GOLDER

REPORT

Unstable Areas Demonstration

Nucla Station Ash Disposal Facility

Submitted to:

Tri-State Generation and Transmission Association, Inc.

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Submitted by:

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1779126B

October 9, 2018

Table of Contents

1.0 INTRODUCTION

1.1 Background

Golder Associates Inc. (Golder) has prepared this report for Tri-State Generation and Transmission Association, Inc. (Tri-State) to summarize our assessment of Tri-State's Nucla Station Ash Disposal Facility (the Facility) with respect to factors that could cause an area to be considered an unstable area, and to provide supporting information demonstrating that the Facility is not located in an unstable area. This report includes written certification by a qualified professional engineer registered in Colorado stating that the Facility is not located in an unstable area and is in compliance with 40 CFR 257.64.

1.2 Facility Information

The Facility is located in Montrose County, approximately 5.5 miles southeast of Nucla, Colorado. It serves as the location for final deposition of coal combustion residuals (CCRs or ash) generated at Tri-State's Nucla Station, a 110-megawatt, coal-fired electric generation plant located near Nucla, Colorado, and classifies as an existing CCR landfill under 40 CFR 257.

2.0 UNSTABLE AREA ASSESSMENT

2.1 Requirements

An unstable area is defined under 40 CFR 257.53 as follows:

> Unstable area means a location that is susceptible to natural or human-induced events or forces capable of impairing the integrity, including structural components of some or all of the CCR unit that are responsible for preventing releases from such unit. Unstable areas can include poor foundation conditions, areas susceptible to mass movements, and karst terrains.

Under 40 CFR 257.64(b), the following factors, at a minimum, must be considered as part of the assessment to determine whether the Facility is located in an unstable area:

- On-site or local soil conditions that may result in significant differential settling
- On-site or local geologic or geomorphologic features
- On-site or local human-made features or events (both surface and subsurface)

2.2 Review of Available Information

Golder reviewed the following information in the course of completing the unstable area assessment:

- Engineering design and operations report for ash disposal on the initial 40-acre landfill footprint (Colorado-Ute Electric Association, Inc. 1987)
- Hydrogeologic investigation report for ash disposal on the initial 40-acre landfill footprint (Western Colorado Testing, Inc., and J.F.T. Agapito & Associates, Inc. 1987)
- Design and operations report for ash disposal on a 40-acre lateral expansion footprint (GeoTrans Inc. 2002)
- Landslides dataset for Colorado (Colorado Geological Survey, Colorado Landslide Inventory)

- Quaternary faults and folds dataset for the United States (United States Geological Survey and Colorado Geological Survey 2006)
- Karst dataset for the United States (Weary and Doctor 2014)
- Report documenting the final cover system in place over approximately 22 acres of the Facility (Golder 2015)
- 2015 annual inspection report for the Facility (Golder 2016)
- 2016 annual inspection report for the Facility (Golder 2017a)
- Addenda to the design and operations report for the Facility (Golder 2017b)
- Geologic and hydrogeologic site characterization report for the Facility (Golder 2017c)
- Groundwater monitoring system certification for the Facility (Golder 2017d)
- 2017 annual inspection report for the Facility (Golder 2018)
- Historical mine boundaries dataset (United States Geological Survey, Mineral Resources Data System)

In addition to the review of available information, the professional engineer overseeing the unstable area assessment has visited and observed the Facility on several occasions, including the site visits associated with annual inspections conducted for compliance with 40 CFR 257.84(b)(1) in 2015, 2016, and 2017, and has visually assessed the factors that could cause the area within and in close proximity to the Facility to be considered an unstable area.

2.3 Geotechnical and Geologic Information

The site is located within the Paradox Basin, which is an area of the Colorado Plateau that is underlain by a sequence of Pennsylvanian-age evaporites dominated by halite bedding (Masbruch and Shope 2014). The geology of the Paradox Basin is controlled by the Uncompahgre Uplift (Plateau) to the north, the San Juan Volcanic Region to the east, and the Salt Anticlines to the southwest (Hanna and Gandera 2000). The topography of the Paradox Basin is mostly composed of high plateaus with canyons, washes, and dry streambeds.

Subsurface soil and rock conditions encountered at the site can be categorized into the following general strata, presented in sequential order beginning at the ground surface (Golder 2017c):

- Stratum 1 – Regolith (i.e., unconsolidated material) accumulations of sandy lean clay and clayey sand, 0 to 15 feet thick, primarily derived from weathering of the underlying Dakota Sandstone and depositional processes
- Stratum 2 – Dakota Sandstone, 0 to 110 feet thick, an Upper Cretaceous coastal plain deposit primarily composed of sandstone and conglomerate with interbedded mudstone, carbonaceous shale, coal, and claystone (Masbruch and Shope 2014) that is largely absent on the western edge of the site
- Stratum 3 – Burro Canyon Formation, 90 to 210 feet thick, a Lower Cretaceous fluvial and floodplain deposit primarily composed of sandstone and conglomerate with interbedded siltstone, shale, and mudstone (Lowe et al. 2007, Masbruch and Shope 2014)
- Stratum 4 – Morrison Formation, at least 355 feet thick, an Upper Jurassic unit comprising the Brushy Basin Member, composed of variegated mudstone, claystone, and siltstone with discontinuous lenses of

conglomerate and sandstone, and the Salt Wash Member, composed of a fine- to medium-grained fluvial sandstone with discontinuous interbedded conglomeratic sandstone and mudstone (Freethey and Cordy 1991, Lowe et al. 2007, Masbruch and Shope 2014)

Five major field programs have been carried out during the history of the Facility for characterization of geotechnical and geologic conditions beneath and around the Facility. In 1987, the first drilling program was performed within the northern half of the site to assess its suitability for construction of an ash landfill (Western Colorado Testing, Inc., and J.F.T. Agapito & Associates, Inc. 1987). To characterize the site geology, one corehole and one drillhole were drilled to depths of 250 feet below ground surface (ft bgs) and 305 ft bgs, respectively. In 1988, four boreholes were drilled to a depth of 50 ft bgs (GeoTrans Inc. 2002). In 2001, three boreholes were drilled to a depth of 50 ft bgs and three more boreholes were drilled to depth of 10 ft bgs. This investigation was in support of the engineering design for expansion of the Facility onto the southern half of the site (Geo-Trans Inc. 2002). In 2015, five boreholes were drilled to depths ranging from 97 ft bgs to 240 ft bgs for further characterization of site hydrogeology focused on the Burro Canyon Formation (Golder 2017c). In 2016, six boreholes were drilled to depths ranging from 404 ft bgs to 565 ft bgs for further characterization of site hydrogeology focused on the Morrison Formation and installation of groundwater monitoring wells for compliance with 40 CFR 257 (Golder 2017d).

2.4 Findings

Golder's review of available information and knowledge of the Facility indicate the following with respect to factors that could cause an area to be considered an unstable area:

- On-site or local soil conditions that may result in significant differential settling
  - The thickness of unconsolidated material (soil) at the site prior to construction of the Facility is limited, ranging from 0 to 15 feet (Golder 2017c).
  - The unconsolidated material found at the site consists primarily of soils characterized as clayey sand, sandy lean clay, or silty sand (Golder 2015). The plasticity index for the soils found at the site is generally less than 20 (Golder 2015). Soils having these characteristics are not commonly prone to high compressibility.
  - For purposes of accumulating soil for Facility construction and closure, Tri-State excavated and stockpiled much or all of the unconsolidated material before constructing or expanding the Facility footprint into a given area. Thus, the Facility is primarily founded directly on rock.
  - The Facility is at its full design height across the majority of its footprint, and no evidence of differential settlement has been observed at the Facility during annual inspections by a qualified professional engineer (Golder 2016, Golder 2017a, Golder 2018).
  - Given the limited thickness of unconsolidated material (or more commonly the absence of unconsolidated material) beneath the Facility, the characteristics of the unconsolidated material (i.e., not commonly prone to high compressibility), and site observations, Golder concludes that there are not on-site or local soil conditions that may result in significant differential settling.

- On-site or local geologic or geomorphologic features
  - The Facility is not located in an area with geological conditions that create the potential for karst terrain or features, as shown in Figure 1.
  - The Facility is not located in an area with known faults or folds that demonstrate geological evidence of coseismic surface deformation during the Quaternary Period, as shown in Figure 1.
  - The Facility is not located in an area with landslide potential, as shown in Figure 1.
  - The northeast corner of the Facility lies atop a northwest-trending ridge, and site topography generally slopes south and west towards the southwest corner. The Facility is higher in elevation than the surrounding topography around its full perimeter. As such, the Facility is not susceptible to instability related to mass movement (e.g., landslides, avalanches, debris flows, solifluction, block sliding, or rock fall) from adjacent areas.
  - No evidence of faulting, rock fall, landslides, or local soil conditions that are conducive to downslope movement of soil, rock, or debris have been observed at the Facility during annual inspections by a qualified professional engineer (Golder 2016, Golder 2017a, Golder 2018).
- On-site or local human-made features or events (both surface and subsurface)
  - There are no known historical mine workings at the site, as shown on Figure 1. Geotechnical investigations at the site have not identified coal seams or other subsurface resources of sufficient thickness to have motivated mining at the site.
  - Slope stability analyses for the Facility indicate a factor of safety equal to 1.5 for static conditions and a factor of safety equal to 1.1 under design seismic loading (Golder 2017b). The associated critical slip surfaces are limited to the cover soils (shallow depth) and do not pass into the ash or rock underlying the Facility. The slope stability analyses for the Facility are summarized in Appendix A.
  - The Facility is the only human-made structure or permanent feature on the site. As such, no human-made features having the potential to create unstable conditions have been observed at the Facility during annual inspections by a qualified professional engineer (Golder 2016, Golder 2017a, Golder 2018).

3.0 CONCLUSION

Based upon the assessment described in this report, the undersigned professional engineer registered in Colorado certifies that the Nucla Station Ash Disposal Facility is not located in an unstable area and is in compliance with 40 CFR 257.64.

4.0 REFERENCES

Colorado-Ute Electric Association, Inc. (1987). Nucla Station Fly Ash, Bottom Ash, Slag and Flue Gas Emission Control Waste Disposal Facility – Engineering Design and Operations Report. February 1987.

Colorado Geological Survey. Colorado Landslide Inventory. Available online: http://coloradogeologicalsurvey.org/geologic-hazards/landslides/colorado-landslide-inventory/. Accessed September 12, 2018.

Freethey, G.W., and G.E. Cordy (1991). Geohydrology of Mesozoic rocks in the Upper Colorado River Basin in Arizona, Colorado, New Mexico, Utah, and Wyoming, excluding the San Juan Basin. U.S. Geological Survey Professional Paper 1411–C. Available online: http://pubs.er.usgs.gov/publication/pp1411C. Accessed September 13, 2018.

GeoTrans Inc. (2002). Design and Operations Report, Nucla, Colorado Ash Disposal Facility. Report prepared for Tri-State Generation and Transmission Association, Inc. March 2002.

Golder Associates Inc. (2015). Final Cover Verification Program. Report prepared for Tri-State Generation and Transmission Association, Inc. Project number 103-81938. September 10, 2015.

Golder Associates Inc. (2016). Coal Combustion Residuals Landfill Annual Inspection Report. Report prepared for Tri-State Generation and Transmission Association, Inc. Project number 103-81938. January 18, 2016.

Golder Associates Inc. (2017a). Coal Combustion Residuals Landfill Annual Inspection Report. Report prepared for Tri-State Generation and Transmission Association, Inc. Project number 1657746. January 16, 2017.

Golder Associates Inc. (2017b). Design & Operations Report Addenda. Report prepared for Tri-State Generation and Transmission Association, Inc. Project number 103-81938. April 11, 2017.

Golder Associates Inc. (2017c). Site Characterization Report. Report prepared for Tri-State Generation and Transmission Association, Inc. Project number 153893416B. June 21, 2017.

Golder Associates Inc. (2017d). Coal Combustion Residuals Landfill Groundwater Monitoring System Certification. Report prepared for Tri-State Generation and Transmission Association, Inc. Project number 1779126B. October 16, 2017.

Golder Associates Inc. (2018). Coal Combustion Residuals Landfill Annual Inspection Report. Report prepared for Tri-State Generation and Transmission Association, Inc. Project number 1779126B. January 12, 2018.

Hanna, T.M., and W. Gandera (2000). Paradox Basin, in Aiken and others, eds., Colorado Ground-water Atlas. Colorado Ground-Water Association.

Lowe, M., J. Wallace, S.M. Kirby, and C.E. Bishop (2007). The Hydrogeology of Moab-Spanish Valley, Grand and San Juan Counties, Utah, with Emphasis on Maps for Water-Resource Management and Land-Use Planning. Utah Geological Survey Special Study 120.

Masbruch, M.D., and C.L. Shope (2014). Groundwater and Surface-Water Resources in the Bureau of Land Management Moab Master Leasing Plan Area and Adjacent Areas, Grand and San Juan Counties, Utah, and Mesa and Montrose Counties, Colorado. United States Geological Survey Open-File Report 2014-1062. Available online: https://pubs.usgs.gov/of/2014/1062/pdf/ofr2014-1062.pdf.

United States Geological Survey. Mineral Resources Data System: Historic Mine Boundaries. Available online: http://mining.state.co.us/Reports/Documents/Historic_Mine.zip. Accessed September 12, 2018.

United States Geological Survey and Colorado Geological Survey (2006). Quaternary Fault and Fold Database for the United States. Available online: http://earthquake.usgs.gov/hazards/qfaults. Accessed September 12, 2018.

Weary, D.J., and D.H. Doctor (2014). Karst in the United States: A Digital Map Compilation and Database. United States Geological Survey Open-File Report 2014-1156. Available online: https://pubs.usgs.gov/of/2014/1156/pdf/of2014-1156.pdf. Accessed September 12, 2018.

Western Colorado Testing, Inc., and J.F.T. Agapito & Associates, Inc. (1987). Final Report - Geological and Geohydrological Evaluation of Dry Storage Site, Nucla CFB Demonstration Project. Report prepared for Colorado-Ute Electric Association, Inc. July 1987.

