REPORT

STRUCTURAL STABILITY ASSESSMENT REPORT

Big Brown Steam Electric Station

Submitted To: Luminant
1601 Bryan Street
Dallas, TX 75201

Submitted By: Golder Associates Inc.
500 Century Plaza Drive, Suite 190
Houston, TX 77073 USA

10/10/16

STATE OF TEXAS
JEFFREY B. FASSETT
85675
LICENSED
PROFESSIONAL ENGINEER

Professional Engineering Firm
Registration Number F-2578

October 2016 **Project No. 164816401**

Table of Contents

List of Figures

List of Appendices

1.0 INTRODUCTION

1.1 Purpose

The “Disposal of Coal Combustion Residuals (CCR) from Electric Utilities rule” (40 Code of Federal Regulations (40 CFR) Part 257), effective October 19, 2015, requires that existing CCR surface impoundments meeting the requirements of §257.73(b) conduct initial and periodic structural stability assessments in accordance with §257.73(d). This report provides the structural stability assessment for the Big Brown Steam Electric Station’s (BBSES’s) CCR Impoundment, identified as the North Bottom Ash Pond (NBAP) and South Bottom Ash Pond (SBAP) also referred to collectively as the Bottom Ash Ponds (BAP).

1.2 Site Background

The BBSES generates fly ash, bottom ash and boiler slag during electricity generation. The NBAP and SBAP are active, clay lined, excavated impoundments surrounded and separated by engineered earthen berms. Each pond receives a slurry of bottom ash/boiler slag and water and is used to separate the solids from the water using gravity sedimentation. Water decanted from the ponds is returned to the power plant. Separated solids accumulate in the ponds and are periodically removed and placed in an adjacent surface lignite mine operated by an affiliated Luminant company (Luminant Mining Company). This is the only CCR surface impoundment at the BBSES.

1.3 Previous Evaluations

Golder performed previous evaluations on the BAP as part of the below report submitted to Luminant:

- Ash Pond Slope Stability Investigation Report, Big Brown Power Plant, Freestone County, Texas, dated November 2012

This study found the pond slopes to be adequately stable.

2.0 SUBSURFACE CONDITIONS

2.1 Regional Geology

The BBSES site is located in the western part of the East Texas Basin along the edge of the East Texas Salt Structure Province. Surface geology comprises of the Wilcox formation – irregularly bedded fine to coarse sand, more or less lignitic clay or lignite. Other formations in the region include the Carrizo Sand, the Queen City Sand and Sparta Sand (Guyton & Associates, 1972; Galloway et al, 1983).

2.2 Site Geology

Surficial soils at BBSES consist of loamy, moderately permeable, gently to moderately sloping, well-drained soils. Underlying soils consist of randomly sorted strata containing shale, clayey, and sandy materials (USDA 2002). Despite the abrupt changes in dip, there is no evidence of faulting in the region of the BBSES site (ERM-Southwest Inc., 1986).

2.2.1 Subsurface Investigations and Laboratory Testing

Information from a previous subsurface investigation was used to characterize the subsurface site conditions. Golder conducted a subsurface investigation for the BAP in October 2012, as part of a slope stability evaluation. Golder completed six borings through the crest of the pond embankment at an elevation of approximately 350 feet – mean sea level, ft-msl. The boring depths ranged from 30 to 50 feet below ground surface (bgs) (Golder, 2012). Appendix A includes the boring location map and the boring logs.

Laboratory testing was performed on selected samples in accordance with commonly accepted methods and practices. Undisturbed and disturbed soil samples were tested to determine water content, Atterberg limits, grain size distribution, and shear strength. Water content determination was performed in accordance with ASTM D2216; Atterberg limits were determined in accordance with ASTM D4318; and grain size distribution was performed in accordance with ASTM D422. Shear strength testing consisted of unconsolidated-undrained (UU) and consolidated-undrained (CU) triaxial compression tests in general accordance with ASTM D2850 and D4767, respectively. Laboratory test summary sheets results are presented in Appendix B. The test results can be found in Appendix C.

The soils encountered in the borings generally consisted of very stiff to hard sandy clay and compact to very dense clayey sands. The subsurface stratigraphy generally consisted of clayey or silty sand with interspersed layers of sandy clay and lean clay. A thin layer of loose compact clayey sand was encountered in some boreholes at a depth of around 44 feet bgs.

Saturated soils were encountered in the embankment fill in only one of the six borings at a depth of 20 feet (i.e. at EL 330 ft-msl). Monitoring wells around the BAP indicate that the groundwater elevation is located between EL 309 to 313 ft-msl.

The findings from the above subsurface investigation were reviewed for their applicability to this study, and are summarized in the following sections.

3.0 STRUCTURAL STABILITY ASSESSMENT - §257.73(d)(1)(i)-(vii)

The CCR rules require conducting periodic structural stability assessments by a qualified professional engineer to document whether the design, construction, operation and maintenance is consistent with recognized and generally accepted good engineering practices for the maximum volume of CCR and CCR wastewater that can be impounded therein.

3.1 Foundations and Abutments - §257.73(d)(1)(i)

As noted above, the foundation soils consist of native soils and fill. The foundation soils and abutments are stable.

3.2 Slope Protection - §257.73(d)(1)(ii)

The downstream slope of the embankments in the BAP are protected from erosion and deterioration by the establishment of a vegetative cover. The vegetative cover is inspected weekly for erosion, signs of seepage, animal burrows, sloughing, and plants that could negatively impact the embankment.

3.3 Dikes (Embankment) - §257.73(d)(1)(iii)

The BAP embankment was constructed in 1989, of compacted site soils excavated from within the pond footprint. The BAP is divided into north and south ponds by an interior divided dike. No construction testing of the original embankment fill is available. Nevertheless, Golder's subsurface investigation in 2012 comprised boreholes drilled into the embankment. The embankment soils were generally found to be well-compacted and of sufficient density.

As part of several modifications to the BAP in 1999, a 3-foot thick compacted clay liner was constructed on the interior slopes. The construction drawings indicate that the compacted clay liner was specified to have a hydraulic conductivity of less than 1×10^{-7} cm/s. No significant repairs have been performed to the BAP embankment since its construction, except the addition of the clay liner in 1999.

Based on a review of past inspection reports and on recent observations, the embankment is sufficient to withstand the range of loading conditions they are subjected to.

3.4 Vegetated Slopes - §257.73(d)(1)(iv)

As of June 14, 2016, the US Court of Appeals for the District of Columbia Circuit issued an Order that remanded and vacated the CCR rule requirement that vegetation on the exterior portions of dikes on CCR surface impoundments be maintained not to exceed six inches in height. EPA will issue a new rulemaking in the future to address this issue.

Each of the surface impoundments at the BBSES are inspected weekly. Luminant maintains the vegetation in a manner that ensures adequate inspections can be conducted.

3.5 Spillways - §257.73(d)(1)(v)

There are no spillways on the BAP.

3.6 Hydraulic Structures - §257.73(d)(1)(vi)

Two pipes pass below the west embankment: a 30-in. diameter concrete pipe at the North BAP; and a 42-in. diameter concrete pipe at the South BAP. These pipes provide suction from the BAP to a pump station that returns the process water back to the generating units. These are the only pipes passing through the embankment and are the only outlets from the BAP. The pump station controls the recycling of the discharge back to the plant.

The BAP receives dewatering bin overflow through two sets of pipes entering above the crest of the pond on the east side. High density polyethylene (HDPE) pipes are located along the crest of the west side of the pond, and are used for moving liquid between the north and south BAPs with a mobile pump, during an emergency.

No significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, or debris were observed that may negatively affect the operation of the surface impoundment.

3.7 Downstream Slopes Adjacent to Water Body - §257.73(d)(1)(vii)

The BAP embankment is bordered to the south by a narrow water channel connected to Fairfield Lake (a man-made reservoir) (Figure 1). Based on visual observations, the water channel bank is located approximately 25 feet from the embankment toe and is sloped at approximately 3H:1V (horizontal to vertical). The bank height is estimated to be 20 to 30 feet from the bottom of the channel, based on TWDB, 1999.

The Fairfield Dam has a crest elevation of 322 ft-msl. The south toe of the BAP embankment is approximately 13 feet above the Fairfield Dam crest; therefore, the embankment will likely never be inundated and never subjected to rapid drawdown. Rapid drawdown within the adjacent channel could potentially affect the stability of the channel slopes. However, any slope failures would be shallow and unlikely to affect the BAP embankment.

3.8 Structural Stability Deficiencies - §257.73(d)(2)

No structural stability deficiencies were identified during this assessment.

4.0 CONCLUSION

Based on our review of the information provided by Luminant, on information prepared by Golder Associates Inc., and on our on-site observations, no structural stability deficiencies were identified in the surface impoundment during this assessment.

Golder appreciates the opportunity to assist Luminant with this project. If you have any questions, or require further assistance from Golder, please contact the undersigned at (281) 821-6868.

GOLDER ASSOCIATES INC.

Varenya Kumar
Staff Engineer

Jeffrey B. Fassett, PE
Associate Geotechnical Engineer

5.0 CERTIFICATION

I hereby certify that this report has been prepared in general accordance with normally accepted civil engineering practices and in accordance with the requirements of 40 CFR 257.73(d).

STATE OF TEXAS
JEFFREY B. FASSETT
85675
LICENSED PROFESSIONAL ENGINEER

10/10/16

Jeffrey B. Fassett, PE
Golder Associates Inc.
Firm Registration Number F-2578

6.0 REFERENCES

40 CFR Parts 257 and 261, 2015, Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule, April 17, 2015.

Galloway, W. E., Ewing, T. E., Garrett, C. M., Jr., Tyler, Noel, and Bebout, D. G., 1983, Atlas of major Texas oil reservoirs: The University of Texas at Austin, Bureau of Economic Geology Special Publication, 139 p.

Golder Associates Inc., 2012, Ash Pond Slope Stability Investigation Report, Big Brown Power Plant, Freestone County, Texas, November 2012.

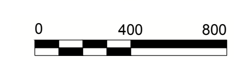
Guyton, W.F., and Associates, 1972, Ground-water conditions in Anderson, Cherokee, Freestone, and Henderson counties, Texas: TWDB Rept. 150, 80 p.

Texas Water Development Board., 1999, Volumetric Survey of Fairfield Lake – prepared for USACE, Fort Worth District; in conjunction with Sabine River Authority and TXU Electric Company.

REFERENCE(S)
AERIAL PHOTO SOURCED FROM GOOGLE EARTH PRO DATED 2014

JEFFREY B. FASSETT
85675
STATE OF TEXAS
LICENSED
PROFESSIONAL ENGINEER
10/10/16

Professional Engineering Firm
Registration Number F-2578



CLIENT LUMINANT POWER BIG BROWN	PROJECT 2016 COAL COMBUSTION RESIDUALS ENGINEERING SERVICES

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-09-19
DESIGNED	VK
PREPARED	TNB
REVIEWED	MX
APPROVED	JBF

TITLE
GENERAL SITE MAP

PROJECT NO.	REV.	FIGURE
1648164-01	----	1

Path: \\houston\drafting_2016\1648164\1648164014A001.dwg | File Name: 164816401A001.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
1 in

APPENDIX A
BORING LOCATION MAP & BORING LOGS

NOTE: Figure Reference - Golder Associates Inc., 2012, Ash Pond Slope Stability Investigation Report, Big Brown Power Plant, Freestone County, Texas, November 2012

J:_2012\123-94128 - Luminant_A - Ash Pond Slope Stability\12394128A001.dwg | Layout: ANSI_A_FIGURE_LANDSCAPE | Modified: HRolwing 11/21/2012 8:09 AM | Plotted: HRolwing 11/21/2012

LEGEND

● BH-1 BORING LOCATION

REFERENCES / SPECIFICATIONS

IMAGE SOURCE:
GOOGLE EARTH PRO. 2010

####	####	####	HPR	VJE	HPR	PCM
REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW

PROJECT

LUMINANT - BIG BROWN
ASH POND SLOPE STABILITY INVESTIGATION REPORT
FREESTONE COUNTY, TEXAS

TITLE

BORING LOCATION PLAN

Golder Associates

PROJECT No.	123-94128	FILE No.	12394128A001
		SCALE	NTS

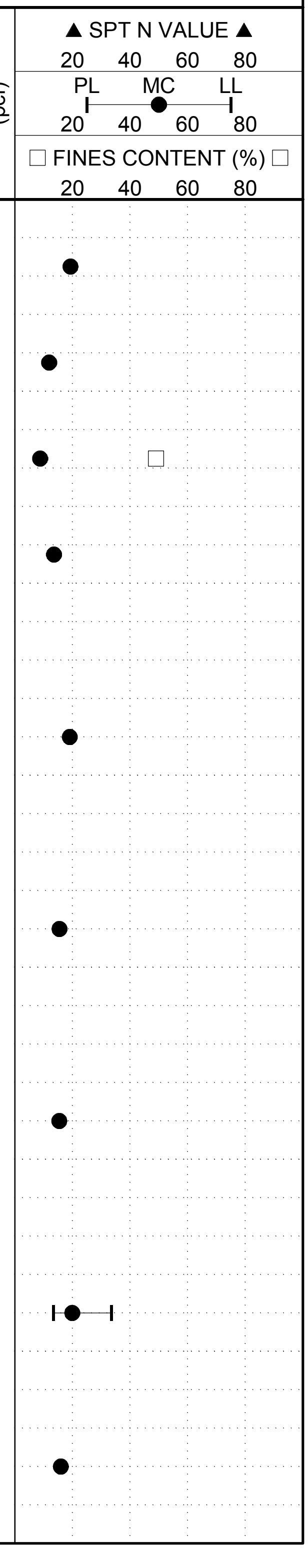
FIG-1

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

BORING NUMBER BH-1

CLIENT Luminant
PROJECT NAME Pond Slope Stability
PROJECT NUMBER 123-94128
PROJECT LOCATION Big Brown Plant
DATE STARTED 10/15/12 **COMPLETED** 10/15/12
GROUND ELEVATION **HOLE SIZE** inches
DRILLING CONTRACTOR Van & Sons Drilling Service
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING ---
LOGGED BY HR **CHECKED BY** PCM
AT END OF DRILLING ---
NOTES
AFTER DRILLING 20.00 ft

