Periodic Safety Factor Assessment

Chesterfield Power Station CCR Surface Impoundment: Upper Ash Pond

Submitted to:

Chesterfield Power Station

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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 Upper 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, PE
Print Name

Senior Project Geotechnical Engineer
Title

Signature

10/14/2021
Date

COMMONWEALTH OF VIRGINIA
Alex Brown
Lic. No. 0402062066
10/14/21
PROFESSIONAL ENGINEER

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 Upper Ash Pond (UAP). 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 UAP, as defined by the Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule (40 CFR §257; the CCR rule). The UAP is also regulated as a dam by the Virginia Department of Conservation and Recreation (DCR) with Inventory Number 041045 (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 UAP 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 UAP embankment were adopted from the previous 5-year Safety Factor Assessment (GAI, 2016) and supplemented with geotechnical information taken from the Geosyntec 2017 Geotechnical Parameters Data Package (Geosyntec, 2017) 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]	
		Peak φ' (°)	Cohesion (*pound per square foot, psf*)
Vegetative Cover	125	30, *24*	720, *576*
Fill	125	30, *24*	0
CCR (Drained)	90	28, *23*	0
CCR (Undrained)	90	24, *19*	0
Alluvium	120	30, *24*	0
SM-SC	135	35, *29*	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 and Geometry

Two critical cross sections were considered for the UAP (Figure 1). The first of these sections was considered for the previous 5-year Safety Factor Assessments by GAI (GAI, 2016) through the stormwater sediment pond at the northeast end of the UAP. This section runs northwest to southeast through the principal spillway, perpendicular to the perimeter berm slope. No changes have occurred to the UAP affecting this section over the past 5 years, so the previous model is assumed to remain accurate. The second critical cross section considered runs roughly north to south through the maximum height of the impounded ash in the UAP along the northern embankment. The groundwater table (GWT) modeled within the embankment is based on Golder's Upper and Lower Ash Ponds Groundwater Monitoring Plan (Golder, 2020) and is approximately 10 feet above mean sea level (ft amsl) through the UAP. The UAP is also covered with 1 foot of intermediate soil cover, and perimeter channels are lined with concrete, thus stormwater within the UAP is efficiently routed to the stormwater sediment pond, limiting the amount of infiltration into the CCR.

5.3 Long-Term Maximum Storage Pool Conditions

In accordance with the CCR Rules, the long-term maximum storage pool elevation was set equal to the UAP principal spillway elevation [26.9 ft amsl]. The principal spillway, located at the southeastern corner of the stormwater sediment pond, consists of a concrete riser structure with multiple orifices beginning at elevation 26.9 ft asml and a 24-inch reinforced concrete discharge pipe (10.73 ft asml), (Geosyntec, 2021). Non-contact stormwater collected in the UAP discharges through the principal spillway to an outfall regulated by the Station's Virginia

Department of Environmental Quality (DEQ) Virginia Pollutant Discharge Elimination System Permit No. VA0004146 (VPDES Permit).

The UAP's emergency spillway is located adjacent to the principal spillway and consists of two 72-inch diameter steels pipes with slide gates (Geosyntec, 2021). The invert elevation of the emergency spillway system is 32.6 ft amsl (Geosyntec, 2021). The analysis of the spillway capacity is described in the Periodic Inflow Design Flood Control System Plan (Golder, 2021).

As a result of the intermediate soil cover, concrete-lined perimeter channels, and well-maintained stormwater controls within the UAP, groundwater levels within the UAP are not significantly impacted by storm events, thus the maximum storage condition is visible in the section through the stormwater sediment pond but not in the section through the CCR mass.

The calculated static factor of safety is 1.63 for the long-term, maximum storage pool loading condition, therefore meeting the requirement for the long-term maximum 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 UAP'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 39.12 ft amsl. The analysis of the hydraulic and hydrologic conditions is included in the Periodic Inflow Design Flood Control System Plan (Golder, 2021).

As a result of the intermediate soil cover, concrete-lined perimeter channels, and well-maintained stormwater controls within the UAP, the water level associated with the maximum surcharge pool condition is not considered to impact the groundwater within the UAP.