Signature Page

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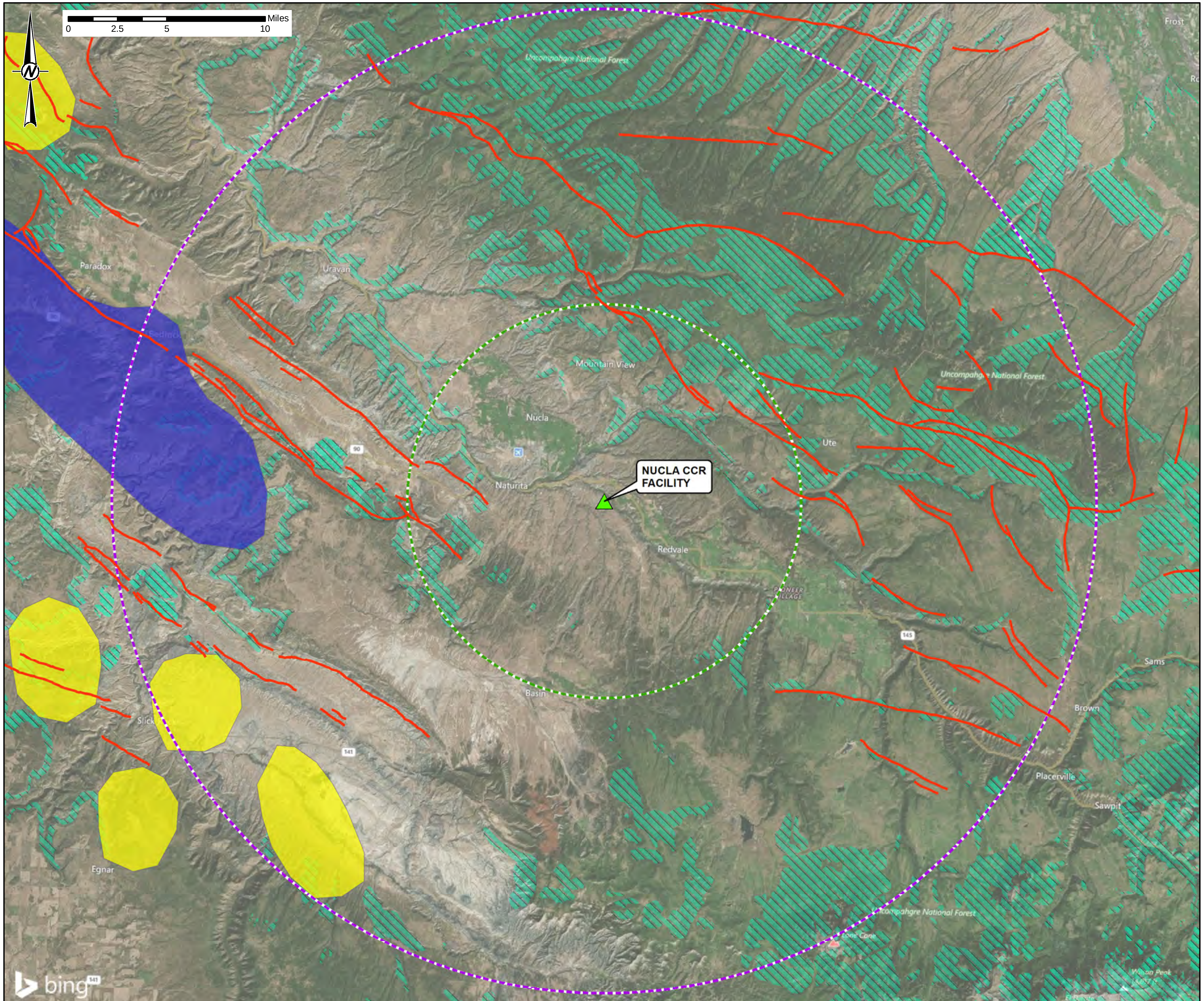
Figure



LEGEND

- SITE LOCATION
- 10-MILE RADIUS FROM SITE
- 25-MILE RADIUS FROM SITE
- QUATERNARY FAULT
- HISTORICAL MINE BOUNDARIES (NONE WITHIN MAP EXTENTS)
- AREA WITH POTENTIAL FOR LANDSLIDES

KARST TYPE

- FISSURES, TUBES AND CAVES GENERALLY LESS THAN 1,000 FT (300 M) LONG; 50 FT (15 M) OR LESS VERTICAL EXTENT; IN GENTLY DIPPING TO FLAT-LYING BEDS OF GYPSUM
- FISSURES, TUBES AND CAVES GENERALLY LESS THAN 1,000 FT (300 M) LONG; 50 FT (15 M) OR LESS VERTICAL EXTENT; IN MODERATELY TO STEEPLY DIPPING BEDS OF CARBONATE ROCK

KEY MAP

REFERENCES

1. KARST DATASET: DIGITAL ENGINEERING ASPECTS OF KARST MAP : A GIS VERSION OF DAVIES, W.E., SIMPSON, J.H., OHLMACHER, G.C., KIRK, W.S., AND NEWTON, E.G., 1984, ENGINEERING ASPECTS OF KARST:
U.S. GEOLOGICAL SURVEY, NATIONAL ATLAS OF THE UNITED STATES OF AMERICA, SCALE 1:7,500,000
BY BRET D. TOBIN AND DAVID J. WEARY
U.S. GEOLOGICAL SURVEY OPEN-FILE REPORT 2004-1352
2. QUATERNARY FAULTS DATASET: U.S. GEOLOGICAL SURVEY AND COLORADO GEOLOGICAL SURVEY, 2006, QUATERNARY FAULT AND FOLD DATABASE FOR THE UNITED STATES, ACCESSED SEPTEMBER 2018, FROM USGS WEB SITE: HTTP//EARTHQUAKE.USGS.GOV/HAZARDS/QFAULTS/.
3. HISTORICAL MINE BOUNDARIES DATASET: MINERAL RESOURCES DATA SYSTEM (MRDS), UNITED STATES GEOLOGICAL SURVEY (USGS).
4. LANDSLIDES DATASET: COLORADO GEOLOGICAL SURVEY, 2004.
5. BASEMAP: ESRI, BING MAPS, MICROSOFT CORPORATION.

CLIENT
TRI-STATE GENERATION AND TRANSMISSION ASSOCIATION, INC.

PROJECT
UNSTABLE AREAS DEMONSTRATION

TITLE
QUATERNARY FAULTS AND KARST FEATURES IN PROXIMITY TO NUCLA CCR FACILITY

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-14
DESIGNED	KJC
PREPARED	KJC
REVIEWED	JEO
APPROVED	TJS

PROJECT NO. 1779126B
FIGURE 1

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

APPENDIX A

Global Slope Stability Calculations

Golder Associates

CALCULATIONS

Date:	March 9, 2017	**Made by:**	ALB
Project No.:	103-81938	**Checked by:**	JEO
Site Name:	Nucla Station Ash Disposal Facility	**Reviewed by:**	JEO
Subject:	**GLOBAL SLOPE STABILITY ANALYSIS**		

1.0 OBJECTIVE

Evaluate the global slope stability of the Nucla Station Ash Disposal Facility (landfill) at final closure. The analysis assesses the stability of the landfill using the existing sideslope grades in areas that have already been constructed and closure grades consistent with the Design and Operations Report above the constructed areas.

2.0 METHODOLOGY

Two cross sections were selected for global slope stability analyses. Limit equilibrium slope stability analyses were performed using Spencer's method in Slide 7.0, a two-dimensional slope stability modeling software platform (Rocscience 2017). Spencer's method considers both moment and force equilibrium. It is common geotechnical practice to analyze the stability of embankment slopes using limit equilibrium methods.

Two sets of analyses were conducted to evaluate different slip surface depth ranges for each cross section. The first set of analyses focused on shallow circular slip surfaces within the soil material used in the construction of the starter berms and containment berms (dikes). This material typically classifies as lean clay and also serves as final cover material for the landfill sideslopes. Movement along the shallow slip surfaces (minimum slip surface depth of 3 feet) considered in the first set of analyses would result in minor sloughing with limited or no financial or environmental consequence. The second set of analyses focused on deeper circular slip surfaces that pass into the comingled fly ash and bottom ash contained in the landfill. Since the comingled ash is stronger than the lean clay, a minimum slip surface depth of 15 feet was used to force

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Site Name:	Nucla Station Ash Disposal Facility	Checked by:	JEO
Date:	March 9, 2017	Reviewed by:	JEO

slip surfaces into the comingled ash. The slope stability analyses were performed to evaluate the minimum factors of safety under static and seismic loading conditions.

2.1 Geometry

Two cross sections were selected to represent critical slope configurations corresponding to: 1) the steepest bedrock topography dipping toward the toe of the embankment, and 2) the longest embankment slope at final closure. A plan view with the cross section locations is included as Figure A-1 and illustrates:

- South Section: Cross section through the south embankment, representing the highest waste grades and some of the steepest bedrock slopes dipping north to south.
- West Section: Cross section through the west embankment, representing one of the longest slopes.

2.2 Analysis

The slope stability analyses were predicated on the following assumptions:

- Factors of safety were computed using Spencer's method (Spencer 1967).
- The critical slip surface was assumed to be circular, since there are no geosynthetics or known planes of geologic weakness underlying the landfill.
- The United States Geological Survey (USGS) seismic hazard analysis indicates a 2% probability of exceeding a peak ground acceleration (PGA) of 0.12 g in 50 years (see Attachment A-1). Pseudo-static analyses were conducted using a horizontal seismic coefficient of 0.06, corresponding to half of the PGA, in accordance with the recommendations of Hynes-Griffin and Franklin (1984).
- Strength properties for lean clay were selected based on the results of consolidated-undrained triaxial testing performed on soil sampled from a stockpile that serves as a borrow source for containment berm construction (refer to Attachment A-2).
- Lean clay was assumed to exhibit drained strengths under static loading and undrained strengths under seismic loading. A 20% reduction was applied to lean clay undrained strengths in the seismic analyses, as recommended by Hynes-Griffin and Franklin (1984).

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Date:	March 9, 2017	Reviewed by:	JEO

- Lean clay density was selected based on the average of 30 in situ density measurements in containment berms at the landfill.
- The bedrock underlying the fly ash was assumed to have infinite strength, constraining slip surfaces to the comingled ash and lean clay.
- Strength properties for comingled ash were selected based on the results of drained direct shear testing performed on comingled ash sampled from the landfill (refer to Attachment A-3). Comingled ash was assumed to exhibit drained strengths under static and seismic loading conditions.
- Comingled ash density was based on an average in-place dry unit weight of 64.9 pounds per cubic foot (pcf), as provided by Tri-State Generation and Transmission Association, Inc., and a typical moisture content of 15%.
- Comingled ash was assumed to be unsaturated.

2.3 Material Properties

A summary of material properties used in the slope stability analyses is presented in Table A-1:

Table A-1: Material Properties

Condition	Material	Total Unit Weight (pcf)	Strength Type	Friction Angle (°)	Cohesion (psf)
Static Loading	Bedrock	120.0	Infinite Strength	--	--
Seismic Loading					
Static Loading	Comingled Ash	74.6	Shear-Normal Function[1]	--	--
Seismic Loading					
Static Loading	Lean Clay	109.0	Mohr-Coulomb	22	90
Seismic Loading			Shear-Normal Function[2]	--	--

Notes:

1). The shear-normal function defining the drained strength of comingled ash is based on the results of drained direct shear testing as follows: shear strength of 450 pounds per square foot (psf) under zero normal stress; shear strength of 6,975 psf under 7,200-psf normal stress; shear strength of 13,072 psf under 14,400-psf normal stress; shear strength of 19,763 psf under 21,600-psf normal stress.

2). The shear-normal function defining the undrained strength of lean clay is based on the results of consolidated-undrained triaxial testing, with a 20% reduction for cyclic

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loading, as follows: shear strength of 72 psf under zero initial effective stress; shear strength of 219 psf under 360-psf initial effective stress; shear strength of 218 psf under 720-psf initial effective stress; shear strength of 346 psf under 1,440-psf initial effective stress.

3.0 RESULTS AND CONCLUSIONS

Results of the slope stability analyses are summarized in Table A-2. The results are also illustrated graphically on the figures in Attachment A-4. The figures depict the critical slip surfaces and computed minimum factors of safety for the analyzed scenarios.

Table A-2: Summary of Analyses and Computed Minimum Factors of Safety

Section	Shallow (Containment Berms)		Deeper (Comingled Ash)	
	Static	*Seismic*	*Static*	*Seismic*
South Section	1.8	1.4	3.5	2.8
West Section	1.5	1.1	2.9	2.4

Based on the factors of safety computed using the methods and assumptions described herein, the landfill is expected to remain stable with an acceptable safety margin. Factors of safety of 1.5 or greater were computed for critical slip surfaces through the containment berms under static loading. Factors of safety of 2.9 or greater were computed for critical slip surfaces through comingled ash under static loading. Factors of safety of 1.1 or greater were computed for critical slip surfaces through the containment berms under seismic loading. Factors of safety of 2.4 or greater were computed for critical slip surfaces through comingled ash under seismic loading. The critical slip surfaces for the south section and the west section were shallow, passing only through the containment berms, and would not be expected to affect the global slope stability of the landfill.

