Periodic Safety Factor Assessment

Chesterfield Power Station CCR Surface Impoundment: Lower Ash Pond

Submitted to:

Chesterfield Power Station

500 Coxendale Road

Chester, VA 23836

Submitted by:

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Project No. 21466315

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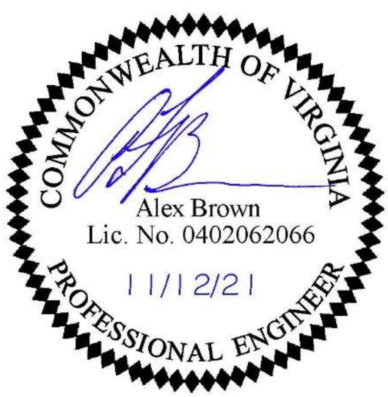
1.0 CERTIFICATION

This periodic Safety Factor Assessment for the Chesterfield Power Station's Lower Ash Pond was prepared by Golder Associates Inc. (Golder). The document and Certification/Statement of Professional Opinion are based on and limited to information that Golder has relied on from Dominion and others, but not independently verified, as well as work products produced by Golder.

On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the Commonwealth of Virginia that this document has been prepared in accordance with good and accepted engineering practices as exercised by other engineers practicing in the same discipline(s), under similar circumstances, at the same time, and in the same locale. It is my professional opinion that the document was prepared consistent with the requirements in §257.73(e) of the United States Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments," published in the Federal Register on April 17, 2015, with an effective date of October 19, 2015 [40 CFR §257.73(e)].

The use of the word "Certification" in this document shall be interpreted and construed as a Statement of Professional Opinion and is not and shall not be interpreted or construed as a guarantee, warranty, or legal opinion.

Alex Brown, P.E.	Senior Project Geotechnical Engineer
Print Name	Title
	11/12/2021
Signature	Date



2.0 INTRODUCTION

This periodic Safety Factor Assessment (Assessment) was prepared for the Chesterfield Power Station's (Station) existing Coal Combustion Residuals (CCR) surface impoundment known as the Lower Ash Pond (LAP). This Safety Factor Assessment was prepared in accordance with 40 CFR Part §257, Subpart D and is consistent with the requirements of 40 CFR §257.73(e).

The Station, owned and operated by Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion), is located in Chesterfield County, Virginia, at 500 Coxendale Road, east of I-95 (Richmond-Petersburg Turnpike) and south of the James River. The Station includes an existing CCR surface impoundment, the LAP, as defined by the Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule (40 CFR §257; the CCR rule). The LAP is also regulated as a dam by the Virginia Department of Conservation and Recreation (DCR) with Inventory Number 041031 (DCR Dam Permit).

3.0 PURPOSE

This periodic Assessment is prepared pursuant to § 257.73(e)(1) of the CCR Rule [40 CFR § 257.73(e)(1)]. The initial Safety Factor Assessment was completed on October 17, 2016 and is required to be updated every five (5) years pursuant to 40 CFR 257.73(f)(3).

4.0 SAFETY FACTOR ASSESSMENT REQUIREMENTS

In accordance with § 257.73(e)(1), the owner or operator of a CCR surface impoundment must conduct periodic safety factor assessments and document whether the calculated factors of safety achieve the minimum safety factors specified for the critical cross section of the embankment. The safety factor assessments must be supported by appropriate engineering calculations. The minimum safety factors specified in § 257.73(e)(1)(i) through(iv) include:

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

5.0 SAFETY FACTOR ASSESSMENT

A slope stability analysis of the LAP embankment was conducted to determine whether the calculated factors of safety for the critical cross sections of the embankment meet or exceed the minimum safety factors specified in 40 CFR §257.73(e)(1).

5.1 Methodology

Stability safety factors were evaluated using a general limit equilibrium (GLE) method and the computer program SLIDE2 Version 9.008. Specifically, the method developed by Morgenstern and Price (1965) was used in SLIDE to evaluate the stability of potential failure surfaces associated with the critical cross sections. For each surface, the method calculates the shear strengths that would be required to maintain equilibrium and then calculates a factor of safety by dividing the available shear strength by the shear strength required to maintain stability. The slip surface producing the minimum factor of safety is reported as the critical slip surface. Golder evaluated slip surfaces using Rocscience's Cuckoo Search, which is a global optimization method. This method typically yields more conservative safety factors than methods assuming either block or circular failure geometries. Material properties and slope geometry for the LAP embankment were based on the Field Investigation and Laboratory Testing Report prepared by Geosyntec (Geosyntec, 2016a) and the previous Initial Safety Factor Assessment for the LAP (Geosyntec, 2016b) and are presented in Table 1 below.

