# Initial Safety Factor Assessment – Primary Ash Pond

**Welsh Power Generating Station**
**Pittsburgh, Texas**

**Auckland Project No. 2015-008A (Revision No. 2)**
**January 14, 2016**

Prepared For:

American Electric Power Company
1 Riverside Plaza
Columbus, Ohio 43215

Prepared By:

Auckland Consulting, LLC
Jacksonville, Texas

TBPE Firm Registration No. F-16721
Expires 2/29/2016

# Table of Contents



## Appendix

# 1.0 Introduction and Embankment Information

## 1.1 Introduction

The following report and evaluation provides the Initial Safety Factor Assessment of the Primary Ash Pond, an existing CCR impoundment (as defined by 40 CFR §257.2) located at the Welsh Power Station near Pittsburgh, Texas. In accordance with 40 CFR §257.73(e)(1)(i) through (iv) this initial assessment provides field and laboratory data, model outputs (detailing multiple stability conditions) and summary of safety factors for the Primary Ash Pond. In accordance with 40 CFR §257.73(e)(2) this report provides the Initial Safety Factor Assessment certification for the Primary Ash Pond.

## 1.2 Referenced Information and Data

Soils data, comprised of field and laboratory testing, utilized in the preparation of this assessment were completed by ETTL Engineers and Consultants, Inc. and documented in the report *Welsh Power Station, Existing Ash Storage Pond Embankment Investigation, Pittsburg, Texas* dated June 21, 2010. Based on a review of the provided field and laboratory data, it appears to be accurate and appropriate for use in the initial structural stability assessment of the Primary Ash Pond [40 CFR §257.73(e)(1)]. Furthermore, based on a recent site visit (October 2015), no modifications or elevation alterations have been made to the embankment since the referenced investigation. No additional field or laboratory activities were conducted. Soil data utilized in this evaluation is provided in the Appendix of this report.

The impoundment pool elevation data cited herein were provided in a separate hydrology and hydraulic (H&H) analysis report completed by Freese and Nichols titled *Hydraulic Analysis of Welsh Power Plant Ash Ponds* dated December 29, 2010 (not included herein). The referenced report generally meets the demonstration requirements of 40 CFR §257.82(a).

Embankment profile dimensions and elevations were determined by using existing information provided by the client. This information is also included in the Appendix of this report.

## 1.3 Embankment Evaluation Criteria

Based on information provided by the client, the existing embankment is constructed of lean clay (CL) and fat clay (CH) with existing side slopes (both up- and downstream) of approximately 2.5:1 (H:V), maximum embankment height of 35 feet (downstream) and top of dam elevation of 340.0 feet MSL. The crest width of the embankment is approximately 50 feet. An embankment cutoff key (key trench) extends below the core structure approximately five (5) feet and has an approximate bottom width of 20 feet.

The downstream toe of the Primary Ash Pond extends below the impounded water level of the adjacent Welsh Reservoir. Based on information provided by the client, the normal pool elevation for the Welsh Reservoir is approximately 320.0 feet (MSL). Reservoir levels are monitored and adjusted as needed to maintain a constant pool elevation of approximately 320.0 feet (MSL). Based on the active management and control of the Welsh Reservoir pool elevation, the downstream toe of the Primary Ash Pond should not be subject to sudden or rapid drawdown conditions, notwithstanding a catastrophic failure of or uncontrolled release from the Welsh Reservoir. Regardless, the sudden drawdown of the Welsh Reservoir along the downstream slope of the Primary Ash Pond is modeled herein (40 CFR §257.73(d)(1)(A)(3)(vii).

In accordance with 40 CFR §257.73(e)(1)(i) and (ii), the maximum storage pool elevation for the Primary Ash Pond as determined by the 25-year, 24-hour storm event is 329.35 feet (MSL). For the purposes of this evaluation, the maximum storage pool elevation of 330.0 feet (MSL) was utilized. Likewise the maximum (or flood) surcharge loading elevation as determined by the 100-year, 24-hour event is 330.80 feet (MSL), for this evaluation a maximum surcharge loading elevation of 331.0 feet (MSL) was utilized. Storage pool elevations were determined in accordance with 40 CFR §257.82(a).

# 2.0 Slope Stability Analyses

## 2.1 General

Soil parameters used for stability analyses of the existing embankment are based on findings of previous laboratory and field testing programs. The probable failure planes were analyzed using the analytical slope stability software, SLIDE by Rocscience, Inc. Methods of evaluation used in SLIDE are considered to be limited equilibrium methods of analysis, where each individual shear plane is evaluated to determine the resulting shear stress at the point of failure. For the purposes of this evaluation the Bishop Method of analysis, which analyzes circular failure planes through the slope was utilized.

Per 40 CFR §257.73(e)(1)(i) through (iii), four (4) modeled scenarios (presented below) were utilized to evaluate the stability of the existing embankment: steady state seepage (long term) condition under maximum storage pool, steady state seepage (long term) condition under maximum surcharge pool, steady state seepage condition with seismic loading under maximum storage pool conditions, and rapid drawdown (of the inundated downstream slope). The following minimum factors of safety (FS) and soil stress parameters were utilized in modeling. Minimum factors of safety are based on demonstration requirements provided in 40 CFR §257.73(e)(1) and guidance provided by the United States Army Corps of Engineers (USACE).

| Summary of Embankment Condition and Factor of Safety | | |
|---|---|---|
| **Embankment Condition** | **Soil Parameters** | **Minimum Factor of Safety** |
| Steady State Seepage – Maximum Pool | Effective Stress | 1.50 |
| Steady State Seepage – Surcharge Pool | Effective Stress | 1.40 |
| Steady State Seepage (Seismic) – Maximum Pool | Total Stress | 1.00 |
| Rapid Drawdown – Downstream Slope | Effective and Total Stress | 1.20 |
| **NOTE:** Minimum factors of safety based on demonstration requirements provided in 40 CFR §257.82 (e)(1). Minimum factor of safety for Rapid Drawdown based on guidance provided by the United States Army Corps of Engineers (USACE). | | |

For evaluation of steady state seepage (long term) conditions with seismic, peak ground acceleration for this location was obtained from the USGS National Seismic Hazard Mapping Project (http://earthquake.usgs.gov/hazards). Based on the seismic survey data, the anticipated site specific peak ground acceleration (PGA) of 0.06g (acceleration at rock sites) for two (2) percent probability of exceedance in 50 years (40 CFR Part 257, Preamble page 21384). Correcting for acceleration at soft soil sites (Seismic Site Classification D) yields an estimated PGA of 0.13g. The seismic coefficient (k) used for pseudo static analysis is determined by reducing the estimated PGA by 50% yielding a seismic coefficient of 0.065g.

## 2.2 Liquefaction Assessment

Liquefaction of soils occurs when horizontal shearing stresses exceed the strength of existing loose, saturated sand. This sudden loss of shear strength and subsequent soil structure is typically associated with earthquake-induced horizontal movement. Recent engineering publications[1] provide criteria to assess liquefaction potential of sands (little to no fines) and clayey soils of low plasticity (e.g. clayey sands, silts). These criteria indicate that water content of fine-grained or cohesive soils needs to be high (≥ 0.85 *Liquid Limit [LL]), a clay fine content (defined as grains smaller than 0.002 mm) of less than 10 percent (< 10%), and relatively low soil density (assessed in terms of SPT blow counts). In addition, the accepted minimum seismic threshold acceleration to cause liquefaction in loose sands is 0.10g, the anticipated site specific PGA for this site is 0.06g.

Native fine grained (or cohesive) material underlying the Primary Ash Pond generally consist of medium stiff to hard lean clay and fat clay (CL and CH) soils and coarse grained (or sandy) material consist of medium dense to very dense clayey sand (SC), silty sand (SM) and silty clayey sand (SC-SM) soils. Based on these soil characteristics and that the Primary Ash Pond is located in a zone of low peak ground acceleration (PGA), the risk of

[1] Seed, R.B., et al, Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework, 26th Annual ASCE Los Angeles Spring Seminar, April 2003

either embankment or underlying soils liquefying are negligible [40 CFR §257.73(e)(1)(iv)].

## 2.3 Embankment and Foundation Stratigraphy

The models developed for this evaluation are based on the existing embankment geometry, results of field and laboratory testing and hydrologic site information provided by the client. Selection of the critical slope section was based on both height and subsurface sensitivity to loading. The following tables provide a summary of soil parameters used for these analyses. Specific soil parameters used for each model are presented in the Appendix.

| Summary of Long Term, Total Stress Soil Parameters: | | | |
|---|---|---|---|
| **Material Type** | **Unit Weight (pcf)** | **Consolidated-Undrained Cohesion (psf)** | **Consolidated-Undrained Angle of Internal Friction (degrees)** |
| Embankment Fill | 125 | 570 | 12 |
| Clayey Sand (SC) | 130 | 360 | 10 |
| Silty Sand (SM) | 125 | 0 | 30 |
| Fat Clay (CH) | 130 | 320 | 19 |
| **NOTE:** Properties used for Steady State Seepage with Seismic and Rapid Drawdown analyses. | | | |

| Summary of Long Term, Effective Stress Soil Parameters | | | |
|---|---|---|---|
| **Material Type** | **Unit Weight (pcf)** | **Consolidated-Drained Cohesion (psf)** | **Consolidated-Drained Angle of Internal Friction (degrees)** |
| Embankment Fill | 125 | 310 | 23 |
| Clayey Sand (SC) | 130 | 320 | 15 |
| Silty Sand (SM) | 125 | 0 | 30 |
| Fat Clay (CH) | 130 | 300 | 28 |
| **NOTE:** Properties used for Steady State Seepage and Rapid Drawdown analyses. Consolidated-drained conditions determined based on pore pressure measurements made during Consolidated-Undrained (CU) triaxial testing. | | | |

## 2.4 Seepage Analysis Parameters

The analysis of embankment seepage is based on laboratory results and estimated values for permeability for various embankment and native foundation soils. These soil parameters were utilized in the models to establish a long term steady state condition and corresponding phreatic surface in the embankment. Hydraulic conductivity test results are provided in the Appendix. Hydraulic conductivity properties utilized in the seepage analysis are provided in the below table.

| Hydraulic Conductivity of Embankment Soils | |
|---|---|
| **Material Type** | **Permeability (ft/sec)** |
| Embankment Fill | $1 \times 10^{-9}$ |
| Clayey Sand (SC) | $1 \times 10^{-7}$ |
| Silty Sand (SM) | $1 \times 10^{-5}$ |
| Fat Clay (CH) | $1 \times 10^{-8}$ |

## 2.5 Stability Analysis Results

The following table provides the results of the stability analysis for each of the conditions cited herein, as required by 40 CFR §257.73(e)(1)(i) through (iii). The graphical representations of each analysis are included in the Appendix.

| Summary of Stability Analyses – Safety Factors | | |
|---|---|---|
| **Modeled Condition** | **Factor of Safety** | |
| | **Actual** | **Minimum** |
| Steady State Seepage – Maximum Pool | 1.51 | 1.50 |
| Steady State Seepage – Surcharge Pool | 1.51 | 1.40 |
| Steady State Seepage with Seismic – Maximum Pool | 1.07 | 1.00 |
| Rapid Drawdown – Downstream Slope | 1.21 | 1.20 |

Based on the findings of this analysis, the evaluated embankment appears to be stable under the modeled conditions and demonstrate the minimum safety factors, as required by 40 CFR §257.73(e)(1)(i) through (iii).

## 3.0 Report Limitations

This report has been prepared for the exclusive use of our client for the specific application to the project discussed and has been prepared in accordance with the generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. The analyses contained in the report are based on the data obtained from the referenced soil borings performed within the project site. This report does not reflect variations that may occur between borings or across the site. Soil borings do not necessarily reflect strata variations that may exist at other locations within the project site.

## 4.0 Initial Structural Stability Assessment Certification

By means of this certification, (i) I have reviewed the requirements of 40 CFR §257.73(e)(1) – *Periodic Safety Factor Assessments*, (ii) I or my agent has visited and examined the facility, (iii) the referenced data used in this evaluation to the best of my knowledge appears correct and appropriate for use, (iv) and this Initial Safety Factor Assessment for the Primary Ash Pond (Welsh Power Station) has been prepared to the best of my knowledge in accordance with §257.73(e)(1).

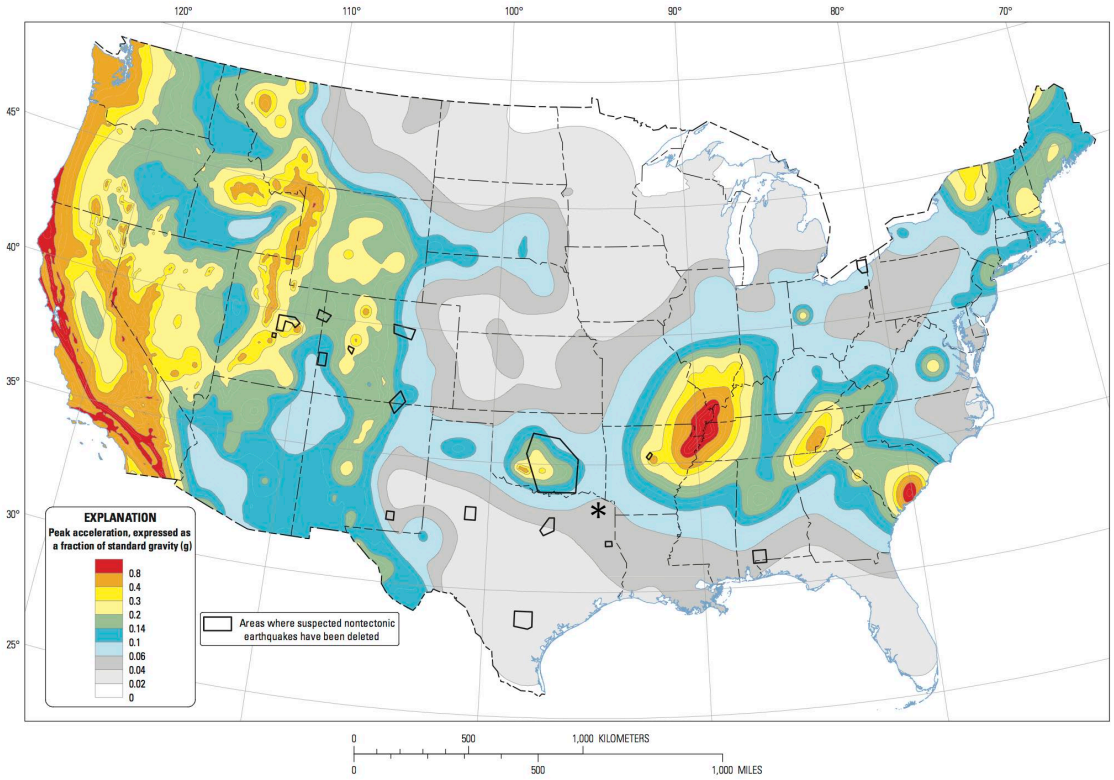
By: _____

Dated: January 14, 2016


TBPE Firm Registration No. F-16721
Expires 2/29/2016

# Appendix

## Stability Analyses
## Reference Data

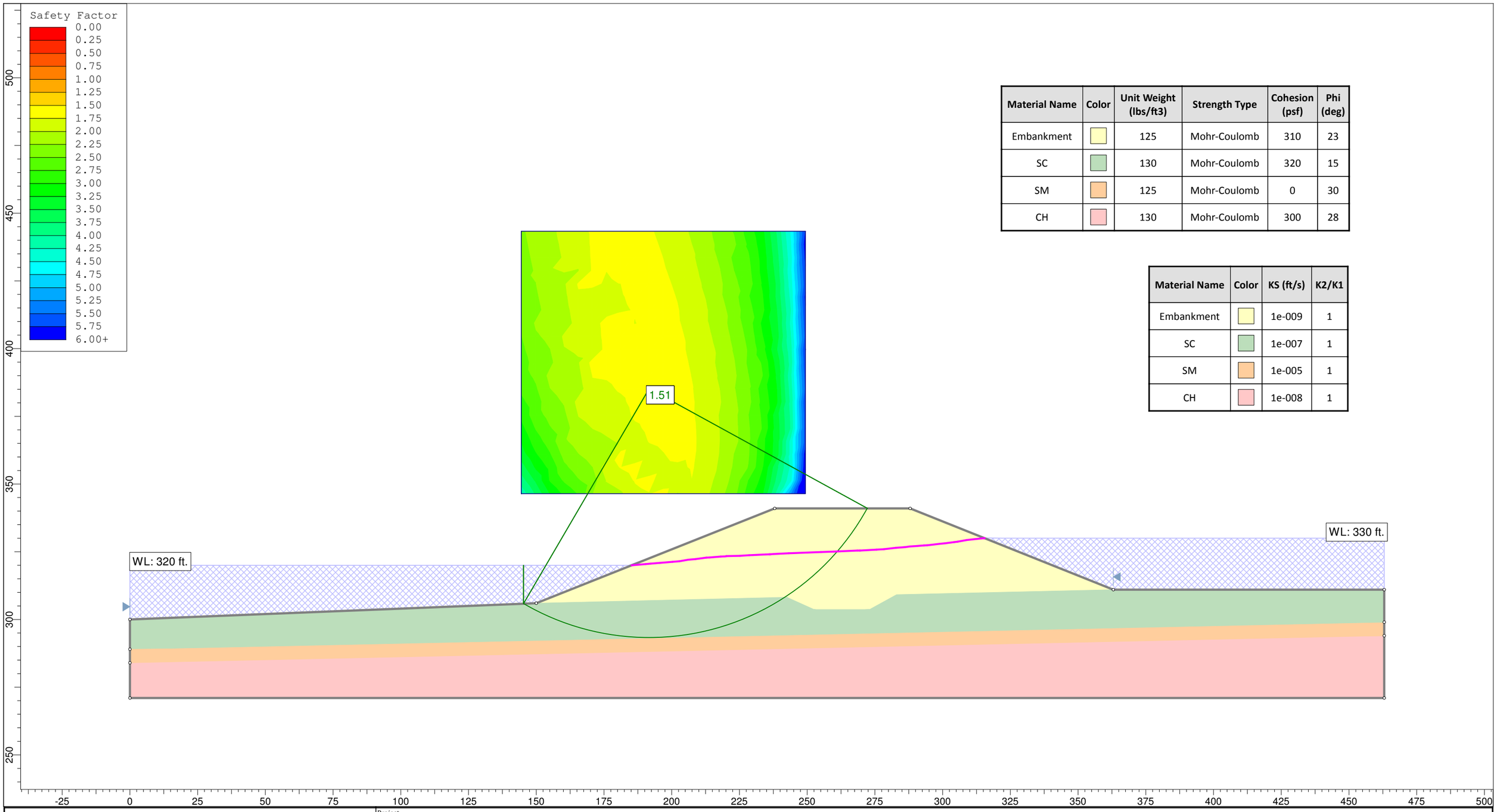



**Two-percent probability of exceedance in 50 years map of peak ground acceleration**

* Approximate location of Welsh Power Generating Station

Provided by USGS National Seismic Hazard Mapping Project.

| **Seismic Probability Map** | |
|---|---|
| Scale: N/A | **Welsh Power Generating Station**<br>**Initial Safety Factor Assessment - Primary Ash Pond**<br>**Pittsburgh, Texas** |
| Auckland Project No. 2015-008A | |



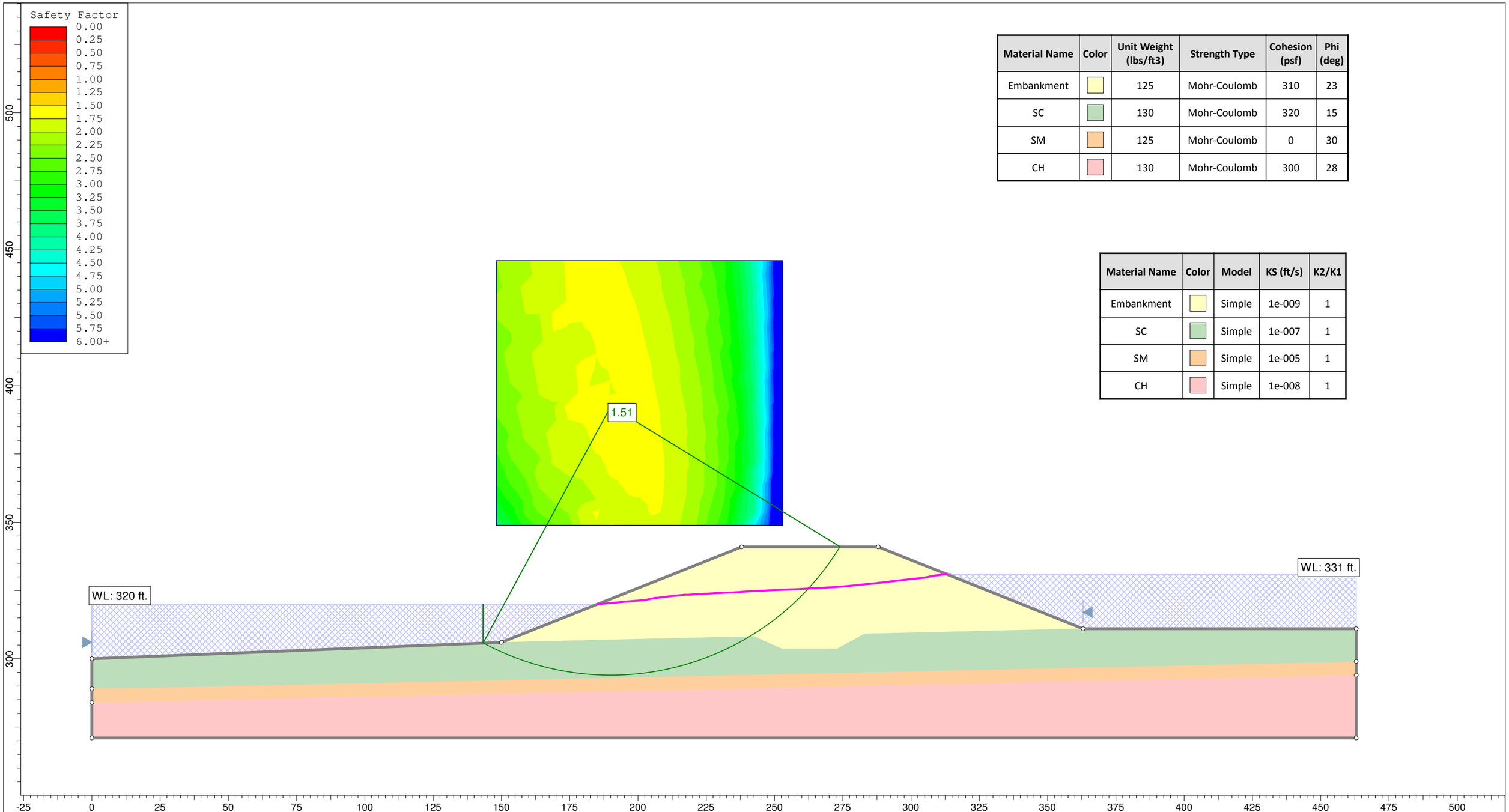

| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type | Cohesion (psf) | Phi (deg) |
|---|---|---|---|---|---|
| Embankment | | 125 | Mohr-Coulomb | 310 | 23 |
| SC | | 130 | Mohr-Coulomb | 320 | 15 |
| SM | | 125 | Mohr-Coulomb | 0 | 30 |
| CH | | 130 | Mohr-Coulomb | 300 | 28 |

| Material Name | Color | KS (ft/s) | K2/K1 |
|---|---|---|---|
| Embankment | | 1e-009 | 1 |
| SC | | 1e-007 | 1 |
| SM | | 1e-005 | 1 |
| CH | | 1e-008 | 1 |

**Auckland Consulting LLC**
**PO Box 8155**
**Jacksonville, Texas 75766**

| | | | |
|---|---|---|---|
| *Project* | Welsh Power Station - Primary Ash Pond | | |
| *Analysis Description* | Maximum Storage Pool at Normal Reservior Pool | | |
| *Drawn By* | JJT | *Company* | |
| *Date* | 12/2/2015 | *File Name* | Primary_SSS_normal_25yr pool_Rev1.slim |