Project No.:	103-81938	Made by:	ALB
Site Name:	Nucla Station Ash Disposal Facility	Checked by:	JEO
Date:	March 9, 2017	Reviewed by:	JEO

4.0 REFERENCES

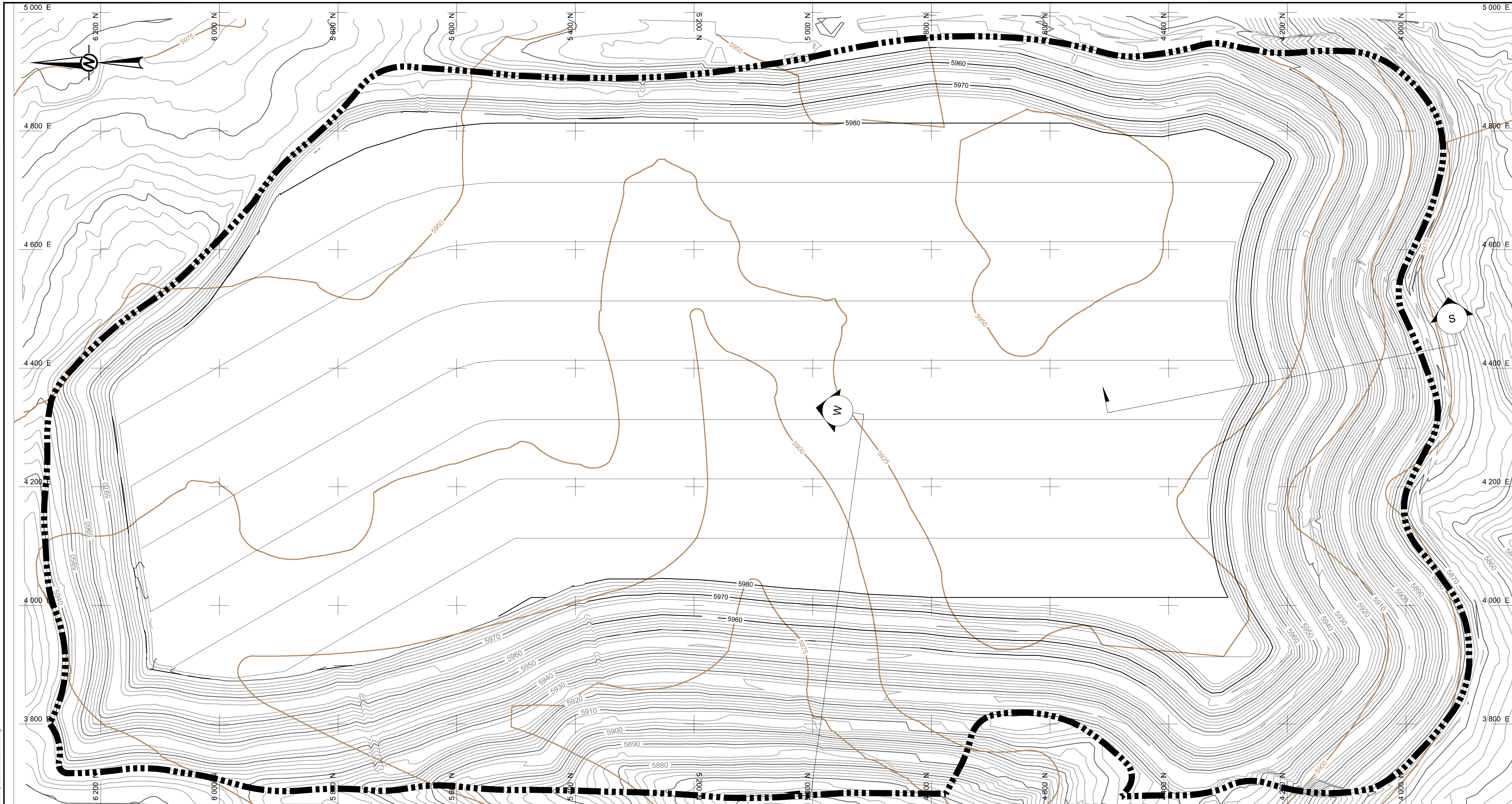
Hynes-Griffin, M. and A. Franklin. 1984. Rationalizing the Seismic Coefficient Method. Miscellaneous Paper GL-84-13. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

RocScience. 2017. Slide Version 7.022. Build date: January 19. 2017.

Spencer, E. 1967. A Method of Analysis of the Stability of Embankments Assuming Parallel Inter-Slice Forces. Geotechnique, Vol. XVII, No. 1, pp. 11–26.

United States Geological Survey (USGS). 2014. PGA with 2% probability of exceedance in 50 years, USGS map, 2014 rev. Available online: http://earthquake.usgs.gov/hazards/products/conterminous/2014/2014pga2pct.pdf accessed July 27, 2015.

FIGURE



LEGEND

- EXISTING GROUND TOPOGRAPHY (REFERENCE 1)
- PROPOSED GROUND TOPOGRAPHY
- TOP OF BEDROCK TOPOGRAPHY (REFERENCE 2)
- APPROXIMATE LIMITS OF ASH

NOTES

1. EXISTING SITE TOPOGRAPHY WAS PROVIDED BY TRI-STATE GENERATION AND TRANSMISSION ASSOCIATION, INC. TOPOGRAPHY IS A COMPOSITE BASED ON SURVEYS PERFORMED BY DEL-MONT CONSULTANTS BETWEEN 2008 AND 2015.
2. TOP OF BEDROCK TOPOGRAPHY WAS TAKEN FROM UNITED STATES GEOLOGICAL SURVEY DATA FOR THE AREA FROM 1964.

CLIENT
TRI-STATE GENERATION AND TRANSMISSION ASSOCIATION, INC.

PROJECT
NUCLA STATION
ASH DISPOSAL FACILITY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-03-08
DESIGNED	MBR
PREPARED	MBR
REVIEWED	ALB
APPROVED	JEO

TITLE
SLOPE STABILITY SECTION LOCATIONS

PROJECT NO. 103-81938 REV. A FIGURE A-1

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ATTACHMENT A-1

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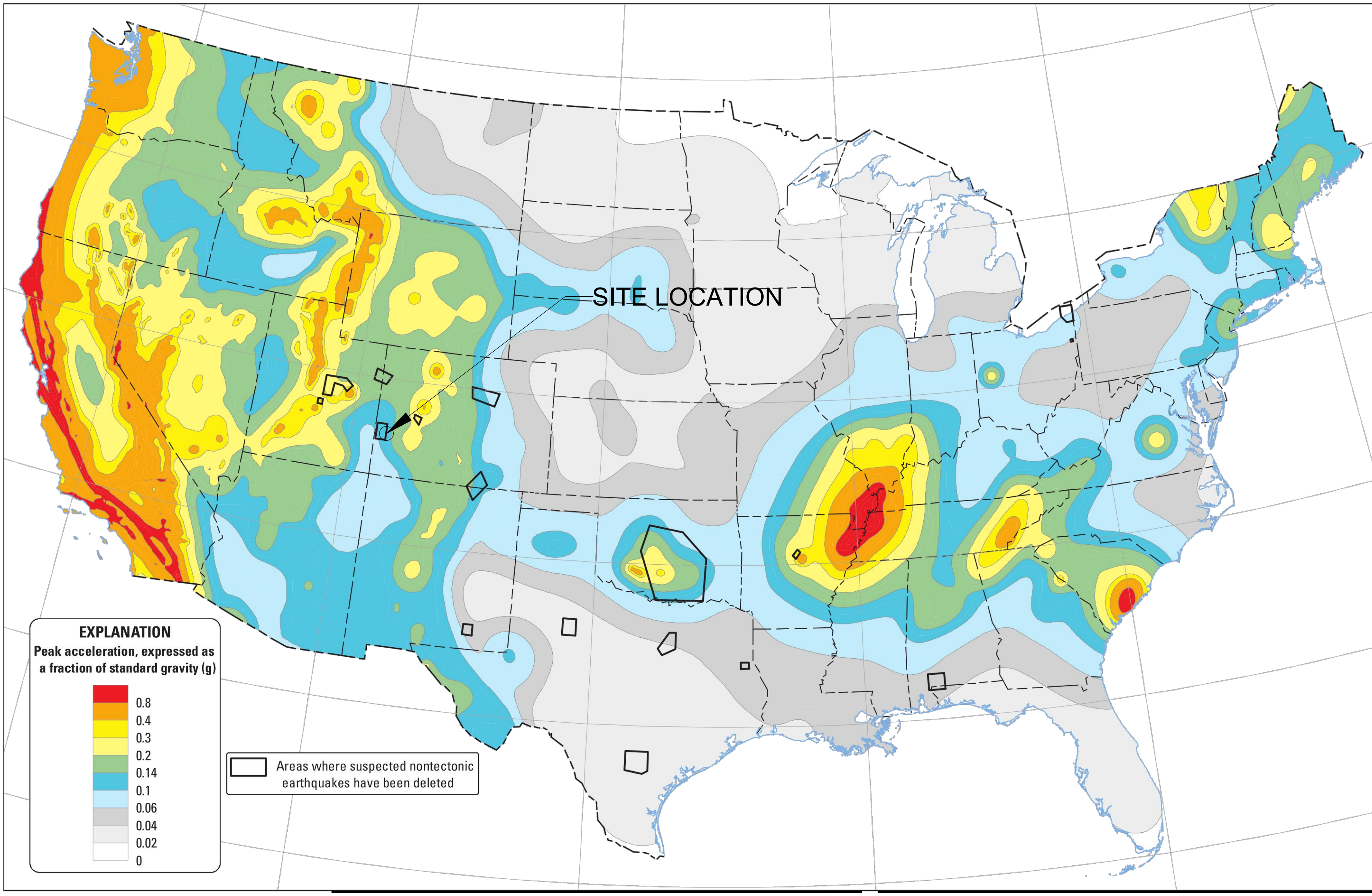

CLIENT
TRI-STATE GENERATION AND TRANSMISSION ASSOCIATION, INC.

PROJECT
NUCLA STATION
ASH DISPOSAL FACILITY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-02-10
PREPARED	ALB
DESIGN	ALB
REVIEW	JEO
APPROVED	JEO

TITLE
TWO PERCENT PROBABILITY OF EXCEEDANCE IN 50 YEARS MAP OF PEAK GROUND ACCELERATION

PROJECT No. 103-81938
Rev. A
ATTACHMENT A-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
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ATTACHMENT A-2

	Point 1		Point 2		Point 3	
Boring or Test Pit:	--		--		--	
Sample:	TP-3A		TP-3A		TP-3A	
Depth:	--	ft	--	ft	--	ft
Point No.:	1		2		3	

Initial

	Point 1		Point 2		Point 3	
Length =	5.765	in	5.765	in	5.765	in
Diameter =	2.863	in	2.865	in	2.867	in
Wet Mass =	2.310	lb	2.308	lb	2.313	lb
Area =	6.438	in^2	6.447	in^2	6.456	in^2
Volume =	37.11	in^3	37.17	in^3	37.22	in^3
Specific Gravity =	2.66	(ASTM D854)	2.66	(ASTM D854)	2.66	(ASTM D854)
Dry Mass of Solids =	1.934	lb	1.933	lb	1.940	lb
Moisture Content =	19.4%		19.4%		19.2%	
Wet Unit Weight =	107.5	pcf	107.3	pcf	107.4	pcf
Dry Unit Weight =	90.1	pcf	89.9	pcf	90.1	pcf
Void Ratio =	0.84		0.84		0.84	
Percent Saturation =	61%		61%		61%	

After Consolidation

	Point 1		Point 2		Point 3	
Length =	5.661	in	5.664	in	5.571	in
Diameter =	2.781	in	2.796	in	2.781	in
Area =	6.073	in^2 (Method B)	6.141	in^2 (Method B)	6.074	in^2 (Method B)
Volume =	34.38	in^3	34.78	in^3	33.84	in^3
Moisture Content =	26.5%		27.3%		25.3%	
Wet Unit Weight =	123.0	pcf	122.2	pcf	124.1	pcf
Dry Unit Weight =	97.2	pcf	96.0	pcf	99.1	pcf
Void Ratio =	0.70		0.73		0.67	
Percent Saturation =	100%		100%		100%	

	Point 1		Point 2		Point 3	
B Parameter =	0.97		0.95		0.96	
Shear Rate =	0.084%	/min.	0.084%	/min.	0.083%	/min.
t_{50} =	0.3	min.	1.6	min.	3.6	min.
Strain at Failure =	0.7%		0.9%		2.6%	

	Point 1		Point 2		Point 3	
Cell Pressure =	52.5	psi	75.0	psi	90.0	psi
Back Pressure =	50.0	psi	70.0	psi	80.0	psi
Confining Pressure =	2.5	psi	5.0	psi	10.0	psi

Notes:

USCS description (ASTM D2487): Gravelly lean clay with sand, dark brown, moist

Atterberg limits: LL = 40 PL = 20 PI = 20 (ASTM D4318)

Percent finer: 3/4 in. = 88% No. 4 = 86% No. 200 = 63% (ASTM D422, refer to separate report for gradation curve)

Specimen type:		Intact	X	Reconstituted	Remold targets: 89.8 pcf (dry) at 19.5% moisture	
Moisture from:		Cuttings	X	Entire specimen		
Saturation method:	X	Wet		Dry		
Failure criterion:		$(\sigma'_1/\sigma'_3)_{max}$	X	$(\sigma'_1-\sigma'_3)_{max}$		% strain
Membrane effect:	X	Corrected		Not Corrected		

Golder Associates Inc.

