



INITIAL SAFETY FACTOR ASSESSMENT

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INITIAL SAFETY FACTOR ASSESSMENT

Chesapeake Energy Center CCR Surface
Impoundment: Bottom Ash Pond



**Dominion
Energy**SM

Submitted To: Chesapeake Energy Center
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Chesapeake, VA 23323

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Project No. 13-00193





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1.0 CERTIFICATION

This Initial Safety Factor Assessment for the Chesapeake Energy Center's Bottom 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 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)), as well as with the requirements in §257.100 resulting from the EPA's "Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; Extension of Compliance Deadlines for Certain Inactive Surface Impoundments; Response to Partial Vacatur" published in the Federal Register on August 5, 2016 with an effective date of October 4, 2016 (40 CFR §257.100).

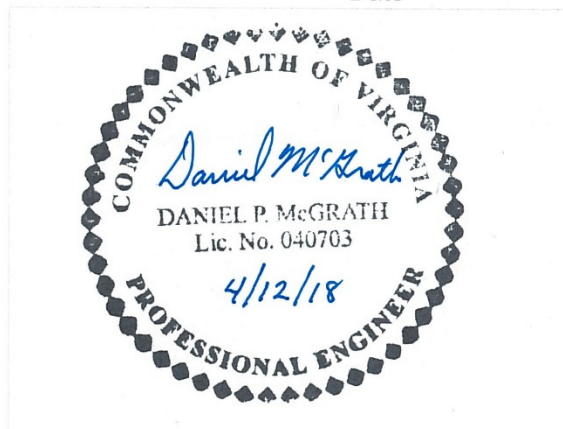
The use of the word "certification" and/or "certify" in this document shall be interpreted and construed as a Statement of Professional Opinion, and is not and shall not be interpreted or construed as a guarantee, warranty, or legal opinion.

Daniel McGrath
Print Name

Associate and Senior Consultant
Title

Daniel McGrath
Signature

4/12/18
Date



2.0 INTRODUCTION

This Initial Safety Factor Assessment provides Golder's stability evaluation of the dike surrounding the Bottom Ash Pond (BAP) at Virginia Electric and Power Company d/b/a Dominion Energy Virginia's Chesapeake Energy Center (CEC) in Chesapeake, VA as it relates to the requirements in the USEPA's 2015 Final Rule on the Disposal of Coal Combustion Residuals (CCR; EPA Rule). Golder analyzed both current and proposed future configurations of the BAP. According to section § 257.73(e) of the rule, stability of earth structures must be assessed under four loading conditions. The four loading conditions include

- Maximum Pool Storage (§ 257.73(e)(i))
- Maximum Pool Surcharge (§ 257.73(e)(ii))
- Seismic Loading Conditions (§ 257.73(e)(iii))
- Post-Seismic Liquefaction Conditions (when liquefaction susceptible materials are present; § 257.73(e)(iv)).

3.0 SLOPE STABILITY ASSESSMENT METHODOLOGY

Stability safety factors were evaluated for each of the loading scenarios using the computer program SLIDE 7.0 Version 7.031 (2018). As required by the EPA rule, a general limit equilibrium (GLE) method (Morgenstern and Price) was used to calculate factors of safety, using the software program SLIDE. The factor of safety is calculated by dividing the resisting forces by the driving forces along the critical slip surface.

Stability was evaluated along six cross-section as shown in Figure 1. Subsurface stratigraphy at each cross-section was developed from cone penetration tests (CPTs) completed during Golder's subsurface exploration in December 2017 and geotechnical data reported in Schnabel's February 2010 report titled "Geotechnical Engineering Study, Chesapeake Energy Center, Stability Evaluation of the Bottom Ash Pond and Sedimentation Pond Dikes" and July 2011 report titled "Geotechnical Engineering Study, Chesapeake Energy Center, Phase 1 Evaluation of Perimeter Dikes of the Columbia Gas Property and Dry Ash Landfill." Similarly, material properties were developed for the dike, foundation materials, and impounded materials from these resources. The Material Properties Calculation Package (Attachment 1) provides details on Golder's geotechnical exploration and evaluation of geotechnical data.

Two configurations of the BAP were analyzed for stability. The first configuration models conditions as they currently exist. The second models conditions as they will be after CCR removal efforts are completed. Specifically, the current closure plan indicates approximately five feet of material in the BAP will be excavated to elevation 9 ft-msl.

3.1 Normal Pool Storage

Since the BAP is normally dry (no surface water), the water level for this evaluation was set to elevation 7.5 feet mean sea level (ft-msl) for normal-pool-storage-stability analyses. This level is below the existing CCR

surface and is consistent with observed water levels in site groundwater monitoring wells and test pits dug in the BAP. After closure activities are completed, the water level is expected to remain below the bottom of the pond. However, Golder conservatively modeled the normal pool storage water level as elevation 7.5 ft-msl in both normal pool scenarios.

3.2 Maximum Pool Surge

For the maximum pool surge scenario, the peak water level within the BAP was calculated during the 1,000 year 24 hour rain event. This event was calculated to cause a temporary water level within the pond to approximately elevation 19 ft-msl for current conditions and 17 ft-msl for the future configuration. For further details, refer to the hydraulic and hydrology stormwater routing calculations presented in the *Inflow Design Flood Control Plan* (Golder 2018).

3.3 Seismic Loading Conditions (Pseudostatic)

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). Golder used the Bray and Travararou displacement-based seismic slope stability screening method to evaluate the seismic stability. For this method, a pseudo-static coefficient corresponding to an allowable displacement of six inches (15 cm) is typically used; however, this coefficient was calculated to be nearly zero due to the low seismic risk at CEC. In an effort to demonstrate an acceptable factor of safety, Golder conservatively used the coefficient for an allowable displacement of two inches (5 cm). The pseudo-static coefficient was calculated to be 0.01g. Details on the calculation of the pseudo-static coefficient are available in the Seismic Hazard Calculation Package (Attachment 2).

3.4 Post-Earthquake Liquefaction Loading Conditions

Golder completed an evaluation of the liquefaction susceptibility of the site soils and CCR materials as presented in the Liquefaction Assessment Calculation Package (Attachment 3). The calculated factor of safety against liquefaction is above 1.2 for all materials analyzed including dike soils and foundation soils. Thus, slope stability analyses evaluating the impact of liquefaction are not necessary. For more detail on liquefaction analysis, please refer to the Liquefaction Assessment Calculation Package.

3.5 Rapid Drawdown Conditions

Golder also considered the impacts of rapid drawdown of slopes facing the Elizabeth River as described in the § 257.73(d)(vii) of the USEPA CCR Rule. The mapped (FIRM zone AE) 100-year flood level in the Elizabeth River is elevation 8.5 ft-msl, indicating a maximum rise of 1.8 meters (5.9 feet) above mean water levels. Thus, dikes around the BAP are not expected to undergo rapid drawdown in excess of 5.9 feet. Impacts of such a drawdown event have been mitigated by armoring the toe of the slopes along the Elizabeth River. Therefore, additional rapid drawdown analyses are not necessary.

4.0 SLOPE STABILITY ASSESSMENT RESULTS

The tables below present the results of the slope stability analyses of the dike impounding the BAP at CEC. The first table shows the calculated factors of safety for existing conditions, while the second table lists the calculated factors of safety for the future conditions after closure of the BAP. For all cases analyzed, the calculated factors of safety are in excess of those required in Sections § 257.73(e)(i) to (iii) of the EPA Rule. The detailed stability result figures are available in the pages following this assessment.

Table 1: Scenario A – Existing Conditions

Analysis Case	Normal Storage Pool	Max. Surcharge Pool	Seismic
Rule Section	§ 257.73(e)(i)	§ 257.73(e)(ii)	§ 257.73(e)(iii)
Target Factor of Safety	1.5	1.4	1.0
Cross-Sections	Factor of Safety		
A-A'	1.7	1.6	1.7
B-B'	1.9	1.6	1.8
C-C'	1.8	1.8	1.7
D-D'	1.7	1.7	1.7
E-E'	1.8	1.8	1.8
F-F'	1.6	1.5	1.6

Table 2: Scenario B – Post-Closure Conditions

Analysis Case	Normal Storage Pool	Max. Surcharge Pool	Seismic
Rule Section	§ 257.73(e)(i)	§ 257.73(e)(ii)	§ 257.73(e)(iii)
Target Factor of Safety	1.5	1.4	1.0
Cross-Sections	Factor of Safety		
A-A'	1.7	1.6	1.5
B-B'	1.9	1.8	1.8
C-C'	1.8	1.8	1.7
D-D'	1.7	1.7	1.7
E-E'	1.8	1.8	1.8
F-F'	1.6	1.5	1.6

5.0 CONCLUSION

Golder evaluated the slope stability of the dikes impounding the Bottom Ash Pond at Dominion Energy Virginia’s Chesapeake Energy Center in accordance with the EPA CCR Rule. Specifically, the dikes surrounding the BAP were evaluated for stability in the four loading scenarios presented in section § 257.73(e) of the EPA Rule:

- Normal Pool Storage (§ 257.73(e)(i))

- Maximum Pool Surge (\S 257.73(e)(ii))
- Seismic Loading Conditions (\S 257.73(e)(iii))
- Post-Seismic Liquefaction Conditions (when liquefaction susceptible materials are present; \S 257.73(e)(iv))

For each loading case, the dikes were calculated to meet the target factor of safety presented in the EPA rule.

6.0 REFERENCES

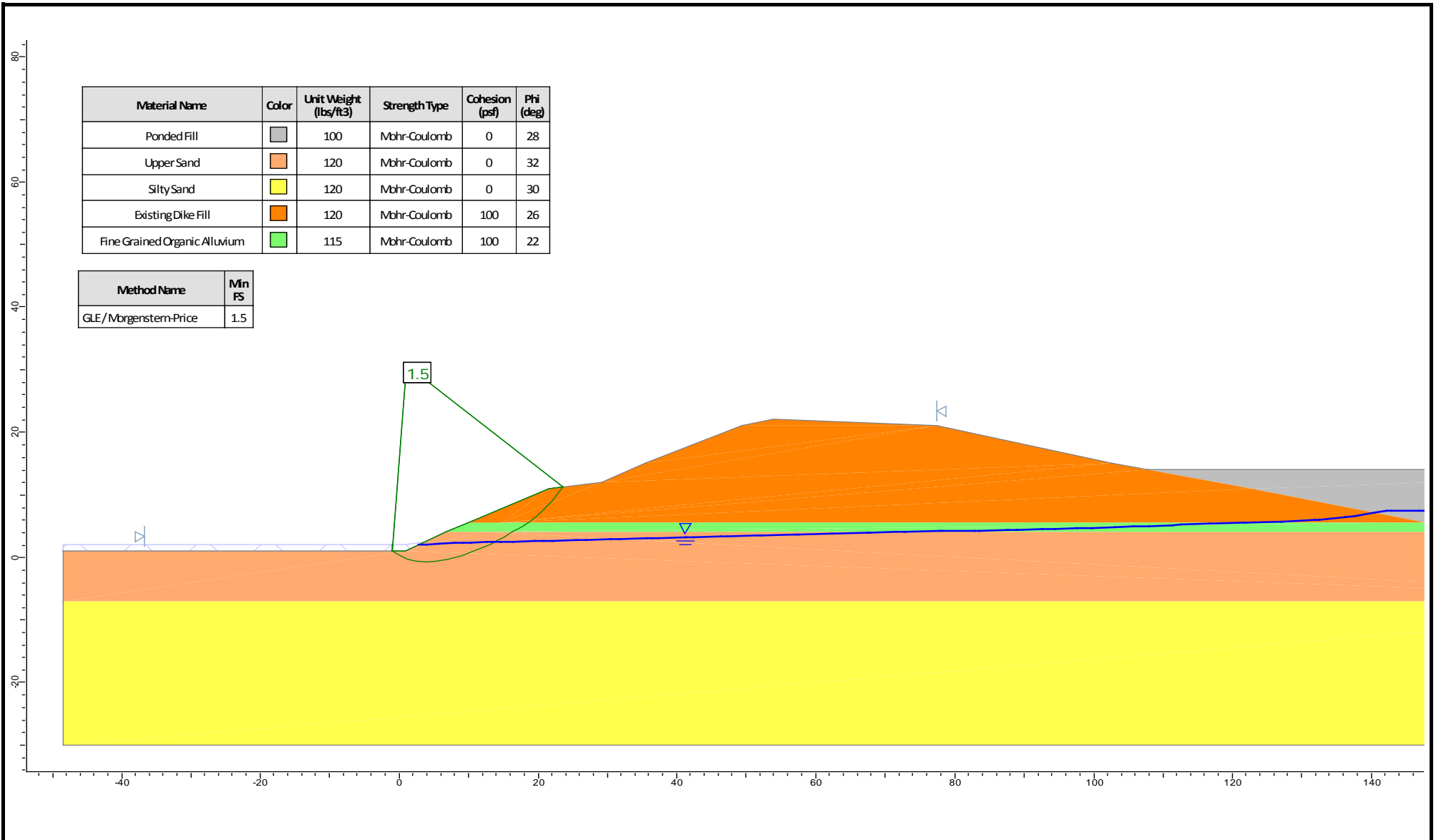
- Bray, J. D., and Travasarou, T. 2007. Simplified Procedure for Estimating Earthquake-Induced Deviatoric Slope Displacements. *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 133, No. 4, pp. 381-392.
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- Schnabel Engineering (2011). "Geotechnical Engineering Study, Chesapeake Energy Center, Phase 1 Evaluation of Perimeter Dikes of the Columbia Gas Property and Dry Ash Landfill." July 18, 2011.
- USEPA (2015), Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities, \S 40 CFR Parts 257 and 261.

FIGURE 1

Stability Analysis Cross Section Location Plan


FIGURES A-1 – A-18

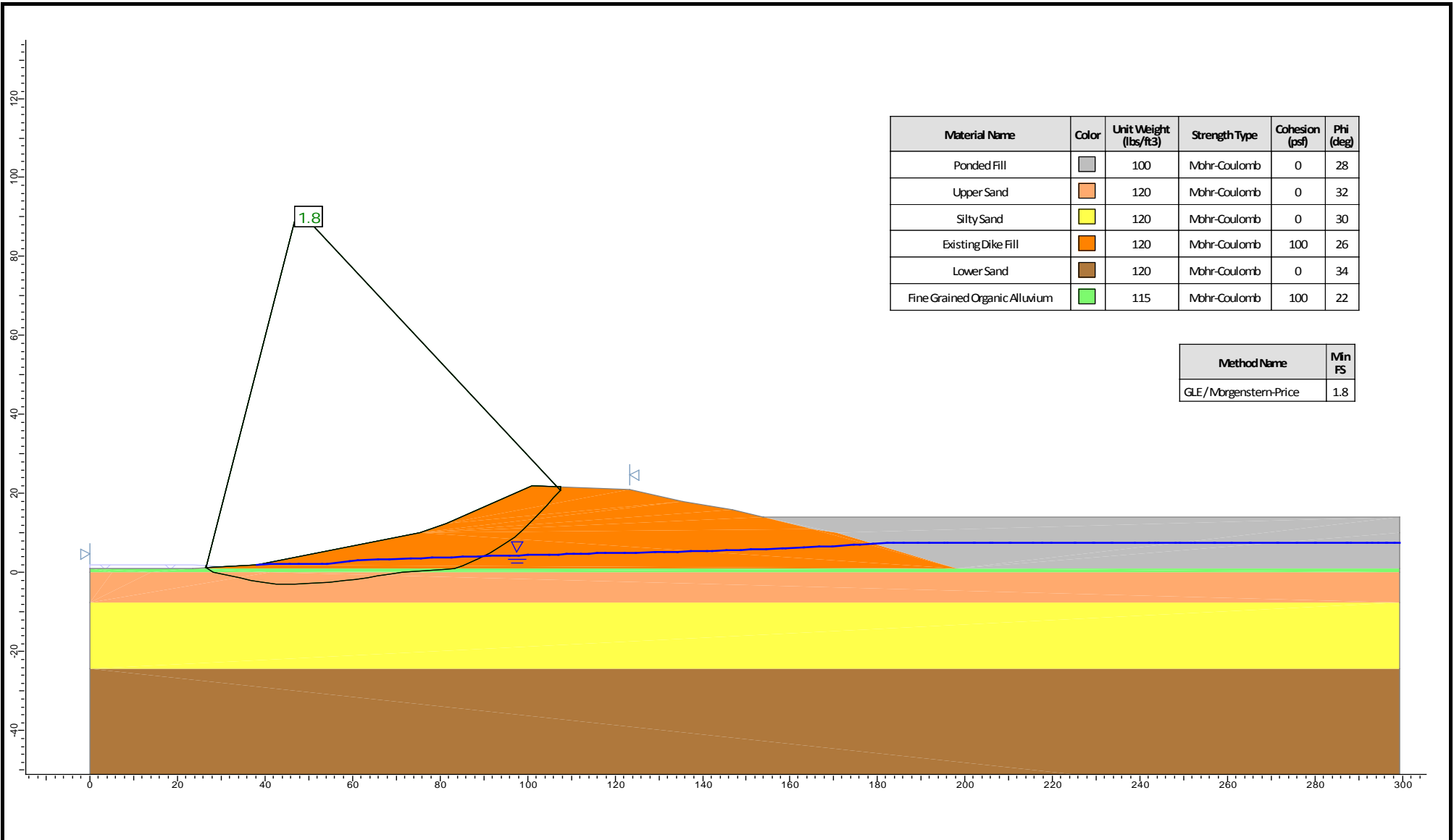
Existing Conditions Stability Assessment Results



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Pondered Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Dark Orange	120	Mohr-Coulomb	100	26
Fine Grained Organic Alluvium	Green	115	Mohr-Coulomb	100	22


Method Name	Min FS
GLE/Morgenstern-Price	1.5

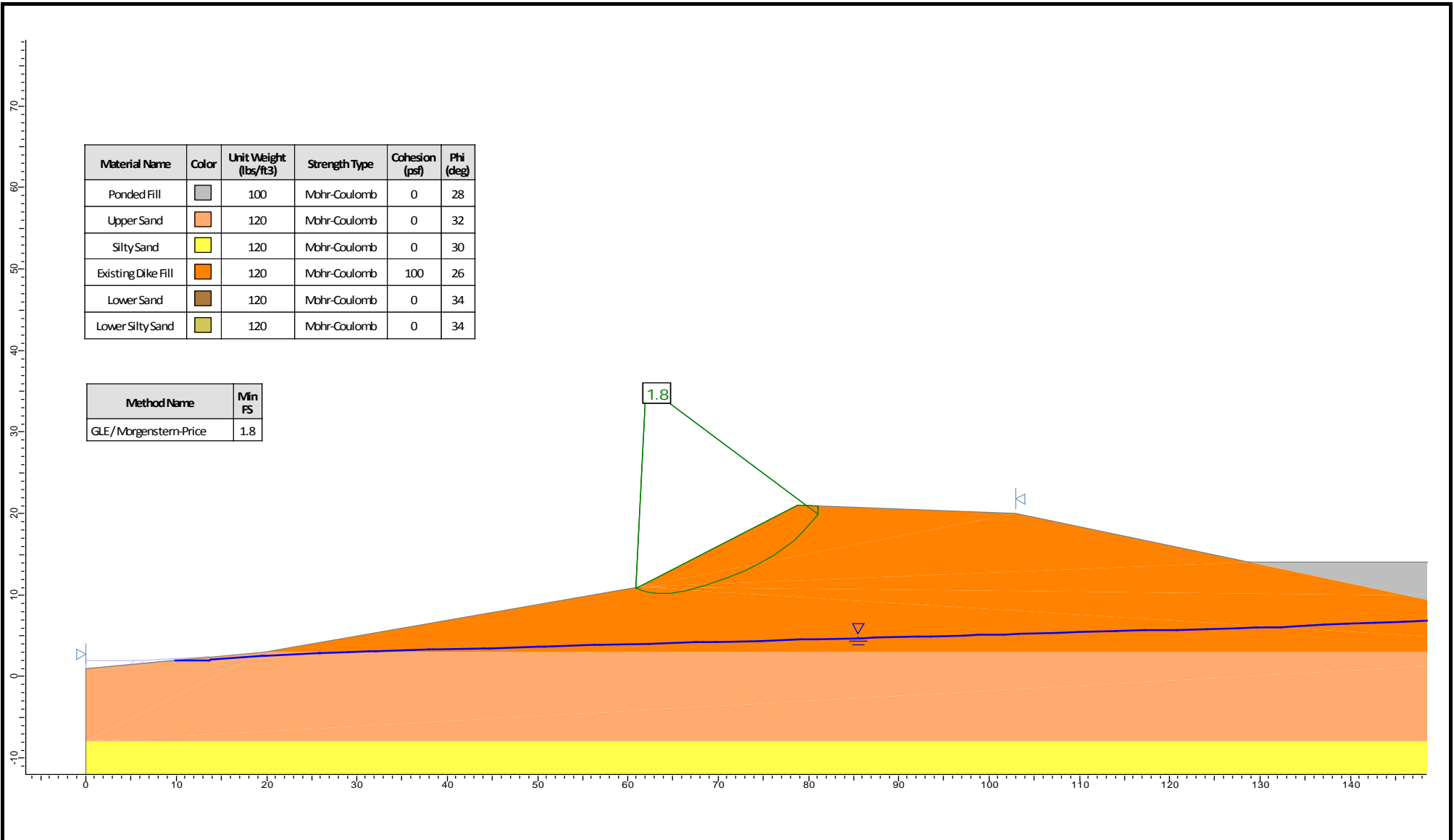
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FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy
PROJECT No.	1300193	REVIEW	GLH	FIGURE	