SLIDEINTERPRET 6.036

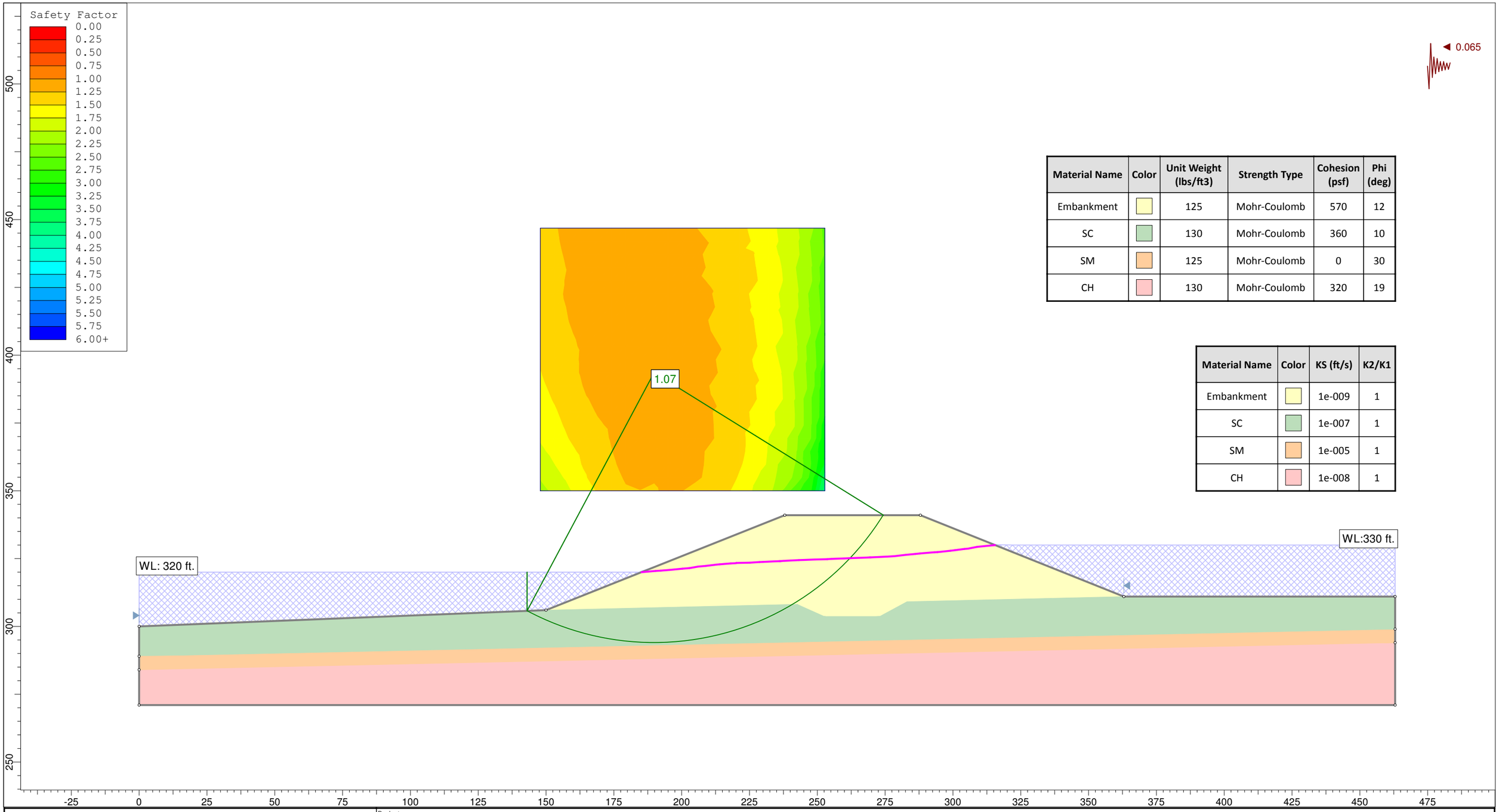



| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type | Cohesion (psf) | Phi (deg) |
|---|---|---|---|---|---|
| Embankment | | 125 | Mohr-Coulomb | 310 | 23 |
| SC | | 130 | Mohr-Coulomb | 320 | 15 |
| SM | | 125 | Mohr-Coulomb | 0 | 30 |
| CH | | 130 | Mohr-Coulomb | 300 | 28 |

| Material Name | Color | Model | KS (ft/s) | K2/K1 |
|---|---|---|---|---|
| Embankment | | Simple | 1e-009 | 1 |
| SC | | Simple | 1e-007 | 1 |
| SM | | Simple | 1e-005 | 1 |
| CH | | Simple | 1e-008 | 1 |

**Auckland Consulting LLC**
**PO Box 8155**
**Jacksonville, Texas 75766**

| | | | |
|---|---|---|---|
| *Project* | Welsh Power Station - Primary Ash Pond | | |
| *Analysis Description* | Maximum Surcharge Pool at Normal Reservior Pool | | |
| *Drawn By* | JJT | *Company* | |
| *Date* | 12/2/2015 | *File Name* | Primary_SSS_normal_100 yr pool_Rev1.slim |



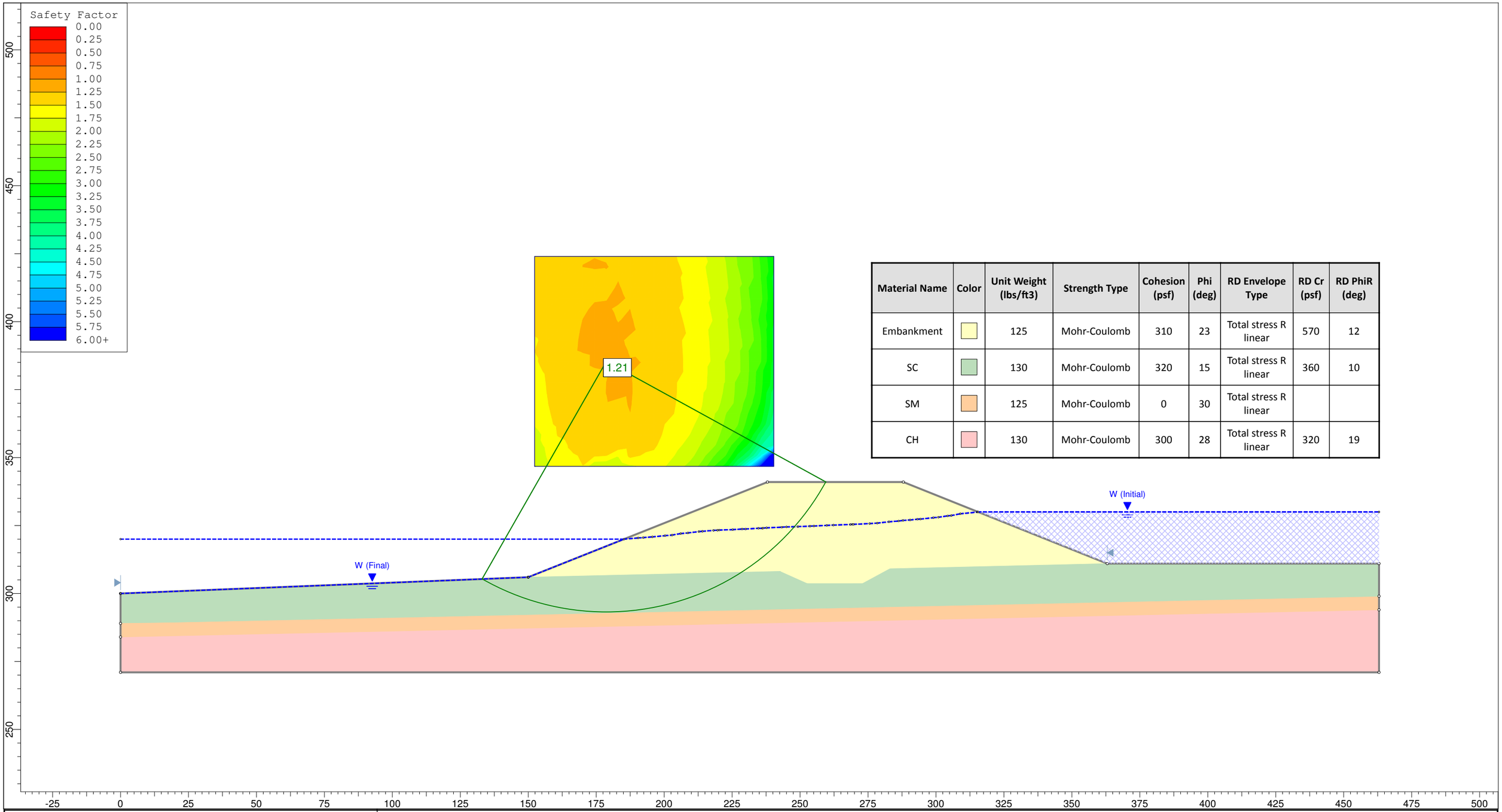

| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type | Cohesion (psf) | Phi (deg) |
|---|---|---|---|---|---|
| Embankment | | 125 | Mohr-Coulomb | 570 | 12 |
| SC | | 130 | Mohr-Coulomb | 360 | 10 |
| SM | | 125 | Mohr-Coulomb | 0 | 30 |
| CH | | 130 | Mohr-Coulomb | 320 | 19 |

| Material Name | Color | KS (ft/s) | K2/K1 |
|---|---|---|---|
| Embankment | | 1e-009 | 1 |
| SC | | 1e-007 | 1 |
| SM | | 1e-005 | 1 |
| CH | | 1e-008 | 1 |

**Auckland Consulting LLC**
**PO Box 8155**
**Jacksonville, Texas 75766**

SLIDEINTERPRET 6.036

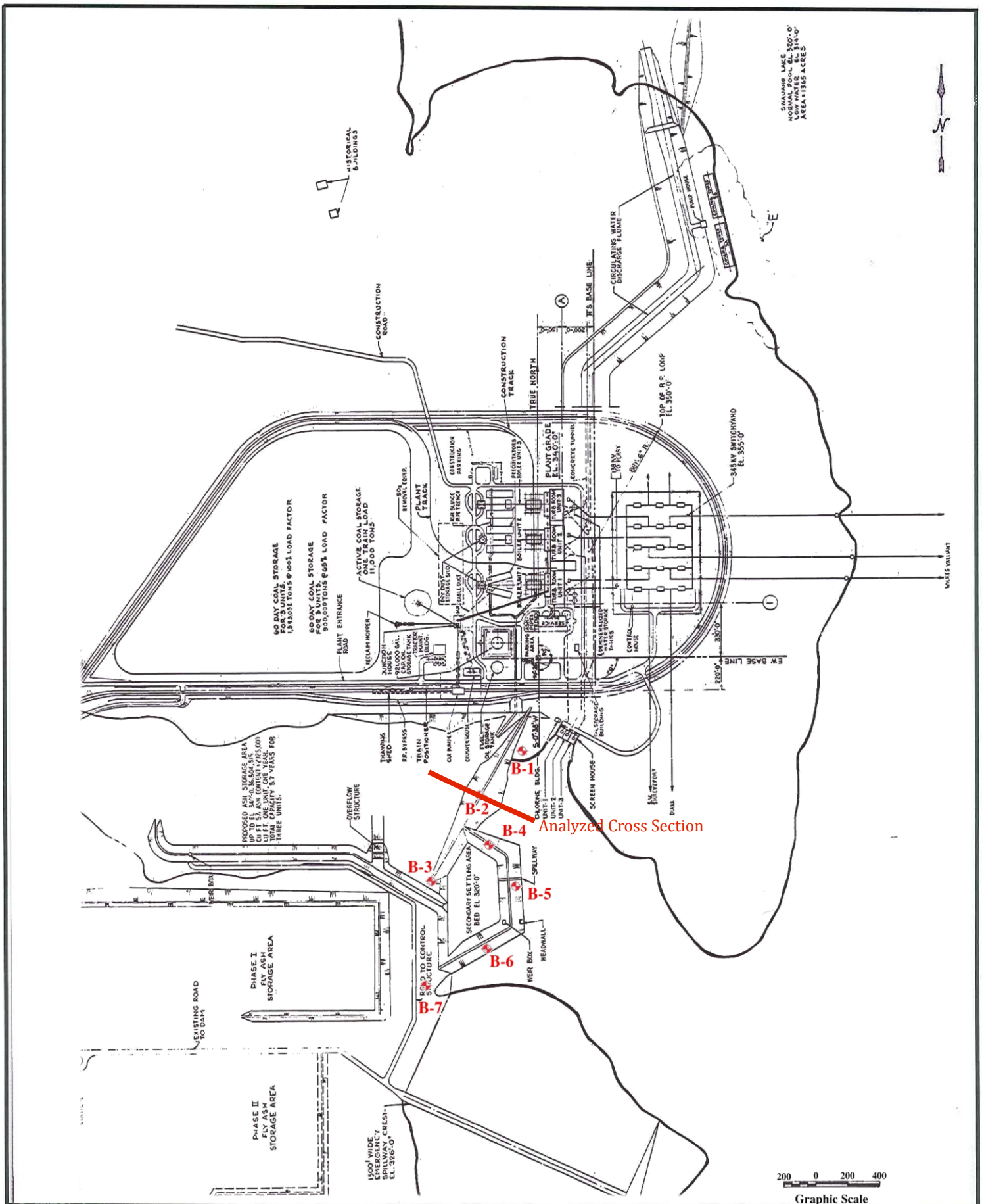
| | | | |
|---|---|---|---|
| *Project* | Welsh Power Station - Primary Ash Pond | | |
| *Analysis Description* | Maximum Storage Pool at Normal Reservior Pool, Seismic Analysis | | |
| *Drawn By* | JJT | *Company* | |
| *Date* | 12/23/2015 | *File Name* | Primary_SSS_seismic_25yr pool.slim |



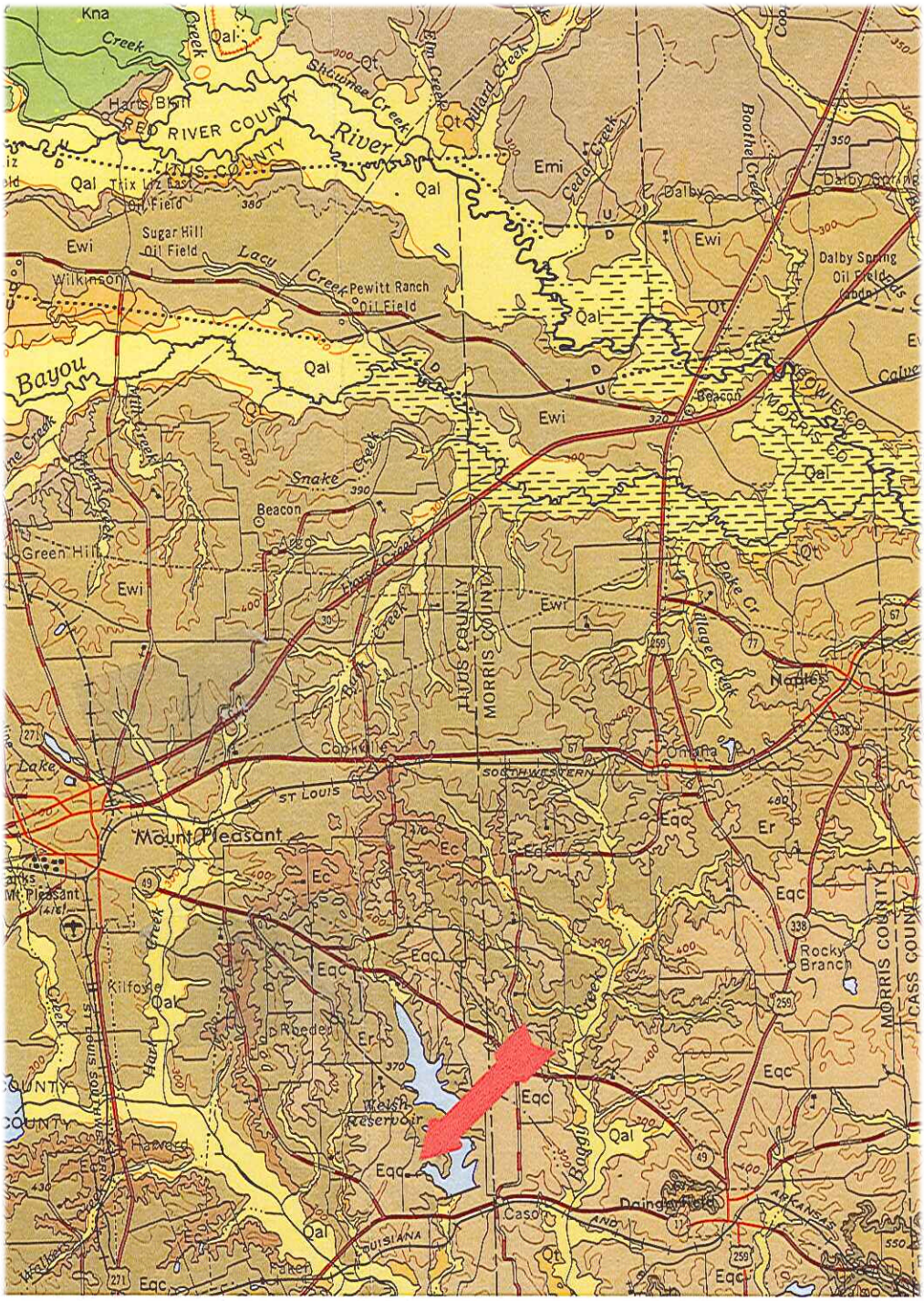

| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type | Cohesion (psf) | Phi (deg) | RD Envelope Type | RD Cr (psf) | RD PhiR (deg) |
|---|---|---|---|---|---|---|---|---|
| Embankment | | 125 | Mohr-Coulomb | 310 | 23 | Total stress R linear | 570 | 12 |
| SC | | 130 | Mohr-Coulomb | 320 | 15 | Total stress R linear | 360 | 10 |
| SM | | 125 | Mohr-Coulomb | 0 | 30 | Total stress R linear | | |
| CH | | 130 | Mohr-Coulomb | 300 | 28 | Total stress R linear | 320 | 19 |

**Auckland Consulting LLC**
**PO Box 8155**
**Jacksonville, Texas 75766**

| | |
|---|---|
| *Project* | Welsh Power Station - Primary Ash Pond |
| *Analysis Description* | Maximum Storage Pool with Rapid Drawdown of Reservior Pool |
| *Drawn By* | JJT |
| *Company* | |
| *Date* | 12/2/2015 |
| *File Name* | Primary_RD Res_normal_25yr pool.slim |




| | | | |
|---|---|---|---|
| ETTL ENGINEERS & CONSULTANTS<br>MAIN OFFICE<br>1717 East Erwin<br>Tyler, Texas 75702<br>(903) 595-4421 | **WELSH POWER PLANT**<br>**PITTSBURGH, TEXAS** | **PLATE 1 - PLAN OF BORINGS** | APPROVED BY: |
| | | JOB NO.: G3242-095 | DRAWN BY: K.C.R. |
| | | DATE: JAN. 2010 | SCALE: AS SHOWN |




EXPLANATION

SEDIMENTARY ROCKS

Qal — Alluvium
*Flood-plain deposits*

Qt — Fluviatile terrace deposits undivided

Etg / Es — Sparta Sand
Quartz sand, fine to medium grained, light gray to brownish gray, slightly cohesive from silt and clay matrix, massive, locally cross-bedded, interbeds of sandy clay more abundant upward, locally carbonaceous; weathers various shades of light gray, at base hard, brown, ferruginous sandstone; lower part 170± feet thick, upper part absent. Locally includes Tyler Green-sand Member, Etg, quartz-glauconite greensand, greenish green, massive, locally cross-bedded; weathers dark reddish brown, abundant ironstone concretions

Ew — Weches Formation
Glauconite and quartz sand, greenish green to greyish olive green, thin bedded, locally cross-bedded to laminated, clay interbeds light brown to moderate light gray, silty, muscovitic, thin bedded; weathers moderate to dark reddish brown, locally forms limonitic and siderotic iron ore and clay ironstone concretions; marine megafossils in southern part; 33± feet thick, range 0–70 feet

Eqc — Queen City Sand
Quartz sand, fine grained to locally medium grained, light gray to brownish gray, locally carbonaceous, and clay, gray to brown, silty, slightly lignitic, sand most abundant to west; weathers red and white mottled, ironstone concretions and ledges common; local beds of glauconite-quartz greensand, cross-bedded, weathers to ferruginous ledges and rubble; 150–400 feet thick, thins southeastward

Er — Reklaw Formation
Upper 100± feet, clay, brownish black to brownish gray, silty, muscovitic, carbonaceous, laminated, interbeds of moderate reddish-brown clay; weathers light brown, ironstone concretions common; a few marine fossils. Lower 125± feet, quartz sand, fine to very fine grained, greyish green, glauconitic, argillaceous, massive, locally cross-bedded; weathers moderate brown to dark yellowish orange with clay ironstone ledges and rubble; fossils, clay ironstone, and clay decrease northward

Ec — Carrizo Sand
Upper part, very fine sand, silt, clayey silt, silty clay, medium to dark gray, carbonaceous; weathers moderate yellowish brown to dark reddish brown, indurated ledges of dark brownish-gray ironstone common. Lower part, quartz sand, fine to medium grained, light brownish gray, weakly cohesive, massive, locally cross-bedded; weathers light gray to various shades of red. Thickness 50–100 feet

Ewi — Wilcox Group undivided
Mostly silty and sandy clay, various shades of gray, local beds of clay, lignite, silt, and quartz sand, in part carbonaceous, laminated to massive, locally cross-bedded, weathers to various shades of gray, brown, yellow, and red; calcareous siltstone and ironstone concretions common; abundant plant fossils, a few marine fossils in southeastern part; 500–1,000 feet thick.