Table 1: Summary of Geotechnical Strength Properties

Material	Total Unit Weight *(pound per cubic foot, pcf)*	Strength Properties[1]		
		Drained Strength		Undrained Shear Strength Ratio
		Peak φ' (°)	Cohesion *(pound per square foot, psf)*	
Embankment > 10 ft amsl	120	34, *28*	0	-
Embankment < 10 ft amsl	115	28, *23*	0	0.35, *0.28*
Sluiced CCR	85	28, *23*	0	0.35, *0.28*
Fine-Grained Alluvium > -15 ft amsl	115	28, *23*	0	0.35, *0.28*
Liquified Fine-Grained Alluvium	115	0	59	-
Fine-Grained Alluvium < -15 ft amsl	115	28, *23*	0	0.35, *0.28*
Coarse-Grained Alluvium	120	30, *24*	0	-
Deep Coarse-Grained Alluvium	120	35, *29*	0	-
Coarse-Grained Cretaceous Sediments	125	36, *30*	0	-

Notes:
1. Seismic strength properties are italicized.

The four loading scenarios required by the CCR rule are discussed in the following sections.

5.2 Critical Cross Sections

The critical section for the LAP runs perpendicular to the embankment slope at the southwest corner of the LAP (Figure 1). This section location is close to Section B that was analyzed in the previous Initial Safety Factor Assessment (Geosyntec, 2016b). Since the initial 5-year assessment, the LAP underwent grading activities within the extent of the pond to prepare the surface to promote drainage and receive a geomembrane rain cover. The groundwater table (GWT) modeled within the embankment for each factor of safety analysis was based on the average GWT elevation measured in piezometer P-28 over the past 2 years (approximately 6.9 ft amsl), which is comparable to the water levels measured in neighboring MW-24 over the past 2 years.

5.3 Long-Term Maximum Storage Pool Conditions

In accordance with the CCR Rules, the long-term maximum storage pool elevation is equal to the LAP principal spillway's weir elevation [6.5 ft amsl].

The principal spillway system, located on the western edge of the LAP, consists of a 17-foot long rectangular, sharp-crested concrete weir (6.5 ft amsl), an 11-inch dewatering orifice set within the weir structure (5.2 ft amsl), and two 58-inch HDPE pipes (4.0 ft amsl) (Geosyntec, 2021). Non-contact stormwater collected in the LAP discharges through the principal spillway to an outfall regulated by the Virginia Stormwater Management Program (Geosyntec, 2021).

As a result of the pond geometry and rain cover, the water level associated with the long-term maximum storage pool condition is not considered to impact the groundwater within the LAP. Thus, the long-term maximum storage pool is modeled as a pond above the CCR.

The calculated static factor of safety is 1.03 for the long-term maximum storage pool loading condition, therefore the embankment does not meet the requirement for the maximum long-term storage pool condition.

5.4 Maximum Surcharge Pool Conditions

The maximum surcharge pool elevation was conservatively calculated based on 90% of the probable maximum flood (PMF) in accordance with DCR regulations, Section 4VAC50-20-50 for impounding structures. The evaluation of the LAP's hydraulic performance using the DCR's requirements for a Spillway Design Flood has been used in lieu of the 1,000-year flood which provides a more conservative approach. The maximum surcharge pool condition corresponds to a water level at elevation 14.34 ft amsl. The analysis of the hydraulic and hydrologic conditions is described in the Periodic Inflow Design Flood Control System Plan (Golder, 2021).

As a result of the pond geometry and rain cover, the water level associated with the maximum surcharge pool condition is not considered to impact the groundwater within the LAP. Thus, the maximum surcharge pool is modeled as a pond above the CCR.

The calculated seismic factor of safety is 1.03 for the maximum surcharge pool loading condition, therefore the embankment does not meet the requirement for the maximum surcharge pool condition.

5.5 Seismic Loading Conditions

Factors of safety for stability under seismic loading conditions were calculated based on the earthquake hazard corresponding to a probability of exceedance of 2% in 50 years (2,475-year return period). The Hynes-Griffin and Franklin Method (1984) was used. This method applies one-half the Peak Ground Acceleration (PGA) for the 2,475-year return period to the model in addition to reducing the material strengths of the model by 20%.

The calculated seismic factor of safety is 0.68 for the long-term, maximum storage pool loading condition, therefore the embankment does not meet the requirement for the maximum storage pool loading condition.

5.6 Post-Seismic Liquefaction Loading Conditions

Geosyntec performed a liquefaction evaluation as part of the 2016 Initial Safety Factor Assessment (Geosyntec, 2016b). Based on the liquefaction evaluations, a potentially liquefiable zone of material within the fine-grained alluvium (FGA) exists between elevation -20 ft amsl and -15 ft amsl. Geosyntec calculated that this material has an undrained residual strength equal to 59 psf following a magnitude 5.7 earthquake (Geosyntec, 2016b).

The calculated factor of safety of 0.62 for post-seismic liquefaction does not meet the requirement for the post-seismic liquefaction loading condition.

5.7 Results

The table below presents the results of Safety Factor Assessments for the LAP analysis cases required in 40 CFR §257.73(e)(1)(i) to (iv) of the CCR rule. For all required conditions evaluated, the calculated factors of safety do not meet the target factors of safety identified in the CCR rule. Stability Analyses figures are included in Appendix A, and the factors of safety are summarized in Table 2 below.