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
0		(SC) CLAYEY SAND, medium to fine, well graded, light brown, and low plasticity clay, moist	SH 1	78		3.0	
5		sandy clay lenses, dry at 3.5'	SH 2			4.9	
		no clay lenses at 6.0'	SH 3	78		4.5	
10		(CL) LEAN CLAY, low plasticity, with sand, brown-orange, cohesive, dry	SH 4			4.5	
15		(SC) CLAYEY SAND, medium to fine, well graded, brown to orange, and low plasticity clay, moist	SH 5	65			
20			SH 6	79		1.5	
25		gray at 23.0'	SH 7	83			
30		(CL) LEAN CLAY, low plasticity, some fine to medium sand, gray to brown, cohesive, moist	SH 8	79			
35			SH 9	83			



(Continued Next Page)

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

BORING NUMBER BH-1

CLIENT Luminant
PROJECT NAME Pond Slope Stability
PROJECT NUMBER 123-94128
PROJECT LOCATION Big Brown Plant

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / □ FINES CONTENT (%) □ 20 40 60 80
35		(CL) LEAN CLAY, low plasticity, some fine to medium sand, gray to brown, cohesive, moist *(continued)*						
		(SC) CLAYEY SAND, medium to fine, well graded, with low plasticity clay, brown, wet	SS 10	83	12-13-14 (27)			
40								
45			SS 11	100	5-5-3 (8)			
50			SS 12	100	8-9-11 (20)			

Bottom of borehole at 50.0 feet.

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

BORING NUMBER BH-2

CLIENT Luminant
PROJECT NAME Pond Slope Stability
PROJECT NUMBER 123-94128
PROJECT LOCATION Big Brown Plant
DATE STARTED 10/16/12 **COMPLETED** 10/16/12
GROUND ELEVATION **HOLE SIZE** inches
DRILLING CONTRACTOR Van & Sons Drilling Service
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING ---
LOGGED BY HR **CHECKED BY** PCM
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / ☐ FINES CONTENT (%) ☐ 20 40 60 80
0		(CL) LEAN CLAY, low plasticity, with sand and gravel, decreasing coarse content with depth, dry, gray and brown						
			SH 1	58		4.5		
5			SH 2	75		4.5		
		(SC) CLAYEY SAND, medium to fine, well graded, with low plasticity clay, brown, moist	SH 3	100		4.5		
10			SH 4	50		3.0		
15			SH 5	67		4.5		
20		decreasing clay with depth at 18.0'	SH 6	44		2.25		
25			SH 7	94		4.5		
30		gray and orange at 28.0'	SH 8	88		4.5		
35			SH 9	90		2.5		

(Continued Next Page)

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

BORING NUMBER BH-2

CLIENT Luminant
PROJECT NAME Pond Slope Stability
PROJECT NUMBER 123-94128
PROJECT LOCATION Big Brown Plant

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / □ FINES CONTENT (%) □ 20 40 60 80
35		(SC) CLAYEY SAND, medium to fine, well graded, with low plasticity clay, brown, moist *(continued)*						
40		wet at 38.5'	SS 10	56	15-18-20 (38)			
45			SS 11	100	3-3-5 (8)			
50			SS 12	100	18-18-17 (35)			

Bottom of borehole at 50.0 feet.

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

BORING NUMBER BH-3

CLIENT Luminant
PROJECT NAME Pond Slope Stability
PROJECT NUMBER 123-94128
PROJECT LOCATION Big Brown Plant
DATE STARTED 10/15/12 **COMPLETED** 10/15/12
GROUND ELEVATION **HOLE SIZE** inches
DRILLING CONTRACTOR Van & Sons Drilling Service
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING ---
LOGGED BY HR **CHECKED BY** PCM
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ / PL MC LL / □ FINES CONTENT (%) □ (20 40 60 80)
0		(SC) CLAYEY SAND, medium to fine, some gravel, brown, moist						
			SH 1	56		2.5		
		increasing clay content and clay lenses at 3.5'	SH 2	67		4.5		
5								
		(CL) LEAN CLAY, low plasticity, and well graded, medium to fine sand, light brown, moist	SH 3	72		4.5		
10			SH 4	89		4.5		
15			SH 5	81		4.5		
		(SC) CLAYEY SAND, medium to fine, brown, moist	SH 6	75		4.0		
20								
		(SP) SAND, poorly graded, medium, tan, moist	SS 7	89	13-18-18 (36)			
25								
30			SS 8	100	13-24-30 (54)			

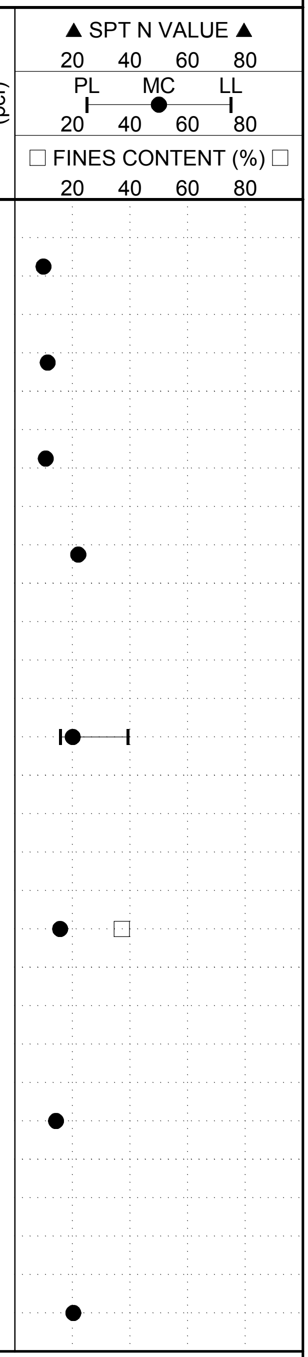
Bottom of borehole at 30.0 feet.

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

BORING NUMBER BH-4

CLIENT Luminant
PROJECT NAME Pond Slope Stability
PROJECT NUMBER 123-94128
PROJECT LOCATION Big Brown Plant
DATE STARTED 10/16/12 **COMPLETED** 10/16/12
GROUND ELEVATION **HOLE SIZE** inches
DRILLING CONTRACTOR Van & Sons Drilling Service
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING ---
LOGGED BY HR **CHECKED BY** PCM
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
0		(SC) CLAYEY SAND, medium to fine, well graded, and low plasticity clay, moist					
			SH 1	56		4.5	
		dry at 3.5'	SH 2	67		4.5	
5		moist at 6.0'	SH 3	72		4.5	
			SH 4	100		4.0	
10							
		(CL) LEAN CLAY, low plasticity, with medium to fine sand, gray - brown, moist, cohesive	SH 5	83		1.5	
15							
		(SC) CLAYEY SAND, medium to fine, well graded, and low plasticity clay, moist	SH 6	54		1.5	
20							
			SH 7	58		2	
25							
30			SH 8	92		1.0	



Bottom of borehole at 30.0 feet.

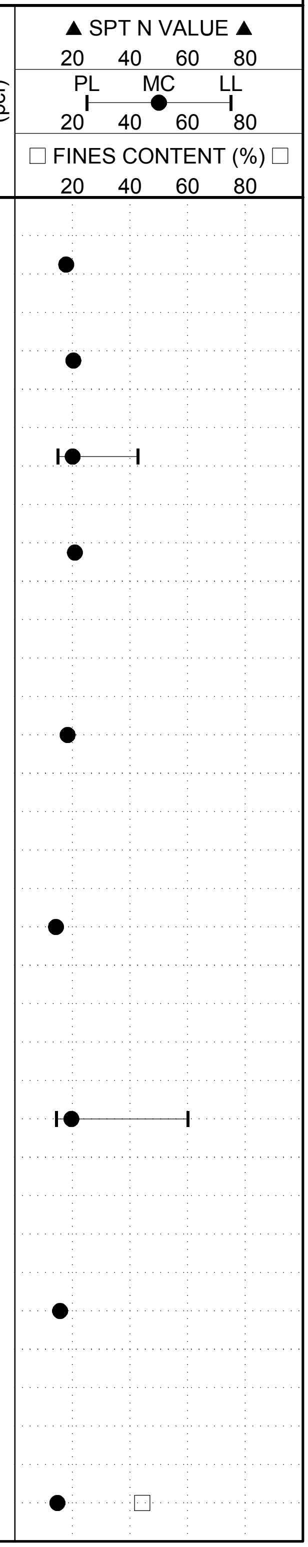
Golder Associates

500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

BORING NUMBER BH-5

CLIENT Luminant
PROJECT NAME Pond Slope Stability
PROJECT NUMBER 123-94128
PROJECT LOCATION Big Brown Plant
DATE STARTED 10/16/12 **COMPLETED** 1/16/12
GROUND ELEVATION **HOLE SIZE** inches
DRILLING CONTRACTOR Van & Sons Drilling Service
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING ---
LOGGED BY HR **CHECKED BY** PCM
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
0		(CL) SANDY LEAN CLAY, low plasticity, medium to fine, well graded, brown and orange, cohesive, moist	SH 1	78		4.5	
		trace gravel, red and gray at 3.5'	SH 2	78		4.5	
5			SH 3	100		2.25	
		(SC) CLAYEY SAND, medium to fine, well graded, some low plasticity clay, orange, cohesive, moist					
		(CL) SANDY LEAN CLAY, low plasticity, medium to fine, well graded, brown and orange, cohesive, moist	SH 4	89		0.75	
10		(SC) CLAYEY SAND, medium to fine, well graded, some low plasticity clay, gray to brown, non-cohesive, moist					
		(CL) SANDY LEAN CLAY, low plasticity, medium to fine, well graded, gray and brown, cohesive, moist	SH 5	75		3.25	
15							
		(SW) WELL GRADED SAND, medium to fine, with low plasticity clay lenses, orange, non-cohesive, moist	SH 6	52		3.0	
20							
		(CH) SANDY FAT CLAY, high plasticity, medium to fine, well graded, gray, cohesive, moist	SH 7	83		2.75	
25							
		(CL) SANDY LEAN CLAY, low plasticity, medium to fine, well graded, gray, cohesive, moist					
		orange and gray at 28.0'	SH 8	73		4.5	
30							
		(SC) CLAYEY SAND, medium to fine, well graded, some low plasticity clay, gray and orange, cohesive, moist	SH 9	67		4.25	
35							



(Continued Next Page)

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

BORING NUMBER BH-5

CLIENT Luminant
PROJECT NAME Pond Slope Stability
PROJECT NUMBER 123-94128
PROJECT LOCATION Big Brown Plant

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / □ FINES CONTENT (%) □ 20 40 60 80
35		(SC) CLAYEY SAND, medium to fine, well graded, some low plasticity clay, gray and orange, cohesive, moist *(continued)*						
40			SS 10	100	13-15-16 (31)			
45		wet at 43.5'	SS 11	100	4-5-5 (10)			
50			SS		10-10-12 (22)			

Bottom of borehole at 50.0 feet.

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

BORING NUMBER BH-6

CLIENT Luminant
PROJECT NAME Pond Slope Stability
PROJECT NUMBER 123-94128
PROJECT LOCATION Big Brown Plant
DATE STARTED 10/16/12 **COMPLETED** 10/16/12
GROUND ELEVATION **HOLE SIZE** inches
DRILLING CONTRACTOR Van & Sons Drilling Service
GROUND WATER LEVELS:
DRILLING METHOD Mud Rotary
AT TIME OF DRILLING ---
LOGGED BY HR **CHECKED BY** PCM
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / ☐ FINES CONTENT (%) ☐ 20 40 60 80
0		(SC) CLAYEY SAND, medium to fine, well graded, some low plasticity clay, brown, cohesive, moist	SH 1	28				
5		and low plasticity clay at 3.5'	SH 2	67		4.5		
		(CL) SANDY LEAN CLAY, low plasticity, some medium to fine sand, orange, wet	SH 3	72		0.0		
		(SW) WELL GRADED SAND, medium to fine, gray, dry						
10		(SC) CLAYEY SAND, medium to fine, well graded, and low plasticity clay, orange, dry, cohesive	SH 4	61		4.5		
15		(CL) LEAN CLAY, low plasticity, some medium to fine sand, orange, moist, cohesive	SH 5	54		4.5		
20		(SC) CLAYEY SAND, medium to fine, well graded, and low plasticity clay, gray, moist, cohesive	SS 6	54	5-7-10 (17)			
25		(CL) SANDY LEAN CLAY, low plasticity, increasing sand with depth, gray, cohesive, moist	SH 7	100		2.0		
30		(SC) CLAYEY SAND, medium to fine, well graded, and low plasticity clay, gray and orange, possible some lignite (black), moist, cohesive	SH 8	88		3.5		
35		no lignite at 33.0'	SH 9	69		3.5		

(Continued Next Page)

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

BORING NUMBER BH-6

CLIENT Luminant **PROJECT NAME** Pond Slope Stability

PROJECT NUMBER 123-94128 **PROJECT LOCATION** Big Brown Plant

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / □ FINES CONTENT (%) □ 20 40 60 80
35		(SC) CLAYEY SAND, medium to fine, well graded, and low plasticity clay, gray and orange, possible some lignite (black), moist, cohesive *(continued)*						
		(SW) WELL GRADED SAND, medium to fine, trace low plasticity clay lenses, gray, non-cohesive, moist	SH 10	60		0.0		
40								
		orange, clay nodules at 43.0'	SH 11	50		0.0		
45								
		with stiff, gray, clay nodules and lenses at 48.0'	SH 12	46		0.0		
50								

Bottom of borehole at 50.0 feet.

