exhibit: A-6

# BORING LOG NO. B-5

Page 1 of 2

PROJECT: Oklaunion Ponds Area Dikes

CLIENT: American Electric Power

SITE: AEP Oklaunion Power Station  
Vernon, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 34.07864° Longitude: -99.17799°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS  LL-PL-PI
								TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)			
	DEPTH												
	0.3				12	3-6-7 N=13	2.5 (HP)				6		
					16	4-6-6 N=12	3.75 (HP)				14		31-14-17
					15	4-6-7 N=13	4.0 (HP)				11		
	4.5												
		5			23						17		33-16-17
					14	3-4-5 N=9	4.5+ (HP)				13		33-12-21
	8.5				13	4-4-7 N=11	3.5 (HP)				16		36-10-26
		10			16	3-6-8 N=14	4.25 (HP)				12		
	12.0												
					17						18		35-15-20
	14.5				14	4-12-14 N=26					12		
		15			17	6-12-20 N=32					15		
					17	14-36-50/5"					11		
					17	17-40-50/5"					8		
	20.0				18	13-28-50/6"					10		
		20			11	20-50/5"					10		
	23.0				11	24-50/5"					9		
		25			10								

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

Hammer Type: Automatic

Advancement Method:  
4.25" Hollow Stem Auger

Abandonment Method:  
Boring backfilled with cement/bentonite grout.

See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

- Shelby tube 5-7': 250 psi down pressure
- Shelby tube 12-14': 350 psi down pressure

## WATER LEVEL OBSERVATIONS

No water encountered while sampling

**Terracon**  
800 Morrison Rd  
Gahanna, OH

Boring Started: 7/11/2016

Drill Rig: CME 850X, Rig #884

Project No.: N4165227

Boring Completed: 7/11/2016

Driller: D. Bowles

Exhibit: A-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL N4165227 OKLAUNION POWER STATION NEW GPJ TERRACON2015.GDT 8/30/16


# BORING LOG NO. B-5

Page 2 of 2

PROJECT: Oklaunion Ponds Area Dikes

CLIENT: American Electric Power

SITE: AEP Oklaunion Power Station  
Vernon, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 34.07864° Longitude: -99.17799°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS  LL-PL-PI
								TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)			
	DEPTH												
	<b>CLAYSTONE</b> , severely weathered, soft, reddish-brown (continued)					30-50/4"					9		
					11	36-50/5"					9		
					10	34-50/4"					9		
					11	28-50/5"					7		
	30.5	30											
	<b>SILTSTONE</b> , severely weathered, soft, reddish-brown				16	21-38-50/4"					9		
					11	30-50/5"					9		
	33.5												
	<b>CLAYSTONE</b> , severely weathered, soft, reddish-brown				12	20-50/6"					11		
		35			9	28-50/3"					9		
					6	50/6"					9		
					11	32-50/5"					10		
	40.3	40			9	41-50/3"					9		
Boring Terminated at 40.3 Feet													

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

Hammer Type: Automatic

Advancement Method:  
4.25" Hollow Stem Auger

Abandonment Method:  
Boring backfilled with cement/bentonite grout.

See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

## WATER LEVEL OBSERVATIONS

No water encountered while sampling

**Terracon**  
800 Morrison Rd  
Gahanna, OH

Boring Started: 7/11/2016

Drill Rig: CME 850X, Rig #884

Project No.: N4165227

Boring Completed: 7/11/2016

Driller: D. Bowles

Exhibit: A-7

# BORING LOG NO. B-5A

Page 1 of 1

**PROJECT:** Oklaunion Ponds Area Dikes

**CLIENT:** American Electric Power

**SITE:** AEP Oklaunion Power Station  
Vernon, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 34.07862° Longitude: -99.17799°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS  LL-PL-PI
								TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)			
	Augered without sampling to 8.5'	5											
8.5													
	Pressed Shelby Tube @ 8.5' - 10.5' - Down pressure = 450 psi	10			18								
10.5													
	Augered without sampling to 20.0'	15											
20.0													
	<b>Boring Terminated at 20 Feet</b>	20											

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

Hammer Type: Automatic

Advancement Method:  
4.25" Hollow Stem Auger

Abandonment Method:  
Boring completed as a piezometer.

See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Boring B-5A offset 4' south of Boring B-5  
Boring completed as a piezometer

## WATER LEVEL OBSERVATIONS

No water encountered while drilling

**Terracon**  
800 Morrison Rd  
Gahanna, OH

Boring Started: 7/12/2016

Drill Rig: CME 850X, Rig #884

Project No.: N4165227

Boring Completed: 7/12/2016

Driller: D. Bowles

Exhibit: A-8

# BORING LOG NO. B-6

Page 1 of 2

PROJECT: Oklaunion Ponds Area Dikes

CLIENT: American Electric Power

SITE: AEP Oklaunion Power Station  
Vernon, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2  Latitude: 34.07864° Longitude: -99.17885°  DEPTH	DEPTH (FL)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS	
								TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)			LL-PL-PI	
<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div></div>	0.3	5			12	8-13-19 N=32	1.25 (HP)				11			
	<b>FILL - LEAN CLAY WITH SAND (CL)</b> , trace gravel, reddish-brown, medium stiff to stiff												32-23-9	
			3	9-7-6 N=13				17						
	4.5	5			8	3-3-3 N=6	3.25 (HP)				16		31-11-20	
	<b>FILL - LEAN CLAY (CL)</b> , trace gravel, reddish-brown, medium stiff to stiff													
			19					15		35-15-20				
	7.0	10			18	3-5-6 N=11	1.75 (HP)				14		27-11-16	
	8.5				18	3-4-7 N=11	3.0 (HP)				18			
	<b>LEAN CLAY WITH SAND (CL)</b> , trace gravel, reddish-brown, stiff to very stiff												31-9-22	
	11.5	15			18	4-8-8 N=16	4.25 (HP)				15			
	<b>LEAN CLAY</b> , reddish-brown, stiff to very stiff												29-14-15	
			19					15						
	14.0	20			18	5-9-21 N=30	4.5+ (HP)				10			
			17	10-24-50/5"				9						
			18	15-27-37 N=64				10						
			18	21-25-49 N=74				11						
		25			17	21-38-50/5"					9			
				11	18-50/5"				6					
				11	20-50/5"				9					

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

Hammer Type: Automatic

Advancement Method:  
4.25" Hollow Stem Auger

Abandonment Method:  
Boring backfilled with cement/bentonite grout.

See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:  
- Shelby tube failed attempt at 21': no recovery

## WATER LEVEL OBSERVATIONS

No water encountered while sampling

**Terracon**  
800 Morrison Rd  
Gahanna, OH

Boring Started: 7/11/2016

Drill Rig: CME 850X, Rig #884

Project No.: N4165227

Boring Completed: 7/11/2016

Driller: D. Bowles

Exhibit: A-9

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL N4165227 OKLAUNION POWER STATION NEW GPJ TERRACON2015 GDT 8/30/16

# BORING LOG NO. B-6

Page 2 of 2

PROJECT: Oklaunion Ponds Area Dikes

CLIENT: American Electric Power

SITE: AEP Oklaunion Power Station  
Vernon, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 34.07864° Longitude: -99.17885°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS  LL-PL-PI
								TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)			
	DEPTH												
X	25.5			X	11	33-50/5"					10		
X	<b>SILTSTONE</b> , severely weathered, soft, reddish-brown to gray			X	9	33-50/3"					10		
X				X	10	37-50/4"					11		
X		30		X	8	33-50/2"					11		
X				X	8	38-50/2"					10		
X				X	6	50/6"					11		
X		35		X	8	41-50/2"					10		
X				X	5	50/5"					9		
X				X	5	50/5"					9		
X				X	5	50/5"					8		
X		39.4		X	5	50/5"					8		
	<b>Boring Terminated at 39.4 Feet</b>												

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

Hammer Type: Automatic

Advancement Method:  
4.25" Hollow Stem Auger

Abandonment Method:  
Boring backfilled with cement/bentonite grout.

See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

## WATER LEVEL OBSERVATIONS

No water encountered while sampling

**Terracon**  
800 Morrison Rd  
Gahanna, OH

Boring Started: 7/11/2016

Drill Rig: CME 850X, Rig #884

Project No.: N4165227

Boring Completed: 7/11/2016

Driller: D. Bowles

Exhibit: A-9

# BORING LOG NO. B-6A

Page 1 of 1

PROJECT: Oklaunion Ponds Area Dikes

CLIENT: American Electric Power

SITE: AEP Oklaunion Power Station  
Vernon, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 34.07864° Longitude: -99.17884°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS  LL-PL-PI
								TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)			
DEPTH													
0.4	<b>GRAVEL (3")</b>												
	Augered without sampling to 8.5'												
8.5													
	Pressed Shelby Tube @ 8.5' - 10.5' - Down pressure = 350 psi				20								
10.5													
	Augered without sampling to 20.0'												
20.0													
	<b>Boring Terminated at 20 Feet</b>												

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

Hammer Type: Automatic

Advancement Method:  
4.25" Hollow Stem Auger

Abandonment Method:  
Boring completed as a piezometer.

See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Boring B-6A offset approximately 4' north of Boring B-6  
Boring completed as piezometer

## WATER LEVEL OBSERVATIONS

No water encountered while drilling

**Terracon**  
800 Morrison Rd  
Gahanna, OH

Boring Started: 7/12/2016

Drill Rig: CME 850X, Rig #884

Project No.: N4165227

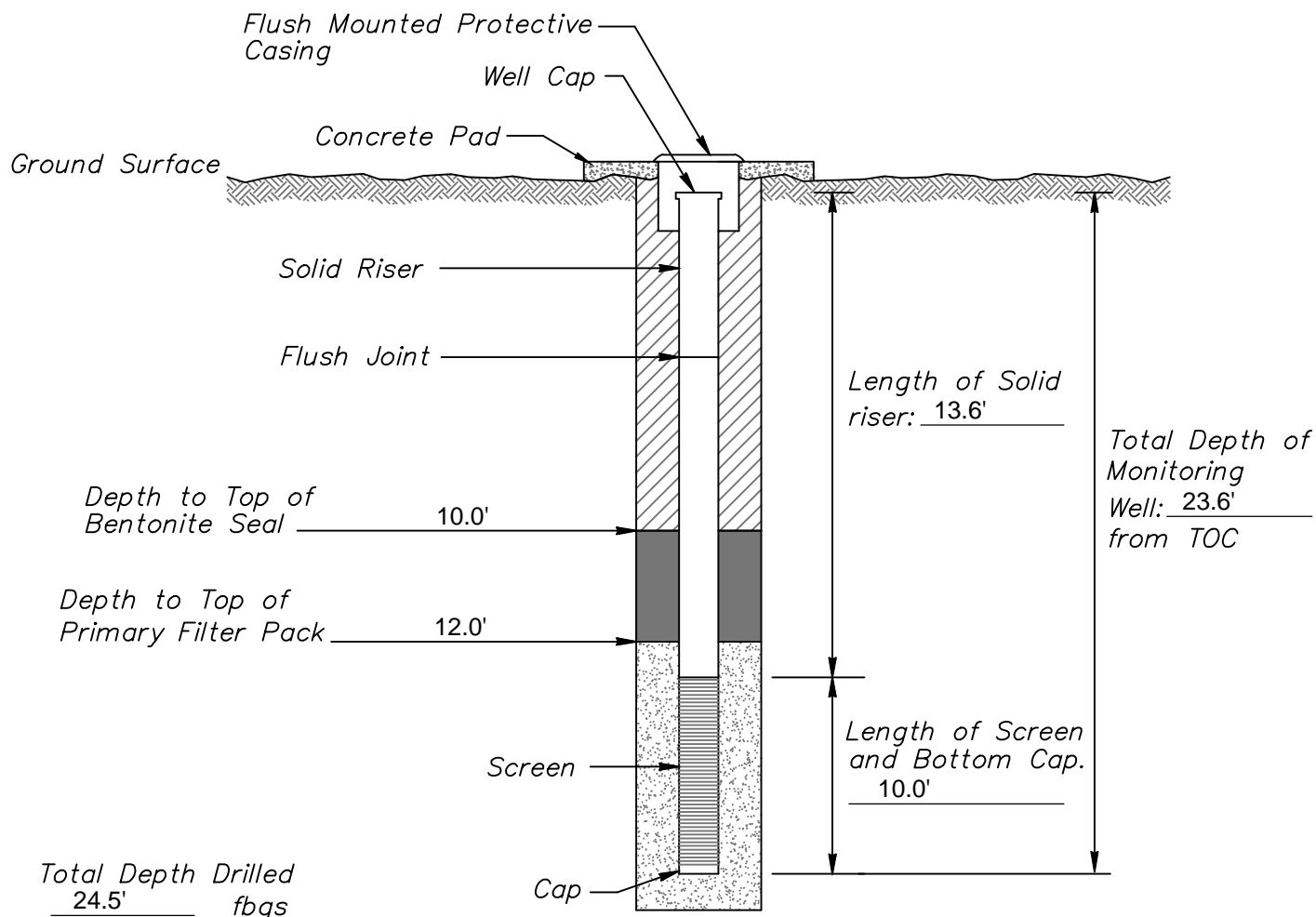
Boring Completed: 7/12/2016

Driller: D. Bowles




Exhibit: A-10

# PIEZOMETER INSTALLATION RECORD

Job Name OKLAUNION PONDS AREA DIKES Well Number B-1  
 Job Number N4165227 Installation Date 7-12-16 Location N 34.07618, W 99.17544  
 Datum Elevation -- Surface Elevation --  
 Datum for Water Level Measurement 0.3' BELOW GROUND SURFACE  
 Screen Diameter & Material 2" PVC SCHEDULE 40 Slot Size 0.010"  
 Riser Diameter & Material 2" PVC SCHEDULE 40 Borehole Diameter 8 1/4" O.D.  
 Granular Backfill Material 12/20 SAND Terracon Representative MARK EVENER  
 Drilling Method 4 1/4" HSA Drilling Contractor TERRACON



(Not to Scale)

-  Portland/Bentonite Grout
-  Bentonite Pellet Plug
-  Granular Backfill

NOTE: LOCATION/ELEVATION DATA FROM

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EXHIBIT A-11

**Terracon**  
 Consulting Engineers and Scientists

800 MORRISON ROAD COLUMBUS, OHIO 43230  
 PH. (614) 863-3113 FAX. (614) 863-0475

## PIEZOMETER INSTALLATION RECORD

PROJECT NUMBER: **N4165227**

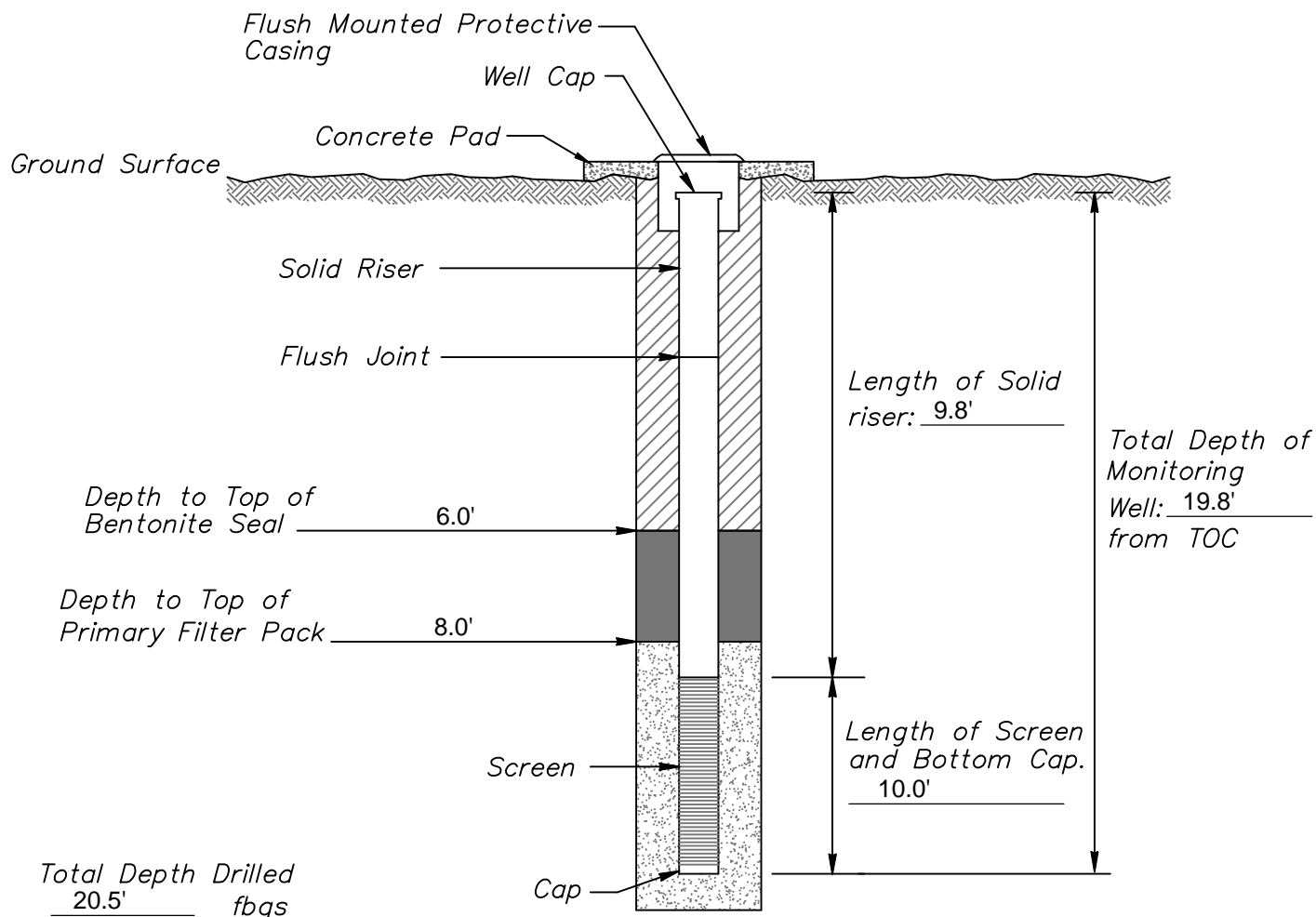
WELL NUMBER: **B-1**

DRAWING NUMBER: **form-mw-b1**




CHECKED BY: **KME**

# PIEZOMETER INSTALLATION RECORD

Job Name OKLAUNION PONDS AREA DIKES Well Number B-3  
 Job Number N4165227 Installation Date 7-13-16 Location N 34.07786, W 99.17542  
 Datum Elevation -- Surface Elevation --  
 Datum for Water Level Measurement 0.3' BELOW GROUND SURFACE  
 Screen Diameter & Material 2" PVC SCHEDULE 40 Slot Size 0.010"  
 Riser Diameter & Material 2" PVC SCHEDULE 40 Borehole Diameter 8 1/4" O.D.  
 Granular Backfill Material 12/20 SAND Terracon Representative MARK EVENER  
 Drilling Method 4 1/4" HSA Drilling Contractor TERRACON



(Not to Scale)

-  Portland/Bentonite Grout
-  Bentonite Pellet Plug
-  Granular Backfill

NOTE: LOCATION/ELEVATION DATA FROM

---

EXHIBIT A-12

**Terracon**  
 Consulting Engineers and Scientists

800 MORRISON ROAD COLUMBUS, OHIO 43230  
 PH. (614) 863-3113 FAX. (614) 863-0475

## PIEZOMETER INSTALLATION RECORD

PROJECT NUMBER: **N4165227**

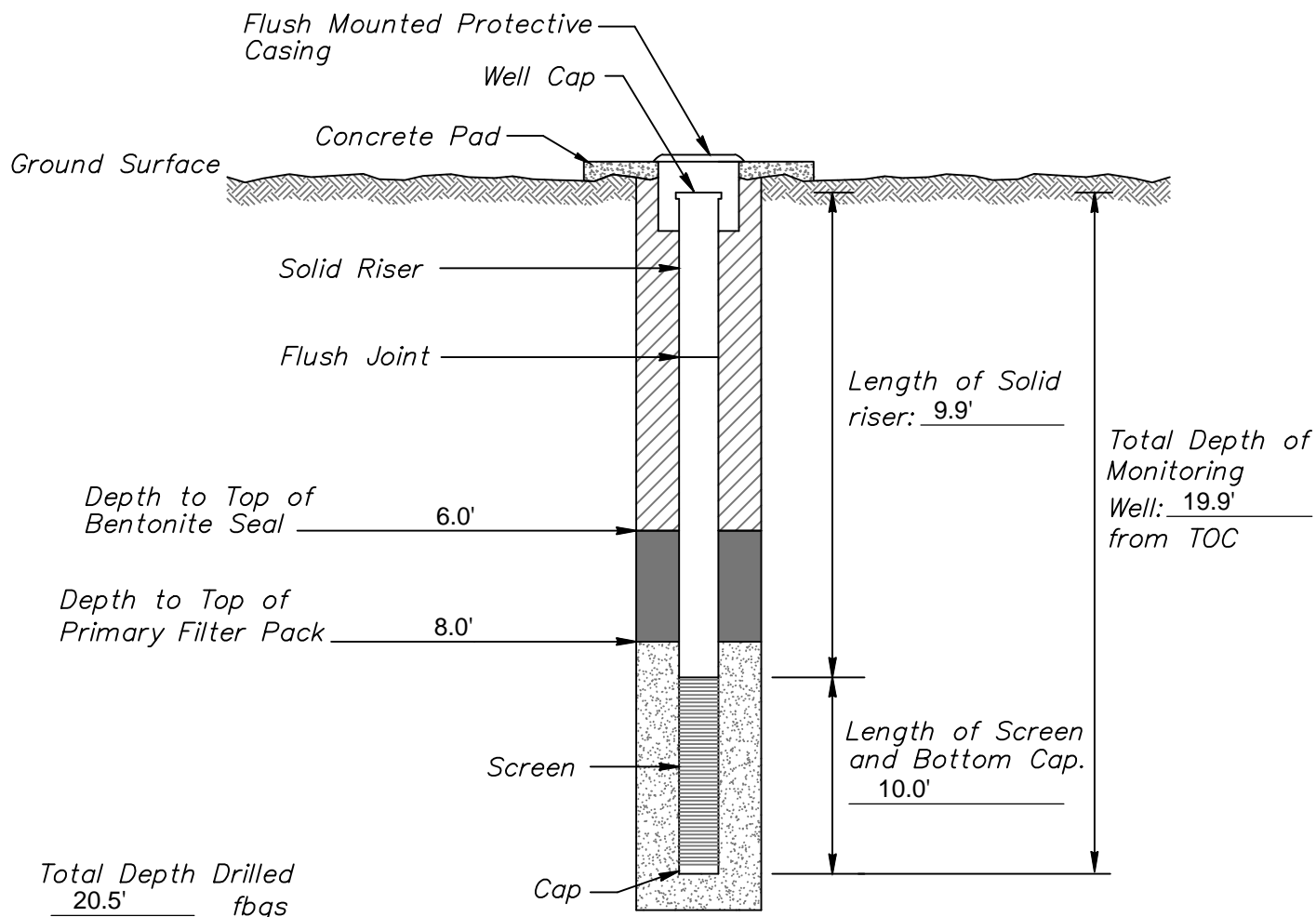
WELL NUMBER: **B-3**

DRAWING NUMBER: **form-mw-b3**

CHECKED BY: **KME**

# PIEZOMETER INSTALLATION RECORD

Job Name OKLAUNION PONDS AREA DIKES Well Number B-4  
 Job Number N4165227 Installation Date 7-12-16 Location N 34.07856, W 99.17702  
 Datum Elevation -- Surface Elevation --  
 Datum for Water Level Measurement 0.4' BELOW GROUND SURFACE  
 Screen Diameter & Material 2" PVC SCHEDULE 40 Slot Size 0.010"  
 Riser Diameter & Material 2" PVC SCHEDULE 40 Borehole Diameter 8 1/4" O.D.  
 Granular Backfill Material 12/20 SAND Terracon Representative MARK EVENER  
 Drilling Method 4 1/4" HSA Drilling Contractor TERRACON



Portland/Bentonite Grout



Bentonite Pellet Plug



Granular Backfill

(Not to Scale)

NOTE: LOCATION/ELEVATION DATA FROM  
---

EXHIBIT A-13

**Terracon**  
Consulting Engineers and Scientists

800 MORRISON ROAD  
PH. (614) 863-3113

COLUMBUS, OHIO 43230  
FAX. (614) 863-0475

## PIEZOMETER INSTALLATION RECORD

PROJECT NUMBER: **N4165227**

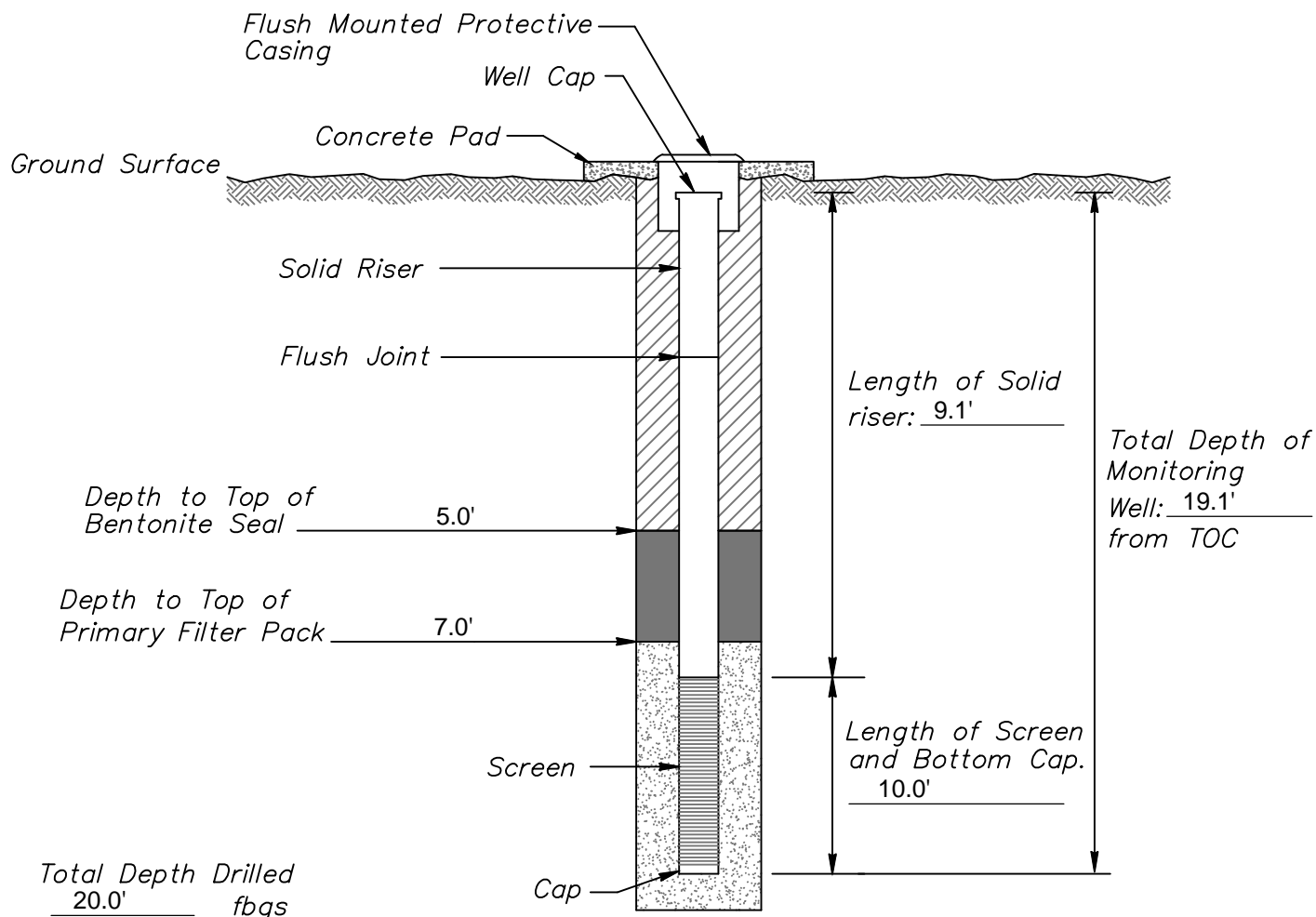
WELL NUMBER: **B-4**

DRAWING NUMBER: **form-mw-b4**

CHECKED BY: **KME**

# PIEZOMETER INSTALLATION RECORD

Job Name OKLAUNION PONDS AREA DIKES Well Number B-5A  
 Job Number N4165227 Installation Date 7-12-16 Location N 34.07862, W 99.17799  
 Datum Elevation -- Surface Elevation --  
 Datum for Water Level Measurement 0.4' BELOW GROUND SURFACE  
 Screen Diameter & Material 2" PVC SCHEDULE 40 Slot Size 0.010"  
 Riser Diameter & Material 2" PVC SCHEDULE 40 Borehole Diameter 8 1/4" O.D.  
 Granular Backfill Material 12/20 SAND Terracon Representative MARK EVENER  
 Drilling Method 4 1/4" HSA Drilling Contractor TERRACON



Portland/Bentonite Grout



Bentonite Pellet Plug



Granular Backfill

(Not to Scale)

NOTE: LOCATION/ELEVATION DATA FROM

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EXHIBIT A-14

**Terracon**

Consulting Engineers and Scientists

800 MORRISON ROAD  
PH. (614) 863-3113

COLUMBUS, OHIO 43230  
FAX. (614) 863-0475

## PIEZOMETER INSTALLATION RECORD

PROJECT NUMBER: **N4165227**

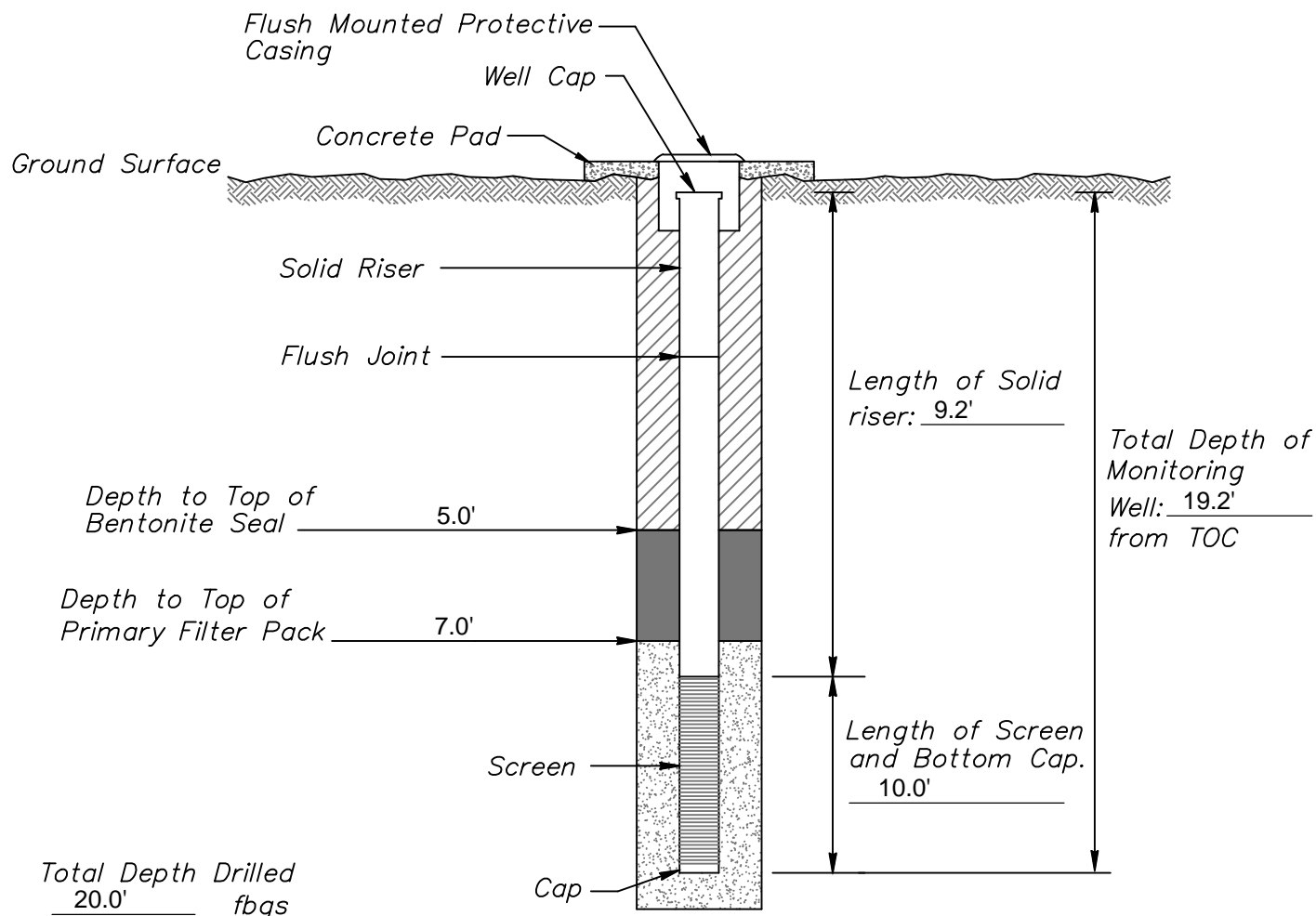
WELL NUMBER: **B-5A**

DRAWING NUMBER: **form-mw-b5a**




CHECKED BY: **KME**

# PIEZOMETER INSTALLATION RECORD

Job Name OKLAUNION PONDS AREA DIKES Well Number B-6A  
 Job Number N4165227 Installation Date 7-12-16 Location N 34.07864, W 99.17884  
 Datum Elevation -- Surface Elevation --  
 Datum for Water Level Measurement 0.3' BELOW GROUND SURFACE  
 Screen Diameter & Material 2" PVC SCHEDULE 40 Slot Size 0.010"  
 Riser Diameter & Material 2" PVC SCHEDULE 40 Borehole Diameter 8 1/4" O.D.  
 Granular Backfill Material 12/20 SAND Terracon Representative MARK EVENER  
 Drilling Method 4 1/4" HSA Drilling Contractor TERRACON



(Not to Scale)

-  Portland/Bentonite Grout
-  Bentonite Pellet Plug
-  Granular Backfill

NOTE: LOCATION/ELEVATION DATA FROM  
---

EXHIBIT A-15

**Terracon**  
Consulting Engineers and Scientists

800 MORRISON ROAD COLUMBUS, OHIO 43230  
PH. (614) 863-3113 FAX. (614) 863-0475

## PIEZOMETER INSTALLATION RECORD

PROJECT NUMBER: **N4165227**

WELL NUMBER: **B-6A**

DRAWING NUMBER: **form-mw-b6a**

CHECKED BY: **KME**

## STATE OF TEXAS WELL REPORT for Tracking #429510

Owner:	<b>American Electric Power-Oklahoma Station</b>	Owner Well #:	<b>B-1</b>
Address:	<b>12567 FM Rd. 3430 Vernon, TX 76384</b>	Grid #:	<b>13-63-5</b>
Well Location:	<b>12567 FM Rd. 3430 Vernon, TX 76384</b>	Latitude:	<b>34° 04' 34.25" N</b>
Well County:	<b>Wilbarger</b>	Longitude:	<b>099° 10' 31.58" W</b>
		Elevation:	<b>No Data</b>
Type of Work:	<b>Geotechnical Piezometer Installation</b>	Proposed Use:	<b>Geotechnical Piezometer Installation</b>

Drilling Start Date: **7/12/2016**      Drilling End Date: **7/12/2016**

	<i>Diameter (in.)</i>	<i>Top Depth (ft.)</i>	<i>Bottom Depth (ft.)</i>
Borehole:	<b>8</b>	<b>0</b>	<b>24.5</b>

Drilling Method: **Hollow Stem Auger**

Borehole Completion: **Geotechnical Piezometer Installation**

	<i>Top Depth (ft.)</i>	<i>Bottom Depth (ft.)</i>	<i>Description (number of sacks &amp; material)</i>
Annular Seal Data:	<b>-0.7</b>	<b>2</b>	<b>Concrete 1 Bags/Sacks</b>
	<b>2</b>	<b>10</b>	<b>Cement 2 Bags/Sacks</b>
	<b>10</b>	<b>12</b>	<b>Bentonite 1 5 gallon bucket bentonite pellets</b>
	<b>12</b>	<b>24.5</b>	<b>12/20 silica sand 8 Bags/Sacks</b>

Seal Method: **Tremie**

Sealed By: **Driller**

Distance to Property Line (ft.): **No Data**

Distance to Septic Field or other  
concentrated contamination (ft.): **No Data**

Distance to Septic Tank (ft.): **No Data**

Method of Verification: **No Data**

Surface Completion: **Alternative Procedure Used**

**Surface Completion by Driller**

Water Level:	<b>16.8 ft. below land surface on 2016-07-12</b>	Measurement Method:	<b>Weighted Line</b>
Packers:	<b>No Data</b>		
Type of Pump:	<b>No Data</b>		
Well Tests:	<b>No Test Data Specified</b>		

Water Quality:

<i>Strata Depth (ft.)</i>	<i>Water Type</i>
<b>No Data</b>	<b>No Data</b>

Chemical Analysis Made: **No**

Did the driller knowingly penetrate any strata which  
contained injurious constituents?: **No**

**The driller did certify that while drilling, deepening or otherwise altering the above described well, injurious water or constituents was encountered and the landowner or person having the well drilled was informed that such well must be completed or plugged in such a manner as to avoid injury or pollution.**

Certification Data: The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the report(s) being returned for completion and resubmittal.

Company Information: **Texplor of Dallas, Inc.**

**PO Box 793928  
Dallas, TX 75379**

Driller Name: **Brent Thomason**

License Number: **2967**

Comments: **Geotechnical soil boring with piezometer installation for water readings.**

Lithology:  
DESCRIPTION & COLOR OF FORMATION MATERIAL

Casing:  
BLANK PIPE & WELL SCREEN DATA

<i>Top (ft.)</i>	<i>Bottom (ft.)</i>	<i>Description</i>
<b>0</b>	<b>0.3</b>	<b>Gravel, fill</b>
<b>0.3</b>	<b>1.5</b>	<b>Sand, sandy, brown, fill</b>
<b>1.5</b>	<b>3</b>	<b>Clay, sandy, reddish brown, trace of gravel, fill</b>
<b>3</b>	<b>14</b>	<b>Clay, sand, reddish brown, trace of gravel, fill</b>
<b>14</b>	<b>17</b>	<b>Clay, sand, reddish brown, trace of gravel</b>
<b>17</b>	<b>24.5</b>	<b>Claystone, weathered, reddish brown</b>

<i>Dia (in.)</i>	<i>Type</i>	<i>Material</i>	<i>Sch./Gage</i>	<i>Top (ft.)</i>	<i>Bottom (ft.)</i>
<b>2</b>	<b>Riser</b>	<b>New Plastic (PVC)</b>	<b>40</b>	<b>-0.5</b>	<b>13.6</b>
<b>2</b>	<b>Screen</b>	<b>New Plastic (PVC)</b>	<b>40 0.010</b>	<b>13.6</b>	<b>23.6</b>

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**IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY**

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking Number on your written request.

**Texas Department of Licensing and Regulation  
P.O. Box 12157  
Austin, TX 78711  
(512) 463-7880**

## STATE OF TEXAS WELL REPORT for Tracking #429513

Owner:	<b>American Electric Power-Oklahoma Station</b>	Owner Well #:	<b>B-3</b>
Address:	<b>12567 FM Rd. 3430 Vernon, TX 76384</b>	Grid #:	<b>13-63-5</b>
Well Location:	<b>12567 FM Rd. 3430 Vernon, TX 76384</b>	Latitude:	<b>34° 04' 40.3" N</b>
Well County:	<b>Wilbarger</b>	Longitude:	<b>099° 10' 31.51" W</b>
		Elevation:	<b>No Data</b>
Type of Work:	<b>Geotechnical Piezometer Installation</b>	Proposed Use:	<b>Geotechnical Piezometer Installation</b>

Drilling Start Date: **7/13/2016**      Drilling End Date: **7/13/2016**

	<i>Diameter (in.)</i>	<i>Top Depth (ft.)</i>	<i>Bottom Depth (ft.)</i>
Borehole:	<b>8</b>	<b>0</b>	<b>20.5</b>

Drilling Method: **Hollow Stem Auger**

Borehole Completion: **Geotechnical Piezometer Installation**

	<i>Top Depth (ft.)</i>	<i>Bottom Depth (ft.)</i>	<i>Description (number of sacks &amp; material)</i>
Annular Seal Data:	<b>-0.5</b>	<b>2</b>	<b>Concrete 1 Bags/Sacks</b>
	<b>2</b>	<b>6</b>	<b>Cement 2 Bags/Sacks</b>
	<b>6</b>	<b>8</b>	<b>Bentonite 1 5 gallon bucket bentonite pellets</b>
	<b>8</b>	<b>20.5</b>	<b>12/20 silica sand 8 Bags/Sacks</b>

Seal Method: **Tremie**

Sealed By: **Driller**

Distance to Property Line (ft.): **No Data**

Distance to Septic Field or other  
concentrated contamination (ft.): **No Data**

Distance to Septic Tank (ft.): **No Data**

Method of Verification: **No Data**

Surface Completion: **Alternative Procedure Used**

**Surface Completion by Driller**

Water Level:	<b>0 ft. below land surface on 2016-07-13</b>	Measurement Method:	<b>Weighted Line</b>
Packers:	<b>No Data</b>		
Type of Pump:	<b>No Data</b>		
Well Tests:	<b>No Test Data Specified</b>		

Water Quality:

<i>Strata Depth (ft.)</i>	<i>Water Type</i>
<b>No Data</b>	<b>No Data</b>

Chemical Analysis Made: **No**

Did the driller knowingly penetrate any strata which  
contained injurious constituents?: **No**

**The driller did certify that while drilling, deepening or otherwise altering the above described well, injurious water or constituents was encountered and the landowner or person having the well drilled was informed that such well must be completed or plugged in such a manner as to avoid injury or pollution.**

Certification Data: The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the report(s) being returned for completion and resubmittal.