Title:

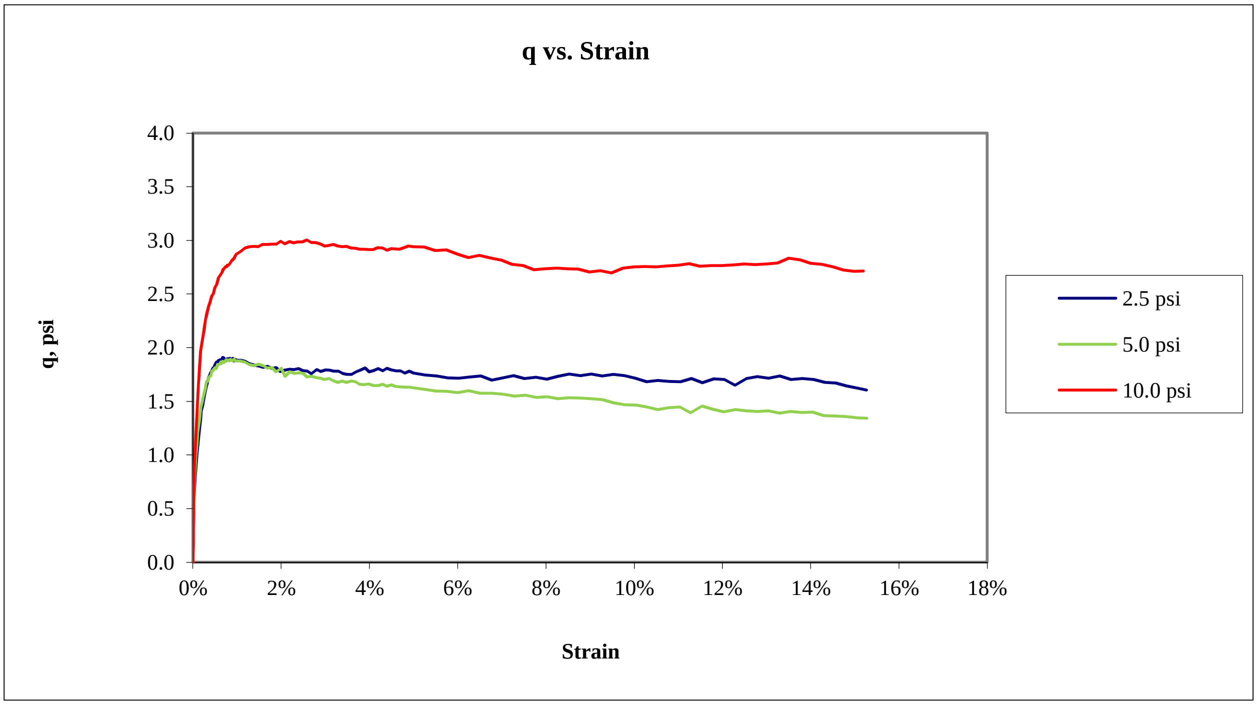
ASTM D4767

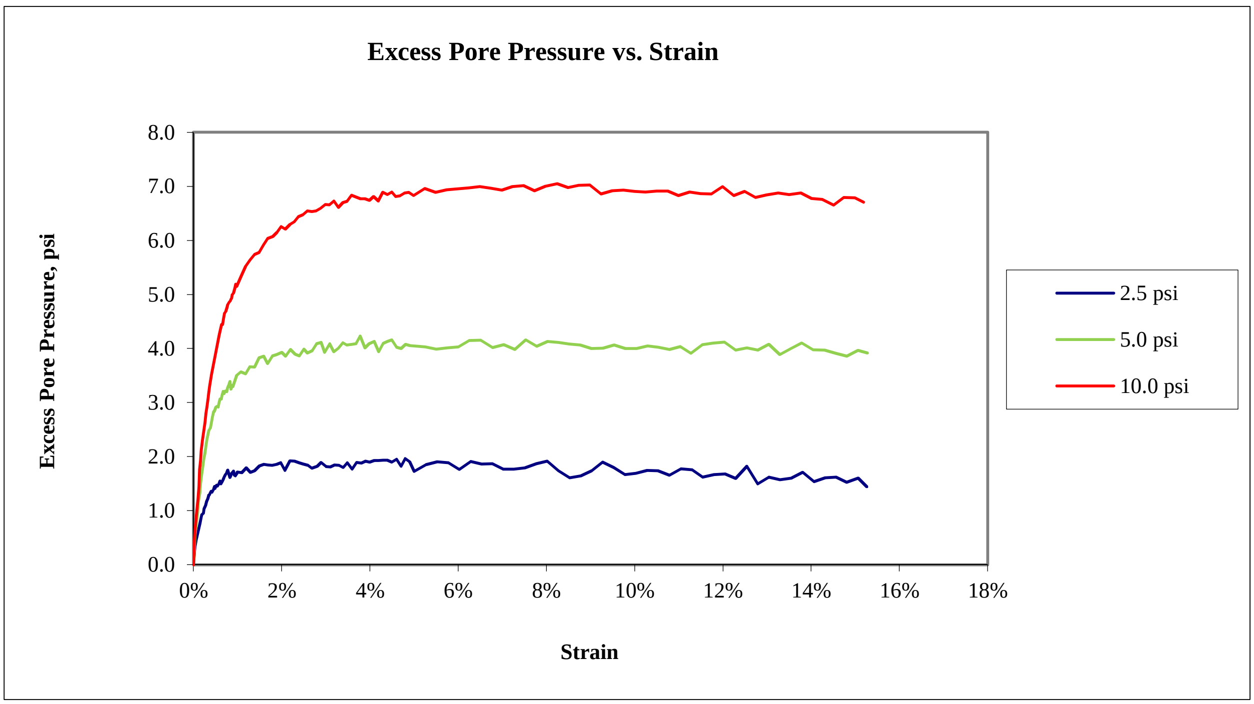
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT

SAMPLE AND TEST DATA

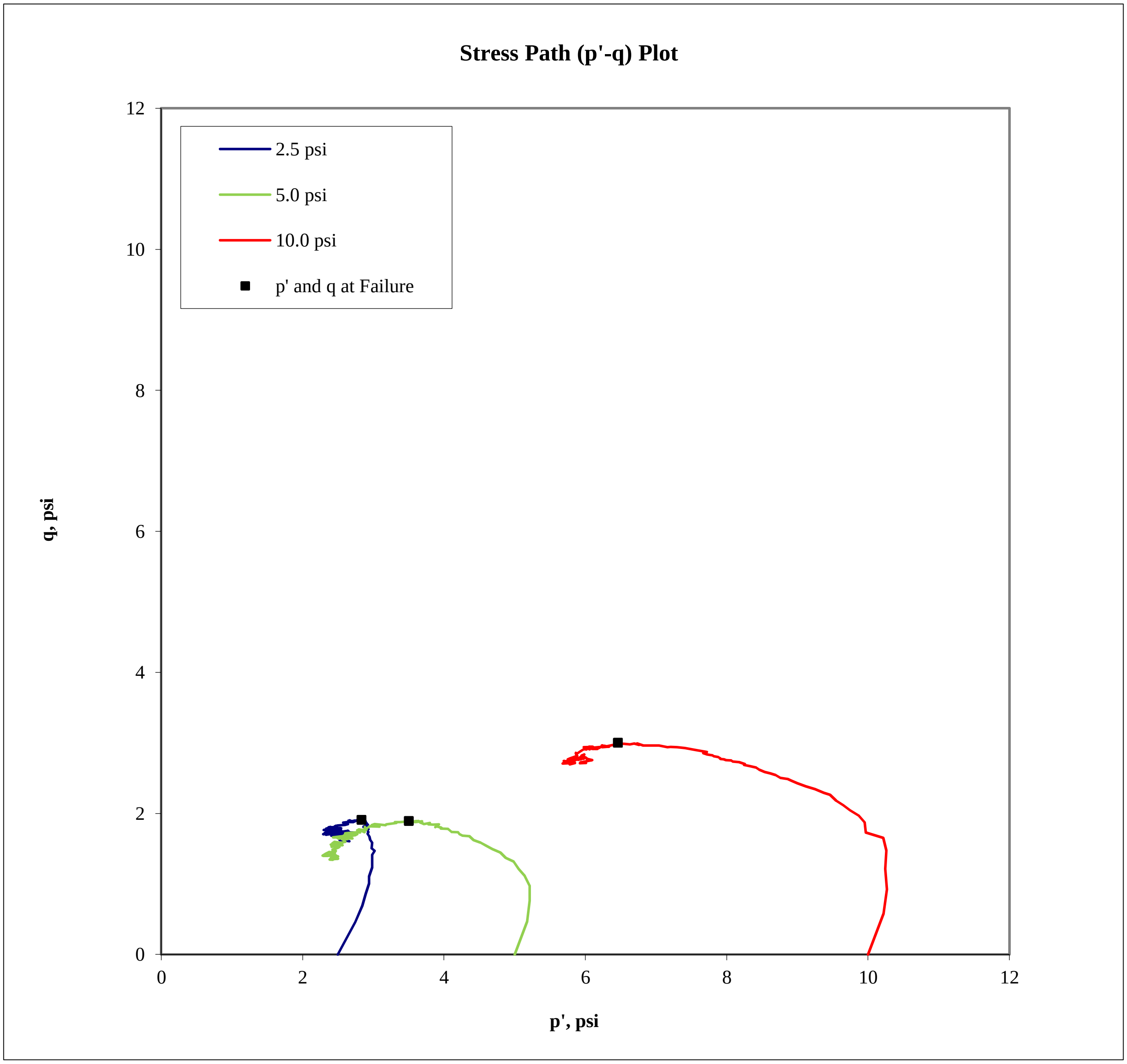
Job Short Title: **Tri-State/Nucla Ash Landfill/CO**

Sample:	Technician:	Reviewed:	Date:	Job Number:	Figure:
TP-3A	RJM	JEO	7/9/2015	103-81938	1



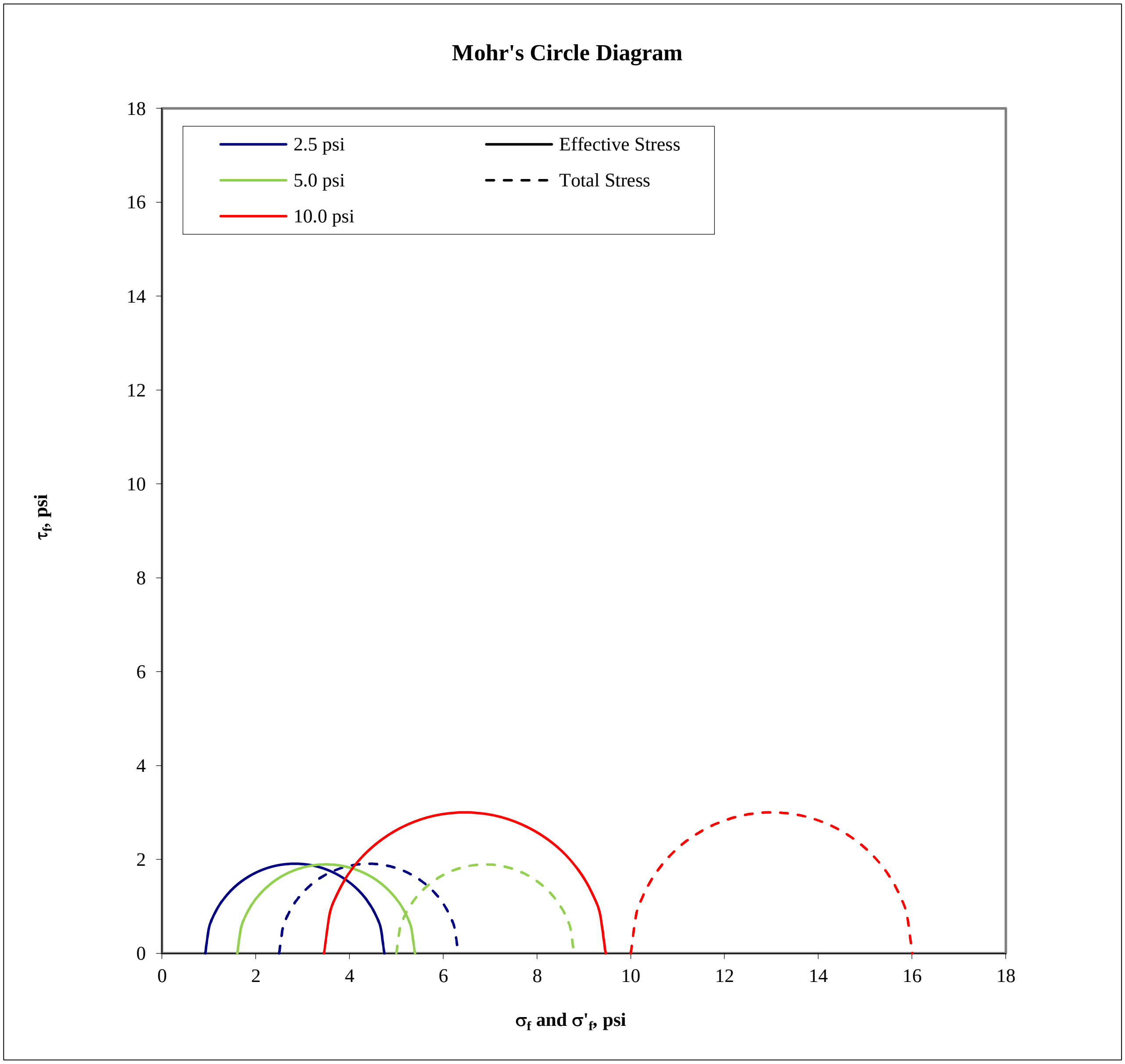


Golder Associates Inc. Golder Associates	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT q AND EXCESS PORE PRESSURE PLOTS				
Job Short Title: Tri-State/Nucla Ash Landfill/CO					
Sample: TP-3A	**Technician:** RJM	**Reviewed:** JEO	**Date:** 7/9/2015	**Job Number:** 103-81938	**Figure:** 2



Confining Pressure (psi)	p at failure (psi)	p' at failure (psi)	q at failure (psi)
2.5	4.4	2.8	1.9
5.0	6.9	3.5	1.9
10.0	13.0	6.5	3.0

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT STRESS PATH PLOT				
Job Short Title: Tri-State/Nucla Ash Landfill/CO					
Sample: TP-3A	**Technician:** RJM	**Reviewed:** JEO	**Date:** 7/9/2015	**Job Number:** 103-81938	**Figure:** 3



Confining Pressure (psi)	σ'_1 at failure (psi)	σ'_3 at failure (psi)	σ_1 at failure (psi)	σ_3 at failure (psi)
2.5	4.7	0.9	6.3	2.5
5.0	5.4	1.6	8.8	5.0
10.0	9.5	3.5	16.0	10.0

Golder Associates Inc. Golder Associates

Title:
ASTM D4767
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT
MOHR'S CIRCLE DIAGRAM

Job Short Title: Tri-State/Nucla Ash Landfill/CO

Sample:	Technician:	Reviewed:	Date:	Job Number:	Figure:
TP-3A	RJM	JEO	7/9/2015	103-81938	4

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 2.5 psi
Job Short Title: Tri-State/Nucla Ash Landfill/CO	

Sample:	Technician:	Reviewed:	Date:	Job Number:	Figure:
TP-3A	RJM	JEO	7/9/2015	103-81938	5

Golder Associates Inc.		**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 5.0 psi
Job Short Title: Tri-State/Nucla Ash Landfill/CO		

Sample:	Technician:	Reviewed:	Date:	Job Number:	Figure:
TP-3A	RJM	JEO	7/9/2015	103-81938	6

Golder Associates Inc.	**Title:**
Job Short Title: Tri-State/Nucla Ash Landfill/CO	**ASTM D4767** **CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT** **SPECIMEN PHOTOGRAPH - 10.0 psi**

Sample:	**Technician:**	**Reviewed:**	**Date:**	**Job Number:**	**Figure:**
TP-3A	RJM	JEO	7/9/2015	103-81938	7