APPENDIX B
LABORATORY TEST SUMMARY SHEETS

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

SUMMARY OF LABORATORY RESULTS

CLIENT Luminant **PROJECT NAME** Pond Slope Stability
PROJECT NUMBER 123-94128 **PROJECT LOCATION** Big Brown Plant

Sample ID	Depth	Natural Moisture (%)	Atterberg Limits			%<#200 Sieve	Class-ification	Unit Weight		Permeability (cm/sec)	Additional Lab Testing
			Liquid Limit	Plastic Limit	Plasticity Index			Moisture Content (%)	Dry Density (psf)		
BH-1	1	19.3									
BH-1	4	11.9									
BH-1	6	8.8									
BH-1	9	13.6									
BH-1	13	19.1									
BH-1	18	15.5									
BH-1	23	15.4									
BH-1	28	19.9	33	13	20						
BH-1	33	16.0									
BH-1	39	22.9									
BH-1	44	25.6									
BH-1	49	27.6									
BH-2	1	20.1									
BH-2	4	13.3									
BH-2	6	16.2									
BH-2	9	9.9									
BH-2	13	18.3									
BH-2	18	17.9									
BH-2	23	15.0									
BH-2	28	17.2	34	17	17						
BH-2	33	22.5									
BH-2	39	24.2									
BH-2	44	26.1									
BH-2	49	25.6									
BH-3	1	12.2									
BH-3	4	17.3									
BH-3	6	16.7									
BH-3	9	18.6									
BH-3	13	18.7									
BH-3	18	14.1									
BH-3	24	8.5									
BH-3	29	7.0				17					
BH-4	1	9.9									
BH-4	4	11.4									
BH-4	6	10.7									
BH-4	9	22.0									
BH-4	13	20.1	39	16	23						
BH-4	18	15.7									
BH-4	23	14.3									
BH-4	28	20.3									
BH-5	1	17.8									

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

SUMMARY OF LABORATORY RESULTS

CLIENT Luminant

PROJECT NAME Pond Slope Stability

PROJECT NUMBER 123-94128

PROJECT LOCATION Big Brown Plant

Sample ID	Depth	Natural Moisture (%)	Atterberg Limits			%<#200 Sieve	Class-ification	Unit Weight		Permeability (cm/sec)	Additional Lab Testing
			Liquid Limit	Plastic Limit	Plasticity Index			Moisture Content (%)	Dry Density (psf)		
BH-5	4	20.3									
BH-5	6	20.0	43	15	28						
BH-5	9	20.8									
BH-5	13	18.3									
BH-5	18	14.2									
BH-5	23	19.6	60	14	46						
BH-5	28	15.7									
BH-5	33	14.8									
BH-5	39	19.6									
BH-5	44	22.5									
BH-5	49	20.9									
BH-6	1	16.5									
BH-6	4	11.9									
BH-6	6	28.2									
BH-6	9	12.3									
BH-6	13	17.7	49	16	33						
BH-6	19	20.6									
BH-6	23	19.3									
BH-6	28	13.3									
BH-6	33	21.9	44	14	30						
BH-6	38	21.5				69					
BH-6	43	26.0									
BH-6	48	31.1									

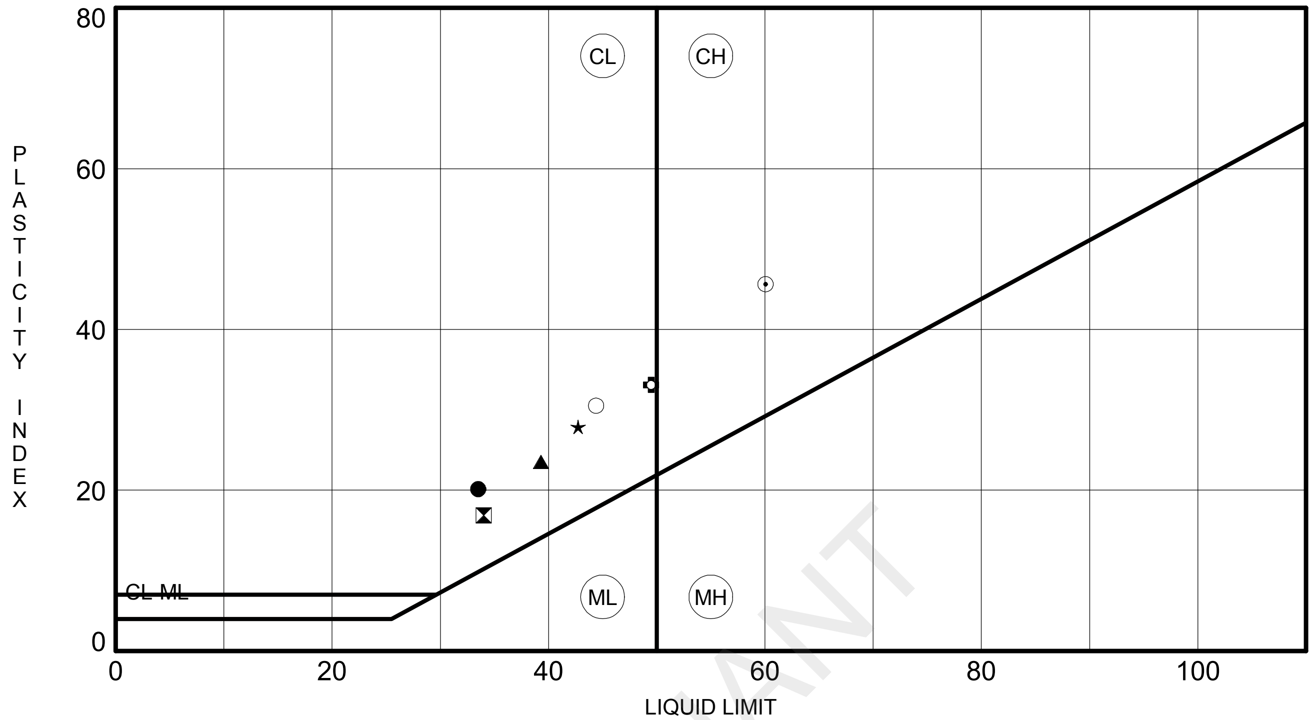
APPENDIX C
LABORATORY TEST RESULTS

ATTERBERG LIMIT RESULTS

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

ATTERBERG LIMITS' RESULTS

CLIENT Luminant
PROJECT NAME Pond Slope Stability
PROJECT NUMBER 123-94128
PROJECT LOCATION Big Brown Plant



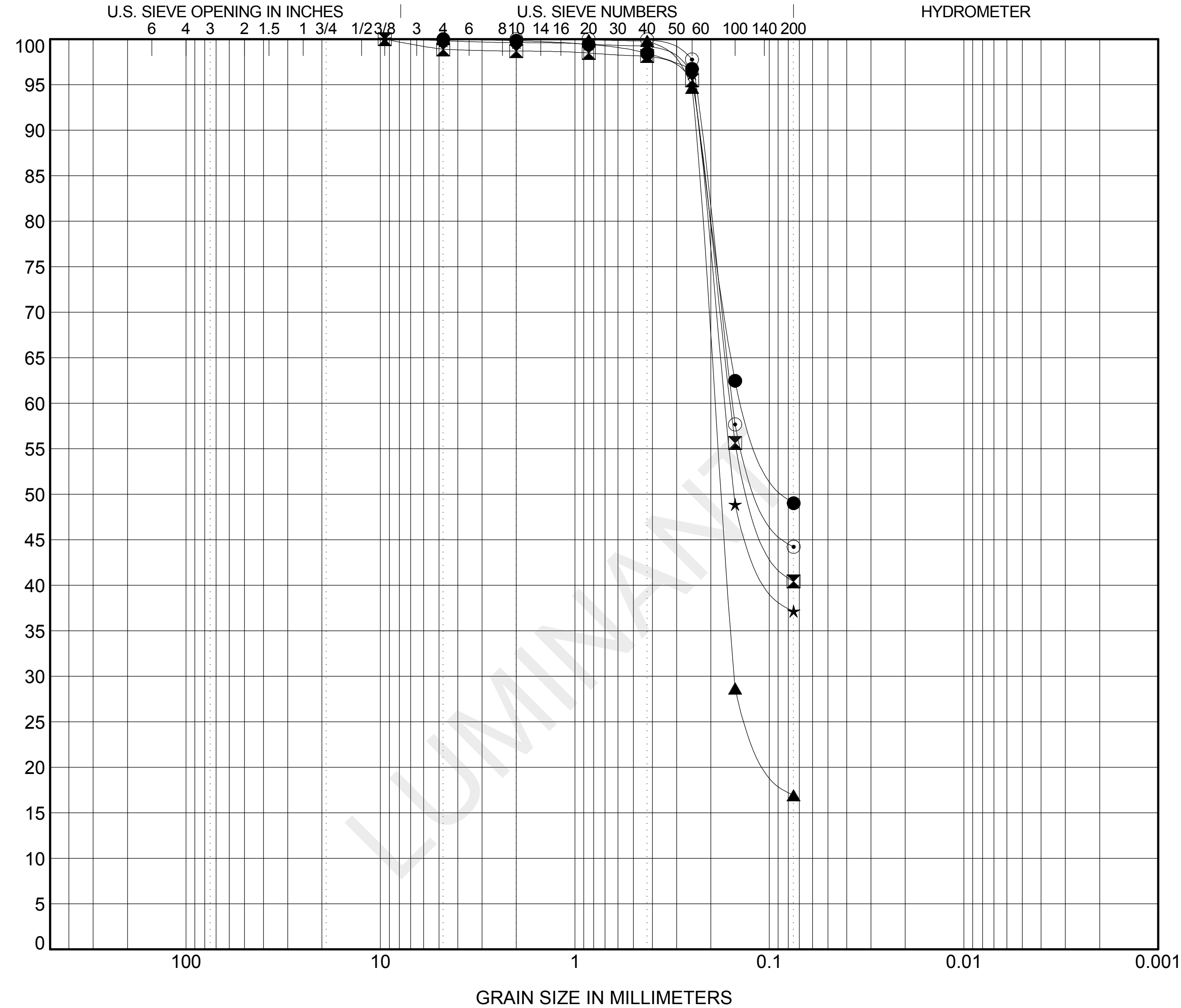
	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**BH-1**	**28.0**	**33**	**13**	**20**		
⧗	**BH-2**	**28.0**	**34**	**17**	**17**		
▲	**BH-4**	**13.0**	**39**	**16**	**23**		
★	**BH-5**	**6.0**	**43**	**15**	**28**		
⊙	**BH-5**	**23.0**	**60**	**14**	**46**		
✪	**BH-6**	**13.0**	**49**	**16**	**33**		
○	**BH-6**	**33.0**	**44**	**14**	**30**		

GRAIN SIZE ANALYSIS

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

GRAIN SIZE DISTRIBUTION

CLIENT Luminant
PROJECT NAME Pond Slope Stability
PROJECT NUMBER 123-94128
PROJECT LOCATION Big Brown Plant



	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**BH-1**	**6**						
⧗	**BH-2**	**39**						
▲	**BH-3**	**29**						
★	**BH-4**	**18**						
⊙	**BH-5**	**33**						