Company Information: **Texplor of Dallas, Inc.**

**PO Box 793928  
Dallas, TX 75379**

Driller Name: **Brent Thomason**

License Number: **2967**

Comments: **Geotechnical soil boring with piezometer installation for water readings.**

Lithology:  
DESCRIPTION & COLOR OF FORMATION MATERIAL

<i>Top (ft.)</i>	<i>Bottom (ft.)</i>	<i>Description</i>
<b>0</b>	<b>0.2</b>	<b>Gravel, fill</b>
<b>0.2</b>	<b>1.5</b>	<b>Sand, sandy, brown, fill</b>
<b>1.5</b>	<b>7</b>	<b>Clay, sandy, reddish brown, trace of gravel, fill</b>
<b>7</b>	<b>14.5</b>	<b>Clay, sand, reddish brown, trace of gravel, fill</b>
<b>14.5</b>	<b>17</b>	<b>Clay, sand, reddish brown, trace of gravel</b>
<b>17</b>	<b>20</b>	<b>Claystone, weathered, reddish brown</b>

Casing:  
BLANK PIPE & WELL SCREEN DATA

<i>Dia (in.)</i>	<i>Type</i>	<i>Material</i>	<i>Sch./Gage</i>	<i>Top (ft.)</i>	<i>Bottom (ft.)</i>
<b>2</b>	<b>Riser</b>	<b>New Plastic (PVC)</b>	<b>40</b>	<b>-0.3</b>	<b>9.5</b>
<b>2</b>	<b>Screen</b>	<b>New Plastic (PVC)</b>	<b>40 0.010</b>	<b>9.5</b>	<b>19.8</b>

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**IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY**

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking Number on your written request.

**Texas Department of Licensing and Regulation  
P.O. Box 12157  
Austin, TX 78711  
(512) 463-7880**

## STATE OF TEXAS WELL REPORT for Tracking #429875

Owner:	<b>American Electric Power-Oklahoma Station</b>	Owner Well #:	<b>B-4</b>
Address:	<b>12567 FM Rd. 3430 Vernon, TX 76384</b>	Grid #:	<b>13-63-5</b>
Well Location:	<b>12567 FM Rd. 3430 Vernon, TX 76384</b>	Latitude:	<b>34° 04' 42.82" N</b>
Well County:	<b>Wilbarger</b>	Longitude:	<b>099° 10' 37.27" W</b>
		Elevation:	<b>No Data</b>
Type of Work:	<b>Geotechnical Piezometer Installation</b>	Proposed Use:	<b>Geotechnical Piezometer Installation</b>

Drilling Start Date: **7/12/2016**      Drilling End Date: **7/12/2016**

	<i>Diameter (in.)</i>	<i>Top Depth (ft.)</i>	<i>Bottom Depth (ft.)</i>
Borehole:	<b>8</b>	<b>0</b>	<b>20.5</b>

Drilling Method: **Hollow Stem Auger**

Borehole Completion: **Geotechnical Piezometer Installation**

	<i>Top Depth (ft.)</i>	<i>Bottom Depth (ft.)</i>	<i>Description (number of sacks &amp; material)</i>
Annular Seal Data:	<b>-0.5</b>	<b>2</b>	<b>Concrete 1 Bags/Sacks</b>
	<b>2</b>	<b>6</b>	<b>Cement 2 Bags/Sacks</b>
	<b>6</b>	<b>8</b>	<b>Bentonite 1 5 gallon bucket bentonite pellets</b>
	<b>8</b>	<b>20.5</b>	<b>12/20 silica sand 8 Bags/Sacks</b>

Seal Method: **Tremie**

Sealed By: **Driller**

Distance to Property Line (ft.): **No Data**

Distance to Septic Field or other  
concentrated contamination (ft.): **No Data**

Distance to Septic Tank (ft.): **No Data**

Method of Verification: **No Data**

Surface Completion: **Alternative Procedure Used**

**Surface Completion by Driller**

Water Level:	<b>0 ft. below land surface on 2016-07-12</b>	Measurement Method:	<b>Weighted Line</b>
Packers:	<b>No Data</b>		
Type of Pump:	<b>No Data</b>		
Well Tests:	<b>No Test Data Specified</b>		

Water Quality:

<i>Strata Depth (ft.)</i>	<i>Water Type</i>
<b>No Data</b>	<b>No Data</b>

Chemical Analysis Made: **No**

Did the driller knowingly penetrate any strata which  
contained injurious constituents?: **No**

**The driller did certify that while drilling, deepening or otherwise altering the above described well, injurious water or constituents was encountered and the landowner or person having the well drilled was informed that such well must be completed or plugged in such a manner as to avoid injury or pollution.**

Certification Data: The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the report(s) being returned for completion and resubmittal.

Company Information: **Texplor of Dallas, Inc.**

**PO Box 793928  
Dallas, TX 75379**

Driller Name: **Brent Thomason**

License Number: **2967**

Comments: **Geotechnical soil boring with piezometer installation for water readings.**

Lithology:  
DESCRIPTION & COLOR OF FORMATION MATERIAL

Casing:  
BLANK PIPE & WELL SCREEN DATA

<i>Top (ft.)</i>	<i>Bottom (ft.)</i>	<i>Description</i>
<b>0</b>	<b>0.8</b>	<b>Gravel, fill</b>
<b>0.8</b>	<b>1.5</b>	<b>Clay, sandy reddish brown, fill</b>
<b>1.5</b>	<b>15.5</b>	<b>Clay, sandy, reddish brown, trace of gravel, fill</b>
<b>15.5</b>	<b>20.5</b>	<b>Claystone, reddish brown to gray</b>

<i>Dia (in.)</i>	<i>Type</i>	<i>Material</i>	<i>Sch./Gage</i>	<i>Top (ft.)</i>	<i>Bottom (ft.)</i>
<b>2</b>	<b>Riser</b>	<b>New Plastic (PVC)</b>	<b>40</b>	<b>-0.3</b>	<b>9.9</b>
<b>2</b>	<b>Screen</b>	<b>New Plastic (PVC)</b>	<b>40 0.010</b>	<b>9.9</b>	<b>19.9</b>

**IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY**

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking Number on your written request.

**Texas Department of Licensing and Regulation  
P.O. Box 12157  
Austin, TX 78711  
(512) 463-7880**

## STATE OF TEXAS WELL REPORT for Tracking #429877

Owner:	<b>American Electric Power-Oklahoma Station</b>	Owner Well #:	<b>B-5A</b>
Address:	<b>12567 FM Rd. 3430 Vernon, TX 76384</b>	Grid #:	<b>13-63-5</b>
Well Location:	<b>12567 FM Rd. 3430 Vernon, TX 76384</b>	Latitude:	<b>34° 04' 43.03" N</b>
Well County:	<b>Wilbarger</b>	Longitude:	<b>099° 10' 40.76" W</b>
		Elevation:	<b>No Data</b>
Type of Work:	<b>Geotechnical Piezometer Installation</b>	Proposed Use:	<b>Geotechnical Piezometer Installation</b>

Drilling Start Date: **7/12/2016**      Drilling End Date: **7/12/2016**

	<i>Diameter (in.)</i>	<i>Top Depth (ft.)</i>	<i>Bottom Depth (ft.)</i>
Borehole:	<b>8</b>	<b>0</b>	<b>20</b>

Drilling Method: **Hollow Stem Auger**

Borehole Completion: **Geotechnical Piezometer Installation**

	<i>Top Depth (ft.)</i>	<i>Bottom Depth (ft.)</i>	<i>Description (number of sacks &amp; material)</i>
Annular Seal Data:	<b>-0.5</b>	<b>2</b>	<b>Concrete 1 Bags/Sacks</b>
	<b>2</b>	<b>5</b>	<b>Cement 2 Bags/Sacks</b>
	<b>5</b>	<b>7</b>	<b>Bentonite 1 5 gallon bucket bentonite pellets</b>
	<b>7</b>	<b>20</b>	<b>12/20 silica sand 8 Bags/Sacks</b>

Seal Method: **Tremie**

Sealed By: **Driller**

Distance to Property Line (ft.): **No Data**

Distance to Septic Field or other  
concentrated contamination (ft.): **No Data**

Distance to Septic Tank (ft.): **No Data**

Method of Verification: **No Data**

Surface Completion: **Alternative Procedure Used**

**Surface Completion by Driller**

Water Level:	<b>0 ft. below land surface on 2016-07-12</b>	Measurement Method:	<b>Weighted Line</b>
Packers:	<b>No Data</b>		
Type of Pump:	<b>No Data</b>		
Well Tests:	<b>No Test Data Specified</b>		

Water Quality:

<i>Strata Depth (ft.)</i>	<i>Water Type</i>
<b>No Data</b>	<b>No Data</b>

Chemical Analysis Made: **No**

Did the driller knowingly penetrate any strata which  
contained injurious constituents?: **No**

**The driller did certify that while drilling, deepening or otherwise altering the above described well, injurious water or constituents was encountered and the landowner or person having the well drilled was informed that such well must be completed or plugged in such a manner as to avoid injury or pollution.**

Certification Data: The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the report(s) being returned for completion and resubmittal.

Company Information: **Texplor of Dallas, Inc.**

**PO Box 793928  
Dallas, TX 75379**

Driller Name: **Brent Thomason**

License Number: **2967**

Comments: **Geotechnical soil boring with piezometer installation for water readings.**

Lithology:  
DESCRIPTION & COLOR OF FORMATION MATERIAL

Casing:  
BLANK PIPE & WELL SCREEN DATA

<i>Top (ft.)</i>	<i>Bottom (ft.)</i>	<i>Description</i>
<b>0</b>	<b>0.3</b>	<b>Gravel, fill</b>
<b>0.3</b>	<b>14.5</b>	<b>Clay, sandy reddish brown, fill</b>
<b>14.5</b>	<b>20</b>	<b>Claystone, reddish brown</b>

<i>Dia (in.)</i>	<i>Type</i>	<i>Material</i>	<i>Sch./Gage</i>	<i>Top (ft.)</i>	<i>Bottom (ft.)</i>
<b>2</b>	<b>Riser</b>	<b>New Plastic (PVC)</b>	<b>40</b>	<b>-0.4</b>	<b>9.1</b>
<b>2</b>	<b>Screen</b>	<b>New Plastic (PVC)</b>	<b>40 0.010</b>	<b>9.1</b>	<b>19.1</b>

**IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY**

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Please include the report's Tracking Number on your written request.

**Texas Department of Licensing and Regulation  
P.O. Box 12157  
Austin, TX 78711  
(512) 463-7880**

## STATE OF TEXAS WELL REPORT for Tracking #429882

Owner:	<b>American Electric Power-Oklahoma Station</b>	Owner Well #:	<b>B-6A</b>
Address:	<b>12567 FM Rd. 3430 Vernon, TX 76384</b>	Grid #:	<b>13-63-5</b>
Well Location:	<b>12567 FM Rd. 3430 Vernon, TX 76384</b>	Latitude:	<b>34° 04' 43.1" N</b>
Well County:	<b>Wilbarger</b>	Longitude:	<b>099° 10' 43.82" W</b>
		Elevation:	<b>No Data</b>
Type of Work:	<b>Geotechnical Piezometer Installation</b>	Proposed Use:	<b>Geotechnical Piezometer Installation</b>

Drilling Start Date: **7/12/2016**      Drilling End Date: **7/12/2016**

	<i>Diameter (in.)</i>	<i>Top Depth (ft.)</i>	<i>Bottom Depth (ft.)</i>
Borehole:	<b>8</b>	<b>0</b>	<b>20</b>

Drilling Method: **Hollow Stem Auger**

Borehole Completion: **Geotechnical Piezometer Installation**

	<i>Top Depth (ft.)</i>	<i>Bottom Depth (ft.)</i>	<i>Description (number of sacks &amp; material)</i>
Annular Seal Data:	<b>-0.5</b>	<b>2</b>	<b>Concrete 1 Bags/Sacks</b>
	<b>2</b>	<b>5</b>	<b>Cement 2 Bags/Sacks</b>
	<b>5</b>	<b>7</b>	<b>Bentonite 1 5 gallon bucket bentonite pellets</b>
	<b>7</b>	<b>20</b>	<b>12/20 silica sand 8 Bags/Sacks</b>

Seal Method: **Tremie**

Sealed By: **Driller**

Distance to Property Line (ft.): **No Data**

Distance to Septic Field or other  
concentrated contamination (ft.): **No Data**

Distance to Septic Tank (ft.): **No Data**

Method of Verification: **No Data**

Surface Completion: **Alternative Procedure Used**

**Surface Completion by Driller**

Water Level:	<b>0 ft. below land surface on 2016-07-12</b>	Measurement Method:	<b>Weighted Line</b>
Packers:	<b>No Data</b>		
Type of Pump:	<b>No Data</b>		
Well Tests:	<b>No Test Data Specified</b>		

Water Quality:

<i>Strata Depth (ft.)</i>	<i>Water Type</i>
<b>No Data</b>	<b>No Data</b>

Chemical Analysis Made: **No**

Did the driller knowingly penetrate any strata which  
contained injurious constituents?: **No**

**The driller did certify that while drilling, deepening or otherwise altering the above described well, injurious water or constituents was encountered and the landowner or person having the well drilled was informed that such well must be completed or plugged in such a manner as to avoid injury or pollution.**

Certification Data: The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the report(s) being returned for completion and resubmittal.

Company Information: **Texplor of Dallas, Inc.**

**PO Box 793928  
Dallas, TX 75379**

Driller Name: **Brent Thomason**

License Number: **2967**

Comments: **Geotechnical soil boring with piezometer installation for water readings.**

Lithology:  
DESCRIPTION & COLOR OF FORMATION MATERIAL

Casing:  
BLANK PIPE & WELL SCREEN DATA

<i>Top (ft.)</i>	<i>Bottom (ft.)</i>	<i>Description</i>
<b>0</b>	<b>0.4</b>	<b>Gravel, fill</b>
<b>0.4</b>	<b>8.5</b>	<b>Clay, sandy, reddish brown, fill,</b>
<b>8.5</b>	<b>14</b>	<b>Clay, sandy, reddish brown</b>
<b>14</b>	<b>20</b>	<b>Claystone, reddish brown to gray</b>

<i>Dia (in.)</i>	<i>Type</i>	<i>Material</i>	<i>Sch./Gage</i>	<i>Top (ft.)</i>	<i>Bottom (ft.)</i>
<b>2</b>	<b>Riser</b>	<b>New Plastic (PVC)</b>	<b>40</b>	<b>-0.4</b>	<b>9.2</b>
<b>2</b>	<b>Screen</b>	<b>New Plastic (PVC)</b>	<b>40 0.010</b>	<b>9.2</b>	<b>19.2</b>

#### **IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY**

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**Texas Department of Licensing and Regulation  
P.O. Box 12157  
Austin, TX 78711  
(512) 463-7880**

**APPENDIX B**  
**LABORATORY TESTING**

# Summary of Laboratory Results

Sheet 1 of 3

Sheet 1 of 3													
BORING ID	Depth	USCS Classification and Soil Description	Compressive Strength (tsf)	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Dry Density (pcf)
B-1	0 - 1.5												
B-1	1.5 - 3	SILTY, CLAYEY SAND(SC-SM)		26	20	6	35.1	8.5	56.3	26.6	8.5	15.0	
B-1	3 - 4.5											16.0	
B-1	5 - 7	LEAN CLAY(CL)		34	16	18	88.4	0.3	11.3	43.3	45.1	16.4	
B-1	7 - 8.5											17.0	
B-1	8.5 - 10	LEAN CLAY with SAND(CL)		32	12	20	83.6	0.5	16.0	41.0	42.6	12.0	
B-1	10 - 11.5											15.0	
B-1	12 - 14	LEAN CLAY(CL)		31	14	17	89.8	0.1	10.1	45.4	44.4	14.6	
B-1	14 - 15.5	LEAN CLAY with SAND(CL)		34	14	20	81.0	0.0	19.0	37.6	43.5	17.0	
B-1	15.5 - 17											17.0	
B-1	17 - 18.5	LEAN CLAY with SAND(CL)		32	11	21	75.1	0.9	24.0	46.9	28.2	19.0	
B-1	18.5 - 20											16.0	
B-1	20 - 21.5											14.0	
B-1	21.5 - 23											15.0	
B-1	23 - 24.5											16.0	
B-2	0 - 1.5												
B-2	1.5 - 3	SILTY SAND(SM)		NP	NP	NP	17.5	6.4	76.1	14.7	2.8	11.0	
B-2	3 - 4.5											17.0	
B-2	5 - 7	LEAN CLAY(CL)		33	17	16	85.5	1.0	13.5	42.6	42.9	15.6	
B-2	7 - 8.5											13.0	
B-2	8.5 - 10											15.0	
B-2	10 - 11.5	LEAN CLAY(CL)		33	13	20	86.5	0.0	13.5	52.8	33.6	15.0	
B-2	12 - 14	LEAN CLAY with SAND(CL)		28	14	14	79.1	0.6	20.3	37.1	42.0	13.7	
B-2	14 - 15.5											14.0	
B-2	15.5 - 17											12.0	
B-2	17 - 18.5	LEAN CLAY with SAND(CL)		33	9	24	80.6	0.7	18.7			15.0	
B-2	18.5 - 20											18.0	
B-2	20 - 21.5	LEAN CLAY with SAND(CL)		37	9	28	76.4	0.0	23.6	41.9	34.5	16.0	
B-2	21.5 - 23											14.0	
B-2	23 - 24.5	LEAN CLAY with SAND(CL)		33	11	22	76.4	0.2	23.3	34.7	41.7	16.0	
B-2	24.5 - 26											16.0	
B-2	26 - 27.42											11.0	
B-3	0 - 1.5												
B-3	1.5 - 3	CLAYEY SAND(SC)		28	17	11	39.9	8.8	51.3	22.7	17.2	12.0	
B-3	3 - 4.5											16.0	
B-3	5 - 7	LEAN CLAY(CL)		32	16	16	85.5	0.1	14.4	44.2	41.3	13.5	
B-3	7 - 8.5											15.0	
B-3	8.5 - 10	LEAN CLAY(CL)		31	12	19	88.7	0.0	11.3	38.8	49.9	13.0	
B-3	10 - 11.5											13.0	
B-3	12 - 14	LEAN CLAY(CL)		34	15	19	90.6	0.6	8.8	47.9	42.7	18.5	
B-3	14 - 15.5	LEAN CLAY(CL)		38	13	25	85.4	0.0	14.6	30.1	55.3	15.0	
B-3	15.5 - 17	LEAN CLAY(CL)		32	11	21	87.0	0.0	13.0	32.5	54.5	15.0	
PROJECT: Oklaunion Ponds Area Dikes			<div>Terracon</div> <div>800 Morrison Rd Gahanna, OH</div>					PROJECT NUMBER: N4165227					
SITE: AEP Oklaunion Power Station Vernon, Texas								CLIENT: American Electric Power					
								EXHIBIT: B-1					

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. OLD-LAB SUMMARY: USCS N4165227 OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

# Summary of Laboratory Results

Sheet 2 of 3

BORING ID	Depth	USCS Classification and Soil Description	Compressive Strength (tsf)	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Dry Density (pcf)
B-3	17 - 18.5											14.0	
B-3	18.5 - 20											9.0	
B-4	0 - 1.5	CLAYEY SAND(SC)		23	11	12	38.5	10.1	51.4	21.6	17.0	6.0	
B-4	1.5 - 3											19.0	
B-4	3 - 4.5	LEAN CLAY with SAND(CL)		32	13	19	70.4	0.0	29.6	31.0	39.4	16.0	
B-4	5 - 7												
B-4	7 - 8.5	LEAN CLAY with SAND(CL)		34	12	22	81.3	0.4	18.3	35.6	45.7	16.0	
B-4	8.5 - 10.5	LEAN CLAY with SAND(CL)		32	10	22	77.3	0.1	22.5	38.0	39.4	17.0	
B-4	10.5 - 12	LEAN CLAY with SAND(CL)		37	11	26	78.9	1.2	19.8	35.3	43.6	17.0	
B-4	12 - 14												
B-4	14 - 15.5											13.0	
B-4	15.5 - 17											13.0	
B-4	17 - 18.5											10.0	
B-4	18.5 - 19.42												
B-5	0 - 1.5											6.0	
B-5	1.5 - 3	LEAN CLAY with SAND(CL)		31	14	17	75.6	0.4	24.0	42.6	32.9	14.0	
B-5	3 - 4.5											11.0	
B-5	5 - 7	LEAN CLAY(CL)		33	16	17	88.6	2.2	9.3	45.8	42.7	17.4	
B-5	7 - 8.5	LEAN CLAY(CL)		33	12	21	85.2	0.1	14.6	45.5	39.8	13.0	
B-5	8.5 - 10	LEAN CLAY with SAND(CL)		36	10	26	71.8	0.6	27.6	36.9	34.9	16.0	
B-5	10 - 11.5											12.0	
B-5	12 - 14	LEAN CLAY(CL)		35	15	20	88.8	1.1	10.1	44.5	44.3	17.6	
B-5	14 - 15.5											12.0	
B-5	15.5 - 17											15.0	
B-5	17 - 18.42											11.0	
B-5	18.5 - 19.92											8.0	
B-5	20 - 21.49											10.0	
B-5	21.5 - 22.42											10.0	
B-5	23 - 23.92											9.0	
B-5	24.5 - 25.33											9.0	
B-5	26 - 26.92											9.0	
B-5	27.5 - 28.33											9.0	
B-5	29 - 29.92											7.0	
B-5	30.5 - 31.83											9.0	
B-5	32 - 32.92											9.0	
B-5	33.5 - 34.49											11.0	
B-5	35 - 35.75											9.0	
B-5	36.5 - 36.99											9.0	
B-5	38 - 38.92											10.0	
B-5	39.5 - 40.25											9.0	
B-6	0 - 1.5											11.0	
B-6	1.5 - 3	CLAYEY SAND(SC)		32	23	9	32.8	3.9	63.3	26.9	5.9	17.0	

PROJECT: Oklaunion Ponds Area Dikes

SITE: AEP Oklaunion Power Station  
Vernon, Texas

**Terracon**  
800 Morrison Rd  
Gahanna, OH

PROJECT NUMBER: N4165227

CLIENT: American Electric Power

EXHIBIT: B-1

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. OLD-LAB SUMMARY: USCS N4165227 OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

# Summary of Laboratory Results

Sheet 3 of 3

BORING ID	Depth	USCS Classification and Soil Description	Compressive Strength (tsf)	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Dry Density (pcf)
B-6	3 - 4.5	LEAN CLAY with SAND(CL)		31	11	20	77.8	0.5	21.7	41.4	36.4	16.0	
B-6	5 - 7	LEAN CLAY(CL)		35	15	20	86.3	1.1	12.6	46.6	39.7	14.9	
B-6	7 - 8.5	LEAN CLAY with SAND(CL)		27	11	16	82.6	0.0	17.4	48.8	33.7	14.0	
B-6	8.5 - 10											18.0	
B-6	10 - 11.5	LEAN CLAY with SAND(CL)		31	9	22	77.1	0.3	22.7	45.2	31.9	15.0	
B-6	12 - 14	LEAN CLAY(CL)		29	14	15	87.4	0.0	12.6	44.7	42.6	14.9	
B-6	14 - 15.5											10.0	
B-6	15.5 - 16.92											9.0	
B-6	17 - 18.5											10.0	
B-6	18.5 - 20											11.0	
B-6	21 - 22.42											9.0	
B-6	22.5 - 23.42											6.0	
B-6	24 - 24.92											9.0	
B-6	25.5 - 26.42											10.0	
B-6	27 - 27.75											10.0	
B-6	28.5 - 29.33											11.0	
B-6	30 - 30.67											11.0	
B-6	31.5 - 32.17											10.0	
B-6	33 - 33.49											11.0	
B-6	34.5 - 35.17											10.0	
B-6	36 - 36.42											9.0	
B-6	37.5 - 37.92											9.0	
B-6	39 - 39.42											8.0	

PROJECT: Oklaunion Ponds Area Dikes

SITE: AEP Oklaunion Power Station  
Vernon, Texas

**Terracon**  
800 Morrison Rd  
Gahanna, OH

PROJECT NUMBER: N4165227

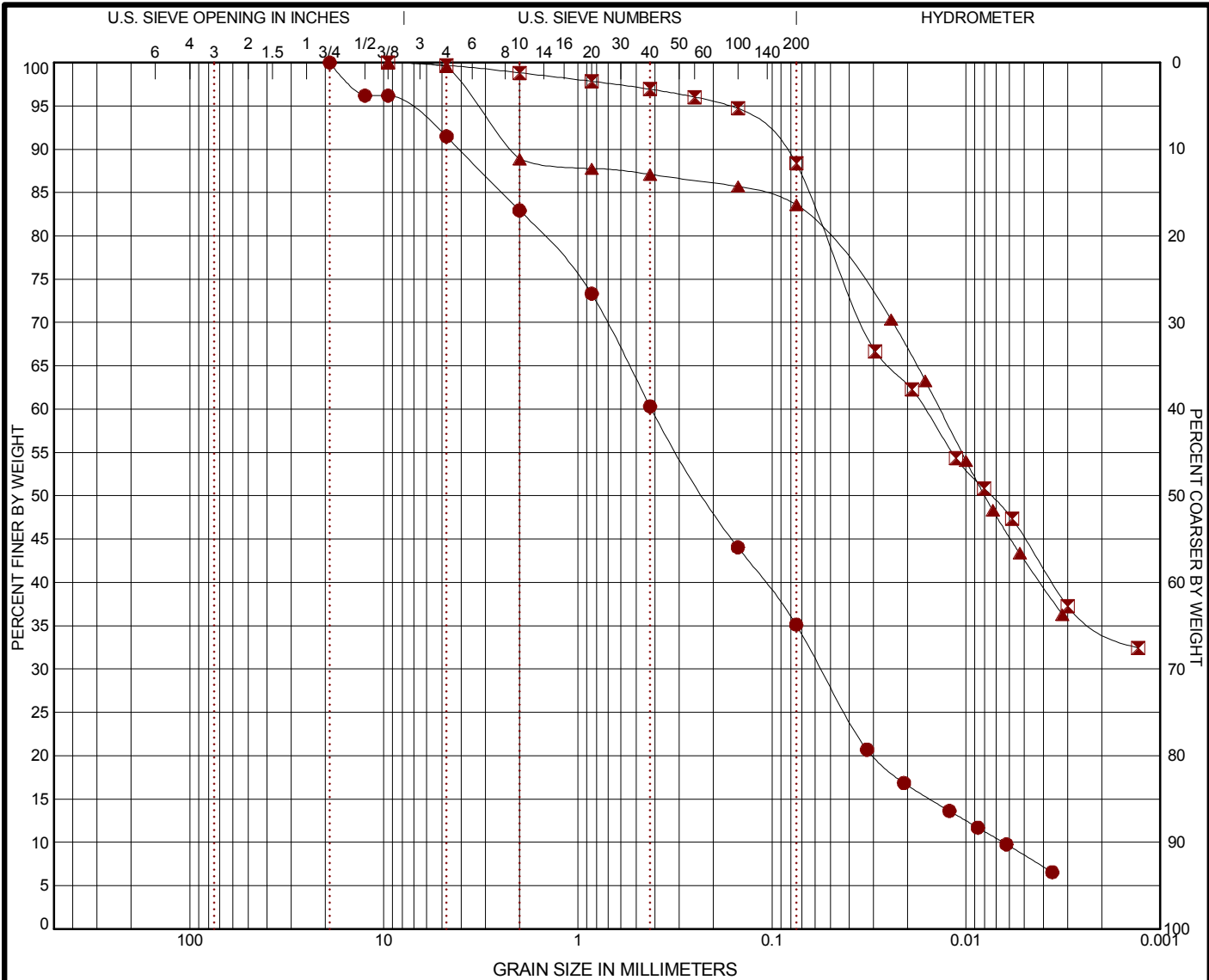
CLIENT: American Electric Power

EXHIBIT: B-1

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. OLD-LAB SUMMARY: USCS N4165227 OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-1	1.5 - 3	0.0	8.5	56.3	26.6		8.5	SC-SM
⊠	B-1	5 - 7	0.0	0.3	11.3	43.3		45.1	CL
▲	B-1	8.5 - 10	0.0	0.5	16.0	41.0		42.6	CL

	GRAIN SIZE			SIEVE (size)	PERCENT FINER			SOIL DESCRIPTION
	●	⊠	▲		●	⊠	▲	
				1 1/2"				SILTY, CLAYEY SAND (SC-SM)
				1"				
				3/4"	100.0			⊠ LEAN CLAY (CL)
				1/2"	96.18			
				3/8"	96.18	100.0	100.0	▲ LEAN CLAY with SAND (CL)
				#4	91.48	99.68	99.55	
				#10	82.94	98.82	98.84	
				#20	73.33	97.84	97.75	
				#40	60.33	96.93	97.1	
				#100	44.06	94.71	95.71	
				#200	35.13	88.36	83.6	

REMARKS
●
⊠
▲

PROJECT: Oklaunion Ponds Area Dikes

SITE: AEP Oklaunion Power Station  
Vernon, Texas

**Terracon**  
800 Morrison Rd  
Gahanna, OH

PROJECT NUMBER: N4165227

CLIENT: American Electric Power

EXHIBIT: B-2

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 N4165227 OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

## ASTM D422 / ASTM C136




	GRAIN SIZE		
			
D <sub>60</sub>	<b>0.018</b>	<b>0.019</b>	<b>0.046</b>
D <sub>30</sub>			<b>0.008</b>
D <sub>10</sub>			
	COEFFICIENTS		
C <sub>C</sub>			
C <sub>U</sub>			

EXHIBIT: B-3

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 N4165227, OKLA UNION POWER STATION NEW, GPJ TERRACON2015.GDT 8/23/16

## ASTM D4318

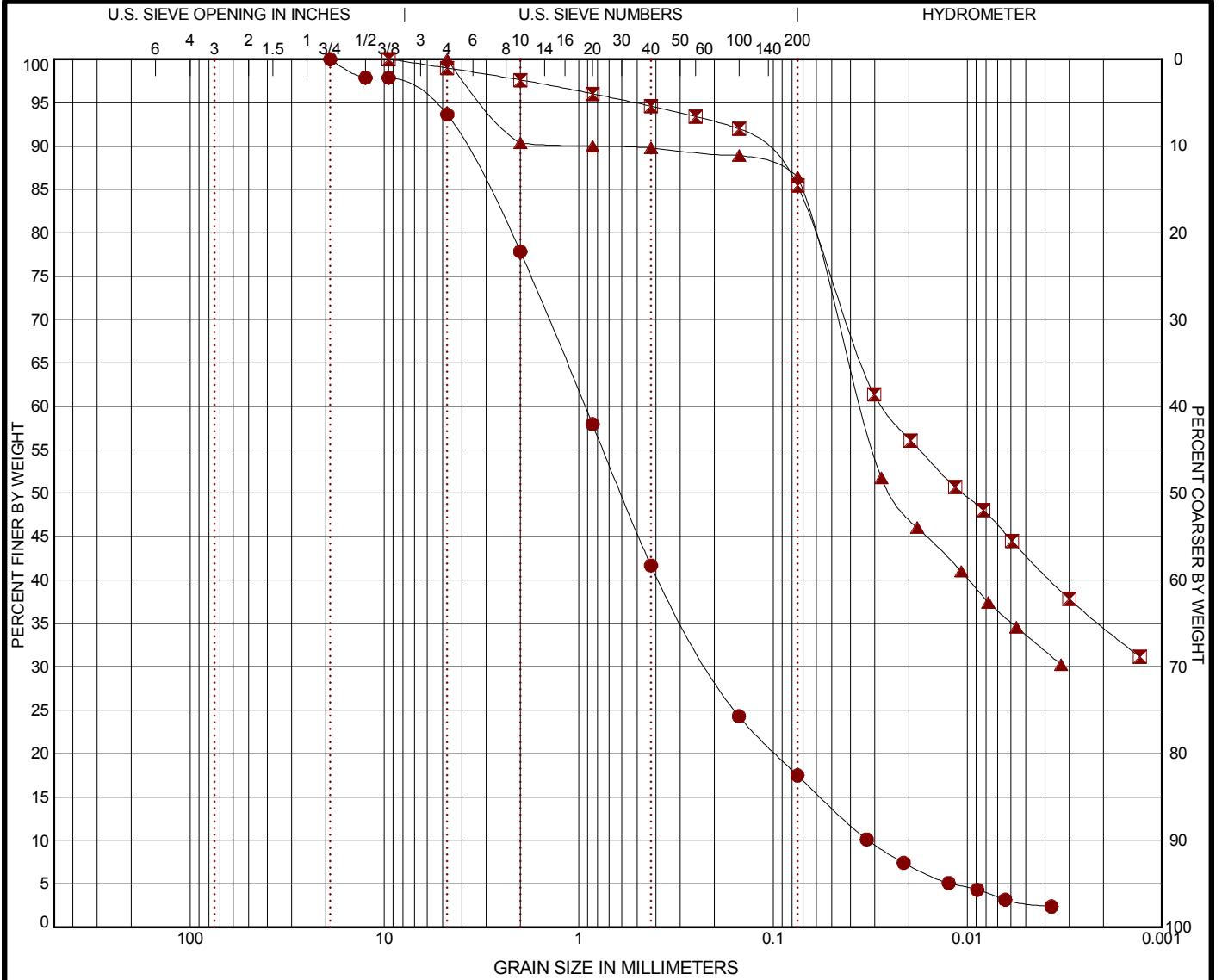


LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS N4165227.OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

EXHIBIT: B-4

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-2	1.5 - 3	0.0	6.4	76.1	14.7		2.8	SM
⊠	B-2	5 - 7	0.0	1.0	13.5	42.6		42.9	CL
▲	B-2	10 - 11.5	0.0	0.0	13.5	52.8		33.6	CL

	GRAIN SIZE		
	●	⊠	▲
D <sub>60</sub>	0.928	0.027	0.035
D <sub>30</sub>	0.211		
D <sub>10</sub>	0.032		
	COEFFICIENTS		
	C <sub>c</sub>	1.48	
C <sub>u</sub>	28.67		

SIEVE (size)	PERCENT FINER		
	●	⊠	▲
1 1/2"			
1"			
3/4"	100.0		
1/2"	97.87		
3/8"	97.87		
#4	93.64	100.0	100.0
#10	77.85	97.62	90.36
#20	57.96	96.03	90.0
#40	41.68	94.6	89.8
#100	24.31	92.0	88.93
#200	17.5	85.49	86.45

SOIL DESCRIPTION
● SILTY SAND (SM)
⊠ LEAN CLAY (CL)
▲ LEAN CLAY (CL)
REMARKS
●
⊠
▲

PROJECT: Oklaunion Ponds Area Dikes

SITE: AEP Oklaunion Power Station  
Vernon, Texas

**Terracon**  
800 Morrison Rd  
Gahanna, OH

PROJECT NUMBER: N4165227

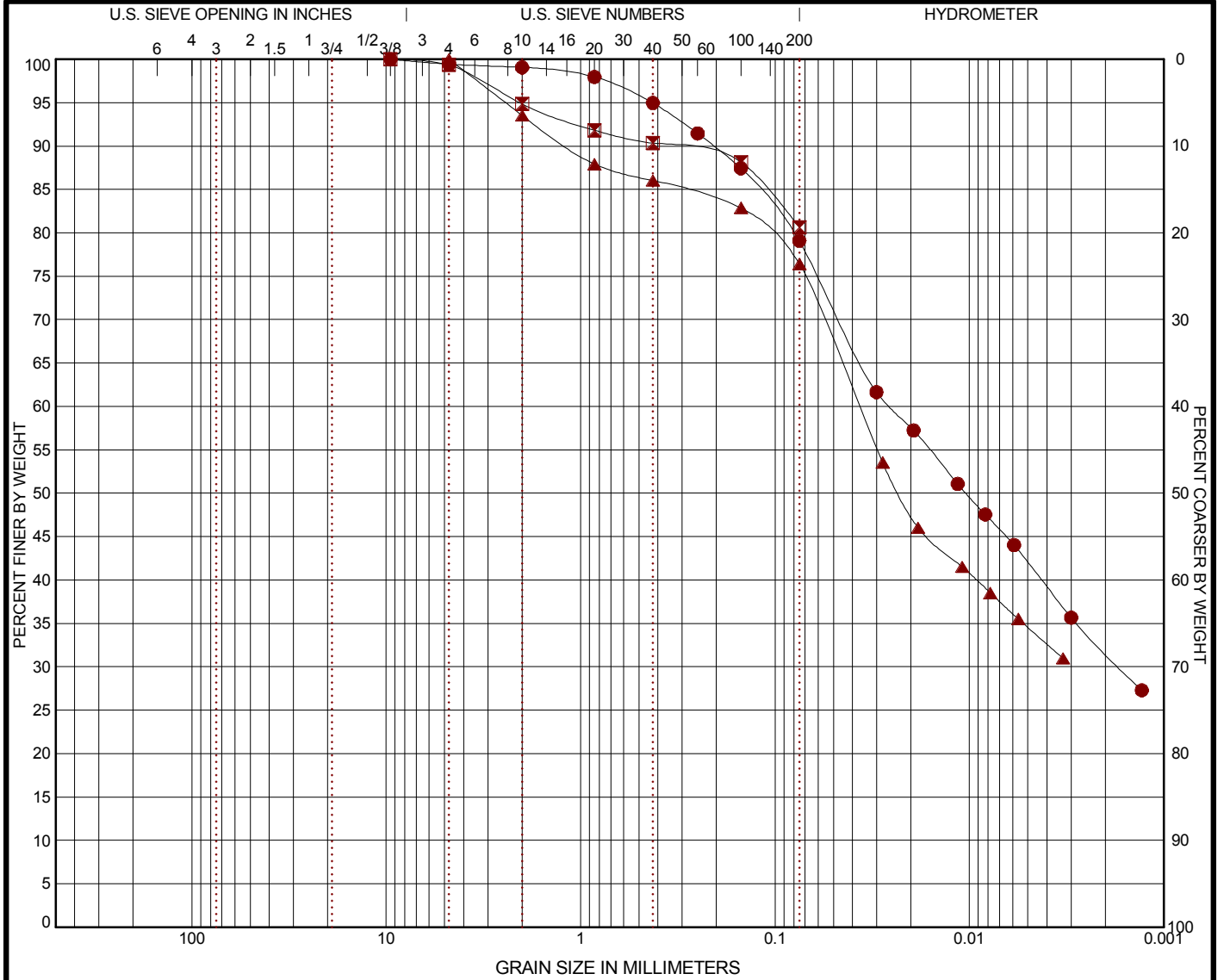
CLIENT: American Electric Power

EXHIBIT: B-5

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 N4165227 OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-2	12 - 14	0.0	0.6	20.3	37.1		42.0	CL
☒	B-2	17 - 18.5	0.0	0.7	18.7		80.6		CL
▲	B-2	20 - 21.5	0.0	0.0	23.6	41.9		34.5	CL

GRAIN SIZE			
	●	☒	▲
D <sub>60</sub>	0.026		0.037
D <sub>30</sub>	0.002		
D <sub>10</sub>			
COEFFICIENTS			
C <sub>c</sub>			
C <sub>u</sub>			

SIEVE (size)	PERCENT FINER		
	●	☒	▲
1 1/2"			
1"			
3/4"			
1/2"			
3/8"	100.0	100.0	
#4	99.43	99.35	100.0
#10	99.07	94.83	93.52
#20	97.96	91.82	87.92
#40	94.97	90.33	86.03
#100	87.45	88.15	82.87
#200	79.1	80.63	76.42