ATTACHMENT A-3

	Point 1			Point 2			Point 3	
Boring or Test Pit:	--		Boring or Test Pit:	--		Boring or Test Pit:	--	
Sample:	LF Ash		Sample:	LF Ash		Sample:	LF Ash	
Depth:	--	ft	Depth:	--	ft	Depth:	--	ft
Point No.:	1		Point No.:	2		Point No.:	3	

Initial

	Point 1			Point 2			Point 3	
Thickness =	1.197	in	Thickness =	1.195	in	Thickness =	1.193	in
Diameter =	2.493	in	Diameter =	2.493	in	Diameter =	2.493	in
Wet Mass =	0.222	lb	Wet Mass =	0.222	lb	Wet Mass =	0.222	lb
Area =	4.881	in^2	Area =	4.881	in^2	Area =	4.881	in^2
Volume =	5.843	in^3	Volume =	5.833	in^3	Volume =	5.823	in^3
Specific Gravity =	2.60	(ASTM D854)	Specific Gravity =	2.60	(ASTM D854)	Specific Gravity =	2.60	(ASTM D854)
Dry Mass of Solids =	0.196	lb	Dry Mass of Solids =	0.196	lb	Dry Mass of Solids =	0.196	lb
Moisture Content =	13.2%		Moisture Content =	13.4%		Moisture Content =	13.2%	
Wet Unit Weight =	65.6	pcf	Wet Unit Weight =	65.9	pcf	Wet Unit Weight =	65.9	pcf
Dry Unit Weight =	57.9	pcf	Dry Unit Weight =	58.1	pcf	Dry Unit Weight =	58.2	pcf
Void Ratio =	1.80		Void Ratio =	1.79		Void Ratio =	1.78	
Percent Saturation =	19%		Percent Saturation =	19%		Percent Saturation =	19%	

Pre-Shear

	Point 1			Point 2			Point 3	
Thickness =	1.155	in	Thickness =	1.142	in	Thickness =	1.110	in
Diameter =	2.493	in	Diameter =	2.493	in	Diameter =	2.493	in
Area =	4.881	in^2	Area =	4.881	in^2	Area =	4.881	in^2
Volume =	5.639	in^3	Volume =	5.573	in^3	Volume =	5.417	in^3
Moisture Content =	12.2%		Moisture Content =	12.7%		Moisture Content =	12.5%	
Wet Unit Weight =	67.4	pcf	Wet Unit Weight =	68.5	pcf	Wet Unit Weight =	70.4	pcf
Dry Unit Weight =	60.0	pcf	Dry Unit Weight =	60.8	pcf	Dry Unit Weight =	62.5	pcf
Void Ratio =	1.70		Void Ratio =	1.67		Void Ratio =	1.59	
Percent Saturation =	19%		Percent Saturation =	20%		Percent Saturation =	20%	

	Point 1			Point 2			Point 3	
Shear Rate =	0.0033	in/min	Shear Rate =	0.0033	in/min	Shear Rate =	0.0033	in/min
Normal Stress =	7,200	psf	Normal Stress =	14,400	psf	Normal Stress =	21,600	psf

Notes:

USCS description (ASTM D2487): Silty sand, gray, moist

Atterberg limits: LL = NP PL = NP PI = NP (ASTM D4318)

Percent finer: 3/4 in. = 100% No. 4 = 100% No. 200 = 18% (ASTM D422, refer to separate report)

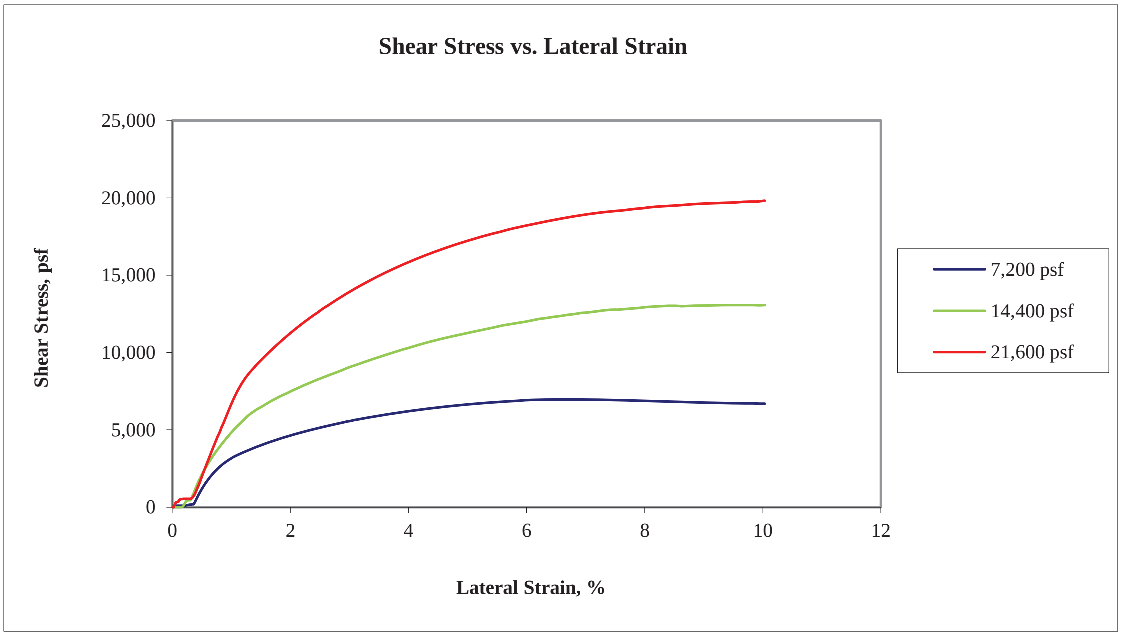
Specimen type: [ ] Intact [X] Reconstituted

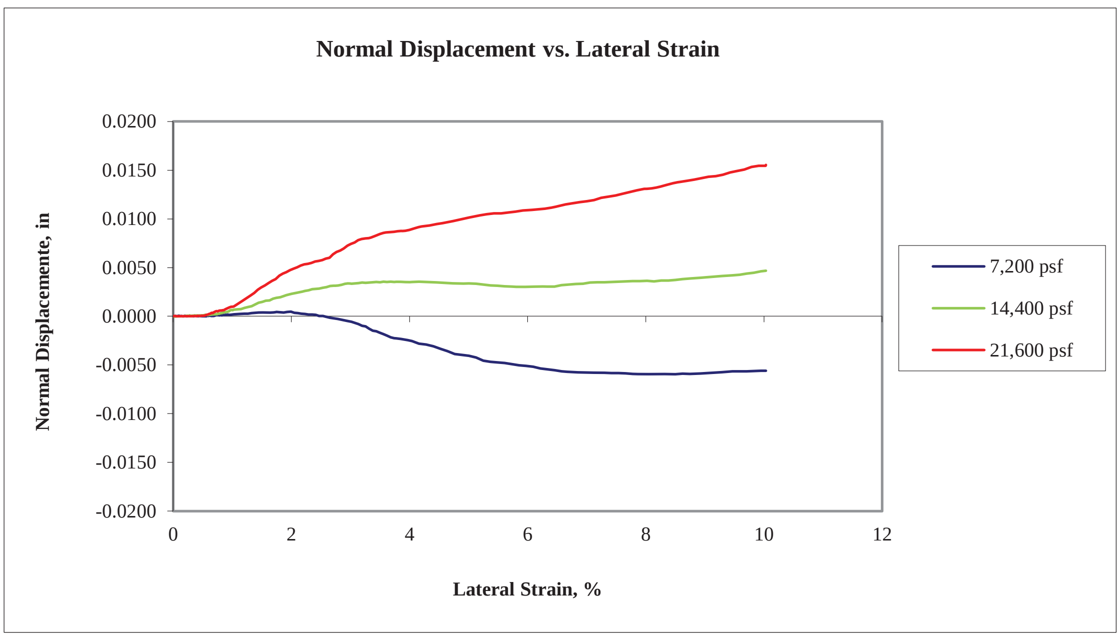
Inundation: No

Apparatus: 2.5 -inch nominal diameter box, GeoTac automated test system, GeoJac loading system

Specimens remolded at delivered moisture content using moderate compactive effort

Golder Associates Inc.	Title: ASTM D3080 CONSOLIDATED DRAINED DIRECT SHEAR TEST REPORT SAMPLE AND TEST DATA				
Job Short Title: Tri-State/Nucla Ash Landfill/CO					
Sample: LF Ash	Technician: PRH	Reviewed: JEO	Date: 2/17/2015	Job Number: 103-81938	Figure: 1





Golder Associates Inc.	**Title:** ASTM D3080 CONSOLIDATED DRAINED DIRECT SHEAR TEST REPORT SHEAR STRESS AND NORMAL DISPLACEMENT PLOTS				
Job Short Title: Tri-State/Nucla Ash Landfill/CO					
Sample: LF Ash	**Technician:** PRH	**Reviewed:** JEO	**Date:** 2/17/2015	**Job Number:** 103-81938	**Figure:** 2

Consolidation Data Used to Determine Shear Rate

The shear rate for Point No. 1 was based on ASTM D3080 guidance for:

-Soil description of SW-SM, SP-SM, or SM

-Minimum time to failure = 60 min

-Soil other than normally consolidated fine-grained soil

-Displacement at failure = 0.2 in

The shear rate for Point No. 2 was based on ASTM D3080 guidance for:

-Soil description of SW-SM, SP-SM, or SM

-Minimum time to failure = 60 min

-Soil other than normally consolidated fine-grained soil

-Displacement at failure = 0.2 in

The shear rate for Point No. 3 was based on ASTM D3080 guidance for:

-Soil description of SW-SM, SP-SM, or SM

-Minimum time to failure = 60 min

-Soil other than normally consolidated fine-grained soil

-Displacement at failure = 0.2 in

Normal Stress, psf	Normal Displacement, in	Load Duration, min
Point No. 1		
100	0.0005	60
7,200	0.0412	1,000
Point No. 2		
100	0.0004	10
13,238	0.0488	15
14,396	0.0040	316
Point No. 3		
102	0.0014	20
21,601	0.0818	1,259

Golder Associates Inc.

Title:

ASTM D3080
CONSOLIDATED DRAINED DIRECT SHEAR TEST REPORT
CONSOLIDATION DATA

Job Short Title: Tri-State/Nucla Ash Landfill/CO

Sample:	Technician:	Reviewed:	Date:	Job Number:	Figure:
LF Ash	PRH	JEO	2/17/2015	103-81938	3

Point No.:	1		Point No.:	2		Point No.:	3	
Normal Stress =	7,200	psf	Normal Stress =	14,400	psf	Normal Stress =	21,600	psf
Shear Rate =	0.0033	in/min	Shear Rate =	0.0033	in/min	Shear Rate =	0.0033	in/min

Shear Stress psf	Lateral Strain %	Normal Displacement in	Shear Stress psf	Lateral Strain %	Normal Displacement in	Shear Stress psf	Lateral Strain %	Normal Displacement in
96	0.1	0.0000	0	0.1	0.0000	334	0.1	0.0000
99	0.2	0.0000	175	0.2	0.0000	536	0.2	0.0000
162	0.3	0.0000	453	0.3	0.0001	546	0.3	0.0000
325	0.4	0.0001	1,093	0.4	0.0001	976	0.4	0.0000
1,065	0.5	0.0000	1,970	0.5	0.0001	1,755	0.5	0.0000
1,652	0.6	0.0001	2,677	0.6	0.0001	2,826	0.6	0.0002
2,153	0.7	0.0000	3,284	0.7	0.0002	3,841	0.7	0.0004
2,548	0.8	0.0001	3,826	0.8	0.0003	4,802	0.8	0.0006
2,864	0.9	0.0001	4,309	0.9	0.0004	5,747	0.9	0.0007
3,123	1.0	0.0002	4,777	1.0	0.0006	6,515	1.0	0.0010
3,936	1.4	0.0004	6,365	1.4	0.0014	9,475	1.5	0.0030
4,618	2.0	0.0005	7,463	2.0	0.0023	11,175	2.0	0.0047
5,120	2.5	0.0000	8,276	2.5	0.0028	12,595	2.5	0.0057
5,537	3.0	-0.0005	8,984	3.0	0.0034	13,808	2.9	0.0072
5,913	3.5	-0.0017	9,704	3.5	0.0035	14,947	3.5	0.0084
6,190	4.0	-0.0024	10,282	4.0	0.0035	15,808	4.0	0.0088
6,407	4.4	-0.0031	10,731	4.4	0.0035	16,540	4.5	0.0095
6,600	4.9	-0.0040	11,163	4.9	0.0034	17,174	4.9	0.0100
6,801	5.5	-0.0047	11,677	5.5	0.0031	17,698	5.4	0.0106
6,910	6.0	-0.0051	11,995	6.0	0.0030	18,135	5.9	0.0109
6,975	6.5	-0.0055	12,297	6.5	0.0031	18,522	6.4	0.0112
6,972	6.9	-0.0058	12,562	6.9	0.0034	18,868	6.9	0.0117
6,934	7.4	-0.0058	12,763	7.4	0.0035	19,152	7.5	0.0124
6,889	7.9	-0.0060	12,888	7.9	0.0036	19,331	8.0	0.0131
6,828	8.4	-0.0059	13,007	8.4	0.0037	19,503	8.5	0.0137
6,775	9.0	-0.0059	13,041	9.0	0.0040	19,637	8.9	0.0142
6,740	9.5	-0.0057	13,072	9.5	0.0042	19,693	9.4	0.0148
6,691	9.9	-0.0056	13,054	9.9	0.0046	19,763	9.9	0.0155

Golder Associates Inc.

