

OCTOBER 2016

# CLECO POWER LLC BRAME ENERGY CENTER



## SAFETY FACTOR ASSESSMENT:

## FLY ASH POND

**Prepared By:**

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Project Number 002-186



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## 1.0 INTRODUCTION

Providence was contracted by Cleco Power LLC (Cleco) to conduct safety factor assessments of the Fly Ash Pond at Cleco's Brame Energy Center located in Lena, Louisiana. Recent Coal Combustion Residual (CCR) regulations at 40 CFR 257.73(e)(1) established requirements for owners and operators to conduct safety factor assessments to document whether the calculated factors of safety for the Fly Ash Pond achieve the minimum safety factors specified below:

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

The Cleco Brame Energy Center is located near Lena in Rapides Parish, Louisiana. A site location map showing the Brame Energy Center is included as **Figure 1**. This safety factor assessment pertains to the Fly Ash surface impoundment (Pond) utilized for the Unit 2 coal-fired generation unit. A site map for the Fly Ash Pond is included as **Figure 2**.

## 2.0 FACTORS OF SAFETY

Providence performed a safety factor analysis (slope stability analysis) for the levees surrounding the Fly Ash Pond. This analysis required a review of the original permit and construction drawings for the Fly Ash Pond, a detailed topographic survey of the perimeter levees of the Fly Ash Pond, and installation of borings in the perimeter levees to determine the soil conditions that exist within the perimeter levee system for the pond.

Providence mobilized to the Brame Energy Center in June of 2011 and again in April of 2016 to install geotechnical borings in the perimeter levees of the Fly Ash Pond. Geotechnical Testing Laboratory, Inc. installed 6 borings spaced approximately 500 feet apart along the center line of the levee in 2011 and 1 additional boring in 2016. Soil profiles were generated for sections along the Fly Ash Pond that shows the results of the geotechnical borings and the laboratory analysis. **Table 1** shows the soil profiles for each section and the characteristics used for the safety factor modeling.

**Table 1 Subsurface Soil Classification and Parameters**

	Soil	Depth (ft)	Unit Wt. (lb/ft <sup>3</sup> )	Cohesion (lb/ft <sup>2</sup> )	Friction Angle( $\Phi$ )
	<b>Fly Ash Pond Section 1 B-15</b>	<b>ML</b>	2.0	118	250
<b>CL-CH</b>		6.5	120	1,000	-
<b>CL-ML</b>		3.5	115	600	-
<b>SM</b>		5.0	115	0	36
<b>CH</b>		11.5	117	440	-
<b>CL</b>		19.5	117	375	-
<b>SM</b>		6.5	115	0	28
<b>CH</b>		14.0	112	550	-
<b>SM</b>		11.5	115	0	30
<b>Landfill Material</b>		-	75	20	-
<b>Fly Ash Pond Section 2 B-6</b>	Soil	Depth (ft)	Unit Wt. (lb/ft <sup>3</sup> )	Cohesion (lb/ft <sup>2</sup> )	Friction Angle( $\Phi$ )
	<b>CL</b>	4.0	120	2,500	-
	<b>SM-SC</b>	21.0	115	500	30
	<b>CH</b>	32.0	120	950	-
	<b>SP-SM</b>	23.0	115	900	27
<b>Fly Ash Pond Section 3 B-8</b>	Soil	Depth (ft)	Unit Wt. (lb/ft <sup>3</sup> )	Cohesion (lb/ft <sup>2</sup> )	Friction Angle( $\Phi$ )
	<b>CL</b>	7.0	105	1,050	-
	<b>SP-SM</b>	15.0	115	475	31
	<b>CH</b>	33.0	108	800	-
	<b>CH</b>	25.0	97	475	-

The safety factor analysis uses the strength of the soil material of which the levee is made of and subgrade to assess levee stability in accordance to the existing conditions. The Spencer Method for slope stability was used since it is the most conservative approach. The Spencer Method is a general method of slices developed on the basis of limit equilibrium. It requires satisfying equilibrium of forces and moments acting on individual blocks. The blocks are created by dividing the soil above the slip surface by dividing planes. Deep failure analysis evaluates the potential of the levees to fail through the bottom of the levees into the existing native soils. The analysis was based upon the following assumptions and input parameters.

- The subgrade stratigraphy was modeled using soil profiles from completed soil borings at the site with the soil profile condition at each section for this pond through the entire levee system.
- The height and exterior slope of the levees were determined based on actual field surveys and previously permitted design data and the bottom

elevation and the interior slope of the levees below the water line was determined based on the previously permitted design provided by Cleco.

- The input parameters used in our analyses were based upon results from geotechnical investigations conducted for this safety factor analysis. **Appendix A** includes a copy of the geotechnical results as provided by the geotechnical contractor.
- The fill material in the pond was assumed to be water for the Fly Ash Pond. Maximum water elevation in the Fly Ash Pond is 102.5 feet NAVD 88.