SOIL DESCRIPTION	
●	LEAN CLAY with SAND (CL)
☒	LEAN CLAY with SAND (CL)
▲	LEAN CLAY with SAND (CL)
REMARKS	
●	
☒	
▲	

PROJECT: Oklaunion Ponds Area Dikes

SITE: AEP Oklaunion Power Station  
Vernon, Texas

**Terracon**  
800 Morrison Rd  
Gahanna, OH

PROJECT NUMBER: N4165227

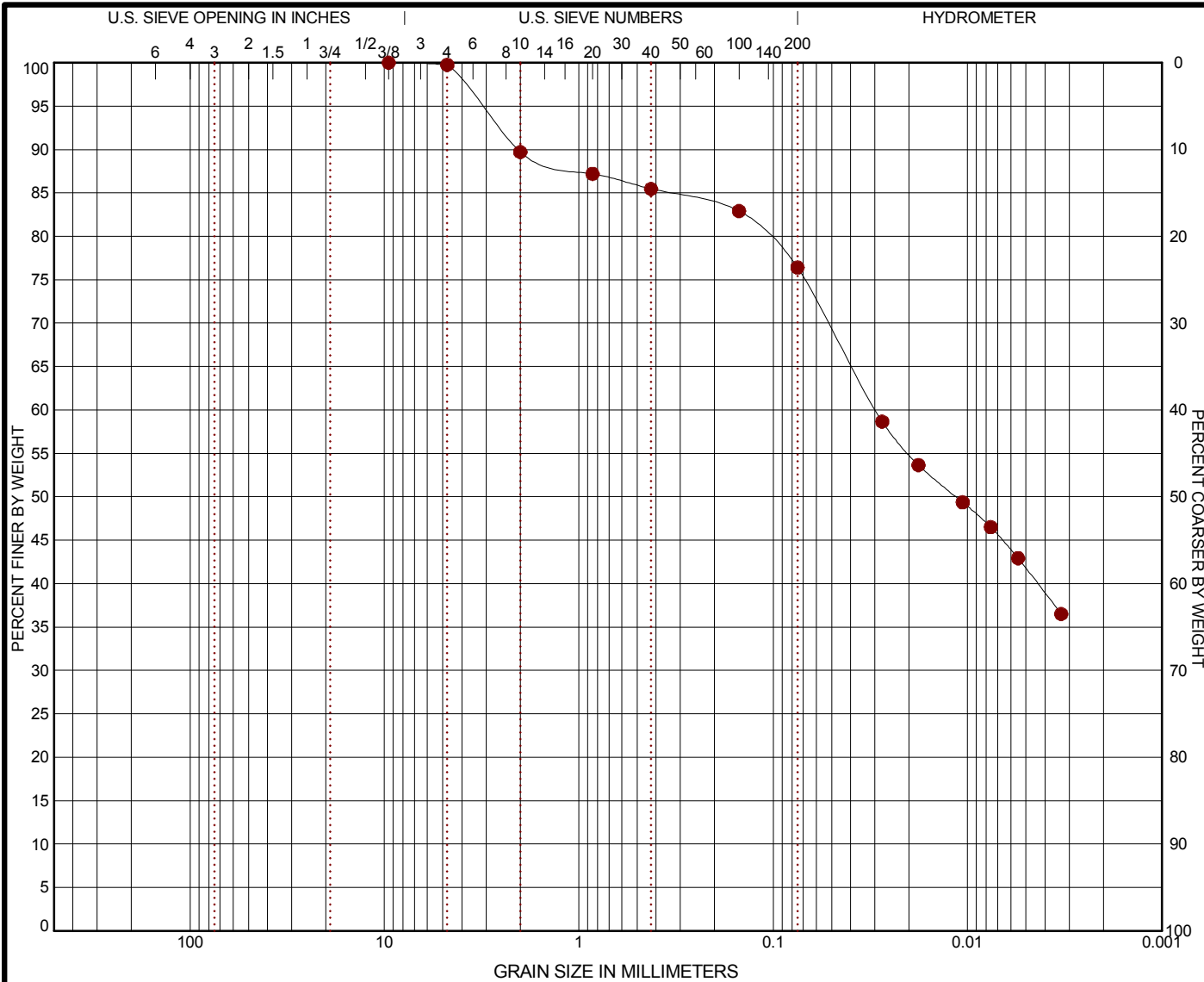
CLIENT: American Electric Power

EXHIBIT: B-6

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 N4165227 OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



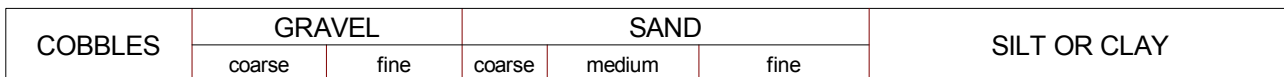
## ASTM D4318



LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS N4165227.OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

EXHIBIT: B-8

## ASTM D422 / ASTM C136



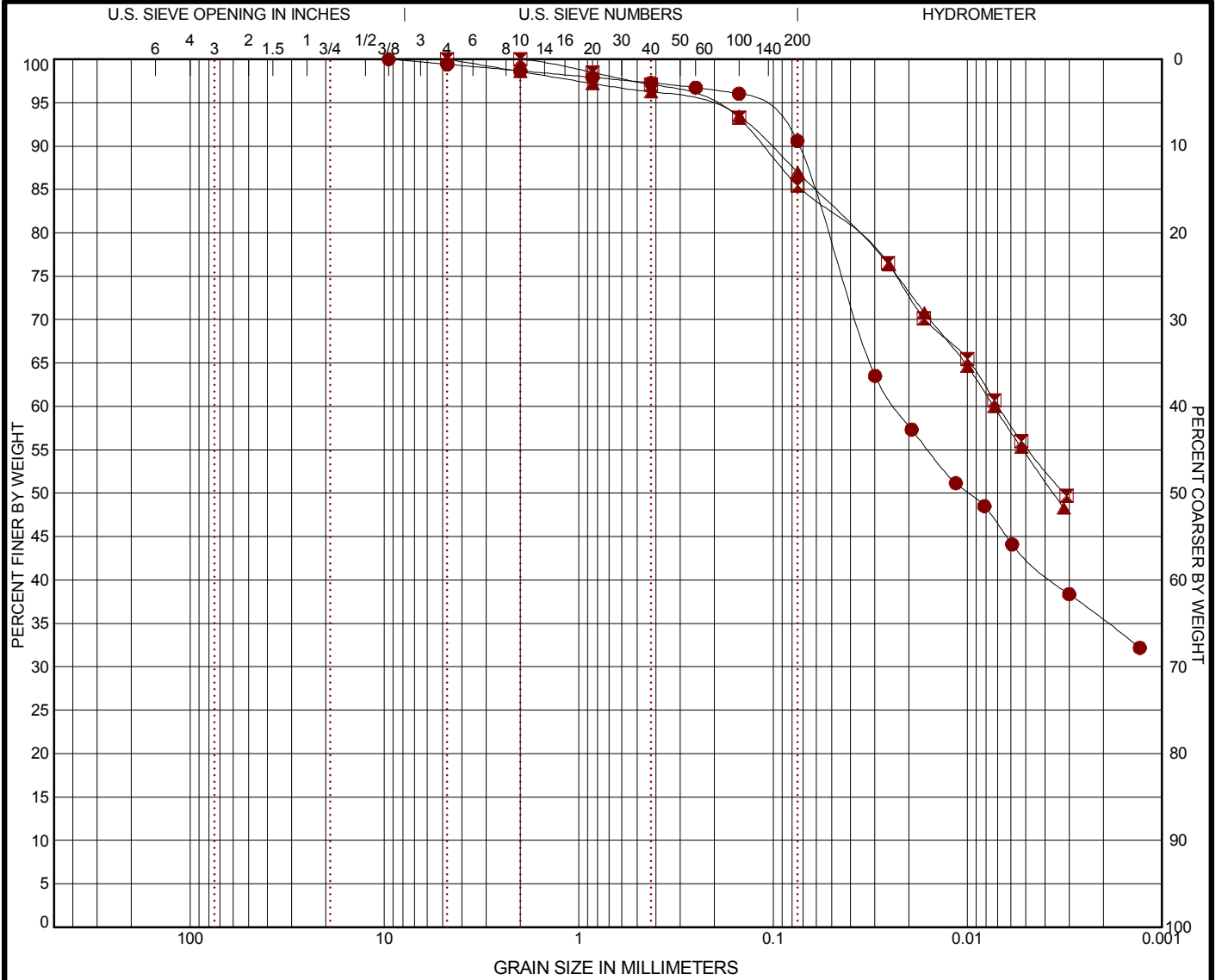
				SIEVE (size)	PERCENT FINER			SOIL DESCRIPTION
					●	☒	▲	● CLAYEY SAND (SC)
GRAIN SIZE								☒ LEAN CLAY (CL)
								▲ LEAN CLAY (CL)
D <sub>60</sub>	0.368	0.027	0.01	1 1/2"				
D <sub>30</sub>	0.027	0.002		1"				
D <sub>10</sub>				3/4"				
				1/2"	100.0			
				3/8"	98.28	100.0		
				#4	91.16	99.88	100.0	
				#10	82.17	98.88	99.22	
				#20	73.95	97.77	98.6	
				#40	62.05	96.28	97.95	
				#100	47.13	92.37	95.17	
				#200	39.89	85.48	88.73	
COEFFICIENTS								
C <sub>c</sub>								
C <sub>u</sub>								
								REMARKS
								●
								☒
								▲

EXHIBIT: B-9

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 N4165227,OKLAUNION POWER STATION NEW.GPI TERRACON2015.GDT 8/23/16

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-3	12 - 14	0.0	0.6	8.8	47.9		42.7	CL
⊠	B-3	14 - 15.5	0.0	0.0	14.6	30.1		55.3	CL
▲	B-3	15.5 - 17	0.0	0.0	13.0	32.5		54.5	CL

GRAIN SIZE			
	●	⊠	▲
D <sub>60</sub>	0.023	0.007	0.007
D <sub>30</sub>			
D <sub>10</sub>			
COEFFICIENTS			
C <sub>c</sub>			
C <sub>u</sub>			

SIEVE (size)	PERCENT FINER		
	●	⊠	▲
1 1/2"			
1"			
3/4"			
1/2"			
3/8"	100.0		
#4	99.41	100.0	100.0
#10	98.66	99.99	98.58
#20	97.91	98.49	97.2
#40	97.28	97.09	96.24
#100	96.04	93.24	93.49
#200	90.59	85.45	87.0

SOIL DESCRIPTION
● LEAN CLAY (CL)
⊠ LEAN CLAY (CL)
▲ LEAN CLAY (CL)
REMARKS
●
⊠
▲

PROJECT: Oklaunion Ponds Area Dikes

SITE: AEP Oklaunion Power Station  
Vernon, Texas

**Terracon**  
800 Morrison Rd  
Gahanna, OH

PROJECT NUMBER: N4165227

CLIENT: American Electric Power

EXHIBIT: B-10

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 N4165227 OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

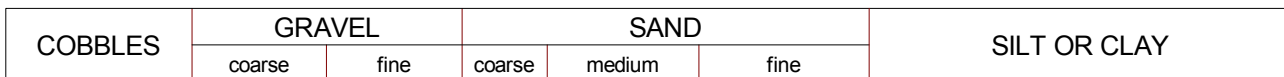
## ASTM D4318






LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS N4165227.OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

EXHIBIT: B-11

## ASTM D422 / ASTM C136



	GRAIN SIZE		
			
D <sub>60</sub>	<b>0.352</b>	<b>0.032</b>	<b>0.015</b>
D <sub>30</sub>	<b>0.026</b>		
D <sub>10</sub>			
	COEFFICIENTS		
C <sub>C</sub>			
C <sub>U</sub>			

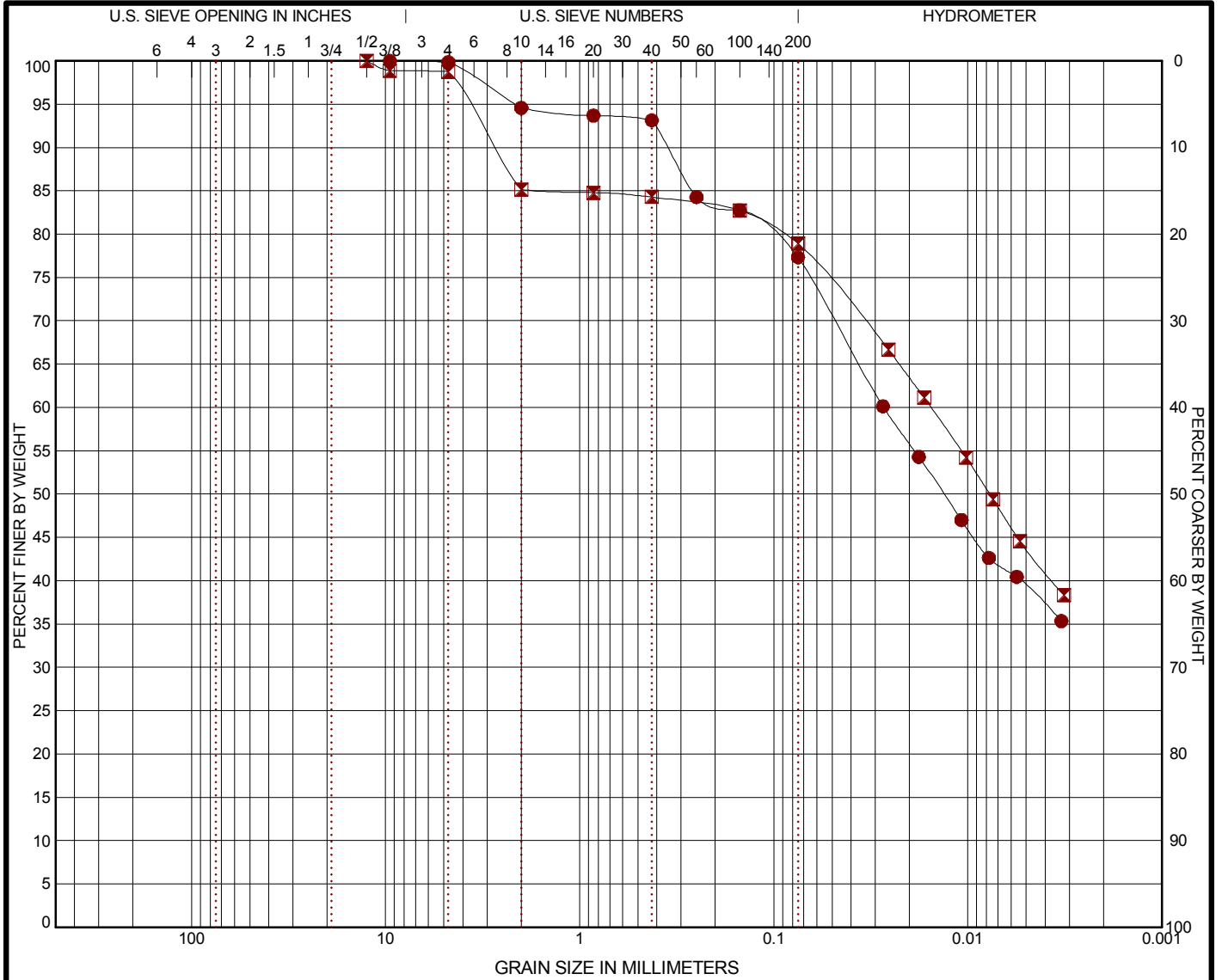
SOIL DESCRIPTION	
●	CLAYEY SAND (SC)
☒	LEAN CLAY with SAND (CL)
▲	LEAN CLAY with SAND (CL)
<u>REMARKS</u>	
●	
☒	
▲	

EXHIBIT: B-12

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 N4165227.OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
B-4	8.5 - 10.5	0.0	0.1	22.5	38.0		39.4	CL
B-4	10.5 - 12	0.0	1.2	19.8	35.3		43.6	CL

GRAIN SIZE			
	●	☒	
D <sub>60</sub>	0.027	0.015	
D <sub>30</sub>			
D <sub>10</sub>			
COEFFICIENTS			
C <sub>c</sub>			
C <sub>u</sub>			

SIEVE (size)	PERCENT FINER	
	●	☒
1 1/2"		
1"		
3/4"		
1/2"		100.0
3/8"	100.0	98.86
#4	99.85	98.75
#10	94.57	85.16
#20	93.69	84.79
#40	93.14	84.3
#100	82.75	82.75
#200	77.33	78.92

SOIL DESCRIPTION
● LEAN CLAY with SAND (CL)
☒ LEAN CLAY with SAND (CL)
REMARKS
●
☒

PROJECT: Oklaunion Ponds Area Dikes

SITE: AEP Oklaunion Power Station  
Vernon, Texas

**Terracon**  
800 Morrison Rd  
Gahanna, OH

PROJECT NUMBER: N4165227

CLIENT: American Electric Power

EXHIBIT: B-13

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 N4165227 OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

## ASTM D4318

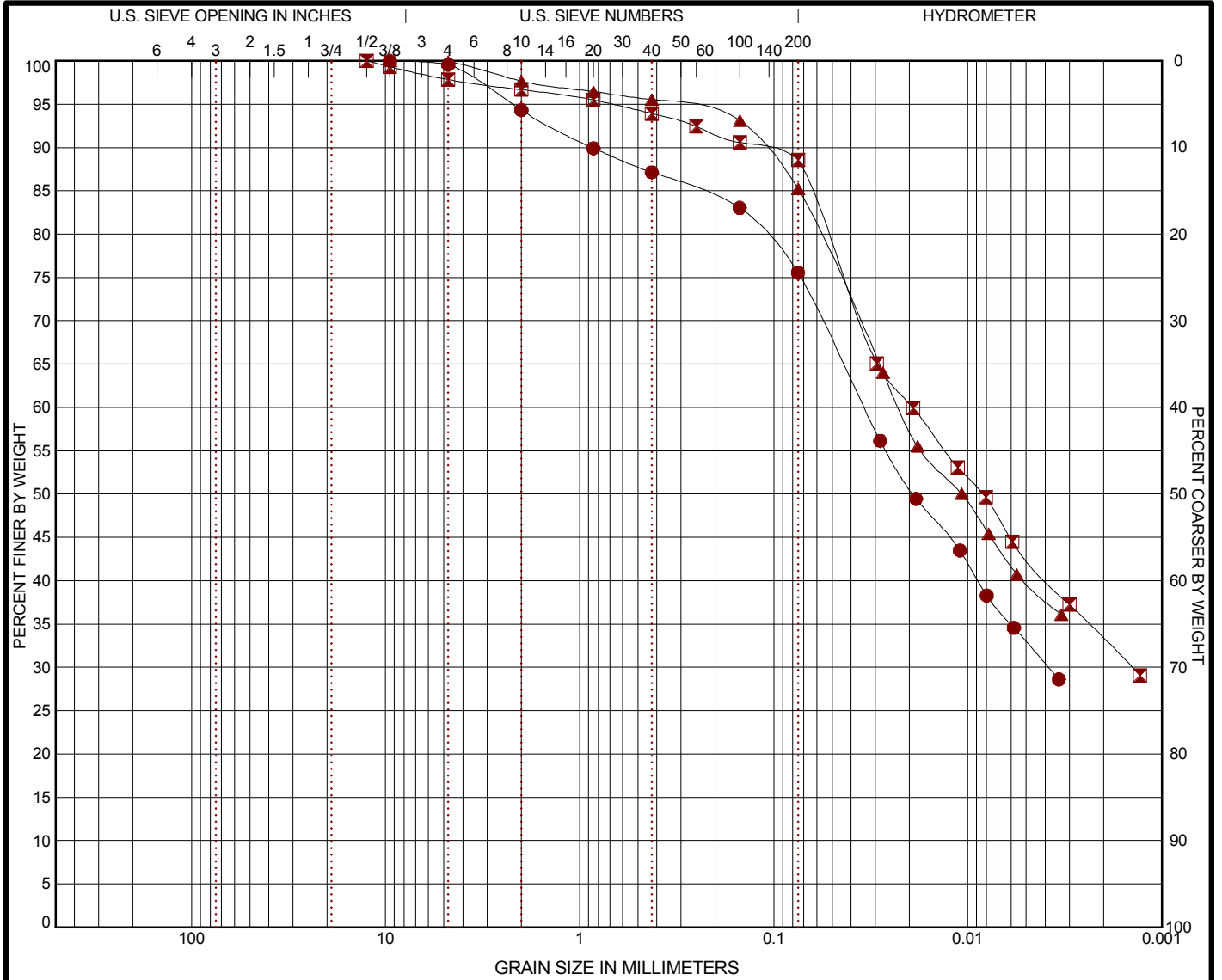


LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS N4165227.OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

EXHIBIT: B-14

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



## ASTM D422 / ASTM C136



	GRAIN SIZE		
			
D <sub>60</sub>	<b>0.036</b>	<b>0.016</b>	
D <sub>30</sub>		<b>0.001</b>	
D <sub>10</sub>			
	COEFFICIENTS		
C <sub>c</sub>			
C <sub>u</sub>			

EXHIBIT: B-16

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 N4165227, OKLA UNION POWER STATION NEW, GPJ TERRACON2015.GDT 8/23/16

## ASTM D4318

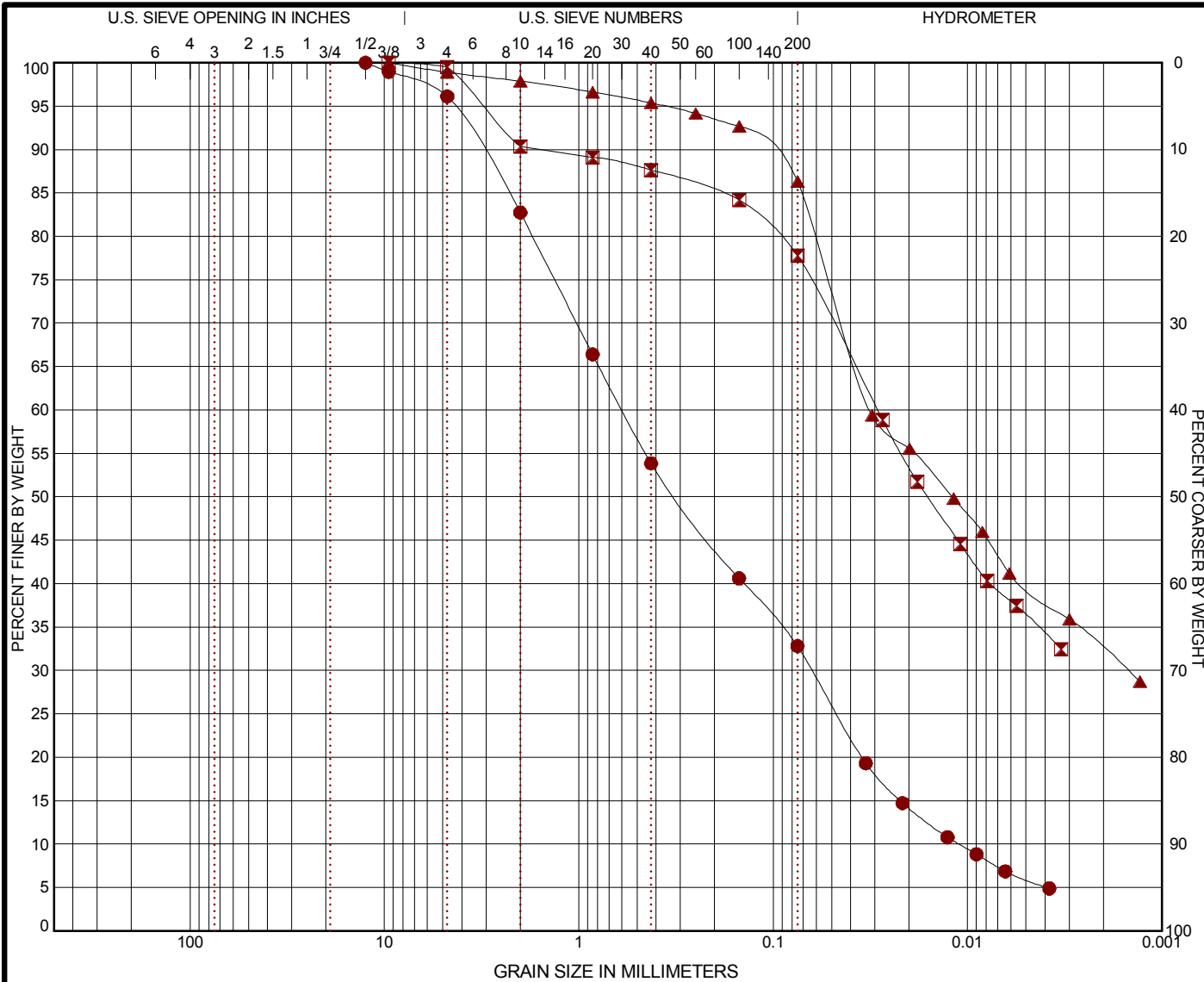


LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS N4165227.OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

EXHIBIT: B-17

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-6	1.5 - 3	0.0	3.9	63.3	26.9		5.9	SC
⊠	B-6	3 - 4.5	0.0	0.5	21.7	41.4		36.4	CL
▲	B-6	5 - 7	0.0	1.1	12.6	46.6		39.7	CL

	GRAIN SIZE			SIEVE (size)	PERCENT FINER			SOIL DESCRIPTION
	●	⊠	▲		●	⊠	▲	
D <sub>60</sub>	0.596	0.029	0.032	1 1/2"	100.0	100.0	100.0	CLAYEY SAND (SC)
D <sub>30</sub>	0.063		0.002	1"	98.96	100.0	98.89	
D <sub>10</sub>	0.011			3/4"	96.12	100.0	97.87	LEAN CLAY with SAND (CL)
				1/2"	82.75	90.34	96.63	
				3/8"	66.42	89.08	95.37	LEAN CLAY (CL)
				#4	53.86	87.65	94.15	
				#10	40.62	84.19	92.67	
				#20	32.81	77.79	86.33	
				#40				
				#60				
				#100				
				#200				

SOIL DESCRIPTION

● CLAYEY SAND (SC)

⊠ LEAN CLAY with SAND (CL)

▲ LEAN CLAY (CL)

## REMARKS

●

⊠

▲

PROJECT: Oklaunion Ponds Area Dikes

SITE: AEP Oklaunion Power Station  
Vernon, Texas

**Terracon**

800 Morrison Rd  
Gahanna, OH

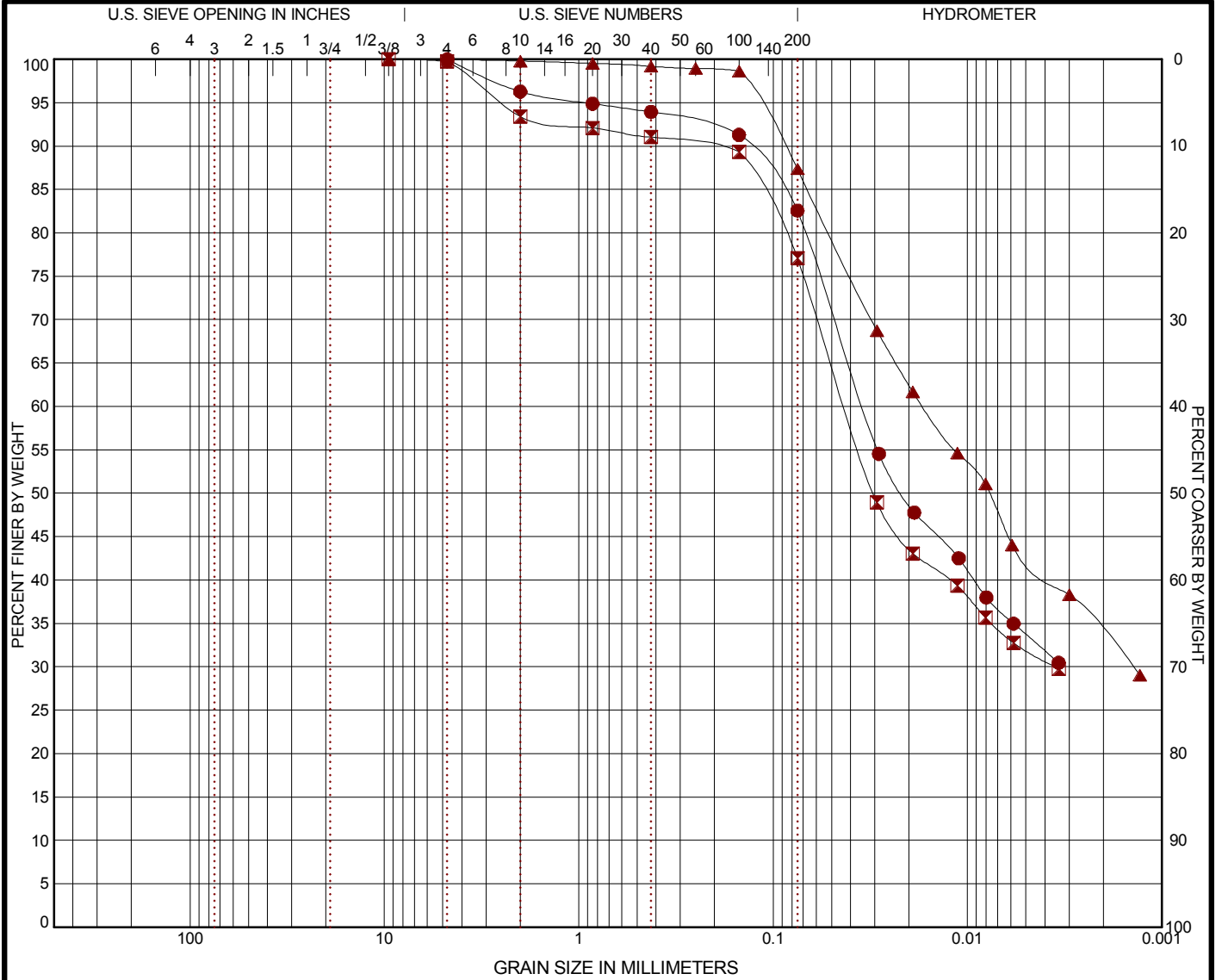
PROJECT NUMBER: N4165227

CLIENT: American Electric Power

EXHIBIT: B-18

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-6	7 - 8.5	0.0	0.0	17.4	48.8		33.7	CL
⊠	B-6	10 - 11.5	0.0	0.3	22.7	45.2		31.9	CL
▲	B-6	12 - 14	0.0	0.0	12.6	44.7		42.6	CL

	GRAIN SIZE		
	●	⊠	▲
D <sub>60</sub>	0.035	0.042	0.017
D <sub>30</sub>		0.004	0.001
D <sub>10</sub>			
COEFFICIENTS			
C <sub>c</sub>			
C <sub>u</sub>			

SIEVE (size)	PERCENT FINER		
	●	⊠	▲
1 1/2"			
1"			
3/4"			
1/2"			
3/8"			
#4	100.0	100.0	99.96
#10	96.27	93.38	99.8
#20	94.87	92.09	99.52
#40	93.93	91.02	99.17
#60			98.94
#100	91.29	89.31	98.63
#200	82.56	77.09	87.37

SOIL DESCRIPTION
● LEAN CLAY with SAND (CL)
⊠ LEAN CLAY with SAND (CL)
▲ LEAN CLAY (CL)
REMARKS
●
⊠
▲

PROJECT: Oklaunion Ponds Area Dikes

SITE: AEP Oklaunion Power Station  
Vernon, Texas

**Terracon**  
800 Morrison Rd  
Gahanna, OH

PROJECT NUMBER: N4165227

CLIENT: American Electric Power

EXHIBIT: B-19

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 N4165227 OKLAUNION POWER STATION NEW GPJ TERRACON2015.GDT 8/23/16

## ASTM D4318



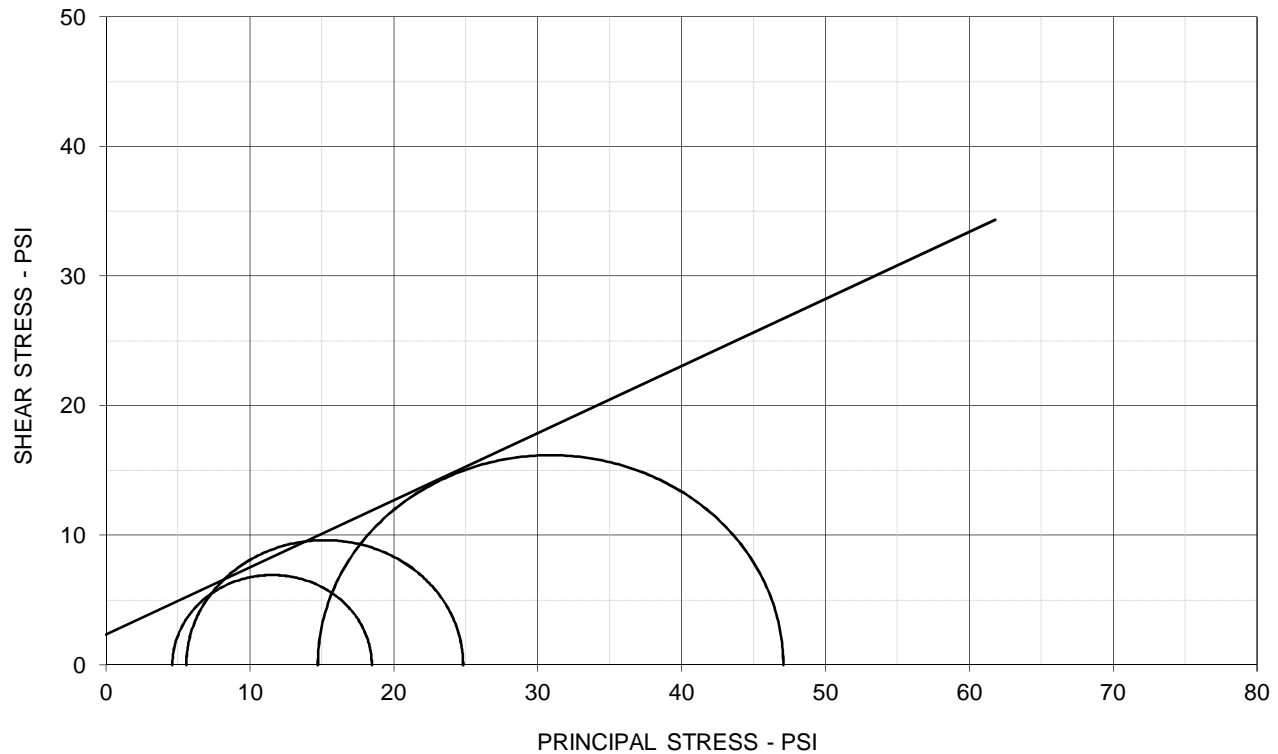
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS N4165227.OKLAUNION POWER STATION NEW.GPJ TERRACON2015.GDT 8/23/16

EXHIBIT: B-20

# TRIAXIAL SHEAR TEST REPORT



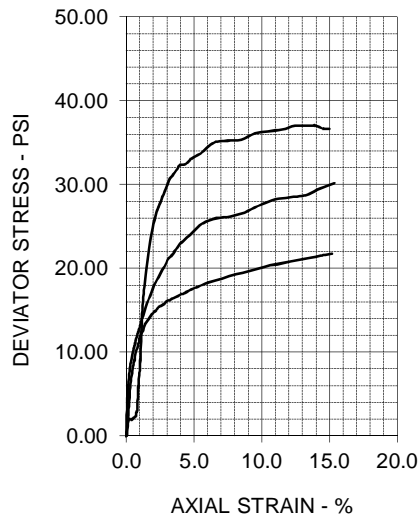
P.O. Box 5010, 51 Lost Mound Drive, Suite 135 Chattanooga, TN 37406



## EFFECTIVE STRESS PARAMETERS

$\phi' = 27.4 \text{ deg}$

$c' = 2.3 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	15.1	17.6	15.4	
Dry Density - pcf	115.3	110.2	116.8	
Diameter - inches	1.89	1.91	1.94	
Height - inches	3.95	3.95	4.00	

#### AT TEST

Final Moisture - %	16.9	19.1	15.2	
Dry Density - pcf	115.3	110.4	118.8	
Calculated Diameter (in.)	1.87	1.90	1.92	
Height - inches	3.89	3.90	3.95	
Effect. Cell Pressure - psi	6.0	12.0	24.0	
Failure Stress - psi	13.86	19.24	32.35	
Total Pore Pressure - psi	51.4	56.4	59.3	
Strain Rate - inches/min.	0.00040	0.00040	0.00040	
Failure Strain - %	1.6	2.5	4.0	
$S_1'$ Failure - psi	18.47	24.82	47.07	
$S_3'$ Failure - psi	4.61	5.58	14.72	

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-1, ST-1, 5.0-7.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 34 PL: 16 PI: 18 Percent -200: 88.4  
 REMARKS: Specimens trimmed to 2.0" diameter.

## PROJECT INFORMATION

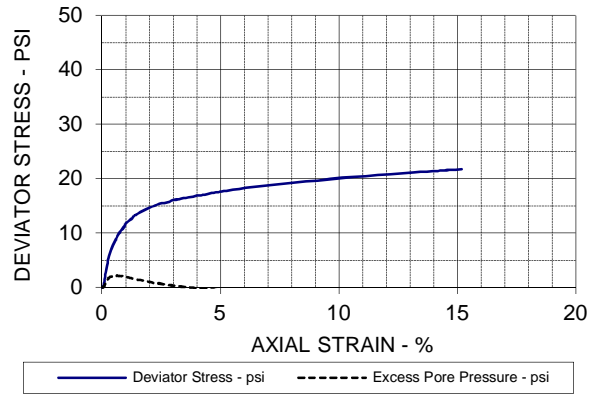
PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/19/16

**TERRACON**

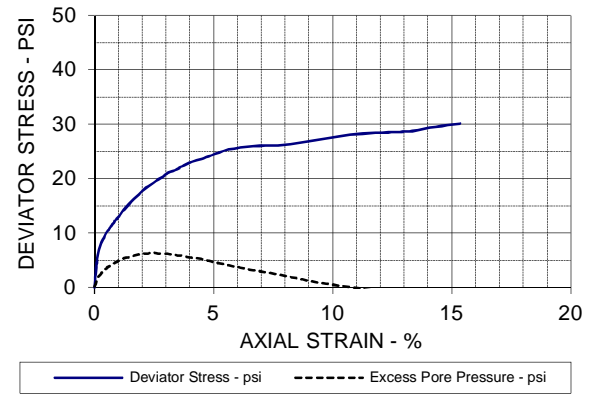
Exhibit: B-21

Note: Stage two (2) specimen subjected to Hydraulic Conductivity test prior to Triaxial Shear Testing.