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Pounded Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Dark Orange	120	Mohr-Coulomb	100	26
Lower Sand	Brown	120	Mohr-Coulomb	0	34
Fine Grained Organic Alluvium	Green	115	Mohr-Coulomb	100	22


Method Name	Min FS
GLE/Morgenstern-Price	1.8

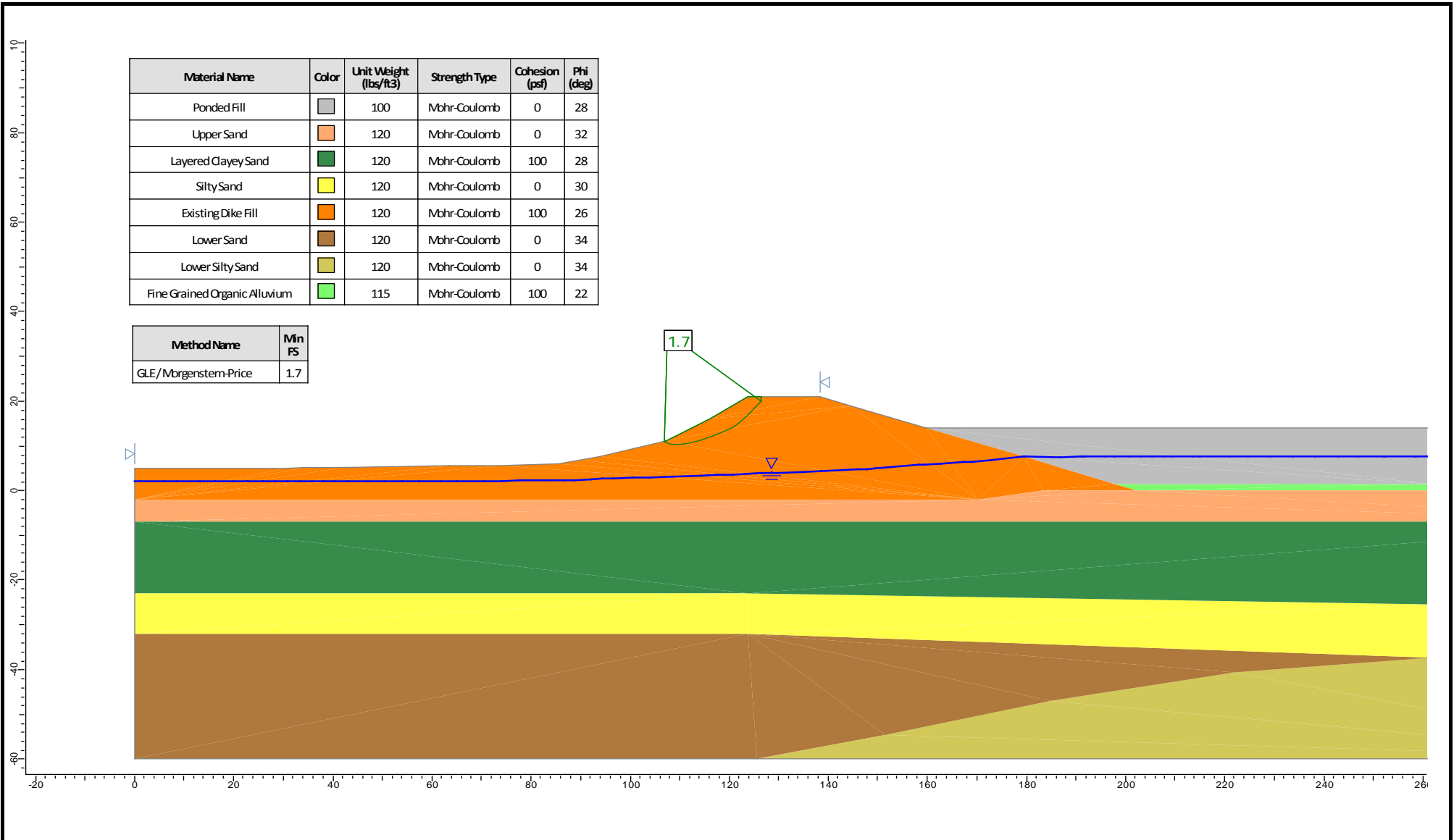
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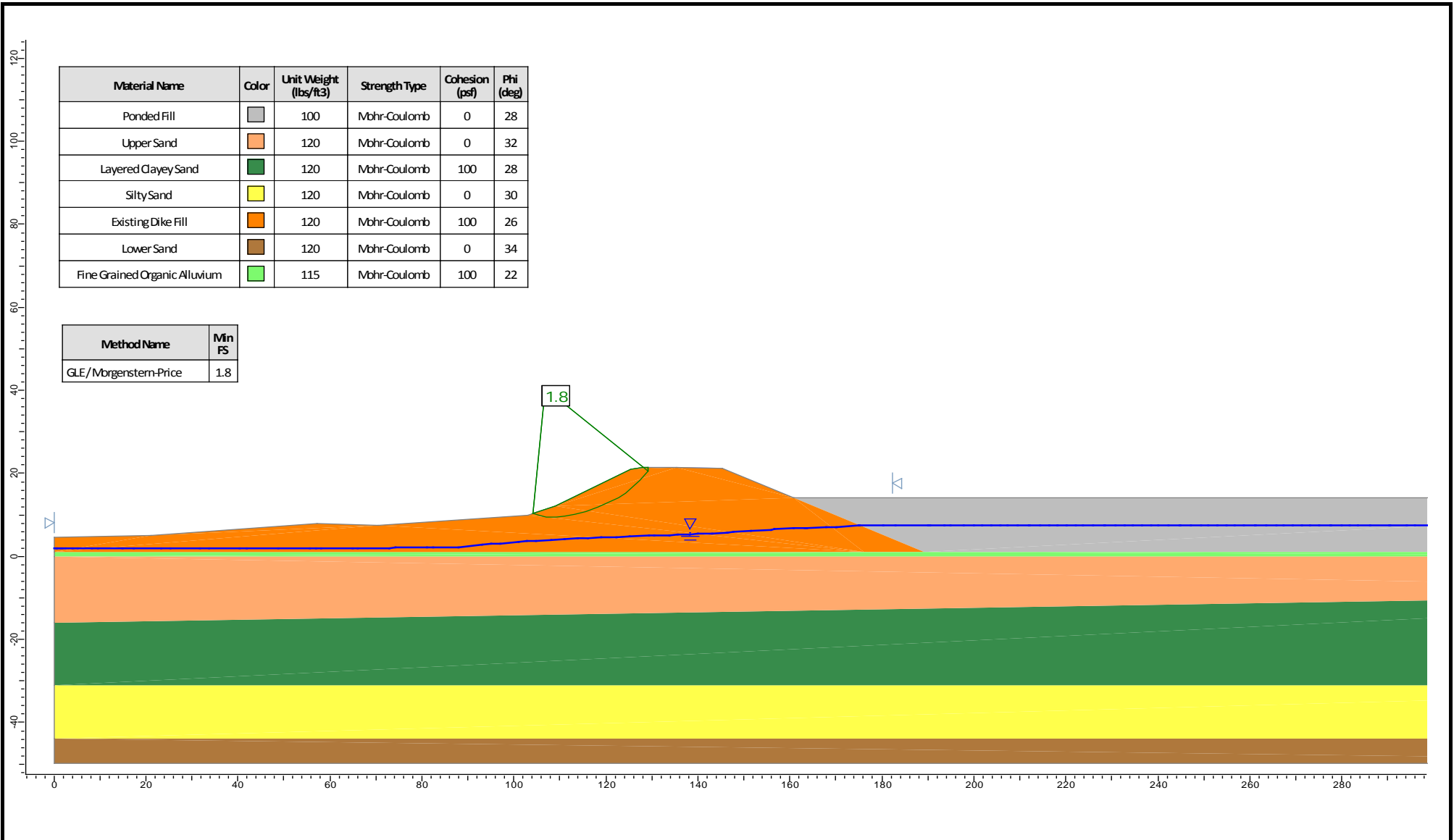
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Upper Sand	Orange	120	Mohr-Coulomb	0	32
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Dark Orange	120	Mohr-Coulomb	100	26
Lower Sand	Brown	120	Mohr-Coulomb	0	34
Lower Silty Sand	Light Yellow	120	Mohr-Coulomb	0	34

Method Name	Min FS
GLE/Morgenstern-Price	1.8

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PROJECT No.	1300193	REVIEW	GLH	FIGURE	




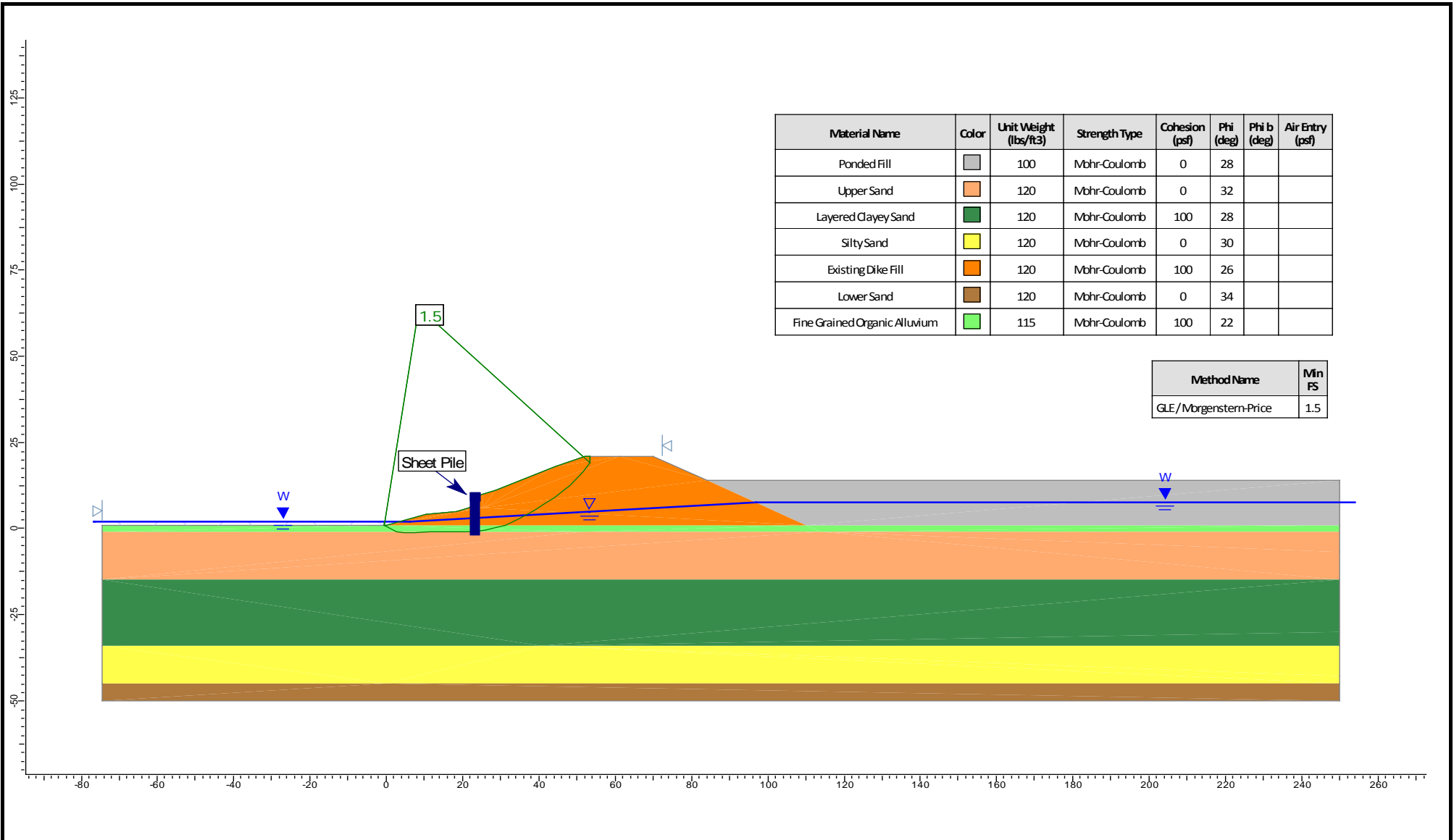
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	CAD	-			
FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy
PROJECT No.	1300193	REVIEW	GLH	FIGURE	



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Ponded Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Layered Clayey Sand	Green	120	Mohr-Coulomb	100	28
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Orange	120	Mohr-Coulomb	100	26
Lower Sand	Brown	120	Mohr-Coulomb	0	34
Fine Grained Organic Alluvium	Light Green	115	Mohr-Coulomb	100	22


Method Name	Min FS
GLE/Morgenstern-Price	1.8

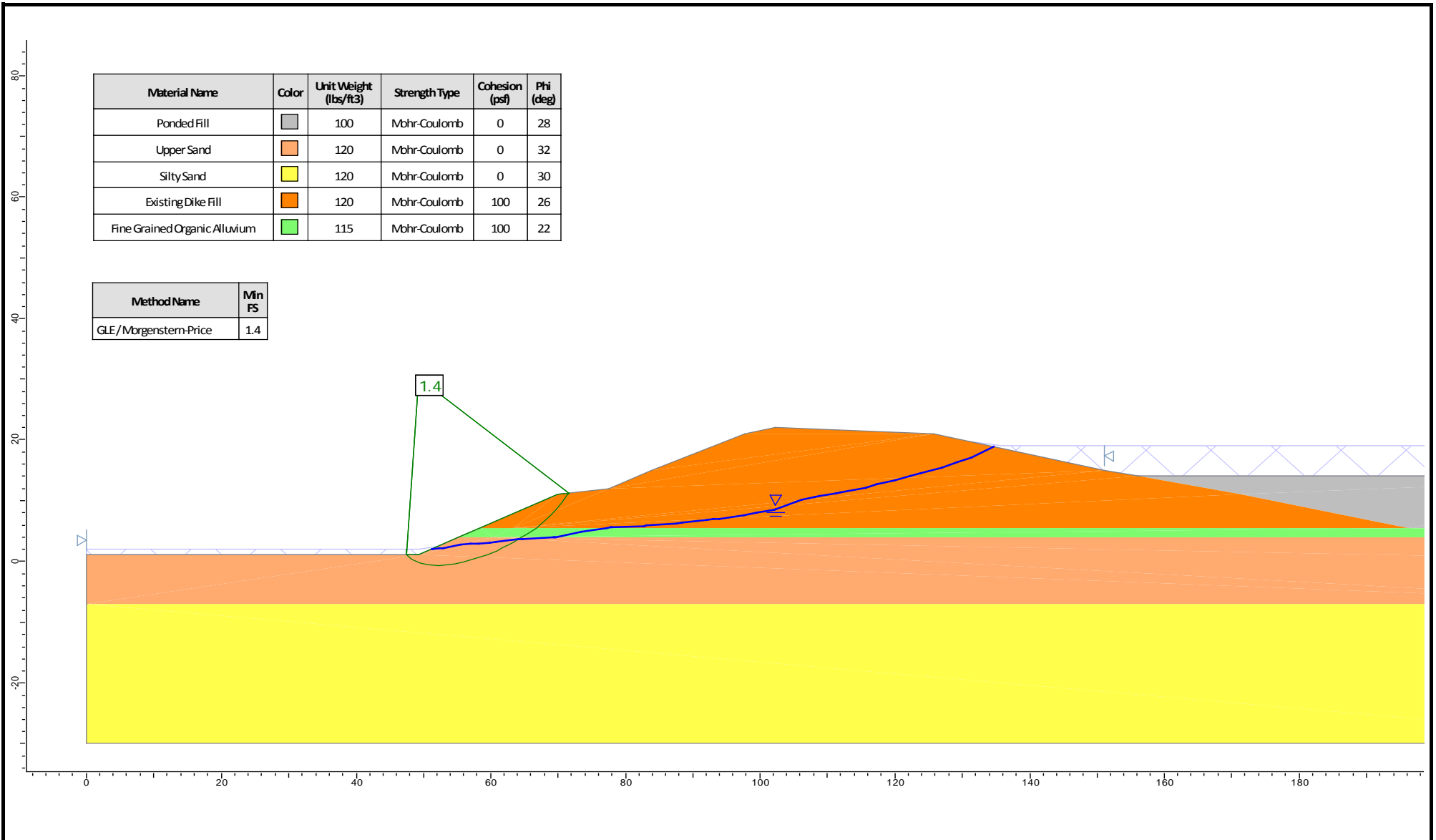
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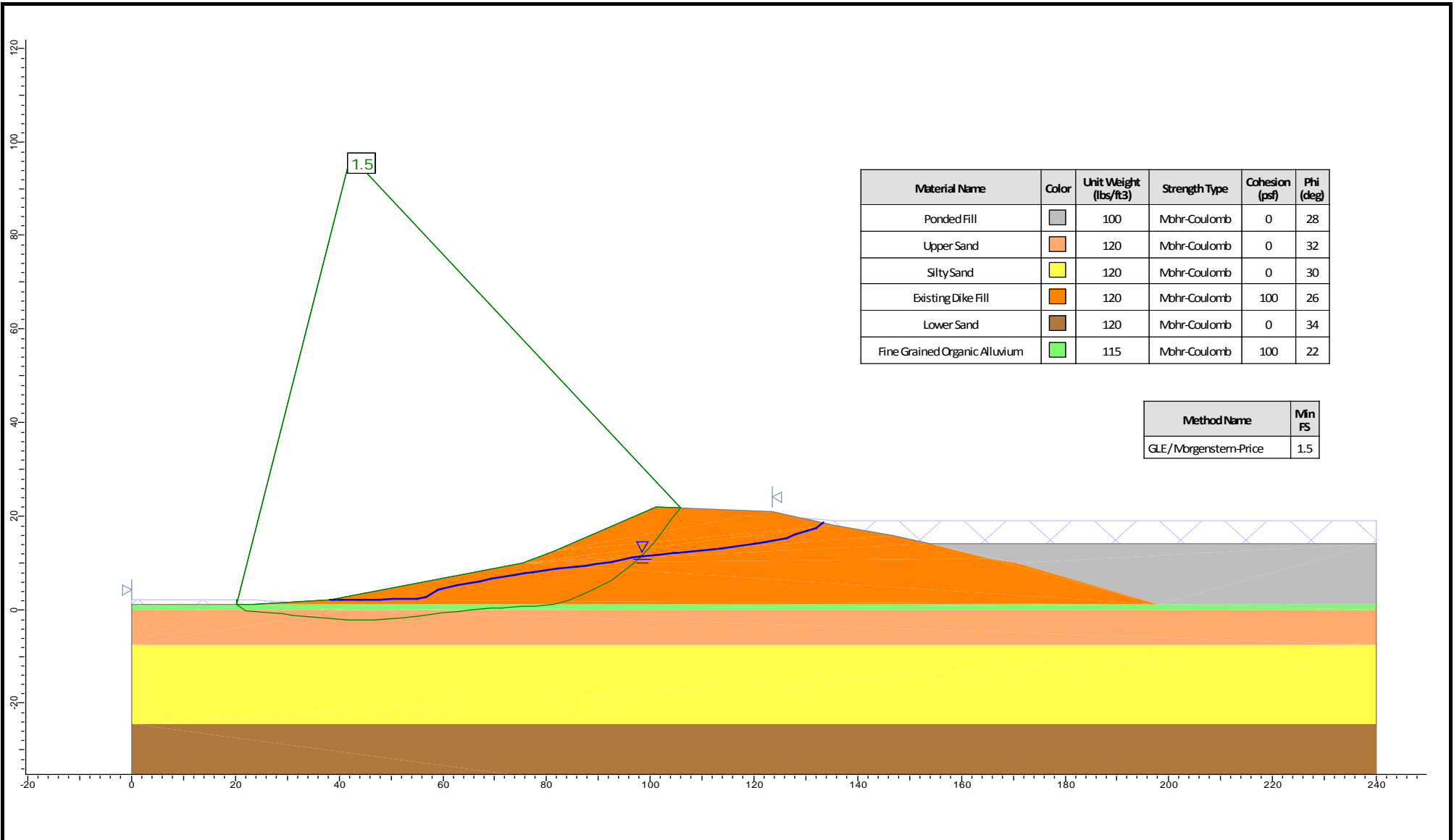
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Pounded Fill	Grey	100	Mohr-Coulomb	0	28		
Upper Sand	Orange	120	Mohr-Coulomb	0	32		
Layered Clayey Sand	Green	120	Mohr-Coulomb	100	28		
Silty Sand	Yellow	120	Mohr-Coulomb	0	30		
Existing Dike Fill	Light Orange	120	Mohr-Coulomb	100	26		
Lower Sand	Brown	120	Mohr-Coulomb	0	34		
Fine Grained Organic Alluvium	Light Green	115	Mohr-Coulomb	100	22		