**The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50**

Providence modeled the pond under the long-term, maximum storage to the freeboard level for the Fly Ash surface impoundment. Based on the results of the slope stability analysis, the following minimum factors of safety were obtained:

**Table 2 Long-Term Factors of Safety**

Surface Impoundment	Section Number	Soil Boring No.	Maximum Water Elevation (feet NAVD 88)	Analysis	Factor of Safety
Fly Ash	Section 1	B-15	102.5	Spencer Method Deep Failure	2.48
Fly Ash	Section 2	B-6	102.5	Spencer Method Deep Failure	1.53
Fly Ash	Section 3	B-8	102.5	Spencer Method Deep Failure	1.79

The calculated long-term static factor of safety under maximum storage pool loading conditions is greater than 1.50, therefore these safety factors are adequate.

**The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40**

Providence modeled the pond under the short-term scenario where the facility allows the pond to fill to the freeboard level for the Fly Ash surface impoundment. This scenario represents the flood/heavy rainfall conditions. The new elevation was determined using 2.5 feet of freeboard from the lowest levee crown elevation for each pond.

Based on the results of the slope stability analysis, the following minimum factors of safety were obtained:

**Table 3 Short-Term Factors of Safety**

Surface Impoundment	Section Number	Soil Boring No.	Maximum Water Elevation (feet NAVD 88)	Analysis	Factor of Safety
Fly Ash	Section 1	B-15	102.5	Spencer Method Deep Failure	1.56
Fly Ash	Section 2	B-6	102.5	Spencer Method Deep Failure	1.82
Fly Ash	Section 3	B-8	102.5	Spencer Method Deep Failure	2.75

The calculated short-term static factor of safety under maximum surcharge pool loading conditions is greater than 1.40, therefore these safety factors are adequate.

**The calculated seismic factor of safety must equal or exceed 1.00**

The Brame Energy Center is not located in a seismic area. The Louisiana Geological Survey and the United States Geological Survey classifies the entire state of Louisiana as a low seismic risk area. This low seismic risk classification denotes that the levels of horizontal shaking that have a 2 in 100 chance of being exceeded in in a 50-year period range from 0-8% g where g is the acceleration of a falling object due to gravity. The nearest published fault system to the Brame Energy Center is approximately 100 miles away. Therefore, the calculated seismic factor of safety is not applicable to the Fly Ash Pond.

**For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.2**

The clayey soils encountered at the Fly Ash Pond are not susceptible to liquefaction.

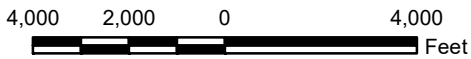
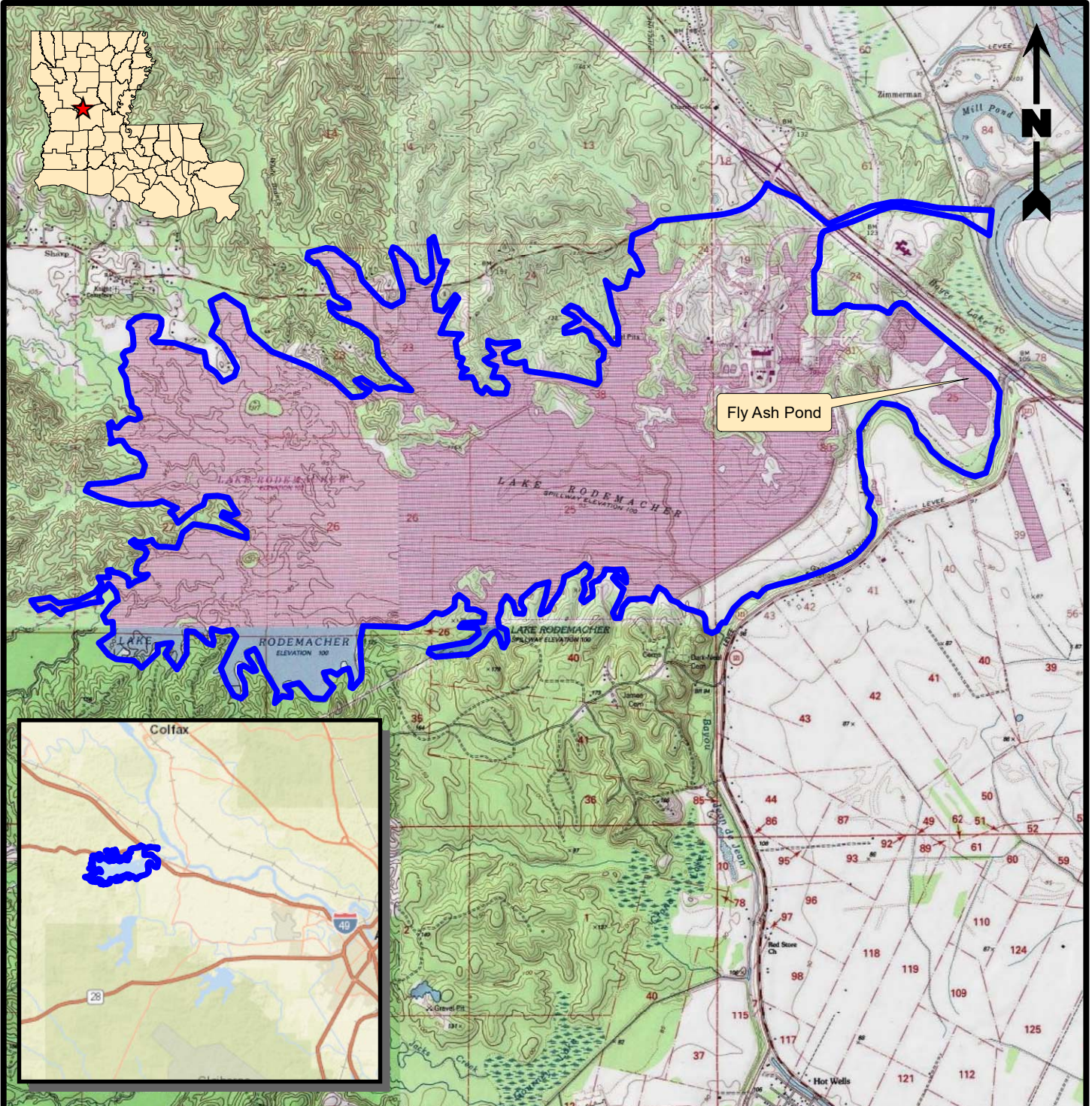
It must be noted that Cleco keeps the operating water levels in the Fly Ash Pond at lower levels. The low operating levels for this pond will not adversely affect the structural stability of the perimeter levees around the Fly Ash Pond. The normal operating water level in the Fly Ash Pond ranges from 86 to 92 feet NAVD 88. These levels are significantly lower than the modeled flooded/heavy rainfall conditions.