The calculated static factor of safety is 1.64 for the maximum surcharge pool loading condition, therefore meeting 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 1.07 for the long-term, maximum storage pool loading condition, therefore meeting the requirement for the maximum storage pool loading condition.

5.6 Post-Seismic Liquefaction Loading Conditions

GAI Consultants, Inc. (GAI) performed a liquefaction evaluation as part of the 2016 Safety Factor Assessment. Based on the liquefaction evaluations, the foundation and embankment materials of the UAP were determined not to be susceptible to liquefaction under the design earthquake hazard (GAI, 2016). Because the embankment is not constructed of materials or on foundation materials calculated to be susceptible to liquefaction, no post-liquefaction demonstration is required in the CCR rule.

5.7 Results

The table below presents the results of the Safety Factor Assessments for the UAP 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 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: Upper Ash Pond - Factors of Safety

Case	Pool Elevation (ft amsl)	Target Factor of Safety (FS)	FS
Max Storage Pool	28.33	1.5	1.63
Max Surcharge Pool	39.58	1.4	1.64
Seismic	28.33	1.0	1.07
Liquefied Ash	N/A	1.2	N/A

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 UAP meets the minimum factors of safety as required by §257.73(e)(1) for each of the conditions analyzed.

7.0 REFERENCES

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

GAI Consultants, Inc. Coal Combustion Residuals Unit Factor of Safety Assessment. October 2016.

Geosyntec Consultants. Chesterfield Power Station Lower and Upper Ash Ponds Catalog of Subsurface Data, Appendix D, 2017 Geotechnical Parameters Data Package. June 16, 2016.

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

Golder Associates. Groundwater Monitoring Plan, Upper and Lower Ash Ponds. September 2017, Revised October 2020.

Golder Associates. Periodic Inflow Design Flood Control System Plan, Chesterfield Power Station, Upper Ash Pond. October 2021.

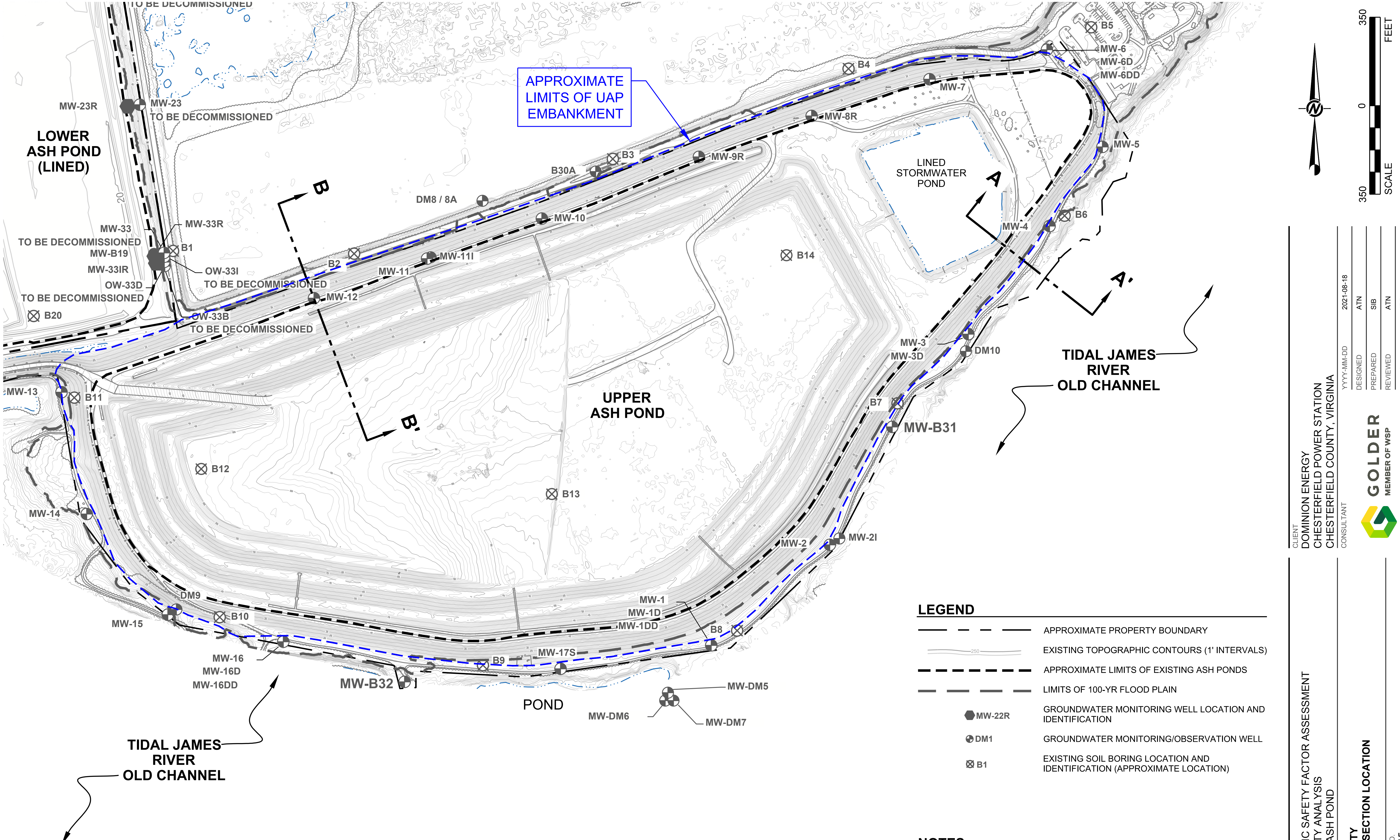
Hynes-Griffin, Mary E. and Franklin, Arley G. (1984). "Rationalizing the Seismic Coefficient Method," Miscellaneous Paper Prepared for the U.S. Army Corps of Engineers. July 1984.