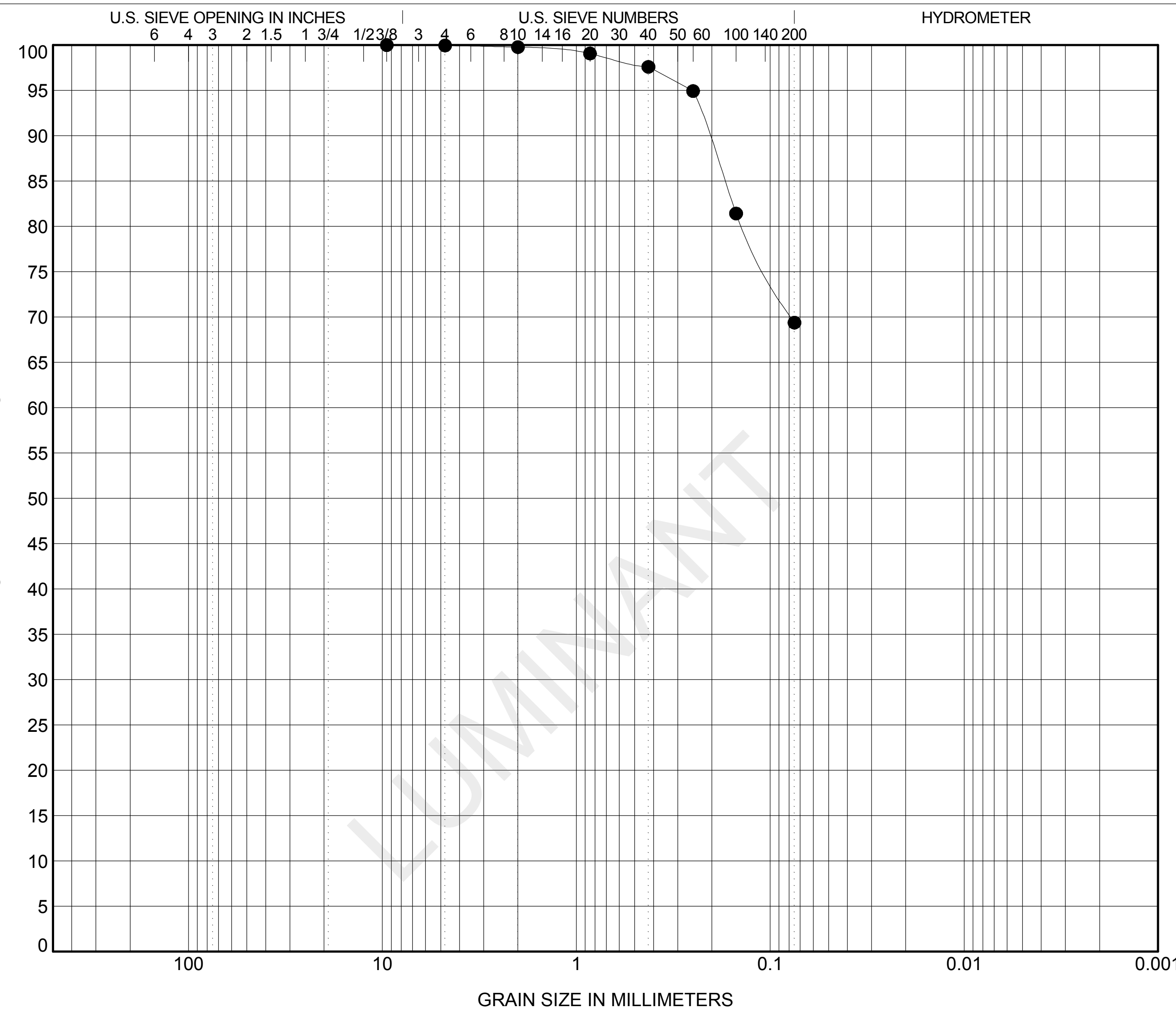
	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**BH-1**	**6**	**4.75**	**0.132**			**0.0**	**51.0**	**49.0**	
⧗	**BH-2**	**39**	**9.5**	**0.159**			**1.1**	**58.5**	**40.4**	
▲	**BH-3**	**29**	**4.75**	**0.191**	**0.152**		**0.0**	**83.1**	**16.9**	
★	**BH-4**	**18**	**9.5**	**0.169**			**0.2**	**62.7**	**37.2**	
⊙	**BH-5**	**33**	**2**	**0.155**			**0.0**	**55.8**	**44.2**	

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

GRAIN SIZE DISTRIBUTION

CLIENT Luminant **PROJECT NAME** Pond Slope Stability

PROJECT NUMBER 123-94128 **PROJECT LOCATION** Big Brown Plant

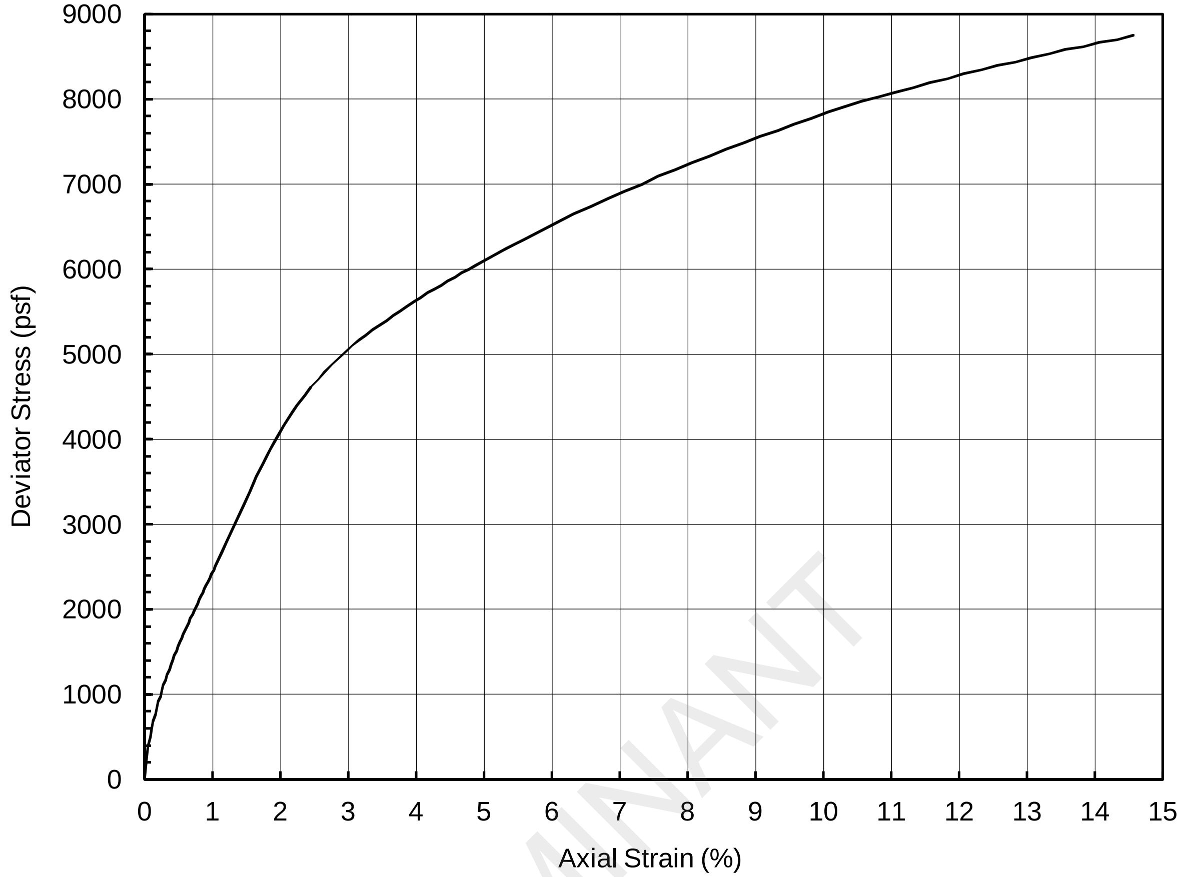


	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**BH-6**	**38**						

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**BH-6**	**38**	**9.5**				**0.1**	**30.6**	**69.4**	

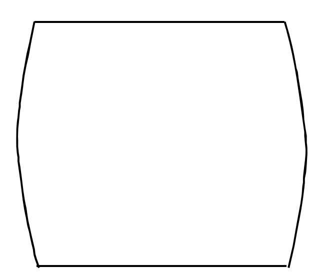
UNCONSOLIDATED / UNDRAINED COMPRESSIVE STRENGTH (UU)

UNCONSOLIDATED / UNDRAINED COMPRESSIVE STRENGTH
ASTM D 2850



Specimen Description	Light Tan and Gray Clayey Sand						
LL	33	PI	20	LI	0.2	USCS	CL

Depth (ft)	28.0	Confining Pressure (psf)	2879
Specimen Height (inch)	5.9	Strain Rate (%/min)	1.0
Specimen Diameter (inch)	2.8	Peak Deviator Stress (psf)	8784
Initial Specimen Weight (g)	1253.7	Axial Strain at Peak Stress (%)	15.0
Moist Unit Weight (pcf)	132.8		
Initial Water Content (%)	17		
Initial Dry Unit Weight (pcf)	113.3		



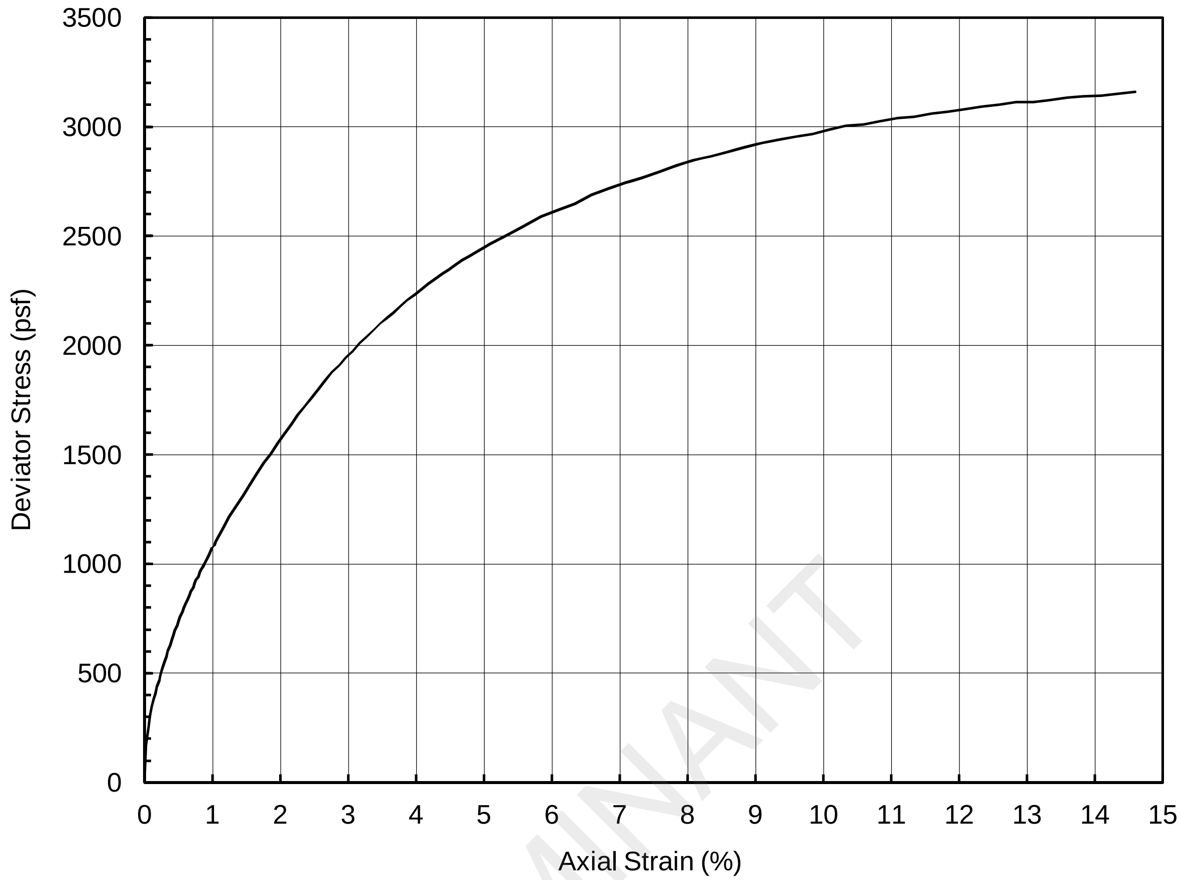
Failure Sketch

Project Title	Luminant - Big Brown Slope Stability
Project Number	123-94128
Sample Type	Shelby Tube
Sample ID	BH-2 TO-8
Comments	

Golder Associates

Performed by	**PN**
Date	**7-Nov-12**
Check	**HR**
Review	**PCM**

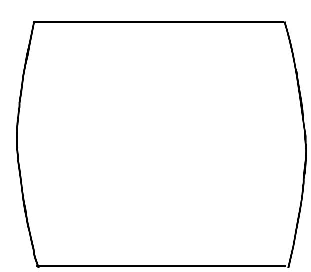
UNCONSOLIDATED / UNDRAINED COMPRESSIVE STRENGTH
ASTM D 2850



Specimen Description	Light Tan and Gray Clayey Sand						
LL	39	PI	23	LI	0.2	USCS	CL

Depth (ft)	13.0	Confining Pressure (psf)	1754
Specimen Height (inch)	4.9	Strain Rate (%/min)	1.0
Specimen Diameter (inch)	2.8	Peak Deviator Stress (psf)	3164
Initial Specimen Weight (g)	950.5	Axial Strain at Peak Stress (%)	14.8
Moist Unit Weight (pcf)	121.4		
Initial Water Content (%)	20		
Initial Dry Unit Weight (pcf)	101.3		

Project Title	Luminant - Big Brown Slope Stability
Project Number	123-94128
Sample Type	Shelby Tube
Sample ID	BH-4 TO-5
Comments	Sample L/D ratio < 2