Table 2: Lower Ash Pond - Factors of Safety

Case	Pool Elevation (ft amsl)	Target Factor of Safety (FS)	FS
Max Storage Pool	6.5	1.50	1.03
Max Surcharge Pool	14.34	1.40	1.03
Seismic	6.5	1.00	0.68
Liquefied Ash	6.5	1.20	0.62

6.0 CONCLUSION

Based on known site conditions, information referenced herein, as well as work performed by Golder for this Periodic Safety Factor Assessment, the LAP does not meet the minimum factors of safety as required by §257.73(e)(1) for each of the four conditions analyzed.

In response to this evaluation, Dominion Energy plans to enhance the strength of the southwest corner of the Lower Ash Pond berm by installing deep soil mixing shear panels (or similar type enhancements). Engineering efforts are ongoing through the end of this year and construction is expected to begin in the first quarter of 2022 with an estimated completion in mid-2022.

7.0 REFERENCES

Code of Virginia, 4VAC50-20-50. Performance standards required for impounding structures; effective March 23, 2016.

Geosyntec Consultants. Field Investigation and Laboratory Testing Report: Lower Ash Pond Closure. August 2016a.

Geosyntec Consultants. Coal Combustion Residuals Initial Safety Factor Assessment. October 2016b.

Geosyntec Consultants. Dam Breach Inundation Analysis, Lower Ash Pond and Upper Ash Pond Embankments. April 2021.

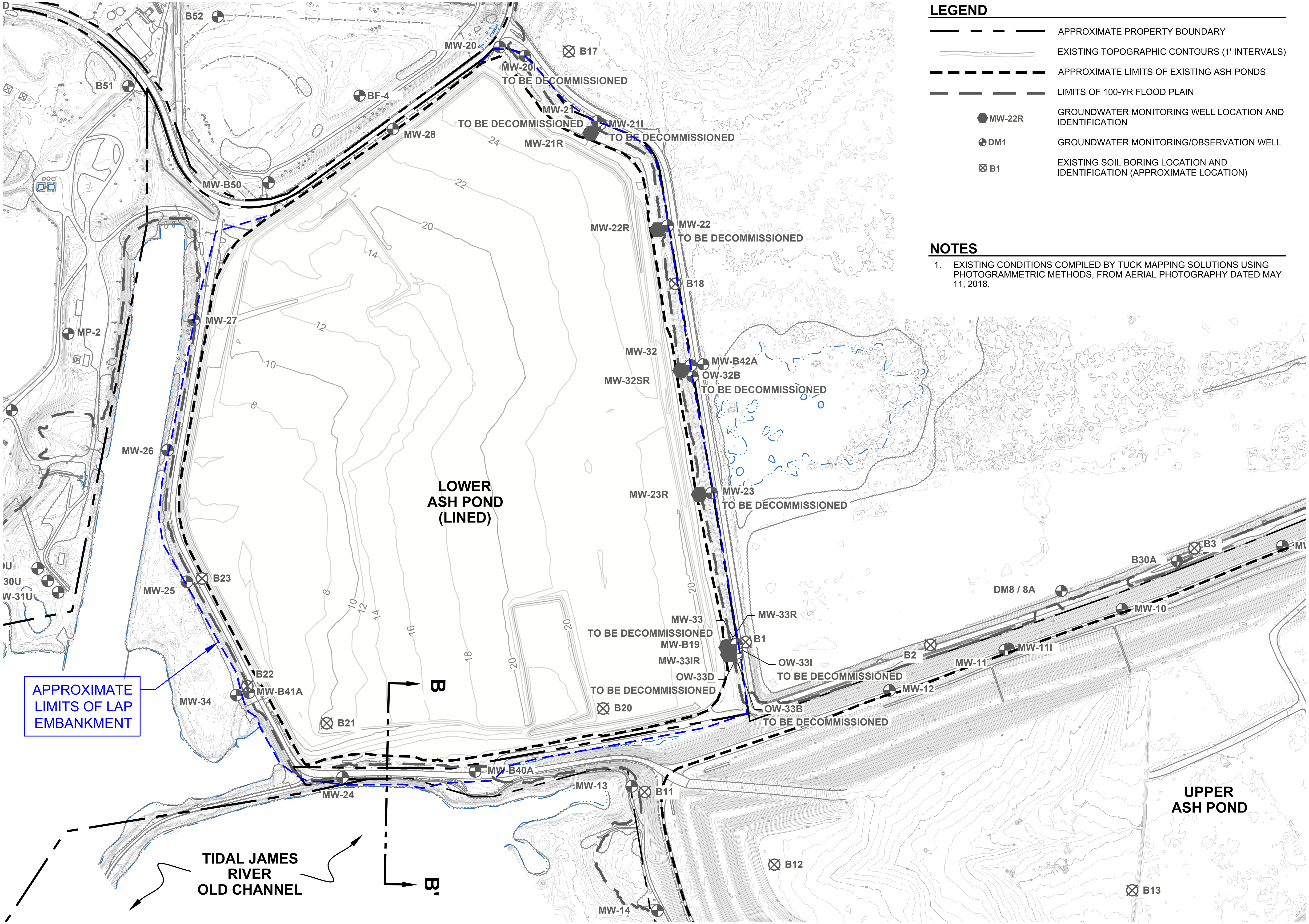
Golder Associates. Periodic Inflow Design Flood Control System Plan, Chesterfield Power Station CCR Surface Impoundment: Lower Ash Pond. October 2021.