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/

Virginia DCR Dam Permit, Inventory No. 041045.



LEGEND

(long dash line)	APPROXIMATE PROPERTY BOUNDARY
(contour line, 250)	EXISTING TOPOGRAPHIC CONTOURS (1' INTERVALS)
(heavy short dash line)	APPROXIMATE LIMITS OF EXISTING ASH PONDS
(heavy long dash line)	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)

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
UPPER ASH POND

TITLE
STABILITY
CROSS SECTION LOCATION

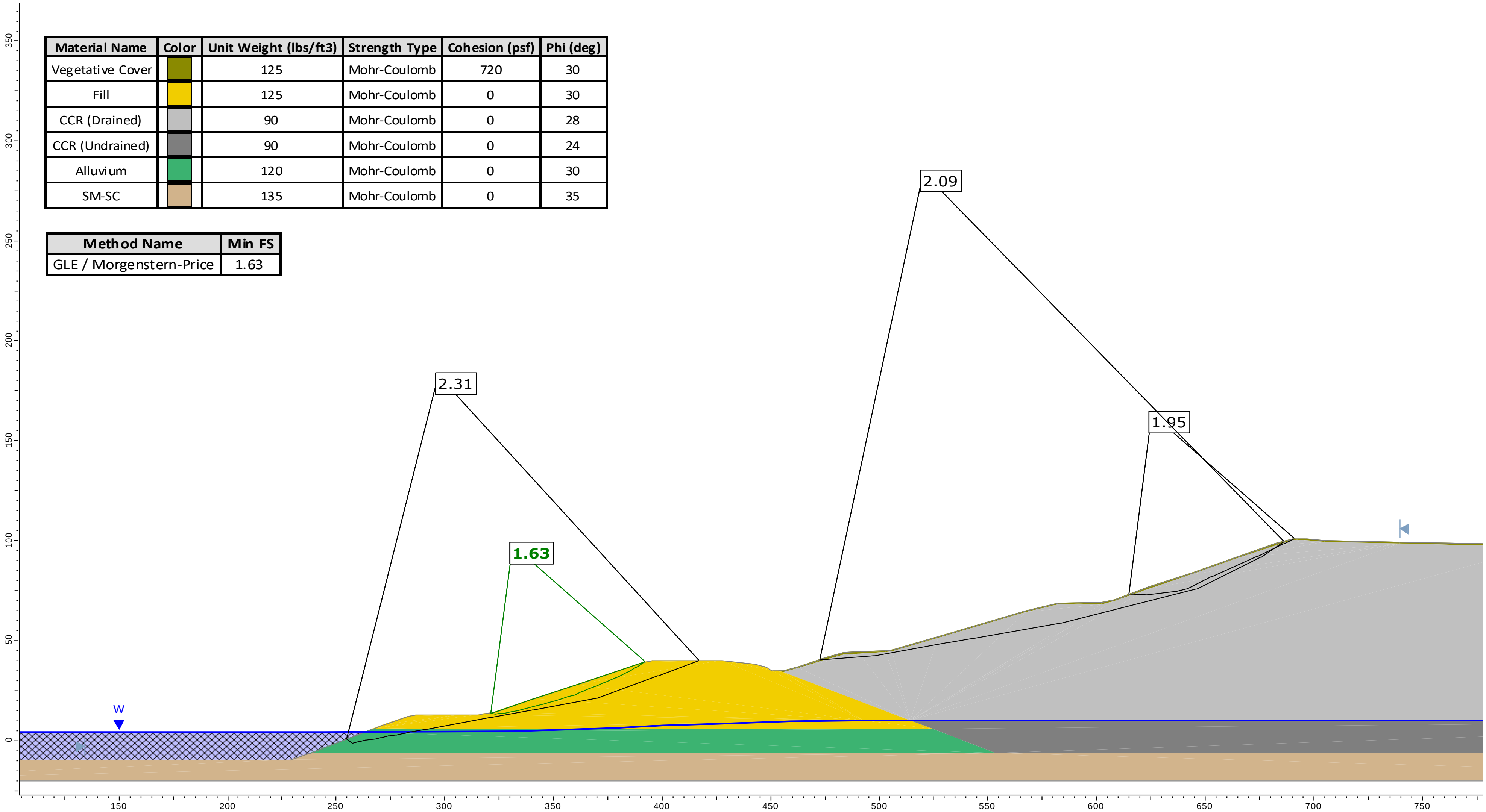
PROJECT NO. 21-466315
REV. 0
FIGURE 1

APPENDIX A

Upper Ash Pond Stability Analysis

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Vegetative Cover		125	Mohr-Coulomb	720	30
Fill		125	Mohr-Coulomb	0	30
CCR (Drained)		90	Mohr-Coulomb	0	28
CCR (Undrained)		90	Mohr-Coulomb	0	24
Alluvium		120	Mohr-Coulomb	0	30
SM-SC		135	Mohr-Coulomb	0	35

Method Name	Min FS
GLE / Morgenstern-Price	1.63



Note: GLE/Morgenstern Price method results displayed.