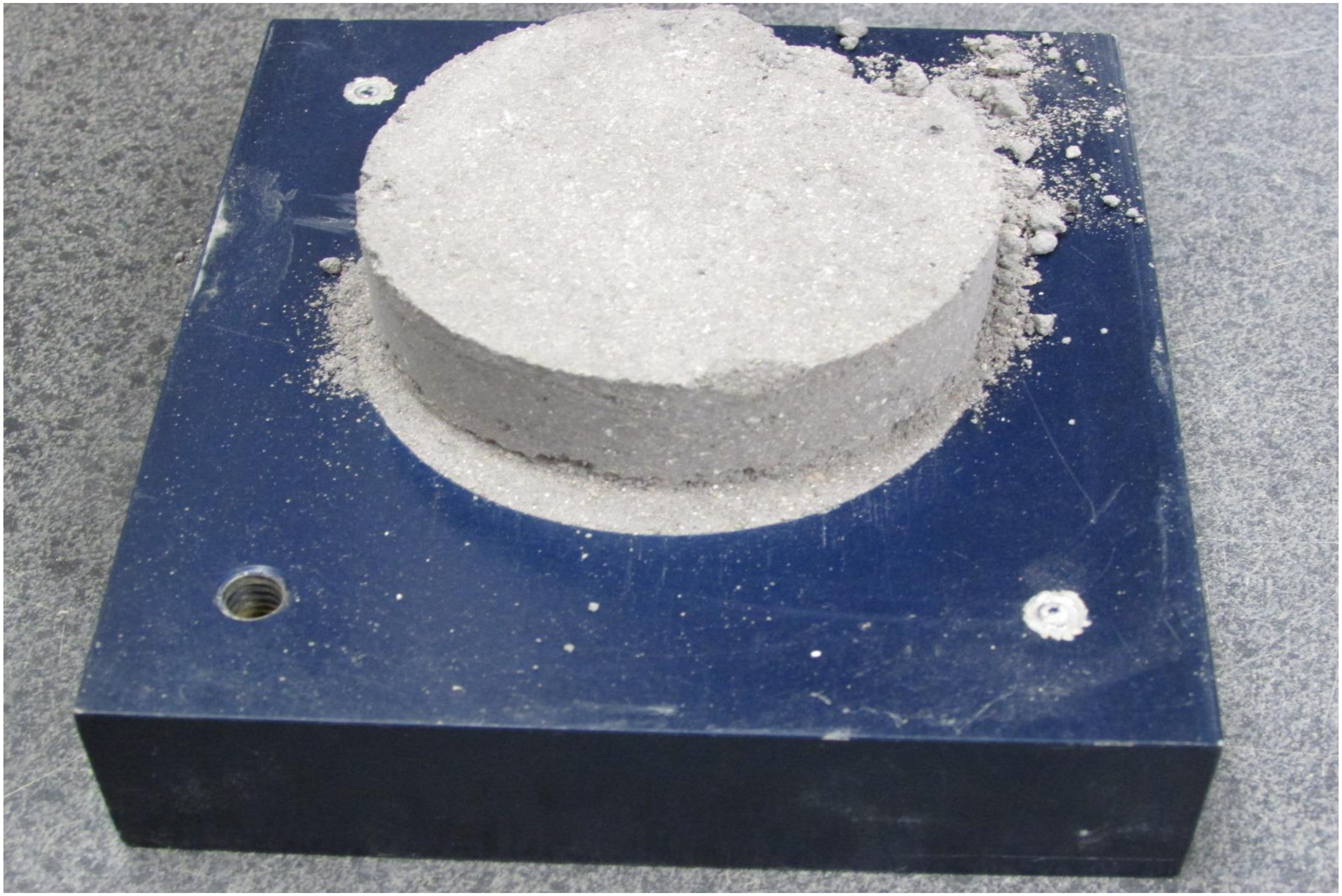
Title:

ASTM D3080
CONSOLIDATED DRAINED DIRECT SHEAR TEST REPORT
SHEAR DATA

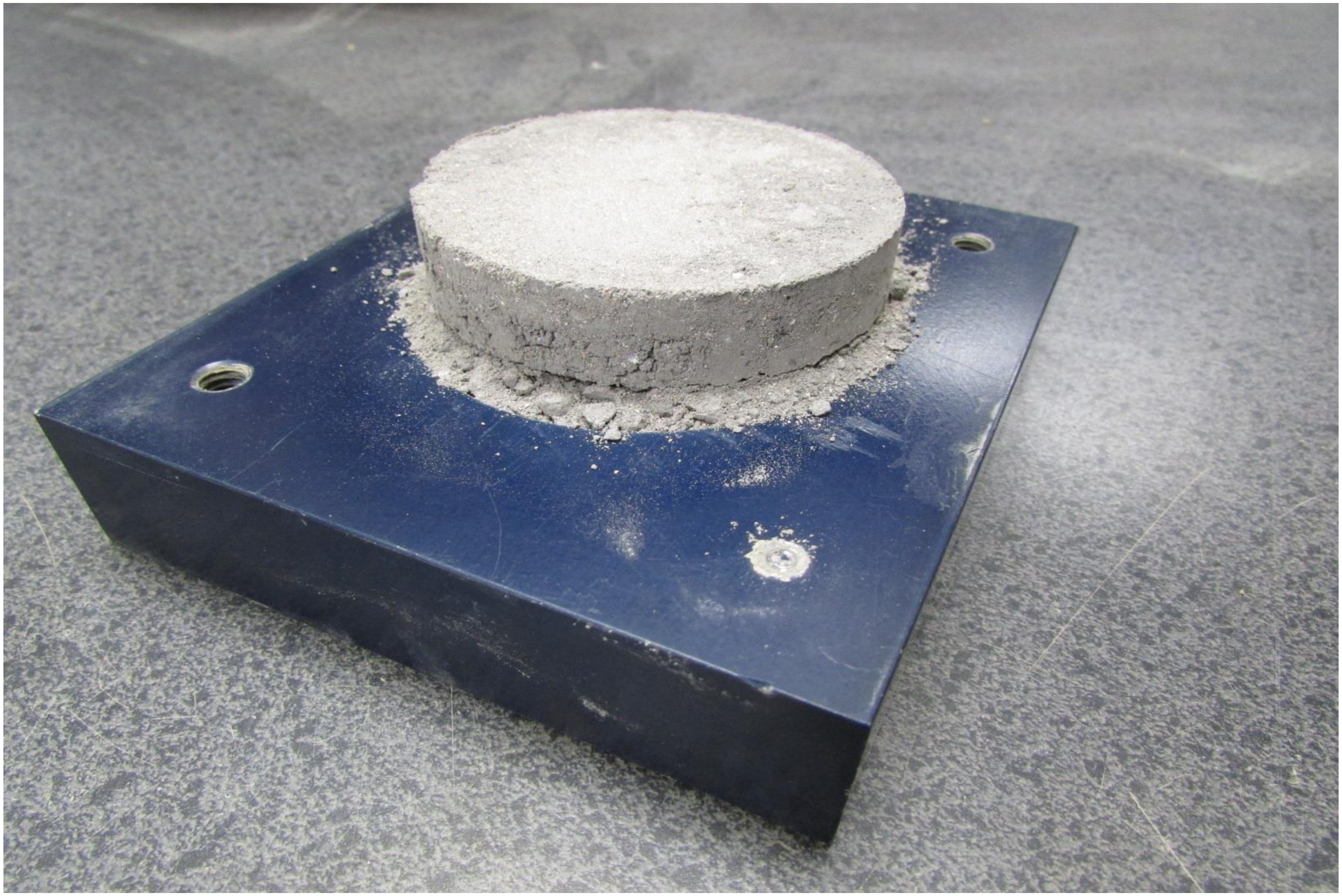
Job Short Title: Tri-State/Nucla Ash Landfill/CO

Sample: LF Ash

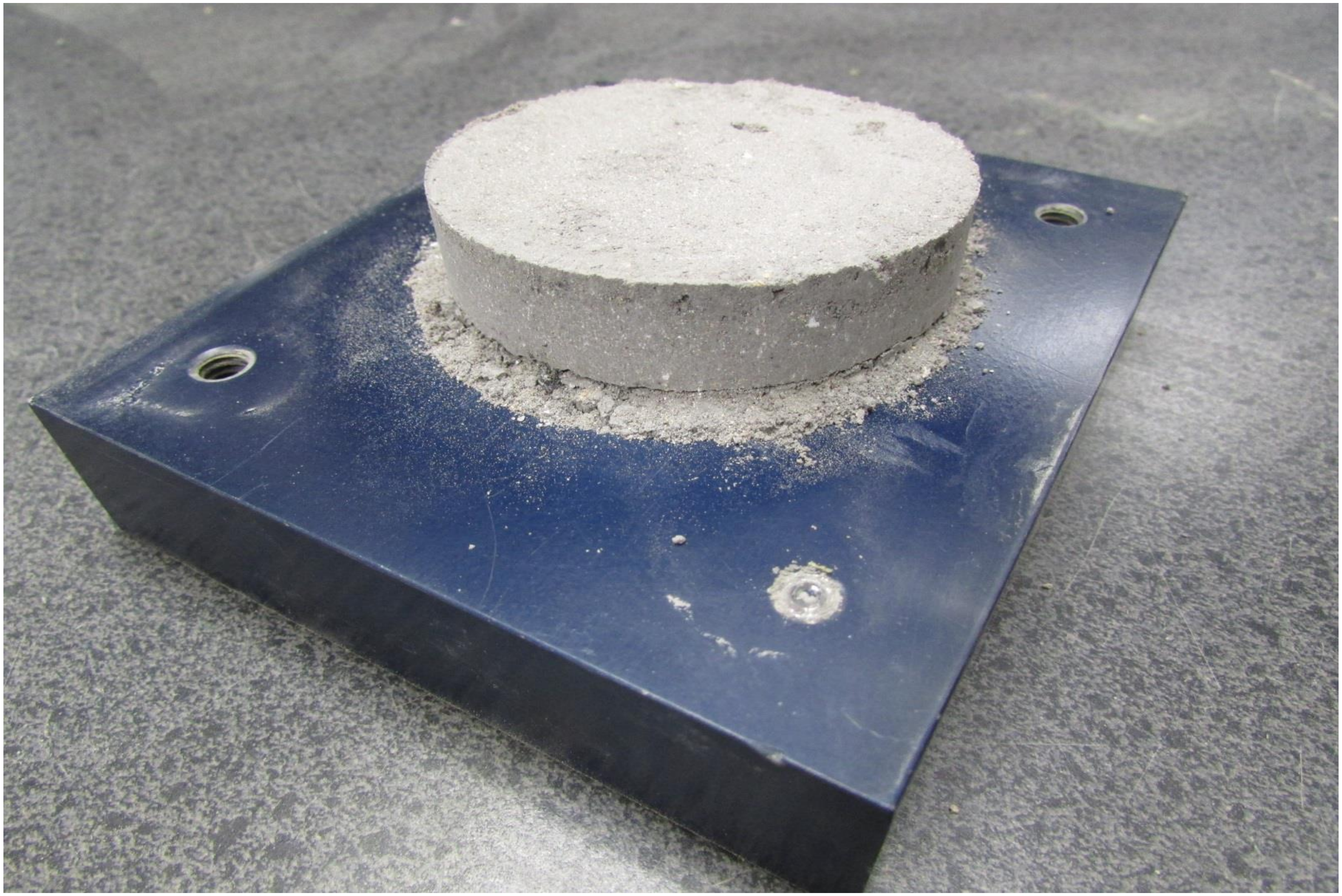
Technician:	Reviewed:	Date:	Job Number:	Figure:
PRH	JEO	2/17/2015	103-81938	4



Golder Associates Inc. (Golder Associates)	Title: ASTM D3080 CONSOLIDATED DRAINED DIRECT SHEAR TEST REPORT SPECIMEN PHOTOGRAPH - 7,200 psf				
Job Short Title: Tri-State/Nucla Ash Landfill/CO					
Sample: LF Ash	Technician: PRH	Reviewed: JEO	Date: 2/17/2015	Job Number: 103-81938	Figure: 5



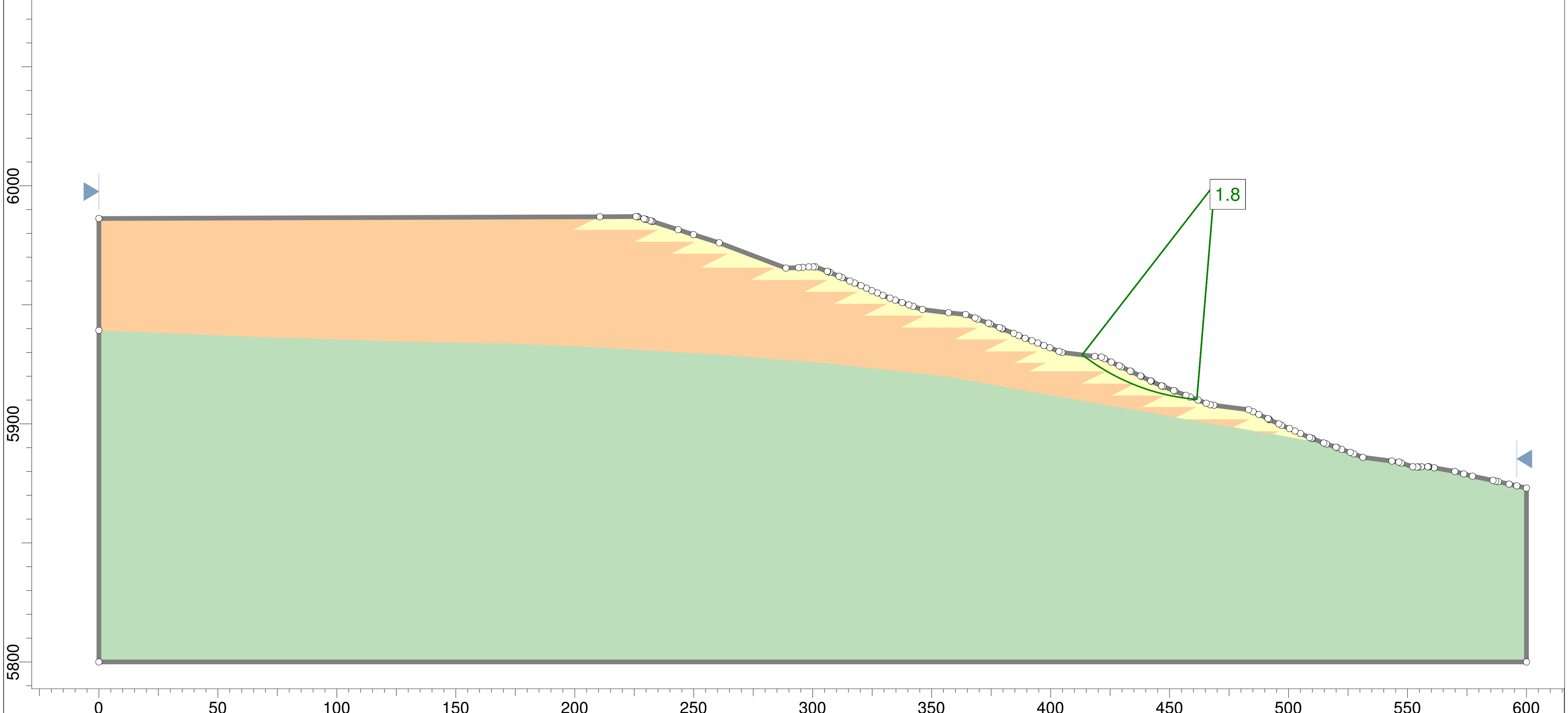
Golder Associates Inc.	Title: ASTM D3080 CONSOLIDATED DRAINED DIRECT SHEAR TEST REPORT SPECIMEN PHOTOGRAPH - 14,400 psf			
Job Short Title: Tri-State/Nucla Ash Landfill/CO				
Sample: LF Ash	Technician: PRH	Reviewed: JEO	Date: 2/17/2015	Job Number: 103-81938	Figure: 6