**3.0 CONCLUSIONS**

Based on the results from the safety factor analysis, the existing levee design for the Fly Ash Pond achieves the minimum safety factor requirements of the 40 CFR 257.73(e)(1) CCR regulations. Results of the safety factor analysis and model input parameters can be found in **Appendix A**. **Appendix B** contains a P.E. Certification that attests to the safety factor assessment.

**FIGURE 1**  
**SITE LOCATION MAP**





**Legend**

 Property Boundary

**Reference**

Base map comprised of U.S.G.S. 7.5 minute topographic maps, "Lena, LA", "Boyce, LA", "Jericho, LA", and "Gardner, LA".

**Site Location Map**

**Safety Factor Assessment - Fly Ash Pond**  
Boyce, Rapides Parish, Louisiana

**Cleco Power LLC**  
Brame Energy Center



Drawn By	LMM	10/04/16
Checked By	LMH	10/04/16
Approved By	CVH	10/04/16

Project Number	002-186	<b>1</b> Figure
Drawing Number	002-186-A015	



**FIGURE 2**  
**SITE MAP**

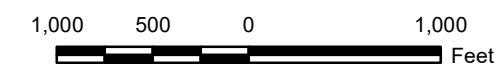


**Legend**

 Property Boundary

**Reference**

Base map comprised of Google Earth aerial imagery from 10/03/14.



**Site Map**

**Safety Factor Assessment - Fly Ash Pond**  
Boyce, Rapides Parish, Louisiana

**Cleco Power LLC**  
Brame Energy Center



Drawn By	LMM	10/04/16
Checked By	LMH	10/04/16
Approved By	CVH	10/04/16
Project Number	002-186	
Drawing Number	002-186-B016	
	2 Figure	

**APPENDIX A**  
**SAFETY FACTOR ANALYSIS**

**PROVIDENCE**

1201 Main Street  
Baton Rouge, LA 70802

**Attn: Mr. Gary Leonards, P.E.**

**Re: Slope Stability Analysis of Fly Ash Pond  
Cleco Brame Energy Center  
Lena, Louisiana**

**Dear Mr. Leonards:**

APS Engineering and Testing, LLC has completed slope stability analysis of the Fly Ash Pond located at Cleco Brame Energy Center in Lena, Louisiana. Authorization to proceed with this work was received from **Mr. Gary Leonards** via email on July 18, 2016. Our analysis was performed based on the soil boring log data provided by the client. Our scope of services included performing landside stability of the existing levee with maximum water elevation, as requested by the client. All sections were modeled and analyzed based on the survey data and soil boring data provided by the client. This report presents the results of Sections 1, 2 and 3 of the Fly Ash Pond.

**Background**

The Fly Ash Pond at the Brame Energy Center was initially constructed in 1981. The facility was expanded in 1982 when an additional coal fired boiler system (Unit #2) came on line. The Fly Ash Pond levee along the southern side was added in 1984 to reduce the size of the original pond. The fly ash is trucked to the Fly Ash Pond. The Fly Ash Pond is an existing unit that is essential for the management of solid residuals generated at the Brame Energy Center.

**TABLE 1.0**

Pond	Section #	Soil boring # (Report No.) *	Boring Depth (Feet)	Average Top of Levee Elevation (feet, NAVD88)	Pond Max. Water Elevation (feet, NAVD88)
Fly Ash	Section 1	B-15 (04-16-061)	80	105.0	102.5
	Section 2	B-6 (06-11-090)	80	104.0	102.5
	Section 3	B-8 (06-11-090)	80	103.5	102.5

\*Boring data was obtained from Reports prepared by Geotechnical Testing Laboratory (GTL), Inc.

All three sections achieved the minimum desired factor of safety of 1.50. Please refer to *Attachments* of this report.

### Assumptions and Observations:

- Soil layers are horizontal with uniform thickness.
- Soil layers encountered in Levee Centerline boring were used for the analysis.
- Cross section profiles limits were extended horizontally on the land side, whenever the failure plane passes the limits.