Hynes-Griffin, Mary E. and Franklin, Arley G. (1984). “Rationalizing the Seismic Coefficient Method,” Miscellaneous Paper Prepared for the U.S. Army Corps of Engineers. July 1984.

Morgenstern, N. R., and Price, V. E. (1965). "The Analysis of the Stability of General Slip Surfaces," Geotechnique Vol 15 1, p. 79.

RocScience (2021). Slide Version 9.017. Build date: June 2, 2021.

United States Geological Survey (USGS). Unified Hazard Tool. Dynamic: Conterminous U.S. 2014 (update) Edition. PGA with 2% probability of exceedance in 50 years. Available online: https://earthquake.usgs.gov/hazards/interactive/



LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- EXISTING TOPOGRAPHIC CONTOURS (1' INTERVALS)
- APPROXIMATE LIMITS OF EXISTING ASH PONDS
- LIMITS OF 100-YR FLOOD PLAIN
- MW-22R — GROUNDWATER MONITORING WELL LOCATION AND IDENTIFICATION
- DM1 — GROUNDWATER MONITORING/OBSERVATION WELL
- B1 — EXISTING SOIL BORING LOCATION AND IDENTIFICATION (APPROXIMATE LOCATION)

350 0 350
FEET
SCALE

NOTES

1. EXISTING CONDITIONS COMPILED BY TUCK MAPPING SOLUTIONS USING PHOTOGRAMMETRIC METHODS, FROM AERIAL PHOTOGRAPHY DATED MAY 11, 2018.

CLIENT
DOMINION ENERGY
CHESTERFIELD POWER STATION
CHESTERFIELD COUNTY, VIRGINIA

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-08-18
DESIGNED	ATN
PREPARED	SIB
REVIEWED	ATN
APPROVED	JRD

PROJECT
PERIODIC SAFETY FACTOR ASSESSMENT
STABILITY ANALYSIS
LOWER ASH POND

TITLE
STABILITY CROSS SECTION LOCATION

PROJECT NO. 21-466315 | REV. 0 | FIGURE 1

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

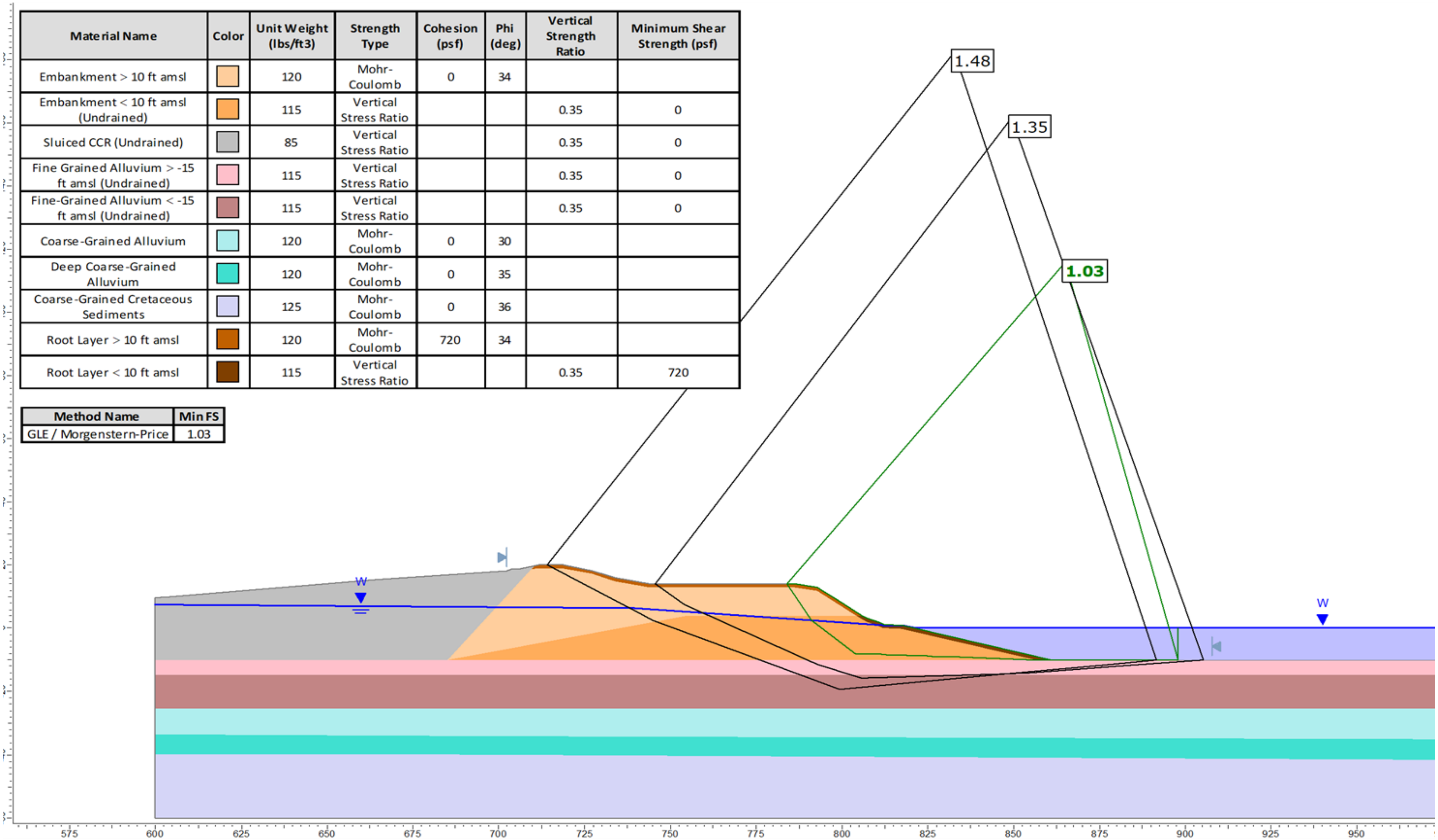
Path: G:\Plan Production Data Files\Drawing Data Files\21-466315\020_CPS 5-yr Assessments\Active Drawings\21466315-020-01.dwg