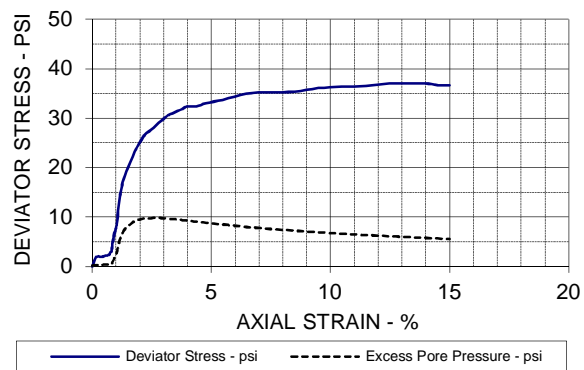
SPECIMEN NO. 1



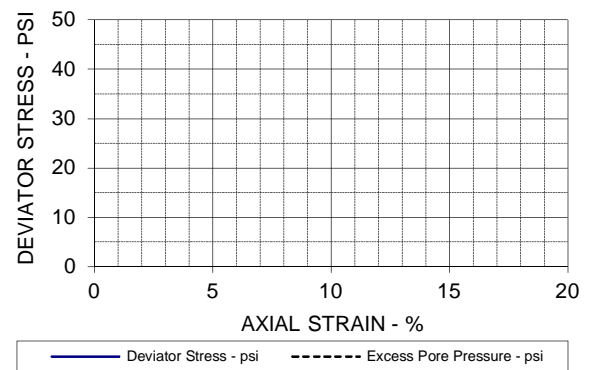
SPECIMEN NO. 2



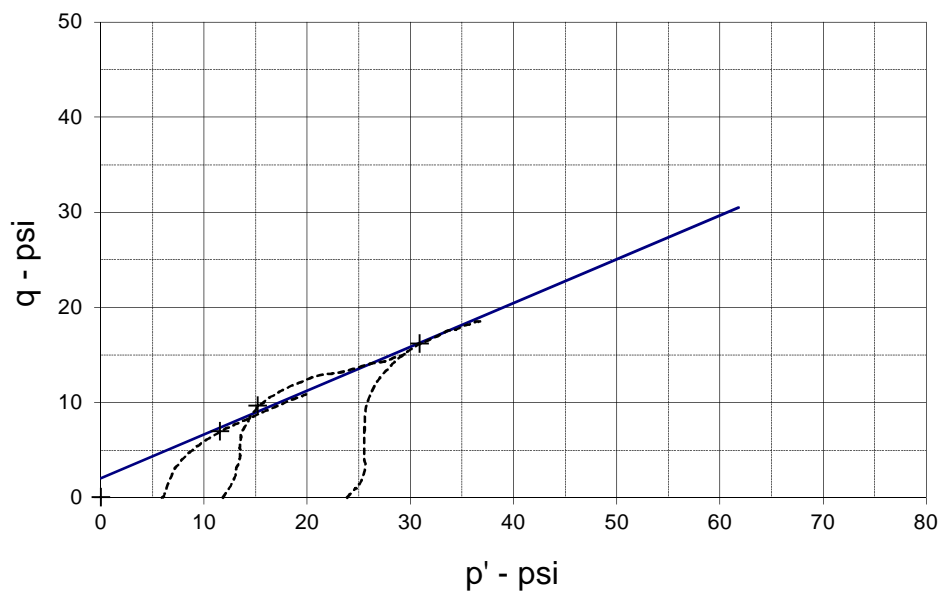
SPECIMEN NO. 3



SPECIMEN NO. 4

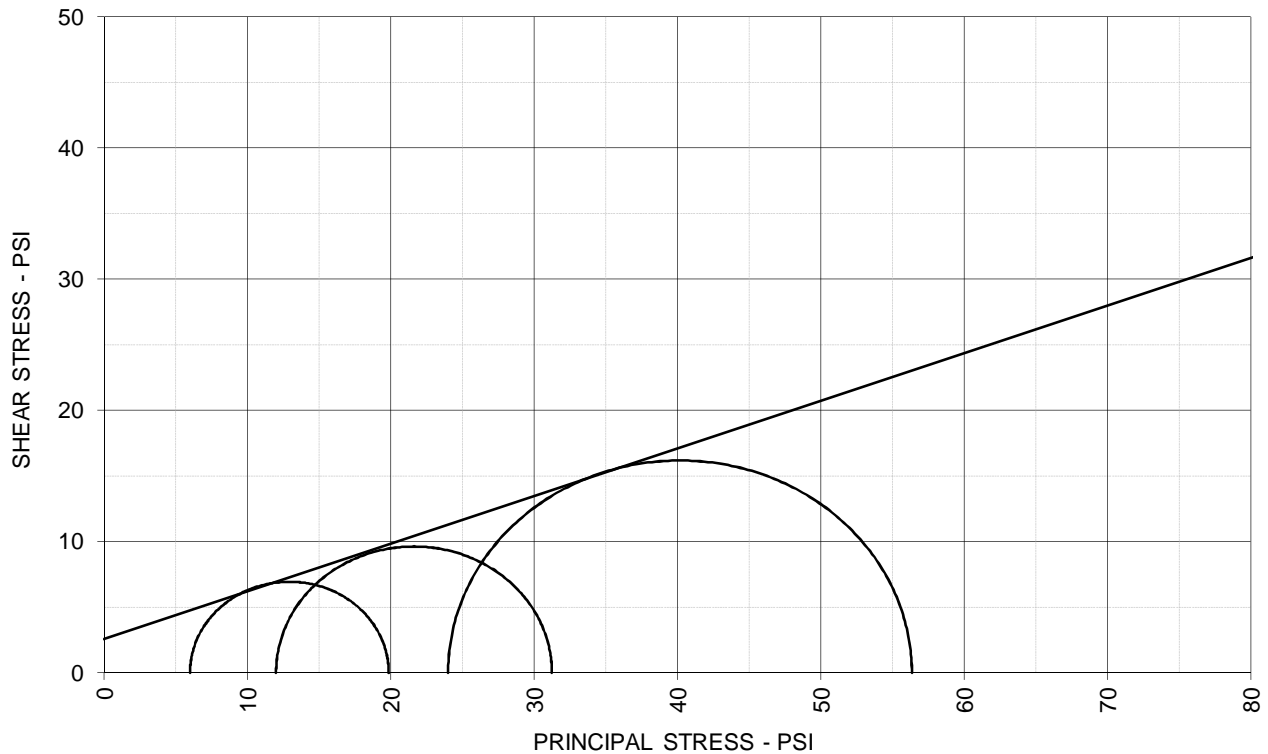


p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS	$R^2 = 0.99$	$a \text{ (deg)} = 24.7$	$a \text{ (psi)} = 2.1$
PROJECT: Oklaunion- Ponds Area Dikes	TYPE OF TEST & NO: CU with Pore Pressure		
PROJECT NO: N4165227	<b>TERRACON</b>		
DESCRIPTION: Lean Clay (CL)			
			Exhibit: B-21

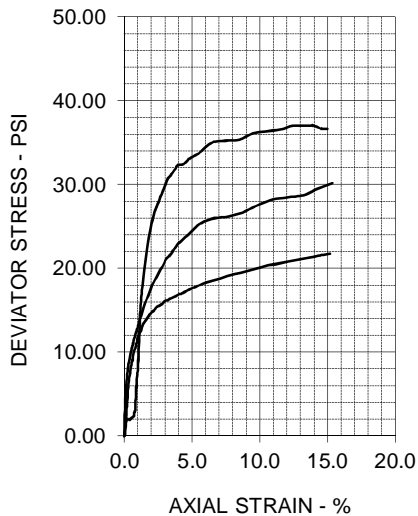
# TRIAXIAL SHEAR TEST REPORT



## TOTAL STRESS PARAMETERS

$\phi = 20.0 \text{ deg}$

$c = 2.6 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	15.1	17.6	15.4
Dry Density - pcf	115.3	110.2	116.8
Diameter - inches	1.89	1.91	1.94
Height - inches	3.95	3.95	4.00

#### AT TEST

Final Moisture - %	16.9	19.1	15.2
Dry Density - pcf	115.3	110.4	118.8
Calculated Diameter (in.)	1.87	1.90	1.92
Height - inches	3.89	3.90	3.95
Effect. Cell Pressure - psi	6.0	12.0	24.0
Failure Stress - psi	13.86	19.24	32.35
Total Pore Pressure - psi	51.4	56.4	59.3
Strain Rate - inches/min.	0.00040	0.00040	0.00040
Failure Strain - %	1.6	2.5	4.0
$S_1$ Failure - psi	19.86	31.24	56.35
$S_3$ Failure - psi	6.00	12.00	24.00

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-1, ST-1, 5.0-7.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 34 PL: 16 PI: 18 Percent -200: 88.4  
 REMARKS: Specimens trimmed to 2.0" diameter.

## PROJECT INFORMATION

PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/19/16

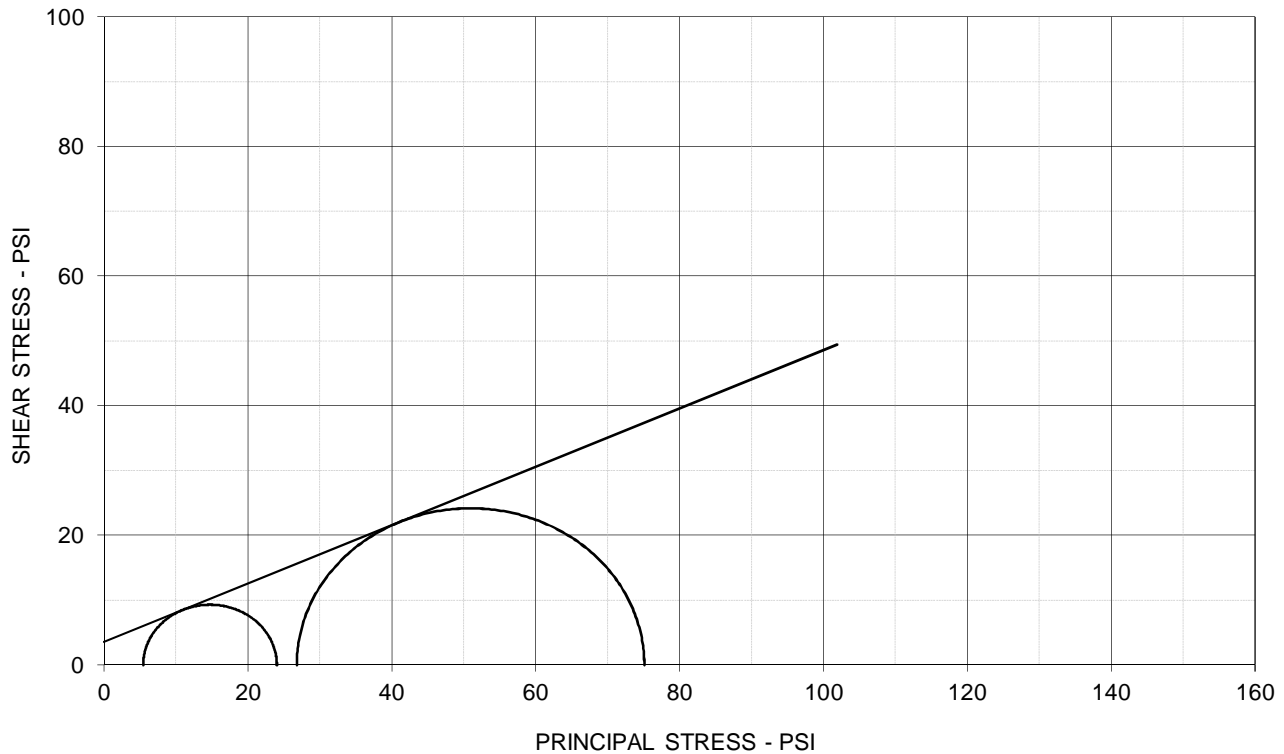
**TERRACON**

Exhibit: B-21

# TRIAXIAL SHEAR TEST REPORT



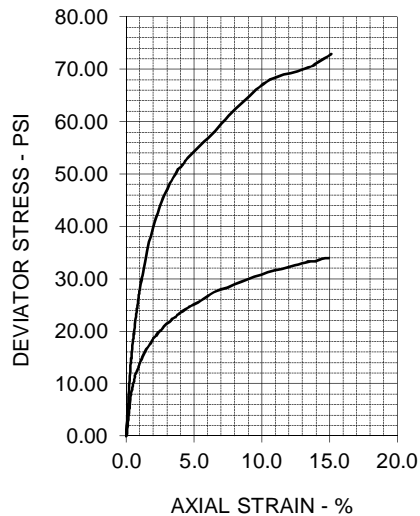
P.O. Box 5010, 51 Lost Mound Drive, Suite 135 Chattanooga, TN 37406



## EFFECTIVE STRESS PARAMETERS

$\phi' = 24.2 \text{ deg}$

$c' = 3.6 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	14.8	14.9		
Dry Density - pcf	116.8	118.8		
Diameter - inches	1.35	1.38		
Height - inches	2.81	2.80		

#### AT TEST

Final Moisture - %	15.9	15.0		
Dry Density - pcf	116.9	119.2		
Calculated Diameter (in.)	1.34	1.36		
Height - inches	2.77	2.75		
Effect. Cell Pressure - psi	8.0	32.0		
Failure Stress - psi	18.58	48.31		
Total Pore Pressure - psi	52.6	55.2		
Strain Rate - inches/min.	0.00030	0.00030		
Failure Strain - %	2.0	3.3		
$S_1'$ Failure - psi	24.02	75.10		
$S_3'$ Failure - psi	5.44	26.79		

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-1, ST-2, 12.0-14.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 31 PL: 14 PI: 17 Percent -200: 89.8  
 REMARKS: Specimens trimmed to 1.4" diameter.

## PROJECT INFORMATION

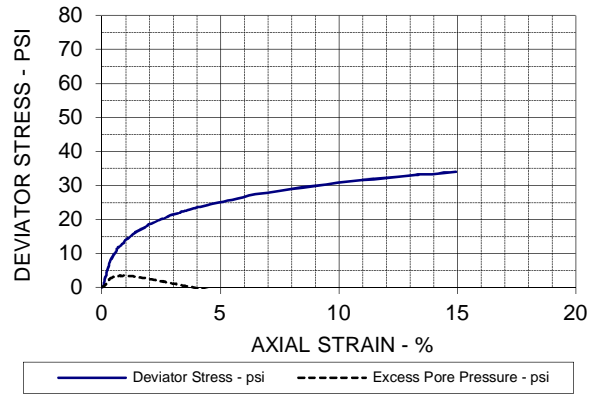
PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/19/16

**TERRACON**

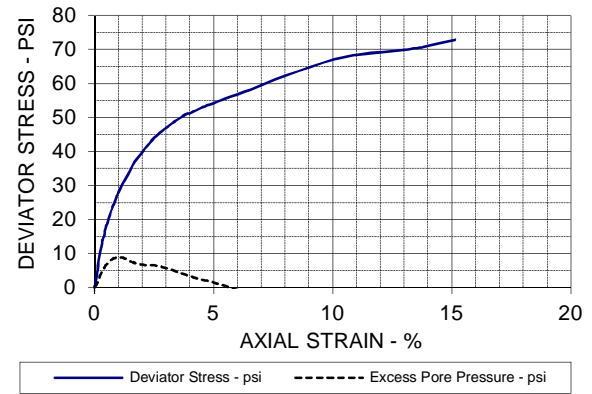
Exhibit: B-22

Note: Stage two (2) specimen subjected to Hydraulic Conductivity test prior to Triaxial Shear Testing.

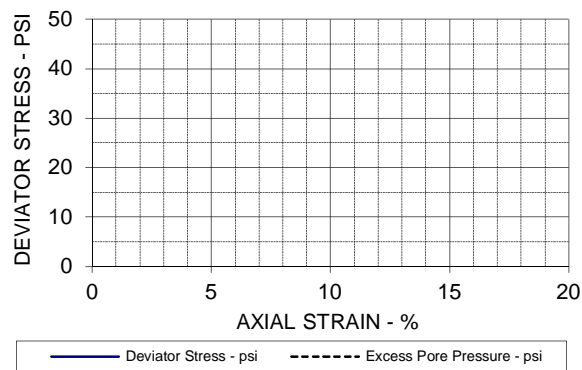
SPECIMEN NO. 1



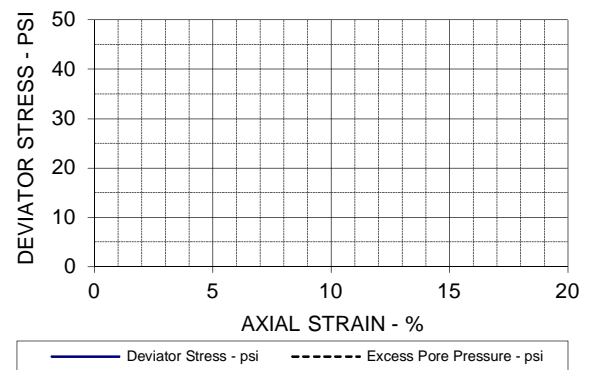
SPECIMEN NO. 2



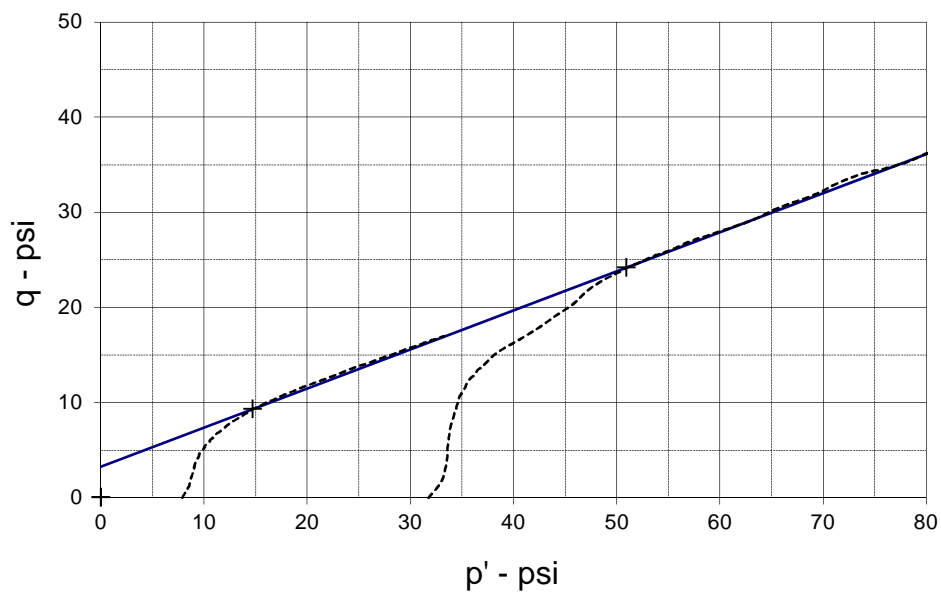
SPECIMEN NO. 3



SPECIMEN NO. 4

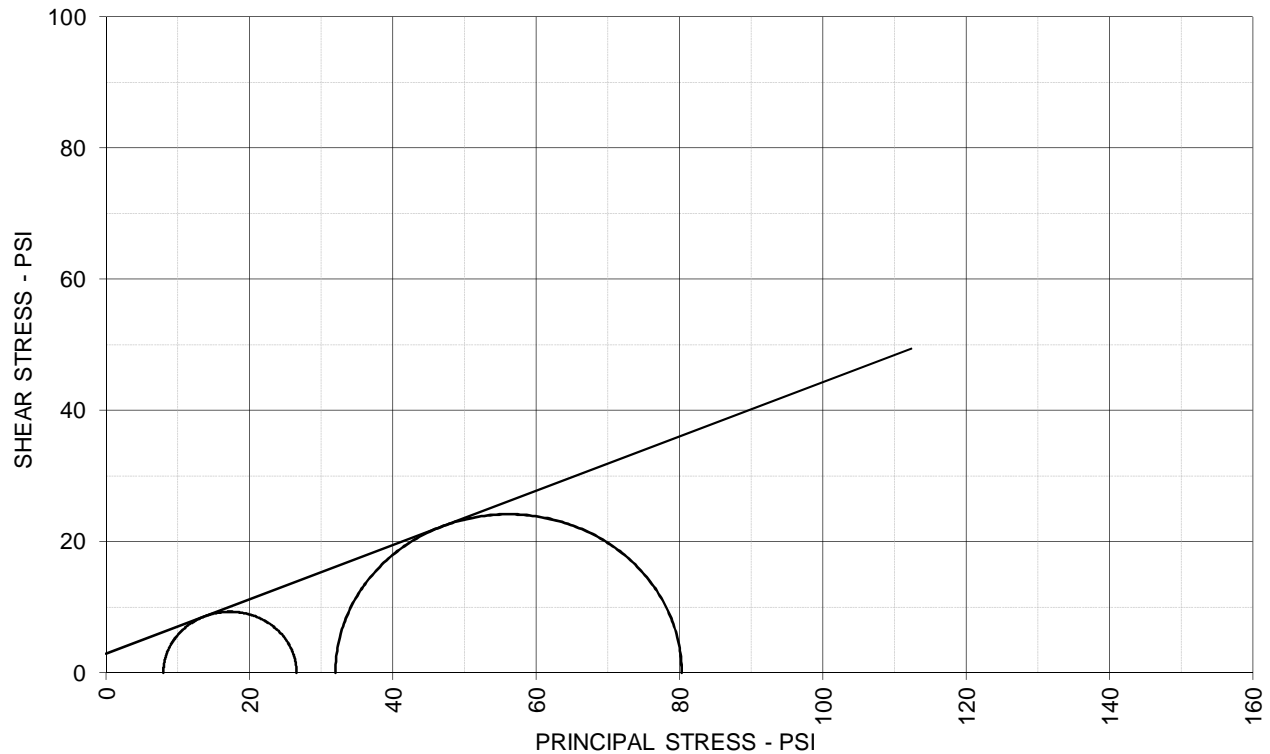


p - q DIAGRAM



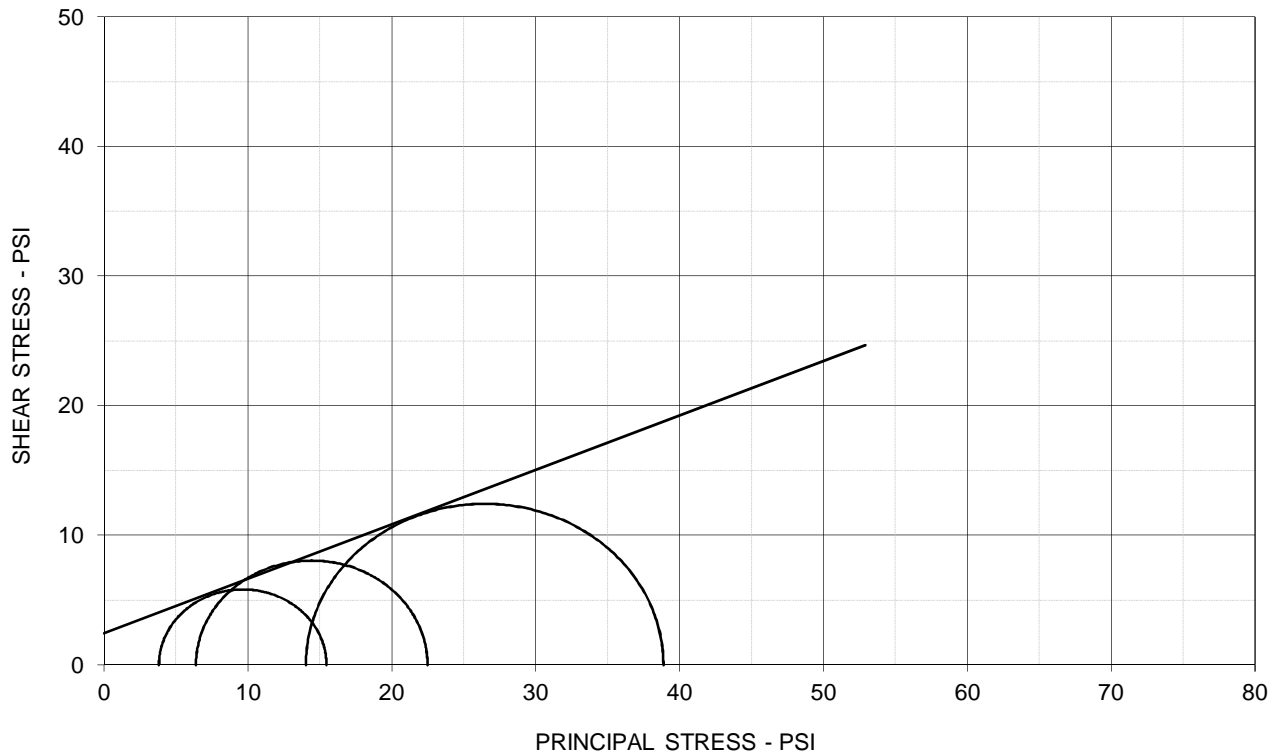
EFFECTIVE STRESS PARAMETERS	$R^2 = 1.00$	$a \text{ (deg)} = 22.3$	$a \text{ (psi)} = 3.2$
PROJECT: Oklaunion- Ponds Area Dikes	TYPE OF TEST & NO: CU with Pore Pressure		
PROJECT NO: N4165227	<b>TERRACON</b>		
DESCRIPTION: Lean Clay (CL)			
			Exhibit: B-22

# TRIAXIAL SHEAR TEST REPORT



TOTAL STRESS PARAMETERS		$\phi = 22.5 \text{ deg}$		$c = 2.9 \text{ psi}$	
	SPECIMEN NO.	1	2	3	4
	INITIAL				
	Moisture Content - %	14.8	14.9		
	Dry Density - pcf	116.8	118.8		
	Diameter - inches	1.35	1.38		
	Height - inches	2.81	2.80		
	AT TEST				
	Final Moisture - %	15.9	15.0		
	Dry Density - pcf	116.9	119.2		
	Calculated Diameter (in.)	1.34	1.36		
TEST DESCRIPTION		PROJECT INFORMATION			
TYPE OF TEST & NO: CU with Pore Pressure SAMPLE TYPE: Tube DESCRIPTION: Lean Clay (CL) SAMPLE LOCATION: B-1, ST-2, 12.0-14.0 ft ASSUMED SPECIFIC GRAVITY: 2.70 LL: 31    PL: 14    PI: 17    Percent -200: 89.8 REMARKS: Specimens trimmed to 1.4" diameter.		PROJECT: Oklaunion- Ponds Area Dikes			
		LOCATION: Vernon, TX			
		PROJECT NO: N4165227			
		CLIENT: AEP			
		DATE: 8/19/16			
		TERRACON		Exhibit: B-22	

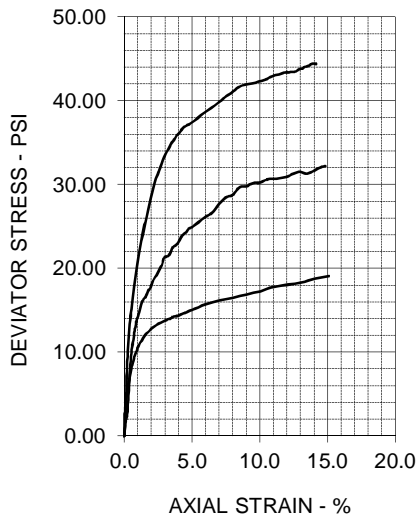
# TRIAXIAL SHEAR TEST REPORT



## EFFECTIVE STRESS PARAMETERS

$\phi' = 22.8 \text{ deg}$

$c' = 2.4 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

### INITIAL

Moisture Content - %	16.9	16.6	14.3
Dry Density - pcf	113.6	117.0	117.3
Diameter - inches	1.93	1.92	1.95
Height - inches	3.97	3.99	4.00

### AT TEST

Final Moisture - %	17.6	15.2	15.3
Dry Density - pcf	113.6	119.1	118.6
Calculated Diameter (in.)	1.92	1.91	1.93
Height - inches	3.93	3.97	3.95
Effect. Cell Pressure - psi	6.0	12.0	24.0
Failure Stress - psi	11.64	16.09	24.85
Total Pore Pressure - psi	52.2	55.6	60.0
Strain Rate - inches/min.	0.00040	0.00040	0.00040
Failure Strain - %	1.4	1.4	1.5
$S_1'$ Failure - psi	15.46	22.48	38.88
$S_3'$ Failure - psi	3.82	6.39	14.03

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-2, ST-1, 5.0-7.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 33 PL: 17 PI: 16 Percent -200: 85.5  
 REMARKS: Specimens trimmed to 2.0" diameter.

## PROJECT INFORMATION

PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/19/16

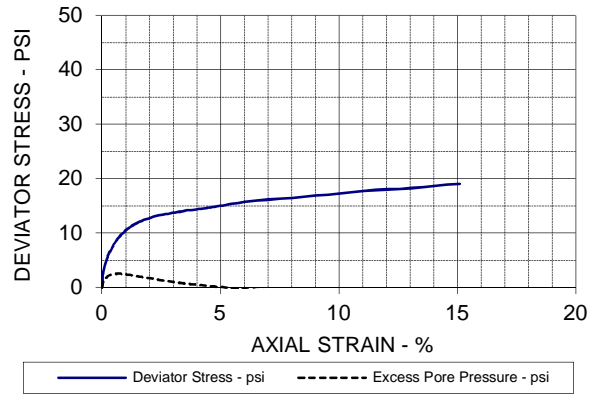
**TERRACON**

**Exhibit: B-23**

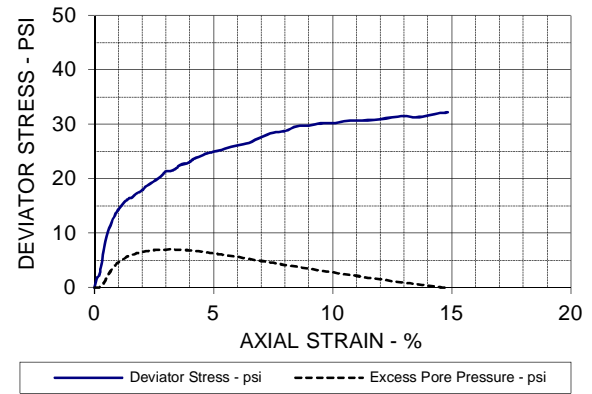
Note: Stage two (2) specimen subjected to Hydraulic Conductivity test prior to Triaxial Shear Testing.

TRIAX B2@7.xls

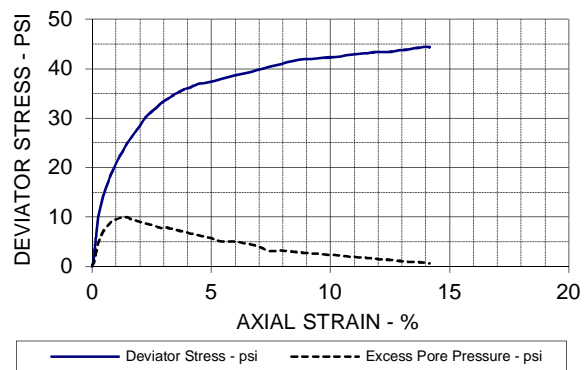
SPECIMEN NO. 1



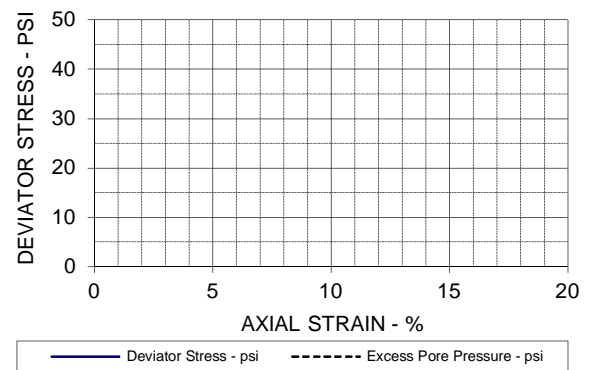
SPECIMEN NO. 2



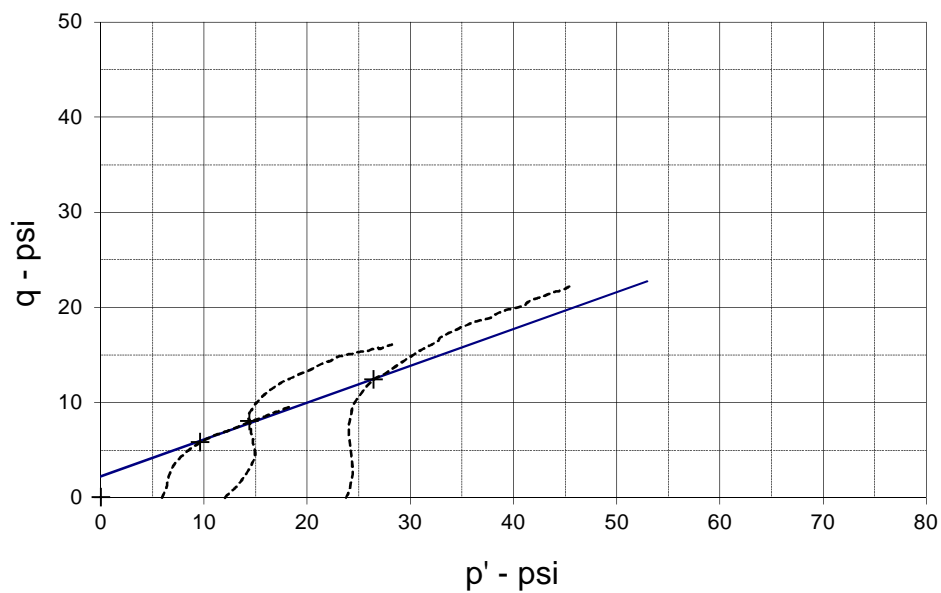
SPECIMEN NO. 3



SPECIMEN NO. 4

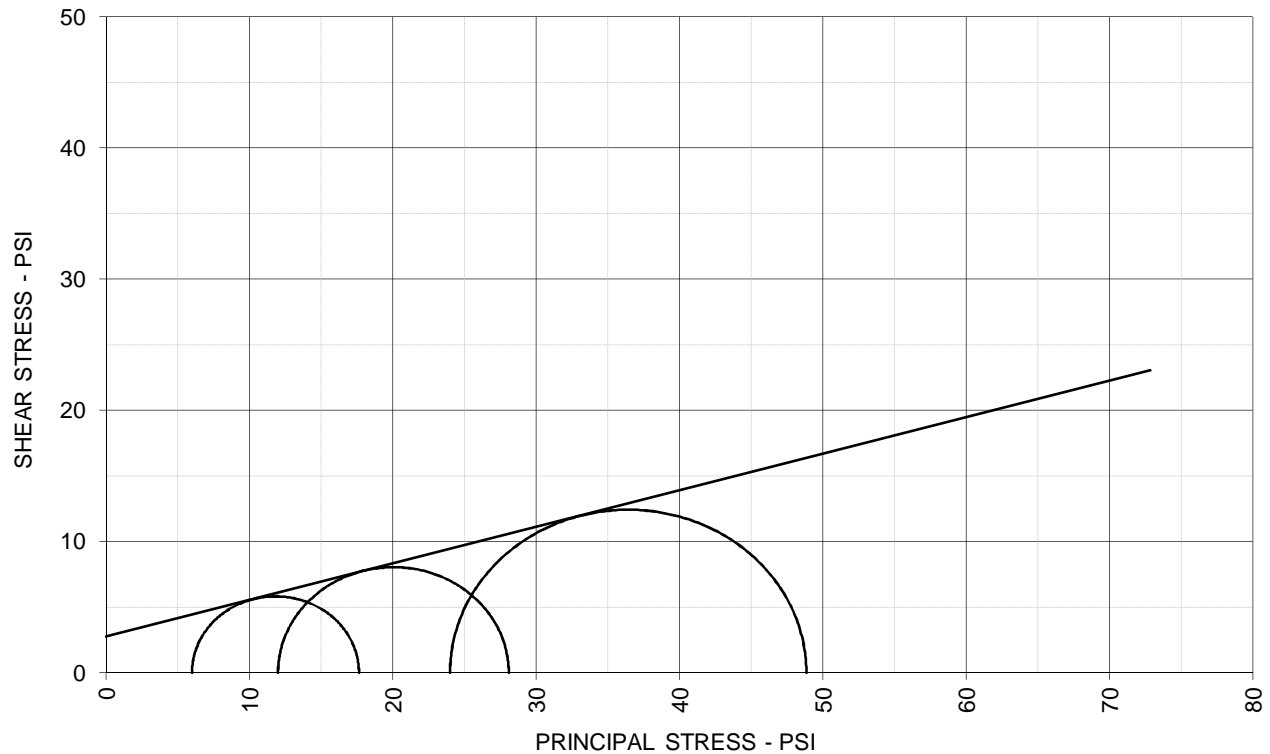


p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS	$R^2 = 1.00$	a (deg) = 21.2	a (psi) = 2.2
PROJECT: Oklaunion- Ponds Area Dikes	TYPE OF TEST & NO: CU with Pore Pressure		
PROJECT NO: N4165227	<b>TERRACON</b>		
DESCRIPTION: Lean Clay (CL)			
			Exhibit: B-23

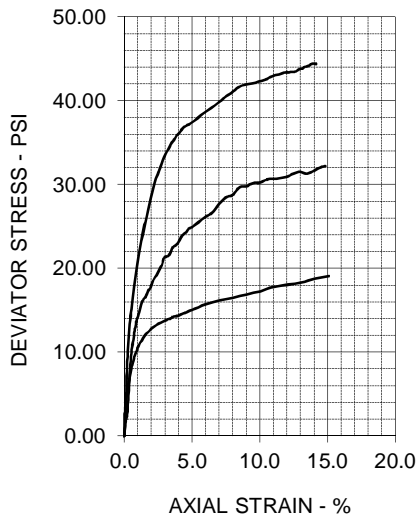
# TRIAXIAL SHEAR TEST REPORT



## TOTAL STRESS PARAMETERS

$\phi = 15.6 \text{ deg}$

$c = 2.8 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	16.9	16.6	14.3
Dry Density - pcf	113.6	117.0	117.3
Diameter - inches	1.93	1.92	1.95
Height - inches	3.97	3.99	4.00

#### AT TEST

Final Moisture - %	17.6	15.2	15.3
Dry Density - pcf	113.6	119.1	118.6
Calculated Diameter (in.)	1.92	1.91	1.93
Height - inches	3.93	3.97	3.95
Effect. Cell Pressure - psi	6.0	12.0	24.0
Failure Stress - psi	11.64	16.09	24.85
Total Pore Pressure - psi	52.2	55.6	60.0
Strain Rate - inches/min.	0.00040	0.00040	0.00040
Failure Strain - %	1.4	1.4	1.5
$S_1$ Failure - psi	17.64	28.09	48.85
$S_3$ Failure - psi	6.00	12.00	24.00

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-2, ST-1, 5.0-7.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 33 PL: 17 PI: 16 Percent -200: 85.5  
 REMARKS: Specimens trimmed to 2.0" diameter.

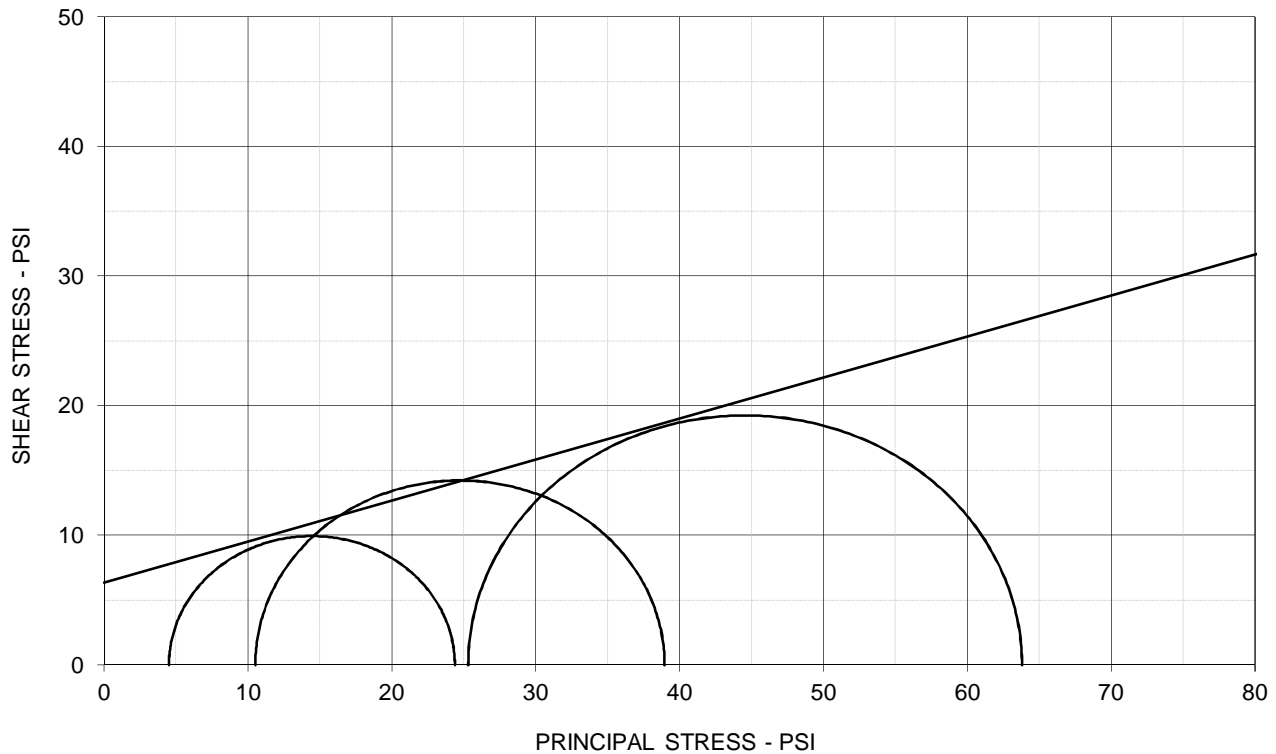
## PROJECT INFORMATION

PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/19/16

**TERRACON**

Exhibit: B-23

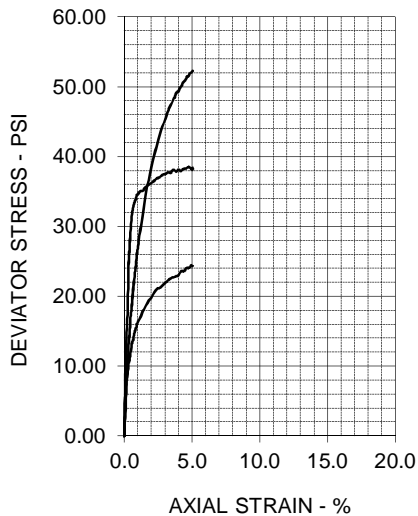
# TRIAXIAL SHEAR TEST REPORT



## EFFECTIVE STRESS PARAMETERS

$\phi' = 17.6 \text{ deg}$

$c' = 6.3 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	13.7	13.7	13.7
Dry Density - pcf	117.6	117.6	117.6
Diameter - inches	1.40	1.40	1.40
Height - inches	2.81	2.81	2.81

#### AT TEST

Final Moisture - %			14.6
Dry Density - pcf	118.4	119.6	120.1
Calculated Diameter (in.)	1.38	1.41	1.40
Height - inches	2.74	2.82	2.81
Effect. Cell Pressure - psi	8.0	16.0	32.0
Failure Stress - psi	19.87	28.45	38.49
Total Pore Pressure - psi	53.5	55.5	56.7
Strain Rate - inches/min.	0.00030	0.00030	0.00030
Failure Strain - %	2.0	0.4	2.0
$S_1'$ Failure - psi	24.38	38.96	63.80
$S_3'$ Failure - psi	4.51	10.51	25.31

## TEST DESCRIPTION

## PROJECT INFORMATION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay with Sand (CL)  
 SAMPLE LOCATION: B-2, ST-2, 12.0-14.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 28 PL: 14 PI: 14 Percent -200: 79.1  
 REMARKS: Multistage Triaxial

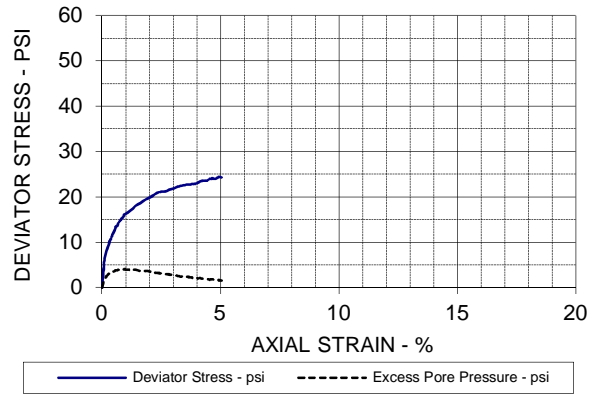
PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/19/16

**TERRACON**

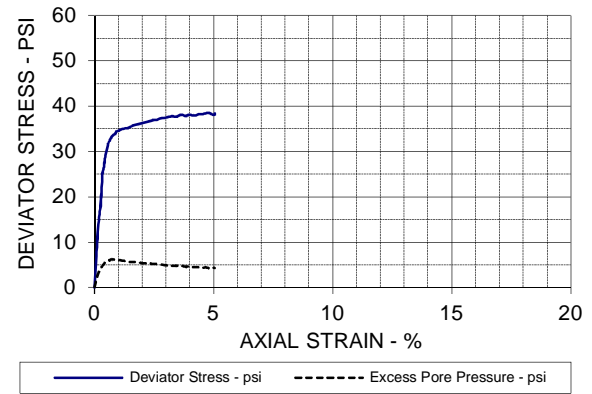
**Exhibit: B-24**

Note: Stage two (2) specimen subjected to Hydraulic Conductivity test prior to Triaxial Shear Testing.