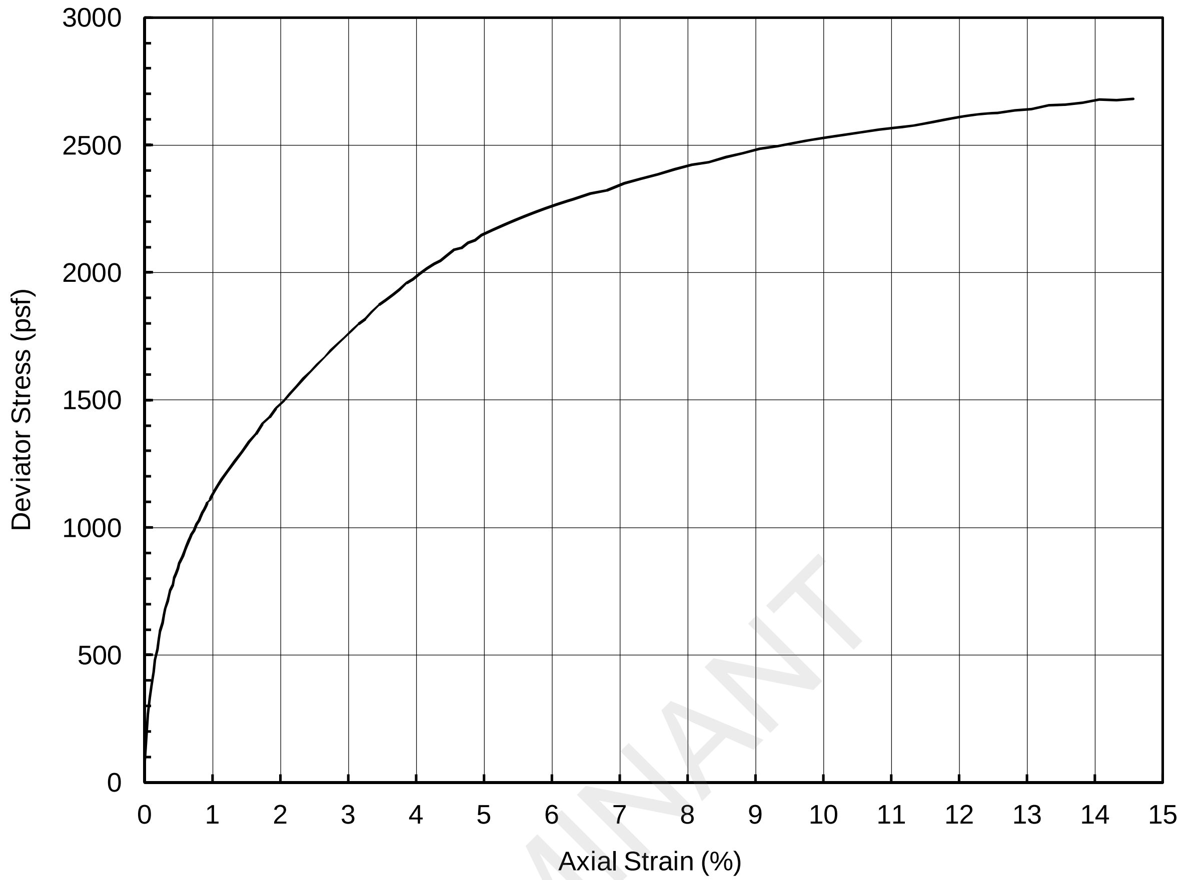


Failure Sketch

Golder Associates

Performed by	**PN**
Date	**7-Nov-12**
Check	**HR**
Review	**PCM**

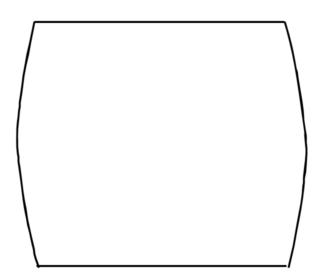
UNCONSOLIDATED / UNDRAINED COMPRESSIVE STRENGTH
ASTM D 2850



Specimen Description	Reddish Gray Clayey Sand						
LL	43	PI	28	LI	0.2	USCS	CL

Depth (ft)	6.0	Confining Pressure (psf)	891
Specimen Height (inch)	4.6	Strain Rate (%/min)	1.0
Specimen Diameter (inch)	2.8	Peak Deviator Stress (psf)	2688
Initial Specimen Weight (g)	926.5	Axial Strain at Peak Stress (%)	14.8
Moist Unit Weight (pcf)	122.1		
Initial Water Content (%)	20		
Initial Dry Unit Weight (pcf)	101.5		

Project Title	Luminant - Big Brown Slope Stability
Project Number	123-94128
Sample Type	Shelby Tube
Sample ID	BH-5 TO-3
Comments	Sample L/D ratio < 2

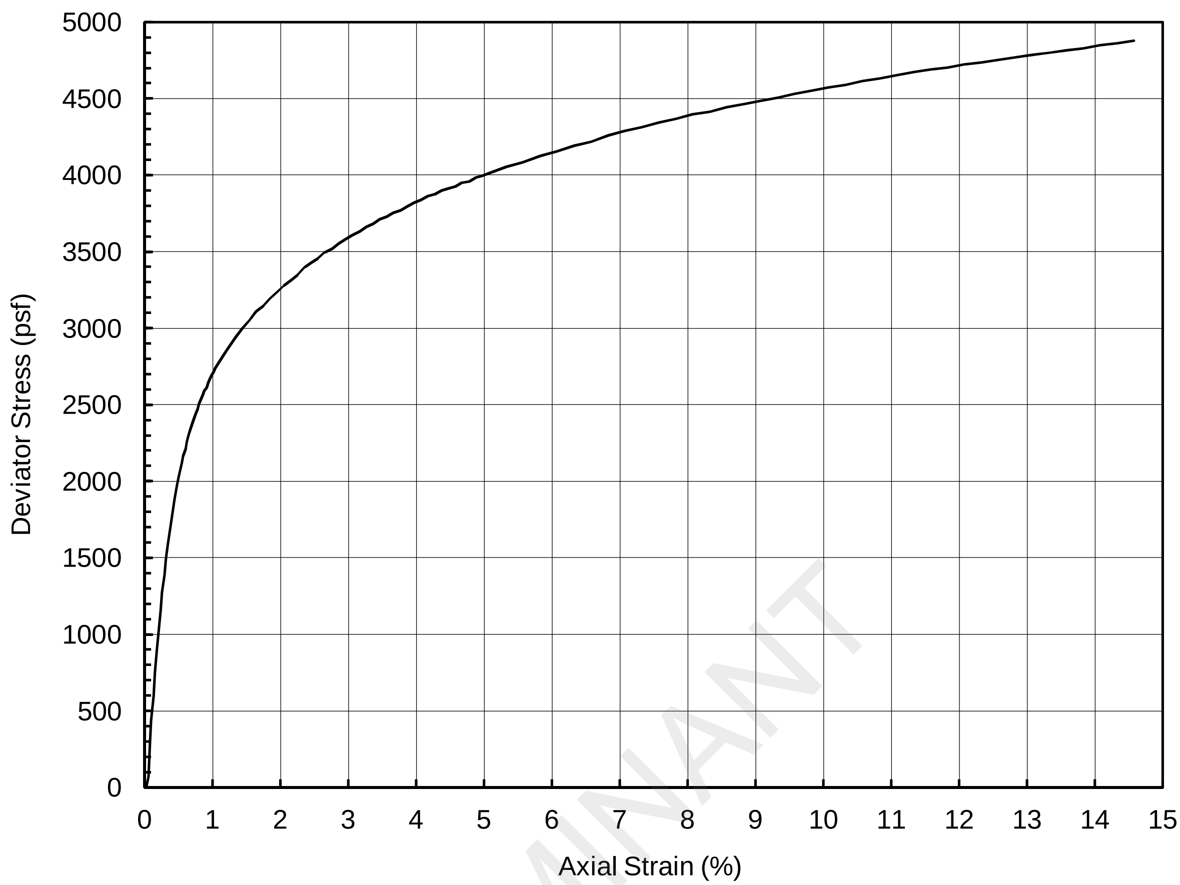


Failure Sketch

Golder Associates

Performed by	PN
Date	7-Nov-12
Check	HR
Review	PCM

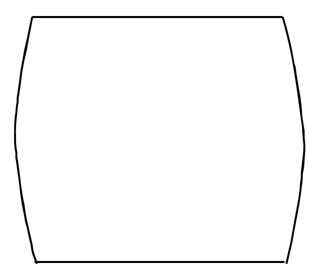
UNCONSOLIDATED / UNDRAINED COMPRESSIVE STRENGTH
ASTM D 2850



Specimen Description	Reddish Gray Clay						
LL	60	PI	46	LI	0.1	USCS	CH

Depth (ft)	23.0	Confining Pressure (psf)	2879
Specimen Height (inch)	6.0	Strain Rate (%/min)	1.0
Specimen Diameter (inch)	2.8	Peak Deviator Stress (psf)	4887
Initial Specimen Weight (g)	1218.0	Axial Strain at Peak Stress (%)	15.0
Moist Unit Weight (pcf)	131.2		
Initial Water Content (%)	20		
Initial Dry Unit Weight (pcf)	109.1		

Project Title	Luminant - Big Brown Slope Stability
Project Number	123-94128
Sample Type	Shelby Tube
Sample ID	BH-5 TO-7
Comments	

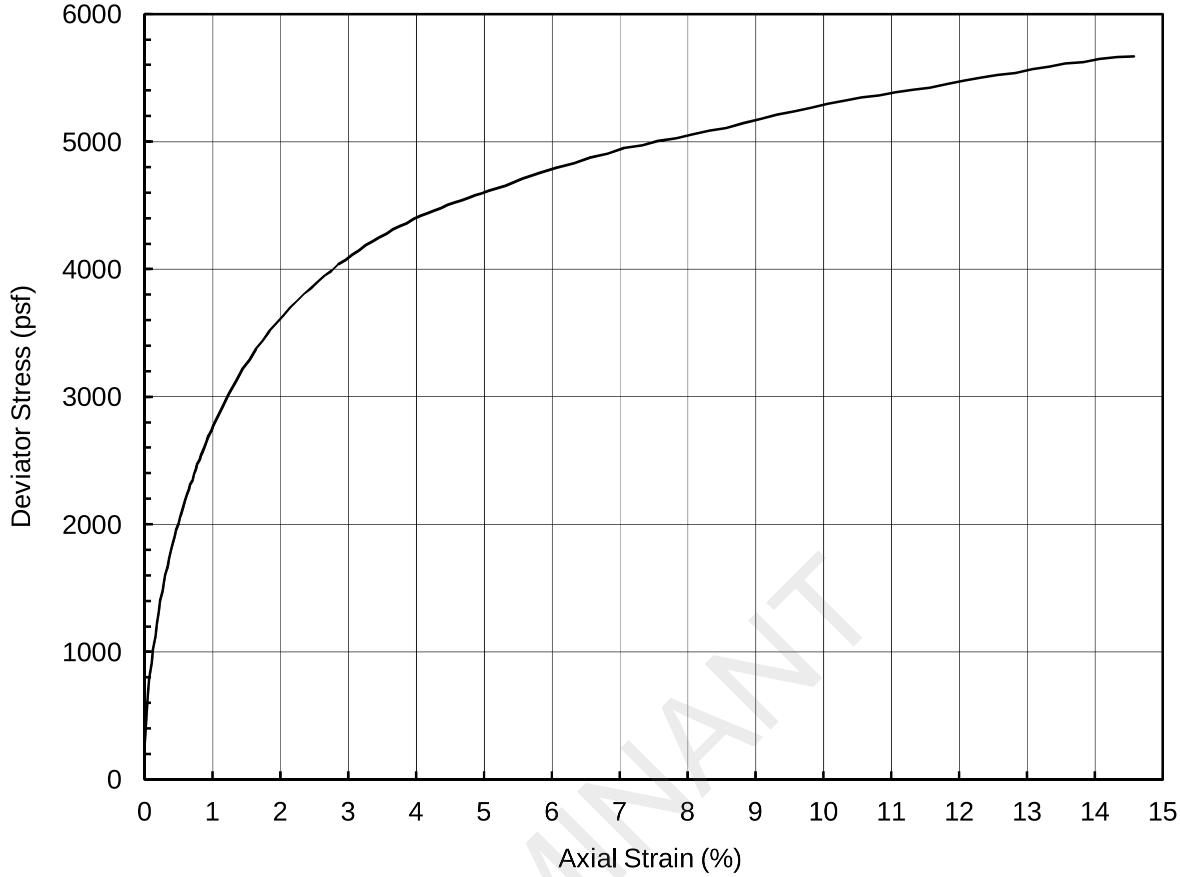


Failure Sketch

Golder Associates

Performed by	**PN**
Date	**8-Nov-12**
Check	**HR**
Review	**PCM**

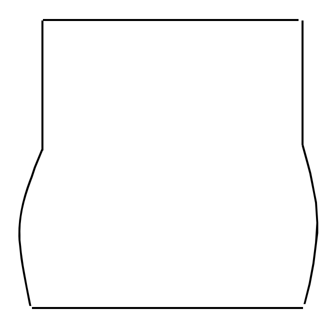
UNCONSOLIDATED / UNDRAINED COMPRESSIVE STRENGTH
ASTM D 2850



Specimen Description	Light Red Sandy Clay						
LL	49	PI	33	LI	0.0	USCS	CL

Depth (ft)	13.0	Confining Pressure (psf)	1752
Specimen Height (inch)	5.7	Strain Rate (%/min)	1.0
Specimen Diameter (inch)	2.8	Peak Deviator Stress (psf)	5685
Initial Specimen Weight (g)	1150.2	Axial Strain at Peak Stress (%)	14.8
Moist Unit Weight (pcf)	125.3		
Initial Water Content (%)	17		
Initial Dry Unit Weight (pcf)	107.5		

Project Title	Luminant - Big Brown Slope Stability
Project Number	123-94128
Sample Type	Shelby Tube
Sample ID	BH-6 TO-5
Comments	