APPENDIX A

Lower Ash Pond Stability Analysis

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (psf)
Embankment > 10 ft amsl		120	Mohr-Coulomb	0	34		
Embankment < 10 ft amsl (Undrained)		115	Vertical Stress Ratio			0.35	0
Sluiced CCR (Undrained)		85	Vertical Stress Ratio			0.35	0
Fine Grained Alluvium > -15 ft amsl (Undrained)		115	Vertical Stress Ratio			0.35	0
Fine-Grained Alluvium < -15 ft amsl (Undrained)		115	Vertical Stress Ratio			0.35	0
Coarse-Grained Alluvium		120	Mohr-Coulomb	0	30		
Deep Coarse-Grained Alluvium		120	Mohr-Coulomb	0	35		
Coarse-Grained Cretaceous Sediments		125	Mohr-Coulomb	0	36		
Root Layer > 10 ft amsl		120	Mohr-Coulomb	720	34		
Root Layer < 10 ft amsl		115	Vertical Stress Ratio			0.35	720

Method Name	Min FS
GLE / Morgenstern-Price	1.03

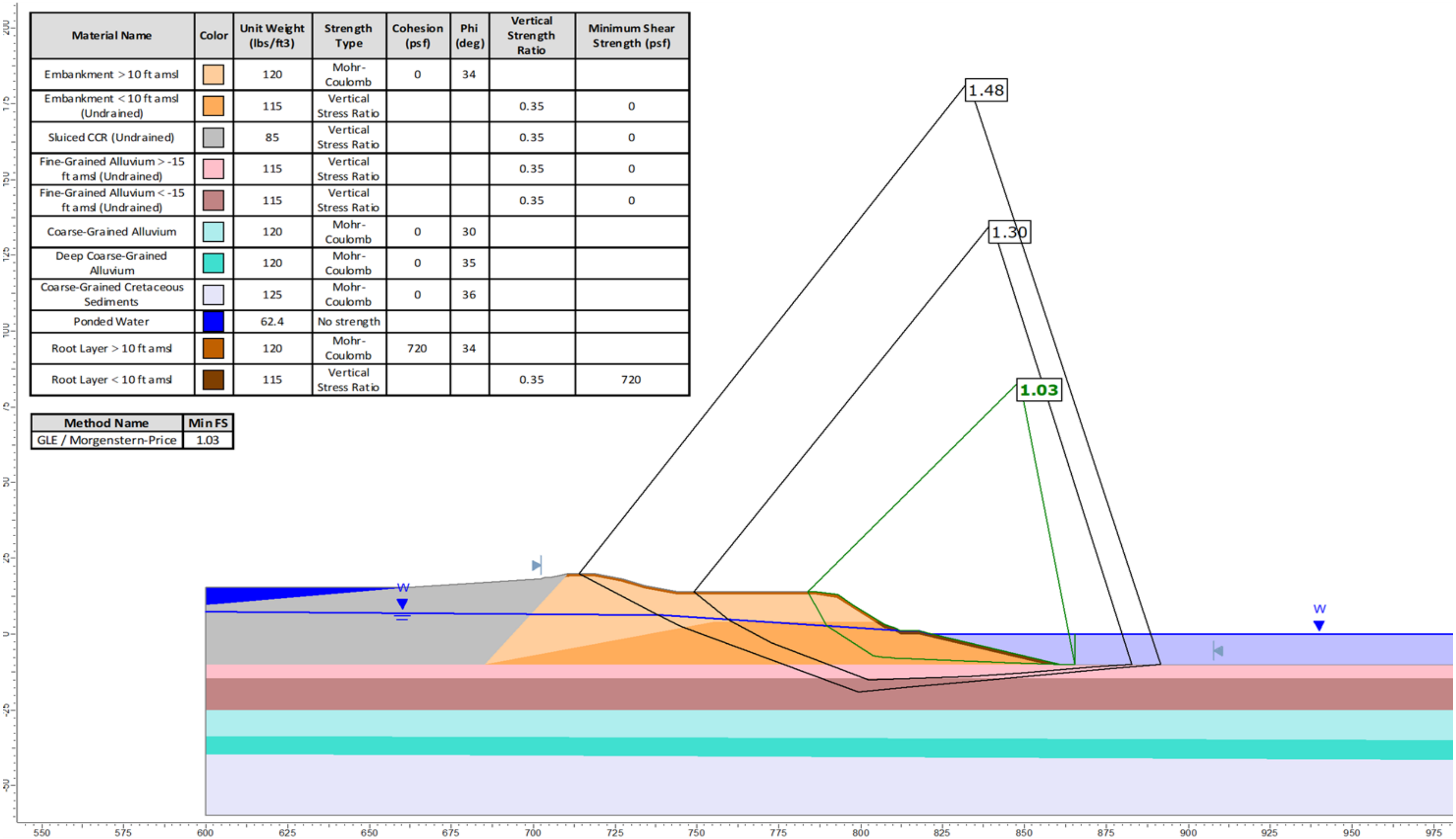


Note: GLE/Morgenstern Price method results displayed.

GOLDER MEMBER OF WSP	SCALE AS SHOWN	PROJECT	Chesterfield Power Station
	DATE Oct 2021	TITLE	Lower Ash Pond Section B-B' Maximum Pool Storage