Method Name	Min FS
GLE/Morgenstern-Price	1.5

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PROJECT No.	1300193	REVIEW	GLH	FIGURE	




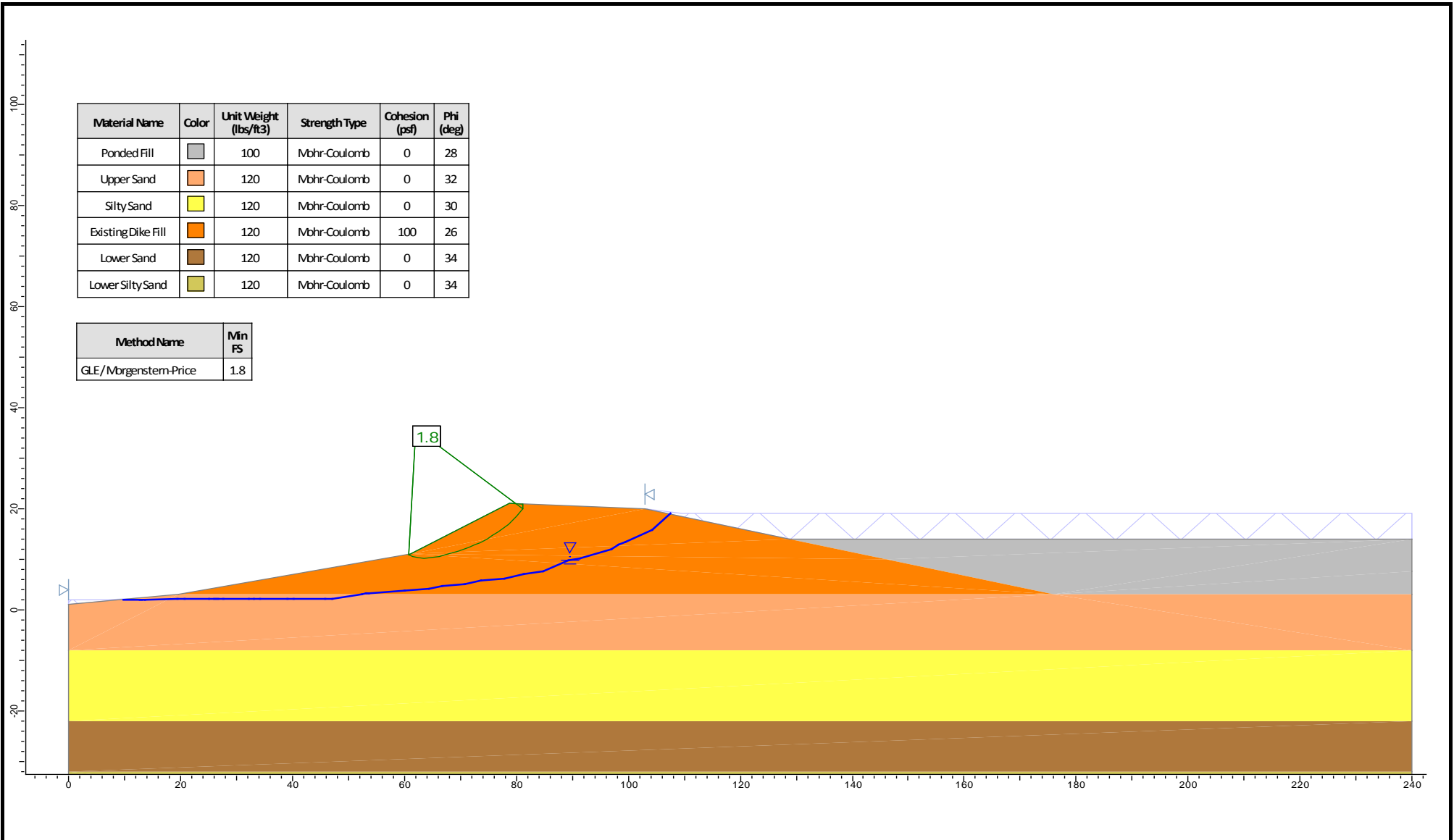
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PROJECT No.	1300193	REVIEW	GLH	FIGURE	



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Ponded Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Dark Orange	120	Mohr-Coulomb	100	26
Lower Sand	Brown	120	Mohr-Coulomb	0	34
Fine Grained Organic Alluvium	Green	115	Mohr-Coulomb	100	22


Method Name	Min FS
GLE/Morgenstern-Price	1.5

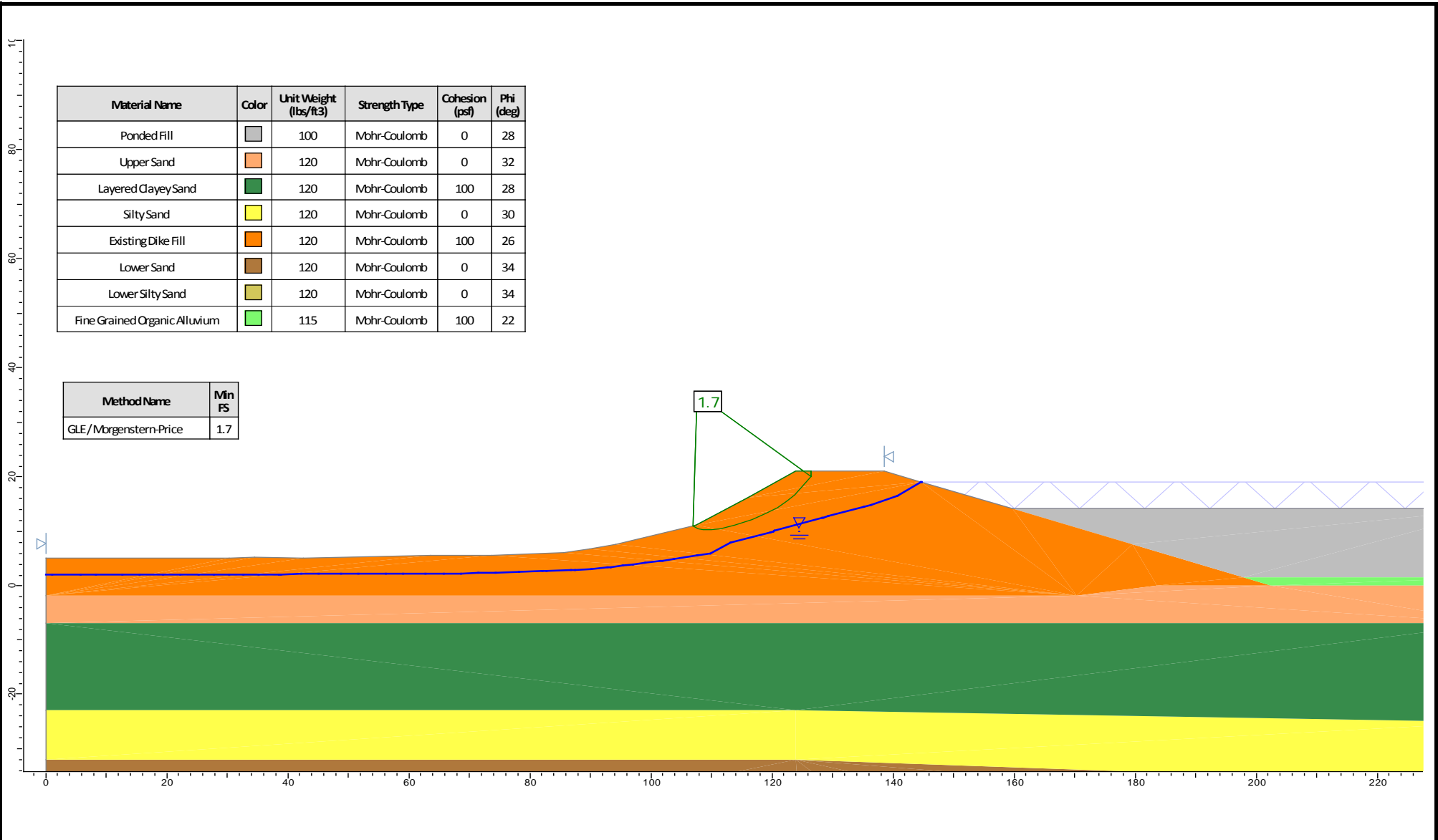
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PROJECT No.	1300193	REVIEW	GLH	FIGURE	
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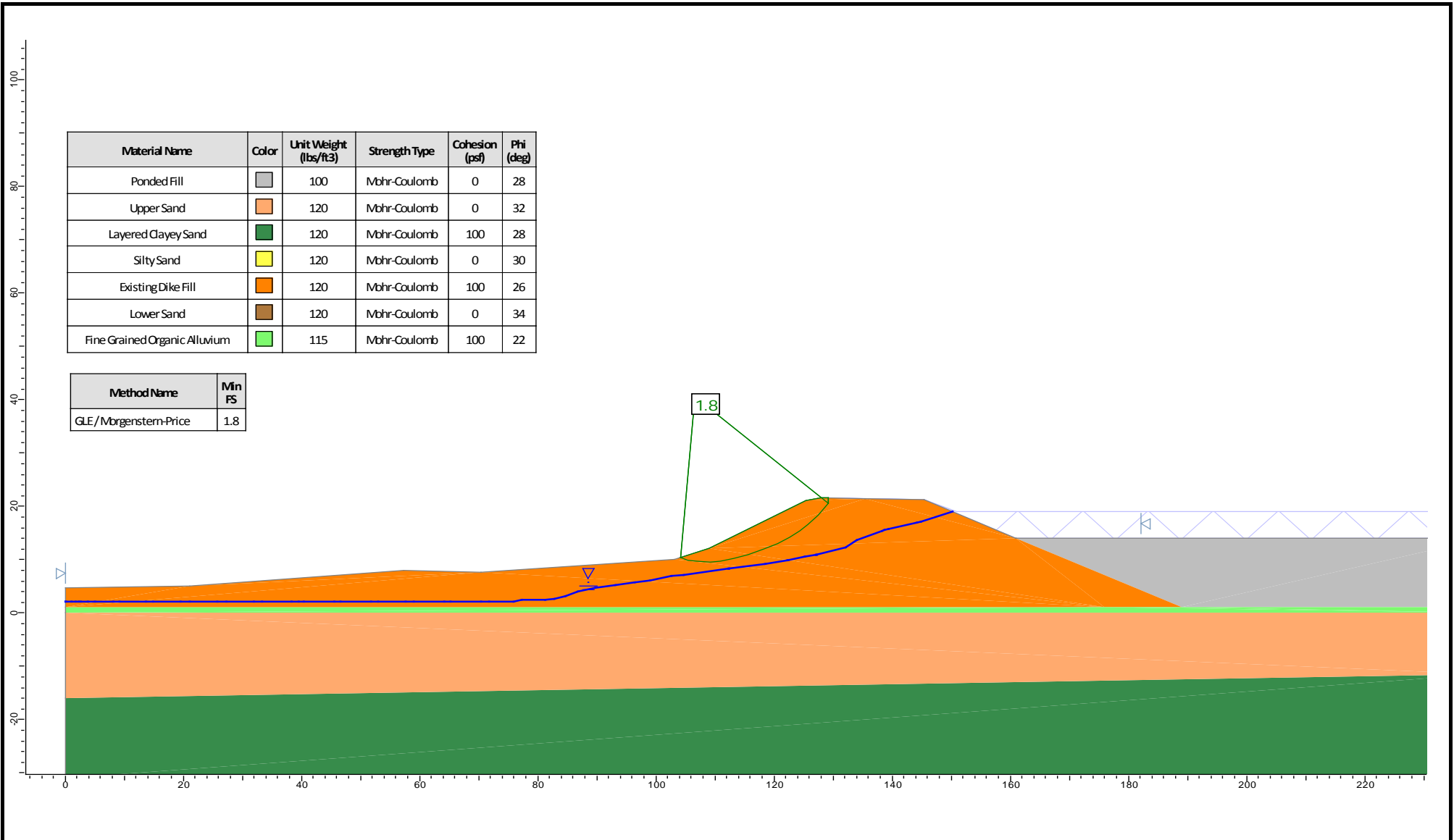
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Pounded Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Dark Orange	120	Mohr-Coulomb	100	26
Lower Sand	Brown	120	Mohr-Coulomb	0	34
Lower Silty Sand	Light Yellow	120	Mohr-Coulomb	0	34

Method Name	Min FS
GLE/Morgenstern-Price	1.8

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PROJECT No.	1300193	REVIEW	GLH	FIGURE	




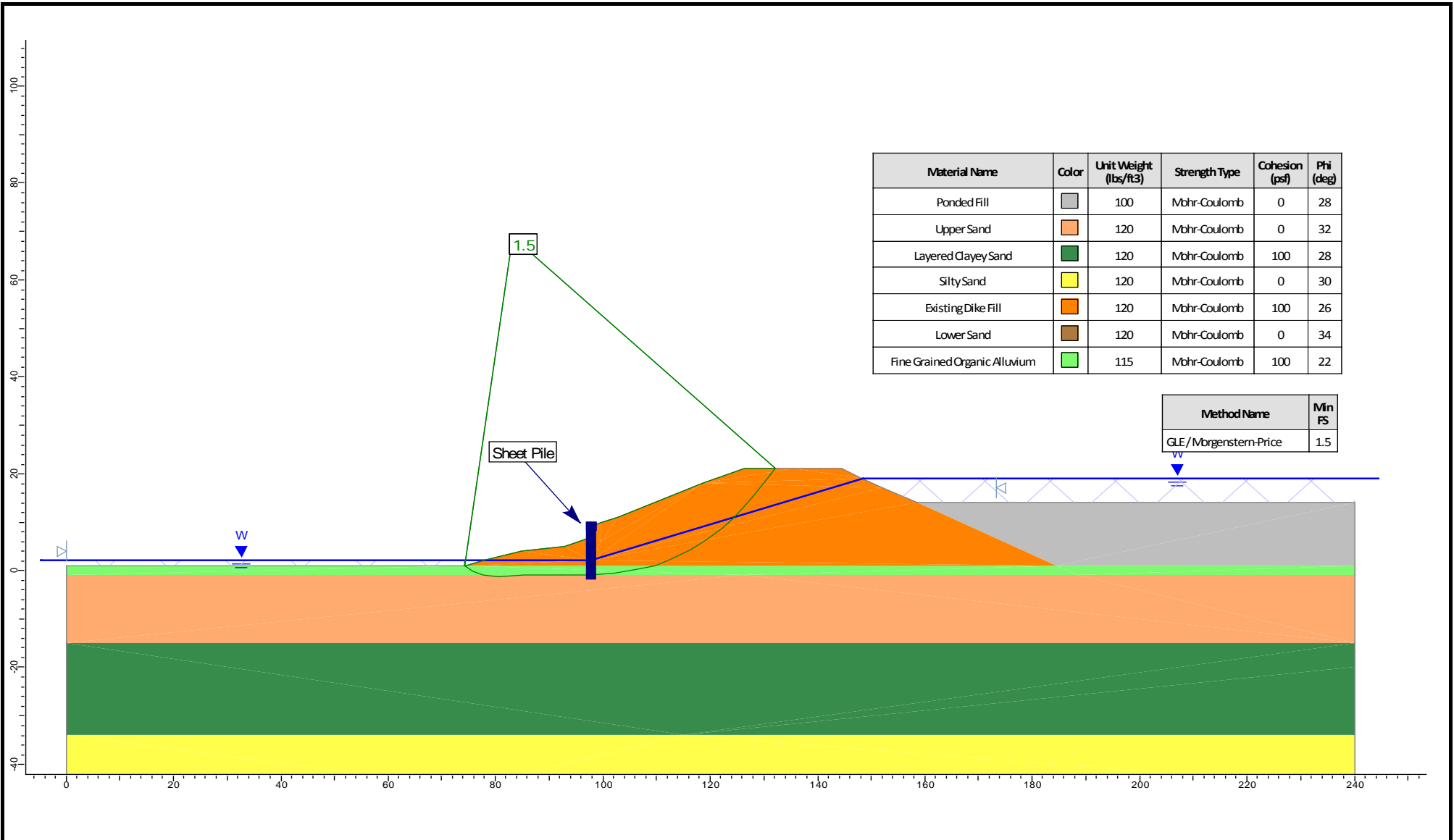
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PROJECT No.	1300193	REVIEW	GLH	FIGURE	



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Pounded Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Layered Clayey Sand	Green	120	Mohr-Coulomb	100	28
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Orange	120	Mohr-Coulomb	100	26
Lower Sand	Brown	120	Mohr-Coulomb	0	34
Fine Grained Organic Alluvium	Light Green	115	Mohr-Coulomb	100	22