### Slope Stability Analysis Results

Slope stability analysis was performed using Spencer method for both the short term and long term conditions as requested by the client. Changes in slopes, structural loadings, and other conditions may affect the results of slope stability analysis. Factors of safety (FoS) obtained from slope stability analysis results do meet 1.50 according to HSDRRS guidelines for Steady Water Level conditions.

**TABLE 2.0**

Soil Type	Phi	Cohesion (psf)
Silt (ML)	28°	0
Clay (CL/CH)	28°	0
Sand (SP / SM)	37°	0

**TABLE 3.0**

Pond	Section #	Condition	Flood Side Water Elevation (feet, NAVD88)	Factor of Safety Obtained	Notes
Fly Ash Pond	1	Short Term	102.5	1.56	Landfill Material is required on the protected side of the levee to achieve min. FS.
	1	Long Term	102.5	2.48	--
	2	Short Term	102.5	1.80	--
	2	Long Term	102.5	1.53	--
	3	Short Term	102.5	2.71	--
	3	Long Term	102.5	1.79	--

Based on the results presented in the above table, all three sections of the Fly Ash Pond meet minimum required factor of safety with the projected maximum water elevation as shown in above table for both short term and long term conditions. This is based on the soil boring data provided by the client.

### Liquefaction

Clayey soils encountered at the Fly Ash Pond site are not susceptible to liquefaction.

If you have any questions pertaining to this report, or if we may be of further service, please contact our office.

Respectfully submitted,  
**APS ENGINEERING AND TESTING, LLC**



Sairam Eddanapudi, P.E.  
Project Manager



Sergio Aviles, P.E.  
President

**Attachments**

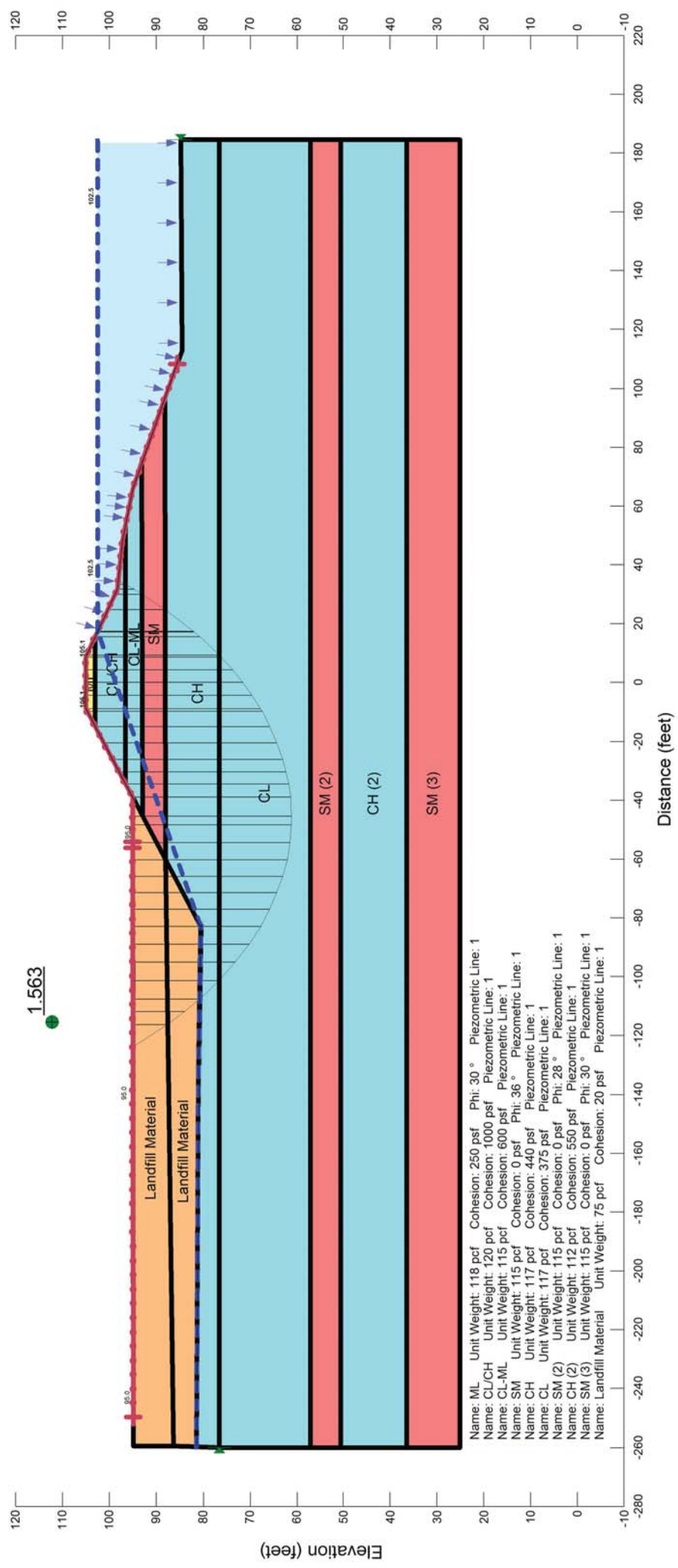
Boring Location Plan  
Slope Stability Analysis Results