	MADE BY SDRM		
	CAD -		
FILE SAFETY FACTOR ASSESSMENT	CHECK ALB	CLIENT	Dominion Energy
PROJECT No. 21466315 REV. 0	REVIEW ATN	FIGURE	1

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (psf)
Embankment > 10 ft amsl		120	Mohr-Coulomb	0	34		
Embankment < 10 ft amsl (Undrained)		115	Vertical Stress Ratio			0.35	0
Sluiced CCR (Undrained)		85	Vertical Stress Ratio			0.35	0
Fine-Grained Alluvium > -15 ft amsl (Undrained)		115	Vertical Stress Ratio			0.35	0
Fine-Grained Alluvium < -15 ft amsl (Undrained)		115	Vertical Stress Ratio			0.35	0
Coarse-Grained Alluvium		120	Mohr-Coulomb	0	30		
Deep Coarse-Grained Alluvium		120	Mohr-Coulomb	0	35		
Coarse-Grained Cretaceous Sediments		125	Mohr-Coulomb	0	36		
Ponded Water		62.4	No strength				
Root Layer > 10 ft amsl		120	Mohr-Coulomb	720	34		
Root Layer < 10 ft amsl		115	Vertical Stress Ratio			0.35	720

Method Name	Min FS
GLE / Morgenstern-Price	1.03



Note: GLE/Morgenstern Price method results displayed.