GOLDER MEMBER OF WSP

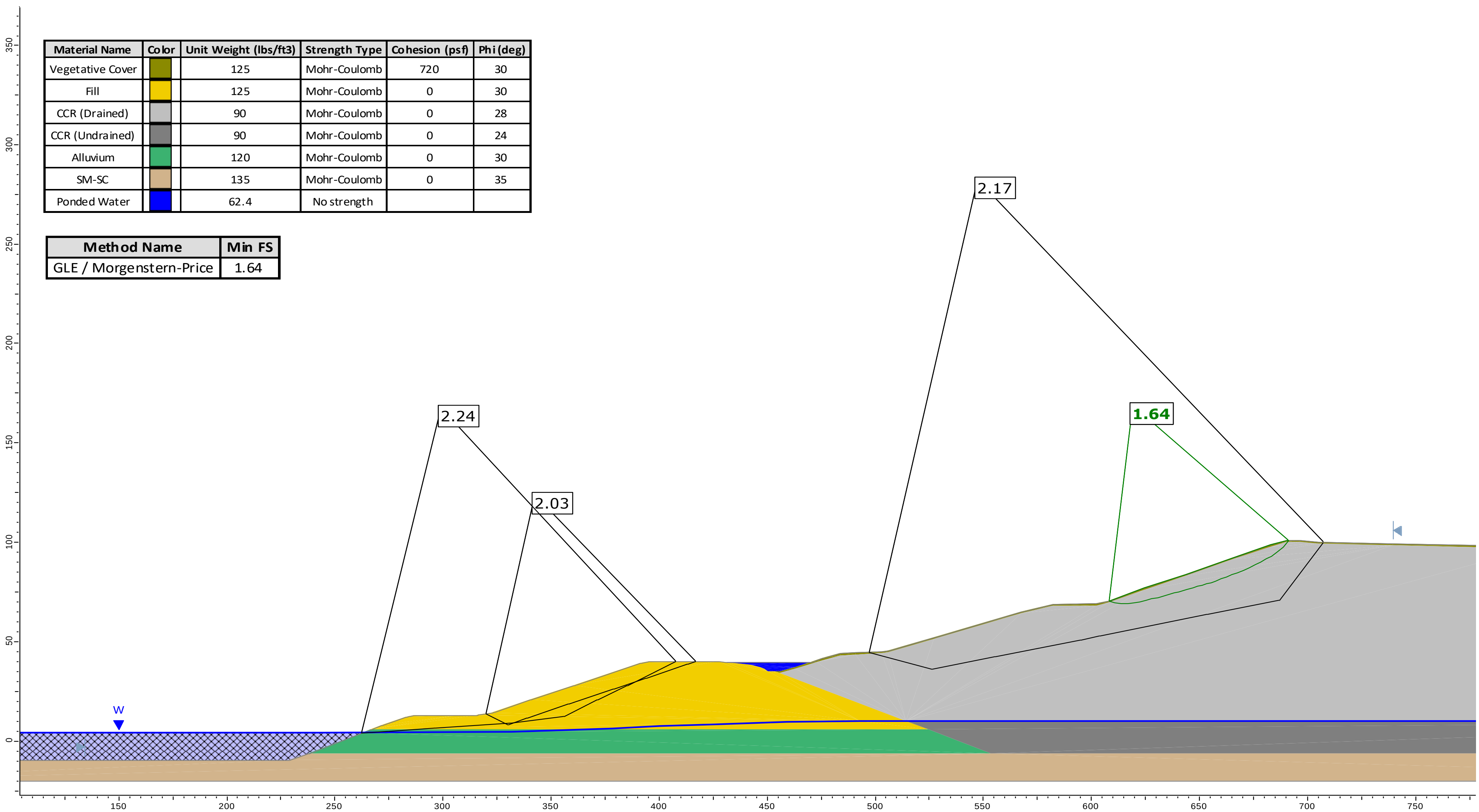
SCALE	AS SHOWN	PROJECT	Chesterfield Power Station
DATE	Aug 2021	TITLE	Upper Ash Pond Maximum Pool Storage
MADE BY	SDRM		
CAD	-		
CHECK	ALB	CLIENT	Dominion Energy
REVIEW	ATN	FIGURE	1

FILE: SAFETY FACTOR ASSESSMENT

PROJECT No. 21466315 REV. 0

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Vegetative Cover		125	Mohr-Coulomb	720	30
Fill		125	Mohr-Coulomb	0	30
CCR (Drained)		90	Mohr-Coulomb	0	28
CCR (Undrained)		90	Mohr-Coulomb	0	24
Alluvium		120	Mohr-Coulomb	0	30
SM-SC		135	Mohr-Coulomb	0	35
Ponded Water		62.4	No strength		

Method Name	Min FS
GLE / Morgenstern-Price	1.64



Note: GLE/Morgenstern Price method results displayed.