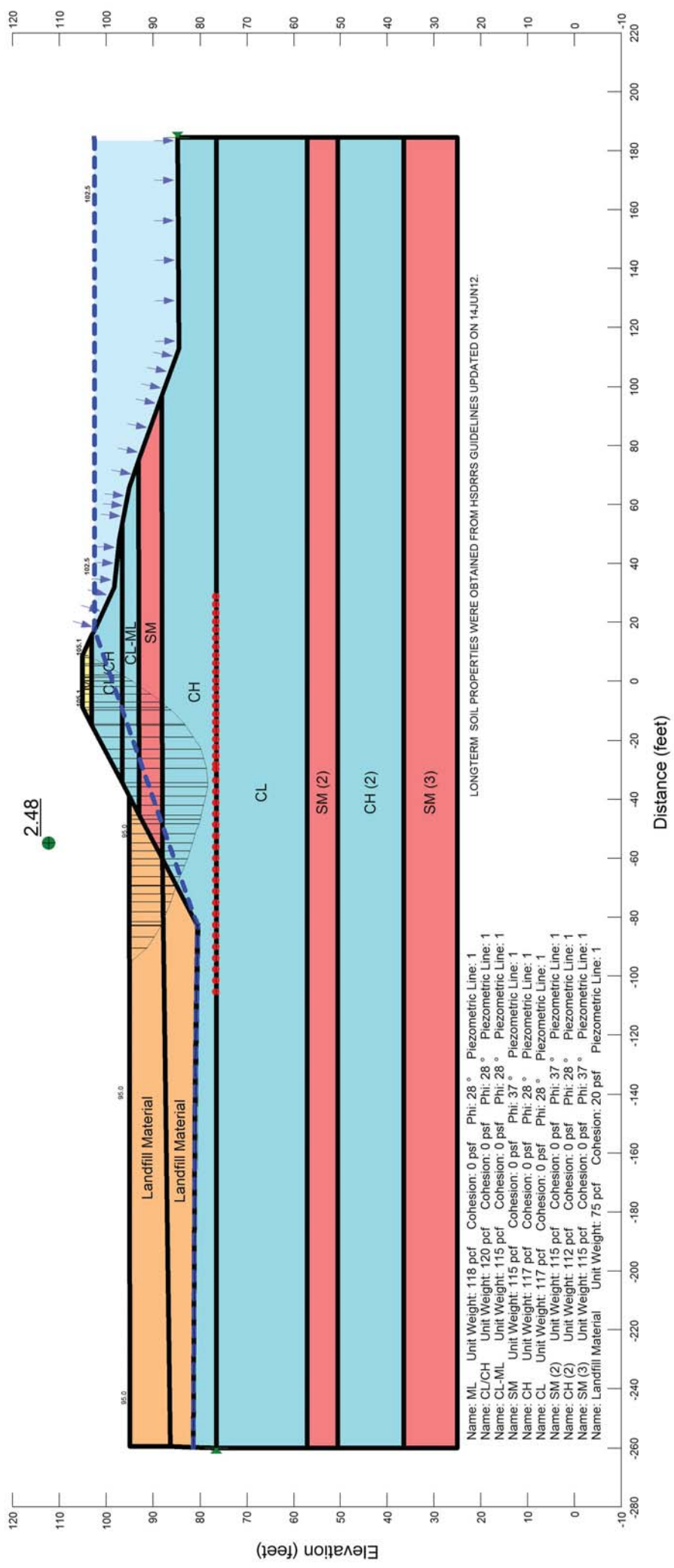


Image USDA Farm Service Agency

# CLECO BRAME ENERGY CENTER FLY ASH POND - SECTION 1 SHORT TERM SLOPE STABILITY ANALYSIS SOIL BORING B-15 (FROM GTL REPORT NO.: 04-16-061)