GOLDER
MEMBER OF WSP

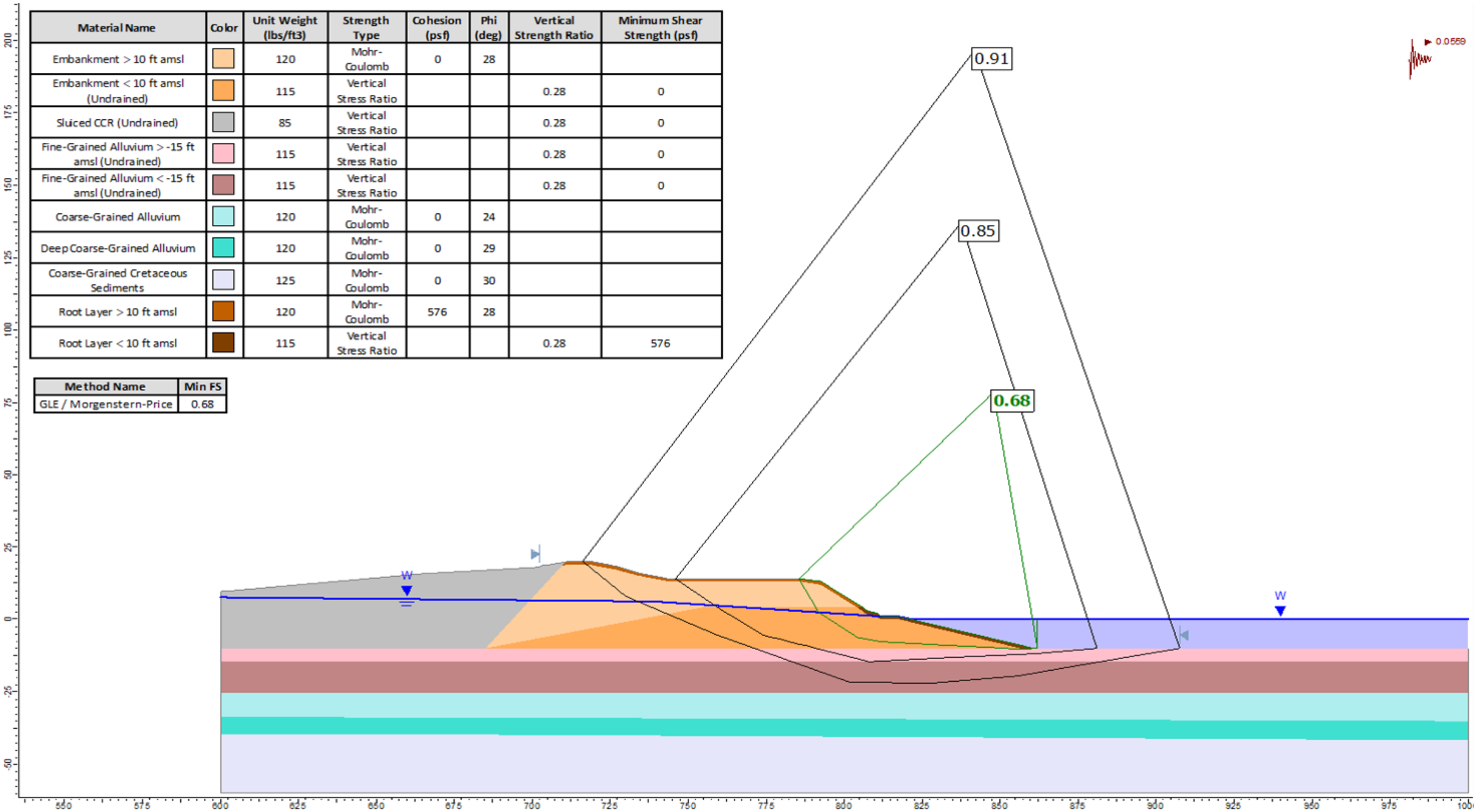
SCALE	AS SHOWN	PROJECT	Chesterfield Power Station
DATE	Oct 2021	TITLE	Lower Ash Pond Section B-B' Maximum Pool Surcharge
MADE BY	SDRM		
CAD	-		
CHECK	ALB	CLIENT	Dominion Energy
REVIEW	ATN	FIGURE	2

FILE SAFETY FACTOR ASSESSMENT

PROJECT No. 21466315 REV. 0

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (psf)
Embankment > 10 ft amsl		120	Mohr-Coulomb	0	28		
Embankment < 10 ft amsl (Undrained)		115	Vertical Stress Ratio			0.28	0
Sluiced CCR (Undrained)		85	Vertical Stress Ratio			0.28	0
Fine-Grained Alluvium > -15 ft amsl (Undrained)		115	Vertical Stress Ratio			0.28	0
Fine-Grained Alluvium < -15 ft amsl (Undrained)		115	Vertical Stress Ratio			0.28	0
Coarse-Grained Alluvium		120	Mohr-Coulomb	0	24		
Deep Coarse-Grained Alluvium		120	Mohr-Coulomb	0	29		
Coarse-Grained Cretaceous Sediments		125	Mohr-Coulomb	0	30		
Root Layer > 10 ft amsl		120	Mohr-Coulomb	576	28		
Root Layer < 10 ft amsl		115	Vertical Stress Ratio			0.28	576