Method Name	Min FS
GLE/Morgenstern-Price	1.8

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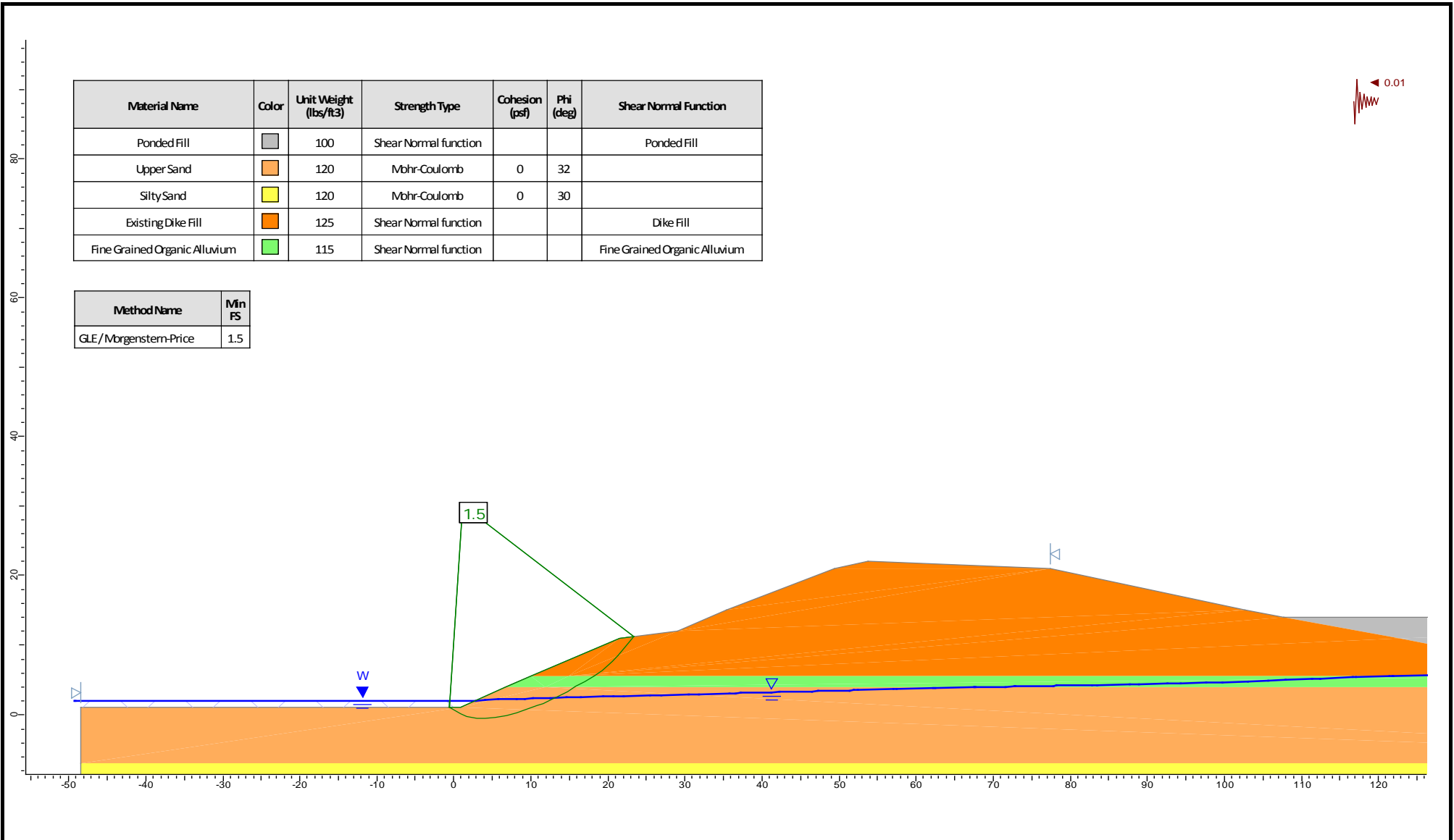
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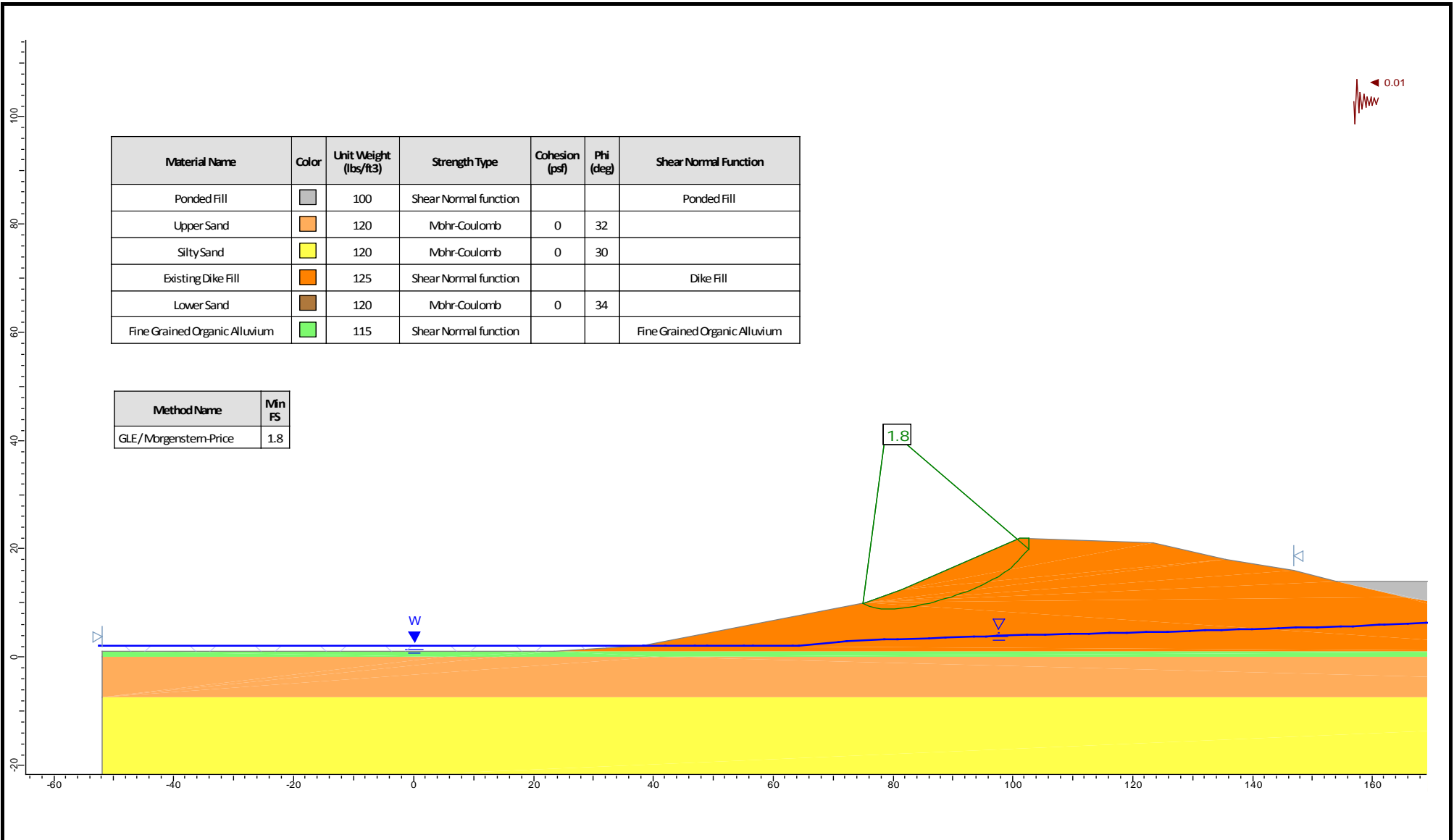
FIGURE **A - 12**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function
Ponded Fill	Grey	100	Shear Normal function			Ponded Fill
Upper Sand	Orange	120	Mohr-Coulomb	0	32	
Silty Sand	Yellow	120	Mohr-Coulomb	0	30	
Existing Dike Fill	Orange	125	Shear Normal function			Dike Fill
Fine Grained Organic Alluvium	Green	115	Shear Normal function			Fine Grained Organic Alluvium


Method Name	Min FS
GLE/Morgenstern-Price	1.5

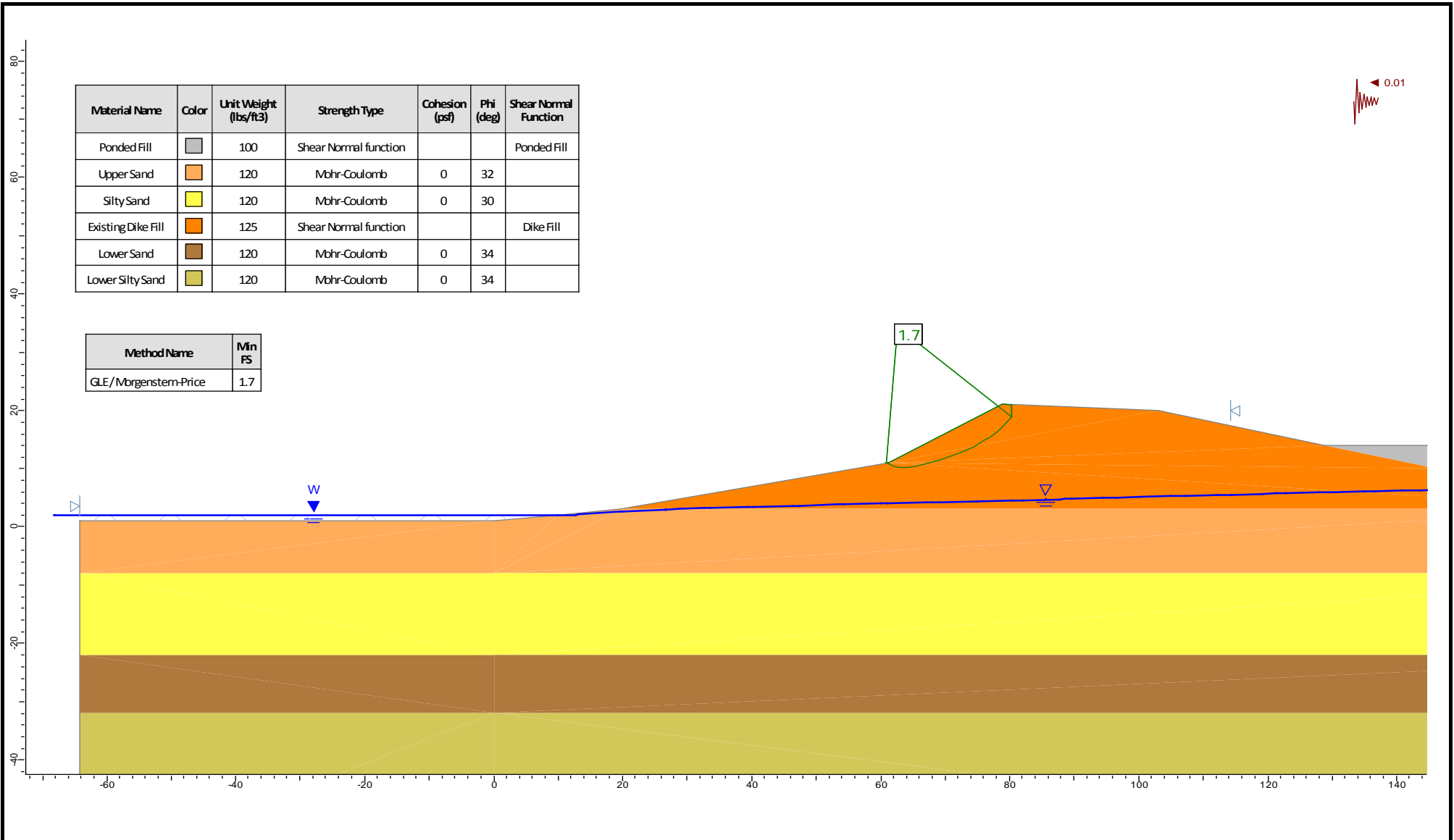
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PROJECT No.	1300193	REV.	0	CHECK	JGM	CLIENT	Dominion Energy	FIGURE	A - 13
		REVIEW	GLH						



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psi)	Phi (deg)	Shear Normal Function
Ponded Fill	Grey	100	Shear Normal function			Ponded Fill
Upper Sand	Orange	120	Mohr-Coulomb	0	32	
Silty Sand	Yellow	120	Mohr-Coulomb	0	30	
Existing Dike Fill	Dark Orange	125	Shear Normal function			Dike Fill
Lower Sand	Brown	120	Mohr-Coulomb	0	34	
Fine Grained Organic Alluvium	Light Green	115	Shear Normal function			Fine Grained Organic Alluvium

Method Name	Min FS
GLE/Morgenstern-Price	1.8

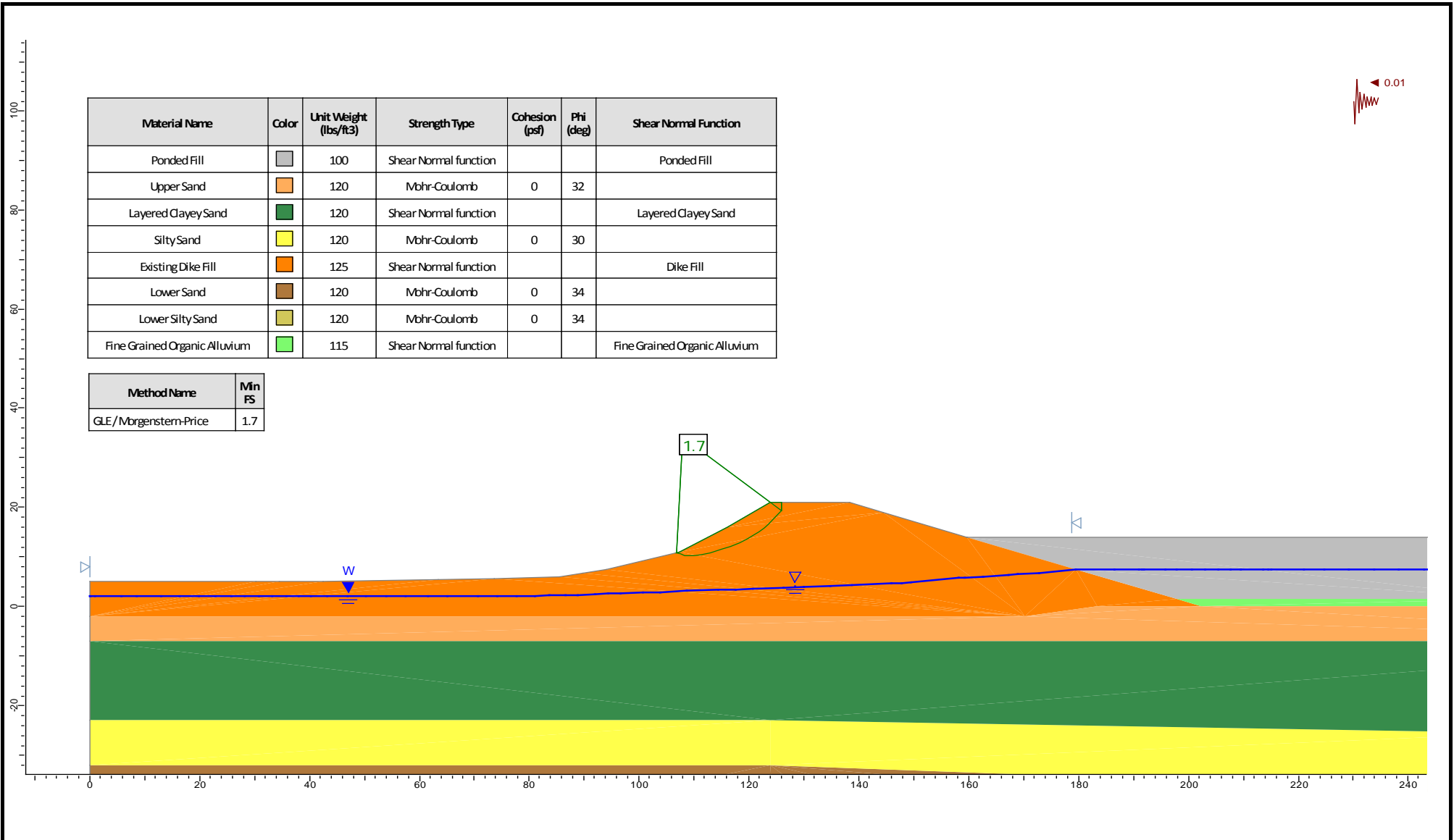
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	MADE BY	LJ					
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PROJECT No.	1300193	REV.	0	REVIEW	GLH	FIGURE	A - 14



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function
Ponded Fill	Grey	100	Shear Normal function			Ponded Fill
Upper Sand	Light Orange	120	Mohr-Coulomb	0	32	
Silty Sand	Yellow	120	Mohr-Coulomb	0	30	
Existing Dike Fill	Dark Orange	125	Shear Normal function			Dike Fill
Lower Sand	Brown	120	Mohr-Coulomb	0	34	
Lower Silty Sand	Light Green	120	Mohr-Coulomb	0	34	


Method Name	Min FS
GLE/Morgenstern-Price	1.7

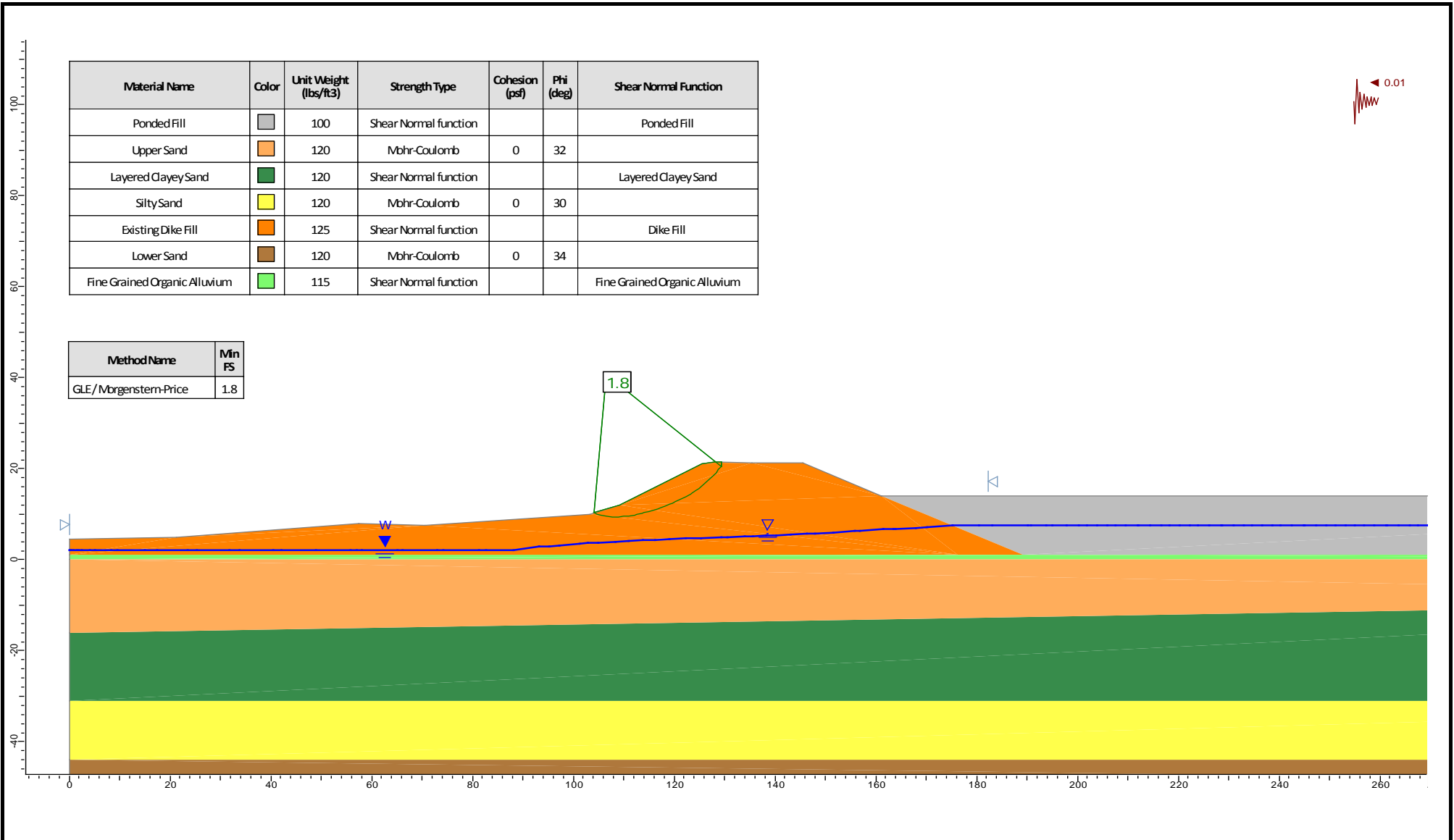
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	DATE	3/14/2018	TITLE	Section C-C Seismic screening	
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	CAD	-			
FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy
PROJECT No.	1300193	REVIEW	GLH	FIGURE	