Golder Associates Inc.	Title: ASTM D3080 CONSOLIDATED DRAINED DIRECT SHEAR TEST REPORT SPECIMEN PHOTOGRAPH - 21,600 psf			
Job Short Title: Tri-State/Nucla Ash Landfill/CO				
Sample: LF Ash	Technician: PRH	Reviewed: JEO	Date: 2/17/2015	Job Number: 103-81938	Figure: 7

ATTACHMENT A-4

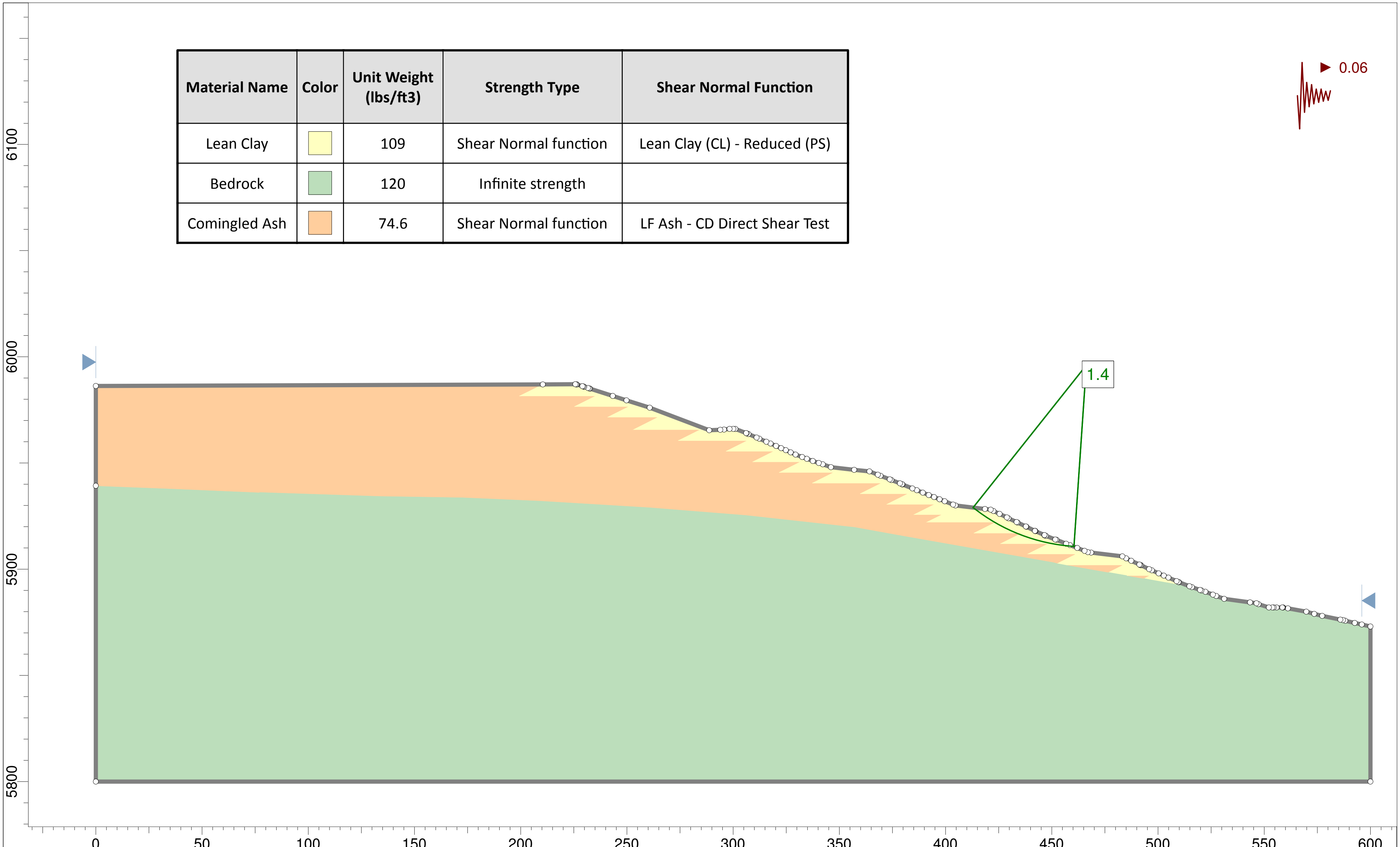
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function
Lean Clay		109	Mohr-Coulomb	90	22	
Bedrock		120	Infinite strength			
Comingled Ash		74.6	Shear Normal function			LF Ash - CD Direct Shear Test



SLIDEINTERPRET 7.022

Project	Nucla Station Ash Disposal Site
Analysis Description	South Section - Shallow Slip Surfaces - Static Loading
Drawn By	ALEBrown
Company	Golder Associates Inc.
Date	02/09/2017, 11:53:52 AM
File Name	South-Shallow-09FEB2017.slim

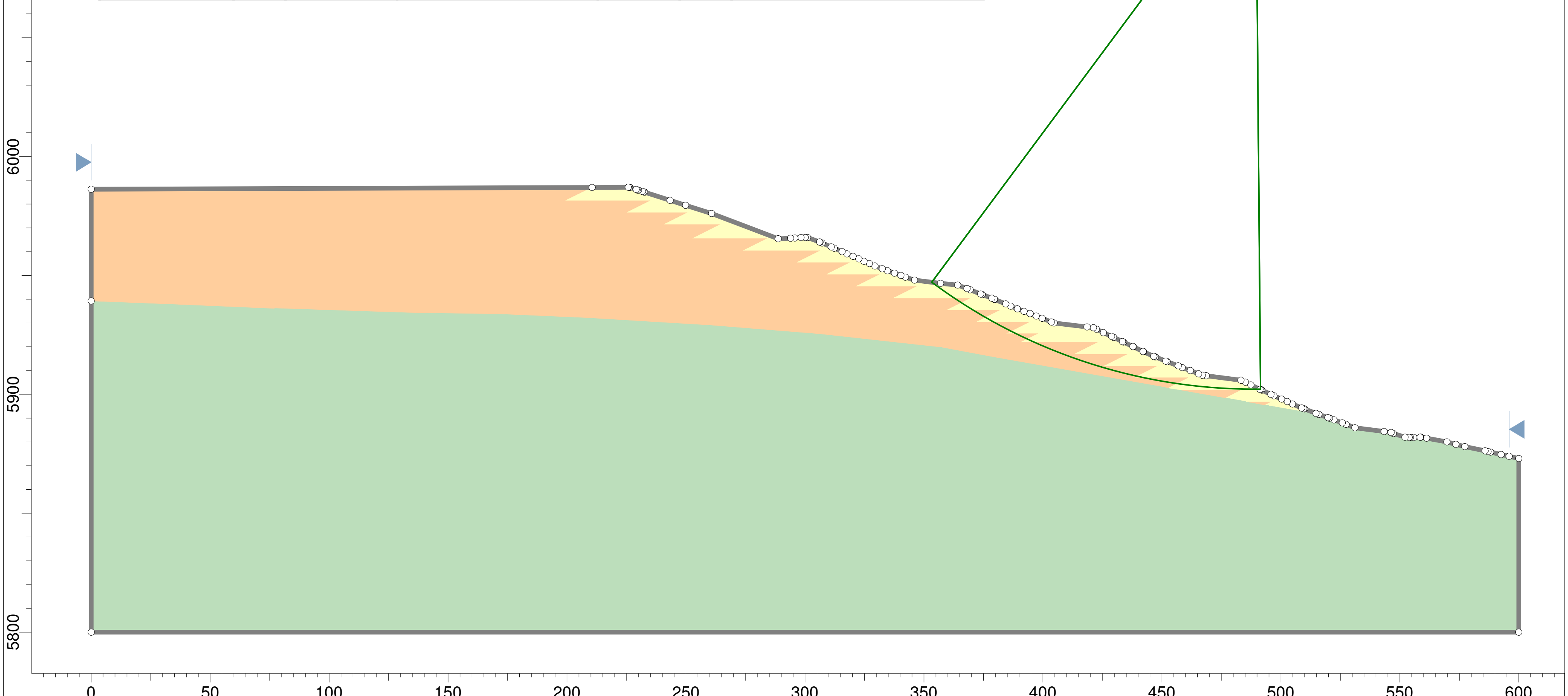
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear Normal Function
Lean Clay		109	Shear Normal function	Lean Clay (CL) - Reduced (PS)
Bedrock		120	Infinite strength	
Comingled Ash		74.6	Shear Normal function	LF Ash - CD Direct Shear Test



SLIDEINTERPRET 7.022

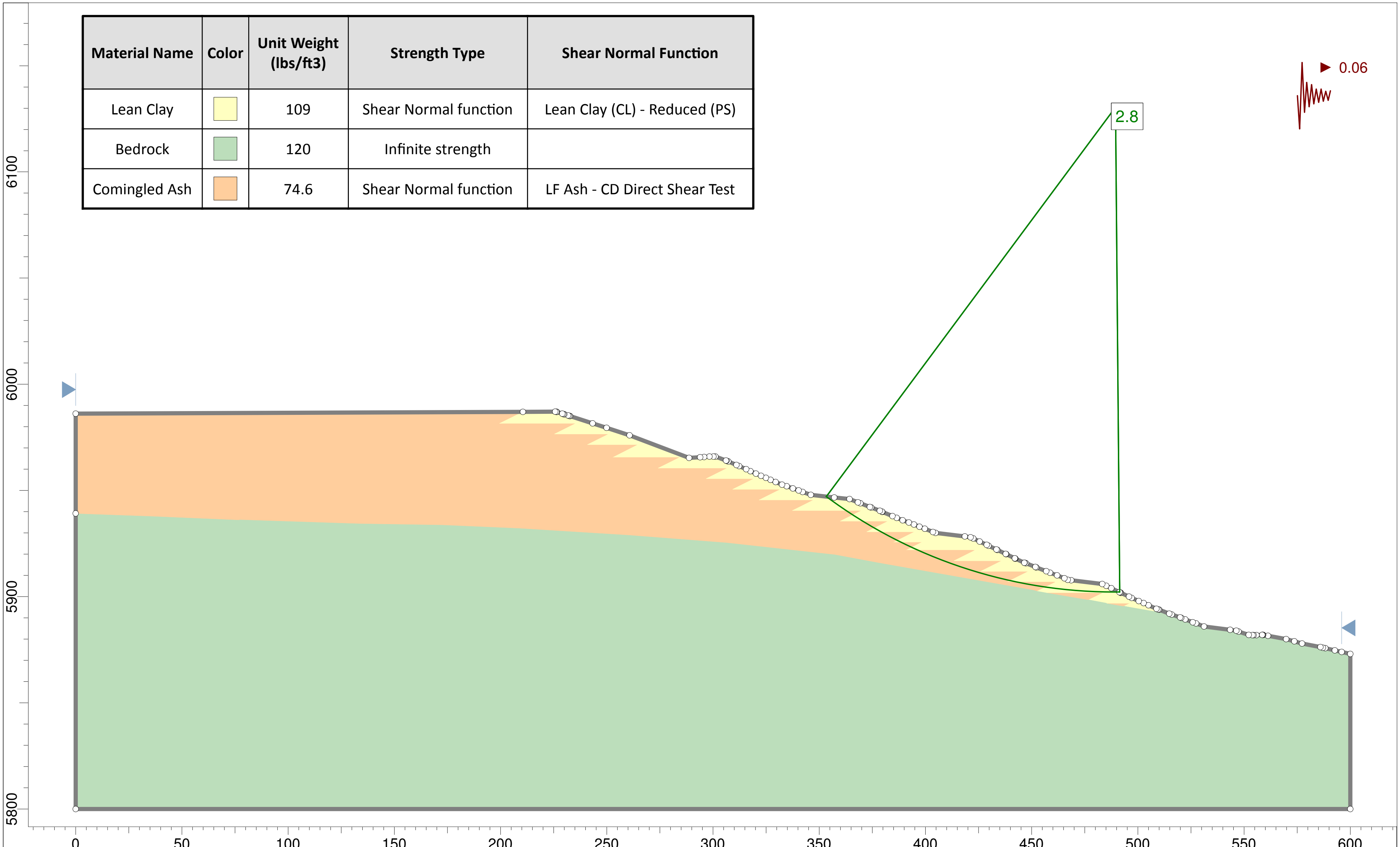
Project	Nucla Station Ash Disposal Site		
Analysis Description	South Section - Shallow Slip Surfaces - Seismic Loading		
Drawn By	ALEBrown	*Company*	Golder Associates Inc.
Date	02/09/2017, 11:53:52 AM	*File Name*	South-Shallow-Seismic-09FEB2017.slim

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function
Lean Clay		109	Mohr-Coulomb	90	22	
Bedrock		120	Infinite strength			
Comingled Ash		74.6	Shear Normal function			LF Ash - CD Direct Shear Test



Project	Nucla Station Ash Disposal Site		
Analysis Description	South Section - Deeper Slip Surfaces - Static Loading		
Drawn By	ALEBrown	*Company*	Golder Associates Inc.
Date	02/09/2017, 11:53:52 AM	*File Name*	South-Deep-09FEB2017.slim