Method Name	Min FS
GLE / Morgenstern-Price	0.68

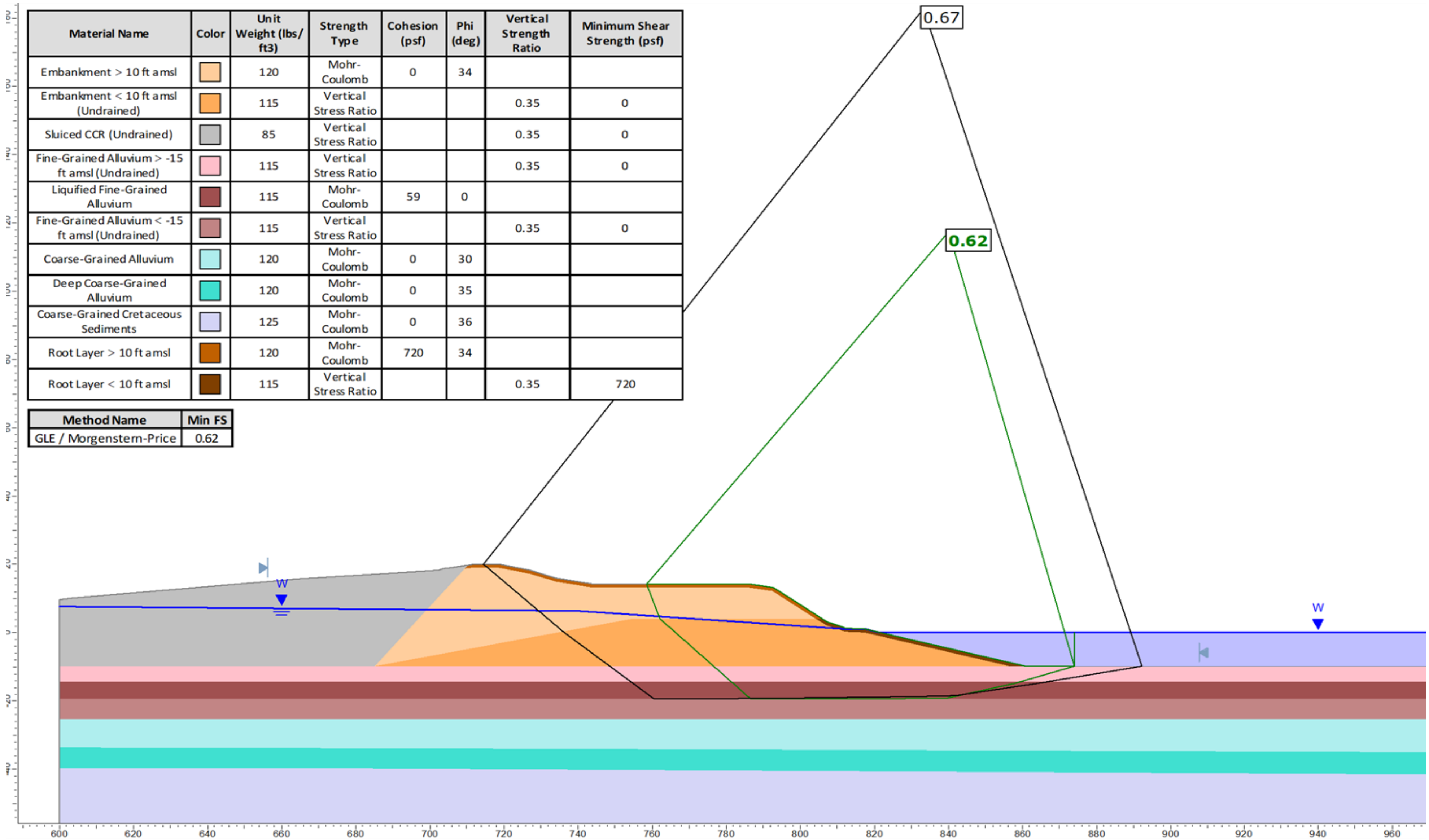


Note: GLE/Morgenstern Price method results displayed.

GOLDER MEMBER OF WSP	SCALE: AS SHOWN	PROJECT	**Chesterfield Power Station**
	DATE: Oct 2021	TITLE	**Lower Ash Pond** **Section B-B'** **Seismic**
	MADE BY: SDRM		
	CAD: -		
FILE: SAFETY FACTOR ASSESSMENT	CHECK: ALB	CLIENT	**Dominion Energy**
PROJECT No. 21466315 REV. 1	REVIEW: ATN	FIGURE	3

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (psf)
Embankment > 10 ft amsl		120	Mohr-Coulomb	0	34		
Embankment < 10 ft amsl (Undrained)		115	Vertical Stress Ratio			0.35	0
Sluiced CCR (Undrained)		85	Vertical Stress Ratio			0.35	0
Fine-Grained Alluvium > -15 ft amsl (Undrained)		115	Vertical Stress Ratio			0.35	0
Liquified Fine-Grained Alluvium		115	Mohr-Coulomb	59	0		
Fine-Grained Alluvium < -15 ft amsl (Undrained)		115	Vertical Stress Ratio			0.35	0
Coarse-Grained Alluvium		120	Mohr-Coulomb	0	30		
Deep Coarse-Grained Alluvium		120	Mohr-Coulomb	0	35		
Coarse-Grained Cretaceous Sediments		125	Mohr-Coulomb	0	36		
Root Layer > 10 ft amsl		120	Mohr-Coulomb	720	34		
Root Layer < 10 ft amsl		115	Vertical Stress Ratio			0.35	720

Method Name	Min FS
GLE / Morgenstern-Price	0.62



Note: GLE/Morgenstern Price method results displayed.

GOLDER
MEMBER OF WSP

SCALE	AS SHOWN	PROJECT	Chesterfield Power Station
DATE	Oct 2021	TITLE	Lower Ash Pond Section B-B' Liquefaction
MADE BY	SDRM		
CAD	-		
CHECK	ALB	CLIENT	Dominion Energy
REVIEW	ATN	FIGURE	4

FILE SAFETY FACTOR ASSESSMENT

PROJECT No. 21466315 REV. 0

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