E — Eocene rocks undivided
*Reklaw Formation, Carrizo Sand, Wilcox Group, and Midway Group on Brooks dome, not separately shown*

Ewp — Wills Point Formation
Clay, medium bluish gray, greenish gray, greyish green, brownish gray, silt increases upward, laminated to locally massive, glauconitic near base, rough calcareous siltstone concretions common in upper part, locally lignitic in upper part, thin bed of fossile limestone, near middle; weathers medium gray to yellowish gray; fossiliferous; 300± feet thick

Ek — Kincaid Formation
Clay, medium gray to dark gray, greenish gray, brownish gray, glauconitic, calcareous, selenitic, locally silty or sandy, locally phosphatic near base, thin beds of limestone in upper part, gray, hard, detrital; weathers medium gray; fossiliferous; 180± feet thick

Kke — Kemp Clay
Clay, dark gray to bluish gray, calcareous, silty, glauconitic, calcareous concretions common; weathers dark greenish gray and black; upper part only cross cut

Ku — Upper Cretaceous rocks undivided
*Navarro Group, Taylor Group, and Austin Chalk on Brooks dome not separately shown*

Pleistocene Recent — QUATERNARY
Eocene — TERTIARY
Upper Cretaceous — CRETACEOUS

Scale 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

5 0 5 10 Nautical Miles

CONTOUR INTERVAL 100 FEET
WITH SUPPLEMENTARY CONTOURS AT 50 FOOT INTERVALS

ETTL ENGINEERS & CONSULTANTS
MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

# SITE SURFACE GEOLOGY

JOB No.: G3242-09

DATE: 1975

SCALE: 1:250,000

# LOG OF BORING B-1

**ETTL ENGINEERS & CONSULTANTS**

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

**PROJECT:** Welsh Power Plant
Pittsburgh, Texas

**PROJECT NO.:** G3242-09 **BORING TYPE:** Flight Auger

**DATE** 10/27/09

**SURFACE ELEVATION** 324.1

| DEPTH (ft) | USC | MATERIAL DESCRIPTION | FIELD STRENGTH DATA | MOISTURE CONTENT (%) | ATTERBERG LIMITS(%) LL | PL | PI | MINUS #200 SIEVE (%) | OTHER TESTS PERFORMED (Page Ref. #) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | CL | SANDY LEAN CLAY(CL) very stiff; brownish orange | P=4.0 SF | | | | | | |
| | SM | SILTY SAND(SM) tannish orange | | | | | | | |
| | CH | SANDY FAT CLAY(CH) medium stiff; tannish orange | N=7 | 20 | 54 | 16 | 38 | 63 | +40Sieve=10%, +4 Sieve=1% |
| 5 | | --stiff | P=1.5 | | | | | | |
| | SC | CLAYEY SAND(SC) medium dense; tannish orange; with clay seams | P=1.75 | 19 | 34 | 17 | 17 | 32 | +40 Sieve=7%, +4 Sieve=3% |
| 10 | CL | SANDY LEAN CLAY(CL) stiff; orange | | | | | | | |
| | SC | CLAYEY SAND(SC) medium dense; orange; saturated; with iron oxide cemented sandstone rock | N=15 | 22 | 24 | 15 | 9 | 19 | +40Sieve=35%, +4 Sieve=22% |
| 15 | | | | | | | | | |
| | CL | LEAN CLAY WITH SAND(CL) hard; dark gray; with clay seams | N=35 | 21 | 41 | 21 | 20 | 75 | +40 Sieve=2%, +4 Sieve=0% |
| 20 | | | | | | | | | |
| | CL | SANDY LEAN CLAY(CL) hard; dark brown | P=4.5+ | 15 | 33 | 17 | 16 | 52 | +40 Sieve=1%, +4 Sieve=0% |
| 25 | | | | | | | | | |
| | | --grayish brown; laminated with silt | P=4.5+ | | | | | | |
| 30 | | Bottom of Boring @ 30' | | | | | | | |

FIELD STRENGTH DATA: BLOW COUNT 20 40 60 80; Qu (tsf) 1 2 3 4; PPR (tsf) 1.0 2.0 3.0 4.0; Torvane (tsf) 1.0 2.0 3.0 4.0

DRY DENSITY (pcf) | COMPRESSIVE STRENGTH (tsf) | FAILURE STRAIN (%) | CONFINING PRESSURE (psi)

Natural Moisture Content and Atterberg Limits: Plastic Limit | Moisture Content | Liquid Limit; 20 40 60 80

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: Seepage @ 5' while drilling. Water level @ 4' and open to 30' upon completion.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
GPS Coordinates: N 33°03.090', W 94°50.417'

# LOG OF BORING B-2

**ETTL ENGINEERS & CONSULTANTS**

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

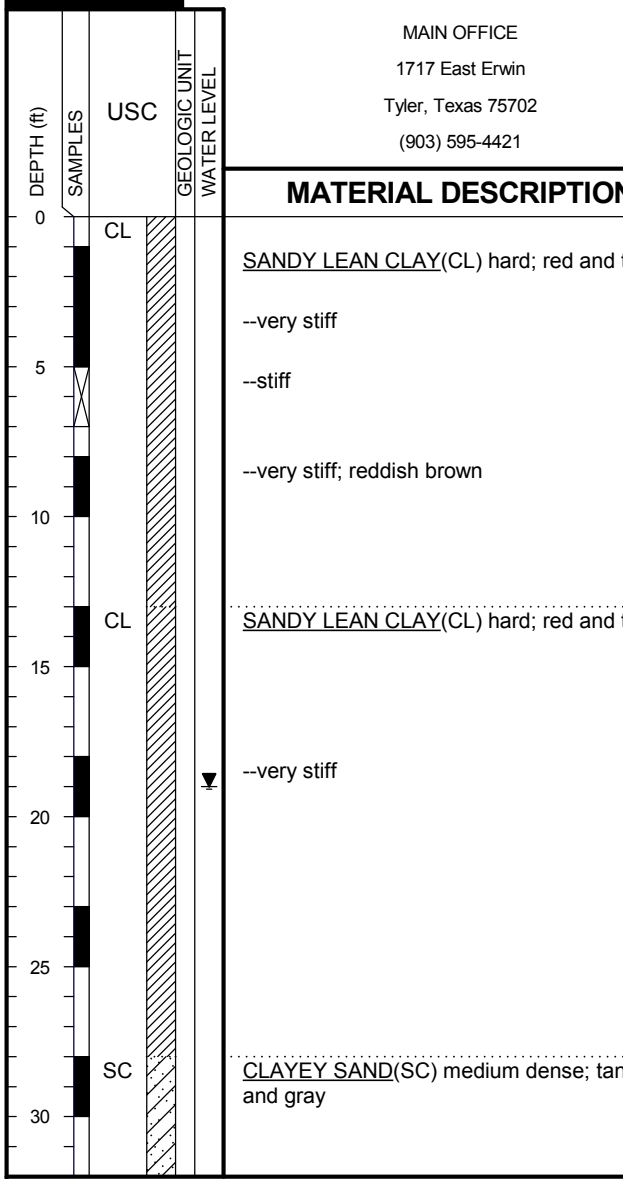
**PROJECT:** Welsh Power Plant
Pittsburgh, Texas

**PROJECT NO.:** G3242-09

**BORING TYPE:** Flight Auger

**DATE** 10/28/09

**SURFACE ELEVATION** 339.7




## MATERIAL DESCRIPTION

| Depth (ft) | USC | Material Description | Field Strength Data | Dry Density (pcf) | Compressive Strength (tsf) | Failure Strain (%) | Confining Pressure (psi) | Moisture Content (%) | Liquid Limit (LL) | Plastic Limit (PL) | Plasticity Index (PI) | Minus #200 Sieve (%) | Other Tests Performed (Page Ref. #) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | CL | SANDY LEAN CLAY(CL) hard; red and tan | P=4.5+ | | | | | 13 | 28 | 14 | 14 | 61 | +40 Sieve=3%, +4 Sieve=0% |
| | | --very stiff | P=3.5 | | | | | | | | | | |
| 5 | | --stiff | N=14 | | | | | 14 | 40 | 16 | 24 | 65 | +40 Sieve=0%, +4 Sieve=0% |
| | | --very stiff; reddish brown | P=2.75 | | | | | 13 | 30 | 14 | 16 | 58 | +40 Sieve=0%, +4 Sieve=0% |
| 10 | | | | | | | | | | | | | |
| | CL | SANDY LEAN CLAY(CL) hard; red and tan | P=4.5+ | | | | | | | | | | |
| 15 | | | | | | | | | | | | | |
| | | --very stiff | P=3.5 | | | | | 14 | 34 | 15 | 19 | 54 | +40 Sieve=0%, +4 Sieve=0% |
| 20 | | | | | | | | | | | | | |
| | | | P=4.0 | | | | | | | | | | |
| 25 | | | | | | | | | | | | | |
| | SC | CLAYEY SAND(SC) medium dense; tan, red, and gray | P=4.5 | | | | | 15 | 37 | 16 | 21 | 47 | +40 Sieve=5%, +4 Sieve=3% |
| 30 | | | | | | | | | | | | | |

Field Strength Data: BLOW COUNT (20, 40, 60, 80); Qu (tsf) (1, 2, 3, 4); PPR (tsf) (1.0, 2.0, 3.0, 4.0); Torvane (tsf) (1.0, 2.0, 3.0, 4.0)

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations:
Water level @ 19' and open to 24' upon completion.

Key to Abbrevations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
GPS Coordinates: N 33°03.078', W 94°50.449'

# LOG OF BORING B-2

**ETTL ENGINEERS & CONSULTANTS**

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

**PROJECT:** Welsh Power Plant
Pittsburgh, Texas

**PROJECT NO.:** G3242-09

**BORING TYPE:** Flight Auger

**DATE** 10/28/09

**SURFACE ELEVATION** 339.7

| DEPTH (ft) | SAMPLES | USC | GEOLOGIC UNIT | WATER LEVEL | MATERIAL DESCRIPTION | FIELD STRENGTH DATA | DRY DENSITY (pcf) | COMPRESSIVE STRENGTH (tsf) | FAILURE STRAIN (%) | CONFINING PRESSURE (psi) | MOISTURE CONTENT (%) | ATTERBERG LIMITS(%) LIQUID LIMIT (LL) | PLASTIC LIMIT (PL) | PLASTICITY INDEX (PI) | MINUS #200 SIEVE (%) | OTHER TESTS PERFORMED (Page Ref. #) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | --red and tan | P=2.5 | | | | | | | | | | |
| 35 | | | | | | | | | | | | | | | | |
| | | SM SC | | | SILTY CLAYEY SAND(SM-SC) red, tan, and gray; saturated | SF | | | | | 12 | 22 | 15 | 7 | 48 | +40 Sieve=0%, +4 Sieve=0% |
| 40 | | | | | | | | | | | | | | | | |
| | | CH | | | FAT CLAY(CH) hard; brown, tan, and gray; with ferric joints; with lignite and sand seams | P=4.5+ | | | | | | | | | | |
| 45 | | | | | | | | | | | | | | | | |
| | | SM | | | SILTY SAND(SM) black and gray | SF | | | | | | | | | | |
| 50 | | | | | Bottom of Boring @ 50' | | | | | | | | | | | |

FIELD STRENGTH DATA: BLOW COUNT 20 40 60 80; Qu (tsf) 1 2 3 4; PPR (tsf) 1.0 2.0 3.0 4.0; Torvane (tsf) 1.0 2.0 3.0 4.0

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit; 20 40 60 80

Water Level Est.: ▽ Measured: ▼ Perched: ⧩

Water Observations: Water level @ 19' and open to 24' upon completion.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
GPS Coordinates: N 33°03.078', W 94°50.449'

# LOG OF BORING B-3


**ETTL ENGINEERS & CONSULTANTS**

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

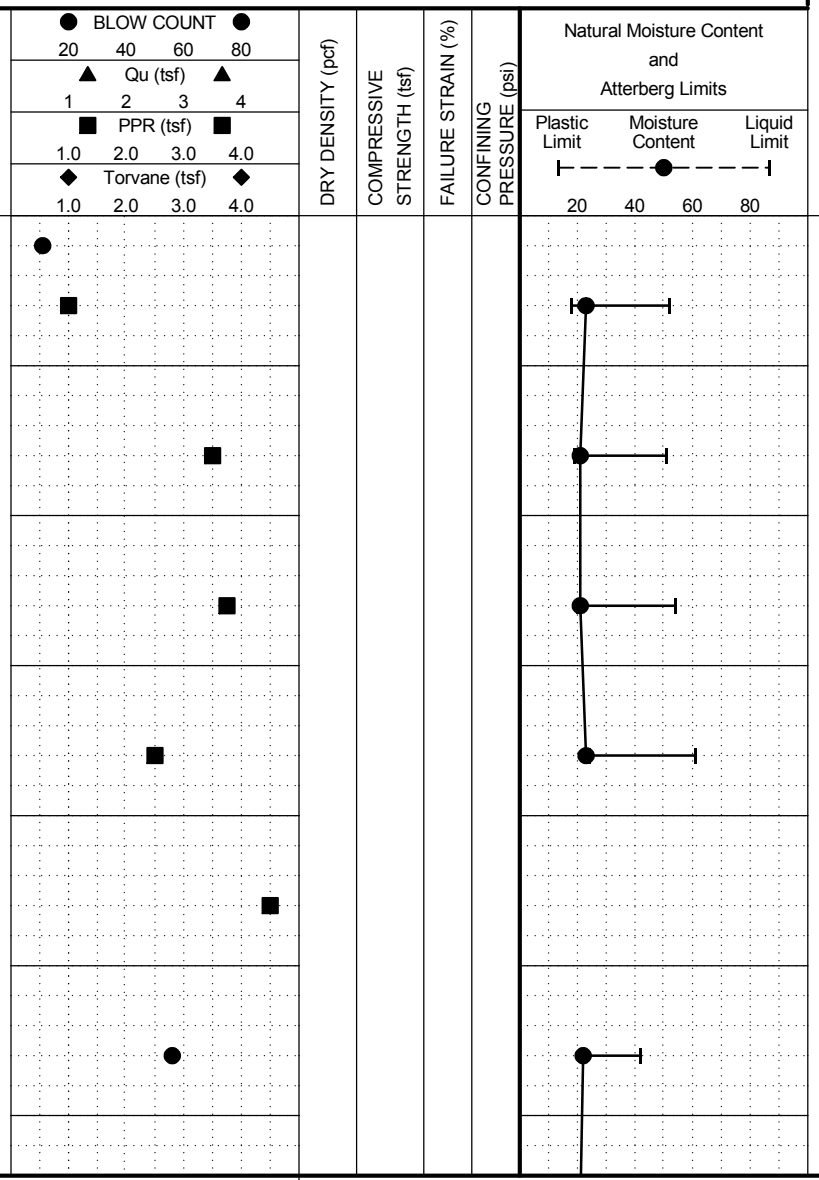

**PROJECT:** Welsh Power Plant
Pittsburgh, Texas

**PROJECT NO.:** G3242-09 **BORING TYPE:** Flight Auger

**DATE** 10/27/09

**SURFACE ELEVATION** 339.6

| DEPTH (ft) | USC | MATERIAL DESCRIPTION | FIELD STRENGTH DATA | MOISTURE CONTENT (%) | ATTERBERG LIMITS(%) LL | PL | PI | MINUS #200 SIEVE (%) | OTHER TESTS PERFORMED (Page Ref. #) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | SC | CLAYEY SAND(SC) medium dense; gray and red | N=11 | | | | | | |
| | CH | FAT CLAY(CH) stiff; red and tan; with sand seams | P=1.0 | 23 | 52 | 18 | 34 | 87 | +40 Sieve=3%, +4 Sieve=0% |
| 5 | | --very stiff | P=3.5 | 21 | 51 | 19 | 32 | 86 | +40 Sieve=3%, +4 Sieve=0% |
| 10 | CH | FAT CLAY WITH SAND(CH) very stiff; brown; with ferric joints | P=3.75 | 21 | 54 | 20 | 34 | 85 | +40Sieve=10%, +4 Sieve=1% |
| 15 | | --red and tan; layered; with ferric seams | P=2.5 | 23 | 61 | 24 | 37 | 81 | +40Sieve=11%, +4 Sieve=0% |
| 20 | CH | FAT CLAY(CH) hard; gray; with sand seams | P=4.5+ | | | | | | |
| 25 | SC | CLAYEY SAND(SC) very dense; gray; with sand seams | N=56 | 22 | 42 | 22 | 20 | 35 | +40 Sieve=1%, +4 Sieve=0% |
| 30 | | | | | | | | | |




Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: Seepage @ 13' while drilling. Water level @ 19' and open to 24' upon completion.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
GPS Coordinates: N 33°02.998', W 94°50.514'

# LOG OF BORING B-3

**ETTL ENGINEERS & CONSULTANTS**

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

**PROJECT:** Welsh Power Plant
Pittsburgh, Texas

**PROJECT NO.:** G3242-09

**BORING TYPE:** Flight Auger

**DATE** 10/27/09

**SURFACE ELEVATION** 339.6

| DEPTH (ft) | USC | MATERIAL DESCRIPTION | FIELD STRENGTH DATA | DRY DENSITY (pcf) | COMPRESSIVE STRENGTH (tsf) | FAILURE STRAIN (%) | CONFINING PRESSURE (psi) | MOISTURE CONTENT (%) | ATTERBERG LIMITS(%) LL | PL | PI | MINUS #200 SIEVE (%) | OTHER TESTS PERFORMED (Page Ref. #) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | CH | FAT CLAY(CH) hard; brown; layered and with sand seams | P=4.5+ | | | | | 21 | 60 | 24 | 36 | 95 | +40 Sieve=1%, +4 Sieve=0% |
| | | --gray and green | P=4.5+ | | | | | | | | | | |
| 40 | CL | SANDY LEAN CLAY(CL) very stiff; gray and dark green; layered; with sand seams | P=3.5 | | | | | | | | | | |
| 45 | CH | FAT CLAY(CH) hard; gray and dark green; layered; with silt seams | P=4.5+ | | | | | | | | | | |
| 50 | | Bottom of Boring @ 50' | | | | | | | | | | | |

BLOW COUNT: 20 40 60 80
Qu (tsf): 1 2 3 4
PPR (tsf): 1.0 2.0 3.0 4.0
Torvane (tsf): 1.0 2.0 3.0 4.0

Natural Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
20 40 60 80

Water Level Est.: ▽ Measured: ▼ Perched: ⧩

Water Observations: Seepage @ 13' while drilling. Water level @ 19' and open to 24' upon completion.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
GPS Coordinates: N 33°02.998', W 94°50.514'

# LOG OF BORING B-4

**ETTL ENGINEERS & CONSULTANTS**

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

**PROJECT:** Welsh Power Plant
Pittsburgh, Texas

**PROJECT NO.:** G3242-09 **BORING TYPE:** Flight Auger

**DATE** 10/27/09

**SURFACE ELEVATION** 340.6

| DEPTH (ft) | SAMPLES | USC | GEOLOGIC UNIT | WATER LEVEL | MATERIAL DESCRIPTION | FIELD STRENGTH DATA | DRY DENSITY (pcf) | COMPRESSIVE STRENGTH (tsf) | FAILURE STRAIN (%) | CONFINING PRESSURE (psi) | MOISTURE CONTENT (%) | ATTERBERG LIMITS(%) LIQUID LIMIT LL | PLASTIC LIMIT PL | PLASTICITY INDEX PI | MINUS #200 SIEVE (%) | OTHER TESTS PERFORMED (Page Ref. #) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | SM | | | SILTY SAND(SM) medium dense; tan; with gravel | N=19 | | | | | | | | | | |
| | | CL | | | SANDY LEAN CLAY(CL) dark brown | SF | | | | | 14 | 24 | 15 | 9 | 59 | +40 Sieve=1%, +4 Sieve=0% |
| 5 | | | | | --tannish orange<br>--hard; orangish tan | P=4.5 | | | | | | | | | | |
| | | | | | | P=3.25 | | | | | 22 | 45 | 21 | 24 | 94 | +40 Sieve=2%, +4 Sieve=0% |
| 10 | | | | | --very stiff; white | | | | | | | | | | | |
| | | SC | | | CLAYEY SAND(SC) medium dense; tan | P=3.25 | | | | | 15 | 31 | 15 | 16 | 40 | +40 Sieve=1%, +4 Sieve=0% |
| 15 | | | | | --orangish gray; with sand seams | | | | | | | | | | | |
| | | CL | | ▼ | SANDY LEAN CLAY(CL) stiff; orangish tan | N=9 | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | |
| | | CH | | | FAT CLAY(CH) very stiff; orangish tan; with ferric seams | P=4.0 | | | | | 25 | 59 | 24 | 35 | 88 | +40 Sieve=4%, +4 Sieve=0% |
| 25 | | | | | | | | | | | | | | | | |
| | | | | | --tannish brown; with iron ore seams | P=2.75 | | | | | | | | | | |
| 30 | | | | | | | | | | | | | | | | |

BLOW COUNT 20 40 60 80
Qu (tsf) 1 2 3 4
PPR (tsf) 1.0 2.0 3.0 4.0
Torvane (tsf) 1.0 2.0 3.0 4.0

Natural Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
20 40 60 80

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations:
Water level @ 18' and open to 48' upon completion.

Key to Abbrevations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
GPS Coordinates: N 33°03.011', W 94°50.462'

# LOG OF BORING B-4

**ETTL ENGINEERS & CONSULTANTS**

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

**PROJECT:** Welsh Power Plant
Pittsburgh, Texas

**PROJECT NO.:** G3242-09

**BORING TYPE:** Flight Auger

**DATE** 10/27/09

**SURFACE ELEVATION** 340.6

| DEPTH (ft) | SAMPLES | USC | GEOLOGIC UNIT | WATER LEVEL | MATERIAL DESCRIPTION | FIELD STRENGTH DATA | DRY DENSITY (pcf) | COMPRESSIVE STRENGTH (tsf) | FAILURE STRAIN (%) | CONFINING PRESSURE (psi) | MOISTURE CONTENT (%) | ATTERBERG LIMITS(%) LIQUID LIMIT (LL) | PLASTIC LIMIT (PL) | PLASTICITY INDEX (PI) | MINUS #200 SIEVE (%) | OTHER TESTS PERFORMED (Page Ref. #) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | | | | | --hard; light gray; layered and with silt seams | N=30 | | | | | | | | | | |
| 40 | | CL | | | LEAN CLAY(CL) hard; light gray; layered and with silt seams | N=50/5.75" | | | | | 21 | 44 | 25 | 19 | 93 | +40 Sieve=1%, +4 Sieve=0% |
| 45 | | | | | --light gray | N=41 | | | | | | | | | | |
| 50 | | | | | --layered and with sand seams; with lignite | N=43 | | | | | | | | | | |
| | | | | | Bottom of Boring @ 50' | | | | | | | | | | | |

BLOW COUNT: 20 40 60 80
Qu (tsf): 1 2 3 4
PPR (tsf): 1.0 2.0 3.0 4.0
Torvane (tsf): 1.0 2.0 3.0 4.0

Natural Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
20 40 60 80

Water Level Est.: ▽ Measured: ▼ Perched: ⧩

Water Observations:
Water level @ 18' and open to 48' upon completion.

Key to Abbrevations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
GPS Coordinates: N 33°03.011', W 94°50.462'

# LOG OF BORING B-5

**ETTL ENGINEERS & CONSULTANTS**

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

**PROJECT:** Welsh Power Plant
Pittsburgh, Texas

**PROJECT NO.:** G3242-09

**BORING TYPE:** Flight Auger

**DATE** 10/27/09

**SURFACE ELEVATION** 340.0

| DEPTH (ft) | SAMPLES | USC | GEOLOGIC UNIT | WATER LEVEL | MATERIAL DESCRIPTION | FIELD STRENGTH DATA | DRY DENSITY (pcf) | COMPRESSIVE STRENGTH (tsf) | FAILURE STRAIN (%) | CONFINING PRESSURE (psi) | MOISTURE CONTENT (%) | ATTERBERG LIMITS(%) LIQUID LIMIT LL | PLASTIC LIMIT PL | PLASTICITY INDEX PI | MINUS #200 SIEVE (%) | OTHER TESTS PERFORMED (Page Ref. #) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | CL | | | LEAN CLAY WITH SAND(CL) stiff; red and tan | P=2.0 | | | | | 22 | 47 | 19 | 28 | 81 | +40 Sieve=9%, +4 Sieve=3% |
| | | CL | | | LEAN CLAY(CL) hard; red and tan | P=4.5+ | | | | | | | | | | |
| 5 | | | | | --very stiff | P=4.0 | | | | | 21 | 46 | 18 | 28 | 94 | +40 Sieve=3%, +4 Sieve=0% |
| | | CH | | | FAT CLAY(CL) very stiff; brown and tan | P=3.0 | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | |
| | | CH | | | FAT CLAY WITH SAND(CH) hard; red and tan | P=4.5+ | | | | | 22 | 52 | 24 | 28 | 88 | +40 Sieve=3%, +4 Sieve=0% |
| 15 | | | | | | | | | | | | | | | | |
| | | CL | | | SANDY LEAN CLAY(CL) very stiff; red and gray; with sand seams | P=3.0 | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | |
| | | SC | | | CLAYEY SAND(SC) very loose; tan, red, and gray | P=0.5 | | | | | 19 | 33 | 17 | 16 | 44 | +40 Sieve=1%, +4 Sieve=0% |
| 25 | | | | | | | | | | | | | | | | |
| | | CH | | | FAT CLAY WITH SAND(CH) stiff; red and gray | P=2.0 | | | | | 25 | 61 | 19 | 42 | 83 | +40 Sieve=5%, +4 Sieve=3% |
| 30 | | | | | | | | | | | | | | | | |

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20 40 60 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: Seepage @ 35' while drilling. Water level @ 31' and open to 35' upon completion and after 30 minutes.

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
GPS Coordinates: N 33°02.964', W 94°50.428'

# LOG OF BORING B-5


**ETTL ENGINEERS & CONSULTANTS**

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421


**PROJECT:** Welsh Power Plant
Pittsburgh, Texas

**PROJECT NO.:** G3242-09 **BORING TYPE:** Flight Auger

**DATE** 10/27/09

**SURFACE ELEVATION** 340.0

| DEPTH (ft) | SAMPLES | USC | GEOLOGIC UNIT | WATER LEVEL | MATERIAL DESCRIPTION | FIELD STRENGTH DATA | DRY DENSITY (pcf) | COMPRESSIVE STRENGTH (tsf) | FAILURE STRAIN (%) | CONFINING PRESSURE (psi) | Natural Moisture Content and Atterberg Limits | MOISTURE CONTENT (%) | ATTERBERG LIMITS(%) LIQUID LIMIT LL | PLASTIC LIMIT PL | PLASTICITY INDEX PI | MINUS #200 SIEVE (%) | OTHER TESTS PERFORMED (Page Ref. #) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | | SC | | | SILTY CLAYEY SAND(SC) gray and red; saturated | SF | | | | | | | | | | | |
| 40 | | CH | | | FAT CLAY(CH) hard; red and gray; with sand seams | P=4.5+ | | | | | | 25 | 51 | 31 | 20 | 87 | +40 Sieve=6%, +4 Sieve=0% |
| 45 | | | | | --gray, tan, and red; with sand seams | P=4.5+ | | | | | | | | | | | |
| 50 | | SM SC | | | SILTY SAND(SM-SC) red and gray | SF | | | | | | | | | | | |
| | | | | | Bottom of Boring @ 50' | | | | | | | | | | | | |

BLOW COUNT 20 40 60 80
Qu (tsf) 1 2 3 4
PPR (tsf) 1.0 2.0 3.0 4.0
Torvane (tsf) 1.0 2.0 3.0 4.0

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit; 20 40 60 80

Water Level Est.: ▽ Measured: ▼ Perched: ⧩

Water Observations: Seepage @ 35' while drilling. Water level @ 31' and open to 35' upon completion and after 30 minutes.