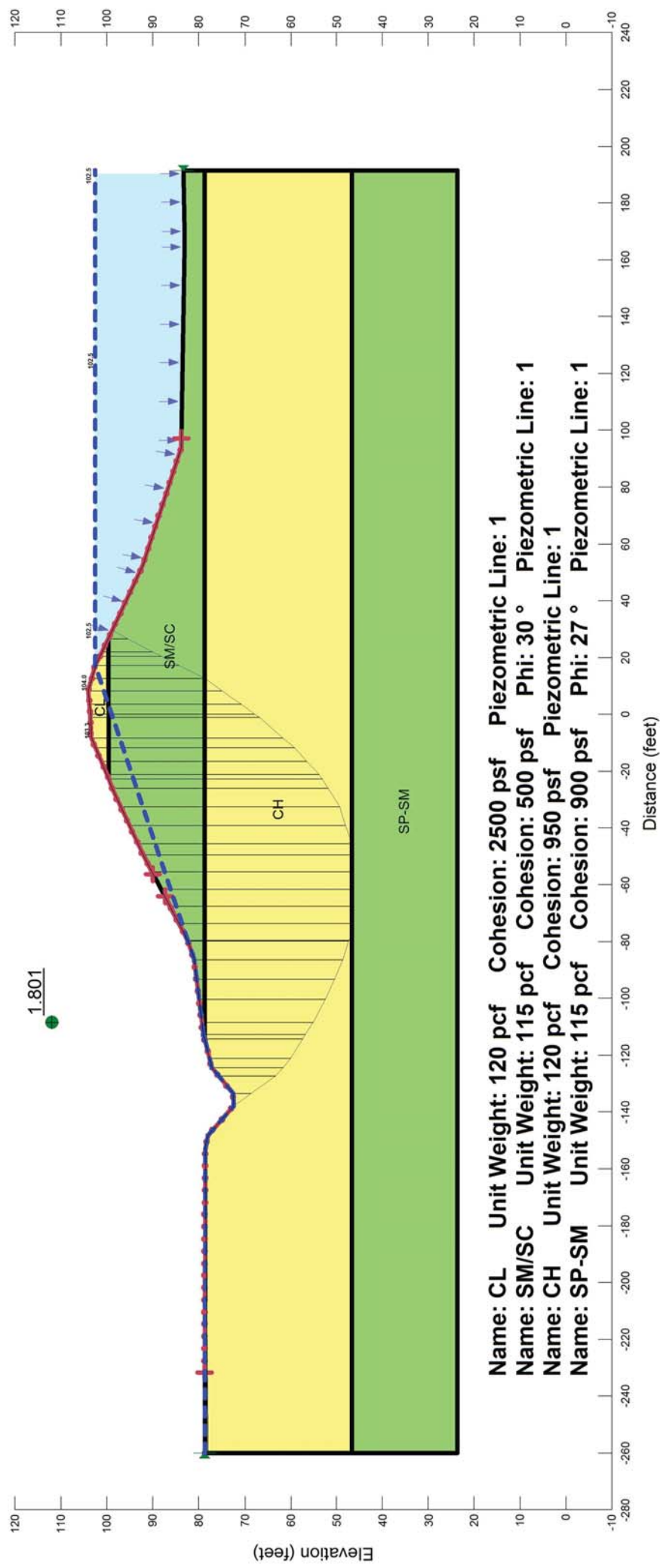


**CLECO BRAME ENERGY CENTER  
 FLY ASH POND - SECTION 1  
 LONG TERM SLOPE STABILITY ANALYSIS (S-CASE)  
 SOIL BORING B-15 (FROM GTL REPORT NO.: 04-16-061)**



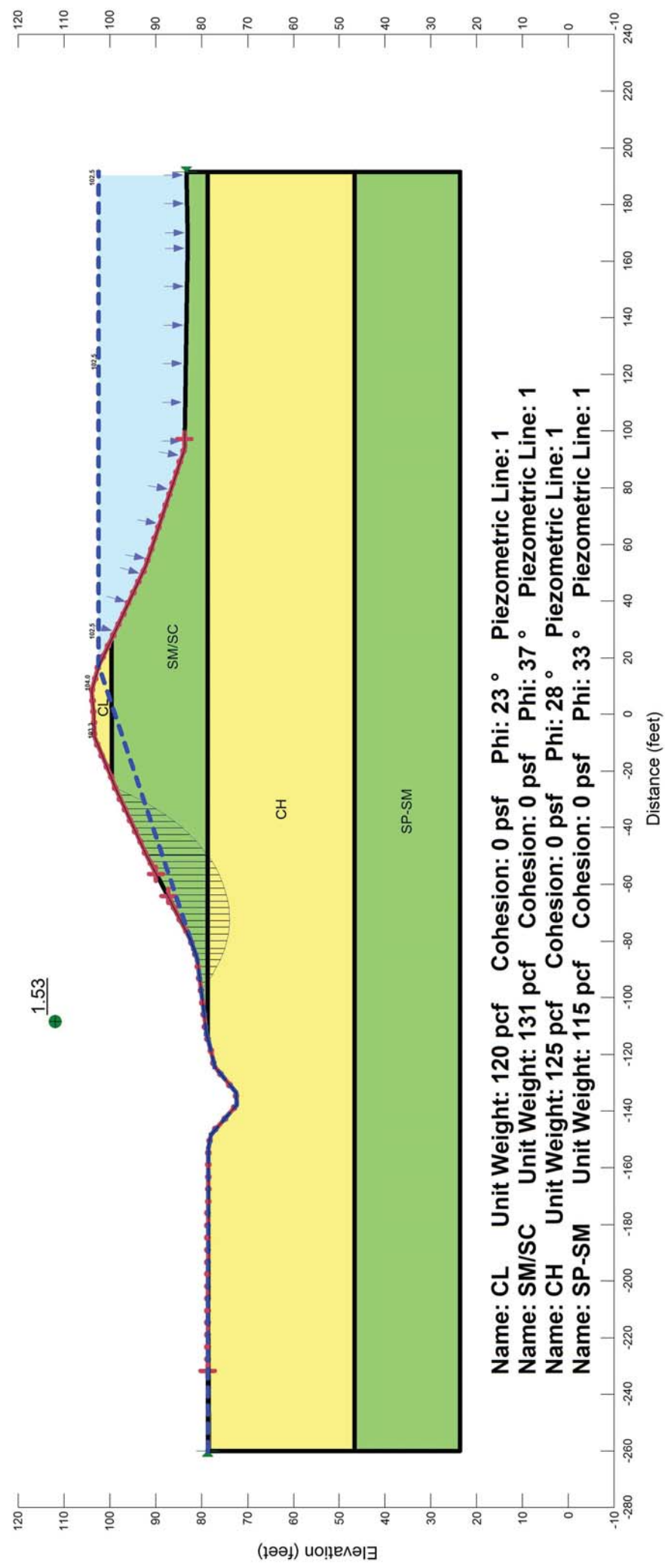


**CLECO BRAME ENERGY CENTER**  
**FLY ASH POND - SECTION 2**  
**SHORT TERM SLOPE STABILITY ANALYSIS**  
**SOIL BORING B-6 (FROM GTL REPORT NO.: 06-11-090)**