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function
Ponded Fill	Grey	100	Shear Normal function			Ponded Fill
Upper Sand	Orange	120	Mohr-Coulomb	0	32	
Layered Clayey Sand	Green	120	Shear Normal function			Layered Clayey Sand
Silty Sand	Yellow	120	Mohr-Coulomb	0	30	
Existing Dike Fill	Orange	125	Shear Normal function			Dike Fill
Lower Sand	Brown	120	Mohr-Coulomb	0	34	
Lower Silty Sand	Yellow	120	Mohr-Coulomb	0	34	
Fine Grained Organic Alluvium	Green	115	Shear Normal function			Fine Grained Organic Alluvium


Method Name	Min FS
GLE/Morgenstern-Price	1.7

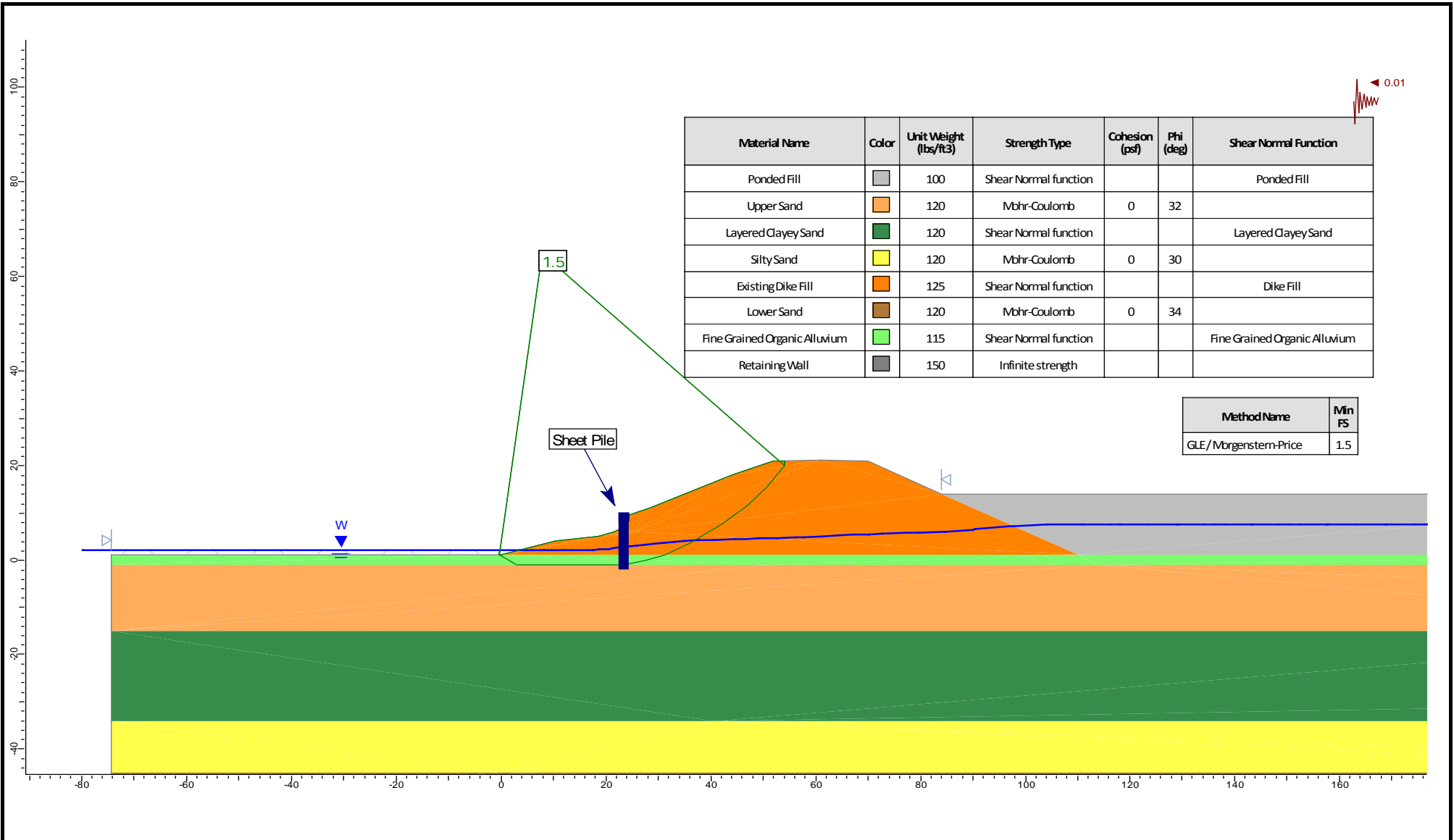
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	MADE BY	LJ							
FILE	STABILITY	CAD	-						
PROJECT No.	1300193	REV.	0	CHECK	JGM	CLIENT	Dominion Energy	FIGURE	A - 16
		REVIEW	GLH						



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function
Ponded Fill	Grey	100	Shear Normal function			Ponded Fill
Upper Sand	Orange	120	Mohr-Coulomb	0	32	
Layered Clayey Sand	Green	120	Shear Normal function			Layered Clayey Sand
Silty Sand	Yellow	120	Mohr-Coulomb	0	30	
Existing Dike Fill	Orange	125	Shear Normal function			Dike Fill
Lower Sand	Brown	120	Mohr-Coulomb	0	34	
Fine Grained Organic Alluvium	Light Green	115	Shear Normal function			Fine Grained Organic Alluvium

Method Name	Min FS
GLE/Morgenstern-Price	1.8

	SCALE	AS SHOWN	PROJECT	CEC BAP - Inactive Pond Demonstration					
	DATE	3/14/2018	TITLE	Section E-E Seismic screening					
	MADE BY	LJ							
FILE	STABILITY	CAD							
PROJECT No.	1300193	REV.	0	CHECK	JGM	CLIENT	Dominion Energy	FIGURE	A - 17
		REVIEW	GLH						



SCALE AS SHOWN
 DATE 3/14/2018
 MADE BY LJ
 CAD -

PROJECT CEC BAP - Inactive Pond Demonstration

TITLE Section F-F
 Seismic screening

FILE STABILITY
 PROJECT No. 1300193 REV. 0

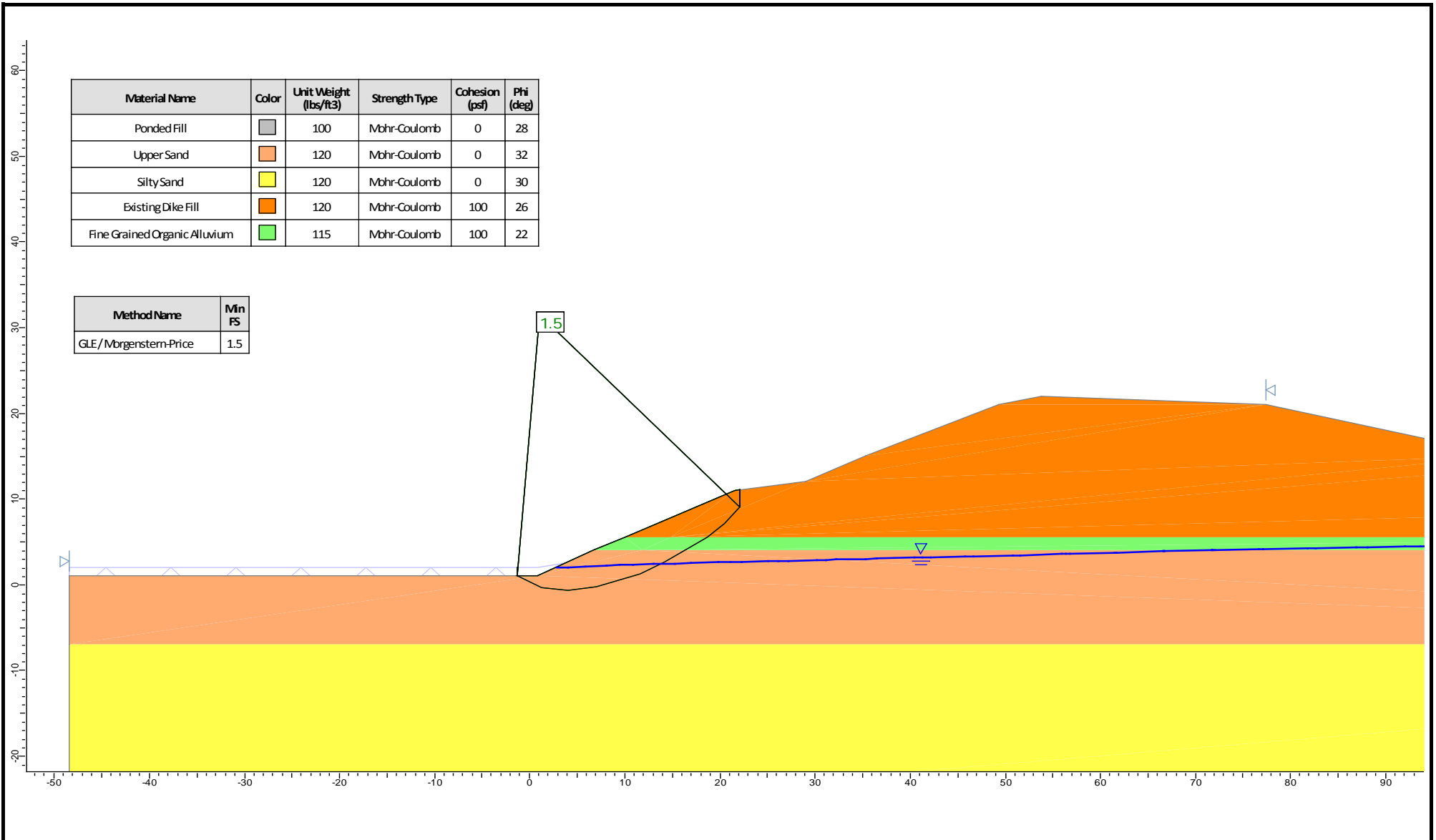
CHECK JGM
 REVIEW GLH

CLIENT Dominion Energy

FIGURE A - 18


FIGURES B-1 – B-18

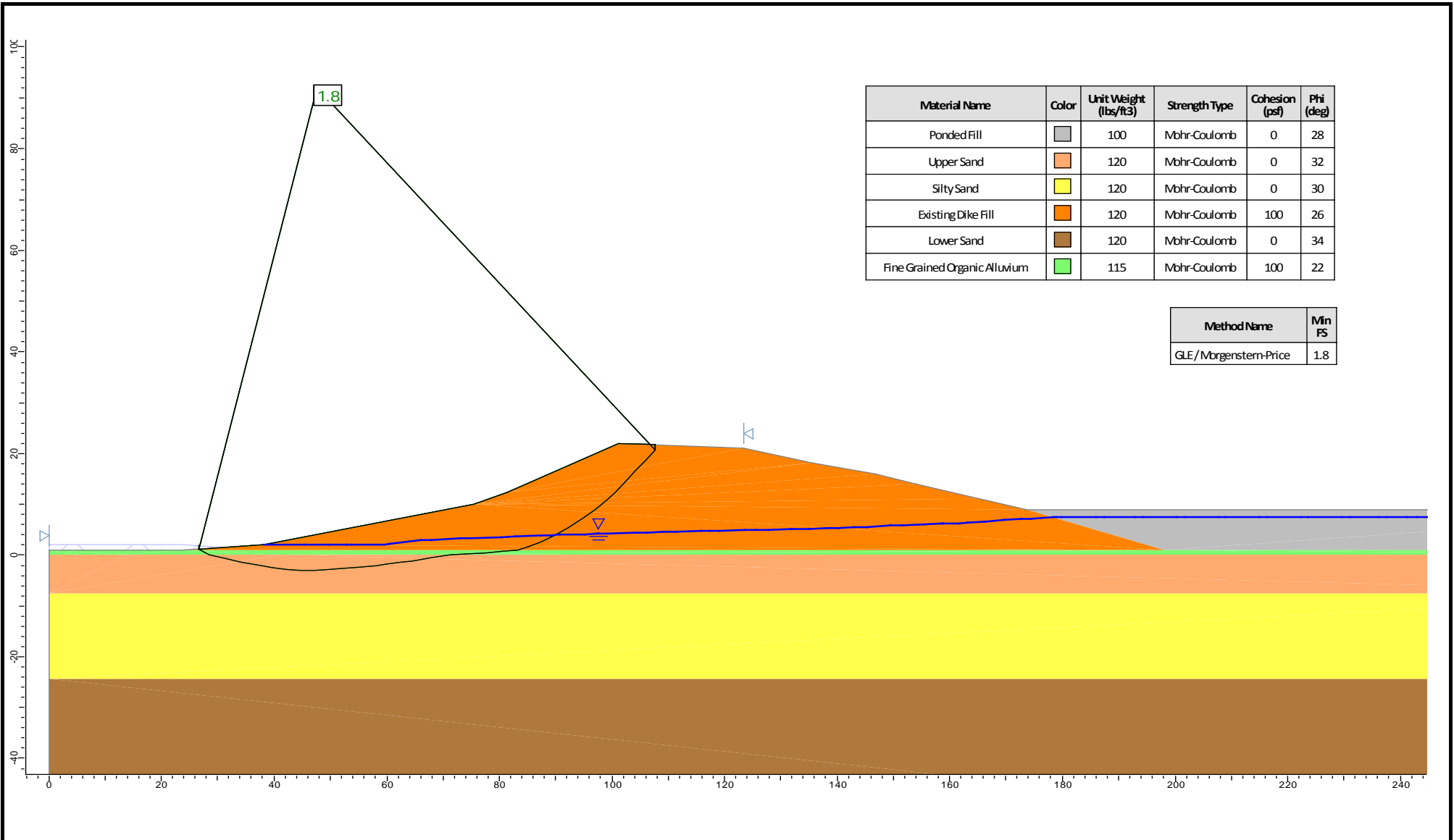
Final Conditions Stability Assessment Results



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Ponded Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Orange	120	Mohr-Coulomb	100	26
Fine Grained Organic Alluvium	Green	115	Mohr-Coulomb	100	22


Method Name	Min FS
GLE/Morgenstern-Price	1.5

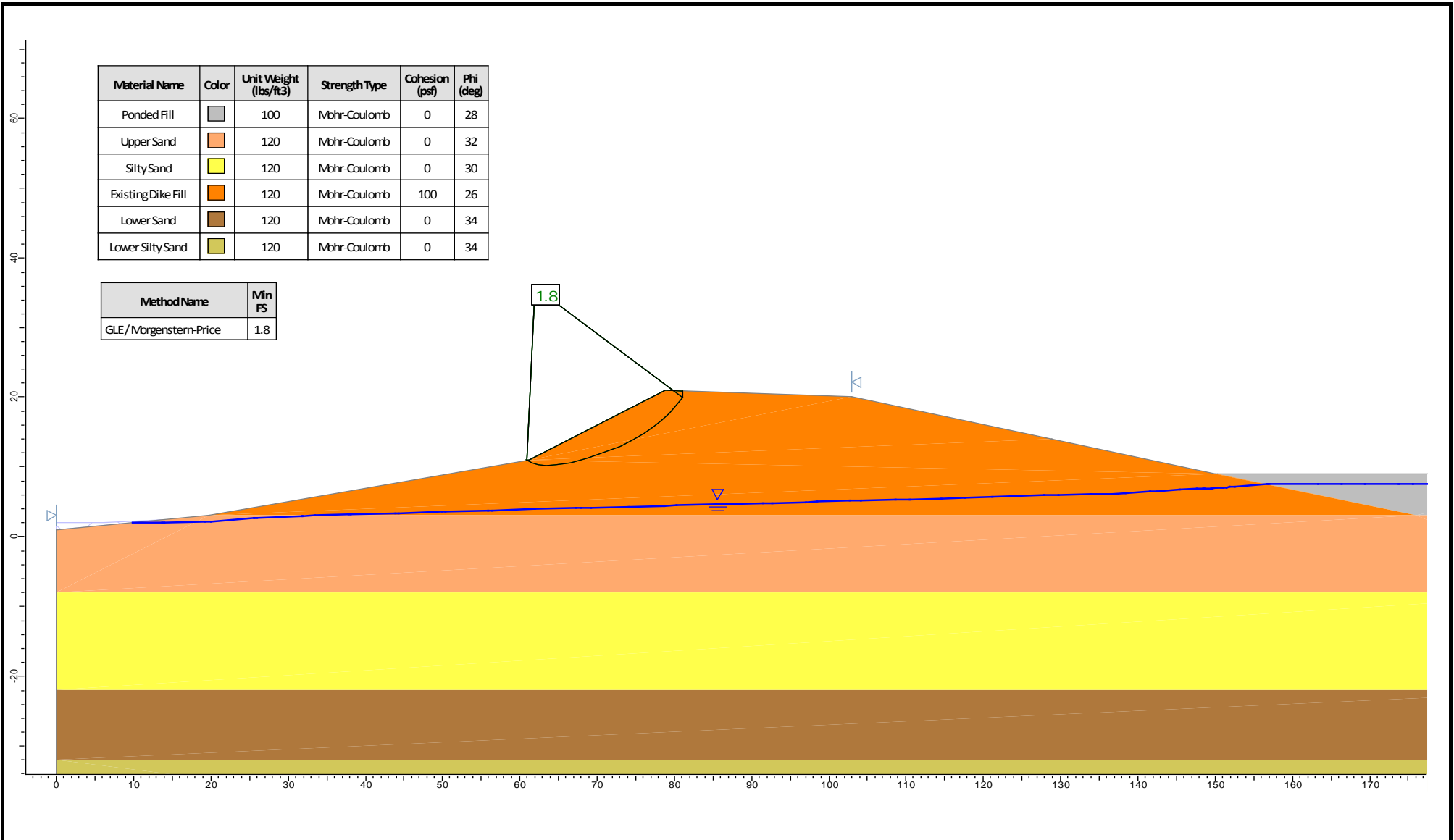
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	CAD	-			
FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy
PROJECT No.	1300193	REVIEW	GLH	FIGURE	