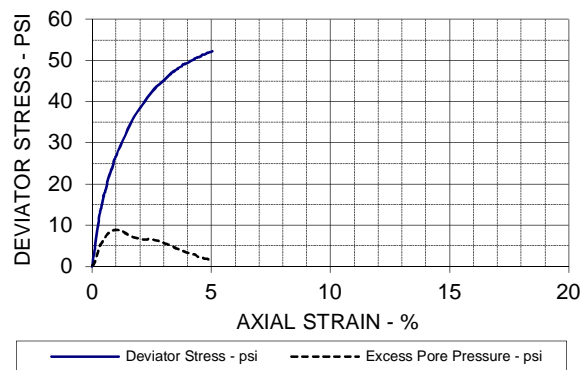
SPECIMEN NO. 1



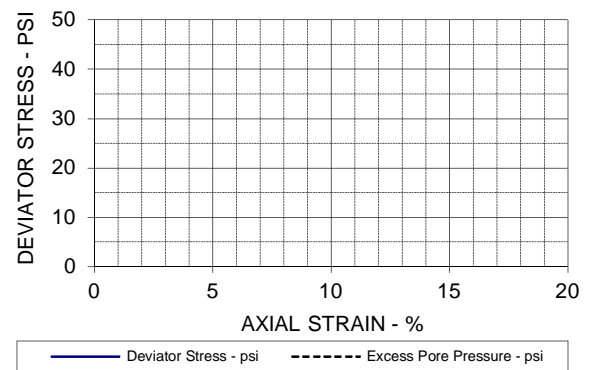
SPECIMEN NO. 2



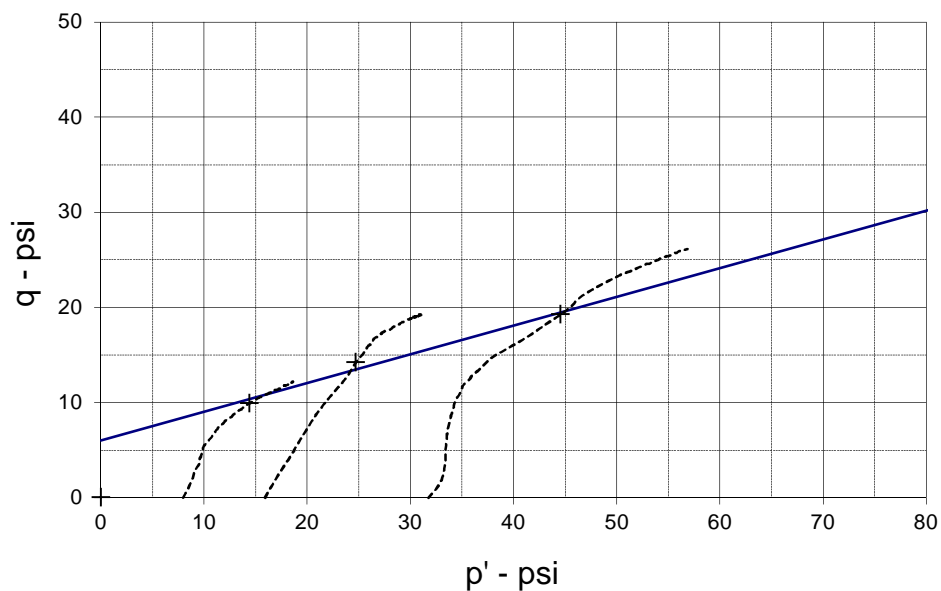
SPECIMEN NO. 3



SPECIMEN NO. 4

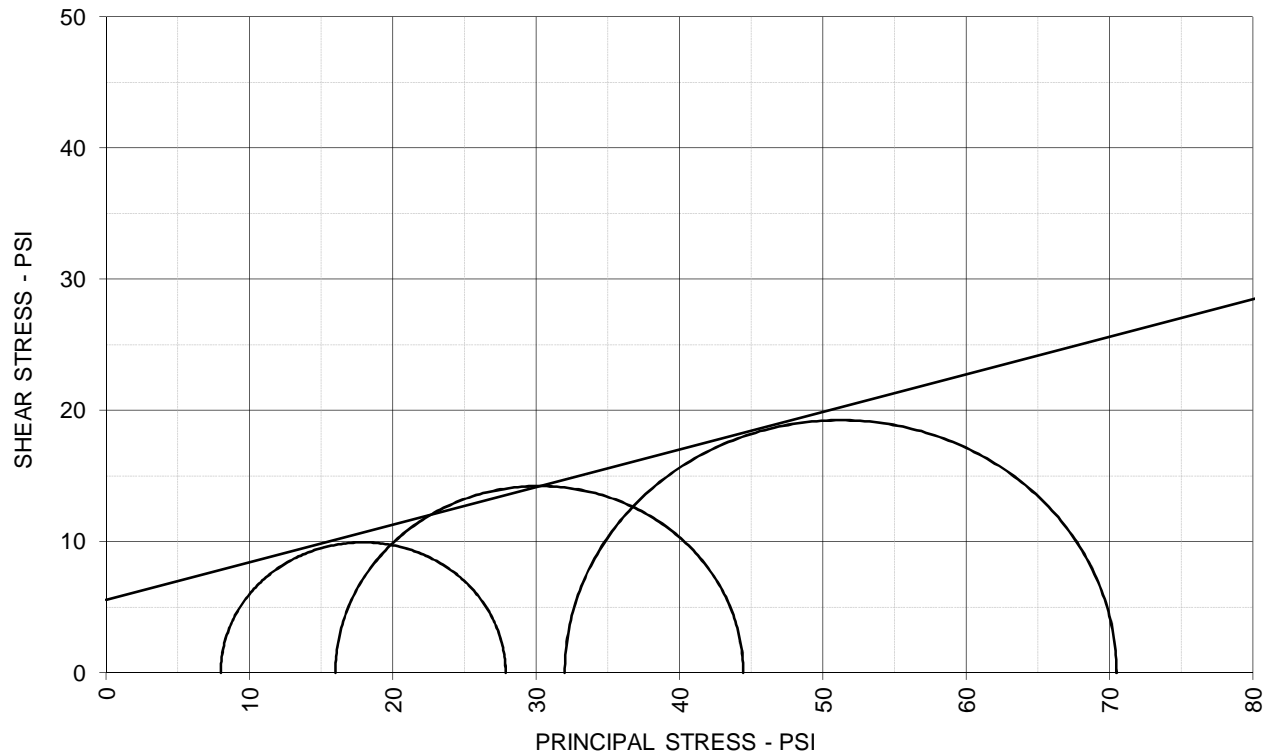


p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS	$R^2 = 0.99$	$a \text{ (deg)} = 16.8$	$a \text{ (psi)} = 6.0$
PROJECT: Oklaunion- Ponds Area Dikes	TYPE OF TEST & NO: CU with Pore Pressure		
PROJECT NO: N4165227	<b>TERRACON</b>		
DESCRIPTION: Lean Clay with Sand (CL)			
			Exhibit: B-24

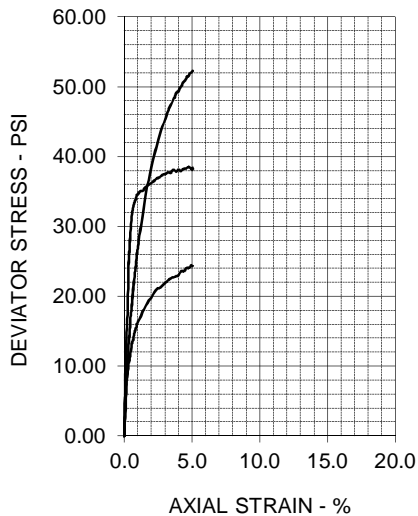
# TRIAXIAL SHEAR TEST REPORT



## TOTAL STRESS PARAMETERS

$\phi = 16.0 \text{ deg}$

$c = 5.6 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	13.7	13.7	13.7
Dry Density - pcf	117.6	117.6	117.6
Diameter - inches	1.40	1.40	1.40
Height - inches	2.81	2.81	2.81

#### AT TEST

Final Moisture - %			14.6
Dry Density - pcf	118.4	119.6	120.1
Calculated Diameter (in.)	1.38	1.41	1.40
Height - inches	2.74	2.82	2.81
Effect. Cell Pressure - psi	8.0	16.0	32.0
Failure Stress - psi	19.87	28.45	38.49
Total Pore Pressure - psi	53.5	55.5	56.7
Strain Rate - inches/min.	0.00030	0.00030	0.00030
Failure Strain - %	2.0	0.4	2.0
$S_1$ Failure - psi	27.87	44.45	70.49
$S_3$ Failure - psi	8.00	16.00	32.00

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay with Sand (CL)  
 SAMPLE LOCATION: B-2, ST-2, 12.0-14.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 28 PL: 14 PI: 14 Percent -200: 79.1  
 REMARKS: Multistage Triaxial

## PROJECT INFORMATION

PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/19/16

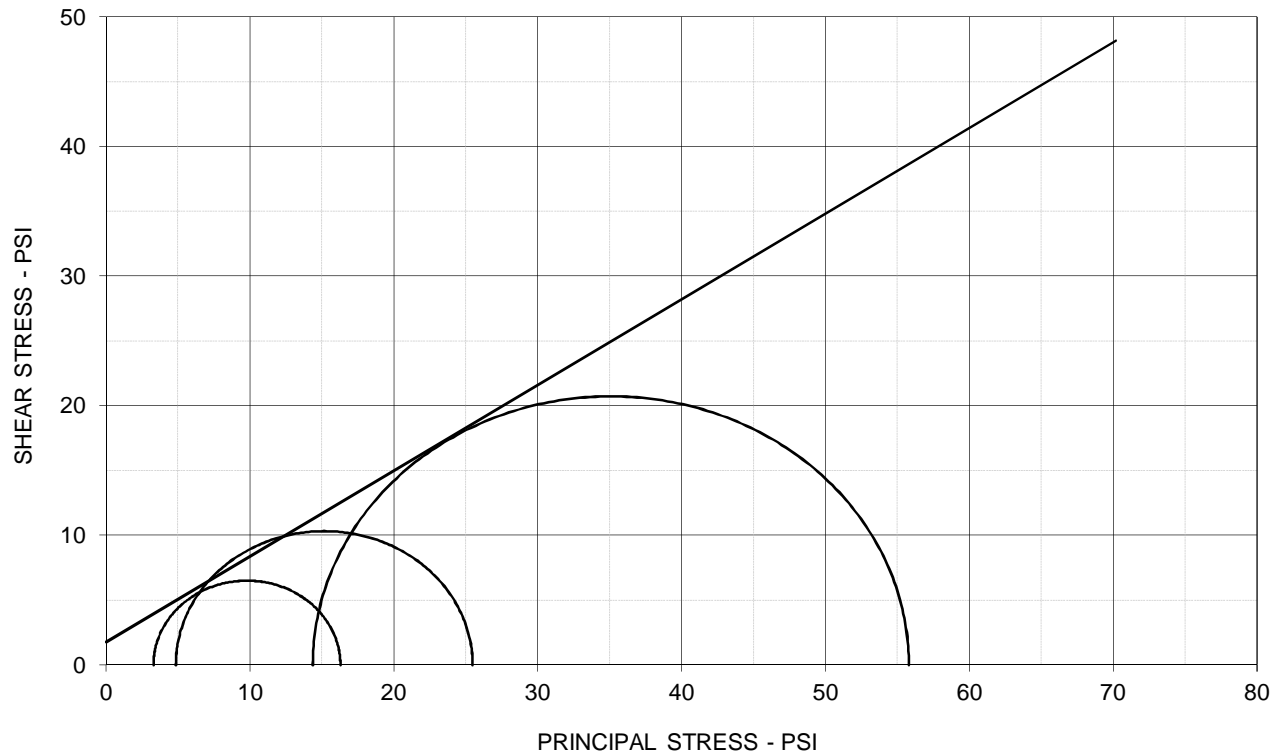
**TERRACON**

Exhibit: B-24

# TRIAXIAL SHEAR TEST REPORT



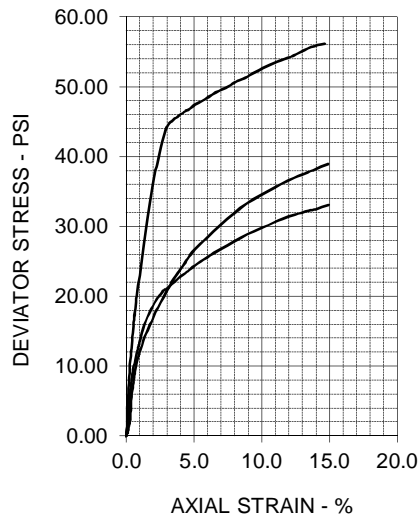
P.O. Box 5010, 51 Lost Mound Drive, Suite 135 Chattanooga, TN 37406



## EFFECTIVE STRESS PARAMETERS

$\phi' = 33.5 \text{ deg}$

$c' = 1.8 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	13.9	13.6	13.0	
Dry Density - pcf	116.9	117.6	119.1	
Diameter - inches	1.40	1.42	1.44	
Height - inches	2.80	2.81	2.78	

#### AT TEST

Final Moisture - %	16.2	15.8	14.5	
Dry Density - pcf	116.9	117.6	120.7	
Calculated Diameter (in.)	1.39	1.42	1.42	
Height - inches	2.78	2.79	2.74	
Effect. Cell Pressure - psi	6.0	12.0	24.0	
Failure Stress - psi	12.99	20.63	41.43	
Total Pore Pressure - psi	52.7	57.2	59.6	
Strain Rate - inches/min.	0.00030	0.00030	0.00030	
Failure Strain - %	0.9	3.0	2.6	
$S_1'$ Failure - psi	16.29	25.48	55.80	
$S_3'$ Failure - psi	3.30	4.85	14.37	

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-3, ST-1, 5.0-7.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 32 PL: 16 PI: 16 Percent -200: 85.5  
 REMARKS: Specimens trimmed to 1.4" diameter.

## PROJECT INFORMATION

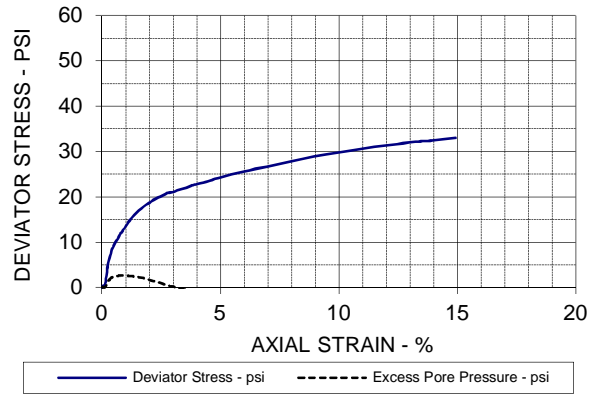
PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/19/16

**TERRACON**

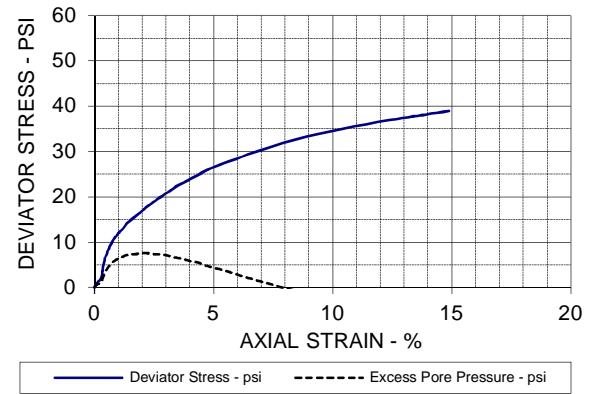
Exhibit: B-25

Note: Stage two (2) specimen subjected to Hydraulic Conductivity test prior to Triaxial Shear Testing.

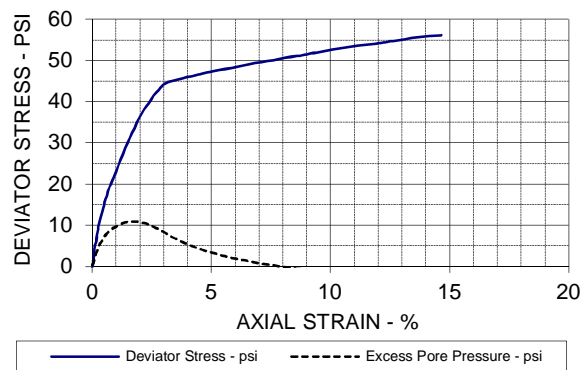
SPECIMEN NO. 1



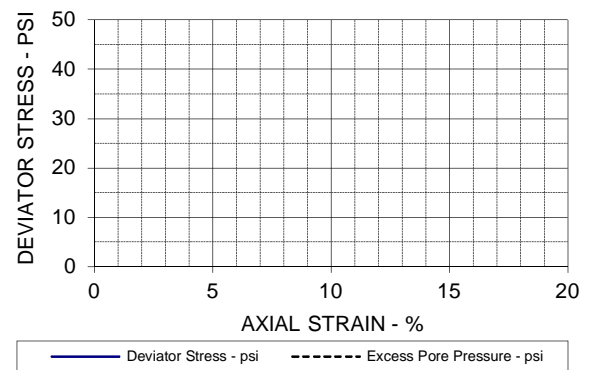
SPECIMEN NO. 2



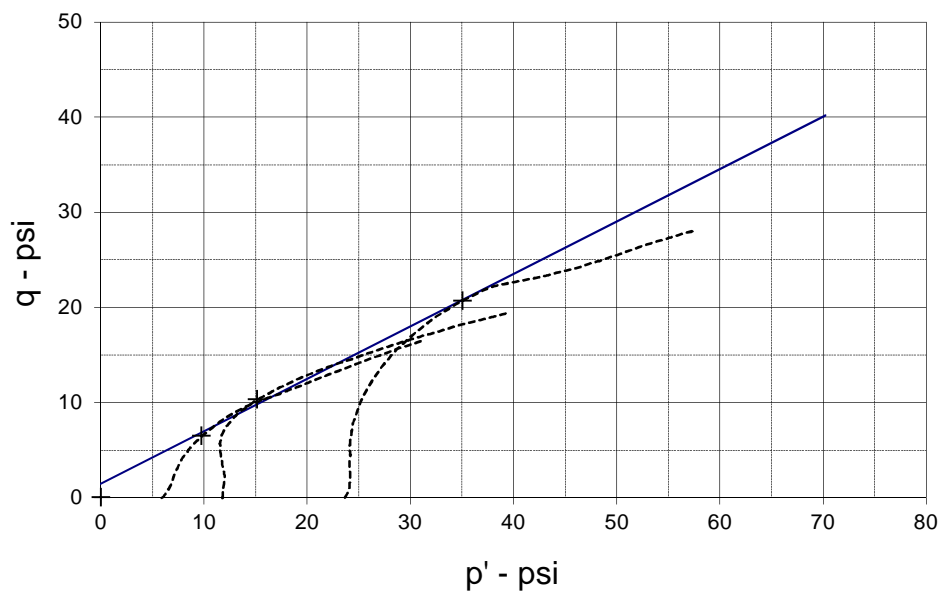
SPECIMEN NO. 3



SPECIMEN NO. 4

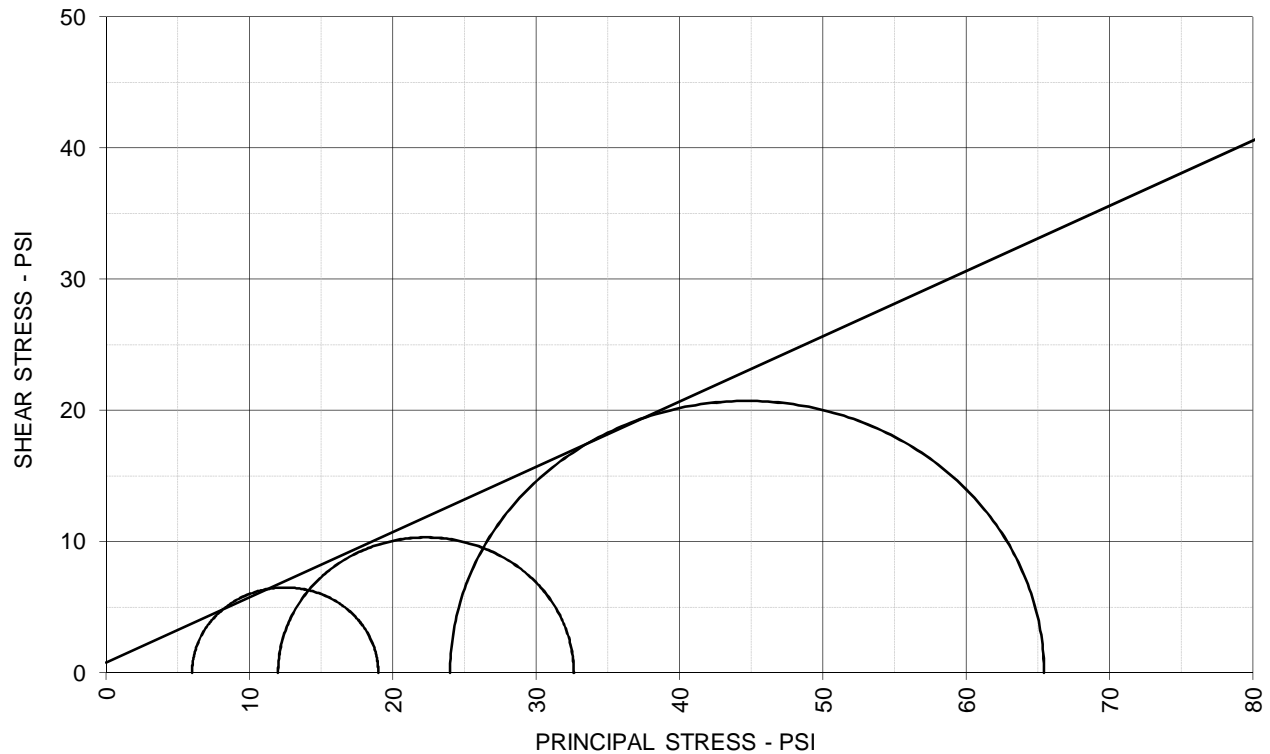


p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS	$R^2 = 1.00$	a (deg) = 28.9	a (psi) = 1.5
PROJECT: Oklaunion- Ponds Area Dikes	TYPE OF TEST & NO: CU with Pore Pressure		
PROJECT NO: N4165227	<b>TERRACON</b>		
DESCRIPTION: Lean Clay (CL)			
			Exhibit: B-25

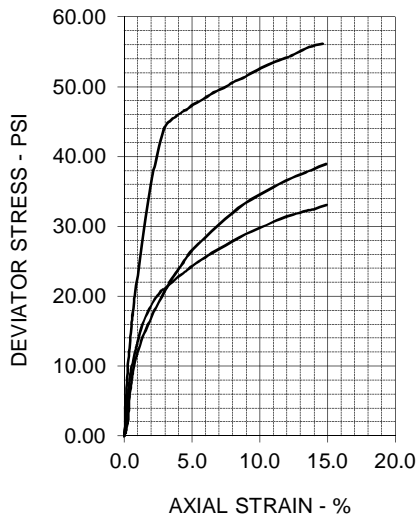
# TRIAXIAL SHEAR TEST REPORT



## TOTAL STRESS PARAMETERS

$\phi = 26.4 \text{ deg}$

$c = 0.8 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	13.9	13.6	13.0
Dry Density - pcf	116.9	117.6	119.1
Diameter - inches	1.40	1.42	1.44
Height - inches	2.80	2.81	2.78

#### AT TEST

Final Moisture - %	16.2	15.8	14.5
Dry Density - pcf	116.9	117.6	120.7
Calculated Diameter (in.)	1.39	1.42	1.42
Height - inches	2.78	2.79	2.74
Effect. Cell Pressure - psi	6.0	12.0	24.0
Failure Stress - psi	12.99	20.63	41.43
Total Pore Pressure - psi	52.7	57.2	59.6
Strain Rate - inches/min.	0.00030	0.00030	0.00030
Failure Strain - %	0.9	3.0	2.6
$S_1$ Failure - psi	18.99	32.63	65.43
$S_3$ Failure - psi	6.00	12.00	24.00

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-3, ST-1, 5.0-7.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 32 PL: 16 PI: 16 Percent -200: 85.5  
 REMARKS: Specimens trimmed to 1.4" diameter.

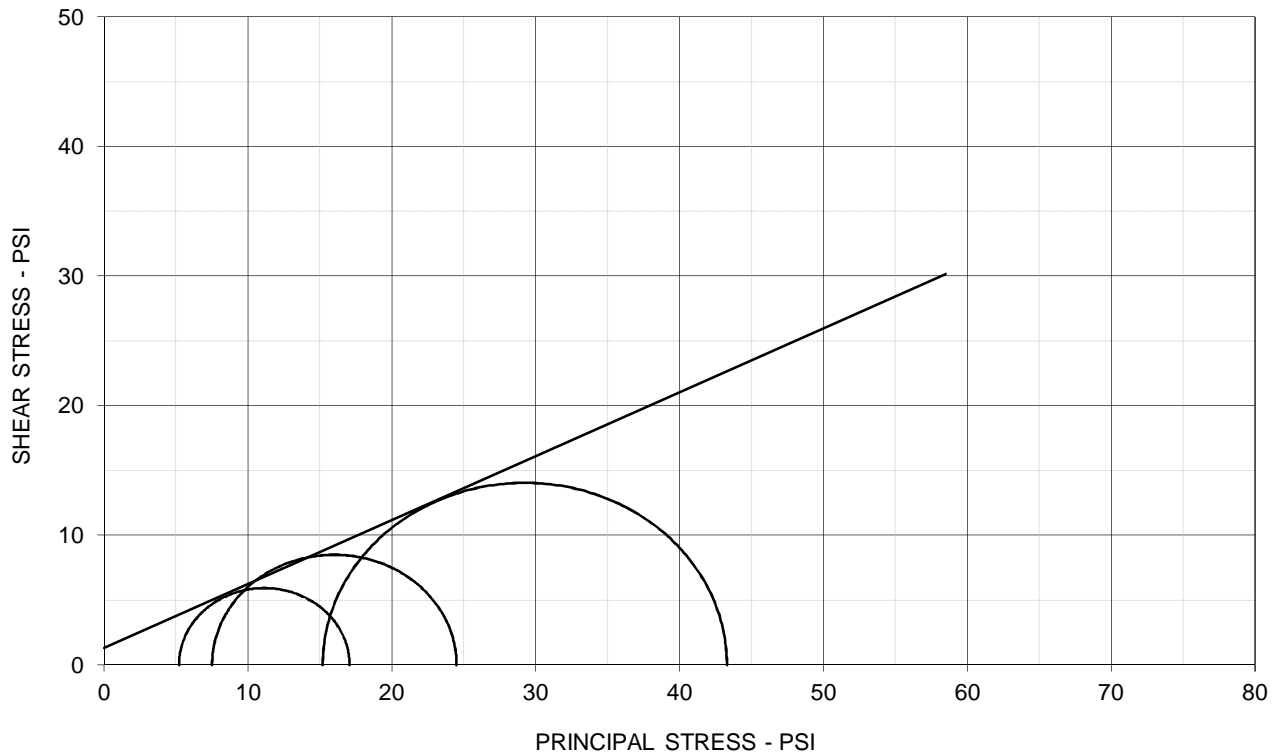
## PROJECT INFORMATION

PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/19/16

**TERRACON**

Exhibit: B-25

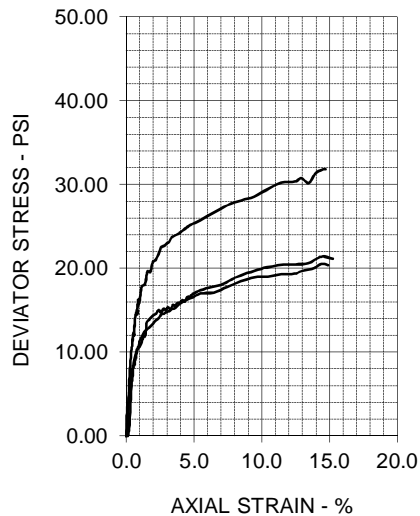
# TRIAXIAL SHEAR TEST REPORT



## EFFECTIVE STRESS PARAMETERS

$\phi' = 26.2 \text{ deg}$

$c' = 1.3 \text{ psi}$



### SPECIMEN NO.

1

2

3

4

### INITIAL

Moisture Content - %

19.6

18.1

18.7

Dry Density - pcf

105.9

107.7

105.6

Diameter - inches

1.35

1.35

1.38

Height - inches

2.81

2.82

2.80

### AT TEST

Final Moisture - %

21.2

19.7

19.9

Dry Density - pcf

106.2

109.2

109.2

Calculated Diameter (in.)

1.34

1.33

1.36

Height - inches

2.79

2.77

2.72

Effect. Cell Pressure - psi

8.0

16.0

32.0

Failure Stress - psi

11.85

16.99

28.09

Total Pore Pressure - psi

52.8

58.5

66.8

Strain Rate - inches/min.

0.00030

0.00030

0.00030

Failure Strain - %

1.4

5.5

8.5

$S_1'$  Failure - psi

17.06

24.50

43.29

$S_3'$  Failure - psi

5.21

7.51

15.20

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure

SAMPLE TYPE: Tube

DESCRIPTION: Lean Clay (CL)

SAMPLE LOCATION: B-3, ST-2, 12.0-14.0 ft

ASSUMED SPECIFIC GRAVITY: 2.70

LL: 34 PL: 15 PI: 19 Percent -200: 90.6

REMARKS: Specimens trimmed to 1.4" diameter.

## PROJECT INFORMATION

PROJECT: Oklaunion- Ponds Area Dikes

LOCATION: Vernon, TX

PROJECT NO: N4165227

CLIENT: AEP

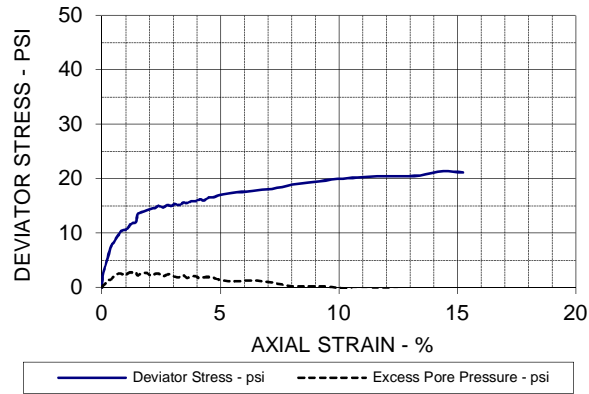
DATE: 8/22/16

**TERRACON**

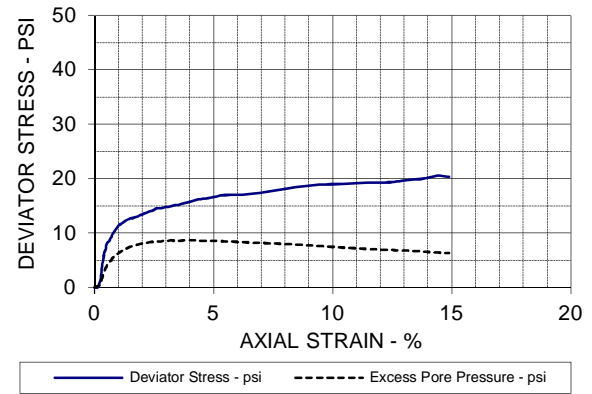
**Exhibit: B-26**

Note: Stage two (2) specimen subjected to Hydraulic Conductivity test prior to Triaxial Shear Testing.

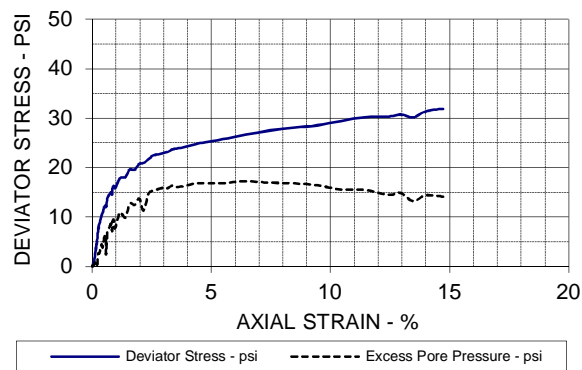
SPECIMEN NO. 1



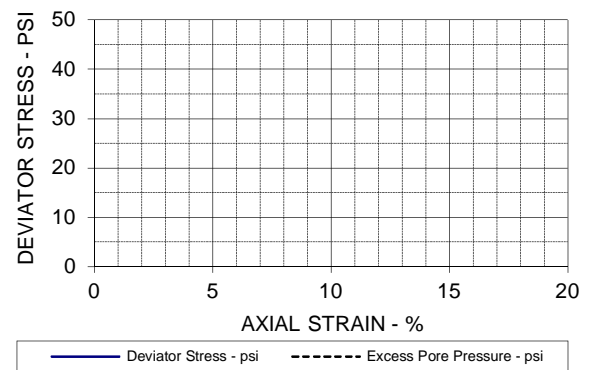
SPECIMEN NO. 2



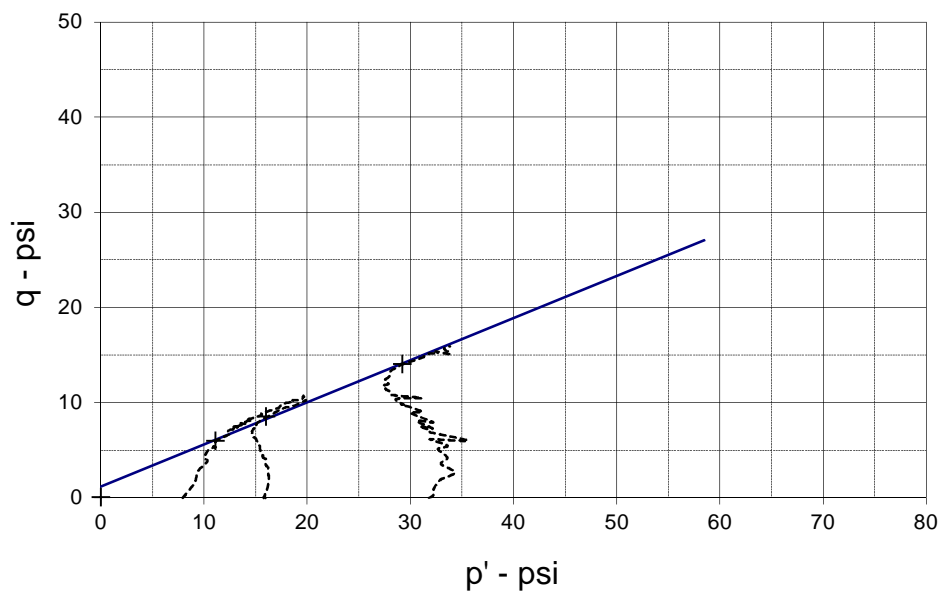
SPECIMEN NO. 3



SPECIMEN NO. 4



p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS

 $R^2 = 1.00$  $a \text{ (deg)} = 23.9$  $a \text{ (psi)} = 1.2$ 

PROJECT: Oklaunion- Ponds Area Dikes

TYPE OF TEST &amp; NO: CU with Pore Pressure

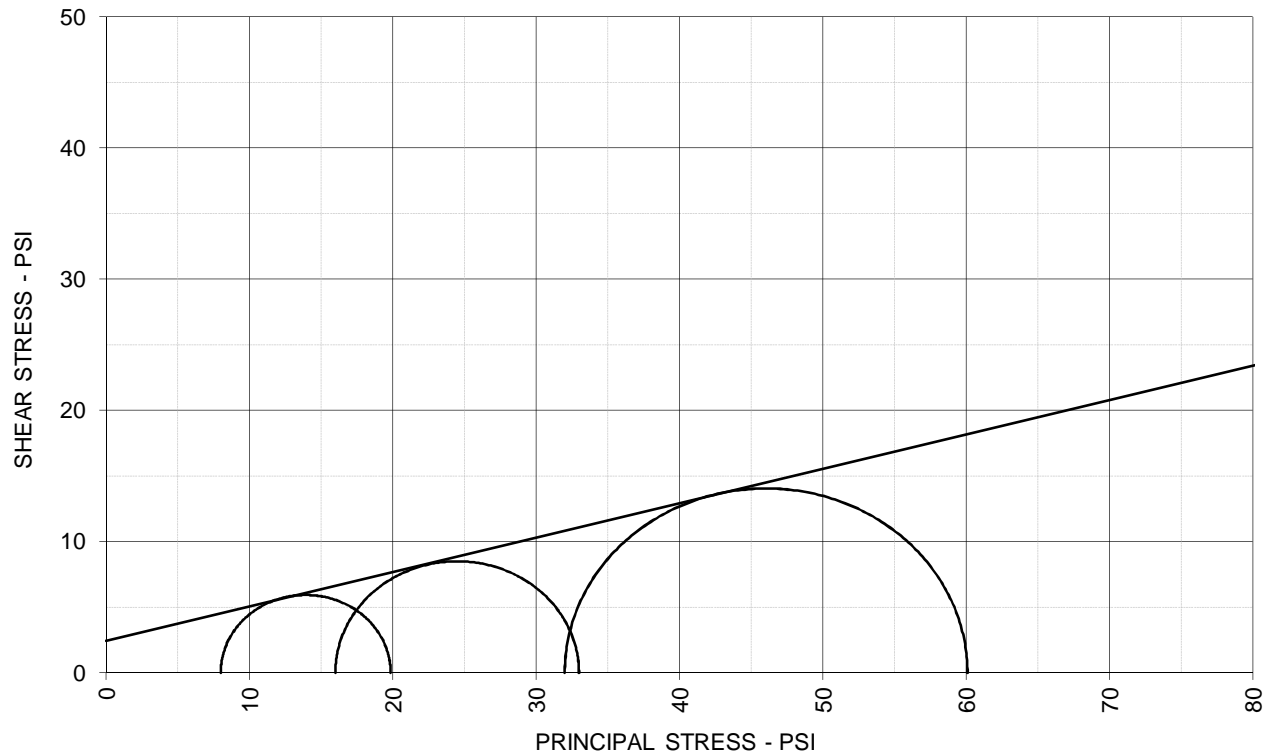
PROJECT NO: N4165227

**TERRACON**

Exhibit: B-26

DESCRIPTION: Lean Clay (CL)

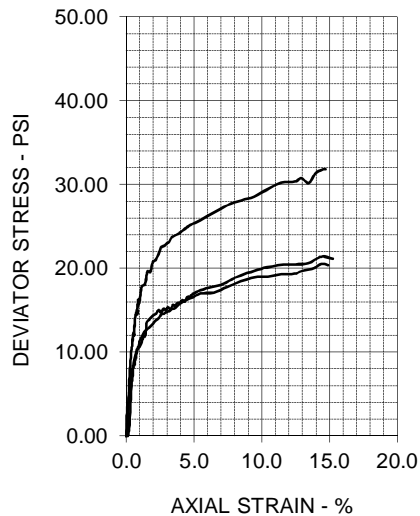
# TRIAXIAL SHEAR TEST REPORT



## TOTAL STRESS PARAMETERS

$\phi = 14.7 \text{ deg}$

$c = 2.4 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	19.6	18.1	18.7	
Dry Density - pcf	105.9	107.7	105.6	
Diameter - inches	1.35	1.35	1.38	
Height - inches	2.81	2.82	2.80	

#### AT TEST

Final Moisture - %	21.2	19.7	19.9	
Dry Density - pcf	106.2	109.2	109.2	
Calculated Diameter (in.)	1.34	1.33	1.36	
Height - inches	2.79	2.77	2.72	
Effect. Cell Pressure - psi	8.0	16.0	32.0	
Failure Stress - psi	11.85	16.99	28.09	
Total Pore Pressure - psi	52.8	58.5	66.8	
Strain Rate - inches/min.	0.00030	0.00030	0.00030	
Failure Strain - %	1.4	5.5	8.5	
$S_1$ Failure - psi	19.85	32.99	60.09	
$S_3$ Failure - psi	8.00	16.00	32.00	

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-3, ST-2, 12.0-14.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 34 PL: 15 PI: 19 Percent -200: 90.6  
 REMARKS: Specimens trimmed to 1.4" diameter.