Key to Abbrevations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
GPS Coordinates: N 33°02.964', W 94°50.428'

# LOG OF BORING B-6

**ETTL ENGINEERS & CONSULTANTS**

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

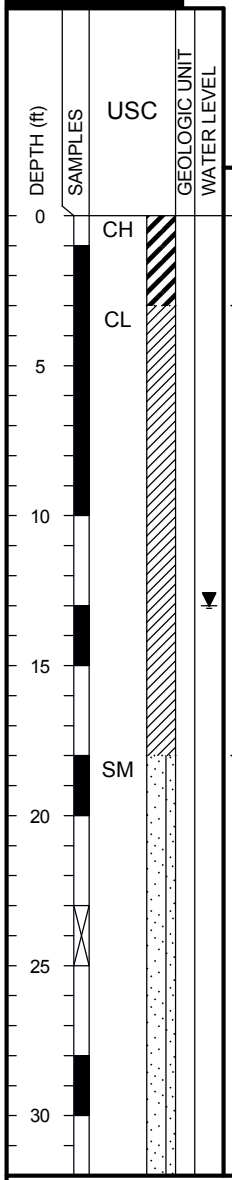
**PROJECT:** Welsh Power Plant
Pittsburgh, Texas

**PROJECT NO.:** G3242-09

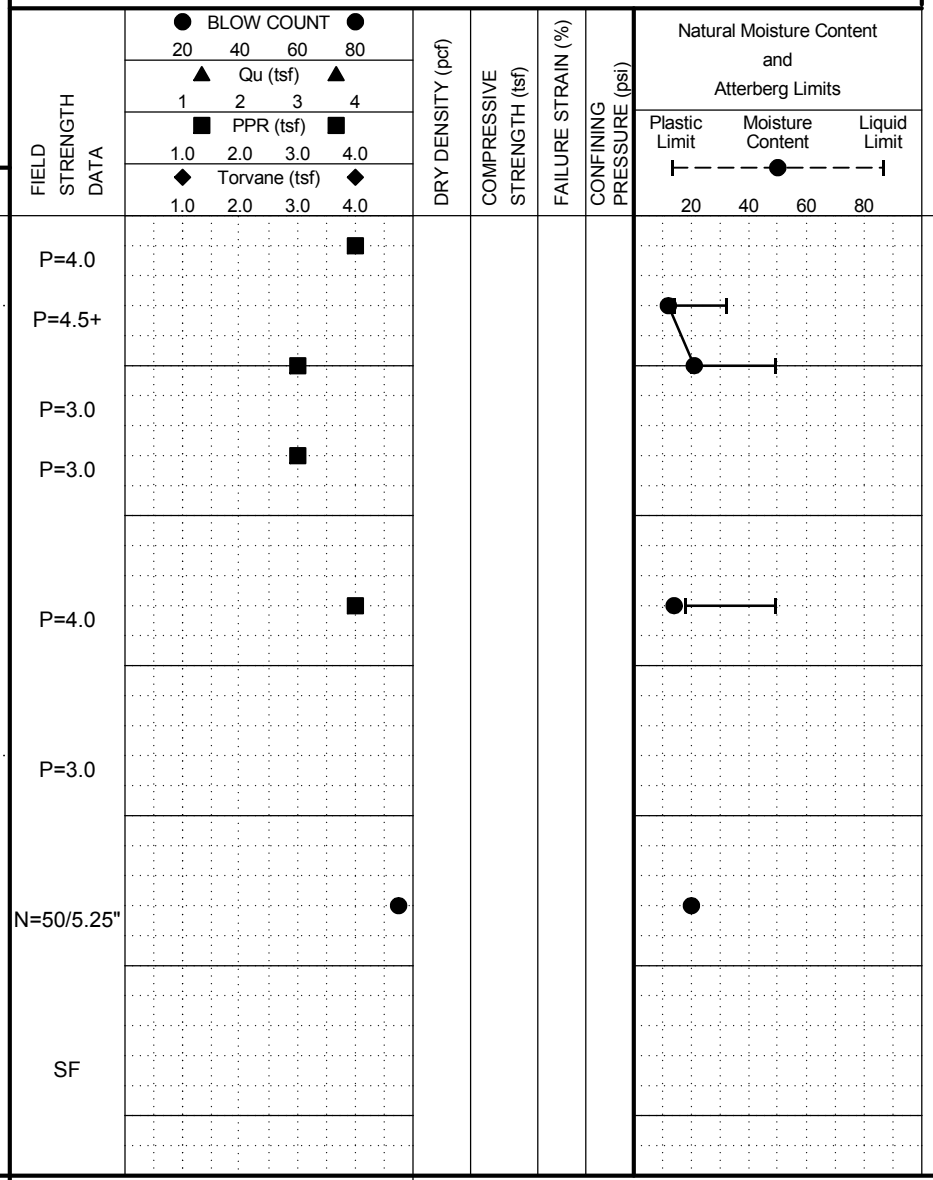
**BORING TYPE:** Flight Auger

**DATE** 10/27/09

**SURFACE ELEVATION** 340.1




## MATERIAL DESCRIPTION




| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| FAT CLAY(CH) very stiff; red and gray; with ferric seams | P=4.0 | | | | | | | | | |
| SANDY LEAN CLAY(CL) hard; red and tan | P=4.5+ | | | | | 12 | 32 | 14 | 18 | 60 | +40 Sieve=0%, +4 Sieve=0% |
| | | | | | | 21 | 49 | 20 | 29 | 93 | +40 Sieve=2%, +4 Sieve=0% |
| --very stiff; red, gray, and brown; with gravel | P=3.0 | | | | | | | | | |
| --with sand seams | P=3.0 | | | | | | | | | |
| | P=4.0 | | | | | 14 | 49 | 18 | 31 | 65 | +40 Sieve=0%, +4 Sieve=0% |
| SILTY SAND(SM) gray; saturated | P=3.0 | | | | | | | | | |
| --very dense; gray and red | N=50/5.25" | | | | | 20 | | | | 18 | +40 Sieve=0%, +4 Sieve=0% |
| | SF | | | | | | | | | |

MOISTURE CONTENT (%) | ATTERBERG LIMITS(%): LIQUID LIMIT (LL) | PLASTIC LIMIT (PL) | PLASTICITY INDEX (PI) | MINUS #200 SIEVE (%) | OTHER TESTS PERFORMED (Page Ref. #)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: Seepage @ 17' while drilling. Water level @ 13' and open to 15' upon completion and after 30 minutes.

Key to Abbrevations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
GPS Coordinates: N 33°02.912', W 94°50.462'

# LOG OF BORING B-6

**ETTL ENGINEERS & CONSULTANTS**

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

**PROJECT:** Welsh Power Plant
Pittsburgh, Texas

**PROJECT NO.:** G3242-09

**BORING TYPE:** Flight Auger

**DATE** 10/27/09

**SURFACE ELEVATION** 340.1

| DEPTH (ft) | SAMPLES | USC | GEOLOGIC UNIT | WATER LEVEL | MATERIAL DESCRIPTION | FIELD STRENGTH DATA | DRY DENSITY (pcf) | COMPRESSIVE STRENGTH (tsf) | FAILURE STRAIN (%) | CONFINING PRESSURE (psi) | Natural Moisture Content and Atterberg Limits | MOISTURE CONTENT (%) | ATTERBERG LIMITS(%) LIQUID LIMIT (LL) | PLASTIC LIMIT (PL) | PLASTICITY INDEX (PI) | MINUS #200 SIEVE (%) | OTHER TESTS PERFORMED (Page Ref. #) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | | CH | | | FAT CLAY(CH) hard; brown; with sand seams | P=4.5+ | | | | | | | | | | | |
| | | | | | | P=4.5+ | | | | | | 22 | 68 | 24 | 44 | 95 | +40 Sieve=0%, +4 Sieve=0% |
| 40 | | | | | --dark green | P=4.5+ | | | | | | | | | | | |
| 45 | | CL | | | LEAN CLAY(CL) hard; dark green; laminated with lignite | P=4.5+ | | | | | | | | | | | |
| 50 | | | | | Bottom of Boring @ 50' | | | | | | | | | | | | |

BLOW COUNT 20 40 60 80
Qu (tsf) 1 2 3 4
PPR (tsf) 1.0 2.0 3.0 4.0
Torvane (tsf) 1.0 2.0 3.0 4.0

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit; 20 40 60 80

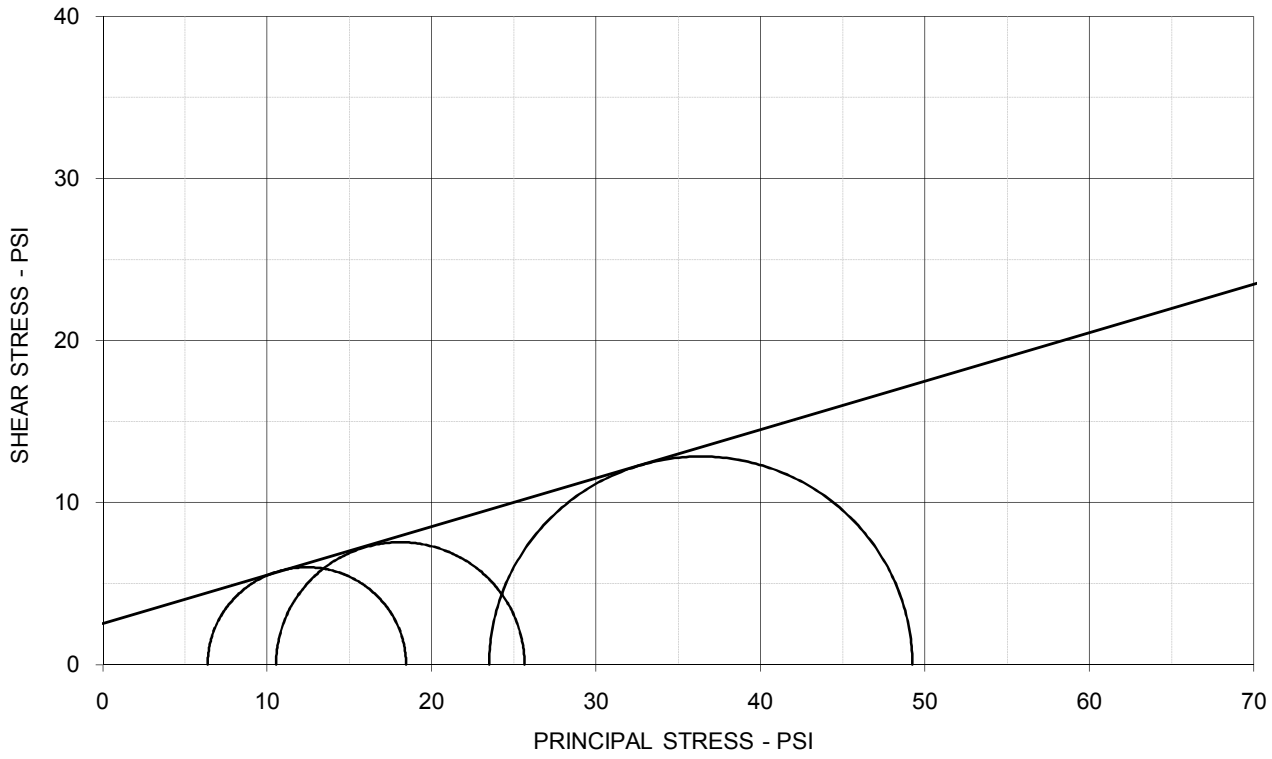
Water Level Est.: ▽ Measured: ▼ Perched: ⧩

Water Observations: Seepage @ 17' while drilling. Water level @ 13' and open to 15' upon completion and after 30 minutes.

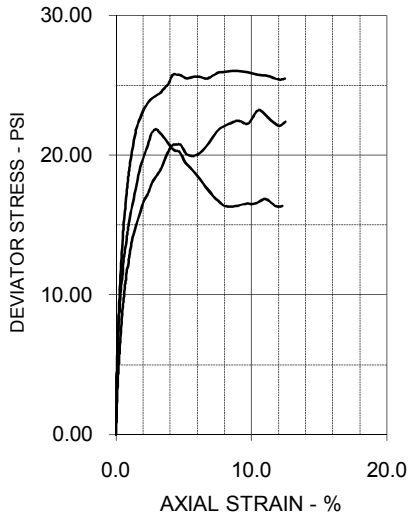
Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)

Notes:
GPS Coordinates: N 33°02.912', W 94°50.462'

# TRIAXIAL SHEAR TEST REPORT




| EFFECTIVE STRESS PARAMETERS | $\phi$ ' = 16.7 deg | c' = 2.5 psi | | |
|---|---|---|---|---|
| SPECIMEN NO. | 1 | 2 | 3 | 4 |
| INITIAL | | | | |
| Moisture Content - % | 23.9 | 24.1 | 26.5 | |
| Dry Density - pcf | 102.5 | 100.6 | 99.0 | |
| Diameter - inches | 2.01 | 2.00 | 2.01 | |
| Height - inches | 4.00 | 3.92 | 3.98 | |
| AT TEST | | | | |
| Final Moisture - % | 25.4 | 24.3 | 25.0 | |
| Dry Density - pcf | 102.7 | 102.4 | 101.9 | |
| Calculated Diameter (in.) | 2.01 | 1.98 | 1.99 | |
| Height - inches | 4.02 | 3.87 | 3.92 | |
| Effect. Cell Pressure - psi | 10.0 | 20.0 | 40.0 | |
| Failure Stress - psi | 12.03 | 15.08 | 25.71 | |
| Total Pore Pressure - psi | 53.6 | 59.4 | 66.5 | |
| Strain Rate - inches/min. | 0.00050 | 0.00050 | 0.00050 | |
| Failure Strain - % | 0.9 | 0.9 | 4.8 | |
| $\sigma_1$' Failure - psi | 18.43 | 25.64 | 49.23 | |
| $\sigma_3$' Failure - psi | 6.40 | 10.56 | 23.52 | |




## TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP
SAMPLE TYPE: Shelby Tube Sample
DESCRIPTION: Tan & Gray Clay & w/ some Ferric Joints
Sampled on Site, B-1 5' to 10' deep
ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve
LL: PL: PI: Percent -200:
REMARKS: Diameter and Both Ends Trimmed + # 4 Sieve

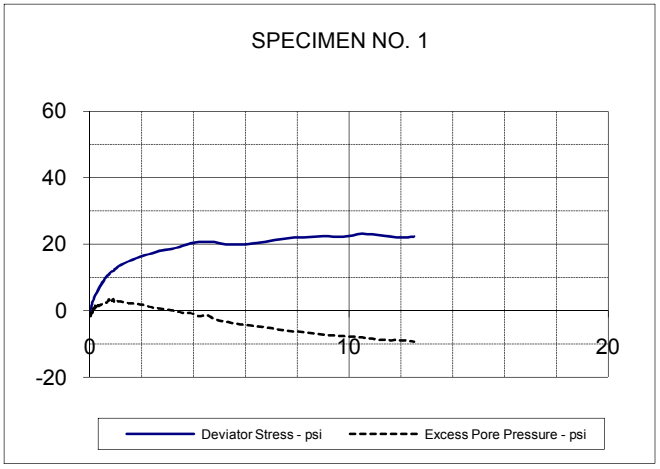
## PROJECT INFORMATION

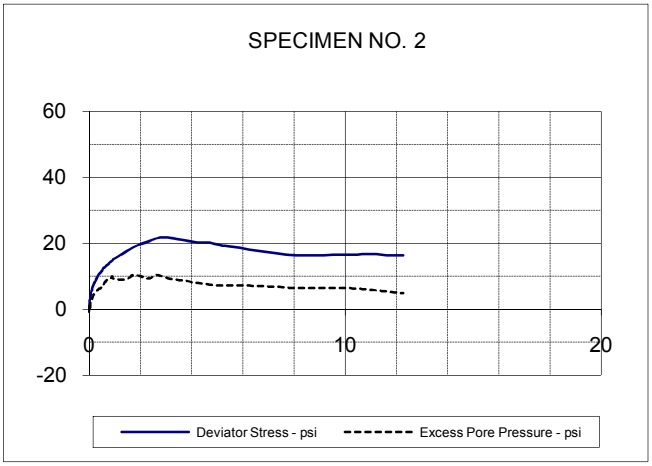
PROJECT: AEP Welsh Power Plant Bottom Ash Ponds
LOCATION: Pittsburg, Texas
PROJECT NO: G 3242 - 095
CLIENT:
December 2009

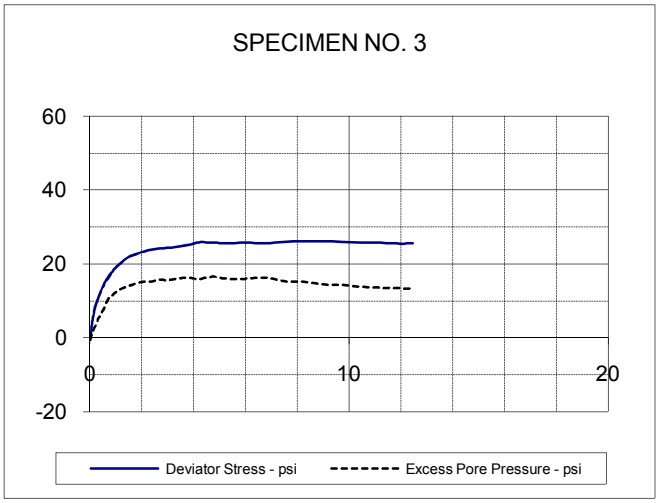
**ETTL ENGINEERS & CONSULTANTS**

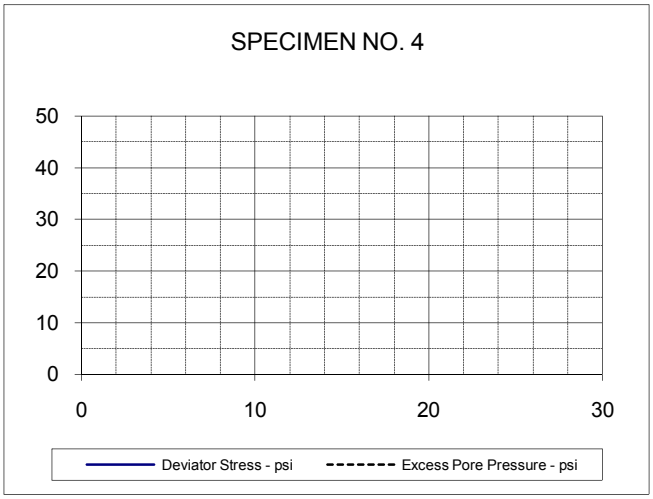
PLATE: B.1

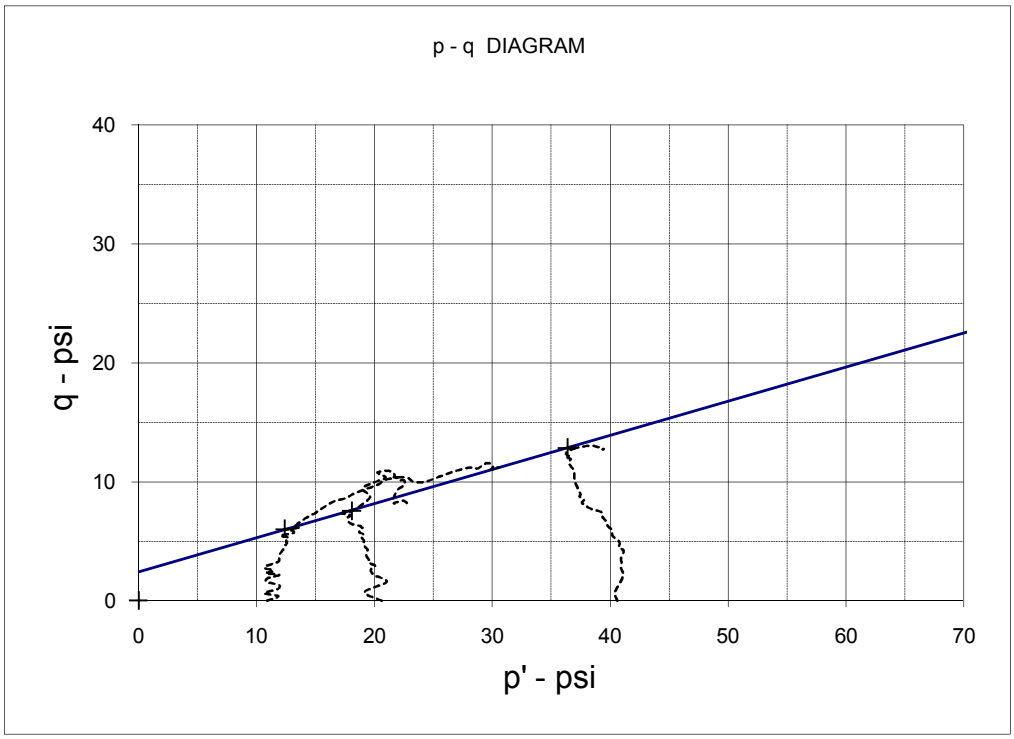
G 3242-095, B-1 5'-10' Welsh



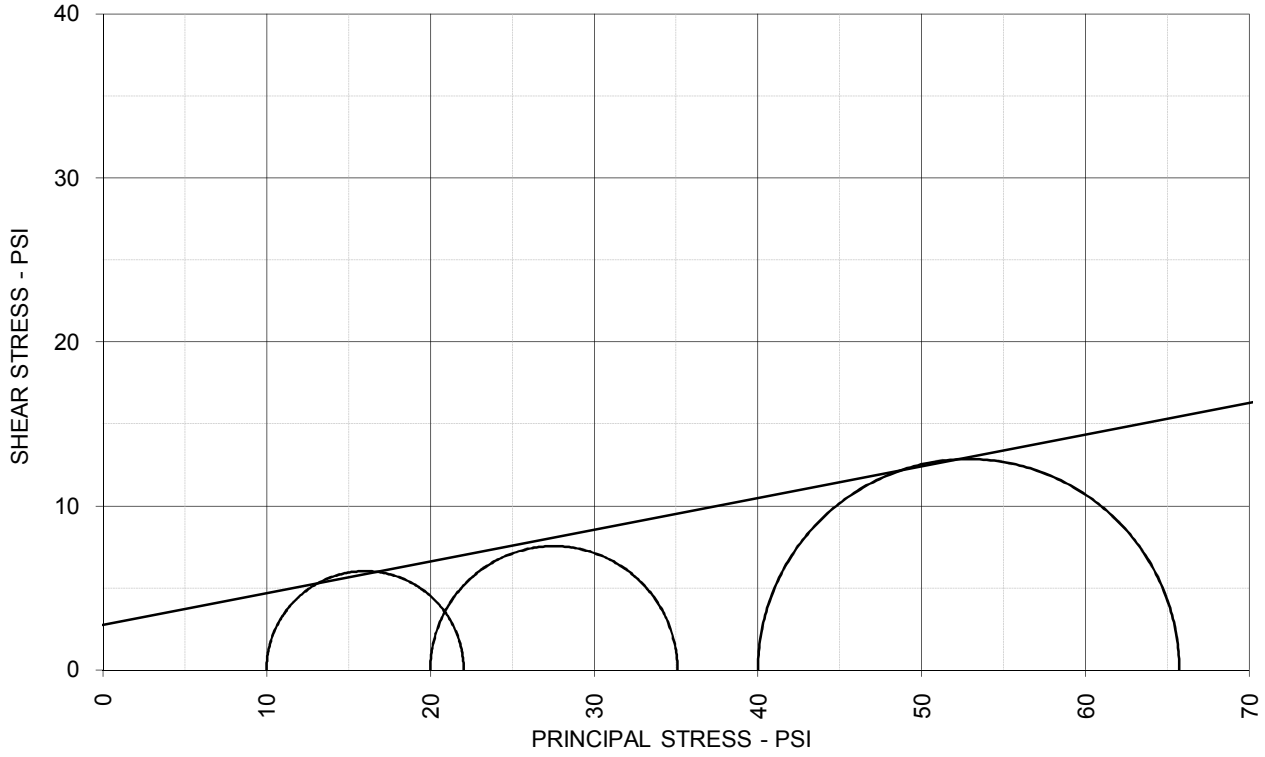



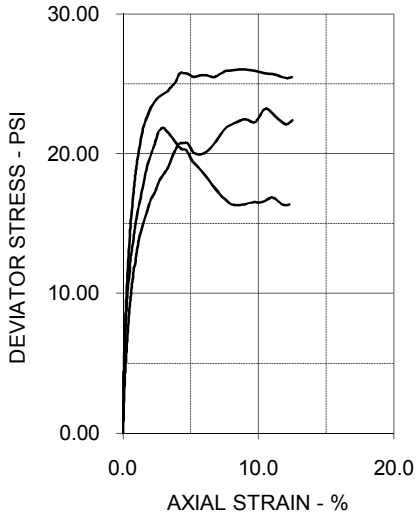

| | | | |
|---|---|---|---|
| EFFECTIVE STRESS PARAMETERS | $R^2$ = 1.00 | $\alpha$ (deg) = 16.0 | a (psi) = 2.4 |
| PROJECT: AEP Welsh Power Plant Bottom Ash Ponds | | TYPE OF TEST & NO: CU with PP | |
| PROJECT NO: G 3242 - 095 | | **ETTL ENGINEERS & CONSULTANTS** | PLATE: B.2 |
| DESCRIPTION: Tan & Gray Clay & w/ some Ferric Joints | | | |