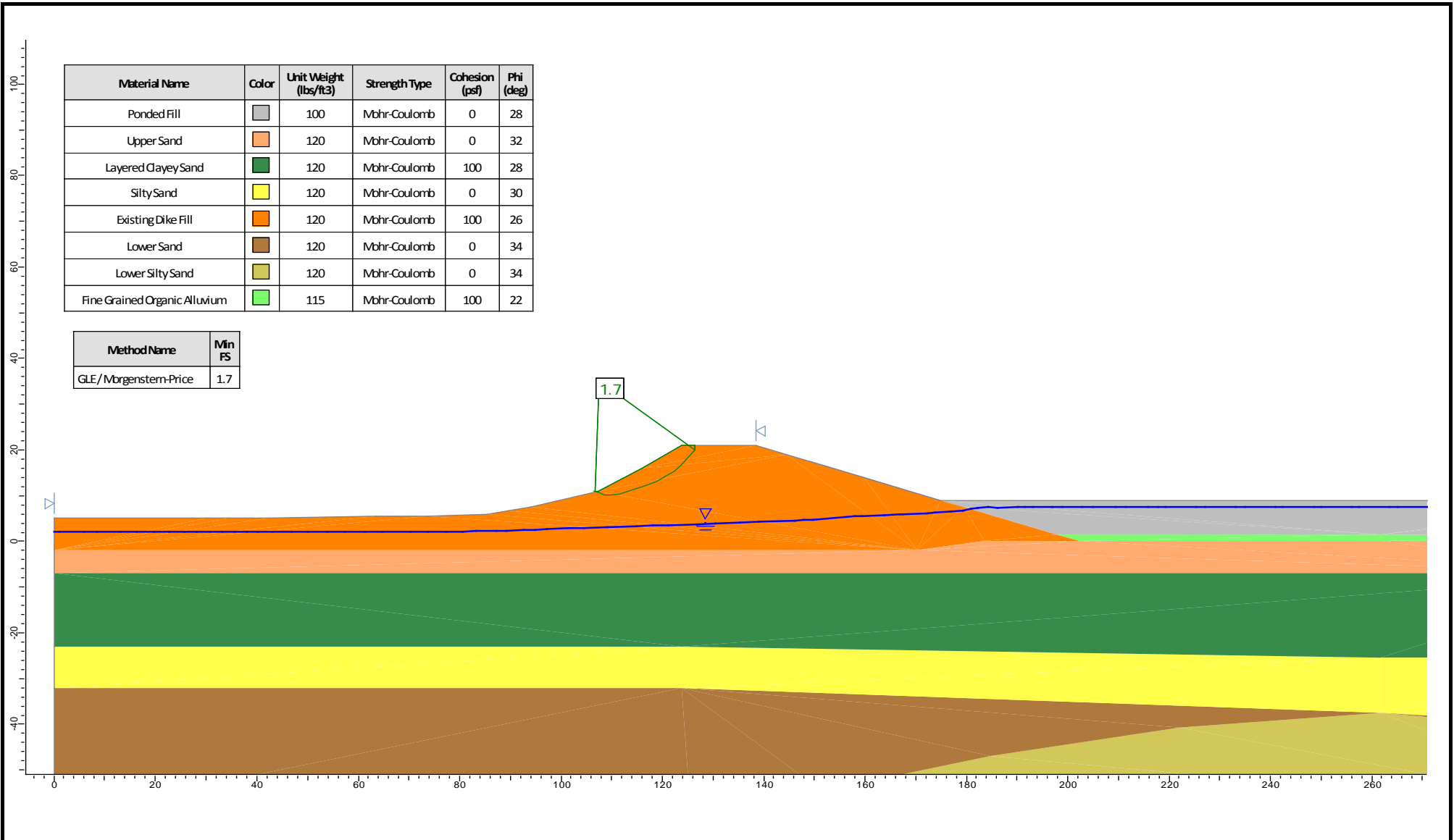
Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Pondered Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Dark Orange	120	Mohr-Coulomb	100	26
Lower Sand	Brown	120	Mohr-Coulomb	0	34
Fine Grained Organic Alluvium	Green	115	Mohr-Coulomb	100	22

Method Name	Min FS
GLE/Morgenstern-Price	1.8

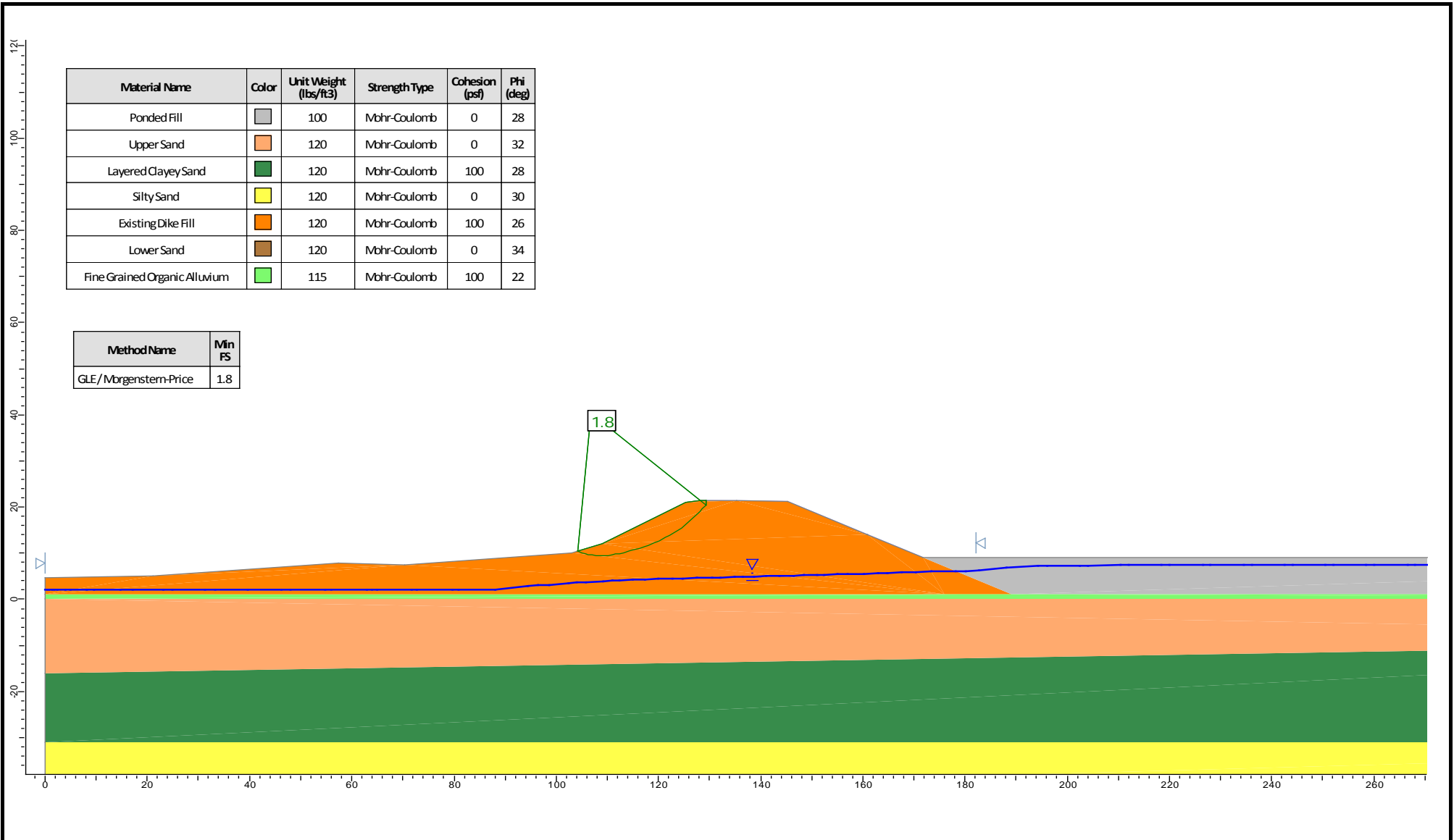
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	DATE	3/14/2018	TITLE	Section B-B Long Term, Normal Storage Pool	
	MADE BY	LJ			
	CAD	-			
FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy
PROJECT No.	1300193	REVIEW	GLH	FIGURE	



	SCALE	AS SHOWN	PROJECT	CEC BAP - Inactive Pond Demonstration	
	DATE	3/14/2018	TITLE	Section C-C Long Term, Normal Storage Pool	
	MADE BY	LJ			
	CAD	-			
FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy
PROJECT No.	1300193	REVIEW	GLH	FIGURE	



SCALE	AS SHOWN	PROJECT	CEC BAP - Inactive Pond Demonstration	
DATE	3/14/2018	TITLE	Section D-D Long Term, Normal Storage Pool	
MADE BY	LJ			
CAD	-			
FILE	STABILITY	CHECK	JGM	CLIENT
PROJECT No.	1300193	REVIEW	GLH	Dominion Energy
REV.	0			FIGURE
				B - 4



SCALE AS SHOWN
 DATE 3/14/2018
 MADE BY LJ
 CAD -

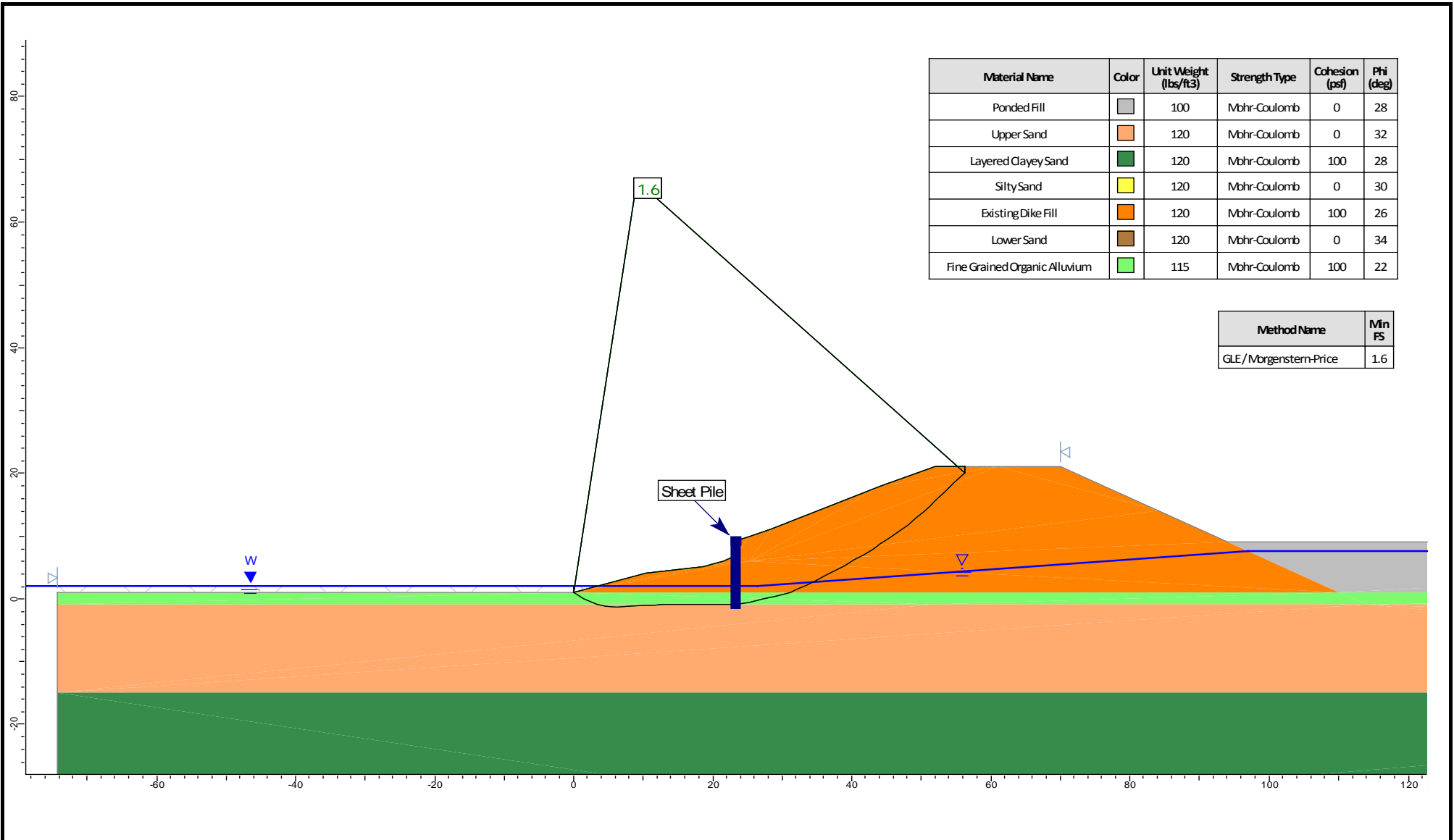
PROJECT CEC BAP - Inactive Pond Demonstration
 TITLE Section E-E
 Long Term, Normal Storage Pool

FILE STABILITY
 PROJECT No. 1300193 REV. 0

CHECK JGM
 REVIEW GLH


CLIENT Dominion Energy

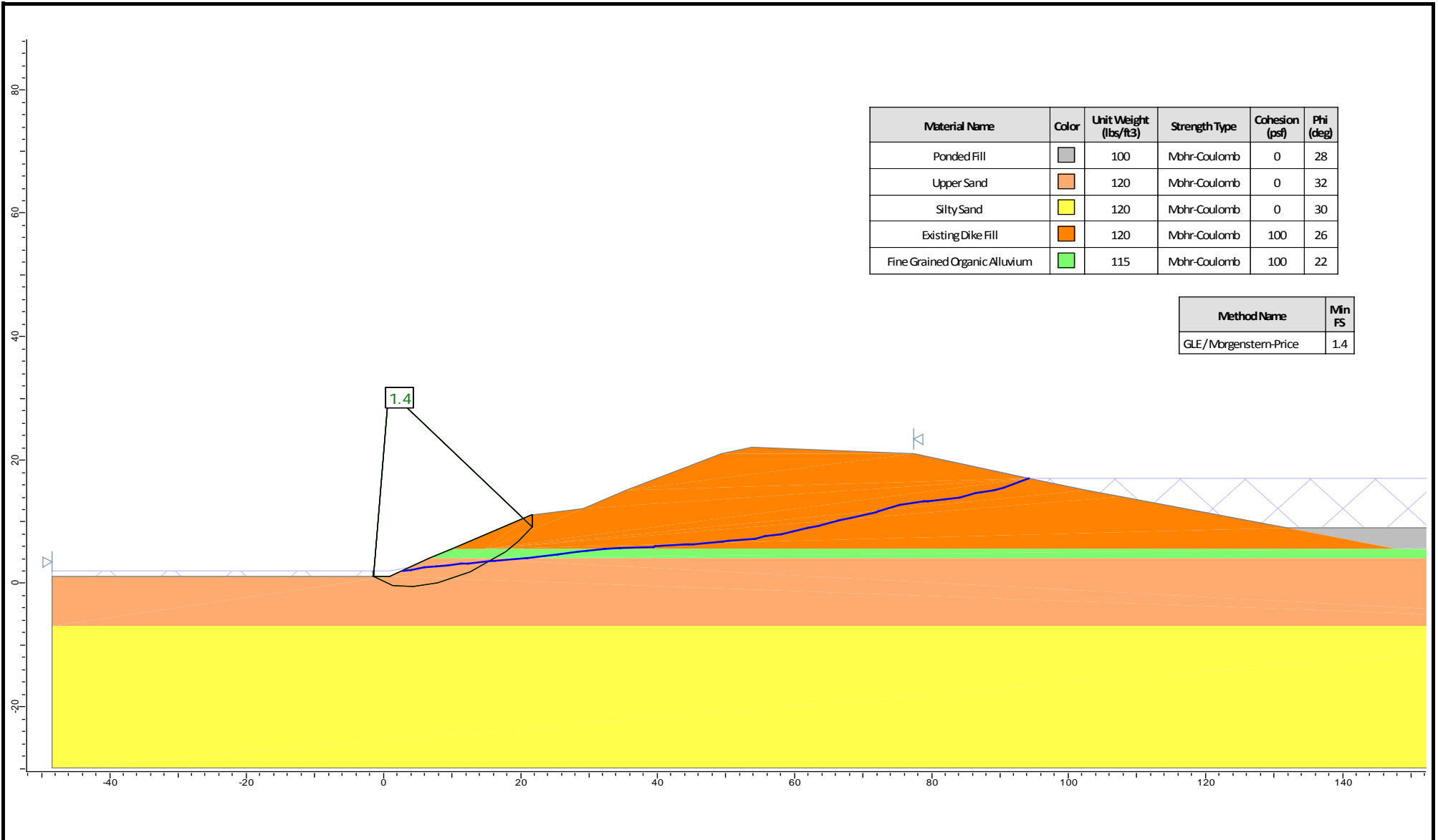
FIGURE B - 5



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Ponded Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Layered Clayey Sand	Green	120	Mohr-Coulomb	100	28
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Light Orange	120	Mohr-Coulomb	100	26
Lower Sand	Brown	120	Mohr-Coulomb	0	34
Fine Grained Organic Alluvium	Light Green	115	Mohr-Coulomb	100	22


Method Name	Min FS
GLE/Morgenstern-Price	1.6

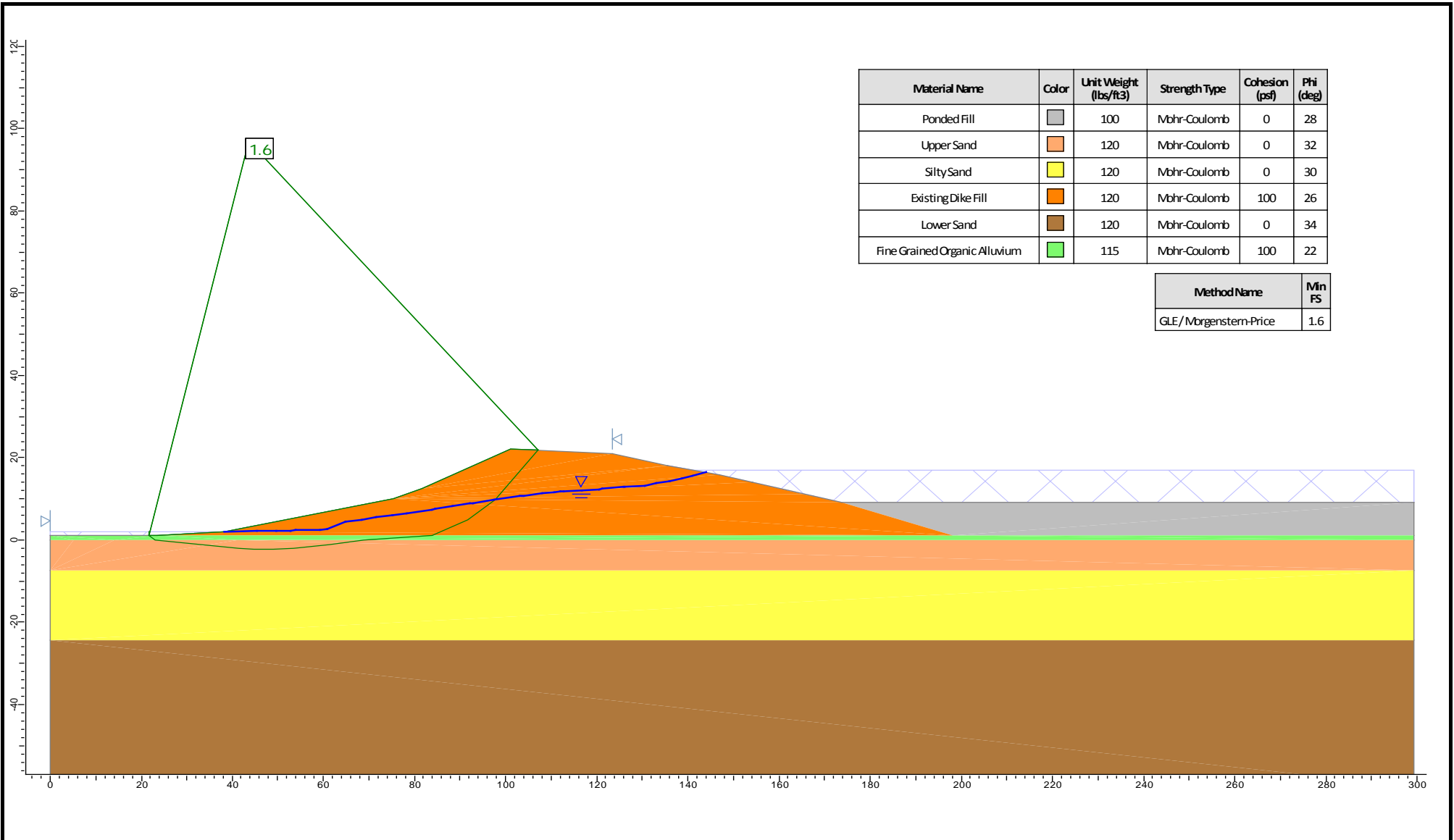
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	DATE	3/14/2018	TITLE	Section F-F Long Term, Normal Storage Pool	
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CAD	-				
FILE	STABILITY	CHECK	JGM	CLIENT	FIGURE B - 6
PROJECT No.	1300193	REVIEW	GLH	Dominion Energy	
	REV.	0			



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Pondered Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Orange	120	Mohr-Coulomb	100	26
Fine Grained Organic Alluvium	Green	115	Mohr-Coulomb	100	22