## PROJECT INFORMATION

PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/22/16

**TERRACON**

Exhibit: B-26

# TRIAXIAL SHEAR TEST REPORT



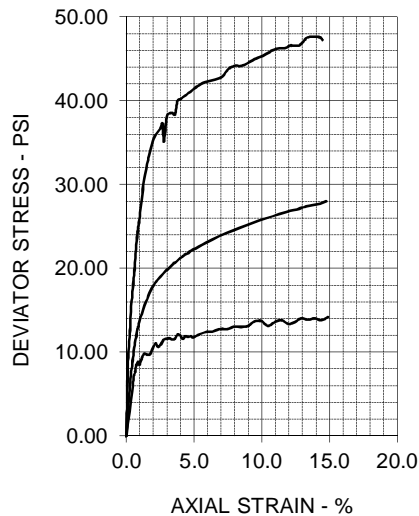
P.O. Box 5010, 51 Lost Mound Drive, Suite 135 Chattanooga, TN 37406



## EFFECTIVE STRESS PARAMETERS

$\phi' = 26.5 \text{ deg}$

$c' = 2.0 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	18.7	16.5	16.1	
Dry Density - pcf	103.9	111.4	116.5	
Diameter - inches	1.36	1.38	1.36	
Height - inches	2.81	2.83	2.80	

#### AT TEST

Final Moisture - %	22.6	18.6	15.0	
Dry Density - pcf	103.9	111.4	119.0	
Calculated Diameter (in.)	1.34	1.36	1.35	
Height - inches	2.75	2.78	2.76	
Effect. Cell Pressure - psi	6.0	16.0	32.0	
Failure Stress - psi	11.47	22.22	40.63	
Total Pore Pressure - psi	53.0	56.1	60.8	
Strain Rate - inches/min.	0.00030	0.00030	0.00030	
Failure Strain - %	2.8	4.9	4.4	
$S_1'$ Failure - psi	14.46	32.16	61.79	
$S_3'$ Failure - psi	2.99	9.94	21.16	

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-4, ST-2, 8.5-10.5 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 37 PL: 17 PI: 20 Percent -200: 93.7  
 REMARKS: Specimens trimmed to 1.4" diameter.

## PROJECT INFORMATION

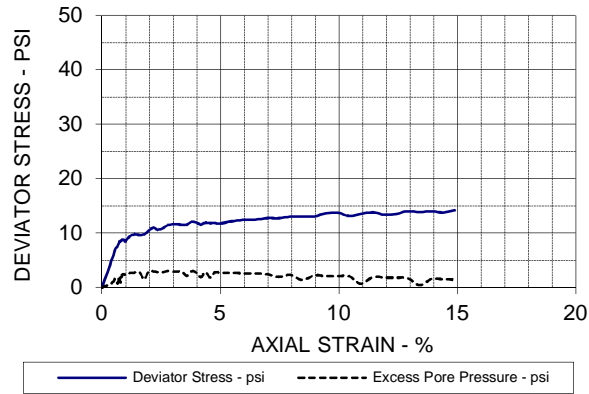
PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/22/16

**TERRACON**

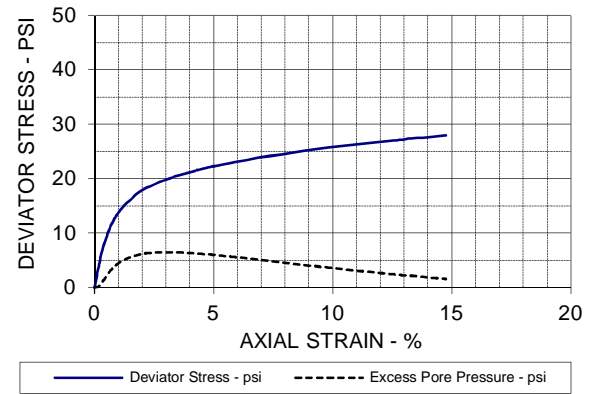
**Exhibit: B-27**

Note: Stage two (2) specimen subjected to Hydraulic Conductivity test prior to Triaxial Shear Testing.

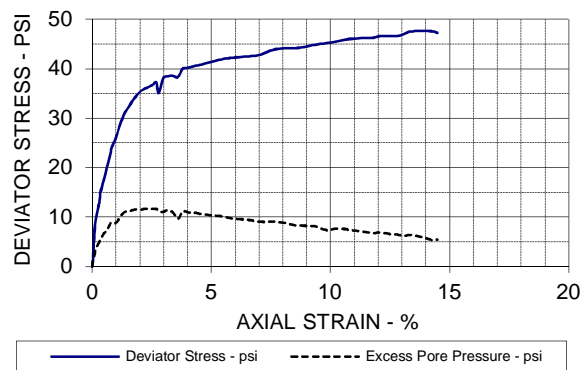
SPECIMEN NO. 1



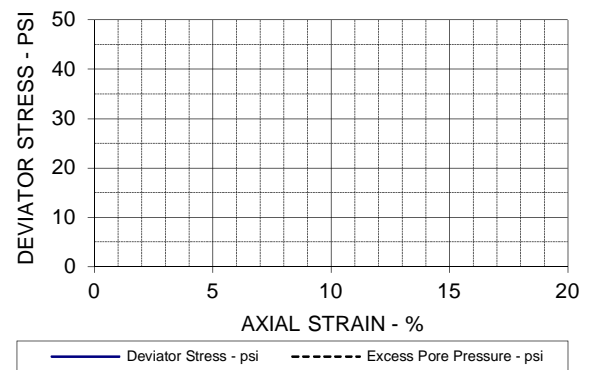
SPECIMEN NO. 2



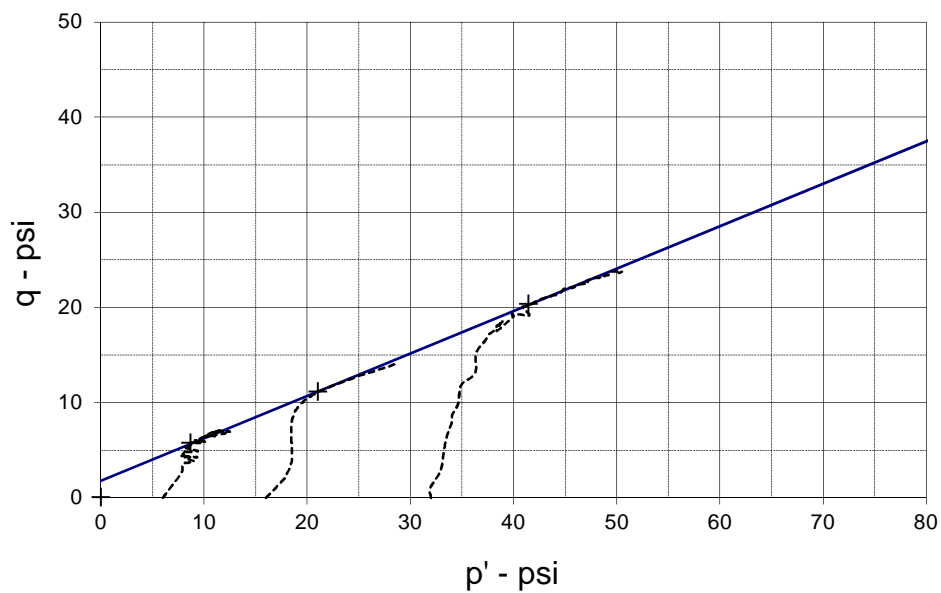
SPECIMEN NO. 3



SPECIMEN NO. 4

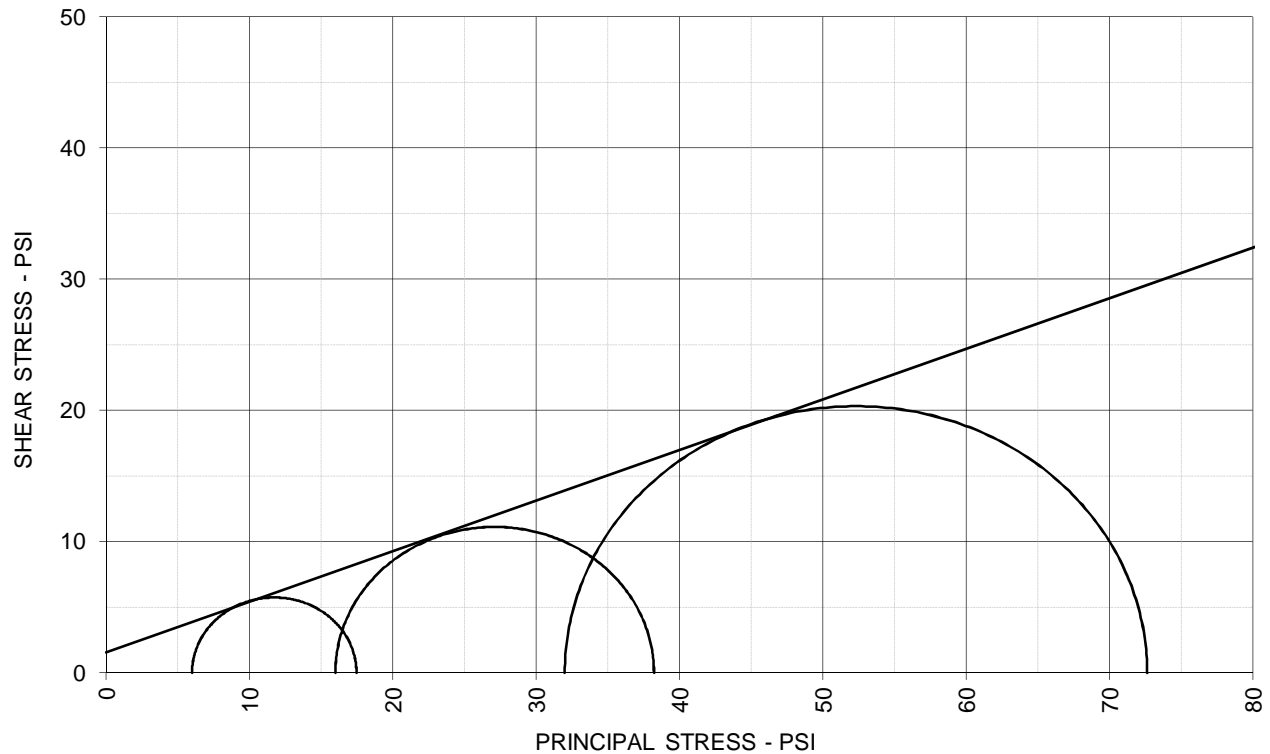


p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS	$R^2 = 1.00$	$a \text{ (deg)} = 24.0$	$a \text{ (psi)} = 1.8$
PROJECT: Oklaunion- Ponds Area Dikes	TYPE OF TEST & NO: CU with Pore Pressure		
PROJECT NO: N4165227	<b>TERRACON</b>		
DESCRIPTION: Lean Clay (CL)			
			Exhibit: B-27

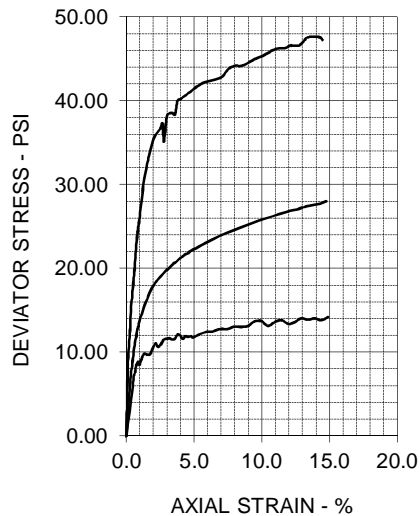
# TRIAXIAL SHEAR TEST REPORT



## TOTAL STRESS PARAMETERS

$\phi = 21.1 \text{ deg}$

$c = 1.6 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	18.7	16.5	16.1	
Dry Density - pcf	103.9	111.4	116.5	
Diameter - inches	1.36	1.38	1.36	
Height - inches	2.81	2.83	2.80	

#### AT TEST

Final Moisture - %	22.6	18.6	15.0	
Dry Density - pcf	103.9	111.4	119.0	
Calculated Diameter (in.)	1.34	1.36	1.35	
Height - inches	2.75	2.78	2.76	
Effect. Cell Pressure - psi	6.0	16.0	32.0	
Failure Stress - psi	11.47	22.22	40.63	
Total Pore Pressure - psi	53.0	56.1	60.8	
Strain Rate - inches/min.	0.00030	0.00030	0.00030	
Failure Strain - %	2.8	4.9	4.4	
$S_1$ Failure - psi	17.47	38.22	72.63	
$S_3$ Failure - psi	6.00	16.00	32.00	

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-4, ST-2, 8.5-10.5 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 37 PL: 17 PI: 20 Percent -200: 93.7  
 REMARKS: Specimens trimmed to 1.4" diameter.

## PROJECT INFORMATION

PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/22/16

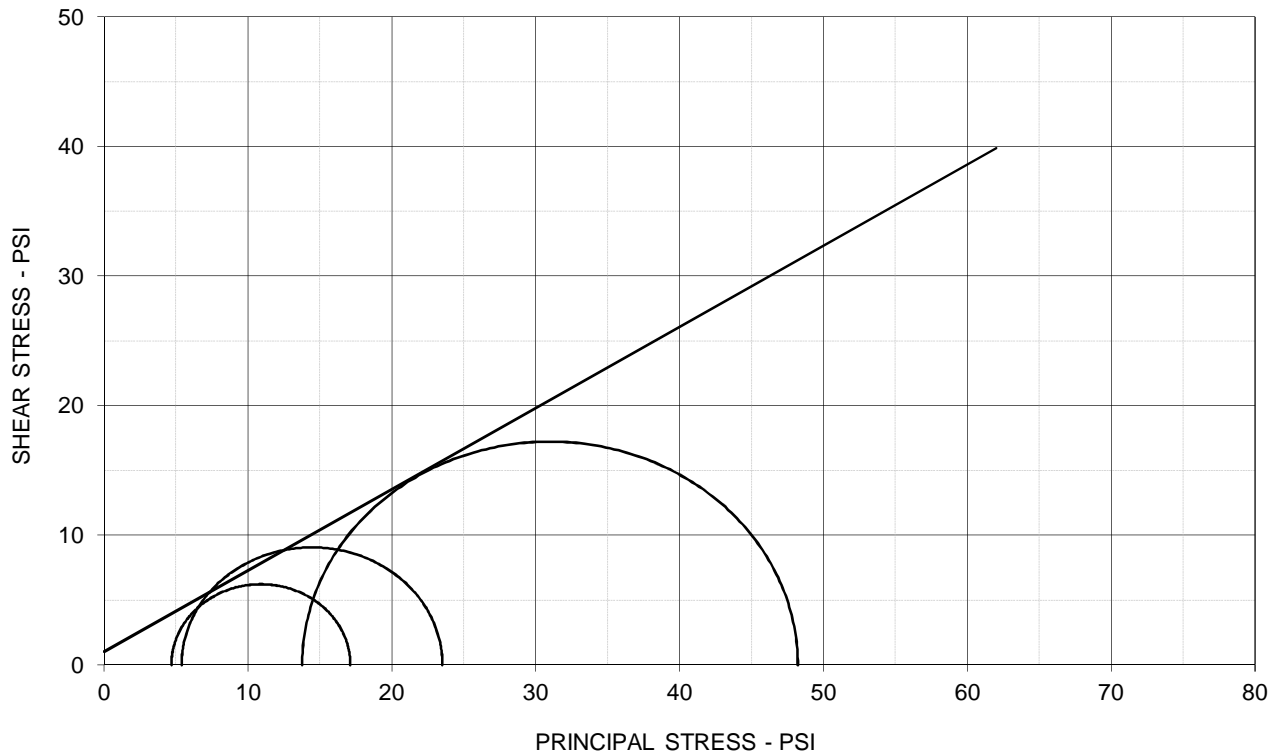
**TERRACON**

Exhibit: B-27

# TRIAXIAL SHEAR TEST REPORT



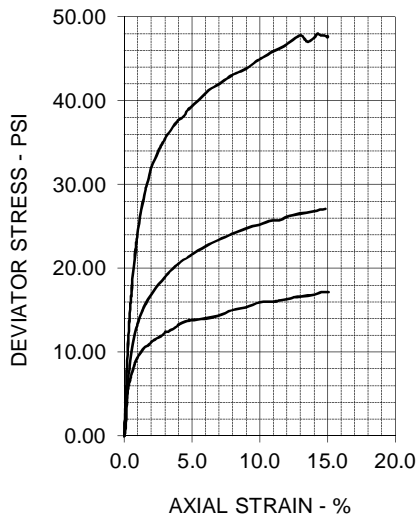
P.O. Box 5010, 51 Lost Mound Drive, Suite 135 Chattanooga, TN 37406



## EFFECTIVE STRESS PARAMETERS

$\phi' = 32.1 \text{ deg}$

$c' = 1.0 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	17.2	17.1	14.4	
Dry Density - pcf	111.2	114.3	119.8	
Diameter - inches	1.90	1.90	1.93	
Height - inches	3.99	4.01	4.00	

#### AT TEST

Final Moisture - %	18.5	16.4	14.0	
Dry Density - pcf	111.2	115.9	121.4	
Calculated Diameter (in.)	1.89	1.88	1.91	
Height - inches	3.95	3.96	3.95	
Effect. Cell Pressure - psi	6.0	12.0	24.0	
Failure Stress - psi	12.44	18.13	34.45	
Total Pore Pressure - psi	51.3	56.6	60.2	
Strain Rate - inches/min.	0.00030	0.00030	0.00030	
Failure Strain - %	3.1	2.6	2.7	
$S_1'$ Failure - psi	17.12	23.52	48.22	
$S_3'$ Failure - psi	4.68	5.39	13.77	

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-5, ST-1, 5.0-7.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 33 PL: 16 PI: 17 Percent -200: 88.6  
 REMARKS: Specimens trimmed to 2.0" diameter.

## PROJECT INFORMATION

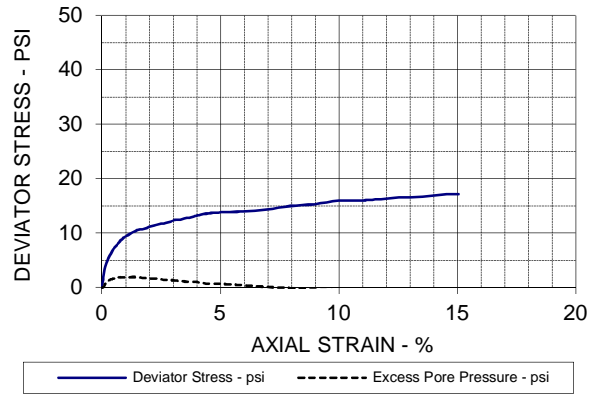
PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/22/16

**TERRACON**

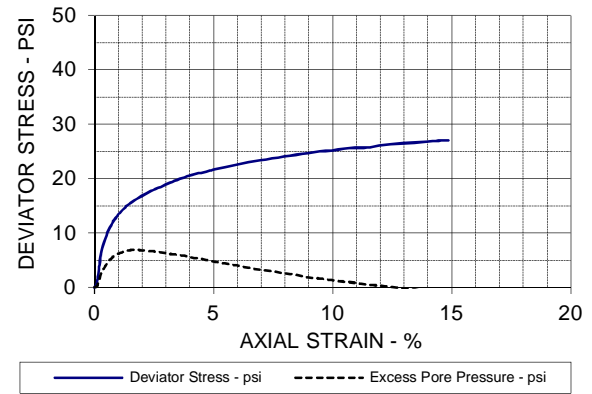
Exhibit: B-28

Note: Stage two (2) specimen subjected to Hydraulic Conductivity test prior to Triaxial Shear Testing.

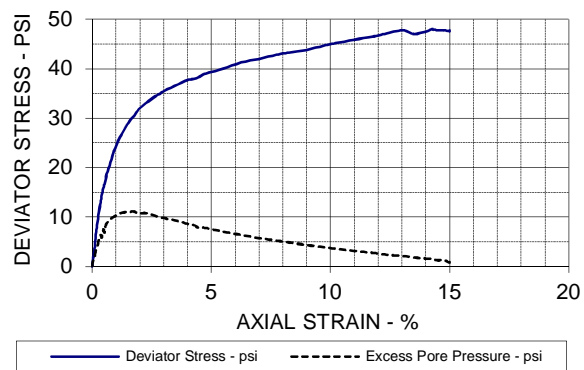
SPECIMEN NO. 1



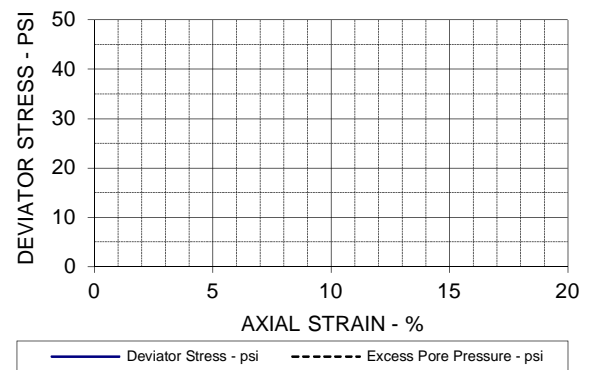
SPECIMEN NO. 2



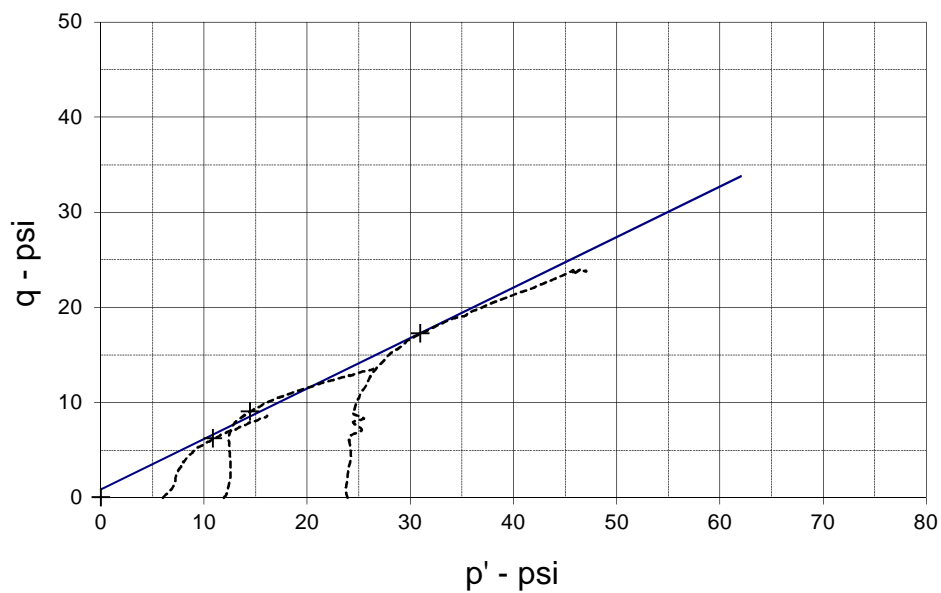
SPECIMEN NO. 3



SPECIMEN NO. 4

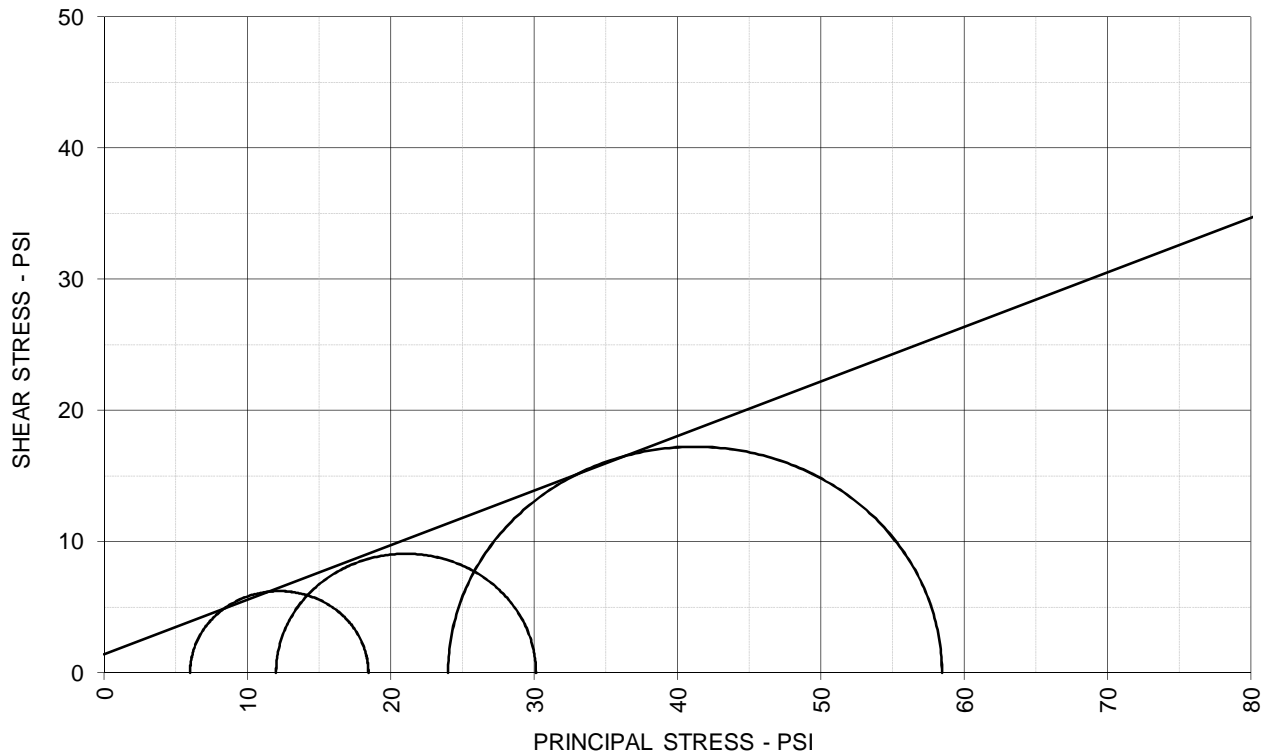


p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS	R <sup>2</sup> = 1.00	a (deg) = 28.0	a (psi) = 0.9
PROJECT: Oklaunion- Ponds Area Dikes		TYPE OF TEST & NO: CU with Pore Pressure	
PROJECT NO: N4165227		TERRACON	Exhibit: B-28
DESCRIPTION: Lean Clay (CL)			

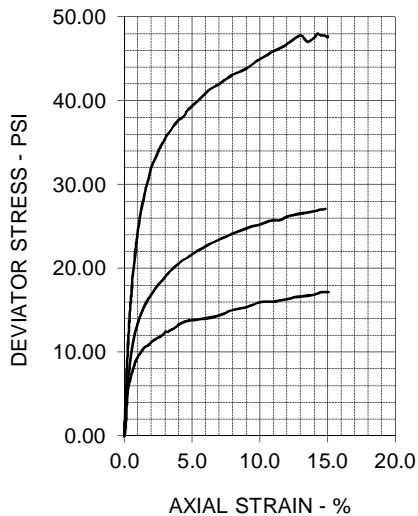
# TRIAXIAL SHEAR TEST REPORT



## TOTAL STRESS PARAMETERS

$\phi = 22.6 \text{ deg}$

$c = 1.4 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	17.2	17.1	14.4	
Dry Density - pcf	111.2	114.3	119.8	
Diameter - inches	1.90	1.90	1.93	
Height - inches	3.99	4.01	4.00	

#### AT TEST

Final Moisture - %	18.5	16.4	14.0	
Dry Density - pcf	111.2	115.9	121.4	
Calculated Diameter (in.)	1.89	1.88	1.91	
Height - inches	3.95	3.96	3.95	
Effect. Cell Pressure - psi	6.0	12.0	24.0	
Failure Stress - psi	12.44	18.13	34.45	
Total Pore Pressure - psi	51.3	56.6	60.2	
Strain Rate - inches/min.	0.00030	0.00030	0.00030	
Failure Strain - %	3.1	2.6	2.7	
$S_1$ Failure - psi	18.44	30.13	58.45	
$S_3$ Failure - psi	6.00	12.00	24.00	

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-5, ST-1, 5.0-7.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 33 PL: 16 PI: 17 Percent -200: 88.6  
 REMARKS: Specimens trimmed to 2.0" diameter.

## PROJECT INFORMATION

PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/22/16

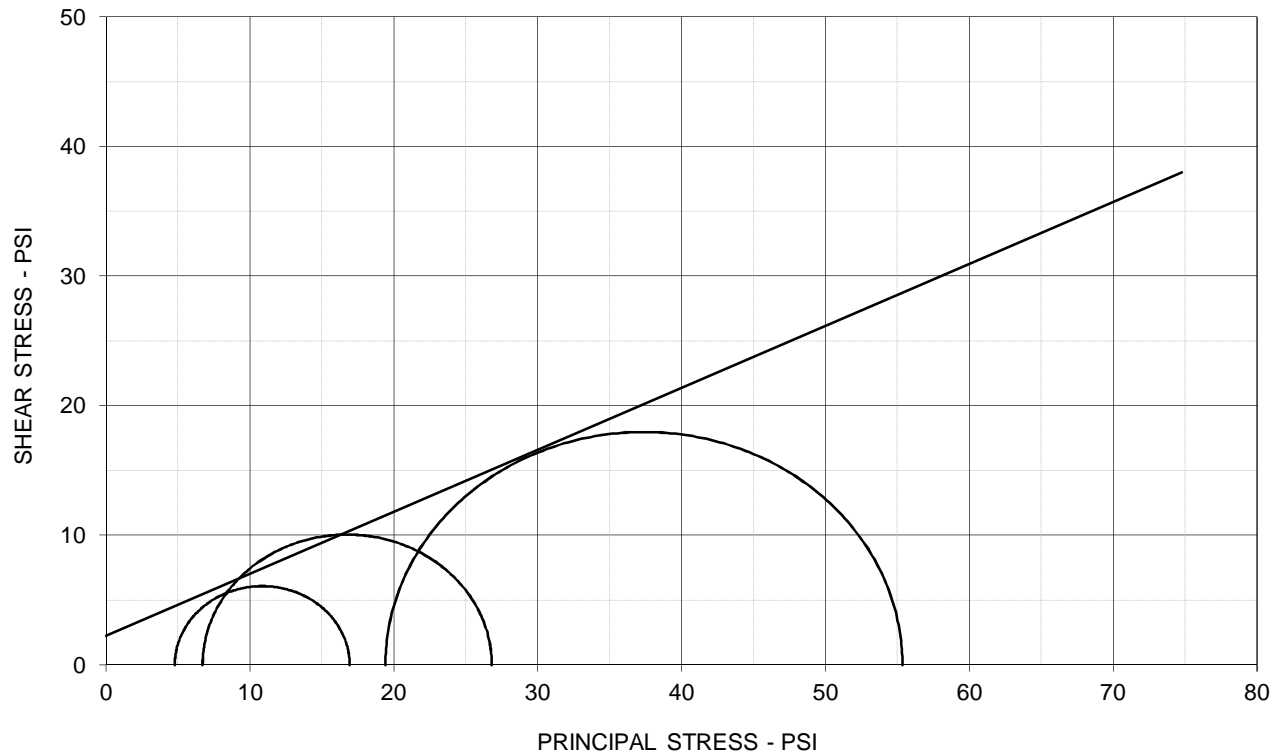
**TERRACON**

Exhibit: B-28

# TRIAXIAL SHEAR TEST REPORT



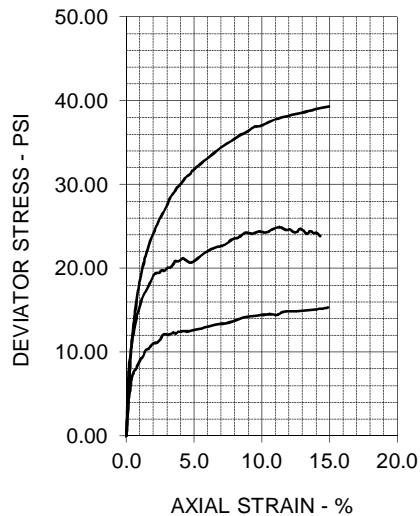
P.O. Box 5010, 51 Lost Mound Drive, Suite 135 Chattanooga, TN 37406



## EFFECTIVE STRESS PARAMETERS

$\phi' = 25.6 \text{ deg}$

$c' = 2.2 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	17.4	16.3	16.0
Dry Density - pcf	110.3	114.3	117.5
Diameter - inches	1.37	1.36	1.36
Height - inches	2.78	2.78	2.80

#### AT TEST

Final Moisture - %	18.8	16.9	14.8
Dry Density - pcf	110.9	115.2	119.6
Calculated Diameter (in.)	1.36	1.35	1.34
Height - inches	2.75	2.74	2.74
Effect. Cell Pressure - psi	8.0	16.0	32.0
Failure Stress - psi	12.15	20.10	35.93
Total Pore Pressure - psi	53.2	59.3	62.6
Strain Rate - inches/min.	0.00030	0.00030	0.00030
Failure Strain - %	2.9	3.3	8.5
$S_1'$ Failure - psi	16.93	26.81	55.35
$S_3'$ Failure - psi	4.78	6.71	19.42

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-5, ST-2, 12.0-14.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 35 PL: 15 PI: 20 Percent -200: 88.8  
 REMARKS: Specimens trimmed to 1.4" diameter.

## PROJECT INFORMATION

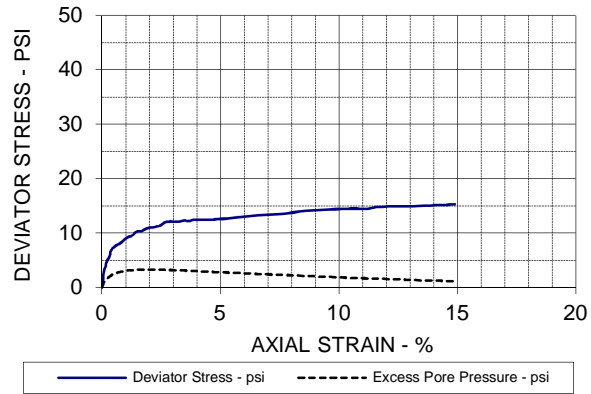
PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/19/16

**TERRACON**

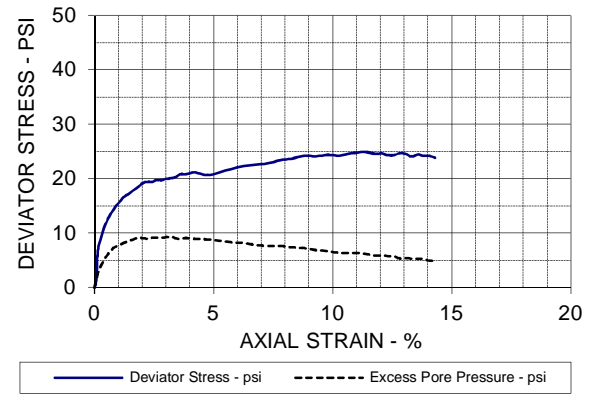
Exhibit: B-29

Note: Stage two (2) specimen subjected to Hydraulic Conductivity test prior to Triaxial Shear Testing.

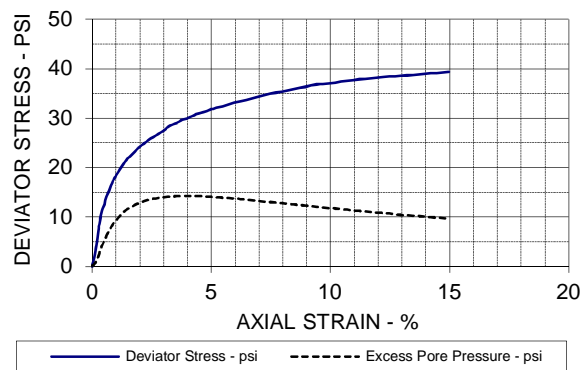
SPECIMEN NO. 1



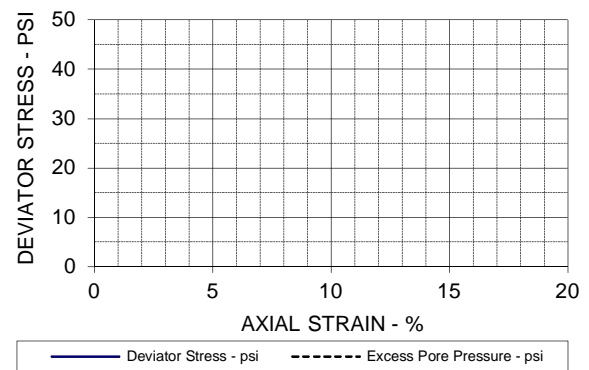
SPECIMEN NO. 2



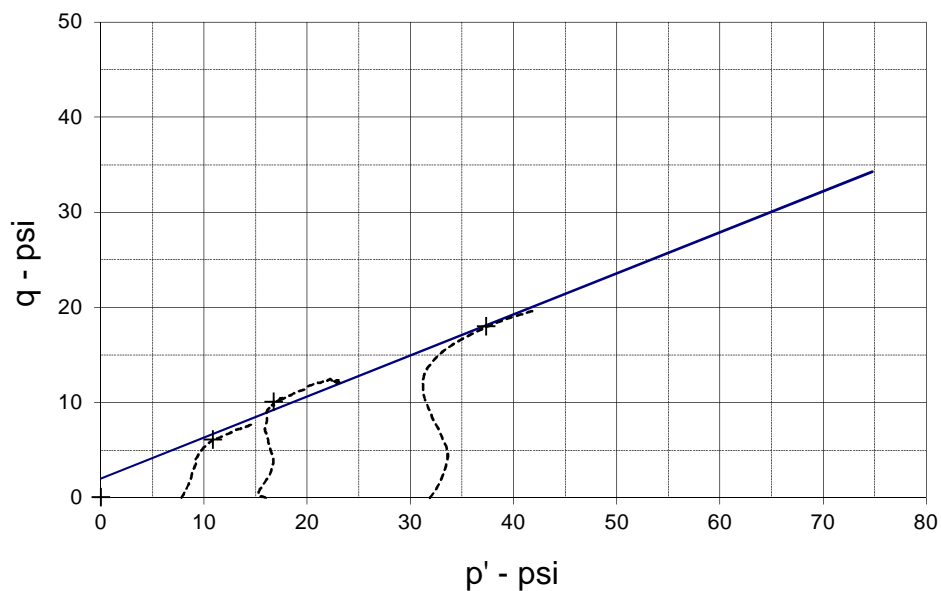
SPECIMEN NO. 3



SPECIMEN NO. 4

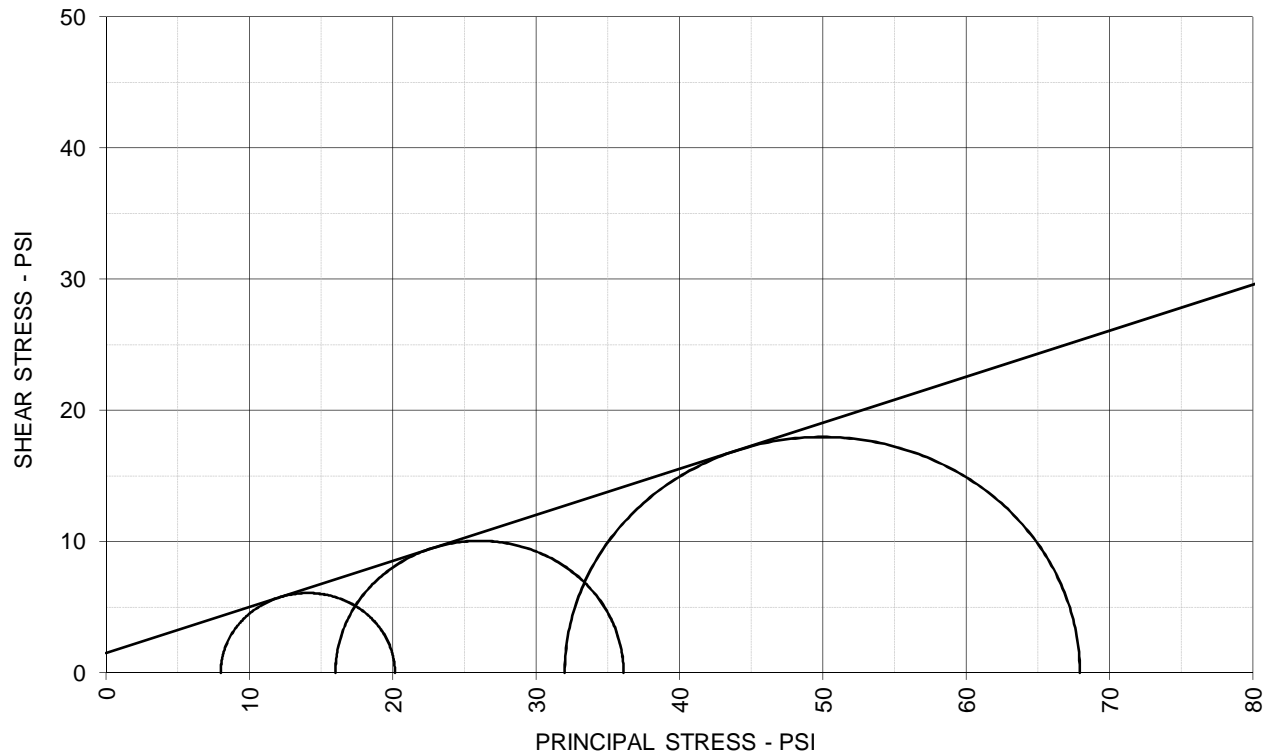


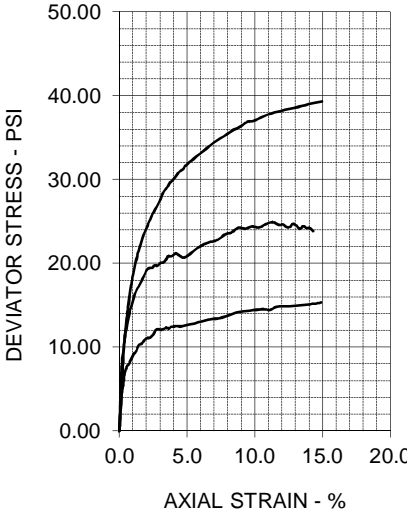
p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS	$R^2 = 0.99$	$a \text{ (deg)} = 23.3$	$a \text{ (psi)} = 2.0$
PROJECT: Oklaunion- Ponds Area Dikes	TYPE OF TEST & NO: CU with Pore Pressure		
PROJECT NO: N4165227	<b>TERRACON</b>		
DESCRIPTION: Lean Clay (CL)			
			Exhibit: B-29