GOLDER
MEMBER OF WSP

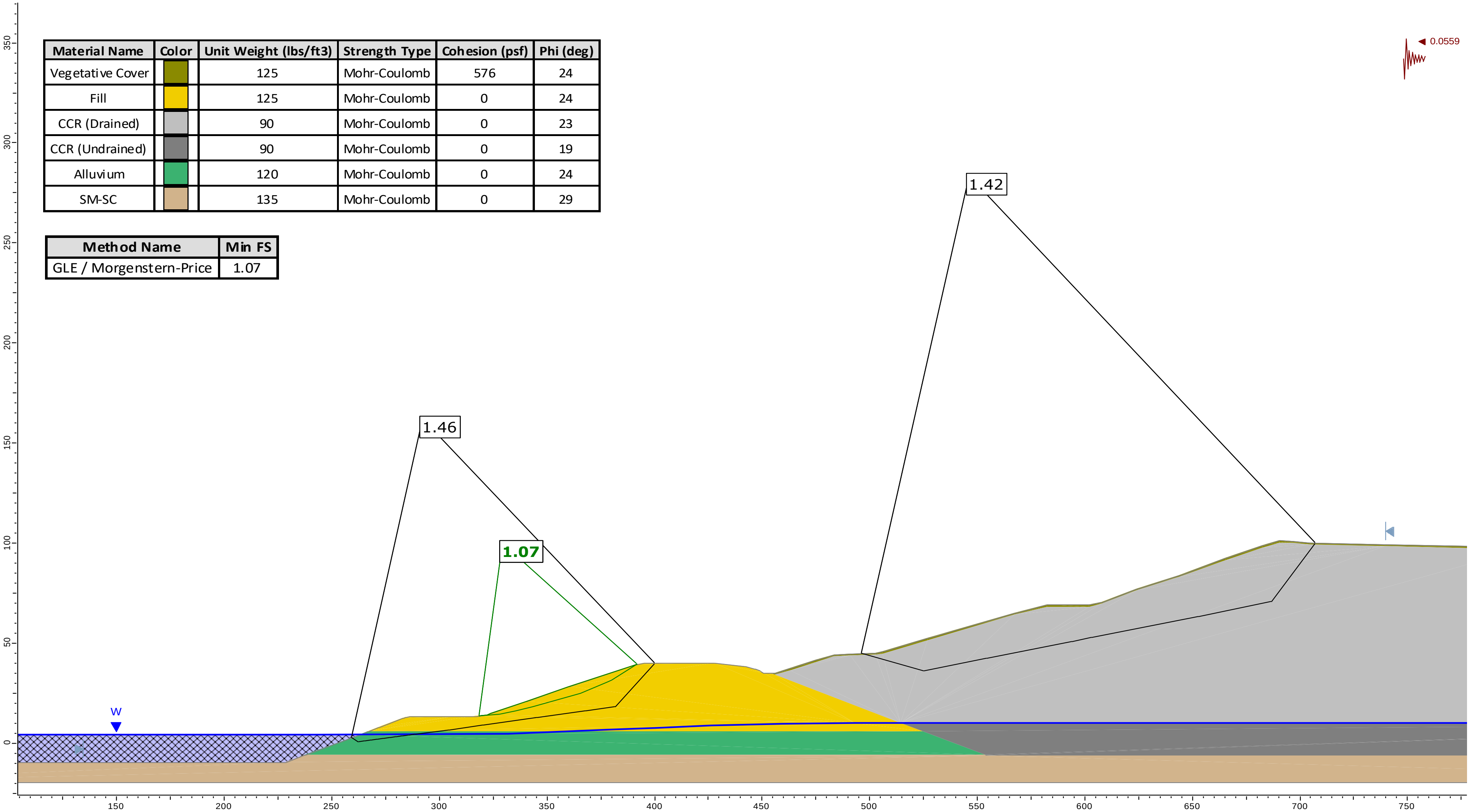
SCALE	AS SHOWN	PROJECT	Chesterfield Power Station
DATE	Aug 2021	TITLE	Upper Ash Pond Maximum Pool Surcharge
MADE BY	SDRM		
CAD	-		
CHECK	ALB	CLIENT	Dominion Energy
REVIEW	ATN	FIGURE	2

FILE SAFETY FACTOR ASSESSMENT

PROJECT No. 21466315 REV. 0

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Vegetative Cover		125	Mohr-Coulomb	576	24
Fill		125	Mohr-Coulomb	0	24
CCR (Drained)		90	Mohr-Coulomb	0	23
CCR (Undrained)		90	Mohr-Coulomb	0	19
Alluvium		120	Mohr-Coulomb	0	24
SM-SC		135	Mohr-Coulomb	0	29

Method Name	Min FS
GLE / Morgenstern-Price	1.07



Note: GLE/Morgenstern Price method results displayed.

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

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