G 3242-095, B-1 5'-10' Welsh

# TRIAXIAL SHEAR TEST REPORT




| TOTAL STRESS PARAMETERS | $\phi$ = 10.9 deg | c = 2.8 psi |
|---|---|---|




| SPECIMEN NO. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| INITIAL | | | | |
| Moisture Content - % | 23.9 | 24.1 | 26.5 | |
| Dry Density - pcf | 102.5 | 100.6 | 99.0 | |
| Diameter - inches | 2.01 | 2.00 | 2.01 | |
| Height - inches | 4.00 | 3.92 | 3.98 | |
| AT TEST | | | | |
| Final Moisture - % | 25.4 | 24.3 | 25.0 | |
| Dry Density - pcf | 102.7 | 102.4 | 101.9 | |
| Calculated Diameter (in.) | 2.01 | 1.98 | 1.99 | |
| Height - inches | 4.02 | 3.87 | 3.92 | |
| Effect. Cell Pressure - psi | 10.0 | 20.0 | 40.0 | |
| Failure Stress - psi | 12.03 | 15.08 | 25.71 | |
| Total Pore Pressure - psi | 53.6 | 59.4 | 66.5 | |
| Strain Rate - inches/min. | 0.00050 | 0.00050 | 0.00050 | |
| Failure Strain - % | 0.9 | 0.9 | 4.8 | |
| $\sigma_1$ Failure - psi | 22.03 | 35.08 | 65.71 | |
| $\sigma_3$ Failure - psi | 10.00 | 20.00 | 40.00 | |

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP
SAMPLE TYPE: Shelby Tube Sample
DESCRIPTION: Tan & Gray Clay & w/ some Ferric Joints
Sampled on Site, B-1 5' to 10' deep
ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve
LL: PL: PI: Percent -200:
REMARKS: Diameter and Both Ends Trimmed + # 4 Sieve

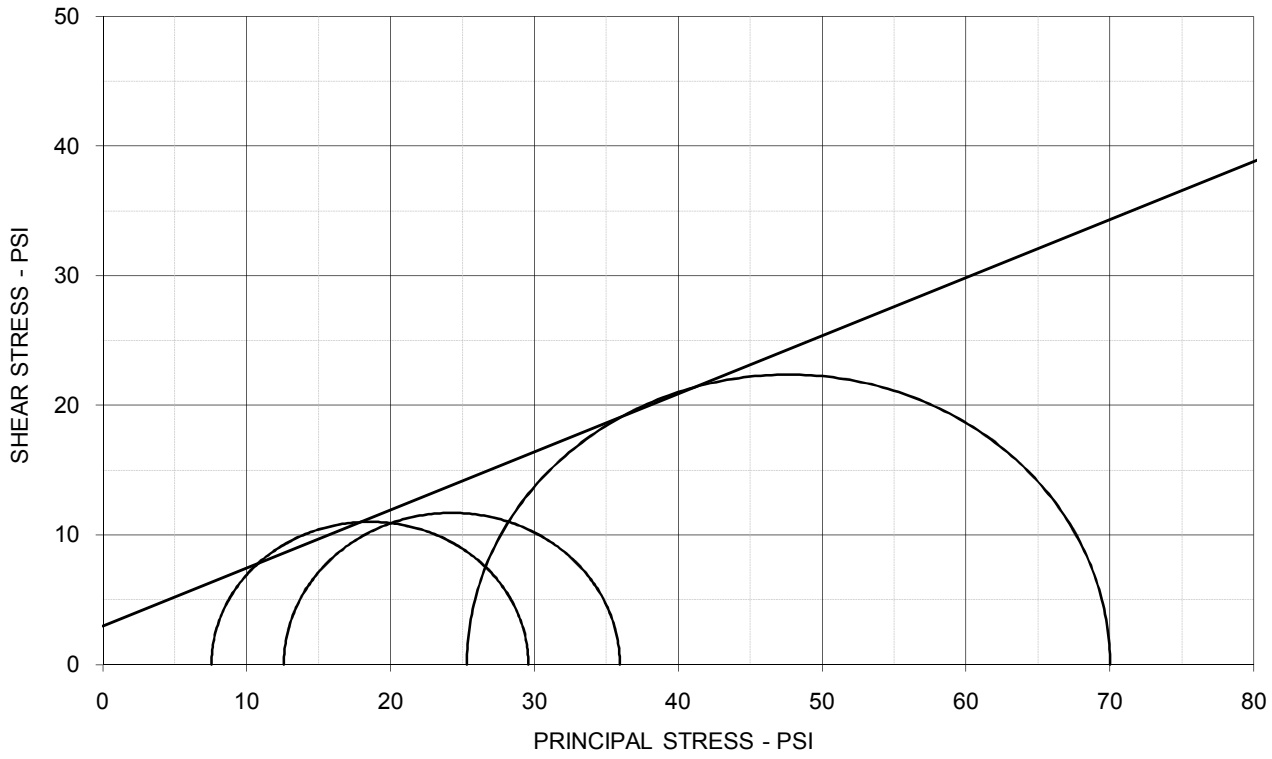
## PROJECT INFORMATION

PROJECT: AEP Welsh Power Plant Bottom Ash Ponds
LOCATION: Pittsburg, Texas
PROJECT NO: G 3242 - 095
CLIENT:
December 2009

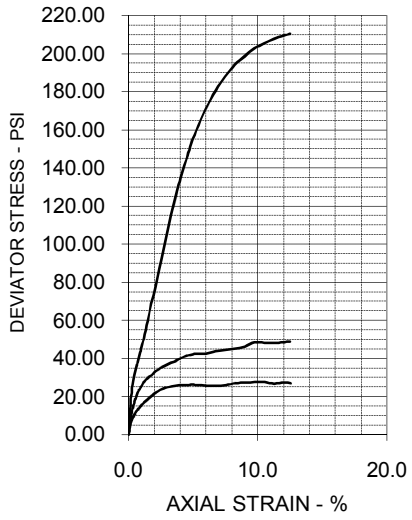
**ETTL ENGINEERS & CONSULTANTS**

PLATE: B.3

# TRIAXIAL SHEAR TEST REPORT




| EFFECTIVE STRESS PARAMETERS | $\phi'$ = 24.1 deg | c' = 2.9 psi | | |
|---|---|---|---|---|
| SPECIMEN NO. | 1 | 2 | 3 | 4 |
| INITIAL | | | | |
| Moisture Content - % | 14.4 | 23.6 | 13.0 | |
| Dry Density - pcf | 114.9 | 100.1 | 122.2 | |
| Diameter - inches | 2.01 | 2.02 | 2.00 | |
| Height - inches | 4.00 | 4.00 | 4.02 | |
| AT TEST | | | | |
| Final Moisture - % | 18.7 | 24.4 | 13.2 | |
| Dry Density - pcf | 115.2 | 101.7 | 123.3 | |
| Calculated Diameter (in.) | 2.00 | 2.01 | 1.99 | |
| Height - inches | 3.99 | 3.97 | 3.98 | |
| Effect. Cell Pressure - psi | 10.0 | 20.0 | 40.0 | |
| Failure Stress - psi | 22.03 | 23.38 | 44.72 | |
| Total Pore Pressure - psi | 52.5 | 57.4 | 64.7 | |
| Strain Rate - inches/min. | 0.00050 | 0.00050 | 0.00050 | |
| Failure Strain - % | 0.7 | 2.4 | 1.0 | |
| $\sigma_1'$ Failure - psi | 29.58 | 35.95 | 70.02 | |
| $\sigma_3'$ Failure - psi | 7.55 | 12.57 | 25.30 | |




## TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP
SAMPLE TYPE: Shelby Tube Sample
DESCRIPTION: Reddish Brown Sandy Lean Clay
Sampled on Site, B-2 8' to 10' deep
ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve
LL: PL: PI: Percent -200:
REMARKS: Diameter and Both Ends Trimmed + # 4 Sieve

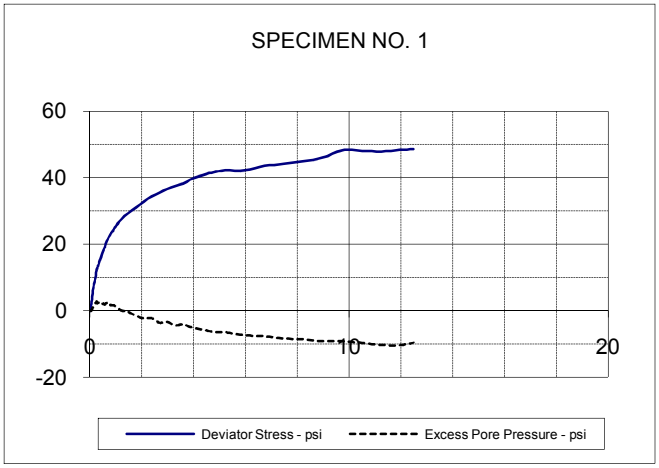
G 3242-095, B-2 8'-10' Welsh

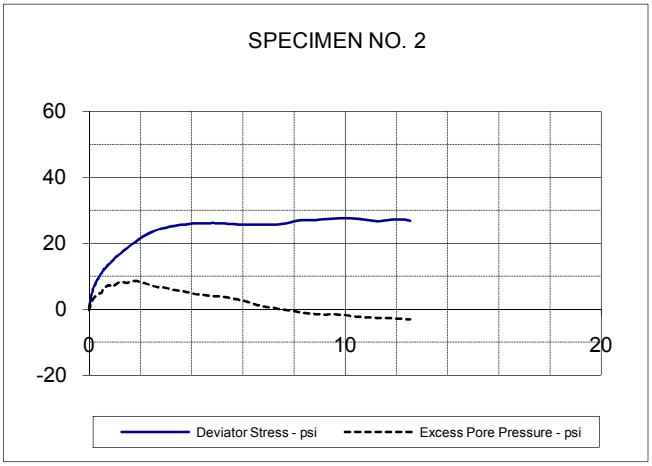
## PROJECT INFORMATION

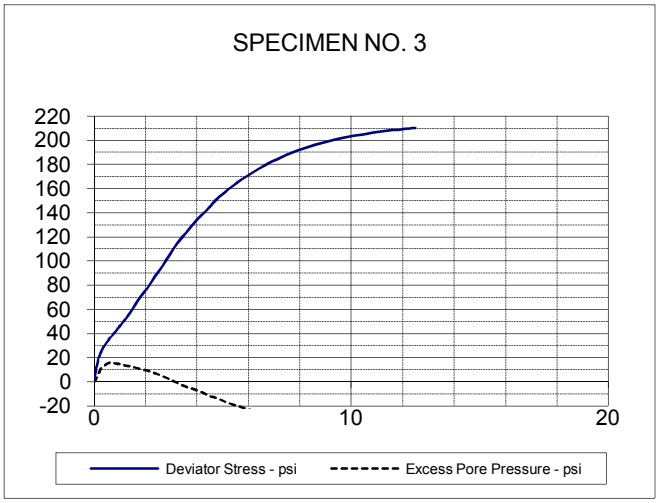
PROJECT: AEP Welsh Power Plant Bottom Ash Ponds
LOCATION: Pittsburg, Texas
PROJECT NO: G 3242 - 095
CLIENT:
December 2009

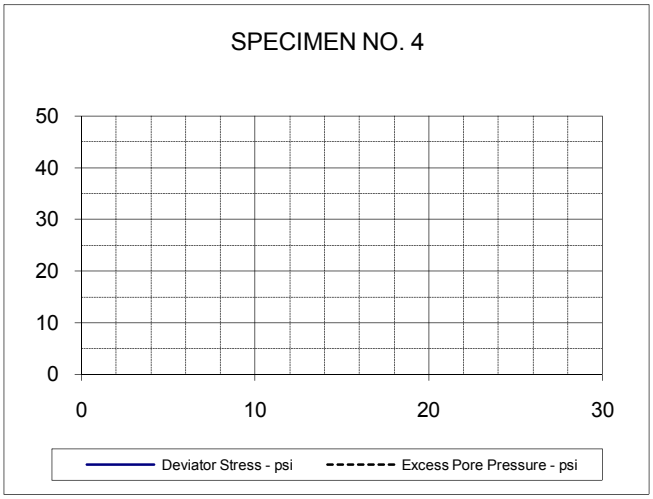
**ETTL ENGINEERS & CONSULTANTS**

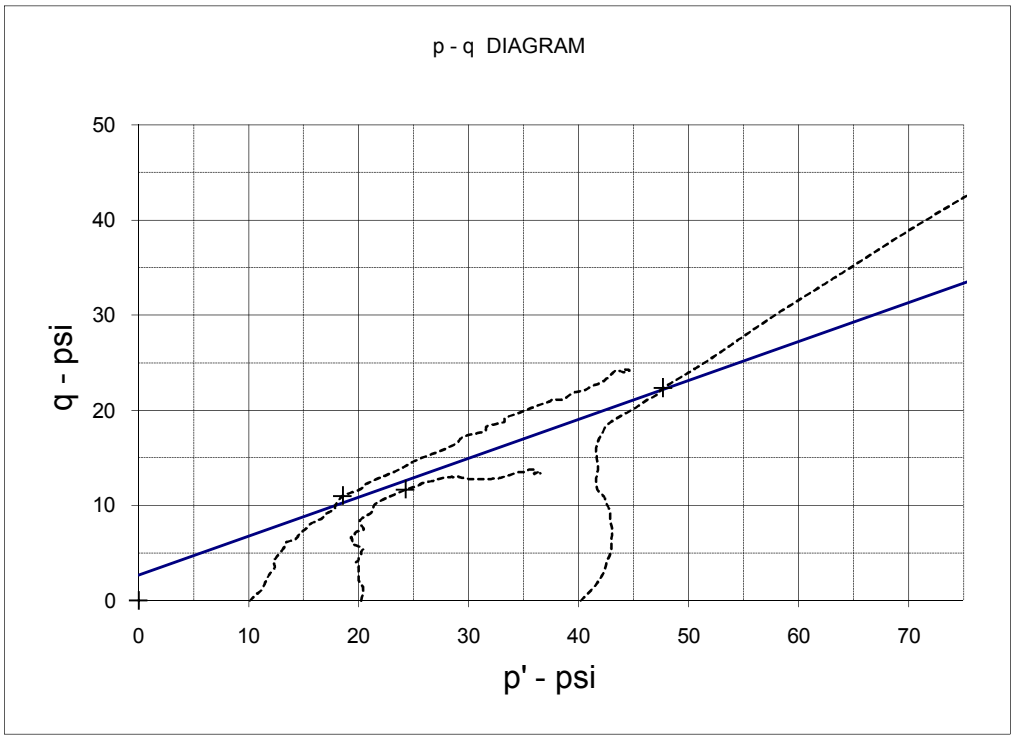
PLATE: B.1



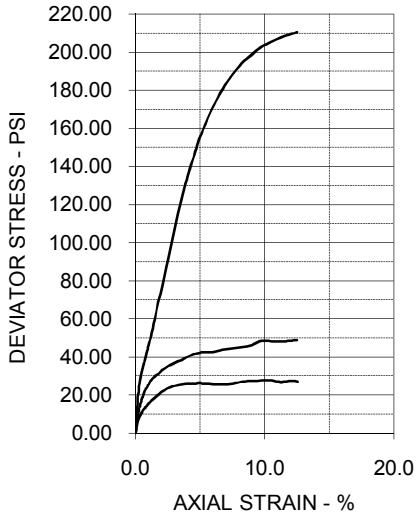




| | | | |
|---|---|---|---|
| EFFECTIVE STRESS PARAMETERS | $R^2$ = 0.98 | $\alpha$ (deg) = 22.3 | a (psi) = 2.7 |
| PROJECT: AEP Welsh Power Plant Bottom Ash Ponds | | TYPE OF TEST & NO: CU with PP | |
| PROJECT NO: G 3242 - 095 | | **ETTL ENGINEERS & CONSULTANTS** | PLATE: B.2 |
| DESCRIPTION: Reddish Brown Sandy Lean Clay | | | |

G 3242-095, B-2 8'-10' Welsh

# TRIAXIAL SHEAR TEST REPORT


| TOTAL STRESS PARAMETERS | $\phi$ = 16.9 deg | c = 4.0 psi |
|---|---|---|




| SPECIMEN NO. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| INITIAL | | | | |
| Moisture Content - % | 14.4 | 23.6 | 13.0 | |
| Dry Density - pcf | 114.9 | 100.1 | 122.2 | |
| Diameter - inches | 2.01 | 2.02 | 2.00 | |
| Height - inches | 4.00 | 4.00 | 4.02 | |
| AT TEST | | | | |
| Final Moisture - % | 18.7 | 24.4 | 13.2 | |
| Dry Density - pcf | 115.2 | 101.7 | 123.3 | |
| Calculated Diameter (in.) | 2.00 | 2.01 | 1.99 | |
| Height - inches | 3.99 | 3.97 | 3.98 | |
| Effect. Cell Pressure - psi | 10.0 | 20.0 | 40.0 | |
| Failure Stress - psi | 22.03 | 23.38 | 44.72 | |
| Total Pore Pressure - psi | 52.5 | 57.4 | 64.7 | |
| Strain Rate - inches/min. | 0.00050 | 0.00050 | 0.00050 | |
| Failure Strain - % | 0.7 | 2.4 | 1.0 | |
| $\sigma_1$ Failure - psi | 32.03 | 43.38 | 84.72 | |
| $\sigma_3$ Failure - psi | 10.00 | 20.00 | 40.00 | |

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP
SAMPLE TYPE: Shelby Tube Sample
DESCRIPTION: Reddish Brown Sandy Lean Clay
Sampled on Site, B-2 8' to 10' deep
ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve
LL: PL: PI: Percent -200:
REMARKS: Diameter and Both Ends Trimmed + # 4 Sieve

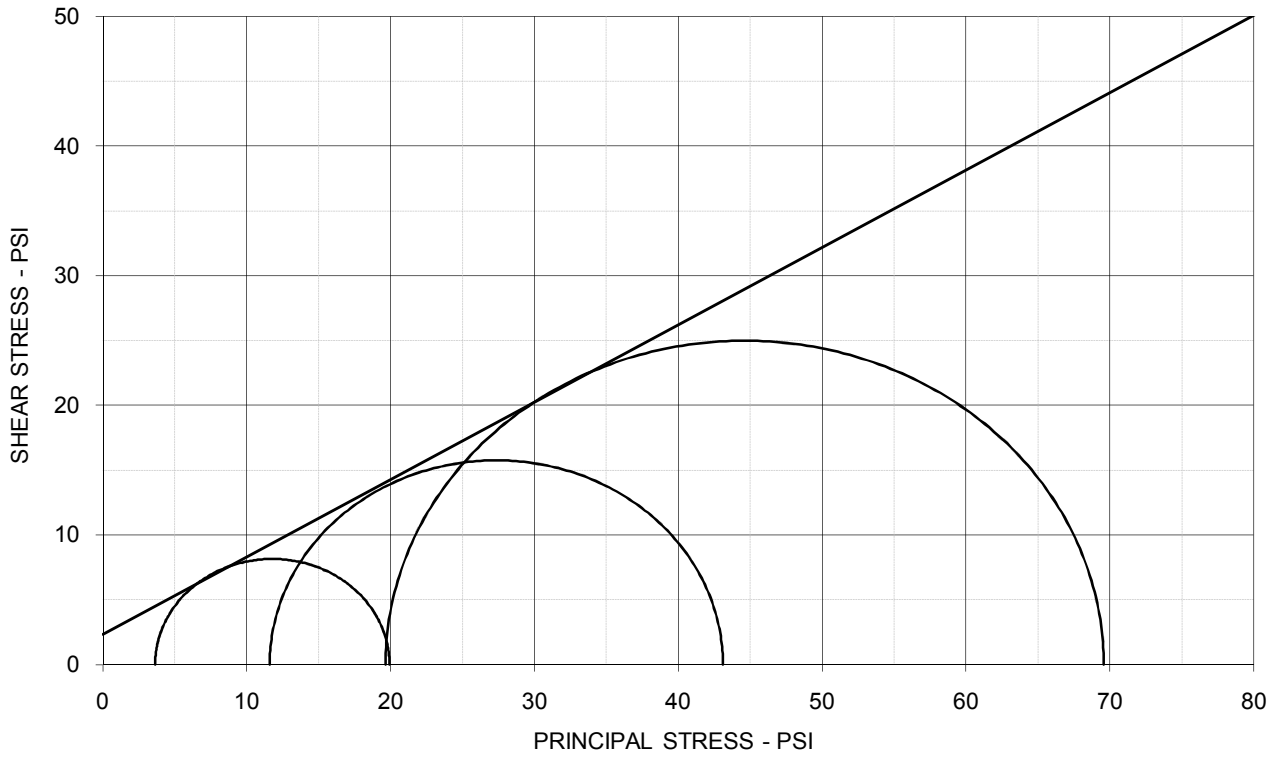
## PROJECT INFORMATION

PROJECT: AEP Welsh Power Plant Bottom Ash Ponds
LOCATION: Pittsburg, Texas
PROJECT NO: G 3242 - 095
CLIENT:
December 2009

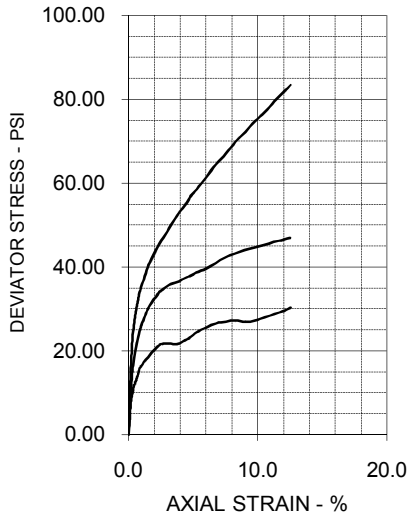
**ETTL ENGINEERS & CONSULTANTS**

PLATE: B.3

# TRIAXIAL SHEAR TEST REPORT




| EFFECTIVE STRESS PARAMETERS | $\phi'$ = 30.8 deg | c' = 2.3 psi | | |
|---|---|---|---|---|
| SPECIMEN NO. | 1 | 2 | 3 | 4 |
| INITIAL | | | | |
| Moisture Content - % | 20.5 | 17.7 | 16.0 | |
| Dry Density - pcf | 106.7 | 111.3 | 117.2 | |
| Diameter - inches | 2.00 | 1.99 | 1.98 | |
| Height - inches | 3.99 | 3.98 | 4.00 | |
| AT TEST | | | | |
| Final Moisture - % | 27.8 | 18.6 | 16.3 | |
| Dry Density - pcf | 106.8 | 112.4 | 118.7 | |
| Calculated Diameter (in.) | 2.00 | 1.99 | 1.97 | |
| Height - inches | 3.98 | 3.97 | 3.96 | |
| Effect. Cell Pressure - psi | 10.0 | 20.0 | 40.0 | |
| Failure Stress - psi | 16.30 | 31.51 | 49.94 | |
| Total Pore Pressure - psi | 56.4 | 58.4 | 70.4 | |
| Strain Rate - inches/min. | 0.00050 | 0.00050 | 0.00050 | |
| Failure Strain - % | 1.0 | 1.8 | 3.3 | |
| $\sigma_1'$ Failure - psi | 19.94 | 43.12 | 69.59 | |
| $\sigma_3'$ Failure - psi | 3.64 | 11.61 | 19.65 | |




## TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP
SAMPLE TYPE: Shelby Tube Sample
DESCRIPTION: Tan, Brown, Gray & Red Clayey Sand
Sampled on Site, B-2 28' to 30' deep
ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve
LL: PL: PI: Percent -200:
REMARKS: Diameter and Both Ends Trimmed + # 4 Sieve