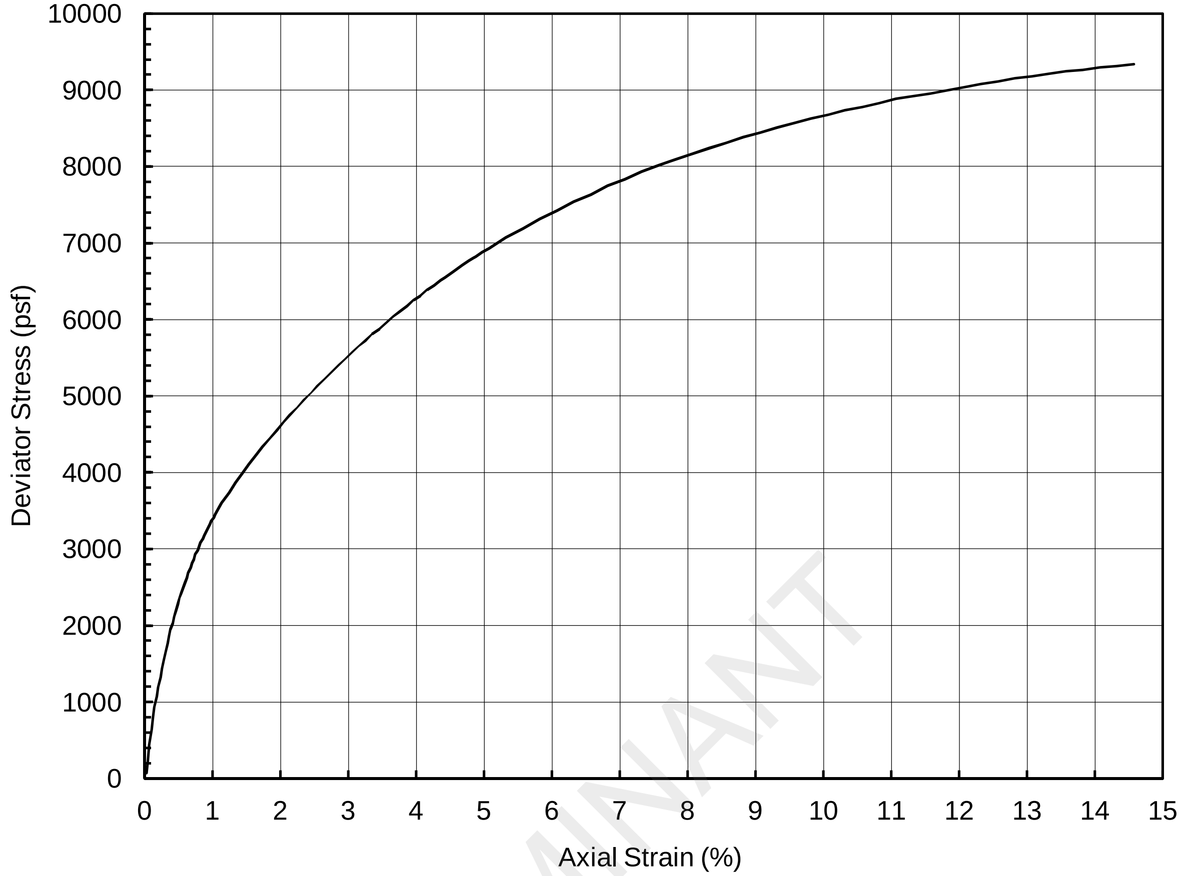


Failure Sketch

Golder Associates

Performed by	**PN**
Date	**8-Nov-12**
Check	**HR**
Review	**PCM**

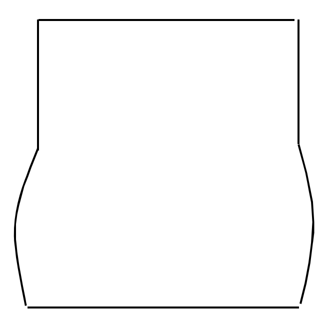
UNCONSOLIDATED / UNDRAINED COMPRESSIVE STRENGTH
ASTM D 2850



Specimen Description	Light Gray Sandy Clay						
LL	44	PI	30	LI	0.1	USCS	CL

Depth (ft)	33.0	Confining Pressure (psf)	3304
Specimen Height (inch)	6.0	Strain Rate (%/min)	1.0
Specimen Diameter (inch)	2.9	Peak Deviator Stress (psf)	9360
Initial Specimen Weight (g)	1270.9	Axial Strain at Peak Stress (%)	15.0
Moist Unit Weight (pcf)	127.4		
Initial Water Content (%)	18		
Initial Dry Unit Weight (pcf)	107.9		

Project Title	Luminant - Big Brown Slope Stability
Project Number	123-94128
Sample Type	Shelby Tube
Sample ID	BH-6 TO-9
Comments	



Failure Sketch

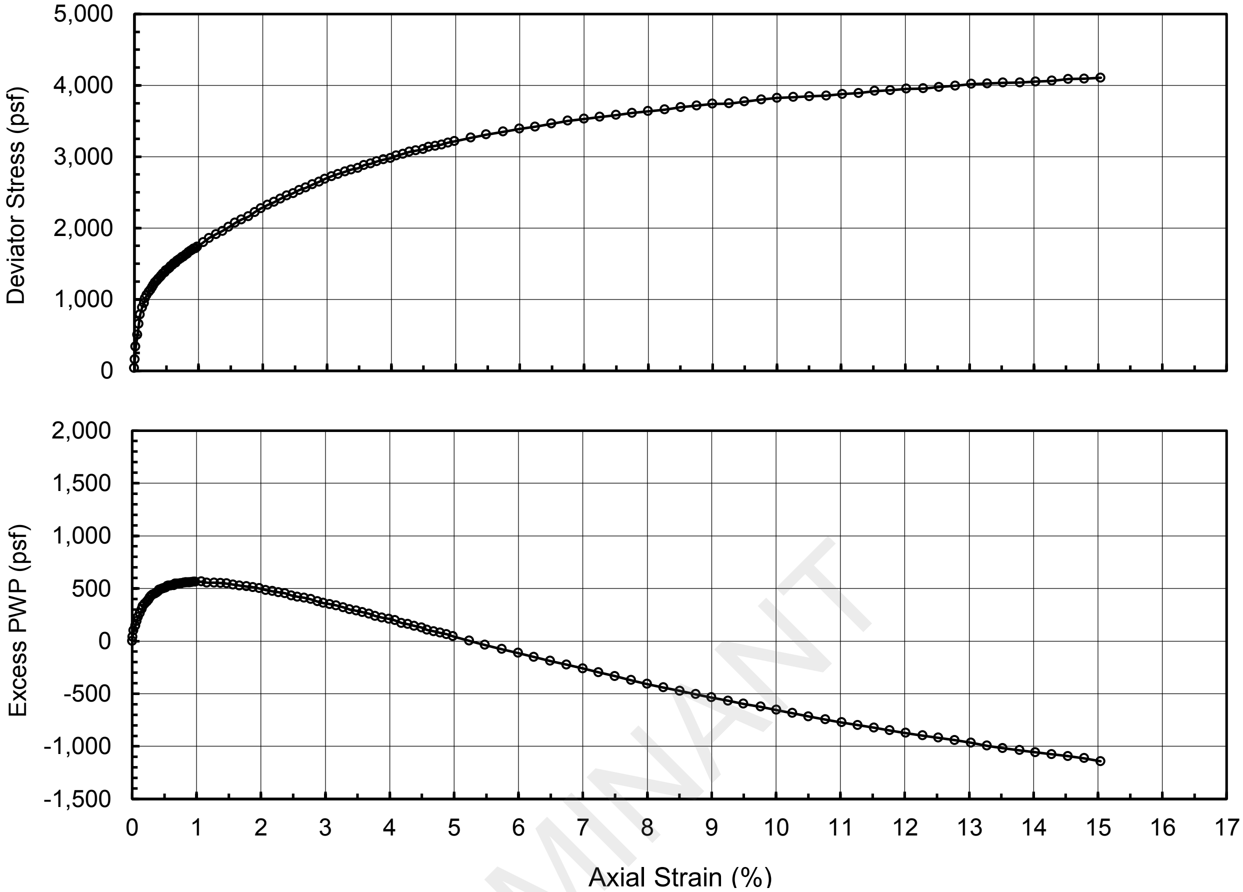
Golder Associates

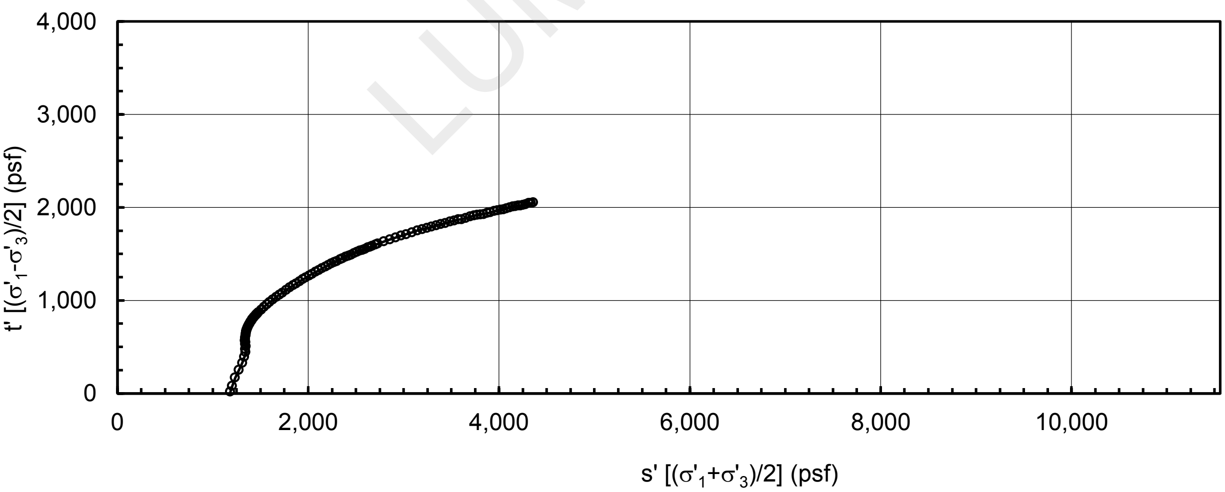
Performed by	**PN**
Date	**9-Nov-12**
Check	**HR**
Review	**PCM**

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL TEST (ICU)

Isotropically Consolidated Undrained Triaxial Test (ICU)

Project Title: Big Brown Plant, Pond Stability **Project Number:** 123-94128 **Date:** 11-Nov-12
Boring Number: BH-1 **Specimen Name:** TO-8 **Depth (ft):** 28.0



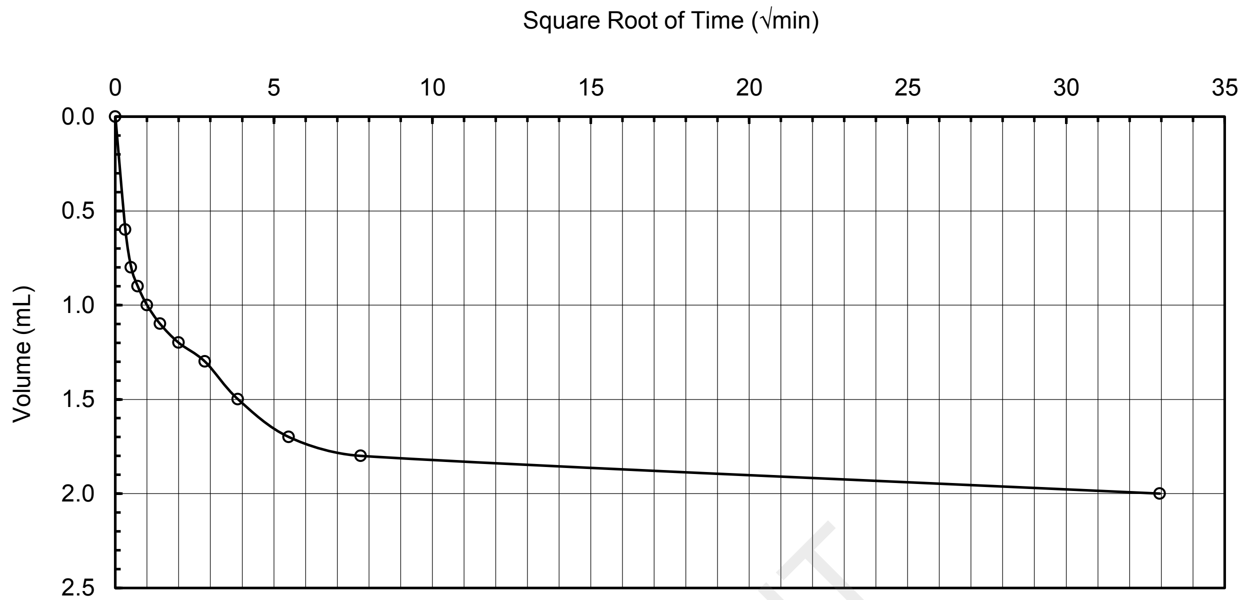


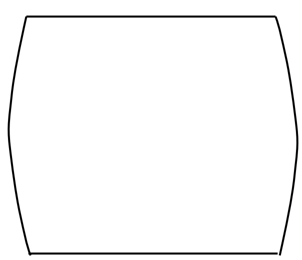
Specimen Description:	Dark Gray Sandy CLAY					
Initial Specimen Diameter (inch) =			2.84	Initial Specimen Height (inch) =		5.95
Initial Water Content (%) =			15.4	Water Content at End of Test (%) =		18.4
Initial Moist Unit Weight (pcf) =			127.6	B-value =		0.98
Back Pressure (BP, psf) =			4320.0	Consolidation Stress (σ'_3, psf) =		1165.6
Initial Lateral Stress (σ'_3, psf) =			1165.6	Consolidation t_{50} (min) =		10
Initial Deviator Stress (σ_1 - σ_3, psf) =			36.4	Rebound Stress (σ'_3, psf) =		NA
Test Strain Rate (%/hour) =			1.0	Rebound t_{50} (min) =		NA
LL =	33	PI =	20	USCS	CL	Performed by: SBK
Comments:						Reviewed by: PCM