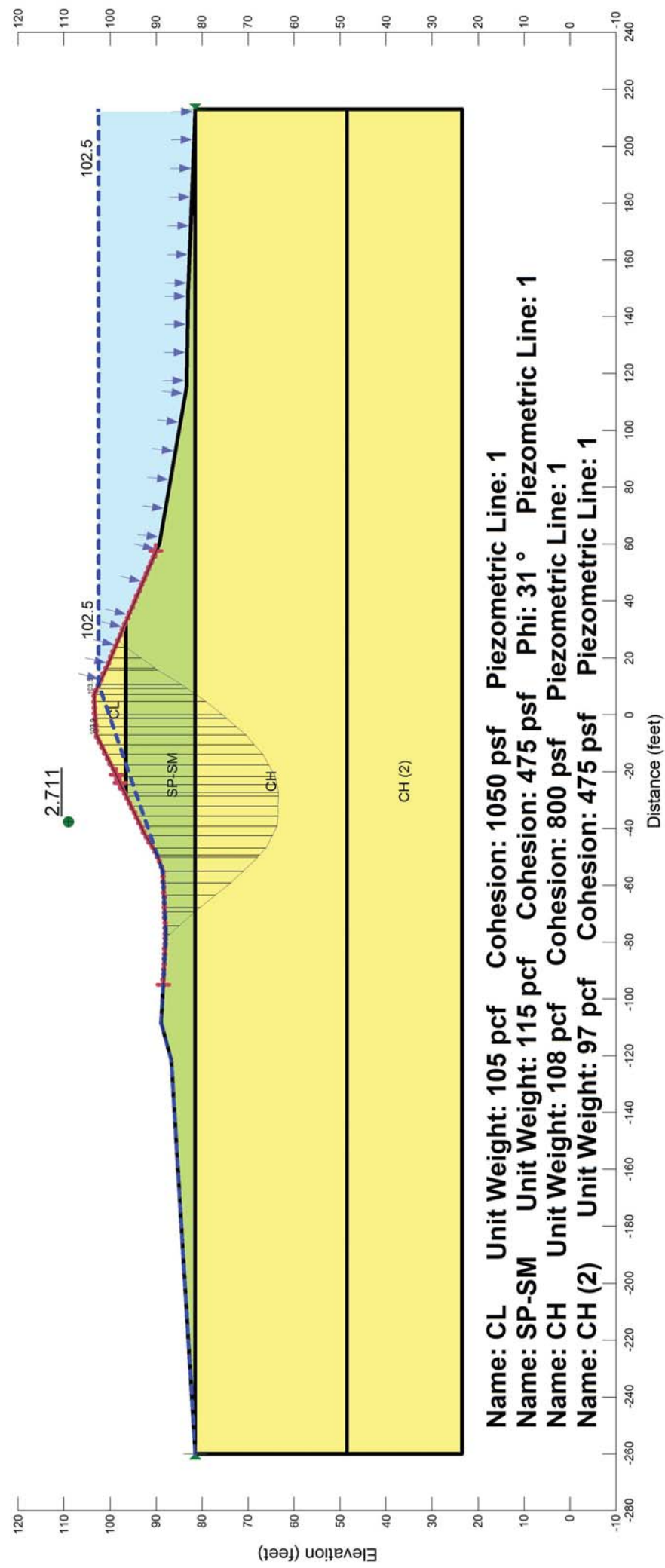


**Name: CL Unit Weight: 120 pcf Cohesion: 2500 psf Piezometric Line: 1**  
**Name: SM/SC Unit Weight: 115 pcf Cohesion: 500 psf Phi: 30 ° Piezometric Line: 1**  
**Name: CH Unit Weight: 120 pcf Cohesion: 950 psf Piezometric Line: 1**  
**Name: SP-SM Unit Weight: 115 pcf Cohesion: 900 psf Phi: 27 ° Piezometric Line: 1**

**CLECO BRAME ENERGY CENTER**  
**FLY ASH POND - SECTION 2**  
**LONG TERM SLOPE STABILITY ANALYSIS (S-CASE)**  
**SOIL BORING B-6 (FROM GTL REPORT NO.: 06-11-090)**