SLIDEINTERPRET 7.022

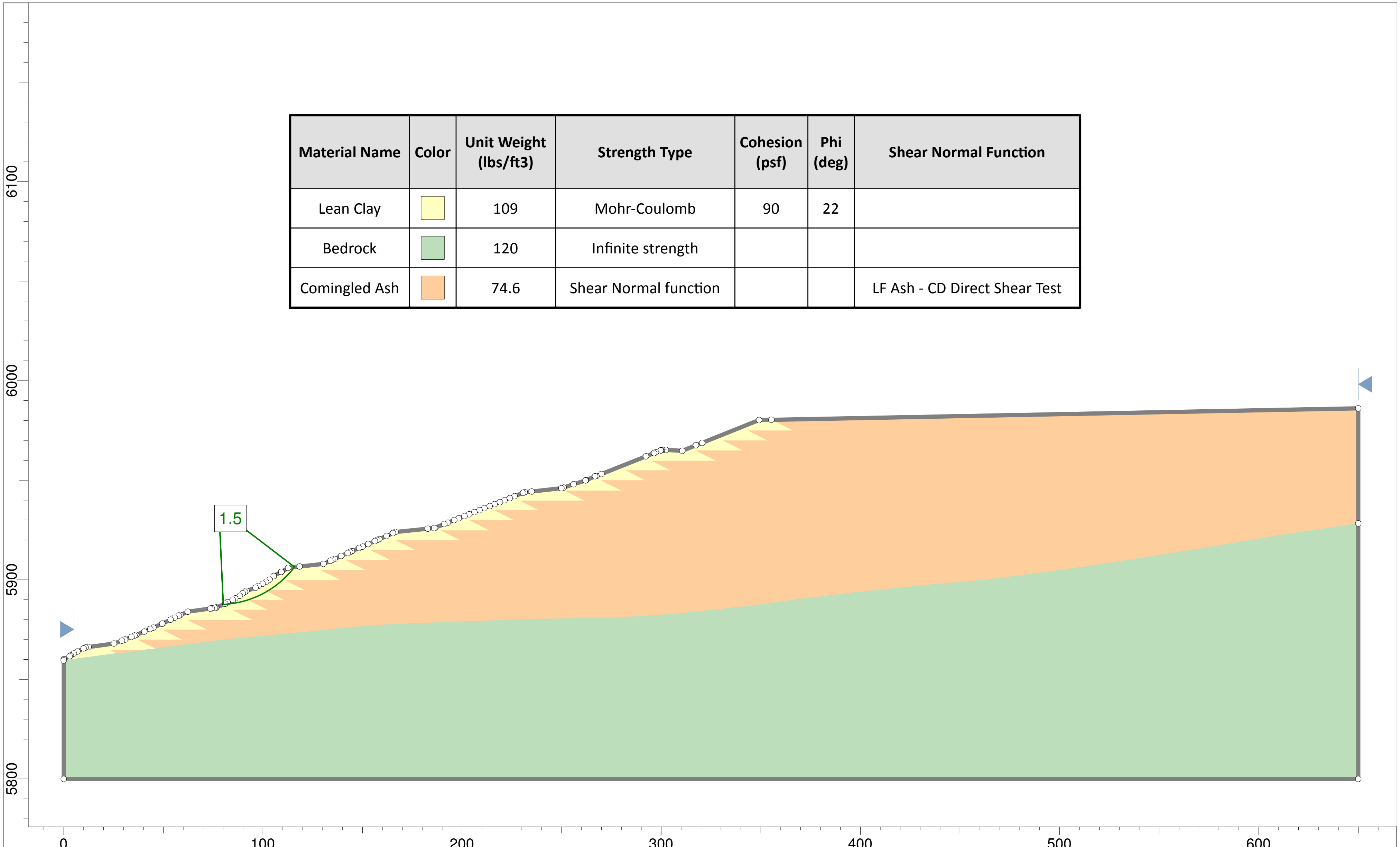


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear Normal Function
Lean Clay		109	Shear Normal function	Lean Clay (CL) - Reduced (PS)
Bedrock		120	Infinite strength	
Comingled Ash		74.6	Shear Normal function	LF Ash - CD Direct Shear Test

Project	Nucla Station Ash Disposal Site		
Analysis Description	South Section - Deeper Slip Surfaces - Seismic Loading		
Drawn By	ALEBrown	*Company*	Golder Associates Inc.
Date	02/09/2017, 11:53:52 AM	*File Name*	South-Deep-Seismic-09FEB2017.slim

SLIDEINTERPRET 7.022

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function
Lean Clay		109	Mohr-Coulomb	90	22	
Bedrock		120	Infinite strength			
Comingled Ash		74.6	Shear Normal function			LF Ash - CD Direct Shear Test



Project: Nucla Station Ash Disposal Site

Analysis Description: West Section - Shallow Slip Surfaces - Static Loading

Drawn By: ALEBrown

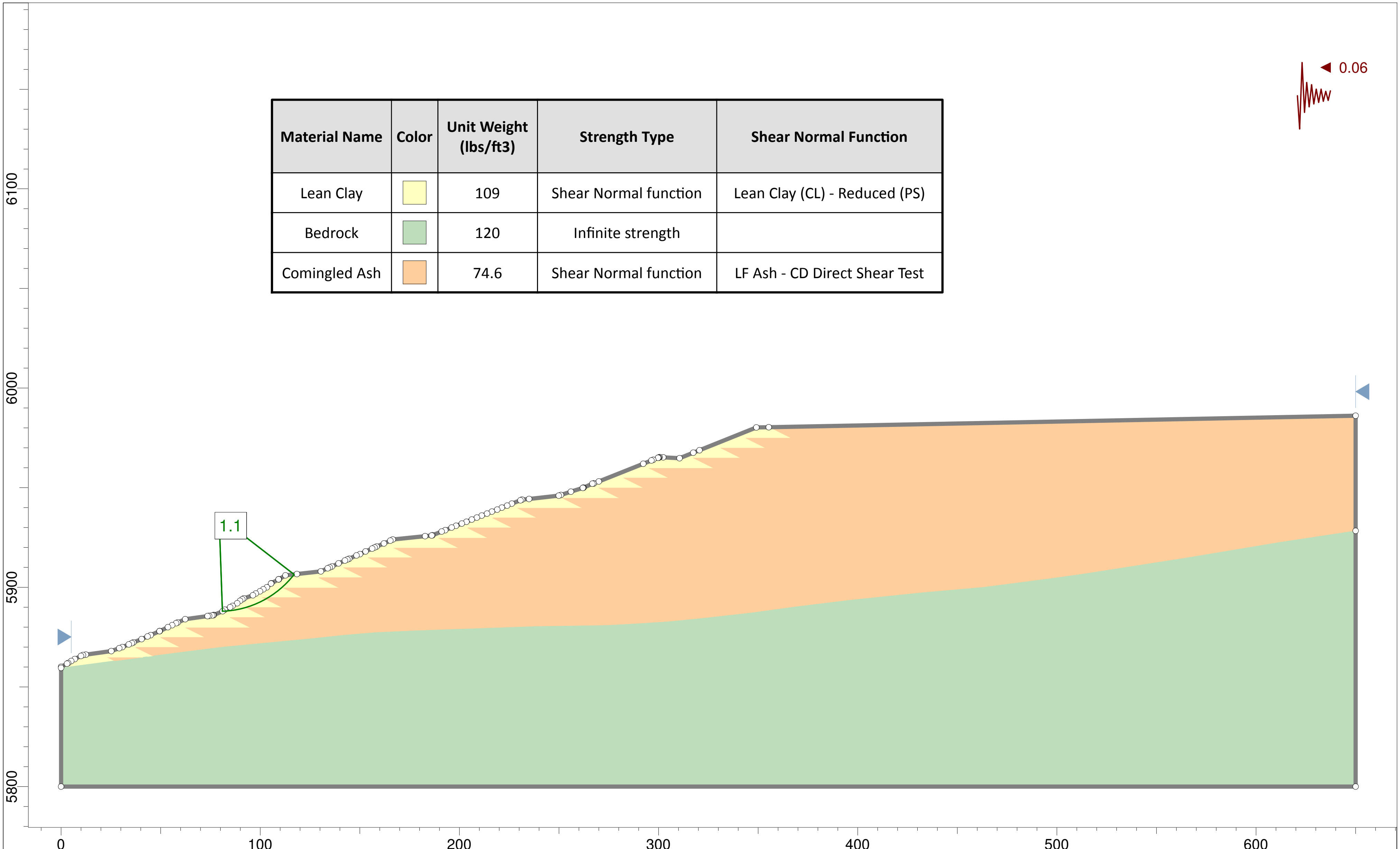
Company: Golder Associates Inc.

Date: 02/09/2017, 11:53:52 AM

File Name: West-Shallow-09FEB2017.slim

SLIDEINTERPRET 7.022

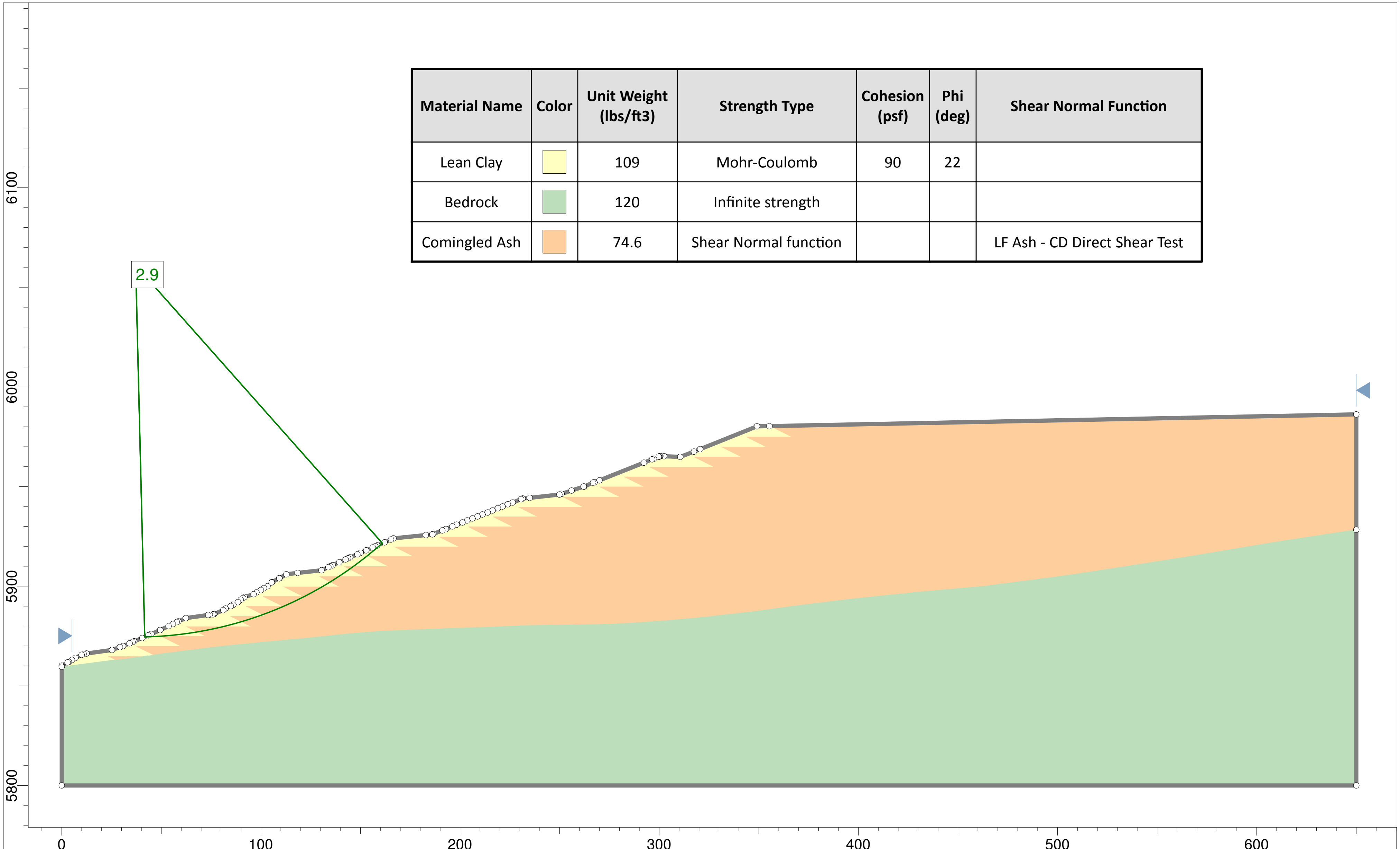
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear Normal Function
Lean Clay		109	Shear Normal function	Lean Clay (CL) - Reduced (PS)
Bedrock		120	Infinite strength	
Comingled Ash		74.6	Shear Normal function	LF Ash - CD Direct Shear Test



Project	Nucla Station Ash Disposal Site		
Analysis Description	West Section - Shallow Slip Surfaces - Seismic Loading		
Drawn By	ALEBrown	*Company*	Golder Associates Inc.
Date	02/09/2017, 11:53:52 AM	*File Name*	West-Shallow-Seismic-09FEB2017.slim

SLIDEINTERPRET 7.022

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function
Lean Clay		109	Mohr-Coulomb	90	22	
Bedrock		120	Infinite strength			
Comingled Ash		74.6	Shear Normal function			LF Ash - CD Direct Shear Test



SLIDEINTERPRET 7.022

Project	Nucla Station Ash Disposal Site
Analysis Description	West Section - Deeper Slip Surfaces - Static Loading
Drawn By	ALEBrown
Company	Golder Associates Inc.
Date	02/09/2017, 11:53:52 AM
File Name	West-Deep-09FEB2017.slim

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear Normal Function
Lean Clay		109	Shear Normal function	Lean Clay (CL) - Reduced (PS)
Bedrock		120	Infinite strength	
Comingled Ash		74.6	Shear Normal function	LF Ash - CD Direct Shear Test

Project	Nucla Station Ash Disposal Site		
Analysis Description	West Section - Deeper Slip Surfaces - Seismic Loading		
Drawn By	ALEBrown	*Company*	Golder Associates Inc.
Date	02/09/2017, 11:53:52 AM	*File Name*	West-Deep-Seismic-09FEB2017.slim

SLIDEINTERPRET 7.022

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