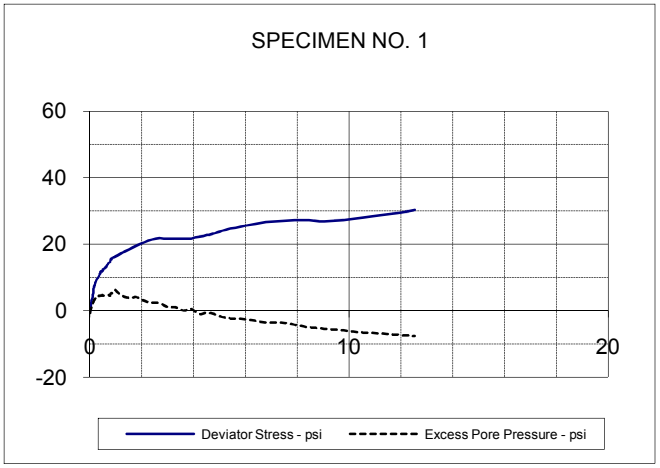
## PROJECT INFORMATION

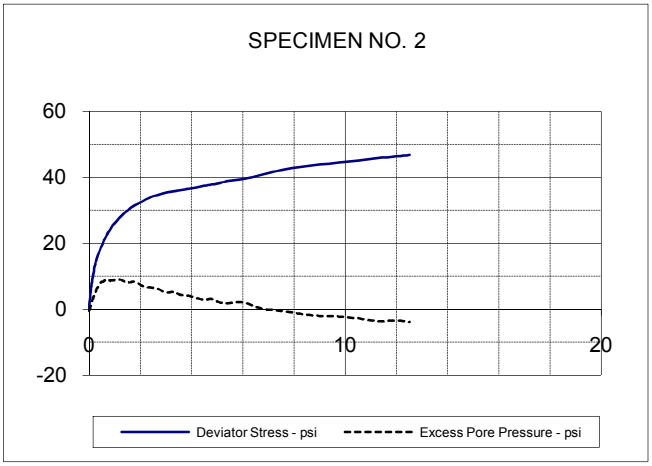
PROJECT: AEP Welsh Power Plant Bottom Ash Ponds
LOCATION: Pittsburg, Texas
PROJECT NO: G 3242 - 095
CLIENT:
December 2009

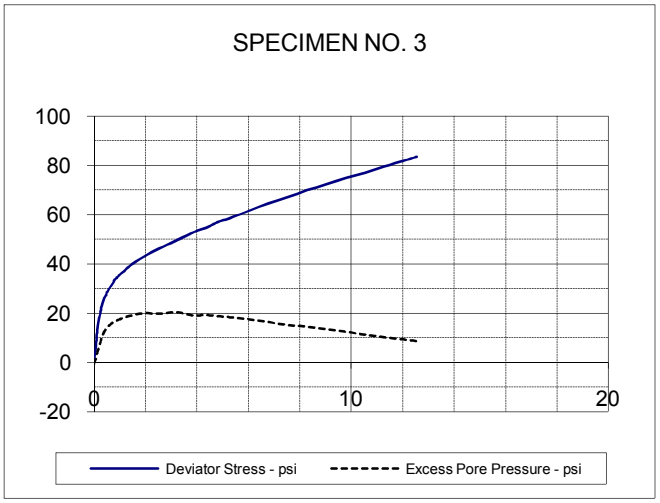
**ETTL ENGINEERS & CONSULTANTS**

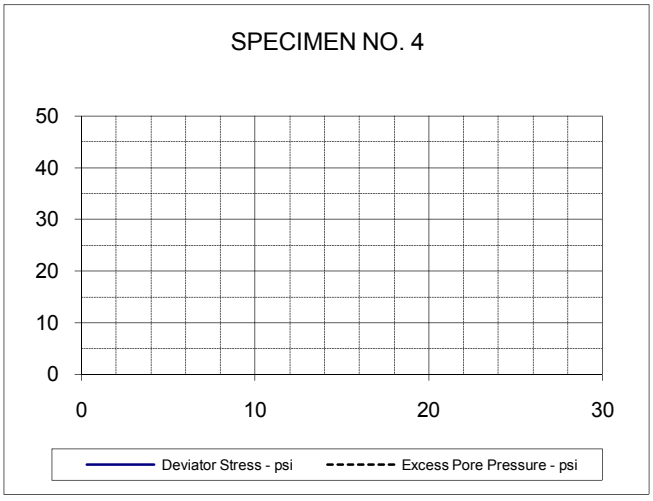
PLATE: B.1

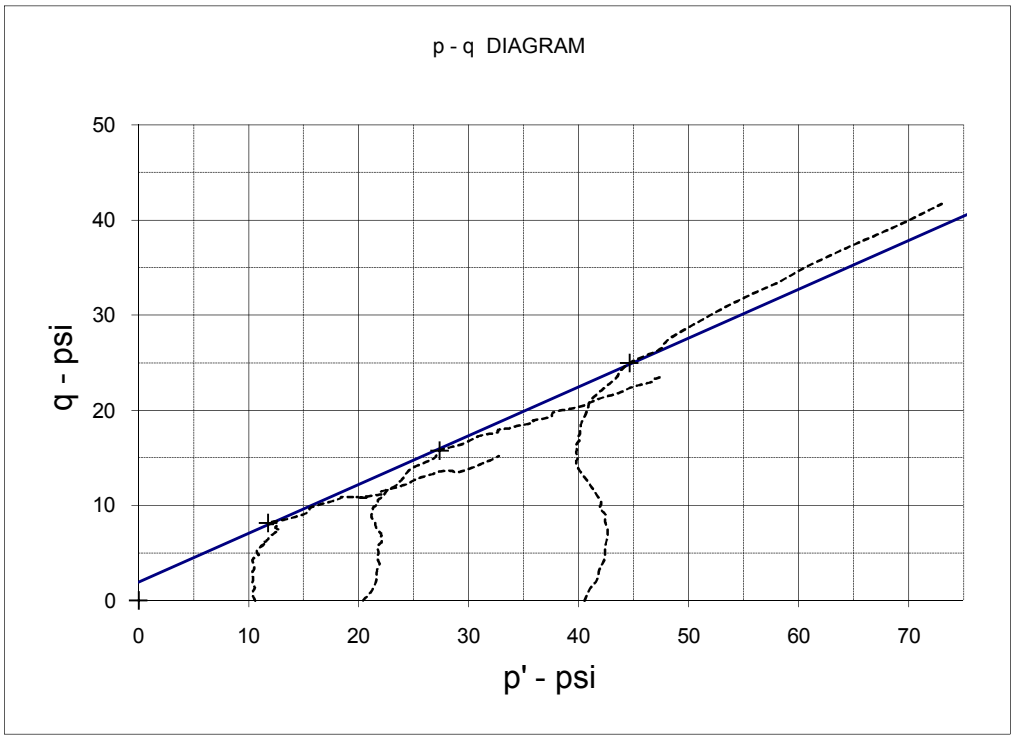
G 3242-095, B-2 28' 30' Welsh



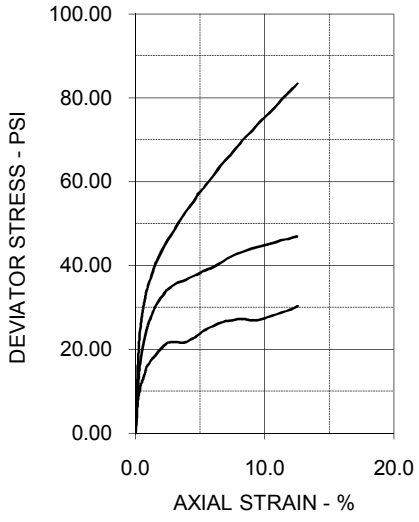




| | | | |
|---|---|---|---|
| EFFECTIVE STRESS PARAMETERS | $R^2$ = 1.00 | $\alpha$ (deg) = 27.1 | a (psi) = 2.0 |
| PROJECT: AEP Welsh Power Plant Bottom Ash Ponds | | TYPE OF TEST & NO: CU with PP | |
| PROJECT NO: G 3242 - 095 | | **ETTL ENGINEERS & CONSULTANTS** | PLATE: B.2 |
| DESCRIPTION: Tan, Brown, Gray & Red Clayey Sand | | | |

G 3242-095, B-2 28'-30' Welsh

# TRIAXIAL SHEAR TEST REPORT


| TOTAL STRESS PARAMETERS | $\phi$ = 20.8 deg | c = 2.4 psi |
|---|---|---|




| SPECIMEN NO. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| INITIAL | | | | |
| Moisture Content - % | 20.5 | 17.7 | 16.0 | |
| Dry Density - pcf | 106.7 | 111.3 | 117.2 | |
| Diameter - inches | 2.00 | 1.99 | 1.98 | |
| Height - inches | 3.99 | 3.98 | 4.00 | |
| AT TEST | | | | |
| Final Moisture - % | 27.8 | 18.6 | 16.3 | |
| Dry Density - pcf | 106.8 | 112.4 | 118.7 | |
| Calculated Diameter (in.) | 2.00 | 1.99 | 1.97 | |
| Height - inches | 3.98 | 3.97 | 3.96 | |
| Effect. Cell Pressure - psi | 10.0 | 20.0 | 40.0 | |
| Failure Stress - psi | 16.30 | 31.51 | 49.94 | |
| Total Pore Pressure - psi | 56.4 | 58.4 | 70.4 | |
| Strain Rate - inches/min. | 0.00050 | 0.00050 | 0.00050 | |
| Failure Strain - % | 1.0 | 1.8 | 3.3 | |
| $\sigma_1$ Failure - psi | 26.30 | 51.51 | 89.94 | |
| $\sigma_3$ Failure - psi | 10.00 | 20.00 | 40.00 | |

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP
SAMPLE TYPE: Shelby Tube Sample
DESCRIPTION: Tan, Brown, Gray & Red Clayey Sand
Sampled on Site, B-2 28' to 30' deep
ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve
LL: PL: PI: Percent -200:
REMARKS: Diameter and Both Ends Trimmed + # 4 Sieve

## PROJECT INFORMATION

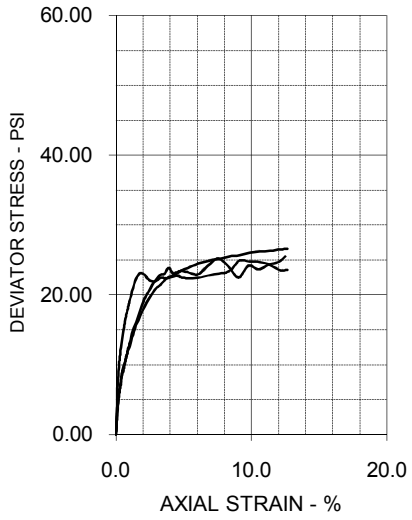
PROJECT: AEP Welsh Power Plant Bottom Ash Ponds
LOCATION: Pittsburg, Texas
PROJECT NO: G 3242 - 095
CLIENT:
December 2009

**ETTL ENGINEERS & CONSULTANTS**

PLATE: B.3

# TRIAXIAL SHEAR TEST REPORT


| EFFECTIVE STRESS PARAMETERS | $\phi'$ = 26.9 deg | c' = 1.8 psi | | |
|---|---|---|---|---|
| SPECIMEN NO. | 1 | 2 | 3 | 4 |
| INITIAL | | | | |
| Moisture Content - % | 24.0 | 23.2 | 20.1 | |
| Dry Density - pcf | 98.6 | 102.2 | 104.5 | |
| Diameter - inches | 2.01 | 2.02 | 2.00 | |
| Height - inches | 3.97 | 4.01 | 4.01 | |
| AT TEST | | | | |
| Final Moisture - % | 26.5 | 24.8 | 24.2 | |
| Dry Density - pcf | 99.5 | 103.0 | 105.7 | |
| Calculated Diameter (in.) | 2.01 | 2.02 | 2.00 | |
| Height - inches | 3.99 | 4.01 | 4.03 | |
| Effect. Cell Pressure - psi | 10.0 | 20.0 | 40.0 | |
| Failure Stress - psi | 12.64 | 23.13 | 24.50 | |
| Total Pore Pressure - psi | 55.7 | 58.4 | 79.8 | |
| Strain Rate - inches/min. | 0.00050 | 0.00050 | 0.00050 | |
| Failure Strain - % | 1.0 | 1.8 | 6.1 | |
| $\sigma_1'$ Failure - psi | 16.87 | 34.74 | 34.66 | |
| $\sigma_3'$ Failure - psi | 4.23 | 11.61 | 10.16 | |




## TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP
SAMPLE TYPE: Shelby Tube Sample
DESCRIPTION: Gray, Brown & Tan Fat Clay w/ Ferric Seams
Sampled on Site, B-5 8' to 10' deep
ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve
LL: PL: PI: Percent -200:
REMARKS: Diameter and Both Ends Trimmed + # 4 Sieve

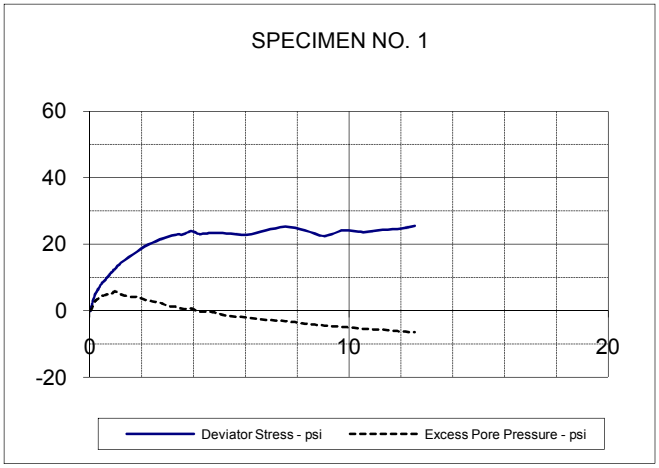
## PROJECT INFORMATION

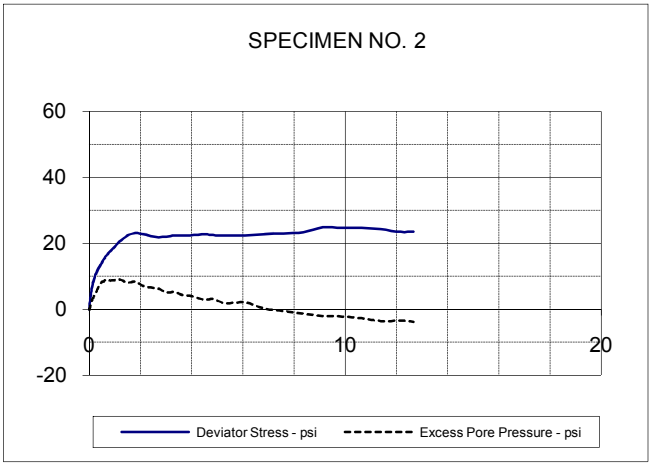
PROJECT: AEP Welsh Power Plant Bottom Ash Ponds
LOCATION: Pittsburg, Texas
PROJECT NO: G 3242 - 095
CLIENT:
December 2009

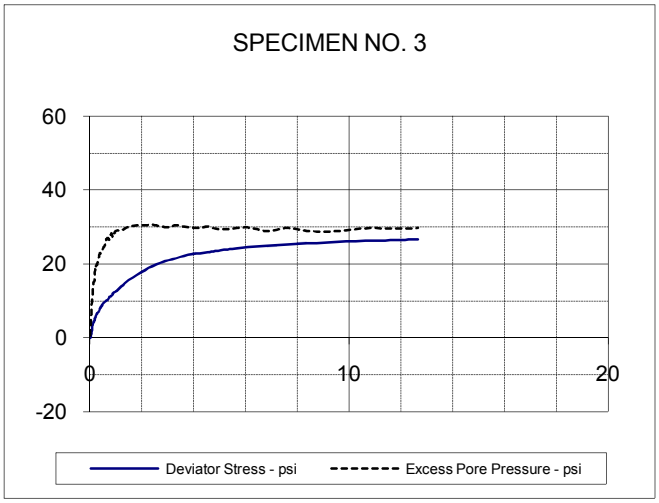
**ETTL ENGINEERS & CONSULTANTS**

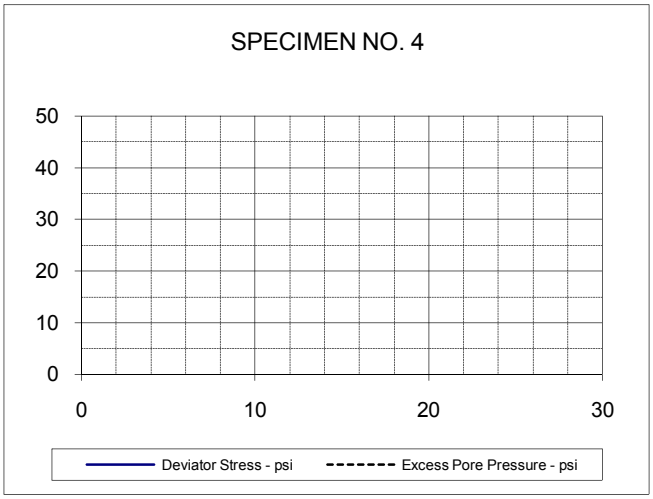
PLATE: B.1

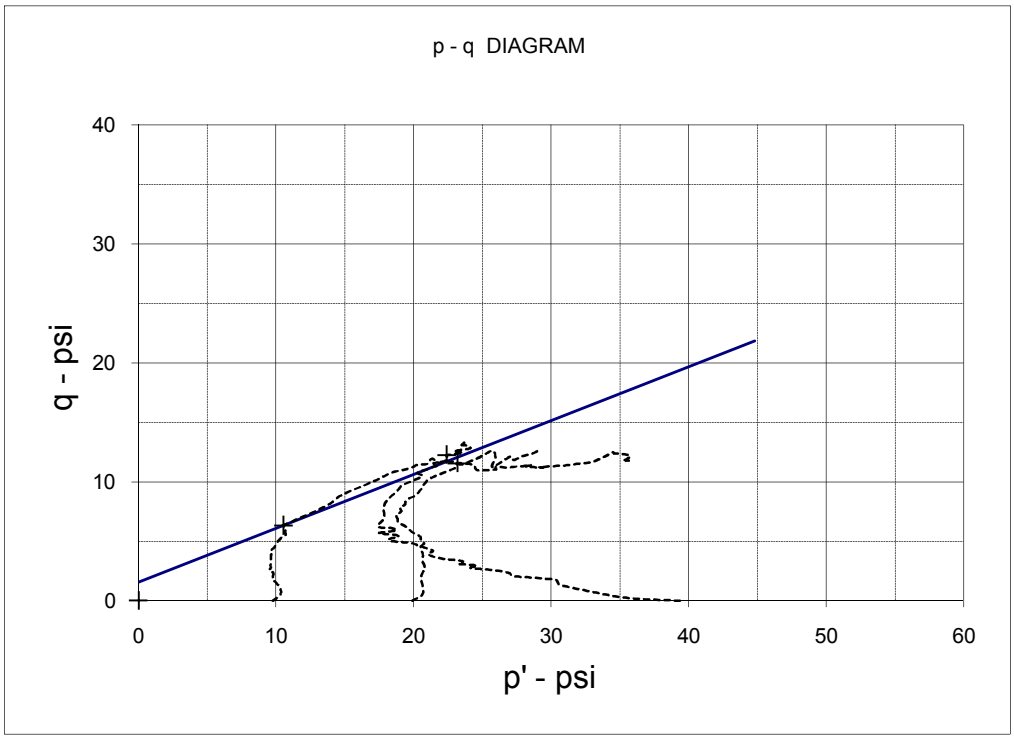
G 3242-095, B-5 8'-10' Welsh



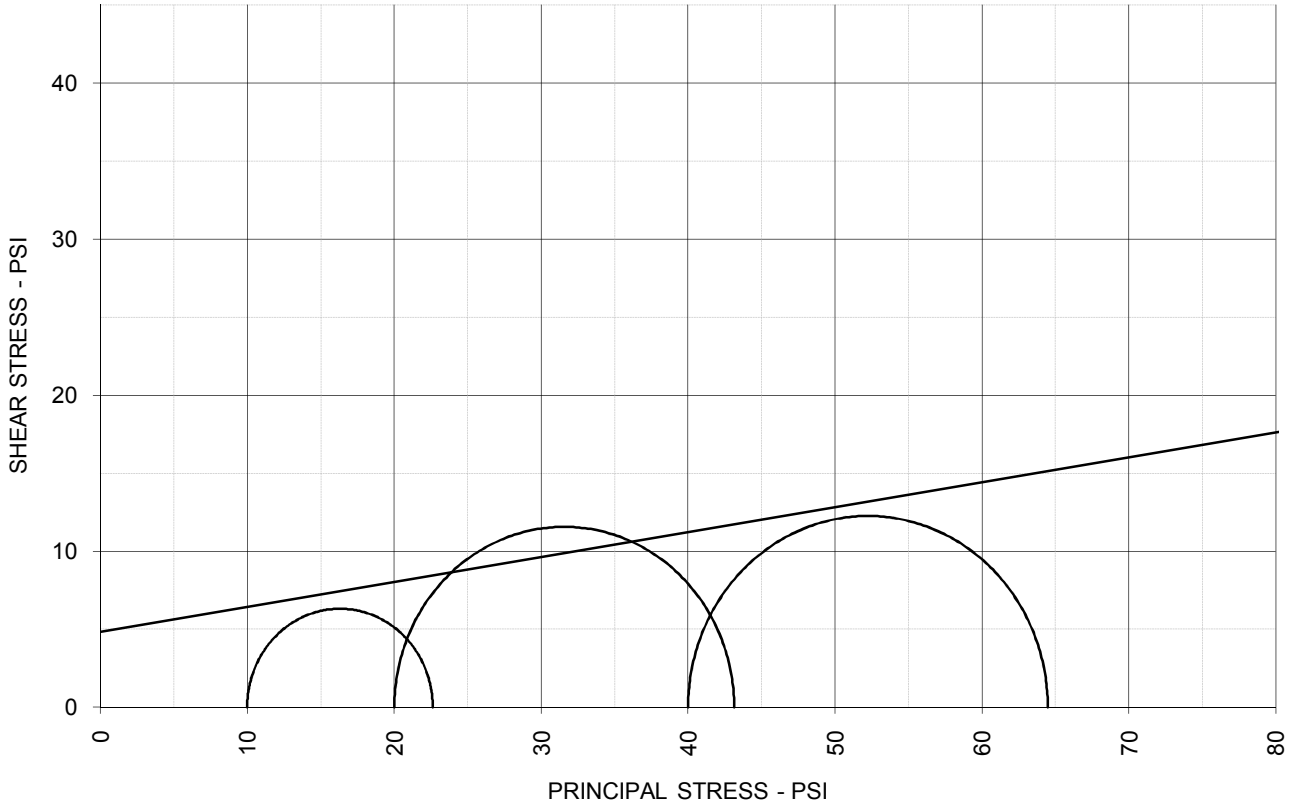



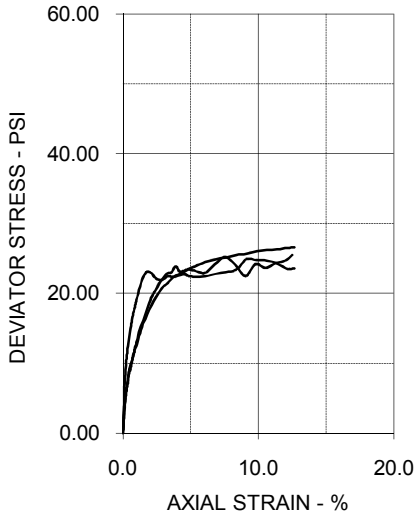

| | | | |
|---|---|---|---|
| EFFECTIVE STRESS PARAMETERS | $R^2$ = 0.97 | $\alpha$ (deg) = 24.3 | a (psi) = 1.6 |
| PROJECT: AEP Welsh Power Plant Bottom Ash Ponds | | TYPE OF TEST & NO: CU with PP | |
| PROJECT NO: G 3242 - 095 | | **ETTL ENGINEERS & CONSULTANTS** | PLATE: B.2 |
| DESCRIPTION: Gray, Brown & Tan Fat Clay w/ Ferric Seams | | | |