Method Name	Min FS
GLE/Morgenstern-Price	1.4

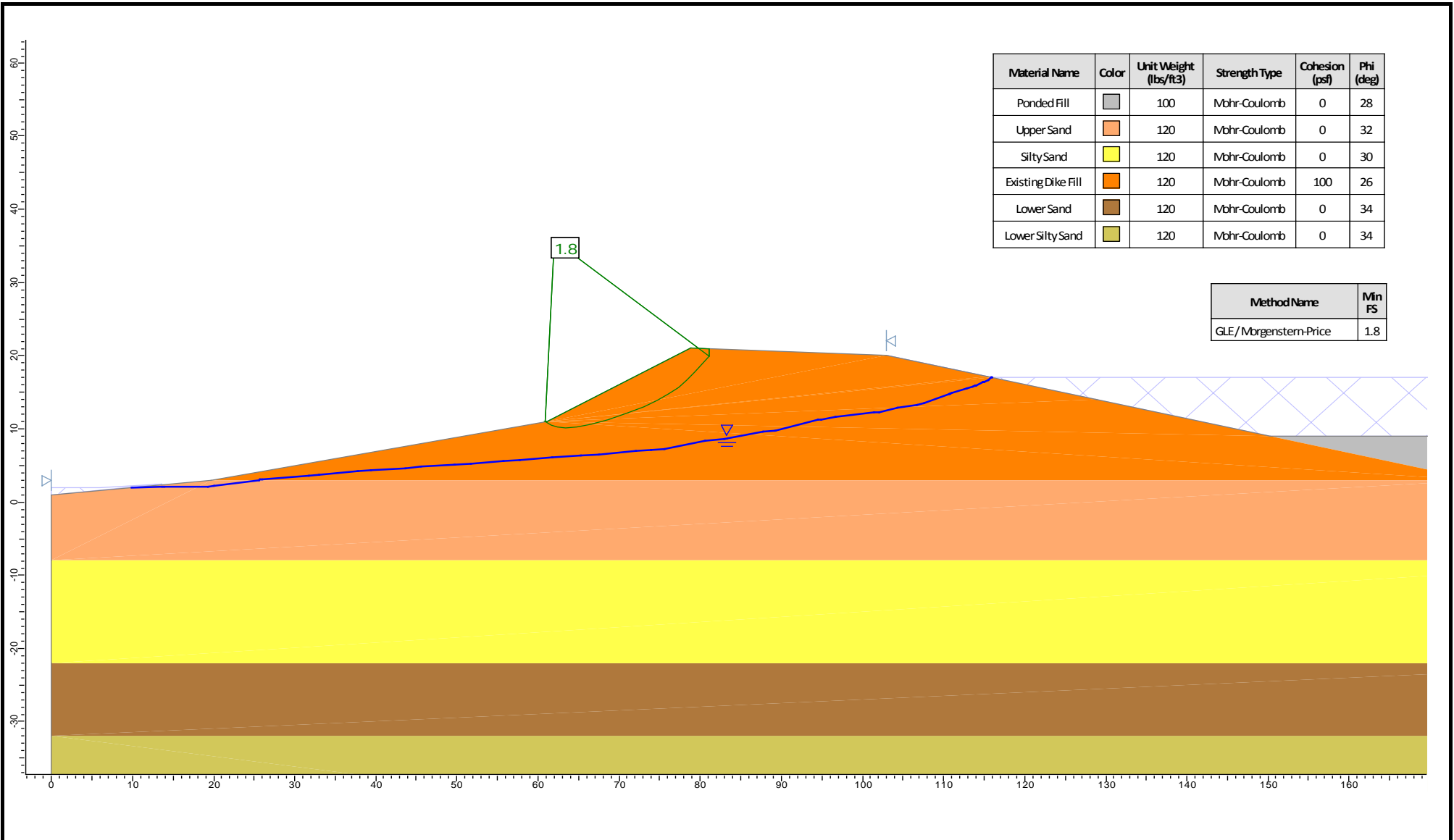
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	DATE	3/14/2018	TITLE	Section A-A Maximum Surcharge Pool	
	MADE BY	LJ			
	CAD	-			
FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy
PROJECT No.	1300193	REVIEW	GLH	FIGURE	
	REV.	0			



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Pounded Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Dark Orange	120	Mohr-Coulomb	100	26
Lower Sand	Brown	120	Mohr-Coulomb	0	34
Fine Grained Organic Alluvium	Green	115	Mohr-Coulomb	100	22

Method Name	Min FS
GLE/Morgenstern-Price	1.6

	SCALE	AS SHOWN	PROJECT	CEC BAP - Inactive Pond Demonstration	
	DATE	3/14/2018	TITLE	<p align="center">Section B-B Maximum Surcharge Pool</p>	
	MADE BY	LJ			
	CAD	-			
FILE	STABILITY	CHECK	JGM	CLIENT	<p align="center">Dominion Energy</p>
PROJECT No.	1300193	REVIEW	GLH	FIGURE	
	REV.	0			



SCALE AS SHOWN
 DATE 3/14/2018
 MADE BY LJ
 CAD -

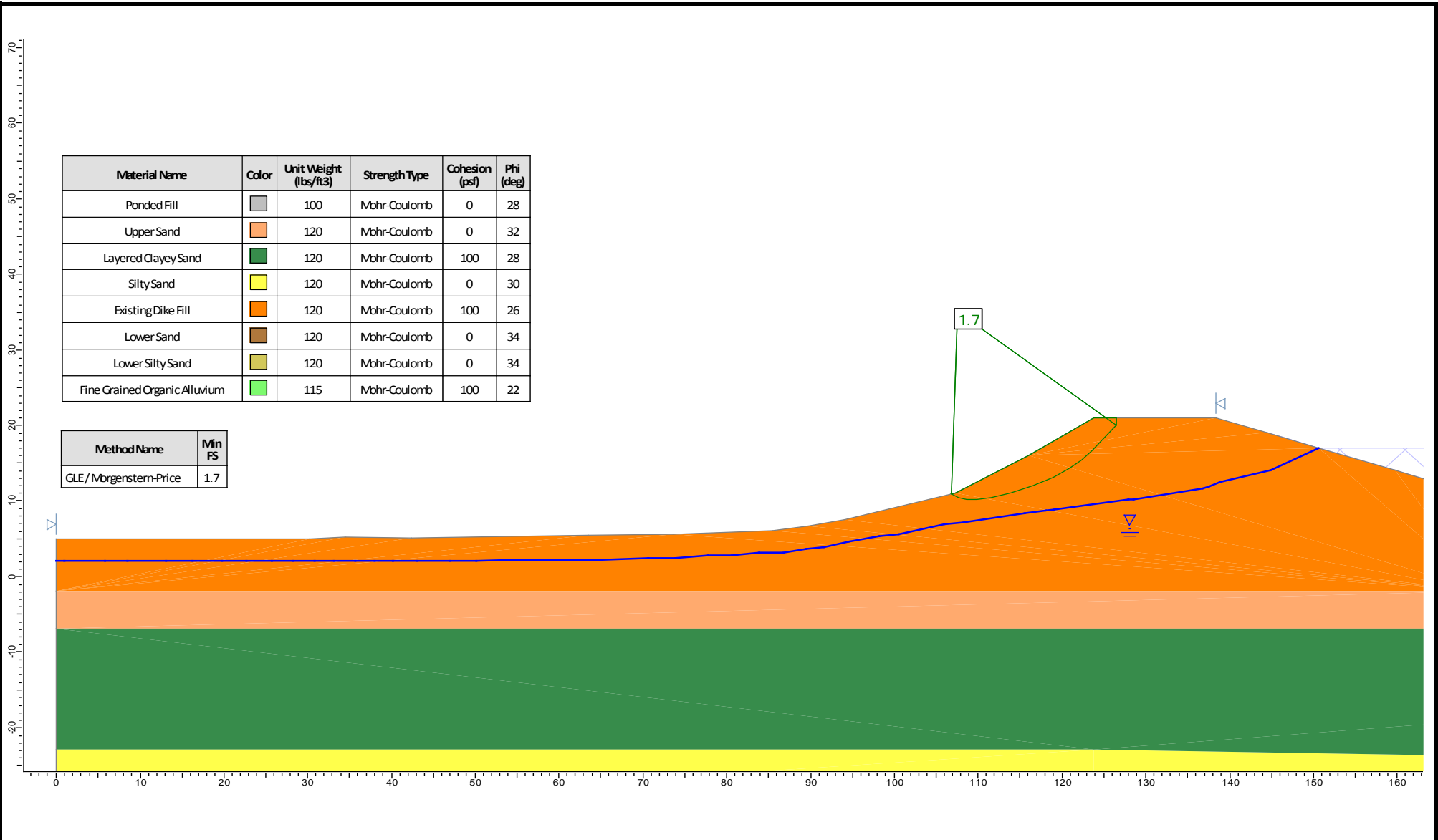
PROJECT **CEC BAP - Inactive Pond Demonstration**
 TITLE **Section C-C
 Maximum Surcharge Pool**

FILE STABILITY
 PROJECT No. 1300193 REV. 0

CHECK JGM
 REVIEW GLH


CLIENT **Dominion Energy**

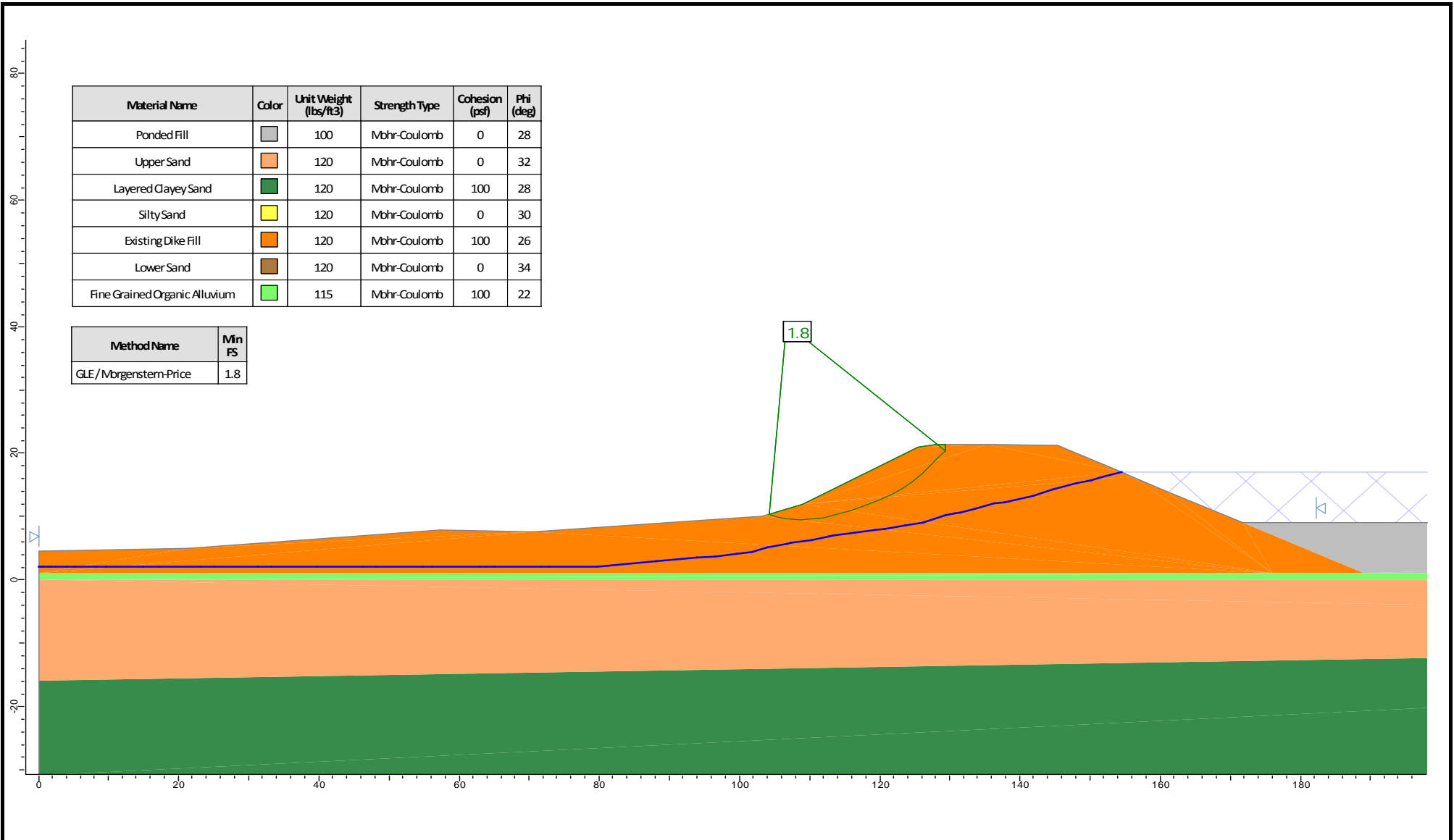
FIGURE **B - 9**



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Pondered Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Layered Clayey Sand	Green	120	Mohr-Coulomb	100	28
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Orange	120	Mohr-Coulomb	100	26
Lower Sand	Brown	120	Mohr-Coulomb	0	34
Lower Silty Sand	Yellow-Green	120	Mohr-Coulomb	0	34
Fine Grained Organic Alluvium	Light Green	115	Mohr-Coulomb	100	22


Method Name	Min FS
GLE/Morgenstern-Price	1.7

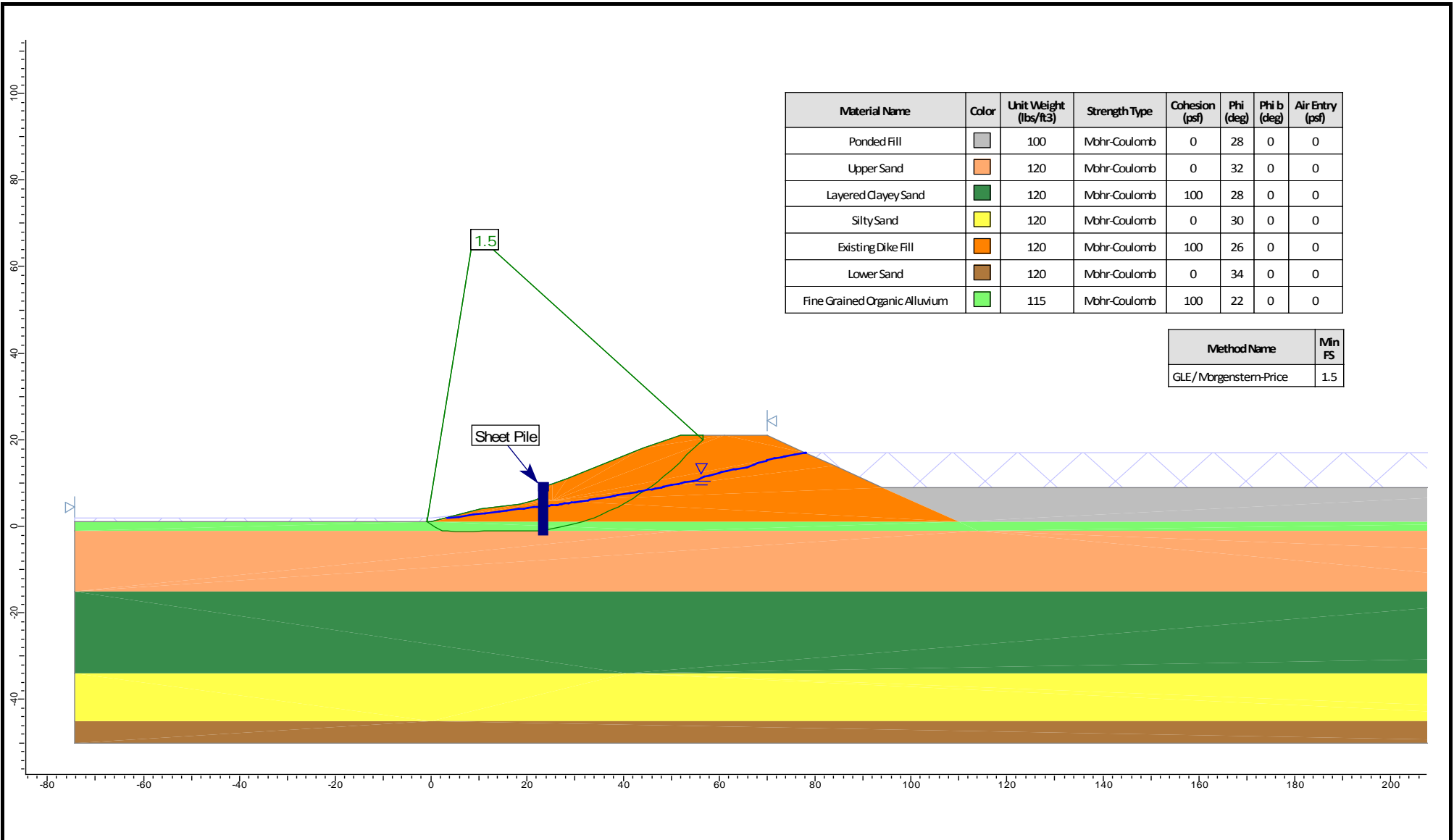
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	CAD	-			
FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy
PROJECT No.	1300193	REVIEW	GLH	FIGURE	



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Pondered Fill	Grey	100	Mohr-Coulomb	0	28
Upper Sand	Orange	120	Mohr-Coulomb	0	32
Layered Clayey Sand	Green	120	Mohr-Coulomb	100	28
Silty Sand	Yellow	120	Mohr-Coulomb	0	30
Existing Dike Fill	Orange	120	Mohr-Coulomb	100	26
Lower Sand	Brown	120	Mohr-Coulomb	0	34
Fine Grained Organic Alluvium	Light Green	115	Mohr-Coulomb	100	22


Method Name	Min FS
GLE/Morgenstern-Price	1.8

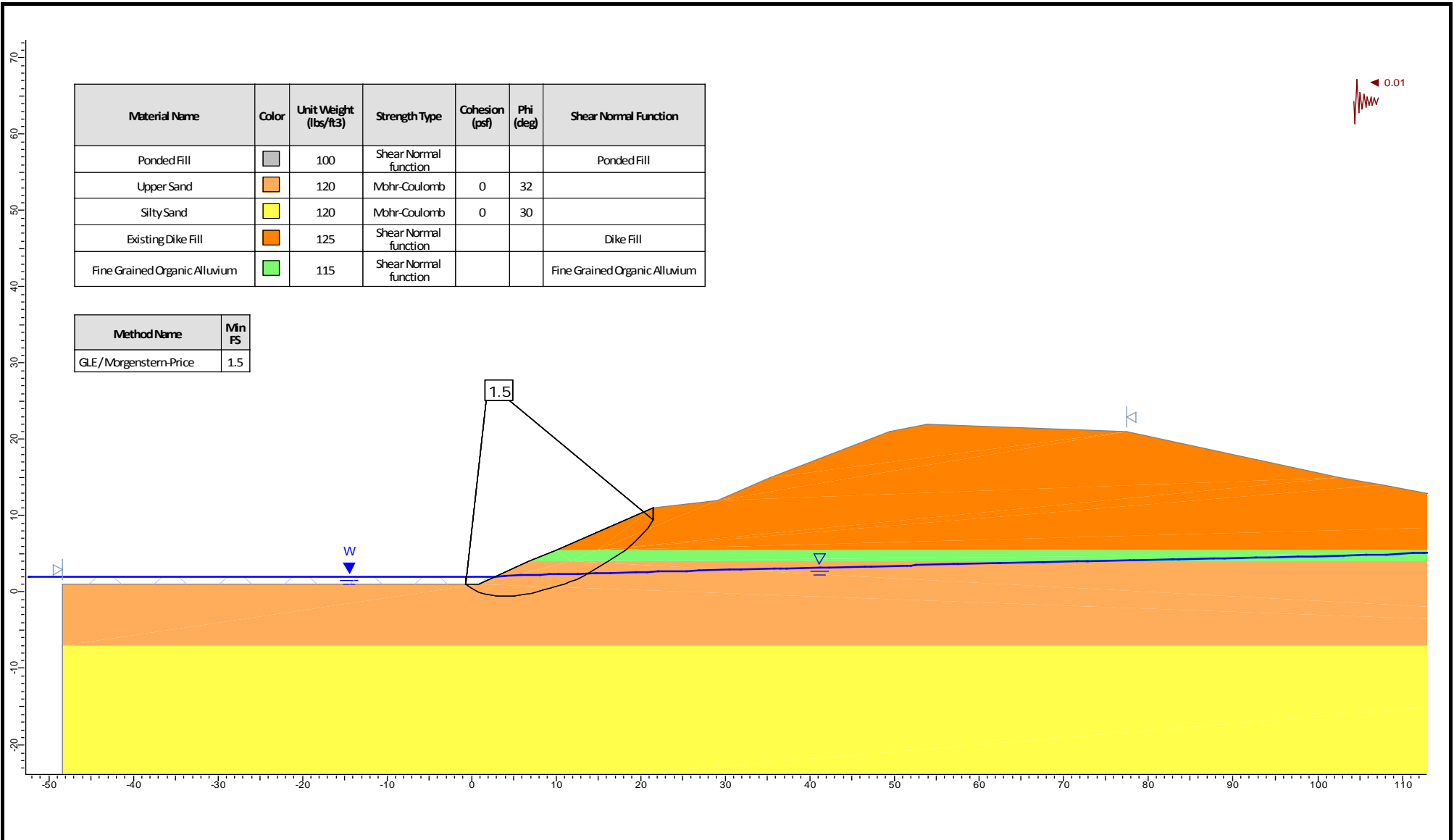
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	DATE	3/14/2018	TITLE	Section E-E Maximum Surcharge Pool	
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CAD	-				
FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy
PROJECT No.	1300193	REVIEW	GLH	FIGURE	
	REV.	0			