Golder Associates

Isotropically Consolidated Undrained Triaxial Test (ICU)

Project Title: Big Brown Plant, Pond Stability **Project Number:** 123-94128 **Date:** 11-Nov-12
Boring Number: BH-1 **Specimen Name:** TO-8 **Depth (ft):** 28.0





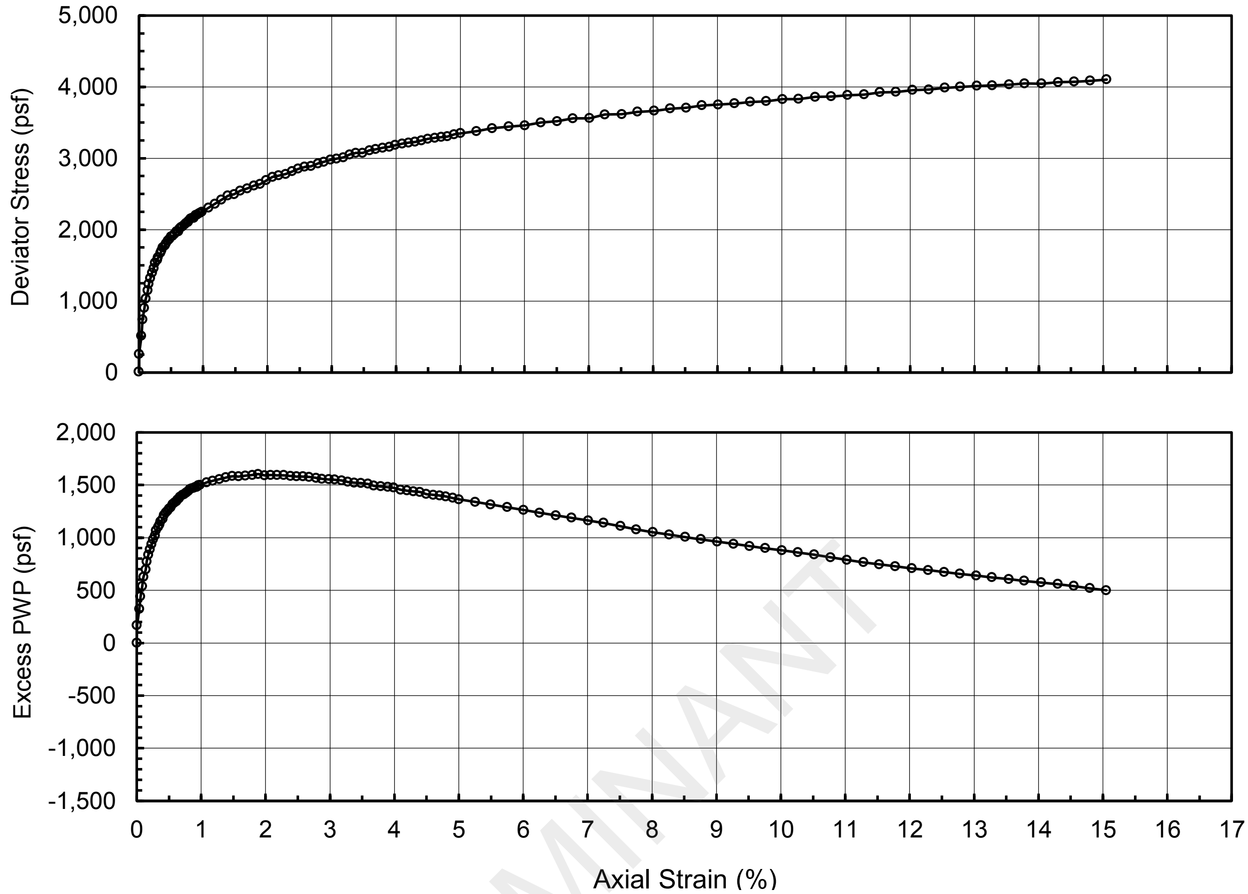
FAILURE SKETCH

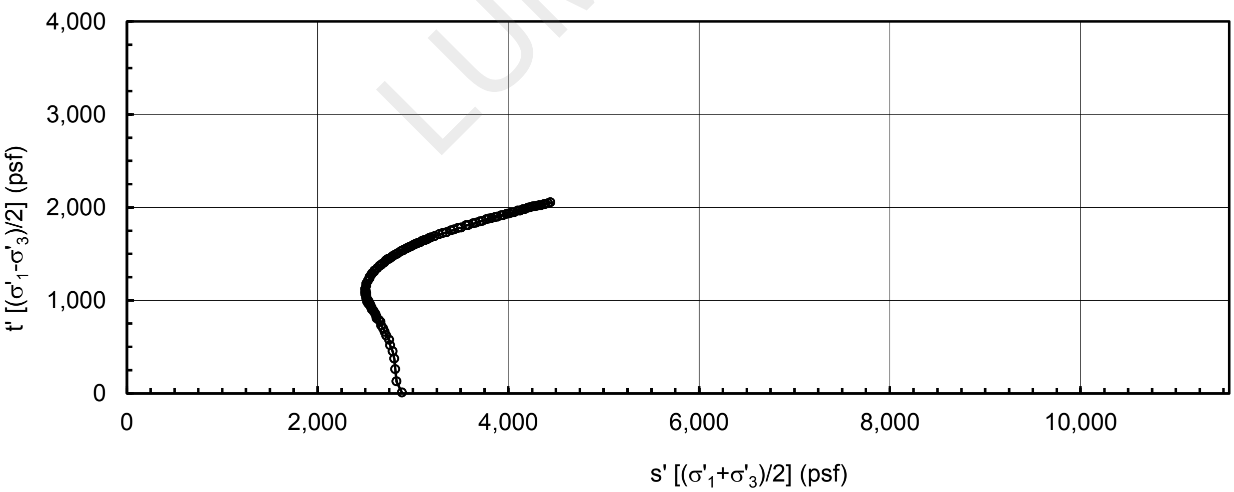
Consolidation Stress (σ'_3, psf) =			1165.6
Consolidation t_{50} (min) =			10
Consolidation Volume Change (mL) =			2.0
Unloading Stress (psf) =			NA
Unloading t_{50} (min) =			NA
Unloading Volume Change (mL) =			NA
LL =	33	PI =	20
USCS	CL		
Gs =	2.65	assumed	

Performed by SBK
Reviewed by PCM

Isotropically Consolidated Undrained Triaxial Test (ICU)

Project Title:	Big Brown Plant, Pond Stability	**Project Number:**	123-94128	**Date:**	12-Nov-12
Boring Number:	BH-1	**Specimen Name:**	TO-8	**Depth (ft):**	28.0



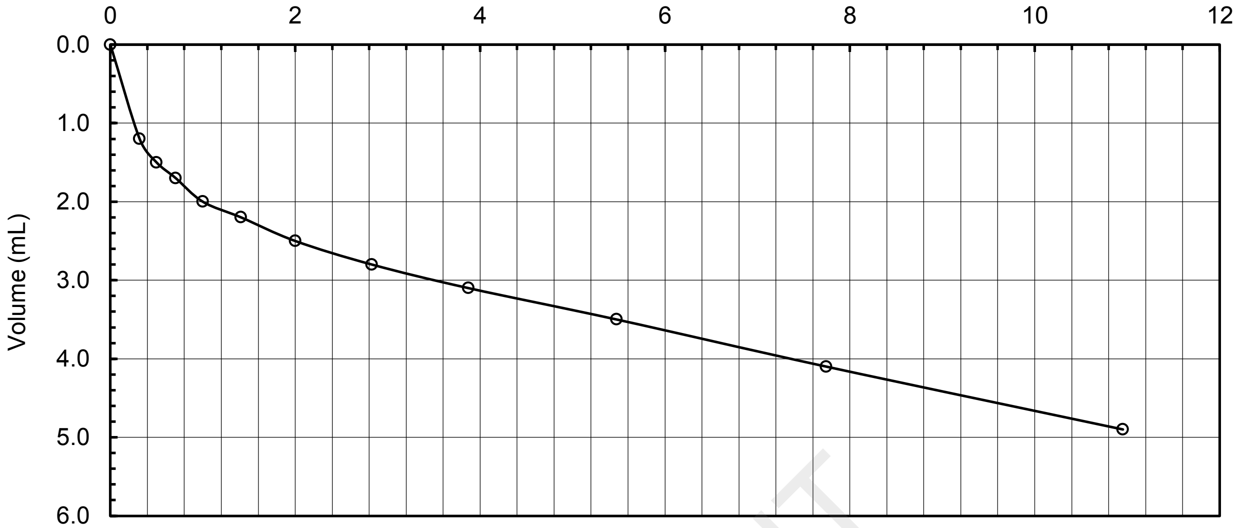


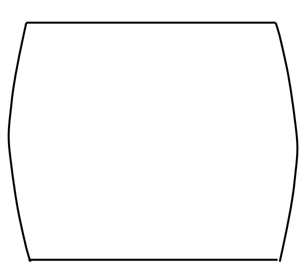
Specimen Description:	Dark Gray Sandy CLAY				
Initial Specimen Diameter (inch) =		2.83	Initial Specimen Height (inch) =		5.95
Initial Water Content (%) =		16.9	Water Content at End of Test (%) =		18.0
Initial Moist Unit Weight (pcf) =		128.7	B-value =		0.99
Back Pressure (BP, psf) =		3600.0	Consolidation Stress (σ'_3, psf) =		2879.8
Initial Lateral Stress (σ'_3, psf) =		2879.8	Consolidation t_{50} (min) =		3
Initial Deviator Stress (σ_1 - σ_3, psf) =		11.4	Rebound Stress (σ'_3, psf) =		NA
Test Strain Rate (%/hour) =		1.0	Rebound t_{50} (min) =		NA
LL =	33	PI =	20	USCS	CL	**Performed by**	SBK
Comments:						**Reviewed by**	PCM

Golder Associates

Isotropically Consolidated Undrained Triaxial Test (ICU)

Project Title: Big Brown Plant, Pond Stability **Project Number:** 123-94128 **Date:** 12-Nov-12
Boring Number: BH-1 **Specimen Name:** TO-8 **Depth (ft):** 28.0





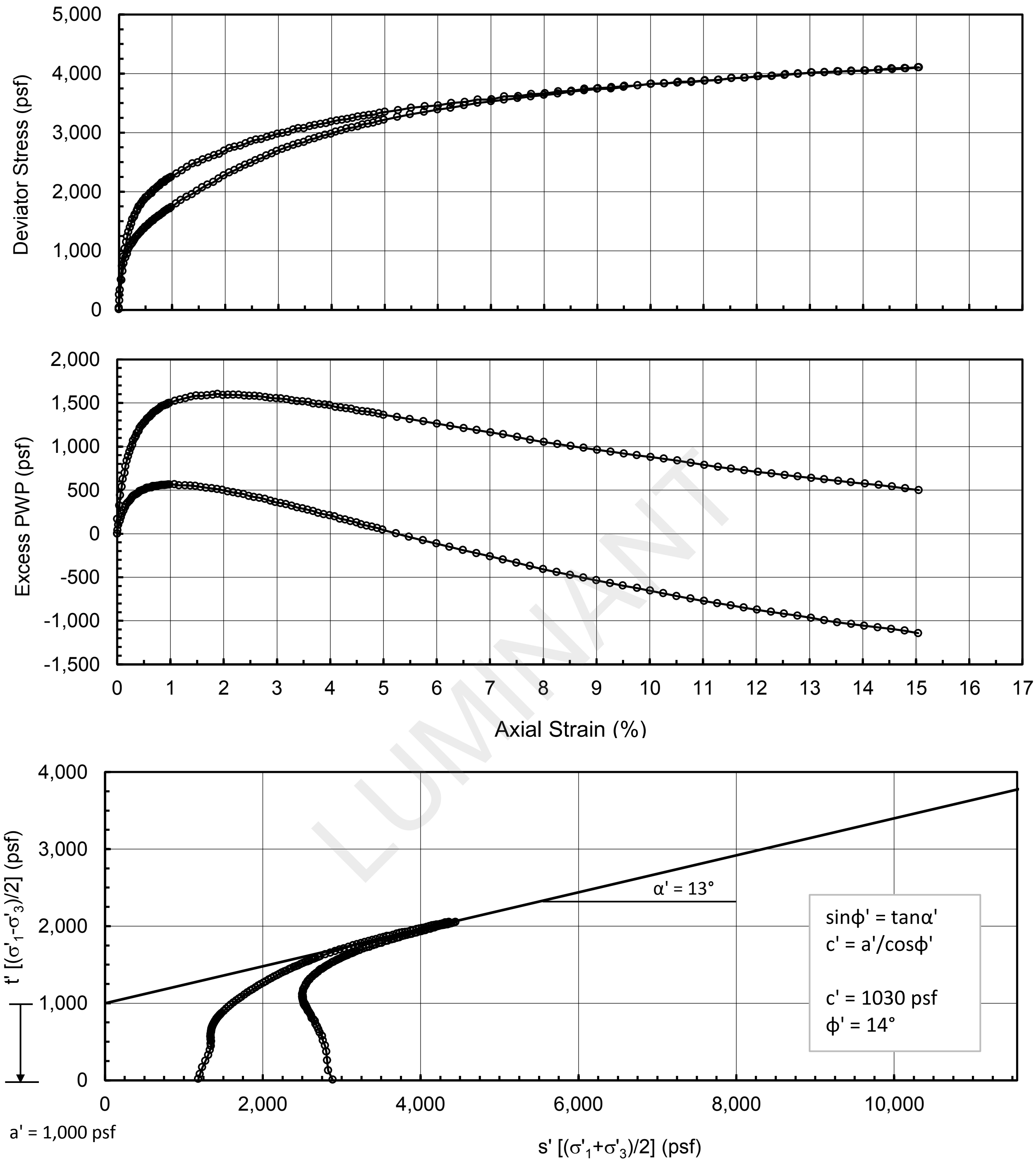
FAILURE SKETCH

Consolidation Stress (σ'_3, psf) =			2879.8
Consolidation t_{50} (min) =			3
Consolidation Volume Change (mL) =			4.9
Unloading Stress (psf) =			NA
Unloading t_{50} (min) =			NA
Unloading Volume Change (mL) =			NA
LL =	33	PI =	20
USCS	CL		
Gs =	2.65	assumed	