G 3242-095, B-5 8'-10' Welsh

# TRIAXIAL SHEAR TEST REPORT




| TOTAL STRESS PARAMETERS | $\phi$ = 9.1 deg | c = 4.9 psi |
|---|---|---|




| SPECIMEN NO. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| INITIAL | | | | |
| Moisture Content - % | 24.0 | 23.2 | 20.1 | |
| Dry Density - pcf | 98.6 | 102.2 | 104.5 | |
| Diameter - inches | 2.01 | 2.02 | 2.00 | |
| Height - inches | 3.97 | 4.01 | 4.01 | |
| AT TEST | | | | |
| Final Moisture - % | 26.5 | 24.8 | 24.2 | |
| Dry Density - pcf | 99.5 | 103.0 | 105.7 | |
| Calculated Diameter (in.) | 2.01 | 2.02 | 2.00 | |
| Height - inches | 3.99 | 4.01 | 4.03 | |
| Effect. Cell Pressure - psi | 10.0 | 20.0 | 40.0 | |
| Failure Stress - psi | 12.64 | 23.13 | 24.50 | |
| Total Pore Pressure - psi | 55.7 | 58.4 | 79.8 | |
| Strain Rate - inches/min. | 0.00050 | 0.00050 | 0.00050 | |
| Failure Strain - % | 1.0 | 1.8 | 6.1 | |
| $\sigma_1$ Failure - psi | 22.64 | 43.13 | 64.50 | |
| $\sigma_3$ Failure - psi | 10.00 | 20.00 | 40.00 | |

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP
SAMPLE TYPE: Shelby Tube Sample
DESCRIPTION: Gray, Brown & Tan Fat Clay w/ Ferric Seams
Sampled on Site, B-5 8' to 10' deep
ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve
LL: PL: PI: Percent -200:
REMARKS: Diameter and Both Ends Trimmed + # 4 Sieve

## PROJECT INFORMATION

PROJECT: AEP Welsh Power Plant Bottom Ash Ponds
LOCATION: Pittsburg, Texas
PROJECT NO: G 3242 - 095
CLIENT:
December 2009

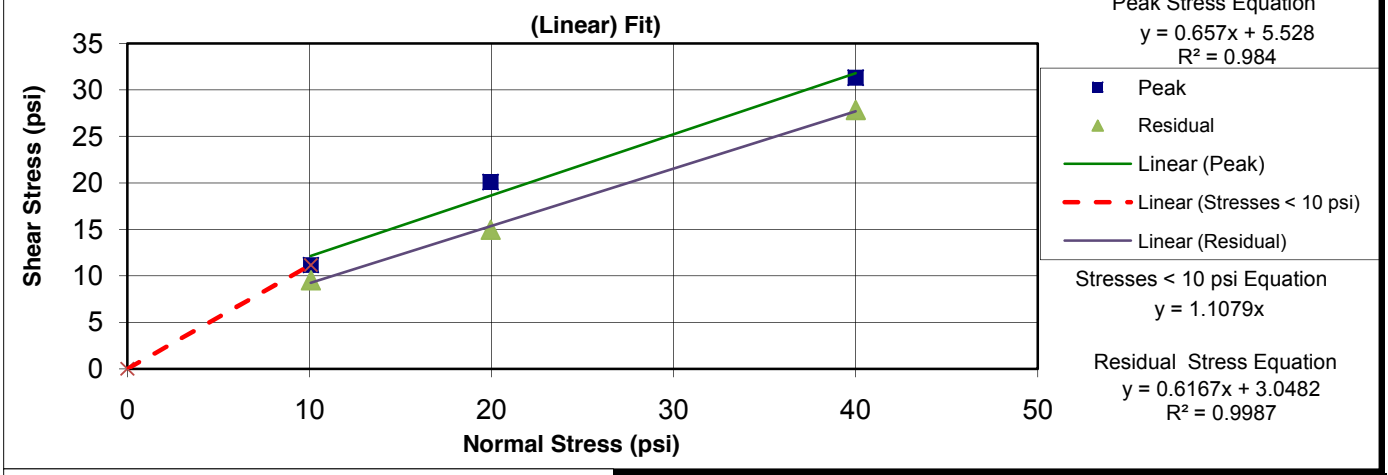
**ETTL ENGINEERS & CONSULTANTS**

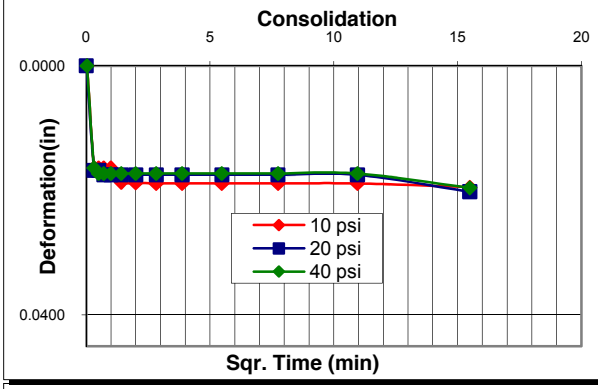
PLATE: B.3

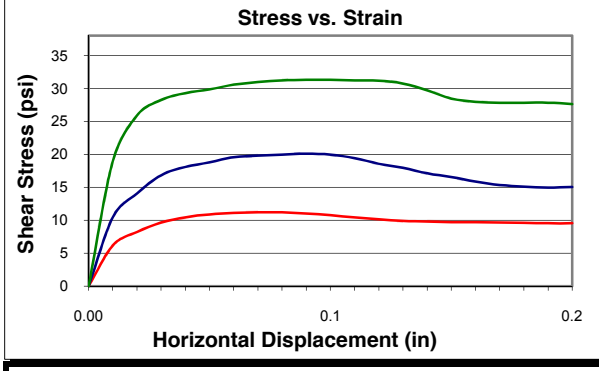
# ETTL Engineers & Consultants Inc.

GEOTECHNICAL ✶ MATERIALS ✶ ENVIRONMENTAL ✶ DRILLING ✶ LANDFILLS


## ASTM 3080 Direct Shear Test Report




## Peak Strength Parameters

| | Peak | | Residual | |
|---|---|---|---|---|
| Friction Angle | 33.3 (deg) | | 31.63 (deg) | |
| Cohesion | 5.53 (psi) | 796.0 (psf) | 3.05 (psi) | 438.9 (psf) |
| Friction Angle Stresses < 10psi | | | 47.91 | (deg) |
| Specimen Number | | 1 | 2 | 3 |
| **Initial** | | | | |
| Moisture Content - % | | 22.5% | 23.5% | 23.2% |
| Dry Density- lb/ft$^3$ | | 103.8 | 100.3 | 101.8 |
| Height-inches | | 1.008 | 1.008 | 1.008 |
| Diameter- inches | | 2.50 | 2.50 | 2.50 |
| **Final** | | | | |
| Moisture Content - % | | 23.1% | 25.4% | 23.5% |
| Dry Density- lb/ft$^3$ | | 103.8 | 100.9 | 102.0 |
| Height after shear-(inches) | | 1.009 | 1.006 | 1.006 |
| Height after consolidation (inches) | | 0.989 | 0.988 | 0.988 |
| Normal Stress-(psi) | | 10 | 20 | 40 |
| Peak Failure Stress-(psi) | | 11.17 | 20.09 | 31.31 |
| Residual Failure Stress-(psi) | | 9.52 | 14.96 | 27.84 |
| Strain Rate - (inches/min) | | 0.0033 | 0.0033 | 0.0033 |

## Project Information

| | |
|---|---|
| **Project :** | Welsh power Plant Embankments |
| **Client:** | AEP |
| **Material Origin:** | , TX |
| **Material Description:** | Dark Red Silty Sand |

| LL | PL | PI |
|---|---|---|
| - | - | NP |
| -200% | 18 | |

| | | | |
|---|---|---|---|
| **Job No:** | G 3241-095 | **Technician:** | Owen Sanderson |
| **Boring No:** | B-6 | **Sample Type:** | Shelby Tube |
| **Depth:** | 28'-31' | **Sampling method:** | Shelby Tube |
| **Date:** | November 24, 2009 | **Testing Device:** | Soiltest B-124BY 2.5 in. round |

**Remarks**

When Calculating stresses < 10 psi: use appropriate Equation above (assuming no Cohesion)

C. Brandon Quinn, P.E.


210 Beech Street
Texarkana, AR 71854
870-772-0013 Phone
870-216-2413 Fax

**1717 East Erwin**
**Tyler, Texas 75702**
**903-595-4421 Phone**
**903-595-6113 Fax**
**www.ettlinc.com**

707 West Cotton Street
Longview, Texas 75604-5505
903-758-0915 Phone
903-758-8245 Fax

# ETTL Engineers & Consultants Inc.

GEOTECHNICAL ✶ MATERIALS ✶ ENVIRONMENTAL ✶ DRILLING ✶ LANDFILLS

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

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Project : | AEP Welsh Power Plant Bottom Ash Ponds: Pittsburg, Texas | | | | | | | |
| Date: | 12/28/2009 | Panel Number : P-3 ; ASTM D 5084 | | | | | | |
| Project No. : | G 3242-095 | Permometer Data | | | | | | |
| Boring No.: | B-2 | $a_p$ = | 0.031416 | $cm^2$ | Set Mercury to Pipet Rp at beginning | Equilibrium | 1.7 | $cm^3$ |
| Sample: | | $a_a$ = | 0.767120 | $cm^2$ | | Pipet **Rp** | **6.7** | $cm^3$ |
| Depth (ft): | 13'-15' | $M_1$ = | 0.030180 | C = 0.000444308 | | Annulus **Ra** | 1.5 | $cm^3$ |
| Other Location: | | $M_2$ = | 1.040953 | T = 0.201660671 | | | | |
| Material Description : | Red & Tan Sandy Lean Clay | | | | | | | |

### SAMPLE DATA

| | | | | | Before Test | | After Test | |
|---|---|---|---|---|---|---|---|---|
| Wet Wt. sample + ring or tare : | | | 602.32 | g | | | | |
| Tare or ring Wt. : | | | 0.0 | g | Tare No.: | T-16 | Tare No.: | T-1 |
| Wet Wt: of Sample : | | | 602.32 | g | Wet Wt.+tare: | 292.51 | Wet Wt.+tare: | 746.56 |
| Diameter : | 2.73 | in | 6.94 | $cm^2$ | Dry Wt.+tare: | 276.22 | Dry Wt.+tare: | 683.49 |
| Length : | 2.76 | in | 7.02 | cm | Tare Wt: | 151.95 | Tare Wt: | 217.27 |
| Area: | 5.87 | in^2 | 37.85 | $cm^2$ | Dry Wt.: | 124.27 | Dry Wt.: | 466.22 |
| Volume : | 16.21 | in^3 | 265.71 | $cm^3$ | Water Wt.: | 16.29 | Water Wt.: | 63.07 |
| Unit Wt.(wet): | **141.45** | pcf | **2.27** | $g/cm^{\wedge 3}$ | % moist.: | **13.1** | % moist.: | **13.5** |
| Unit Wt.(dry): | **125.06** | pcf | **2.00** | $g/cm^{\wedge 3}$ | | | | |

Assumed Specific Gravity: **2.65** Max Dry Density(pcf) = 125.1105 OMC = 13.108554

% of max = 100.0 +/- OMC = 0.00

Calculated % saturation: 111.02 Void ratio (e) = **0.32** Porosity (n)= **0.24**

### TEST READINGS

$Z_1$(Mercury Height Difference @ $t_1$): 5.2 cm Hydraulic Gradient = 9.26

| Date | elapsed t (seconds) | Z (pipet @ t) | ΔZp (cm ) | temp (deg C) | α (temp corr) | k (cm/sec) | k (ft./day) | Reset = * |
|---|---|---|---|---|---|---|---|---|
| 12/28/2009 | 1680 | 6 | 0.6588251 | 23.5 | 0.920 | 3.47E-08 | 9.84E-05 | |
| 12/28/2009 | 2280 | 5.9 | 0.7588251 | 23.5 | 0.920 | 2.98E-08 | 8.44E-05 | |
| 12/28/2009 | 3180 | 5.7 | 0.9588251 | 23.5 | 0.920 | 2.76E-08 | 7.83E-05 | |
| 12/28/2009 | 4140 | 5.55 | 1.1088251 | 23.5 | 0.920 | 2.50E-08 | 7.09E-05 | |

### SUMMARY

$k_a$ = 2.93E-08 cm/sec Acceptance criteria = 25 %

| ki | | Vm | |
|---|---|---|---|
| k1 = | 3.47E-08 cm/sec | 18.5 | % |
| k2 = | 2.98E-08 cm/sec | 1.7 | % |
| k3 = | 2.76E-08 cm/sec | 5.6 | % |
| k4 = | 2.50E-08 cm/sec | 14.6 | % |

$Vm = \frac{|ka-ki|}{ka} \times 100$

| | | | | | |
|---|---|---|---|---|---|
| Hydraulic conductivity | k = | **2.93E-08** | cm/sec | **8.30E-05** | ft/day |
| Void Ratio | e = | **0.32** | | | |
| Porosity | n = | **0.24** | | | |
| Bulk Density | γ = | **2.27** | $g/cm^3$ | **141.5** | pcf |
| Water Content | W = | **0.26** | $cm^3/cm^3$ | ( at 20 deg C) | |
| Intrinsic Permeability | $k_{int}$ = | **3.00E-13** | $cm^2$ | ( at 20 deg C) | |

Robert Duke, P.E.


210 Beech Street
Texarkana, AR 71854
870-772-0013 Phone
870-216-2413 Fax

**1717 East Erwin**
**Tyler, Texas 75702**
**903-595-4421 Phone**
**903-595-6113 Fax**
**www.ettlinc.com**

707 West Cotton Street
Longview, Texas 75604-5505
903-758-0915 Phone
903-758-8245 Fax

# ETTL Engineers & Consultants Inc.

GEOTECHNICAL ✶ MATERIALS ✶ ENVIRONMENTAL ✶ DRILLING ✶ LANDFILLS

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

Project : AEP Welsh Power Plant Bottom Ash Ponds: Pittsburg, Texas
Date: 12/28/2009 Panel Number : P-3 ; ASTM D 5084
Project No. : G 3242-095 Permometer Data
Boring No.: B-2 $a_p$ = 0.031416 $cm^2$ **Set Mercury to Pipet Rp at beginning** Equilibrium 1.7 $cm^3$
Sample: $a_a$ = 0.767120 $cm^2$ Pipet **Rp** **6.7** $cm^3$
Depth (ft): 33'-35' $M_1$ = 0.030180 C = 0.000433922 Annulus **Ra** 1.5 $cm^3$
Other Location: $M_2$ = 1.040953 T = 0.201660671
Material Description : Red & Tan Clayey Sand

### SAMPLE DATA

| | | | | | Before Test | | After Test | |
|---|---|---|---|---|---|---|---|---|
| Wet Wt. sample + ring or tare : | | | 553.04 | g | | | | |
| Tare or ring Wt. : | | | 0.0 | g | Tare No.: | T-21 | Tare No.: | T-13 |
| Wet Wt: of Sample : | | | 553.04 | g | Wet Wt.+tare: | 553.04 | Wet Wt.+tare: | 784.01 |
| Diameter : | 2.76 | in | 7.01 | $cm^2$ | Dry Wt.+tare: | 464.50 | Dry Wt.+tare: | 684.19 |
| Length : | 2.75 | in | 6.98 | cm | Tare Wt: | 0.00 | Tare Wt: | 219.69 |
| Area: | 5.97 | in^2 | 38.54 | $cm^2$ | Dry Wt.: | 464.5 | Dry Wt.: | 464.5 |
| Volume : | 16.42 | in^3 | 269.13 | $cm^3$ | Water Wt.: | 88.54 | Water Wt.: | 99.82 |
| Unit Wt.(wet): | **128.23** | pcf | **2.05** | $g/cm^{\wedge 3}$ | % moist.: | **19.1** | % moist.: | **21.5** |
| Unit Wt.(dry): | **107.70** | pcf | **1.73** | $g/cm^{\wedge 3}$ | | | | |

Assumed Specific Gravity: **2.73** Max Dry Density(pcf) = 107.7462 OMC = 19.0613563
% of max = 100.0 +/- OMC = 0.00
Calculated % saturation: 100.72 Void ratio (e) = **0.58** Porosity (n)= **0.37**

### TEST READINGS

$Z_1$(Mercury Height Difference @ $t_1$): 5.2 cm Hydraulic Gradient = 9.31

| Date | elapsed t (seconds) | Z (pipet @ t) | ΔZp (cm ) | temp (deg C) | α (temp corr) | k (cm/sec) | k (ft./day) | Reset = * |
|---|---|---|---|---|---|---|---|---|
| 12/28/2009 | 1580 | 5.4 | 1.2588251 | 23.5 | 0.920 | 7.40E-08 | 2.10E-04 | |
| 12/28/2009 | 2310 | 5 | 1.6588251 | 23.5 | 0.920 | 7.04E-08 | 2.00E-04 | |
| 12/28/2009 | 2535 | 4.9 | 1.7588251 | 23.5 | 0.920 | 6.90E-08 | 1.96E-04 | |
| 12/28/2009 | 2775 | 4.8 | 1.8588251 | 23.5 | 0.920 | 6.76E-08 | 1.92E-04 | |

### SUMMARY

| | | | | | | |
|---|---|---|---|---|---|---|
| $k_a$ = | 7.03E-08 | cm/sec | | Acceptance criteria = | 25 | % |
| ki | | | Vm | | | |
| k1 = | 7.40E-08 | cm/sec | 5.3 | % | Vm = $\frac{\lvert ka-ki \rvert}{ka} \times 100$ | |
| k2 = | 7.04E-08 | cm/sec | 0.2 | % | | |
| k3 = | 6.90E-08 | cm/sec | 1.8 | % | | |
| k4 = | 6.76E-08 | cm/sec | 3.8 | % | | |

| | | | | | |
|---|---|---|---|---|---|
| Hydraulic conductivity | k = | **7.03E-08** | cm/sec | **1.99E-04** | ft/day |
| Void Ratio | e = | **0.58** | | | |
| Porosity | n = | **0.37** | | | |
| Bulk Density | γ = | **2.05** | $g/cm^3$ | **128.2** | pcf |
| Water Content | W = | **0.33** | $cm^3/cm^3$ | ( at 20 deg C) | |
| Intrinsic Permeability | $k_{int}$ = | **7.20E-13** | $cm^2$ | ( at 20 deg C) | |

Robert Duke, P.E.


210 Beech Street
Texarkana, AR 71854
870-772-0013 Phone
870-216-2413 Fax

**1717 East Erwin**
**Tyler, Texas 75702**
**903-595-4421 Phone**
**903-595-6113 Fax**
**www.ettlinc.com**

707 West Cotton Street
Longview, Texas 75604-5505
903-758-0915 Phone
903-758-8245 Fax

# ETTL Engineers & Consultants Inc.

GEOTECHNICAL ✶ MATERIALS ✶ ENVIRONMENTAL ✶ DRILLING ✶ LANDFILLS

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

Project : AEP Welsh Power Plant Bottom Ash Ponds: Pittsburg, Texas
Date: 12/28/2009 Panel Number : P-3 ; ASTM D 5084
Project No. : G 3242-095 Permometer Data

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Boring No.: | B-3 | $a_p$ = | 0.031416 | $cm^2$ | Set Mercury to Pipet Rp at beginning | Equilibrium | 1.7 | $cm^3$ |
| Sample: | | $a_a$ = | 0.767120 | $cm^2$ | | Pipet **Rp** | **6.7** | $cm^3$ |
| Depth (ft): | 8'-10' | $M_1$ = | 0.030180 | C = 0.000431052 | | Annulus **Ra** | 1.5 | $cm^3$ |
| Other Location: | | $M_2$ = | 1.040953 | T = 0.201660671 | | | | |

Material Description : Red & Tan Fat Clay

### SAMPLE DATA

| | | | | | Before Test | | After Test | |
|---|---|---|---|---|---|---|---|---|
| Wet Wt. sample + ring or tare : | | | 559.11 | g | | | | |
| Tare or ring Wt. : | | | 0.0 | g | Tare No.: | T-23 | Tare No.: | T-3 |
| Wet Wt: of Sample : | | | 559.11 | g | Wet Wt.+tare: | 166.09 | Wet Wt.+tare: | 783.53 |
| Diameter : | 2.75 | in | 6.99 | $cm^2$ | Dry Wt.+tare: | 162.69 | Dry Wt.+tare: | 700.67 |
| Length : | 2.72 | in | 6.90 | cm | Tare Wt: | 140.30 | Tare Wt: | 220.71 |
| Area: | 5.94 | in^2 | 38.32 | $cm^2$ | Dry Wt.: | 22.39 | Dry Wt.: | 479.96 |
| Volume : | 16.13 | in^3 | 264.26 | $cm^3$ | Water Wt.: | 3.4 | Water Wt.: | 82.86 |
| Unit Wt.(wet): | **132.02** | pcf | **2.12** | $g/cm^{\wedge 3}$ | % moist.: | **15.2** | % moist.: | **17.3** |
| Unit Wt.(dry): | **114.62** | pcf | **1.84** | $g/cm^{\wedge 3}$ | | | | |

Assumed Specific Gravity: **2.68** Max Dry Density(pcf) = 114.6685 OMC = 15.1853506
% of max = 100.0 +/- OMC = 0.00
Calculated % saturation: 100.64 Void ratio (e) = **0.46** Porosity (n)= **0.31**

### TEST READINGS

$Z_1$(Mercury Height Difference @ $t_1$): 5.2 cm Hydraulic Gradient = 9.43

| Date | elapsed t (seconds) | Z (pipet @ t) | ΔZp (cm ) | temp (deg C) | α (temp corr) | k (cm/sec) | k (ft./day) | Reset = * |
|---|---|---|---|---|---|---|---|---|
| 12/28/2009 | 1476 | 5.4 | 1.258825 | 23.5 | 0.920 | 7.87E-08 | 2.23E-04 | |
| 12/28/2009 | 2205 | 5 | 1.658825 | 23.5 | 0.920 | 7.33E-08 | 2.08E-04 | |
| 12/28/2009 | 2370 | 4.9 | 1.758825 | 23.5 | 0.920 | 7.33E-08 | 2.08E-04 | |
| 12/28/2009 | 2580 | 4.8 | 1.858825 | 23.5 | 0.920 | 7.22E-08 | 2.05E-04 | |

### SUMMARY

| | | | | | |
|---|---|---|---|---|---|
| $k_a$ = | 7.44E-08 | cm/sec | | Acceptance criteria = | 25 % |
| ki | | | Vm | | |
| k1 = | 7.87E-08 | cm/sec | 5.8 | % | Vm = $\frac{\lvert ka-ki \rvert}{ka} \times 100$ |
| k2 = | 7.33E-08 | cm/sec | 1.5 | % | |
| k3 = | 7.33E-08 | cm/sec | 1.4 | % | |
| k4 = | 7.22E-08 | cm/sec | 2.9 | % | |

| | | | | | |
|---|---|---|---|---|---|
| Hydraulic conductivity | k = | **7.44E-08** | cm/sec | **2.11E-04** | ft/day |
| Void Ratio | e = | **0.46** | | | |
| Porosity | n = | **0.31** | | | |
| Bulk Density | γ = | **2.12** | $g/cm^3$ | **132.0** | pcf |
| Water Content | W = | **0.28** | $cm^3/cm^3$ | ( at 20 deg C) | |
| Intrinsic Permeability | $k_{int}$ = | **7.62E-13** | $cm^2$ | ( at 20 deg C) | |

Robert Duke, P.E.