# TRIAXIAL SHEAR TEST REPORT

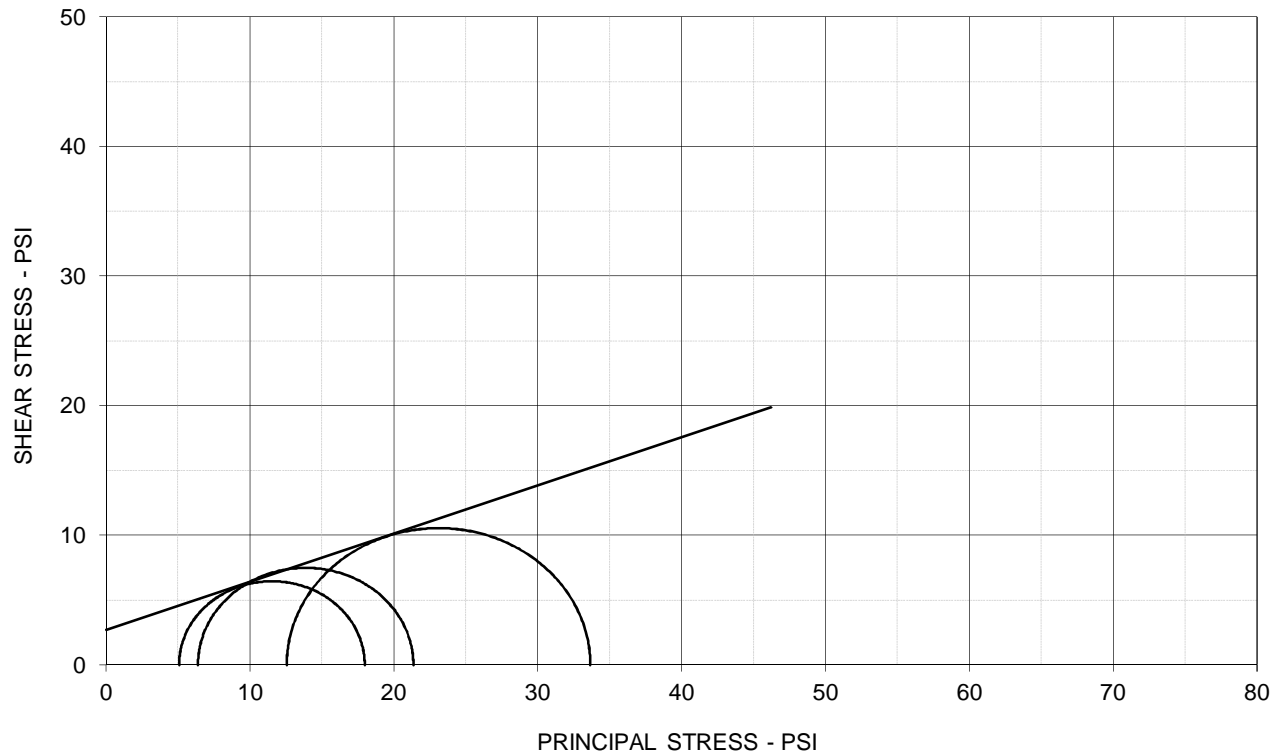


TOTAL STRESS PARAMETERS		f = 19.3 deg		c = 1.5 psi		
	SPECIMEN NO.		1	2	3	4
	INITIAL					
	Moisture Content - %		17.4	16.3	16.0	
	Dry Density - pcf		110.3	114.3	117.5	
	Diameter - inches		1.37	1.36	1.36	
	Height - inches		2.78	2.78	2.80	
	AT TEST					
	Final Moisture - %		18.8	16.9	14.8	
	Dry Density - pcf		110.9	115.2	119.6	
	Calculated Diameter (in.)		1.36	1.35	1.34	
	Height - inches		2.75	2.74	2.74	
	Effect. Cell Pressure - psi		8.0	16.0	32.0	
	Failure Stress - psi		12.15	20.10	35.93	
	Total Pore Pressure - psi		53.2	59.3	62.6	
	Strain Rate - inches/min.		0.00030	0.00030	0.00030	
Failure Strain - %		2.9	3.3	8.5		
S <sub>1</sub> Failure - psi		20.15	36.10	67.93		
S <sub>3</sub> Failure - psi		8.00	16.00	32.00		
TEST DESCRIPTION			PROJECT INFORMATION			
TYPE OF TEST & NO: CU with Pore Pressure SAMPLE TYPE: Tube DESCRIPTION: Lean Clay (CL) SAMPLE LOCATION: B-5, ST-2, 12.0-14.0 ft ASSUMED SPECIFIC GRAVITY: 2.70 LL: 35      PL: 15      PI: 20      Percent -200: 88.8 REMARKS: Specimens trimmed to 1.4" diameter.			PROJECT: Oklaunion- Ponds Area Dikes			
			LOCATION: Vernon, TX			
			PROJECT NO: N4165227			
			CLIENT: AEP			
			DATE: 8/19/16			
			TERRACON		Exhibit: B-29	

# TRIAXIAL SHEAR TEST REPORT



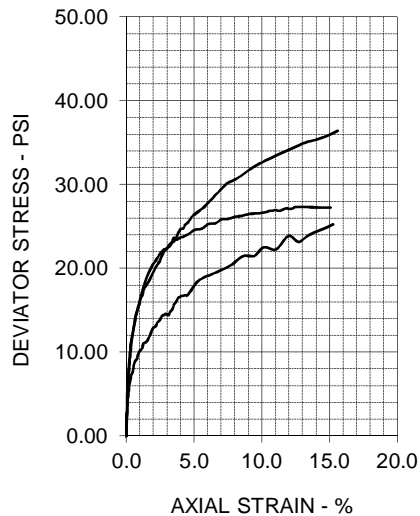
P.O. Box 5010, 51 Lost Mound Drive, Suite 135 Chattanooga, TN 37406



## EFFECTIVE STRESS PARAMETERS

$\phi' = 20.4 \text{ deg}$

$c' = 2.7 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	16.3	16.6	16.1
Dry Density - pcf	112.0	115.3	116.9
Diameter - inches	1.92	1.90	1.90
Height - inches	3.92	3.98	3.96

#### AT TEST

Final Moisture - %	18.2	17.0	15.1
Dry Density - pcf	112.1	115.3	118.7
Calculated Diameter (in.)	1.90	1.90	1.87
Height - inches	3.86	3.95	3.86
Effect. Cell Pressure - psi	6.0	12.0	24.0
Failure Stress - psi	12.90	14.97	21.10
Total Pore Pressure - psi	50.9	55.6	61.4
Strain Rate - inches/min.	0.00040	0.00040	0.00040
Failure Strain - %	2.0	0.8	2.5
$S_1'$ Failure - psi	17.98	21.36	33.66
$S_3'$ Failure - psi	5.08	6.39	12.56

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-6, ST-1, 5.0-7.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 35 PL: 15 PI: 20 Percent -200: 86.3  
 REMARKS: Specimens trimmed to 2.0" diameter.

## PROJECT INFORMATION

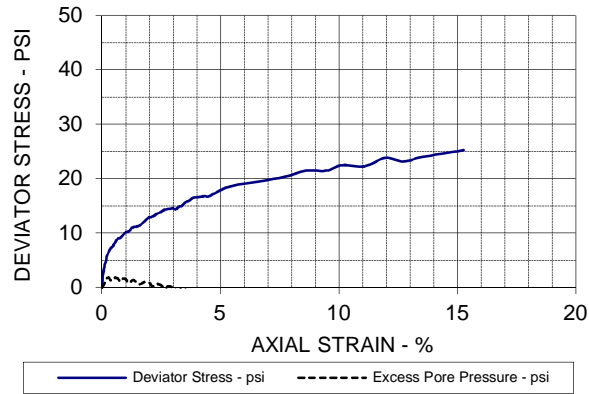
PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/22/16

**TERRACON**

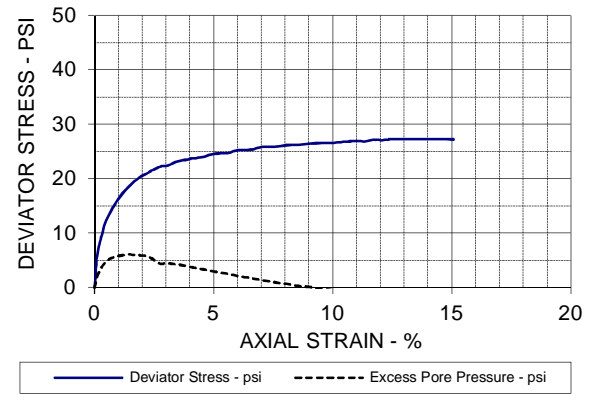
Exhibit: B-30

Note: Stage two (2) specimen subjected to Hydraulic Conductivity test prior to Triaxial Shear Testing.

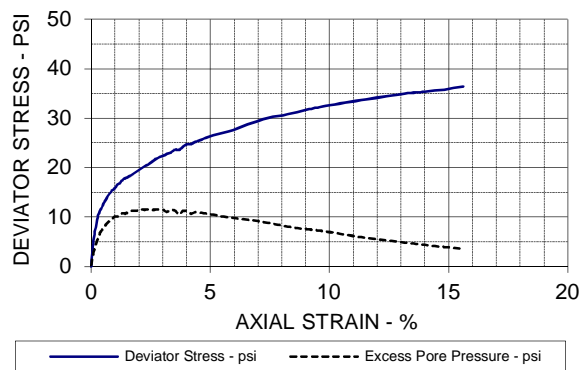
SPECIMEN NO. 1



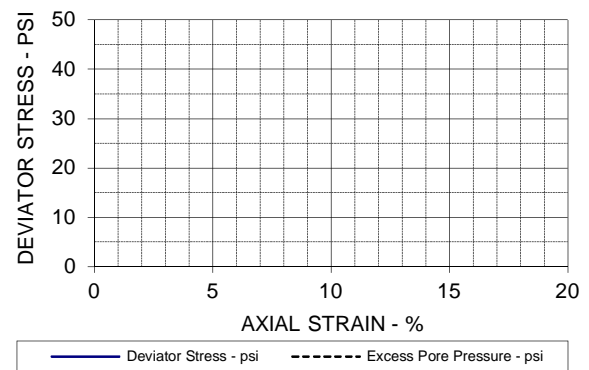
SPECIMEN NO. 2



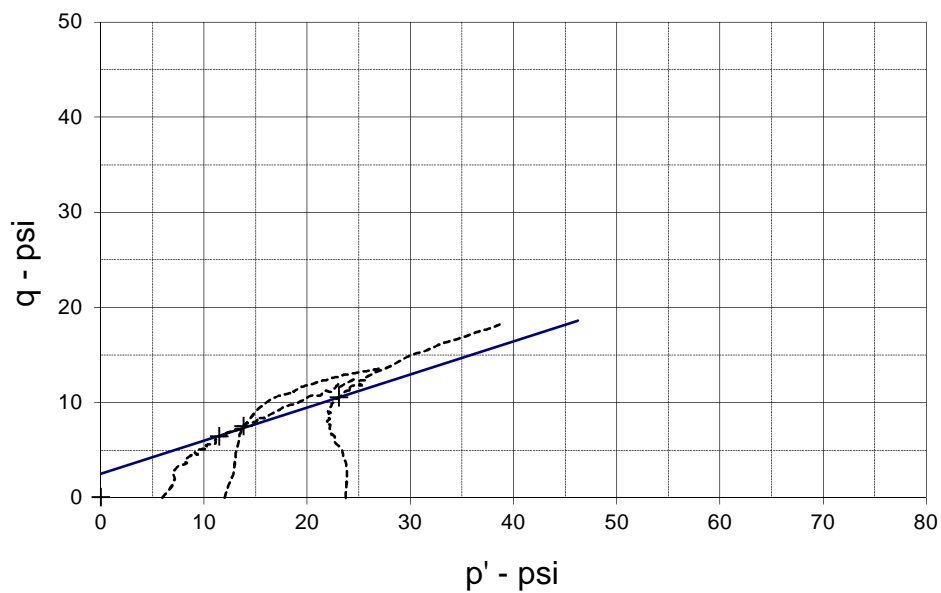
SPECIMEN NO. 3



SPECIMEN NO. 4

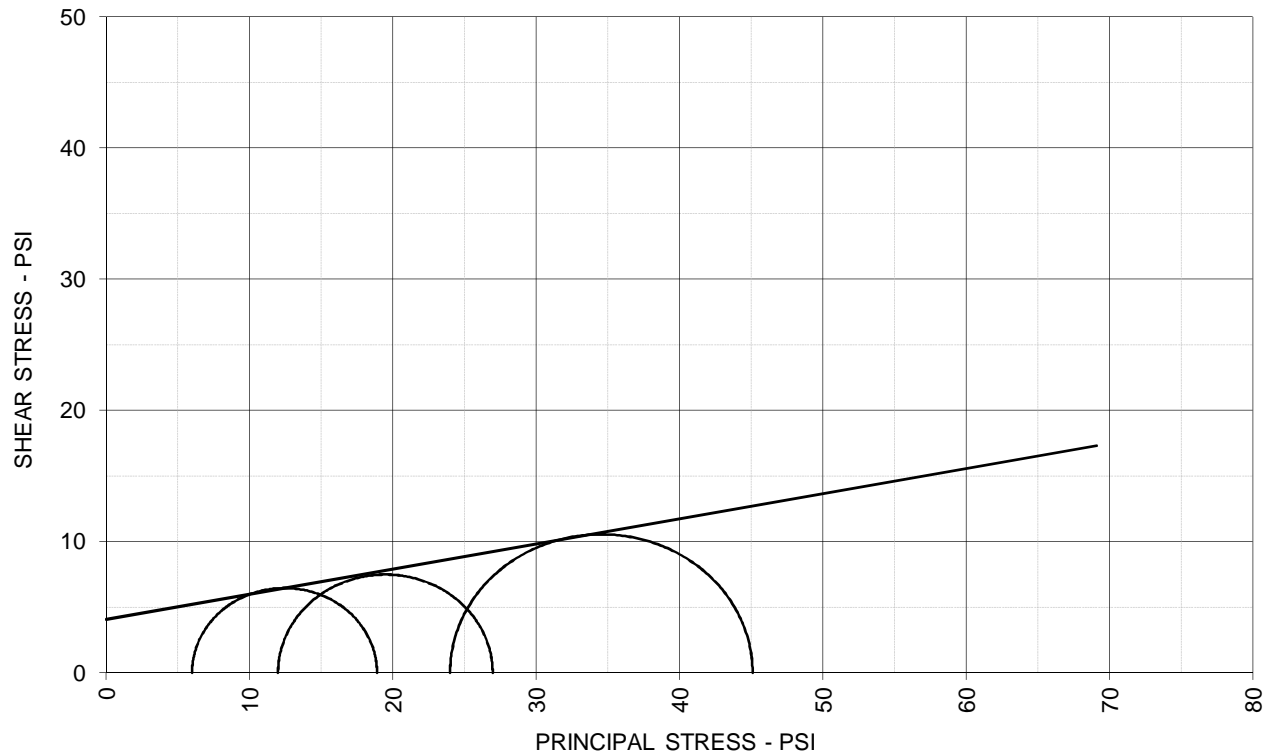


p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS	$R^2 = 1.00$	$a \text{ (deg)} = 19.2$	$a \text{ (psi)} = 2.5$
PROJECT: Oklaunion- Ponds Area Dikes	TYPE OF TEST & NO: CU with Pore Pressure		
PROJECT NO: N4165227	<b>TERRACON</b>		
DESCRIPTION: Lean Clay (CL)			
			Exhibit: B-30

# TRIAXIAL SHEAR TEST REPORT

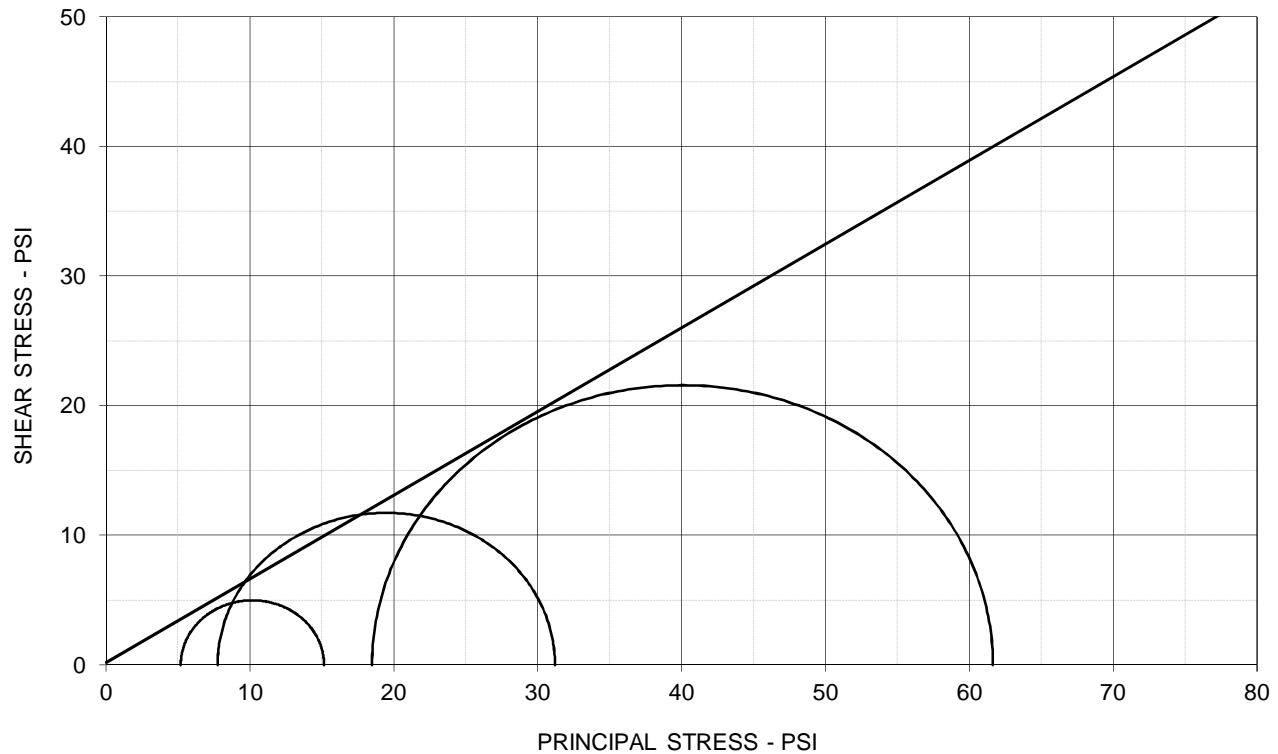


TOTAL STRESS PARAMETERS		$\phi = 10.9 \text{ deg}$		$c = 4.1 \text{ psi}$	
	SPECIMEN NO.	1	2	3	4
	INITIAL				
	Moisture Content - %	16.3	16.6	16.1	
	Dry Density - pcf	112.0	115.3	116.9	
	Diameter - inches	1.92	1.90	1.90	
	Height - inches	3.92	3.98	3.96	
	AT TEST				
	Final Moisture - %	18.2	17.0	15.1	
	Dry Density - pcf	112.1	115.3	118.7	
	Calculated Diameter (in.)	1.90	1.90	1.87	
TEST DESCRIPTION		PROJECT INFORMATION			
TYPE OF TEST & NO: CU with Pore Pressure SAMPLE TYPE: Tube DESCRIPTION: Lean Clay (CL) SAMPLE LOCATION: B-6, ST-1, 5.0-7.0 ft ASSUMED SPECIFIC GRAVITY: 2.70 LL: 35    PL: 15    PI: 20    Percent -200: 86.3 REMARKS: Specimens trimmed to 2.0" diameter.		PROJECT: Oklaunion- Ponds Area Dikes			
		LOCATION: Vernon, TX			
		PROJECT NO: N4165227			
		CLIENT: AEP			
		DATE: 8/22/16			
		TERRACON		Exhibit: B-30	

# TRIAXIAL SHEAR TEST REPORT



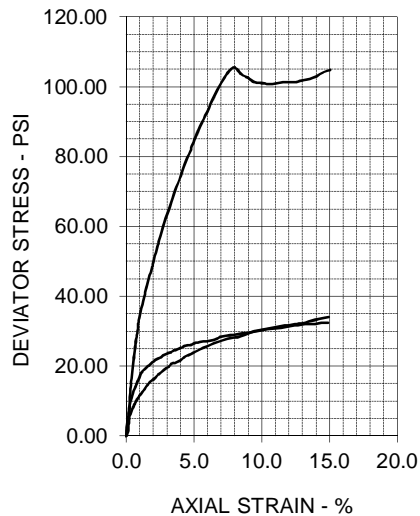
P.O. Box 5010, 51 Lost Mound Drive, Suite 135 Chattanooga, TN 37406



## EFFECTIVE STRESS PARAMETERS

$\phi' = 32.8 \text{ deg}$

$c' = 0.2 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	14.4	13.9	12.8
Dry Density - pcf	115.9	116.7	118.3
Diameter - inches	1.93	1.96	1.96
Height - inches	4.00	4.00	4.00

#### AT TEST

Final Moisture - %	16.3	15.8	14.7
Dry Density - pcf	116.2	117.9	119.7
Calculated Diameter (in.)	1.92	1.95	1.94
Height - inches	3.96	3.96	3.93
Effect. Cell Pressure - psi	8.0	16.0	32.0
Failure Stress - psi	9.96	23.45	43.15
Total Pore Pressure - psi	52.8	58.3	63.5
Strain Rate - inches/min.	0.00040	0.00040	0.00040
Failure Strain - %	0.7	2.9	1.6
$S_1'$ Failure - psi	15.15	31.20	61.64
$S_3'$ Failure - psi	5.19	7.75	18.49

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-6, ST-2, 12.0-14.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 29 PL: 14 PI: 15 Percent -200: 87.4  
 REMARKS: Specimens trimmed to 2.0" diameter.

## PROJECT INFORMATION

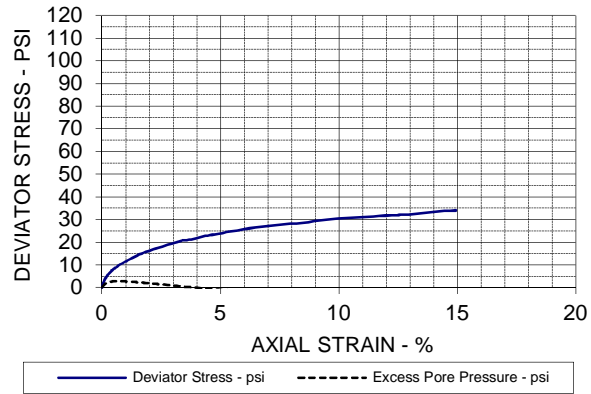
PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/22/16

**TERRACON**

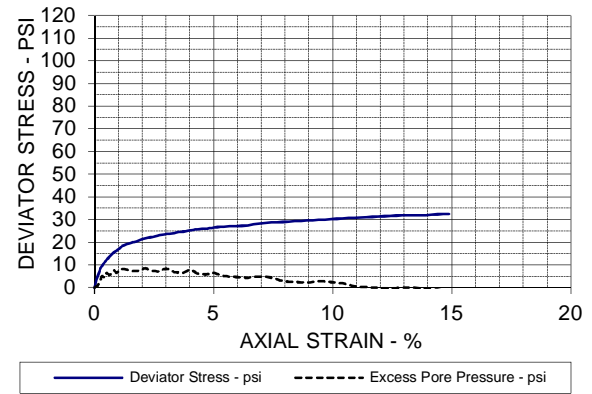
**Exhibit: B-31**

Note: Stage two (2) specimen subjected to Hydraulic Conductivity test prior to Triaxial Shear Testing.

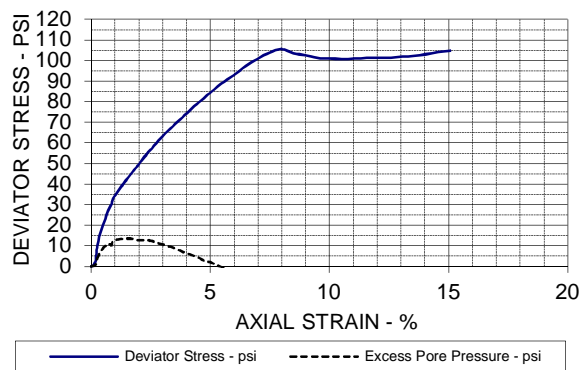
SPECIMEN NO. 1



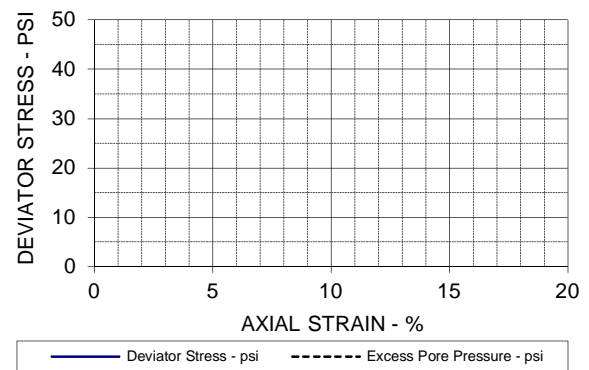
SPECIMEN NO. 2



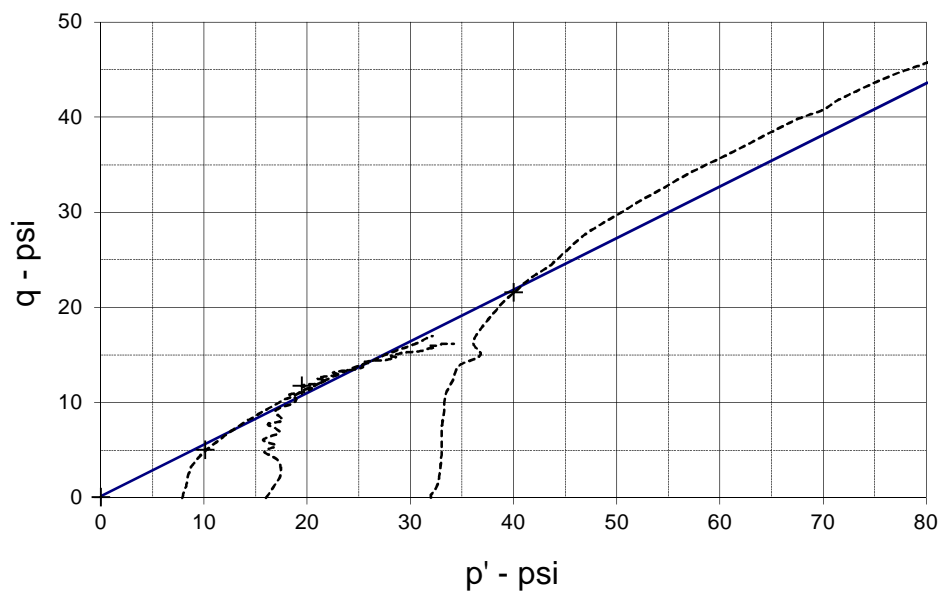
SPECIMEN NO. 3



SPECIMEN NO. 4

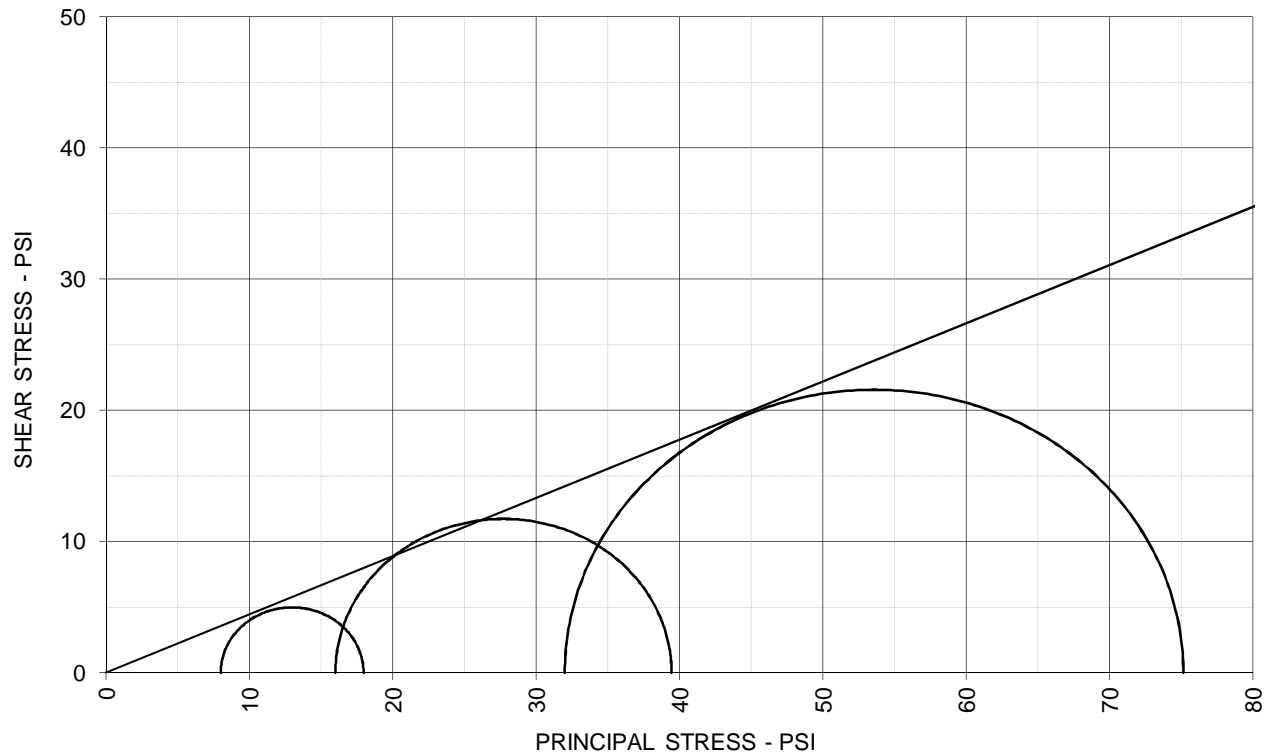


p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS	$R^2 = 0.99$	$a \text{ (deg)} = 28.5$	$a \text{ (psi)} = 0.2$
PROJECT: Oklaunion- Ponds Area Dikes	TYPE OF TEST & NO: CU with Pore Pressure		
PROJECT NO: N4165227	<b>TERRACON</b>		
DESCRIPTION: Lean Clay (CL)			
			Exhibit: B-31

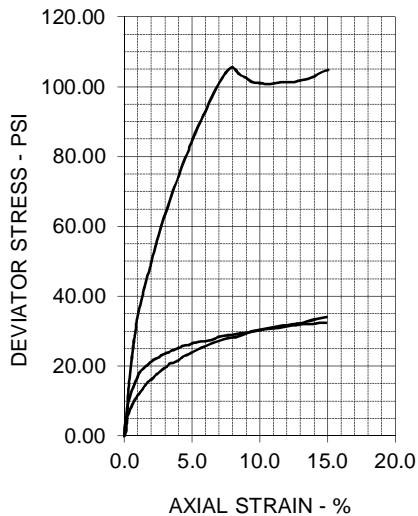
# TRIAXIAL SHEAR TEST REPORT



## TOTAL STRESS PARAMETERS

$\phi = 23.9 \text{ deg}$

$c = 0.0 \text{ psi}$



### SPECIMEN NO.

1 2 3 4

#### INITIAL

Moisture Content - %	14.4	13.9	12.8
Dry Density - pcf	115.9	116.7	118.3
Diameter - inches	1.93	1.96	1.96
Height - inches	4.00	4.00	4.00

#### AT TEST

Final Moisture - %	16.3	15.8	14.7
Dry Density - pcf	116.2	117.9	119.7
Calculated Diameter (in.)	1.92	1.95	1.94
Height - inches	3.96	3.96	3.93
Effect. Cell Pressure - psi	8.0	16.0	32.0
Failure Stress - psi	9.96	23.45	43.15
Total Pore Pressure - psi	52.8	58.3	63.5
Strain Rate - inches/min.	0.00040	0.00040	0.00040
Failure Strain - %	0.7	2.9	1.6
$S_1$ Failure - psi	17.96	39.45	75.15
$S_3$ Failure - psi	8.00	16.00	32.00

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with Pore Pressure  
 SAMPLE TYPE: Tube  
 DESCRIPTION: Lean Clay (CL)  
 SAMPLE LOCATION: B-6, ST-2, 12.0-14.0 ft  
 ASSUMED SPECIFIC GRAVITY: 2.70  
 LL: 29 PL: 14 PI: 15 Percent -200: 87.4  
 REMARKS: Specimens trimmed to 2.0" diameter.

## PROJECT INFORMATION

PROJECT: Oklaunion- Ponds Area Dikes  
 LOCATION: Vernon, TX  
 PROJECT NO: N4165227  
 CLIENT: AEP  
 DATE: 8/22/16

**TERRACON**

Exhibit: B-31

## HYDRAULIC CONDUCTIVITY DETERMINATION FLEXIBLE WALL PERMEAMETER - CONSTANT VOLUME (Mercury Permeometer Test)

Project : Oklaunion- Ponds Area Dikes

Date: 8/18/2016

Panel Number : P-1

Project No. : N4165227

### Permeometer Data

Boring No.: B-1	$a_p = 0.031416 \text{ cm}^2$	Set Mercury to Pipet Rp at beginning	Equilibrium	1.6	$\text{cm}^3$
Sample: ST-1	$a_a = 0.767120 \text{ cm}^2$		Pipet Rp	23.0	$\text{cm}^3$
Depth (ft): 5.0-7.0	$M_1 = 0.030180$	$C = 0.0012949$	Annulus Ra	0.7	$\text{cm}^3$
Other Location: Tube	$M_2 = 1.040953$	$T = 0.046677$			

Material Description : Lean Clay

### SAMPLE DATA

Wet Wt. sample + ring or tare :	386.73	g			
Tare or ring Wt. :	0.0	g			
Wet Wt. of Sample :	386.73	g			
Diameter :	1.91	in	4.86	$\text{cm}^2$	
Length :	3.95	in	10.04	cm	
Area:	2.88	$\text{in}^2$	18.56	$\text{cm}^2$	
Volume :	11.37	$\text{in}^3$	186.29	$\text{cm}^3$	
Unit Wt.(wet):	129.54	pcf	2.08	$\text{g/cm}^3$	
Unit Wt.(dry):	110.19	pcf	1.77	$\text{g/cm}^3$	

	Before Test	After Test
Tare No.:	SW	Tare No.:
Wet Wt.+tare:	130.17	Wet Wt.+tare:
Dry Wt.+tare:	115.28	Dry Wt.+tare:
Tare Wt:	30.50	Tare Wt:
Dry Wt.:	84.78	Dry Wt.:
Water Wt.:	14.89	Water Wt.:
% moist.:	17.6	% moist.:

Assumed Specific Gravity: 2.70 Max Dry Density(pcf) = OMC =

% of max = +/- OMC =

Calculated % saturation: Void ratio (e) = 0.530 Porosity (n) = 0.346

### Test Pressures During Hydraulic Conductivity Test

Cell Pressure (psi) = 55.00 Back Pressure (psi) = 50.00 Confining Pressure = 5.00 psi

Note: The above value is Effective Confining Pressure

### TEST READINGS

$Z_1$ (Mercury Height Difference @  $t_1$ ): 22.3 cm Hydraulic Gradient = 28.00

Date	elapsed t (seconds)	Z (pipet @ t)	DZp (cm)	temp (deg C)	a (temp corr)	k (cm/sec)	k (ft./day)	Reset = *
8/9/2016	300	22.55	0.473826	21	0.977	9.43E-08	2.67E-04	
8/9/2016	600	22.25	0.773826	21	0.977	7.76E-08	2.20E-04	
8/9/2016	900	22.05	0.973826	21	0.977	6.54E-08	1.85E-04	
8/9/2016	1200	21.9	1.123826	21	0.977	5.68E-08	1.61E-04	

### SUMMARY

$k_a = 7.35\text{E-}08 \text{ cm/sec}$	Acceptance criteria = 50 %
$k_i$	$V_m$
$k_1 = 9.43\text{E-}08 \text{ cm/sec}$	28.3 %
$k_2 = 7.76\text{E-}08 \text{ cm/sec}$	5.5 %
$k_3 = 6.54\text{E-}08 \text{ cm/sec}$	11.1 %
$k_4 = 5.68\text{E-}08 \text{ cm/sec}$	22.7 %

$$V_m = \frac{|k_a - k_i|}{k_a} \times 100$$

Hydraulic conductivity	$k = 7.35\text{E-}08 \text{ cm/sec}$	$2.08\text{E-}04 \text{ ft/day}$
Void Ratio	$e =$	
Porosity	$n =$	
Bulk Density	$g = 2.08 \text{ g/cm}^3$	$129.5 \text{ pcf}$
Water Content	$W = 0.31 \text{ cm}^3/\text{cm}^3$	( at 20 deg C)
Intrinsic Permeability	$k_{int} = 7.53\text{E-}13 \text{ cm}^2$	( at 20 deg C)

## HYDRAULIC CONDUCTIVITY DETERMINATION FLEXIBLE WALL PERMEAMETER - CONSTANT VOLUME (Mercury Permmometer Test)

Project : Oklaunion- Ponds Area Dikes

Date: 8/18/2016

Panel Number : P-1

Project No. : N4165227

### Permometer Data

Boring No.:	B-1	$a_p = 0.031416 \text{ cm}^2$	Set Mercury to Pipet Rp at beginning	Equilibrium	1.6	$\text{cm}^3$
Sample:	ST-2	$a_a = 0.767120 \text{ cm}^2$		Pipet Rp	16.8	$\text{cm}^3$
Depth (ft):	12.0-14.0	$M_1 = 0.030180$	$C = 0.0017444$	Annulus Ra	1.0	$\text{cm}^3$
Other Location:	Tube	$M_2 = 1.040953$	$T = 0.0658881$			

Material Description : Lean Clay

### SAMPLE DATA

Wet Wt. sample + ring or tare :	149.04	g				
Tare or ring Wt. :	0.0	g				
Wet Wt. of Sample :	149.04	g				
Diameter :	1.39	in	3.53	$\text{cm}^2$	Before Test	After Test
Length :	2.80	in	7.11	cm	Tare No.:	MCE
Area:	1.51	$\text{in}^2$	9.76	$\text{cm}^2$	Wet Wt.+tare:	139.66
Volume :	4.24	$\text{in}^3$	69.40	$\text{cm}^3$	Dry Wt.+tare:	125.54
Unit Wt.(wet):	134.00	pcf	2.15	$\text{g/cm}^3$	Tare Wt.:	30.82
Unit Wt.(dry):	116.62	pcf	1.87	$\text{g/cm}^3$	Dry Wt.:	94.72
					Water Wt.:	14.12
					% moist.:	14.9

Assumed Specific Gravity: 2.70 Max Dry Density(pcf) = OMC =

% of max = +/- OMC =

Calculated % saturation: Void ratio (e) = 0.419 Porosity (n)= 0.295

### Test Pressures During Hydraulic Conductivity Test

Cell Pressure (psi) = 55.00 Back Pressure (psi) = 50.00 Confining Pressure = 5.00 psi

Note: The above value is Effective Confining Pressure

### TEST READINGS

$Z_1$ (Mercury Height Difference @  $t_1$ ): 15.8 cm Hydraulic Gradient = 28.00

Date	elapsed t (seconds)	Z (pipet @ t)	DZp (cm)	temp (deg C)	a (temp corr)	k (cm/sec)	k (ft./day)	Reset = *
8/9/2016	300	16.55	0.227244	21	0.977	8.57E-08	2.43E-04	
8/9/2016	600	16.45	0.327244	21	0.977	6.19E-08	1.75E-04	
8/9/2016	900	16.35	0.427244	21	0.977	5.41E-08	1.53E-04	
8/9/2016	1200	16.25	0.527244	21	0.977	5.02E-08	1.42E-04	

### SUMMARY

$k_a = 6.30\text{E-}08 \text{ cm/sec}$	Acceptance criteria = 50 %
$k_i$	$V_m$
$k_1 = 8.57\text{E-}08 \text{ cm/sec}$	36.1 %
$k_2 = 6.19\text{E-}08 \text{ cm/sec}$	1.7 %
$k_3 = 5.41\text{E-}08 \text{ cm/sec}$	14.1 %
$k_4 = 5.02\text{E-}08 \text{ cm/sec}$	20.3 %

$$V_m = \frac{|k_a - k_i|}{k_a} \times 100$$

Hydraulic conductivity	$k = 6.30\text{E-}08 \text{ cm/sec}$	$1.78\text{E-}04 \text{ ft/day}$
Void Ratio	$e =$	
Porosity	$n =$	
Bulk Density	$g = 2.15 \text{ g/cm}^3$	$134.0 \text{ pcf}$
Water Content	$W = 0.28 \text{ cm}^3/\text{cm}^3$	( at 20 deg C)
Intrinsic Permeability	$k_{int} = 6.45\text{E-}13 \text{ cm}^2$	( at 20 deg C)