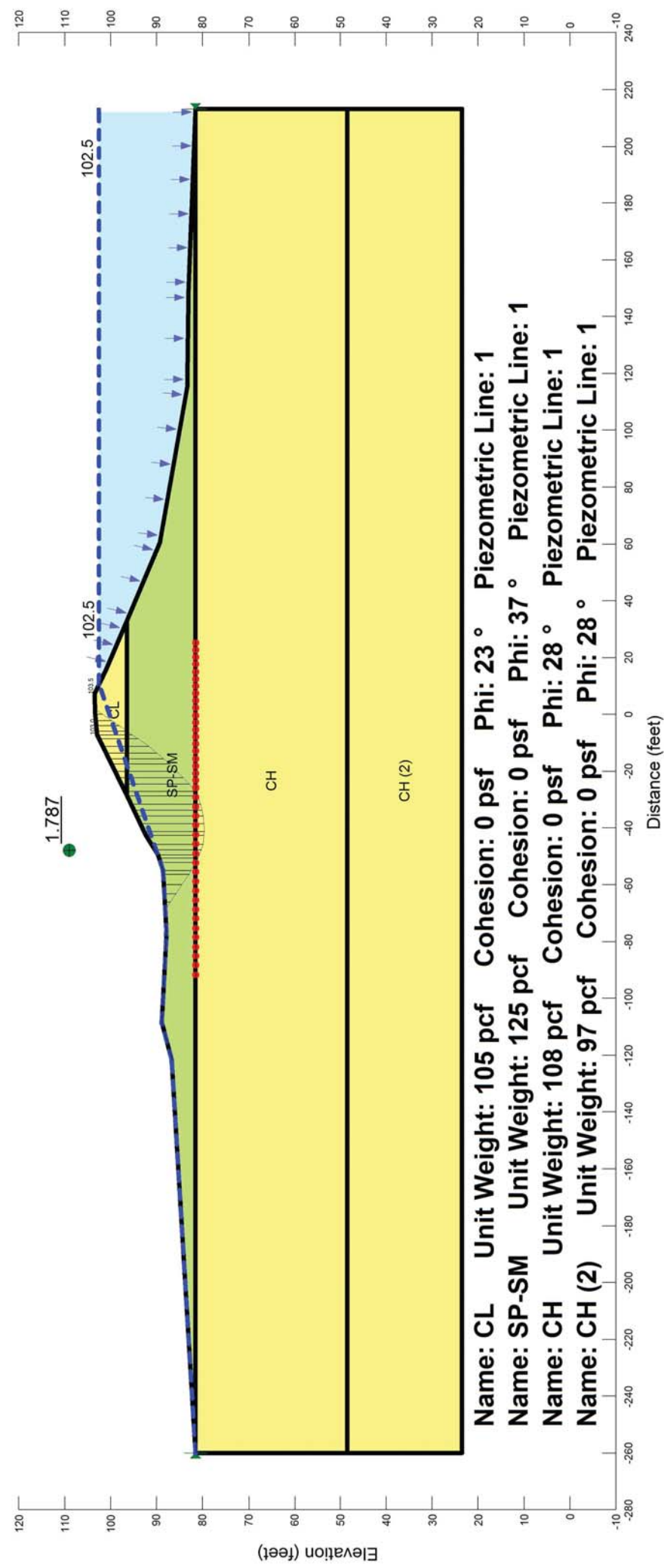
**CLECO BRAME ENERGY CENTER**  
**FLY ASH POND - SECTION 3**  
**SHORT TERM SLOPE STABILITY ANALYSIS**  
**SOIL BORING B-8 (FROM GTL REPORT NO.: 06-11-090)**



**Name: CL    Unit Weight: 105 pcf    Cohesion: 1050 psf    Piezometric Line: 1**  
**Name: SP-SM    Unit Weight: 115 pcf    Cohesion: 475 psf    Phi: 31 °    Piezometric Line: 1**  
**Name: CH    Unit Weight: 108 pcf    Cohesion: 800 psf    Piezometric Line: 1**  
**Name: CH (2)    Unit Weight: 97 pcf    Cohesion: 475 psf    Piezometric Line: 1**



**CLECO BRAME ENERGY CENTER  
 FLY ASH POND - SECTION 3  
 LONG TERM SLOPE STABILITY ANALYSIS (S-CASE)  
 SOIL BORING B-8 (FROM GTL REPORT NO.: 06-11-090)**



**APPENDIX B**  
**P.E. CERTIFICATION**

**CLECO BRAME ENERGY CENTER  
FLY ASH POND  
CCR SAFETY FACTOR ASSESSMENT**

**PROFESSIONAL ENGINEER CERTIFICATION**

I hereby certify that I have performed a safety factor assessment for Cleco's Brame Energy Center Fly Ash Pond in accordance with the 40 CFR 257.73(e)(1) CCR requirements. This safety factor assessment has determined that the Fly Ash Pond has met the following requirements:

- The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
- The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.

And that these requirements were not applicable based on the findings:

- The calculated seismic factor of safety must equal or exceed 1.00.
- For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

**James C. Van Hoof**

Name

**24630**

Registration No.

**LA**

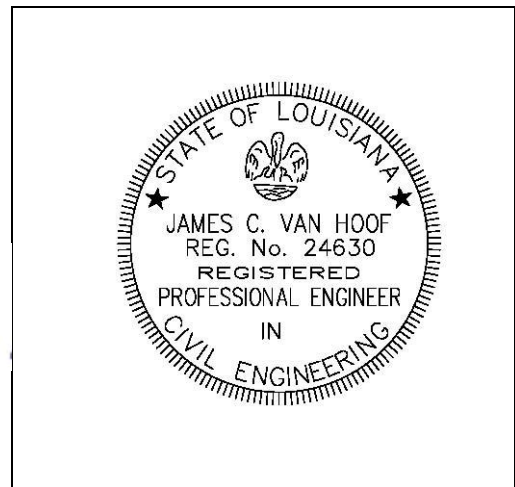
State

*James C. Van Hoof, P.E.*

Signature

10/17/2016

Date



(Seal)