210 Beech Street
Texarkana, AR 71854
870-772-0013 Phone
870-216-2413 Fax

**1717 East Erwin**
**Tyler, Texas 75702**
**903-595-4421 Phone**
**903-595-6113 Fax**
**www.ettlinc.com**

707 West Cotton Street
Longview, Texas 75604-5505
903-758-0915 Phone
903-758-8245 Fax

# ETTL Engineers & Consultants Inc.

GEOTECHNICAL ✶ MATERIALS ✶ ENVIRONMENTAL ✶ DRILLING ✶ LANDFILLS

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

Project : AEP Welsh Power Plant Bottom Ash Ponds: Pittsburg, Texas
Date: 12/28/2009 Panel Number : P-3 ; ASTM D 5084
Project No. : G 3242-095 Permometer Data
Boring No.: B-4 $a_p$ = 0.031416 $cm^2$ Set Mercury to Pipet Rp at beginning Equilibrium 1.7 $cm^3$
Sample: $a_a$ = 0.767120 $cm^2$ Pipet **Rp** **6.7** $cm^3$
Depth (ft): 8'-10' $M_1$ = 0.030180 C = 0.000429664 Annulus **Ra** 1.5 $cm^3$
Other Location: $M_2$ = 1.040953 T = 0.201660671
Material Description : Dark Brown Sandy Lean Clay

### SAMPLE DATA

| | | | | | Before Test | | After Test | |
|---|---|---|---|---|---|---|---|---|
| Wet Wt. sample + ring or tare : | | | 531.96 | g | Tare No.: | T-24 | Tare No.: | T-6 |
| Tare or ring Wt. : | | | 0.0 | g | Wet Wt.+tare: | 230.01 | Wet Wt.+tare: | 759.40 |
| Wet Wt: of Sample : | | | 531.96 | g | Dry Wt.+tare: | 207.52 | Dry Wt.+tare: | 648.84 |
| Diameter : | 2.76 | in | 7.01 | $cm^2$ | Tare Wt: | 112.35 | Tare Wt: | 217.34 |
| Length : | 2.72 | in | 6.92 | cm | Dry Wt.: | 95.17 | Dry Wt.: | 431.5 |
| Area: | 5.98 | in^2 | 38.57 | $cm^2$ | Water Wt.: | 22.49 | Water Wt.: | 110.56 |
| Volume : | 16.29 | in^3 | 266.87 | $cm^3$ | % moist.: | **23.6** | % moist.: | **25.6** |
| Unit Wt.(wet): | **124.38** | pcf | **1.99** | g/cm^3 | | | | |
| Unit Wt.(dry): | **100.61** | pcf | **1.61** | g/cm^3 | | | | |

Assumed Specific Gravity: **2.72** Max Dry Density(pcf) = 100.6512 OMC = 23.6313964
% of max = 100.0 +/- OMC = 0.00
Calculated % saturation: 101.32 Void ratio (e) = **0.69** Porosity (n)= **0.41**

### TEST READINGS

$Z_1$(Mercury Height Difference @ $t_1$): 5.2 cm Hydraulic Gradient = 9.40

| Date | elapsed t (seconds) | Z (pipet @ t) | ΔZp (cm ) | temp (deg C) | α (temp corr) | k (cm/sec) | k (ft./day) | Reset = * |
|---|---|---|---|---|---|---|---|---|
| 12/28/2009 | 2280 | 6.1 | 0.558825 | 23.5 | 0.920 | 2.07E-08 | 5.88E-05 | |
| 12/28/2009 | 2940 | 6 | 0.658825 | 23.5 | 0.920 | 1.92E-08 | 5.44E-05 | |
| 12/28/2009 | 3660 | 5.9 | 0.758825 | 23.5 | 0.920 | 1.79E-08 | 5.09E-05 | |
| 12/28/2009 | 4200 | 5.84 | 0.818825 | 23.5 | 0.920 | 1.70E-08 | 4.82E-05 | |

### SUMMARY

$k_a$ = 1.87E-08 cm/sec Acceptance criteria = 25 %

| ki | | Vm | |
|---|---|---|---|
| k1 = | 2.07E-08 cm/sec | 10.8 | % |
| k2 = | 1.92E-08 cm/sec | 2.5 | % |
| k3 = | 1.79E-08 cm/sec | 4.1 | % |
| k4 = | 1.70E-08 cm/sec | 9.2 | % |

$Vm = \frac{|ka-ki|}{ka} \times 100$

| | | | | | |
|---|---|---|---|---|---|
| Hydraulic conductivity | k = | **1.87E-08** | cm/sec | **5.30E-05** | ft/day |
| Void Ratio | e = | **0.69** | | | |
| Porosity | n = | **0.41** | | | |
| Bulk Density | γ = | **1.99** | $g/cm^3$ | **124.4** | pcf |
| Water Content | W = | **0.38** | $cm^3/cm^3$ | ( at 20 deg C) | |
| Intrinsic Permeability | $k_{int}$ = | **1.92E-13** | $cm^2$ | ( at 20 deg C) | |

Robert Duke, P.E.


210 Beech Street
Texarkana, AR 71854
870-772-0013 Phone
870-216-2413 Fax

**1717 East Erwin**
**Tyler, Texas 75702**
**903-595-4421 Phone**
**903-595-6113 Fax**
**www.ettlinc.com**

707 West Cotton Street
Longview, Texas 75604-5505
903-758-0915 Phone
903-758-8245 Fax

# ETTL Engineers & Consultants Inc.

GEOTECHNICAL ✶ MATERIALS ✶ ENVIRONMENTAL ✶ DRILLING ✶ LANDFILLS

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

Project : AEP Welsh Power Plant Bottom Ash Ponds: Pittsburg, Texas
Date: 12/28/2009 Panel Number : P-3 ; ASTM D 5084
Project No. : G 3242-095 Permometer Data
Boring No.: B-5 $a_p$ = 0.031416 $cm^2$ **Set Mercury to Pipet Rp at beginning** Equilibrium 1.7 $cm^3$
Sample: $a_a$ = 0.767120 $cm^2$ Pipet **Rp** **6.7** $cm^3$
Depth (ft): 23'-25' $M_1$ = 0.030180 C = 0.00043565 Annulus **Ra** 1.5 $cm^3$
Other Location: $M_2$ = 1.040953 T = 0.201660671
Material Description : Orangish Tan Fat Clay

### SAMPLE DATA

| | | | | | Before Test | | After Test | |
|---|---|---|---|---|---|---|---|---|
| Wet Wt. sample + ring or tare : | | | 532.37 | g | | | | |
| Tare or ring Wt. : | | | 0.0 | g | Tare No.: | T-25 | Tare No.: | T-9 |
| Wet Wt: of Sample : | | | 532.37 | g | Wet Wt.+tare: | 532.37 | Wet Wt.+tare: | 765.78 |
| Diameter : | 2.74 | in | 6.97 | $cm^2$ | Dry Wt.+tare: | 441.00 | Dry Wt.+tare: | 661.51 |
| Length : | 2.73 | in | 6.94 | cm | Tare Wt: | 0.00 | Tare Wt: | 220.51 |
| Area: | 5.91 | in^2 | 38.15 | $cm^2$ | Dry Wt.: | 441 | Dry Wt.: | 441 |
| Volume : | 16.16 | in^3 | 264.75 | $cm^3$ | Water Wt.: | 91.37 | Water Wt.: | 104.27 |
| Unit Wt.(wet): | **125.48** | pcf | **2.01** | g/cm^3 | % moist.: | **20.7** | % moist.: | **23.6** |
| Unit Wt.(dry): | **103.94** | pcf | **1.67** | g/cm^3 | | | | |

Assumed Specific Gravity: **2.72** Max Dry Density(pcf) = 103.9846 OMC = 20.7188209
% of max = 100.0 +/- OMC = 0.00
Calculated % saturation: 101.48 Void ratio (e) = **0.63** Porosity (n)= **0.39**

### TEST READINGS

$Z_1$(Mercury Height Difference @ $t_1$): 5.2 cm Hydraulic Gradient = 9.37

| Date | elapsed t (seconds) | Z (pipet @ t) | ΔZp (cm ) | temp (deg C) | α (temp corr) | k (cm/sec) | k (ft./day) | Reset = * |
|---|---|---|---|---|---|---|---|---|
| 12/28/2009 | 212 | 5.5 | 1.158825 | 23.5 | 0.920 | 5.03E-07 | 1.43E-03 | |
| 12/28/2009 | 237 | 5.4 | 1.258825 | 23.5 | 0.920 | 4.95E-07 | 1.40E-03 | |
| 12/28/2009 | 259 | 5.3 | 1.358825 | 23.5 | 0.920 | 4.96E-07 | 1.41E-03 | |
| 12/28/2009 | 289 | 5.2 | 1.458825 | 23.5 | 0.920 | 4.83E-07 | 1.37E-03 | |

### SUMMARY

$k_a$ = 4.95E-07 cm/sec Acceptance criteria = 25 %

| ki | | Vm |
|---|---|---|
| k1 = | 5.03E-07 cm/sec | 1.8 % |
| k2 = | 4.95E-07 cm/sec | 0.2 % |
| k3 = | 4.96E-07 cm/sec | 0.3 % |
| k4 = | 4.83E-07 cm/sec | 2.2 % |

$$Vm = \frac{|ka - ki|}{ka} \times 100$$

| | | | | | |
|---|---|---|---|---|---|
| Hydraulic conductivity | k = | **4.95E-07** | cm/sec | **1.40E-03** | ft/day |
| Void Ratio | e = | **0.63** | | | |
| Porosity | n = | **0.39** | | | |
| Bulk Density | γ = | **2.01** | $g/cm^3$ | **125.5** | pcf |
| Water Content | W = | **0.35** | $cm^3/cm^3$ | ( at 20 deg C) | |
| Intrinsic Permeability | $k_{int}$ = | **5.07E-12** | $cm^2$ | ( at 20 deg C) | |

Robert Duke, P.E.


210 Beech Street
Texarkana, AR 71854
870-772-0013 Phone
870-216-2413 Fax

**1717 East Erwin**
**Tyler, Texas 75702**
**903-595-4421 Phone**
**903-595-6113 Fax**
**www.ettlinc.com**

707 West Cotton Street
Longview, Texas 75604-5505
903-758-0915 Phone
903-758-8245 Fax

# ETTL Engineers & Consultants Inc.

GEOTECHNICAL ✶ MATERIALS ✶ ENVIRONMENTAL ✶ DRILLING ✶ LANDFILLS

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

Project : AEP Welsh Power Plant Bottom Ash Ponds: Pittsburg, Texas
Date: 12/28/2009 Panel Number : P-3 ; ASTM D 5084
Project No. : G 3242-095 Permometer Data

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Boring No.: | B-6 | $a_p$ = | 0.031416 | $cm^2$ | Set Mercury to Pipet Rp at beginning | Equilibrium | 1.7 | $cm^3$ |
| Sample: | | $a_a$ = | 0.767120 | $cm^2$ | | Pipet **Rp** | **6.7** | $cm^3$ |
| Depth (ft): | 28'-30' | $M_1$ = | 0.030180 | C = 0.000408156 | | Annulus **Ra** | 1.5 | $cm^3$ |
| Other Location: | | $M_2$ = | 1.040953 | T = 0.201660671 | | | | |

Material Description : Gray Silty Sand

### SAMPLE DATA

| | | | | | Before Test | | After Test | |
|---|---|---|---|---|---|---|---|---|
| Wet Wt. sample + ring or tare : | | | 457.40 | g | Tare No.: | T-5 | Tare No.: | T-10 |
| Tare or ring Wt. : | | | 0.0 | g | Wet Wt.+tare: | 355.86 | Wet Wt.+tare: | 661.49 |
| Wet Wt: of Sample : | | | 457.40 | g | Dry Wt.+tare: | 328.36 | Dry Wt.+tare: | 581.76 |
| Diameter : | 2.69 | in | 6.83 | $cm^2$ | Tare Wt: | 218.80 | Tare Wt: | 221.13 |
| Length : | 2.46 | in | 6.24 | cm | Dry Wt.: | 109.56 | Dry Wt.: | 360.63 |
| Area: | 5.68 | in^2 | 36.64 | $cm^2$ | Water Wt.: | 27.5 | Water Wt.: | 79.73 |
| Volume : | 13.96 | in^3 | 228.75 | $cm^3$ | % moist.: | **25.1** | % moist.: | **22.1** |
| Unit Wt.(wet): | **124.77** | pcf | **2.00** | $g/cm^{\wedge 3}$ | | | | |
| Unit Wt.(dry): | **99.74** | pcf | **1.60** | $g/cm^{\wedge 3}$ | | | | |

Assumed Specific Gravity: **2.55** Max Dry Density(pcf) = 99.78226 OMC = 25.1004016
% of max = 100.0 +/- OMC = 0.00
Calculated % saturation: 94.57 Void ratio (e) = **0.60** Porosity (n)= **0.37**

### TEST READINGS

$Z_1$(Mercury Height Difference @ $t_1$): 5.2 cm Hydraulic Gradient = 10.42

| Date | elapsed t (seconds) | Z (pipet @ t) | ΔZp (cm ) | temp (deg C) | α (temp corr) | k (cm/sec) | k (ft./day) | Reset = * |
|---|---|---|---|---|---|---|---|---|
| 12/28/2009 | 7 | 4 | 2.658825 | 23.5 | 0.920 | 4.12E-05 | 1.17E-01 | |
| 12/28/2009 | 9 | 3.5 | 3.158825 | 23.5 | 0.920 | 4.23E-05 | 1.20E-01 | |
| 12/28/2009 | 11 | 3 | 3.658825 | 23.5 | 0.920 | 4.57E-05 | 1.30E-01 | |
| 12/28/2009 | 16 | 2.5 | 4.158825 | 23.5 | 0.920 | 4.28E-05 | 1.21E-01 | |

### SUMMARY

ka = 4.30E-05 cm/sec Acceptance criteria = 25 %

| ki | | Vm |
|---|---|---|
| k1 = | 4.12E-05 cm/sec | 4.2 % |
| k2 = | 4.23E-05 cm/sec | 1.7 % |
| k3 = | 4.57E-05 cm/sec | 6.3 % |
| k4 = | 4.28E-05 cm/sec | 0.4 % |

$Vm = \frac{|ka-ki|}{ka} \times 100$

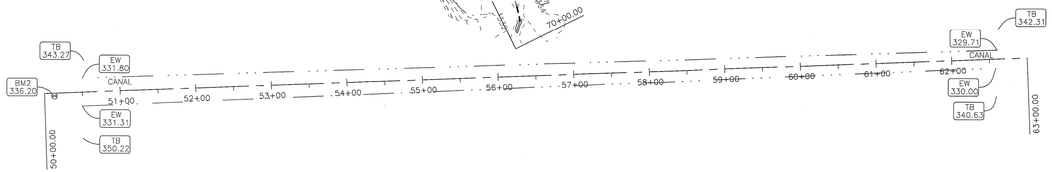
| | | | | | |
|---|---|---|---|---|---|
| Hydraulic conductivity | k = | **4.30E-05** | cm/sec | **1.22E-01** | ft/day |
| Void Ratio | e = | **0.60** | | | |
| Porosity | n = | **0.37** | | | |
| Bulk Density | γ = | **2.00** | $g/cm^3$ | **124.8** | pcf |
| Water Content | W = | **0.40** | $cm^3/cm^3$ | ( at 20 deg C) | |
| Intrinsic Permeability | $k_{int}$ = | **4.41E-10** | $cm^2$ | ( at 20 deg C) | |

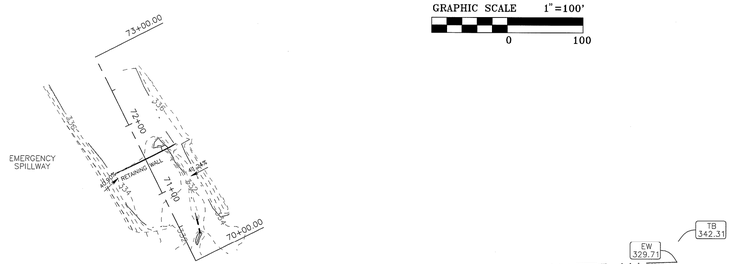
Robert Duke, P.E.


210 Beech Street
Texarkana, AR 71854
870-772-0013 Phone
870-216-2413 Fax

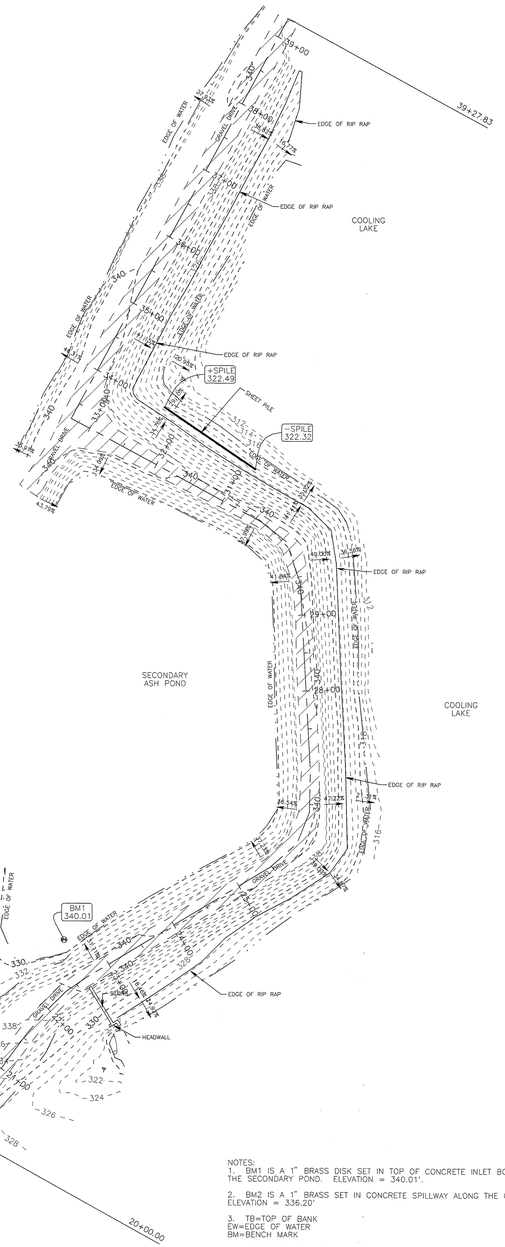
**1717 East Erwin**
**Tyler, Texas 75702**
**903-595-4421 Phone**
**903-595-6113 Fax**
**www.ettlinc.com**

707 West Cotton Street
Longview, Texas 75604-5505
903-758-0915 Phone
903-758-8245 Fax




GRAPHIC SCALE 1"=100'
0 100




NOTES:
1. BM1 IS A 1" BRASS DISK SET IN TOP OF CONCRETE INLET BOX FOR THE SECONDARY POND. ELEVATION = 340.01'.

2. BM2 IS A 1" BRASS SET IN CONCRETE SPILLWAY ALONG THE CANAL. ELEVATION = 336.20'

3. TB=TOP OF BANK
EW=EDGE OF WATER
BM=BENCH MARK

4. CONTOURS ARE ARE 2.0' APART.

5. LAKE ELEVATION PER WELSH POWER PLANT ON NOVEMBER 18, 2010 WAS 317.57 FEET MSL.

SURVEYOR CERTIFICATE:

I HEREBY CERTIFY THAT THIS TOPOGRAPHICAL SURVEY WAS MADE ON THE GROUND UNDER MY SUPERVISION ON NOVEMBER 18, 2010, THAT THIS PLAT (MAP OR DRAWING) REPRESENTS THE FACTS FOUND AT THE TIME.

MIKE GARDNER
REGISTERED PROFESSIONAL LAND SURVEYOR
NO. 5760, STATE OF TEXAS
FIRM CERTIFICATE NO. 101011-00
DATE: NOVEMBER 23, 2010
REVISED: DECEMBER 6, 2010

STATE OF TEXAS
MIKE GARDNER
#5760
PROFESSIONAL LAND SURVEYOR

# TOPOGRAPHIC SURVEY

DIKE'S AT WELSH POWER PLANT
FOR: GREG CARTER

| Date | Revision/Description |
|---|---|
| 12/8/10 | ADDED LAKE LEVEL NOTE |
| 12/6/10 | ADDED CROSS SECTION SHEETS |

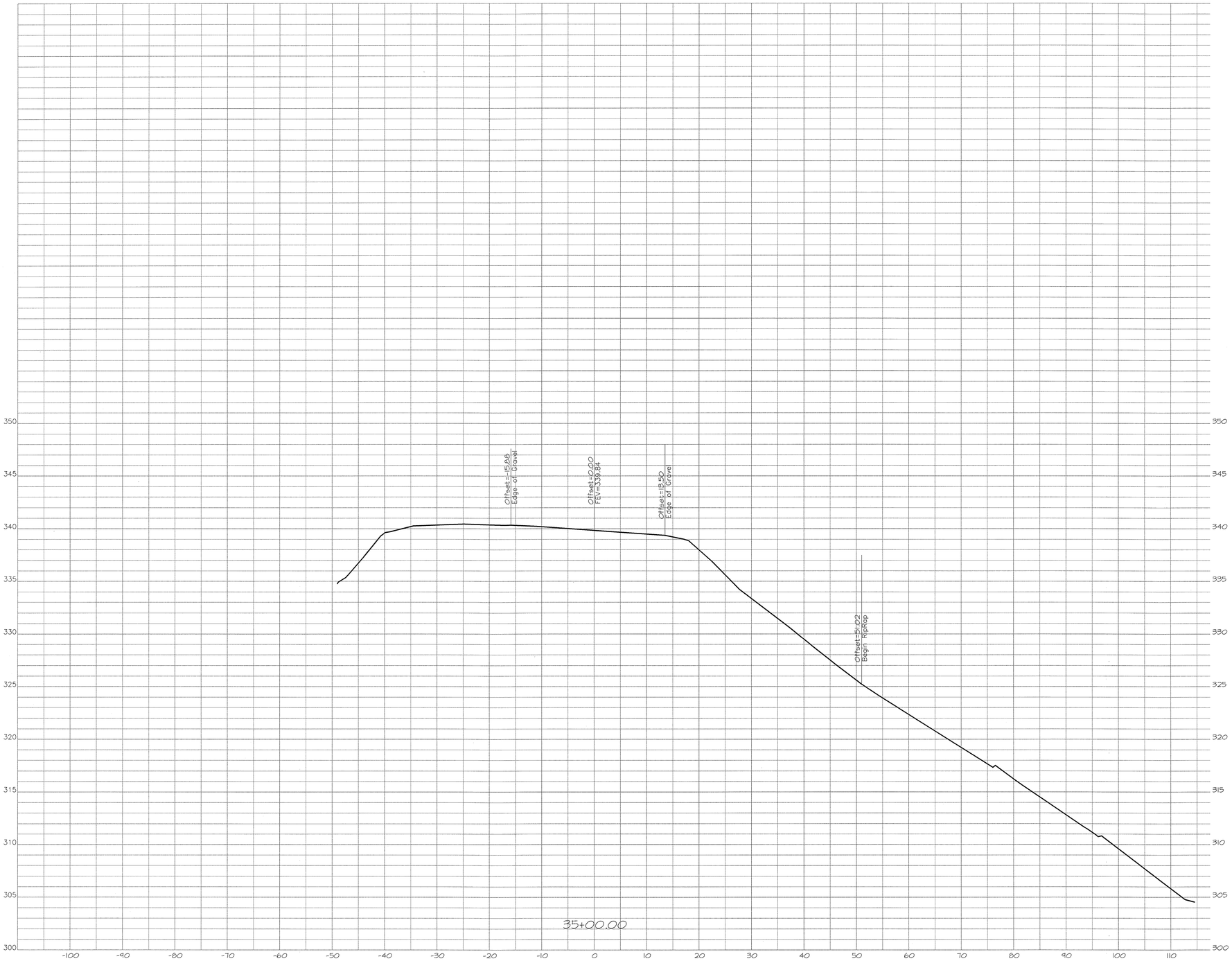
| Drawn By | Checked By | Project No. | Dwg. Date |
|---|---|---|---|
| MG | DW | 104021 | 11/19/10 |

File No. | Sheet No. 1

MTG engineers & surveyors
5930 SUMMERHILL RD. | P.O. BOX 3786
TEXARKANA TEXAS 75501
P 903.838.8533 | F 903.832.4700
www.mtgengineers.com

 TBPE NO. 354

HORIZONTAL SCALE - 1"=10'
VERTICAL SCALE - 1"=5'




SURVEYOR CERTIFICATE:

I HEREBY CERTIFY THAT THIS TOPOGRAPHICAL SURVEY WAS MADE ON THE GROUND UNDER MY SUPERVISION ON NOVEMBER 18, 2010, THAT THIS PLAT (MAP OR DRAWING) REPRESENTS THE FACTS FOUND AT THE TIME.

MIKE GARDNER
REGISTERED PROFESSIONAL LAND SURVEYOR
NO. 5760, STATE OF TEXAS
FIRM CERTIFICATE NO. 101011-00
DATE: NOVEMBER 23, 2010
REVISED: DECEMBER 6, 2010

STATE OF TEXAS
MIKE GARDNER
#5760
PROFESSIONAL LAND SURVEYOR

# CROSS SECTIONS ASH POND BERM

DIKE'S AT WELSH POWER PLANT
FOR: GREG CARTER

| Date | Revision/Description |
|---|---|
| | |
| | |
| | |

| Drawn By | Checked By | Project No. | Dwg. Date |
|---|---|---|---|
| J.B.D. | M.G. | 104021 | 12/6/2010 |

MTG engineers & surveyors
5430 SUMMERHILL RD. | P.O. BOX 3786
TEXARKANA, TEXAS 75501
P 903.838.8533 | F 903.832.4700
www.mtgengineers.com

 TBPE NO. 354

File No. | Sheet No. 5

X:\2010 Projects\104021 TOPO AT WELSH POWER PLANT DAMS\104021 REVISED 12-3-10 G.pro
Mon Dec 06 2010 11:24AM