## HYDRAULIC CONDUCTIVITY DETERMINATION FLEXIBLE WALL PERMEAMETER - CONSTANT VOLUME (Mercury Permometer Test)

Project : Oklaunion- Ponds Area Dikes

Date: 8/18/2016

Panel Number : P-1

Project No. : N4165227

### Permometer Data

Boring No.: B-2	$a_p = 0.031416 \text{ cm}^2$	Set Mercury to Pipet Rp at beginning	Equilibrium	1.6	$\text{cm}^3$
Sample: ST-1	$a_a = 0.767120 \text{ cm}^2$		Pipet Rp	23.3	$\text{cm}^3$
Depth (ft): 5.0-7.0	$M_1 = 0.030180$	$C = 0.0012537$	Annulus Ra	0.7	$\text{cm}^3$
Other Location: Tube	$M_2 = 1.040953$	$T = 0.0461629$			

Material Description : Lean Clay

### SAMPLE DATA

Wet Wt. sample + ring or tare :	414.99 g				
Tare or ring Wt. :	0.0 g				
Wet Wt. of Sample :	414.99 g				
Diameter : 1.96 in	4.97 $\text{cm}^2$		Before Test		After Test
Length : 4.00 in	10.15 cm		Tare No.: 25	Tare No.:	
Area: 3.00 $\text{in}^2$	19.39 $\text{cm}^2$		Wet Wt.+tare: 179.61	Wet Wt.+tare:	
Volume : 12.00 $\text{in}^3$	196.72 $\text{cm}^3$		Dry Wt.+tare: 160.12	Dry Wt.+tare:	
Unit Wt.(wet): 131.64 pcf	2.11 $\text{g/cm}^3$		Tare Wt: 30.91	Tare Wt:	
Unit Wt.(dry): 114.38 pcf	1.83 $\text{g/cm}^3$		Dry Wt.: 129.21	Dry Wt.:	
			Water Wt.: 19.49	Water Wt.:	
			% moist.: 15.1	% moist.:	

Assumed Specific Gravity: 2.70 Max Dry Density(pcf) = OMC =

% of max = +/- OMC =

Calculated % saturation: Void ratio (e) = 0.441 Porosity (n)= 0.306

### Test Pressures During Hydraulic Conductivity Test

Cell Pressure (psi) = 55.00 Back Pressure (psi) = 50.00 Confining Pressure = 5.00 psi

Note: The above value is Effective Confining Pressure

### TEST READINGS

$Z_1$ (Mercury Height Difference @  $t_1$ ): 22.5 cm Hydraulic Gradient = 28.00

Date	elapsed t (seconds)	Z (pipet @ t)	DZp (cm)	temp (deg C)	a (temp corr)	k (cm/sec)	k (ft./day)	Reset = *
8/9/2016	300	22.25	1.012411	21	0.977	1.95E-07	5.54E-04	
8/9/2016	600	21.65	1.612411	21	0.977	1.58E-07	4.48E-04	
8/9/2016	900	21.2	2.062411	21	0.977	1.36E-07	3.86E-04	
8/9/2016	1200	20.85	2.412411	21	0.977	1.20E-07	3.42E-04	

### SUMMARY

$k_a = 1.52\text{E-}07 \text{ cm/sec}$	Acceptance criteria = 50 %
$k_i$	$V_m$
$k_1 = 1.95\text{E-}07 \text{ cm/sec}$	28.1 %
$k_2 = 1.58\text{E-}07 \text{ cm/sec}$	3.5 %
$k_3 = 1.36\text{E-}07 \text{ cm/sec}$	10.7 %
$k_4 = 1.20\text{E-}07 \text{ cm/sec}$	21.0 %
	$V_m = \frac{ k_a - k_i }{k_a} \times 100$

Hydraulic conductivity	$k = 1.52\text{E-}07 \text{ cm/sec}$	$4.32\text{E-}04 \text{ ft/day}$
Void Ratio	$e =$	
Porosity	$n =$	
Bulk Density	$g = 2.11 \text{ g/cm}^3$	131.6 pcf
Water Content	$W = 0.28 \text{ cm}^3/\text{cm}^3$	( at 20 deg C)
Intrinsic Permeability	$k_{int} = 1.56\text{E-}12 \text{ cm}^2$	( at 20 deg C)

## HYDRAULIC CONDUCTIVITY DETERMINATION FLEXIBLE WALL PERMEAMETER - CONSTANT VOLUME (Mercury Permmeter Test)

Project : Oklaunion- Ponds Area Dikes

Date: 8/18/2016

Panel Number : P-1

Project No. : N4165227

### Permometer Data

Boring No.:	B-2	$a_p = 0.031416 \text{ cm}^2$	Set Mercury to Pipet Rp at beginning	Equilibrium	1.6	$\text{cm}^3$
Sample:	ST-2	$a_a = 0.767120 \text{ cm}^2$		Pipet Rp	16.8	$\text{cm}^3$
Depth (ft):	12.0-14.0	$M_1 = 0.030180$	$C = 0.001714$	Annulus Ra	1.0	$\text{cm}^3$
Other Location:	Tube	$M_2 = 1.040953$	$T = 0.0657237$			

Material Description : Lean Clay with Sand

### SAMPLE DATA

Wet Wt. sample + ring or tare :	151.98	g				
Tare or ring Wt. :	0.0	g				
Wet Wt. of Sample :	151.98	g				
Diameter :	1.40	in	3.56	$\text{cm}^2$	Before Test	After Test
Length :	2.81	in	7.13	cm	Tare No.:	8
Area:	1.54	$\text{in}^2$	9.96	$\text{cm}^2$	Wet Wt.+tare:	158.95
Volume :	4.33	$\text{in}^3$	70.99	$\text{cm}^3$	Dry Wt.+tare:	143.03
Unit Wt.(wet):	133.60	pcf	2.14	$\text{g/cm}^3$	Tare Wt:	26.78
Unit Wt.(dry):	117.51	pcf	1.88	$\text{g/cm}^3$	Dry Wt.:	116.25
					Water Wt.:	15.92
					% moist.:	13.7

Assumed Specific Gravity: 2.70 Max Dry Density(pcf) = OMC =

% of max = +/- OMC =

Calculated % saturation: Void ratio (e) = 0.434 Porosity (n)= 0.302

### Test Pressures During Hydraulic Conductivity Test

Cell Pressure (psi) = 55.00 Back Pressure (psi) = 50.00 Confining Pressure = 5.00 psi

Note: The above value is Effective Confining Pressure

### TEST READINGS

$Z_1$ (Mercury Height Difference @  $t_1$ ): 15.8 cm Hydraulic Gradient = 28.00

Date	elapsed t (seconds)	Z (pipet @ t)	DZp (cm)	temp (deg C)	a (temp corr)	k (cm/sec)	k (ft./day)	Reset = *
8/9/2016	300	16.55	0.2652	21	0.977	9.81E-08	2.78E-04	
8/9/2016	600	16.35	0.4652	21	0.977	8.66E-08	2.46E-04	
8/9/2016	900	16.25	0.5652	21	0.977	7.04E-08	2.00E-04	
8/9/2016	1200	16.15	0.6652	21	0.977	6.24E-08	1.77E-04	

### SUMMARY

$k_a = 7.94\text{E-}08 \text{ cm/sec}$	Acceptance criteria = 50 %
$k_i$	$V_m$
$k_1 = 9.81\text{E-}08 \text{ cm/sec}$	23.6 %
$k_2 = 8.66\text{E-}08 \text{ cm/sec}$	9.1 %
$k_3 = 7.04\text{E-}08 \text{ cm/sec}$	11.3 %
$k_4 = 6.24\text{E-}08 \text{ cm/sec}$	21.4 %

$$V_m = \frac{|k_a - k_i|}{k_a} \times 100$$

Hydraulic conductivity	$k = 7.94\text{E-}08 \text{ cm/sec}$	$2.25\text{E-}04 \text{ ft/day}$
Void Ratio	$e =$	
Porosity	$n =$	
Bulk Density	$g = 2.14 \text{ g/cm}^3$	133.6 pcf
Water Content	$W = 0.26 \text{ cm}^3/\text{cm}^3$	( at 20 deg C)
Intrinsic Permeability	$k_{int} = 8.13\text{E-}13 \text{ cm}^2$	( at 20 deg C)

## HYDRAULIC CONDUCTIVITY DETERMINATION FLEXIBLE WALL PERMEAMETER - CONSTANT VOLUME (Mercury Permeometer Test)

Project : Oklaunion- Ponds Area Dikes

Date: 8/18/2016

Panel Number : P-1

Project No. : N4165227

### Permeometer Data

Boring No.: B-3	$a_p = 0.031416 \text{ cm}^2$	Set Mercury to Pipet Rp at beginning	Equilibrium	1.6	$\text{cm}^3$
Sample: ST-1	$a_a = 0.767120 \text{ cm}^2$		Pipet Rp	16.9	$\text{cm}^3$
Depth (ft): 5.0-7.0	$M_1 = 0.030180$	$C = 0.0017208$	Annulus Ra	1.0	$\text{cm}^3$
Other Location: Tube	$M_2 = 1.040953$	$T = 0.0655602$			

Material Description : Lean Clay

### SAMPLE DATA

Wet Wt. sample + ring or tare :	157.28	g			
Tare or ring Wt. :	0.0	g			
Wet Wt. of Sample :	157.28	g			
Diameter :	1.40	in	3.56	$\text{cm}^2$	
Length :	2.81	in	7.15	cm	
Area:	1.54	$\text{in}^2$	9.95	$\text{cm}^2$	
Volume :	4.34	$\text{in}^3$	71.06	$\text{cm}^3$	
Unit Wt.(wet):	138.11	pcf	2.21	$\text{g/cm}^3$	
Unit Wt.(dry):	121.53	pcf	1.95	$\text{g/cm}^3$	

	Before Test	After Test
Tare No.:	61	
Wet Wt.+tare:	119.02	
Dry Wt.+tare:	108.77	
Tare Wt:	33.64	
Dry Wt.:	75.13	
Water Wt.:	10.25	
% moist.:	13.6	

Assumed Specific Gravity: 2.70 Max Dry Density(pcf) = OMC =

% of max = +/- OMC =

Calculated % saturation: Void ratio (e) = 0.434 Porosity (n)= 0.302

### Test Pressures During Hydraulic Conductivity Test

Cell Pressure (psi) = 55.00 Back Pressure (psi) = 50.00 Confining Pressure = 5.00 psi

Note: The above value is Effective Confining Pressure

### TEST READINGS

$Z_1$ (Mercury Height Difference @  $t_1$ ): 15.9 cm Hydraulic Gradient = 28.00

Date	elapsed t (seconds)	Z (pipet @ t)	DZp (cm)	temp (deg C)	a (temp corr)	k (cm/sec)	k (ft./day)	Reset = *
8/9/2016	300	16.7	0.153157	21	0.977	5.65E-08	1.60E-04	
8/9/2016	600	16.6	0.253157	21	0.977	4.69E-08	1.33E-04	
8/9/2016	900	16.55	0.303157	21	0.977	3.75E-08	1.06E-04	
8/9/2016	1200	16.45	0.403157	21	0.977	3.75E-08	1.06E-04	

### SUMMARY

$k_a = 4.46\text{E-}08 \text{ cm/sec}$	Acceptance criteria = 50 %
$k_i$	$V_m$
$k_1 = 5.65\text{E-}08 \text{ cm/sec}$	26.7 %
$k_2 = 4.69\text{E-}08 \text{ cm/sec}$	5.1 %
$k_3 = 3.75\text{E-}08 \text{ cm/sec}$	16.0 %
$k_4 = 3.75\text{E-}08 \text{ cm/sec}$	15.9 %

$$V_m = \frac{|k_a - k_i|}{k_a} \times 100$$

Hydraulic conductivity	$k = 4.46\text{E-}08 \text{ cm/sec}$	$1.26\text{E-}04 \text{ ft/day}$
Void Ratio	$e =$	
Porosity	$n =$	
Bulk Density	$g = 2.21 \text{ g/cm}^3$	$138.1 \text{ pcf}$
Water Content	$W = 0.27 \text{ cm}^3/\text{cm}^3$	( at 20 deg C)
Intrinsic Permeability	$k_{int} = 4.57\text{E-}13 \text{ cm}^2$	( at 20 deg C)

## HYDRAULIC CONDUCTIVITY DETERMINATION FLEXIBLE WALL PERMEAMETER - CONSTANT VOLUME (Mercury Permeometer Test)

Project : Oklaunion- Ponds Area Dikes

Date: 8/18/2016

Panel Number : P-1

Project No. : N4165227

### Permeometer Data

Boring No.: B-3	$a_p = 0.031416 \text{ cm}^2$	Set Mercury to Pipet Rp at beginning	Equilibrium	1.6	$\text{cm}^3$
Sample: ST-2	$a_a = 0.767120 \text{ cm}^2$		Pipet Rp	16.9	$\text{cm}^3$
Depth (ft): 12.0-14.0	$M_1 = 0.030180$	$C = 0.0018401$	Annulus Ra	1.0	$\text{cm}^3$
Other Location: Tube	$M_2 = 1.040953$	$T = 0.0654439$			

Material Description : Lean Clay

### SAMPLE DATA

Wet Wt. sample + ring or tare :	134.77	g			
Tare or ring Wt. :	0.0	g			
Wet Wt. of Sample :	134.77	g			
Diameter :	1.36	in	3.44	$\text{cm}^2$	
Length :	2.82	in	7.16	cm	
Area:	1.44	$\text{in}^2$	9.32	$\text{cm}^2$	
Volume :	4.07	$\text{in}^3$	66.69	$\text{cm}^3$	
Unit Wt.(wet):	126.10	pcf	2.02	$\text{g/cm}^3$	
Unit Wt.(dry):	106.73	pcf	1.71	$\text{g/cm}^3$	

	Before Test	After Test
Tare No.:	68	Tare No.:
Wet Wt.+tare:	165.58	Wet Wt.+tare:
Dry Wt.+tare:	144.88	Dry Wt.+tare:
Tare Wt:	30.82	Tare Wt:
Dry Wt.:	114.06	Dry Wt.:
Water Wt.:	20.7	Water Wt.:
% moist.:	18.1	% moist.:

Assumed Specific Gravity: 2.70 Max Dry Density(pcf) = OMC =

% of max = +/- OMC =

Calculated % saturation: Void ratio (e) = 0.565 Porosity (n)= 0.361

### Test Pressures During Hydraulic Conductivity Test

Cell Pressure (psi) = 55.00 Back Pressure (psi) = 50.00 Confining Pressure = 5.00 psi

Note: The above value is Effective Confining Pressure

### TEST READINGS

$Z_1$ (Mercury Height Difference @  $t_1$ ): 15.9 cm Hydraulic Gradient = 28.00

Date	elapsed t (seconds)	Z (pipet @ t)	DZp (cm)	temp (deg C)	a (temp corr)	k (cm/sec)	k (ft./day)	Reset = *
8/9/2016	300	16.7	0.180269	21	0.977	7.11E-08	2.02E-04	
8/9/2016	600	16.6	0.280269	21	0.977	5.55E-08	1.57E-04	
8/9/2016	900	16.5	0.380269	21	0.977	5.03E-08	1.43E-04	
8/9/2016	1200	16.4	0.480269	21	0.977	4.78E-08	1.36E-04	

### SUMMARY

$k_a = 5.62\text{E-}08 \text{ cm/sec}$	Acceptance criteria = 50 %
$k_i$	$V_m$
$k_1 = 7.11\text{E-}08 \text{ cm/sec}$	26.6 %
$k_2 = 5.55\text{E-}08 \text{ cm/sec}$	1.3 %
$k_3 = 5.03\text{E-}08 \text{ cm/sec}$	10.4 %
$k_4 = 4.78\text{E-}08 \text{ cm/sec}$	14.9 %

$$V_m = \frac{|k_a - k_i|}{k_a} \times 100$$

Hydraulic conductivity	$k = 5.62\text{E-}08 \text{ cm/sec}$	$1.59\text{E-}04 \text{ ft/day}$
Void Ratio	$e =$	
Porosity	$n =$	
Bulk Density	$g = 2.02 \text{ g/cm}^3$	$126.1 \text{ pcf}$
Water Content	$W = 0.31 \text{ cm}^3/\text{cm}^3$	( at 20 deg C)
Intrinsic Permeability	$k_{int} = 5.76\text{E-}13 \text{ cm}^2$	( at 20 deg C)

## HYDRAULIC CONDUCTIVITY DETERMINATION FLEXIBLE WALL PERMEAMETER - CONSTANT VOLUME (Mercury Permmometer Test)

Project : Oklaunion- Ponds Area Dikes

Date: 8/18/2016

Panel Number : P-1

Project No. : N4165227

### Permometer Data

Boring No.: B-4	$a_p = 0.031416 \text{ cm}^2$	Set Mercury to Pipet Rp at beginning	Equilibrium	1.6	$\text{cm}^3$
Sample: ST-2	$a_a = 0.767120 \text{ cm}^2$		Pipet Rp	16.9	$\text{cm}^3$
Depth (ft): 8.5-10.5	$M_1 = 0.030180$	$C = 0.0017587$	Annulus Ra	1.0	$\text{cm}^3$
Other Location: Tube	$M_2 = 1.040953$	$T = 0.0651664$			

Material Description : Lean Clay

### SAMPLE DATA

Wet Wt. sample + ring or tare :	144.07	g			
Tare or ring Wt. :	0.0	g			
Wet Wt. of Sample :	144.07	g			
Diameter :	1.39	in	3.53	$\text{cm}^2$	
Length :	2.83	in	7.19	cm	
Area:	1.52	$\text{in}^2$	9.79	$\text{cm}^2$	
Volume :	4.29	$\text{in}^3$	70.37	$\text{cm}^3$	
Unit Wt.(wet):	127.75	pcf	2.05	$\text{g/cm}^3$	
Unit Wt.(dry):	109.70	pcf	1.76	$\text{g/cm}^3$	

	Before Test	After Test
Tare No.:	145	Tare No.:
Wet Wt.+tare:	171.49	Wet Wt.+tare:
Dry Wt.+tare:	151.53	Dry Wt.+tare:
Tare Wt:	30.20	Tare Wt:
Dry Wt.:	121.33	Dry Wt.:
Water Wt.:	19.96	Water Wt.:
% moist.:	16.5	% moist.:

Assumed Specific Gravity: 2.70 Max Dry Density(pcf) = OMC =

% of max = +/- OMC =

Calculated % saturation: Void ratio (e) = 0.513 Porosity (n)= 0.339

### Test Pressures During Hydraulic Conductivity Test

Cell Pressure (psi) = 55.00 Back Pressure (psi) = 50.00 Confining Pressure = 5.00 psi

Note: The above value is Effective Confining Pressure

### TEST READINGS

$Z_1$ (Mercury Height Difference @  $t_1$ ): 16.0 cm Hydraulic Gradient = 28.00

Date	elapsed t (seconds)	Z (pipet @ t)	DZp (cm)	temp (deg C)	a (temp corr)	k (cm/sec)	k (ft./day)	Reset = *
8/9/2016	300	16.6	0.345337	21	0.977	1.30E-07	3.69E-04	
8/9/2016	600	16.45	0.495337	21	0.977	9.39E-08	2.66E-04	
8/9/2016	900	16.35	0.595337	21	0.977	7.55E-08	2.14E-04	
8/9/2016	1200	16.25	0.695337	21	0.977	6.64E-08	1.88E-04	

### SUMMARY

$k_a = 9.15\text{E-}08 \text{ cm/sec}$	Acceptance criteria = 50 %
$k_i$	$V_m$
$k_1 = 1.30\text{E-}07 \text{ cm/sec}$	42.4 %
$k_2 = 9.39\text{E-}08 \text{ cm/sec}$	2.6 %
$k_3 = 7.55\text{E-}08 \text{ cm/sec}$	17.5 %
$k_4 = 6.64\text{E-}08 \text{ cm/sec}$	27.5 %

$$V_m = \frac{|k_a - k_i|}{k_a} \times 100$$

Hydraulic conductivity	$k = 9.15\text{E-}08 \text{ cm/sec}$	$2.59\text{E-}04 \text{ ft/day}$
Void Ratio	$e =$	
Porosity	$n =$	
Bulk Density	$g = 2.05 \text{ g/cm}^3$	$127.7 \text{ pcf}$
Water Content	$W = 0.29 \text{ cm}^3/\text{cm}^3$	( at 20 deg C)
Intrinsic Permeability	$k_{int} = 9.38\text{E-}13 \text{ cm}^2$	( at 20 deg C)

## HYDRAULIC CONDUCTIVITY DETERMINATION FLEXIBLE WALL PERMEAMETER - CONSTANT VOLUME (Mercury Permometer Test)

Project : Oklaunion- Ponds Area Dikes

Date: 8/18/2016

Panel Number : P-1

Project No. : N4165227

### Permometer Data

Boring No.:	B-5	$a_p = 0.031416 \text{ cm}^2$	Set Mercury to Pipet Rp at beginning	Equilibrium	1.6	$\text{cm}^3$
Sample:	ST-1	$a_a = 0.767120 \text{ cm}^2$		Pipet Rp	23.4	$\text{cm}^3$
Depth (ft):	5.0-7.0	$M_1 = 0.030180$	$C = 0.0013341$	Annulus Ra	0.7	$\text{cm}^3$
Other Location:	Tube	$M_2 = 1.040953$	$T = 0.0459673$			

Material Description : Lean Clay

### SAMPLE DATA

Wet Wt. sample + ring or tare :	397.92	g				
Tare or ring Wt. :	0.0	g				
Wet Wt. of Sample :	397.92	g				
Diameter :	1.90	in	4.83	$\text{cm}^2$	Before Test	After Test
Length :	4.01	in	10.19	cm	Tare No.:	25
Area:	2.84	$\text{in}^2$	18.30	$\text{cm}^2$	Wet Wt.+tare:	208.83
Volume :	11.38	$\text{in}^3$	186.44	$\text{cm}^3$	Dry Wt.+tare:	183.15
Unit Wt.(wet):	133.18	pcf	2.13	$\text{g/cm}^3$	Tare Wt:	32.90
Unit Wt.(dry):	113.74	pcf	1.82	$\text{g/cm}^3$	Dry Wt.:	150.25
					Water Wt.:	25.68
					% moist.:	17.1

Assumed Specific Gravity: 2.70 Max Dry Density(pcf) = OMC =

% of max = +/- OMC =

Calculated % saturation: Void ratio (e) = 0.474 Porosity (n)= 0.322

### Test Pressures During Hydraulic Conductivity Test

Cell Pressure (psi) = 55.00 Back Pressure (psi) = 50.00 Confining Pressure = 5.00 psi

Note: The above value is Effective Confining Pressure

### TEST READINGS

$Z_1$ (Mercury Height Difference @  $t_1$ ): 22.6 cm Hydraulic Gradient = 28.00

Date	elapsed t (seconds)	Z (pipet @ t)	DZp (cm)	temp (deg C)	a (temp corr)	k (cm/sec)	k (ft./day)	Reset = *
8/9/2016	300	22.85	0.504592	21	0.977	1.02E-07	2.89E-04	
8/9/2016	600	22.6	0.754592	21	0.977	7.67E-08	2.17E-04	
8/9/2016	900	22.45	0.904592	21	0.977	6.15E-08	1.74E-04	
8/9/2016	1200	22.35	1.004592	21	0.977	5.13E-08	1.46E-04	

### SUMMARY

$k_a = 7.29\text{E-}08 \text{ cm/sec}$	Acceptance criteria = 50 %
$k_i$	$V_m$
$k_1 = 1.02\text{E-}07 \text{ cm/sec}$	39.9 %
$k_2 = 7.67\text{E-}08 \text{ cm/sec}$	5.2 %
$k_3 = 6.15\text{E-}08 \text{ cm/sec}$	15.6 %
$k_4 = 5.13\text{E-}08 \text{ cm/sec}$	29.5 %

$$V_m = \frac{|k_a - k_i|}{k_a} \times 100$$

Hydraulic conductivity	$k = 7.29\text{E-}08 \text{ cm/sec}$	$2.07\text{E-}04 \text{ ft/day}$
Void Ratio	$e =$	
Porosity	$n =$	
Bulk Density	$g = 2.13 \text{ g/cm}^3$	$133.2 \text{ pcf}$
Water Content	$W = 0.31 \text{ cm}^3/\text{cm}^3$	( at 20 deg C)
Intrinsic Permeability	$k_{int} = 7.46\text{E-}13 \text{ cm}^2$	( at 20 deg C)

## HYDRAULIC CONDUCTIVITY DETERMINATION FLEXIBLE WALL PERMEAMETER - CONSTANT VOLUME (Mercury Permmeter Test)

Project : Oklaunion- Ponds Area Dikes

Date: 8/18/2016

Panel Number : P-1

Project No. : N4165227

### Permometer Data

Boring No.: B-5	$a_p = 0.031416 \text{ cm}^2$	Set Mercury to Pipet Rp at beginning	Equilibrium	1.6	$\text{cm}^3$
Sample: ST-2	$a_a = 0.767120 \text{ cm}^2$		Pipet Rp	16.7	$\text{cm}^3$
Depth (ft): 12.0-14.0	$M_1 = 0.030180$	$C = 0.0018021$	Annulus Ra	1.0	$\text{cm}^3$
Other Location: Tube	$M_2 = 1.040953$	$T = 0.066434$			

Material Description : Lean Clay

### SAMPLE DATA

Wet Wt. sample + ring or tare :	141.62 g				
Tare or ring Wt. :	0.0 g				
Wet Wt. of Sample :	141.62 g				
Diameter : 1.36 in	3.45 $\text{cm}^2$		Before Test		After Test
Length : 2.78 in	7.05 cm		Tare No.:	46	Tare No.:
Area: 1.45 $\text{in}^2$	9.37 $\text{cm}^2$		Wet Wt.+tare:	151.10	Wet Wt.+tare:
Volume : 4.03 $\text{in}^3$	66.08 $\text{cm}^3$		Dry Wt.+tare:	133.71	Dry Wt.+tare:
Unit Wt.(wet): 133.73 pcf	2.14 $\text{g/cm}^3$		Tare Wt:	26.77	Tare Wt:
Unit Wt.(dry): 115.02 pcf	1.84 $\text{g/cm}^3$		Dry Wt.:	106.94	Dry Wt.:
			Water Wt.:	17.39	Water Wt.:
			% moist.:	16.3	% moist.:

Assumed Specific Gravity: 2.70 Max Dry Density(pcf) = OMC =

% of max = +/- OMC =

Calculated % saturation: Void ratio (e) = 0.474 Porosity (n)= 0.322

### Test Pressures During Hydraulic Conductivity Test

Cell Pressure (psi) = 55.00 Back Pressure (psi) = 50.00 Confining Pressure = 5.00 psi

Note: The above value is Effective Confining Pressure

### TEST READINGS

$Z_1$ (Mercury Height Difference @  $t_1$ ): 15.7 cm Hydraulic Gradient = 28.00

Date	elapsed t (seconds)	Z (pipet @ t)	DZp (cm)	temp (deg C)	a (temp corr)	k (cm/sec)	k (ft./day)	Reset = *
8/9/2016	300	16.55	0.102529	21	0.977	4.01E-08	1.14E-04	
8/9/2016	600	16.45	0.202529	21	0.977	3.97E-08	1.13E-04	
8/9/2016	900	16.4	0.252529	21	0.977	3.31E-08	9.38E-05	
8/9/2016	1200	16.3	0.352529	21	0.977	3.48E-08	9.85E-05	

### SUMMARY

$k_a = 3.69\text{E-}08 \text{ cm/sec}$	Acceptance criteria = 50 %
$k_i$	$V_m$
$k_1 = 4.01\text{E-}08 \text{ cm/sec}$	8.6 %
$k_2 = 3.97\text{E-}08 \text{ cm/sec}$	7.6 %
$k_3 = 3.31\text{E-}08 \text{ cm/sec}$	10.4 %
$k_4 = 3.48\text{E-}08 \text{ cm/sec}$	5.9 %
	$V_m = \frac{ k_a - k_i }{k_a} \times 100$

Hydraulic conductivity	$k = 3.69\text{E-}08 \text{ cm/sec}$	$1.05\text{E-}04 \text{ ft/day}$
Void Ratio	$e =$	
Porosity	$n =$	
Bulk Density	$g = 2.14 \text{ g/cm}^3$	$133.7 \text{ pcf}$
Water Content	$W = 0.30 \text{ cm}^3/\text{cm}^3$	( at 20 deg C)
Intrinsic Permeability	$k_{int} = 3.78\text{E-}13 \text{ cm}^2$	( at 20 deg C)

## HYDRAULIC CONDUCTIVITY DETERMINATION FLEXIBLE WALL PERMEAMETER - CONSTANT VOLUME (Mercury Permometer Test)

Project : Oklaunion- Ponds Area Dikes

Date: 8/18/2016

Panel Number : P-1

Project No. : N4165227

### Permometer Data

Boring No.: B-6	$a_p = 0.031416 \text{ cm}^2$	Set Mercury to Pipet Rp at beginning	Equilibrium	1.6	$\text{cm}^3$
Sample: ST-1	$a_a = 0.767120 \text{ cm}^2$		Pipet Rp	23.2	$\text{cm}^3$
Depth (ft): 5.0-7.0	$M_1 = 0.030180$	$C = 0.0013175$	Annulus Ra	0.7	$\text{cm}^3$
Other Location: Tube	$M_2 = 1.040953$	$T = 0.0463602$			

Material Description : Lean Clay

### SAMPLE DATA

Wet Wt. sample + ring or tare :	399.86	g			
Tare or ring Wt. :	0.0	g			
Wet Wt. of Sample :	399.86	g			
Diameter :	1.90	in	4.84	$\text{cm}^2$	
Length :	3.98	in	10.10	cm	
Area:	2.85	$\text{in}^2$	18.37	$\text{cm}^2$	
Volume :	11.33	$\text{in}^3$	185.61	$\text{cm}^3$	
Unit Wt.(wet):	134.43	pcf	2.15	$\text{g/cm}^3$	
Unit Wt.(dry):	115.30	pcf	1.85	$\text{g/cm}^3$	

	Before Test	After Test
Tare No.:	53	Tare No.:
Wet Wt.+tare:	147.39	Wet Wt.+tare:
Dry Wt.+tare:	131.11	Dry Wt.+tare:
Tare Wt:	32.99	Tare Wt:
Dry Wt.:	98.12	Dry Wt.:
Water Wt.:	16.28	Water Wt.:
% moist.:	16.6	% moist.:

Assumed Specific Gravity: 2.70 Max Dry Density(pcf) = OMC =

% of max = +/- OMC =

Calculated % saturation: Void ratio (e) = 0.462 Porosity (n)= 0.316

### Test Pressures During Hydraulic Conductivity Test

Cell Pressure (psi) = 55.00 Back Pressure (psi) = 50.00 Confining Pressure = 5.00 psi

Note: The above value is Effective Confining Pressure

### TEST READINGS

$Z_1$ (Mercury Height Difference @  $t_1$ ): 22.5 cm Hydraulic Gradient = 28.00

Date	elapsed t (seconds)	Z (pipet @ t)	DZp (cm)	temp (deg C)	a (temp corr)	k (cm/sec)	k (ft./day)	Reset = *
8/9/2016	300	23	0.170231	21	0.977	3.40E-08	9.63E-05	
8/9/2016	600	22.9	0.270231	21	0.977	2.70E-08	7.66E-05	
8/9/2016	900	22.8	0.370231	21	0.977	2.48E-08	7.02E-05	
8/9/2016	1200	22.7	0.470231	21	0.977	2.36E-08	6.70E-05	

### SUMMARY

$k_a = 2.74\text{E-}08 \text{ cm/sec}$	Acceptance criteria = 50 %
$k_i$	$V_m$
$k_1 = 3.40\text{E-}08 \text{ cm/sec}$	24.2 %
$k_2 = 2.70\text{E-}08 \text{ cm/sec}$	1.2 %
$k_3 = 2.48\text{E-}08 \text{ cm/sec}$	9.5 %
$k_4 = 2.36\text{E-}08 \text{ cm/sec}$	13.6 %

$$V_m = \frac{|k_a - k_i|}{k_a} \times 100$$

Hydraulic conductivity	$k = 2.74\text{E-}08 \text{ cm/sec}$	$7.75\text{E-}05 \text{ ft/day}$
Void Ratio	$e =$	
Porosity	$n =$	
Bulk Density	$g = 2.15 \text{ g/cm}^3$	$134.4 \text{ pcf}$
Water Content	$W = 0.31 \text{ cm}^3/\text{cm}^3$	( at 20 deg C)
Intrinsic Permeability	$k_{int} = 2.80\text{E-}13 \text{ cm}^2$	( at 20 deg C)

## HYDRAULIC CONDUCTIVITY DETERMINATION FLEXIBLE WALL PERMEAMETER - CONSTANT VOLUME (Mercury Permmometer Test)

Project : Oklaunion- Ponds Area Dikes

Date: 8/18/2016

Panel Number : P-1

Project No. : N4165227

### Permmometer Data

Boring No.: B-6	$a_p = 0.031416 \text{ cm}^2$	Set Mercury to Pipet Rp at beginning	Equilibrium	1.6	$\text{cm}^3$
Sample: ST-2	$a_a = 0.767120 \text{ cm}^2$		Pipet Rp	23.3	$\text{cm}^3$
Depth (ft): 12.0-14.0	$M_1 = 0.030180$	$C = 0.001241$	Annulus Ra	0.7	$\text{cm}^3$
Other Location: Tube	$M_2 = 1.040953$	$T = 0.0460707$			

Material Description : Lean Clay

### SAMPLE DATA

Wet Wt. sample + ring or tare :	421.87	g			
Tare or ring Wt. :	0.0	g			
Wet Wt. of Sample :	421.87	g			
Diameter :	1.97	in	5.00	$\text{cm}^2$	
Length :	4.00	in	10.17	cm	
Area:	3.04	$\text{in}^2$	19.62	$\text{cm}^2$	
Volume :	12.18	$\text{in}^3$	199.54	$\text{cm}^3$	
Unit Wt.(wet):	131.93	pcf	2.11	$\text{g/cm}^3$	
Unit Wt.(dry):	115.79	pcf	1.86	$\text{g/cm}^3$	

	Before Test	After Test
Tare No.:	34	Tare No.:
Wet Wt.+tare:	181.51	Wet Wt.+tare:
Dry Wt.+tare:	162.56	Dry Wt.+tare:
Tare Wt:	26.59	Tare Wt:
Dry Wt.:	135.97	Dry Wt.:
Water Wt.:	18.95	Water Wt.:
% moist.:	13.9	% moist.:

Assumed Specific Gravity: 2.70 Max Dry Density(pcf) = OMC =

% of max = +/- OMC =

Calculated % saturation: Void ratio (e) = 0.445 Porosity (n)= 0.308

### Test Pressures During Hydraulic Conductivity Test

Cell Pressure (psi) = 55.00 Back Pressure (psi) = 50.00 Confining Pressure = 5.00 psi

Note: The above value is Effective Confining Pressure

### TEST READINGS

$Z_1$ (Mercury Height Difference @  $t_1$ ): 22.6 cm Hydraulic Gradient = 28.00

Date	elapsed t (seconds)	Z (pipet @ t)	DZp (cm)	temp (deg C)	a (temp corr)	k (cm/sec)	k (ft./day)	Reset = *
8/9/2016	300	22.25	1.05579	21	0.977	2.01E-07	5.71E-04	
8/9/2016	600	21.75	1.55579	21	0.977	1.50E-07	4.26E-04	
8/9/2016	900	21.45	1.85579	21	0.977	1.20E-07	3.41E-04	
8/9/2016	1200	21.15	2.15579	21	0.977	1.06E-07	3.00E-04	

### SUMMARY

$k_a = 1.44\text{E-}07 \text{ cm/sec}$	Acceptance criteria = 50 %
$k_i$	$V_m$
$k_1 = 2.01\text{E-}07 \text{ cm/sec}$	39.5 %
$k_2 = 1.50\text{E-}07 \text{ cm/sec}$	4.0 %
$k_3 = 1.20\text{E-}07 \text{ cm/sec}$	16.7 %
$k_4 = 1.06\text{E-}07 \text{ cm/sec}$	26.8 %













$$V_m = \frac{|k_a - k_i|}{k_a} \times 100$$

Hydraulic conductivity	$k = 1.44\text{E-}07 \text{ cm/sec}$	$4.09\text{E-}04 \text{ ft/day}$
Void Ratio	$e =$	
Porosity	$n =$	
Bulk Density	$g = 2.11 \text{ g/cm}^3$	131.9 pcf
Water Content	$W = 0.26 \text{ cm}^3/\text{cm}^3$	( at 20 deg C)
Intrinsic Permeability	$k_{int} = 1.48\text{E-}12 \text{ cm}^2$	( at 20 deg C)

**APPENDIX C**  
**SUPPORTING DOCUMENTS**

# GENERAL NOTES

## DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING				WATER LEVEL		Water Initially Encountered	FIELD TESTS	(HP) Hand Penetrometer
						Water Level After a Specified Period of Time		(T) Torvane
						Water Level After a Specified Period of Time		(b/f) Standard Penetration Test (blows per foot)
						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.		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, tsf	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.
	Very Loose	0 - 3	0 - 6	Very Soft	less than 0.25	0 - 1	< 3
	Loose	4 - 9	7 - 18	Soft	0.25 to 0.50	2 - 4	3 - 4
	Medium Dense	10 - 29	19 - 58	Medium-Stiff	0.50 to 1.00	4 - 8	5 - 9
	Dense	30 - 50	59 - 98	Stiff	1.00 to 2.00	8 - 15	10 - 18
	Very Dense	> 50	≥ 99	Very Stiff	2.00 to 4.00	15 - 30	19 - 42
				Hard	> 4.00	> 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

## RELATIVE PROPORTIONS OF FINES

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

## 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)

## PLASTICITY DESCRIPTION

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

# UNIFIED SOIL CLASSIFICATION SYSTEM

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

<sup>A</sup> Based on the material passing the 3-inch (75-mm) sieve

<sup>B</sup> If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

<sup>C</sup> 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.

<sup>D</sup> 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

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

<sup>F</sup> If soil contains  $\geq 15\%$  sand, add "with sand" to group name.

<sup>G</sup> If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

<sup>H</sup> If fines are organic, add "with organic fines" to group name.

<sup>I</sup> If soil contains  $\geq 15\%$  gravel, add "with gravel" to group name.

<sup>J</sup> If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

<sup>K</sup> If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

<sup>L</sup> If soil contains  $\geq 30\%$  plus No. 200 predominantly sand, add "sandy" to group name.

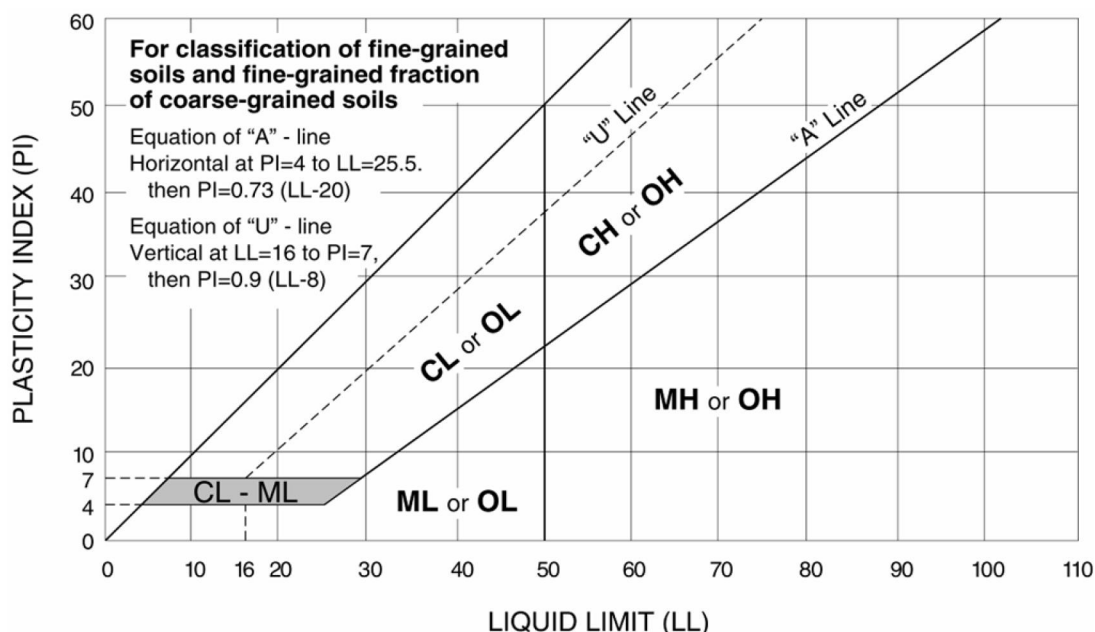
<sup>M</sup> If soil contains  $\geq 30\%$  plus No. 200, predominantly gravel, add "gravelly" to group name.

<sup>N</sup>  $PI \geq 4$  and plots on or above "A" line.

<sup>O</sup>  $PI < 4$  or plots below "A" line.

<sup>P</sup>  $PI$  plots on or above "A" line.

<sup>Q</sup>  $PI$  plots below "A" line.



# DESCRIPTION OF ROCK PROPERTIES

## WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

## HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

### Joint, Bedding, and Foliation Spacing in Rock <sup>a</sup>

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

a. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

### Rock Quality Designator (RQD) <sup>a</sup>

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

a. RQD (given as a percentage) = length of core in pieces  
4 in. and longer/length of run.

### Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.