Performed by	SBK
Reviewed by	PCM

Isotropically Consolidated Undrained Triaxial Test (ICU)

Project Title: Big Brown Plant, Pond Stability **Project Number:** 123-94128 **Date:** 12-Nov-12
Boring Number: BH-1 **Specimen Name:** TO-8 **Depth (ft):** 28.0

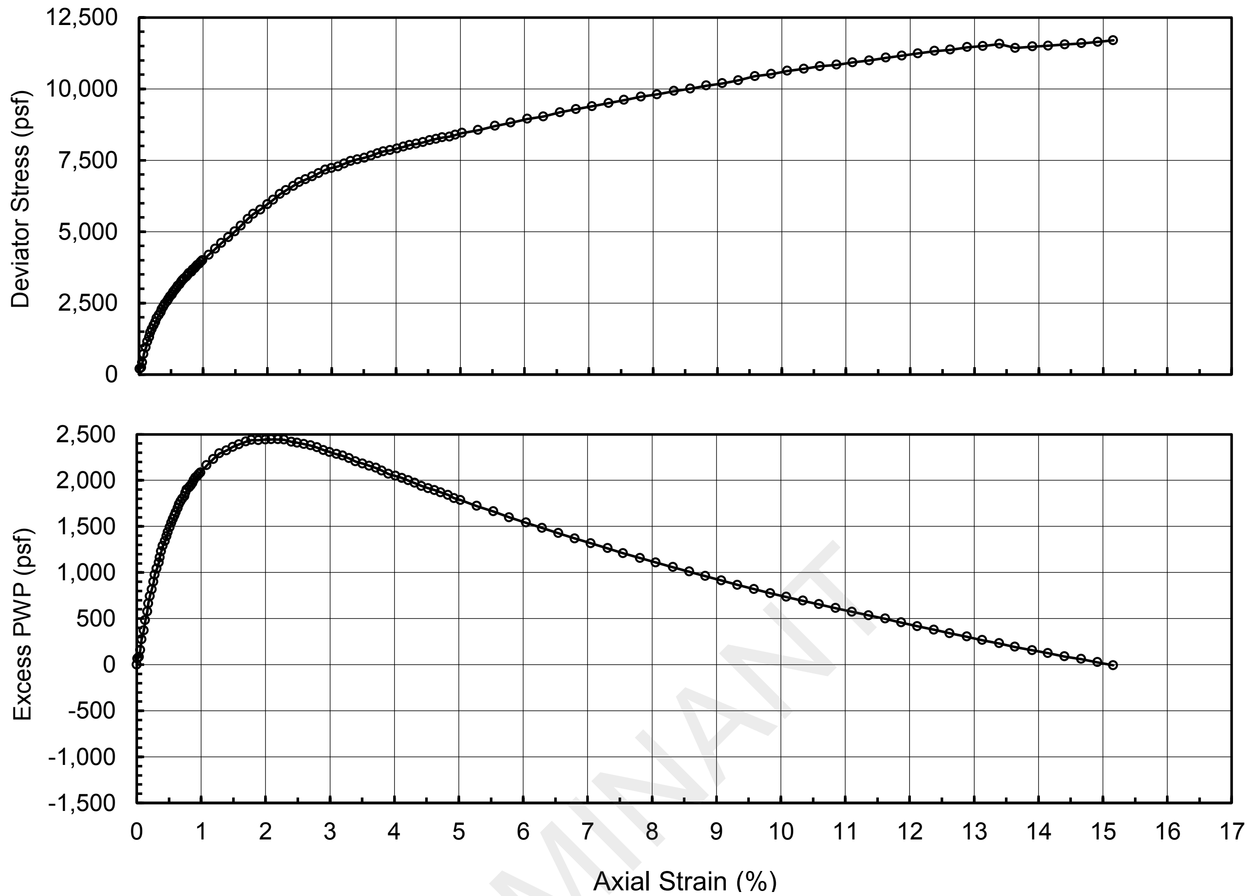


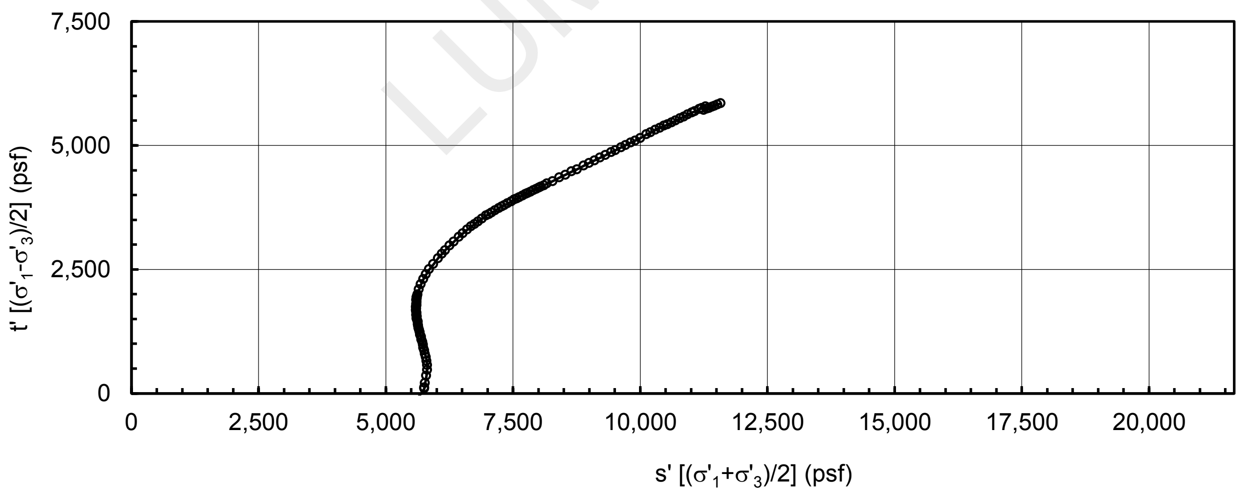
Specimen Description:	Dark Gray Sandy CLAY						
Initial Specimen Diameter (inch) =				Initial Specimen Height (inch) =			
Initial Water Content (%) =				Water Content at End of Test (%) =			
Initial Moist Unit Weight (pcf) =				B-value =			
Back Pressure (BP, psf) =				Consolidation Stress (σ'_3, psf) =			
Initial Lateral Stress (σ'_3, psf) =				Consolidation t_{50} (min) =			
Initial Deviator Stress ($\sigma_1 - \sigma_3$, psf) =				Rebound Stress (σ'_3, psf) =			
Test Strain Rate (%/hour) =				Rebound t_{50} (min) =			
LL =	33	PI =	20	USCS	CL	**Performed by**	SBK
Comments:						**Reviewed by**	PCM

Golder Associates

Isotropically Consolidated Undrained Triaxial Test (ICU)

Project Title: Big Brown Plant, Pond Stability **Project Number:** 123-94128 **Date:** 13-Nov-12
Boring Number: BH-1 **Specimen Name:** TO-9 **Depth (ft):** 33.0

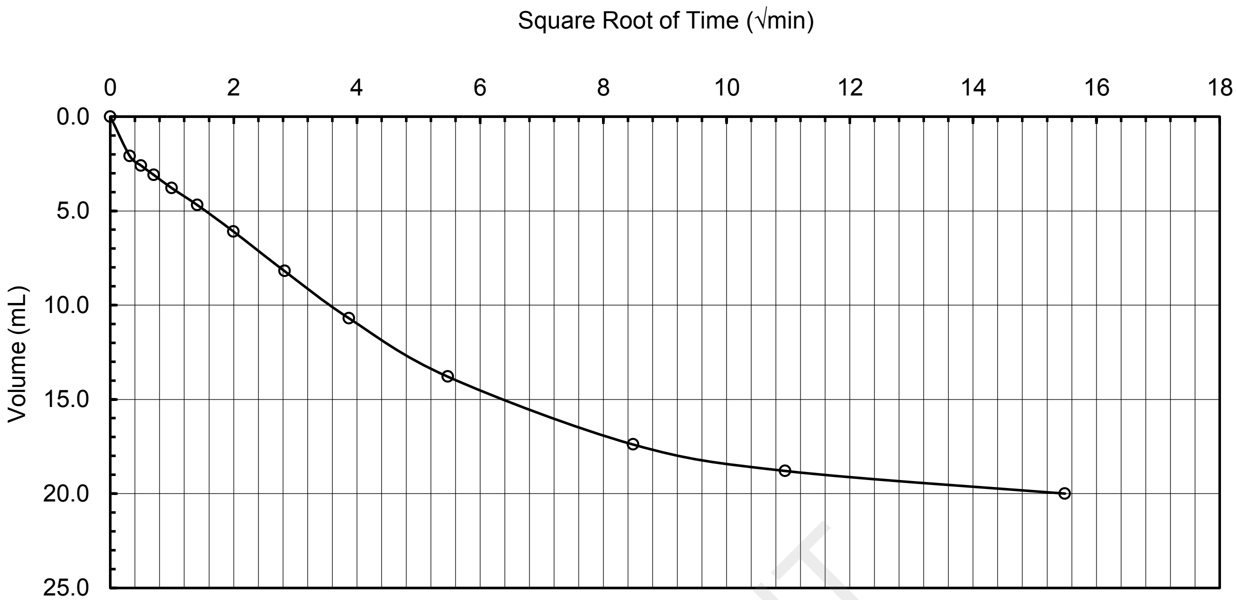


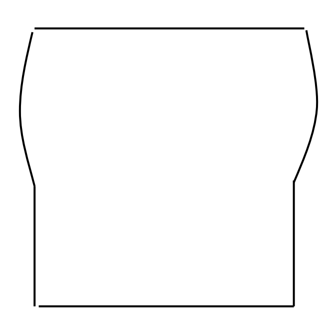


Specimen Description: Light Gray Sandy CLAY (visual classification)			
Initial Specimen Diameter (inch) =	2.83	Initial Specimen Height (inch) =	5.89
Initial Water Content (%) =	16.1	Water Content at End of Test (%) =	17.9
Initial Moist Unit Weight (pcf) =	127.4	B-value =	0.97
Back Pressure (BP, psf) =	5040.0	Consolidation Stress (σ'_3, psf) =	5717.7
Initial Lateral Stress (σ'_3, psf) =	5717.7	Consolidation t_{50} (min) =	11
Initial Deviator Stress ($\sigma_1 - \sigma_3$, psf) =	-164.7	Rebound Stress (σ'_3, psf) =	NA
Test Strain Rate (%/hour) =	1.0	Rebound t_{50} (min) =	NA
LL = PI =	USCS	(CL) **Performed by**	SBK
Comments:		**Reviewed by**	PCM

Isotropically Consolidated Undrained Triaxial Test (ICU)

Project Title: Big Brown Plant, Pond Stability **Project Number:** 123-94128 **Date:** 13-Nov-12
Boring Number: BH-1 **Specimen Name:** TO-9 **Depth (ft):** 33.0





FAILURE SKETCH

Consolidation Stress (σ'_3, psf) =			5717.7
Consolidation t_{50} (min) =			11
Consolidation Volume Change (mL) =			20.0
Unloading Stress (psf) =			NA
Unloading t_{50} (min) =			NA
Unloading Volume Change (mL) =			NA
LL =		PI =	
USCS	(CL)		
Gs =	2.65	assumed	

Performed by	SBK
Reviewed by	PCM

Golder Associates

Established in 1960, Golder Associates is a global, employee-owned organization that helps clients find sustainable solutions to the challenges of finite resources, energy and water supply and management, waste management, urbanization, and climate change. We provide a wide range of independent consulting, design, and construction services in our specialist areas of earth, environment, and energy. By building strong relationships and meeting the needs of clients, our people have created one of the most trusted professional services organizations in the world.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Inc.
500 Century Plaza Drive, Suite 190
Houston, TX 77073 USA
Tel: (281) 821-6868
Fax: (281) 821-6870

Golder Associates

Engineering Earth's Development, Preserving Earth's Integrity