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)	Phi b (deg)	Air Entry (psf)
Ponded Fill	Grey	100	Mohr-Coulomb	0	28	0	0
Upper Sand	Orange	120	Mohr-Coulomb	0	32	0	0
Layered Clayey Sand	Green	120	Mohr-Coulomb	100	28	0	0
Silty Sand	Yellow	120	Mohr-Coulomb	0	30	0	0
Existing Dike Fill	Brown	120	Mohr-Coulomb	100	26	0	0
Lower Sand	Light Green	120	Mohr-Coulomb	0	34	0	0
Fine Grained Organic Alluvium	Light Green	115	Mohr-Coulomb	100	22	0	0

Method Name	Min FS
GLE/Morgenstern-Price	1.5

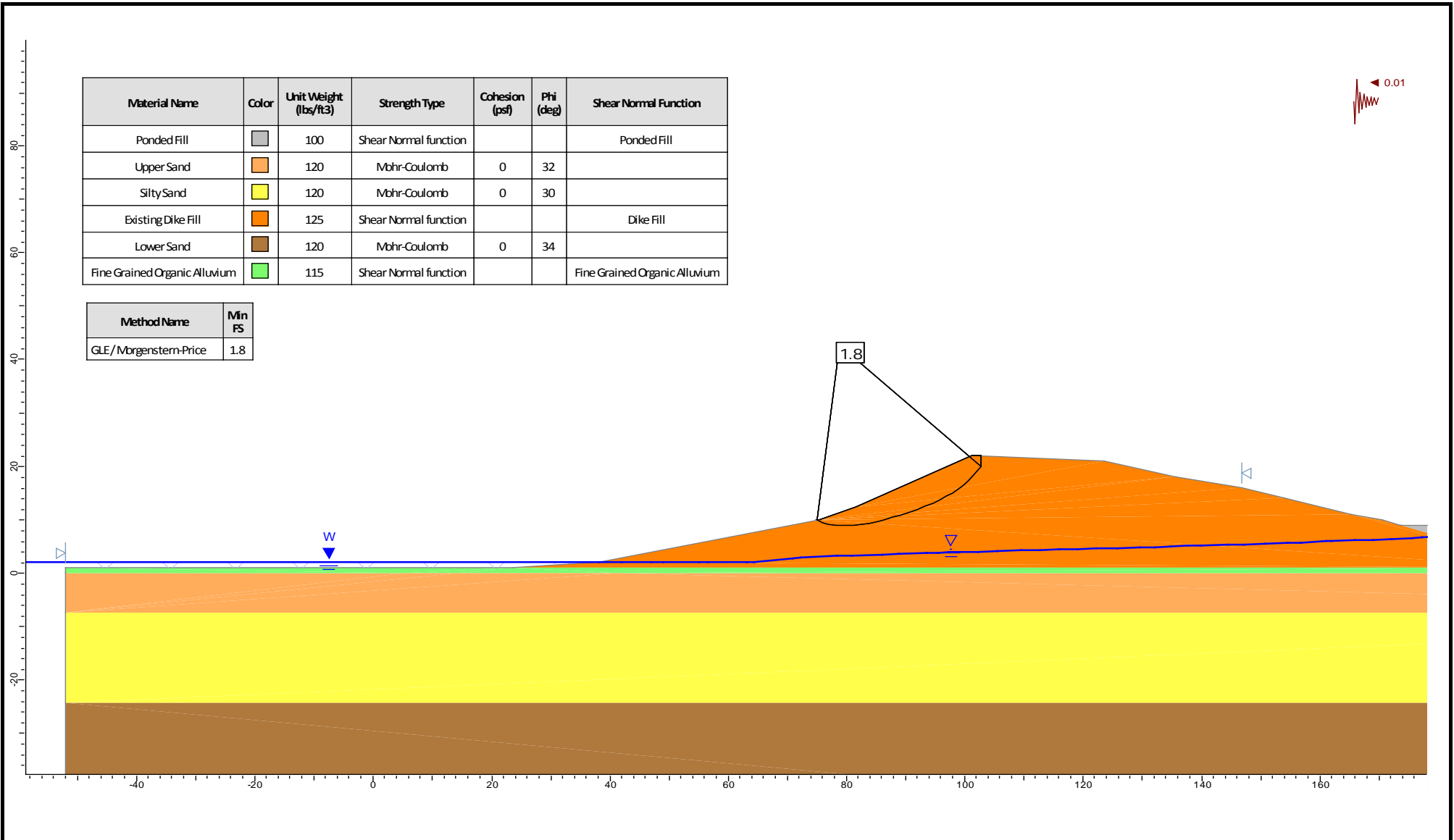
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	DATE	3/14/2018	TITLE	Section F-F Maximum Surcharge Pool	
	MADE BY	LJ			
	CAD	-			
FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy
PROJECT No.	1300193	REVIEW	GLH	FIGURE	
	REV.	0			



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function
Ponded Fill	Grey	100	Shear Normal function			Ponded Fill
Upper Sand	Orange	120	Mohr-Coulomb	0	32	
Silty Sand	Yellow	120	Mohr-Coulomb	0	30	
Existing Dike Fill	Dark Orange	125	Shear Normal function			Dike Fill
Fine Grained Organic Alluvium	Green	115	Shear Normal function			Fine Grained Organic Alluvium


Method Name	Min FS
GLE/Morgenstern-Price	1.5

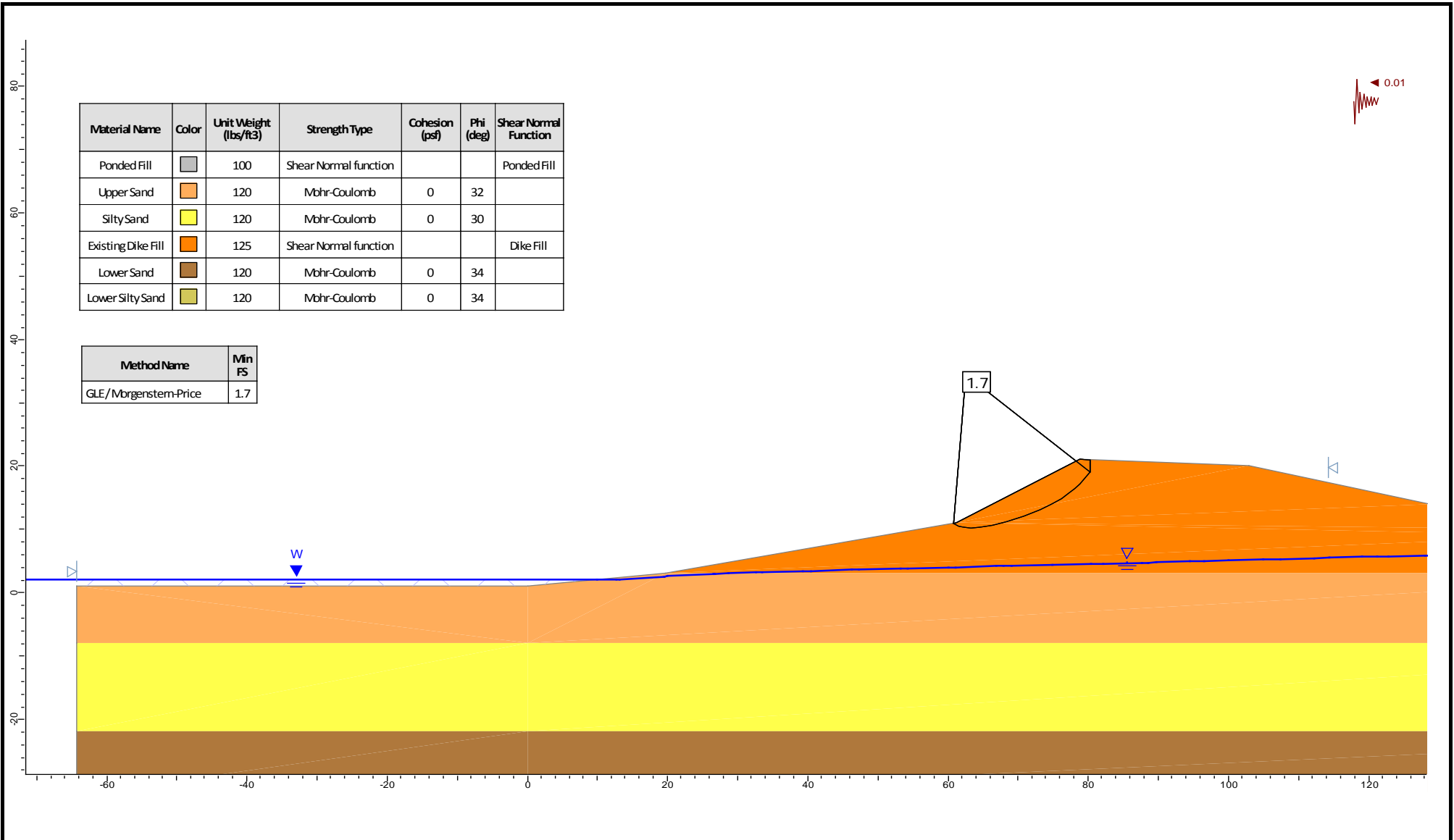
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	DATE	3/14/2018	TITLE	Section A-A Seismic screening	
	MADE BY	LJ			
	CAD	-			
FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy
PROJECT No.	1300193	REVIEW	GLH	FIGURE	



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function
Ponded Fill	Grey	100	Shear Normal function			Ponded Fill
Upper Sand	Orange	120	Mohr-Coulomb	0	32	
Silty Sand	Yellow	120	Mohr-Coulomb	0	30	
Existing Dike Fill	Orange	125	Shear Normal function			Dike Fill
Lower Sand	Brown	120	Mohr-Coulomb	0	34	
Fine Grained Organic Alluvium	Green	115	Shear Normal function			Fine Grained Organic Alluvium


Method Name	Min FS
GLE/Morgenstern-Price	1.8

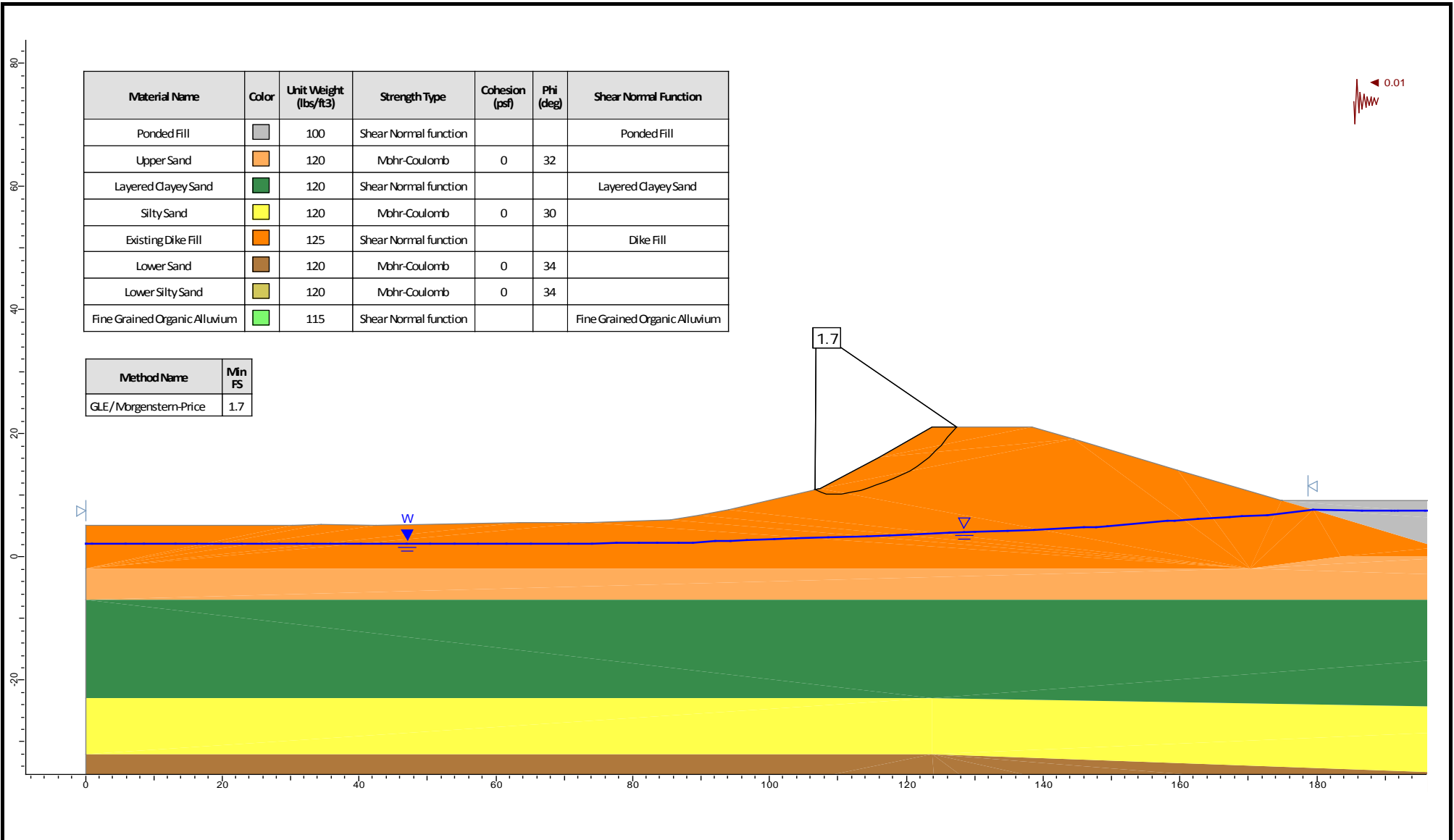
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	DATE	3/14/2018	TITLE	Section B-B Seismic screening			
	MADE BY	LJ					
FILE	STABILITY	CAD	-	CLIENT	Dominion Energy		
PROJECT No.	1300193	REV.	0	REVIEW	GLH	FIGURE	B - 14



Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function
Ponded Fill	Grey	100	Shear Normal function			Ponded Fill
Upper Sand	Orange	120	Mohr-Coulomb	0	32	
Silty Sand	Yellow	120	Mohr-Coulomb	0	30	
Existing Dike Fill	Dark Orange	125	Shear Normal function			Dike Fill
Lower Sand	Brown	120	Mohr-Coulomb	0	34	
Lower Silty Sand	Light Yellow	120	Mohr-Coulomb	0	34	


Method Name	Min FS
GLE/Morgenstern-Price	1.7

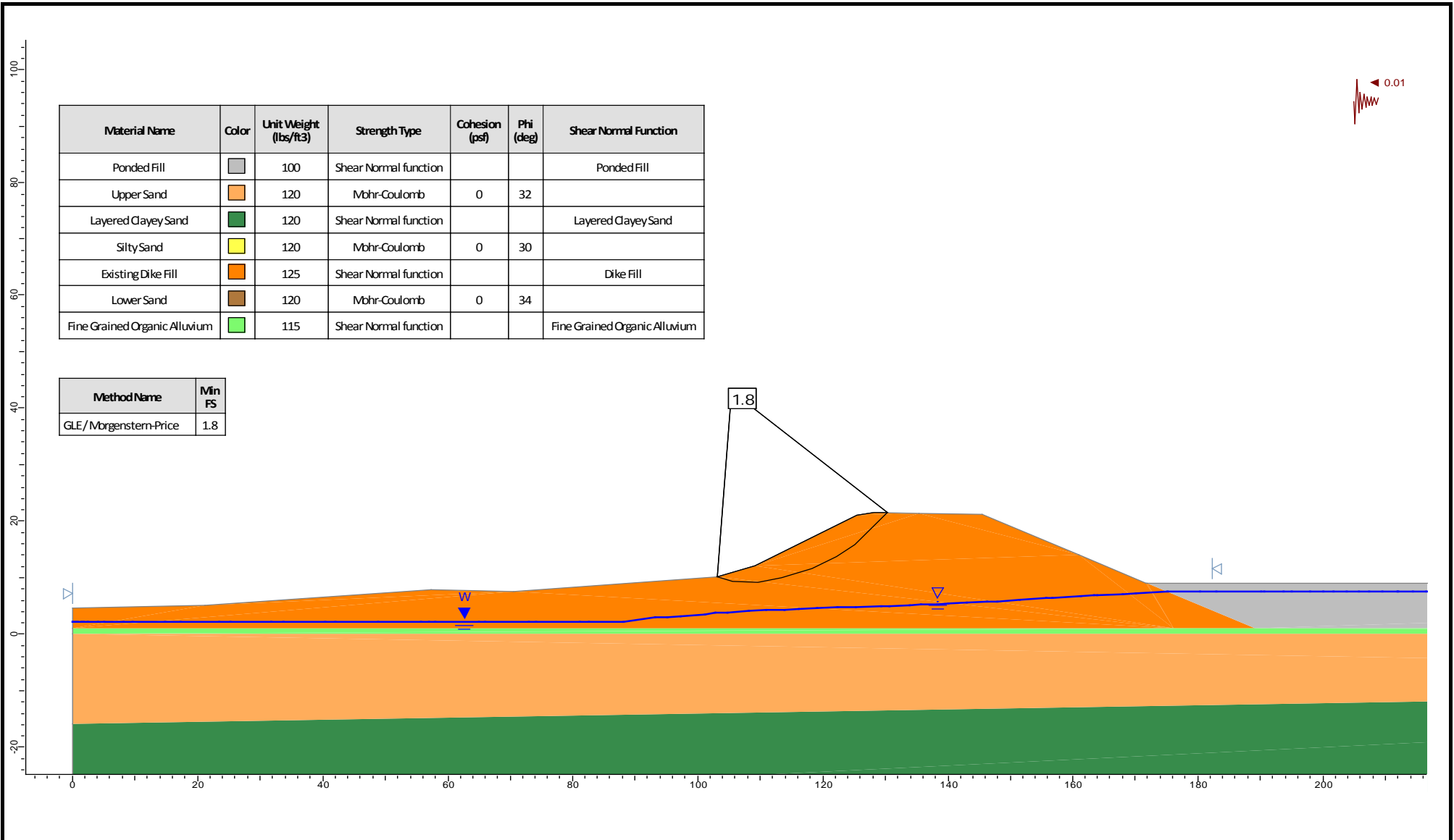
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	DATE	3/14/2018	TITLE	Section C-C Seismic screening		
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FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy	
PROJECT No.	1300193	REV.	0	REVIEW		GLH
					FIGURE	B - 15




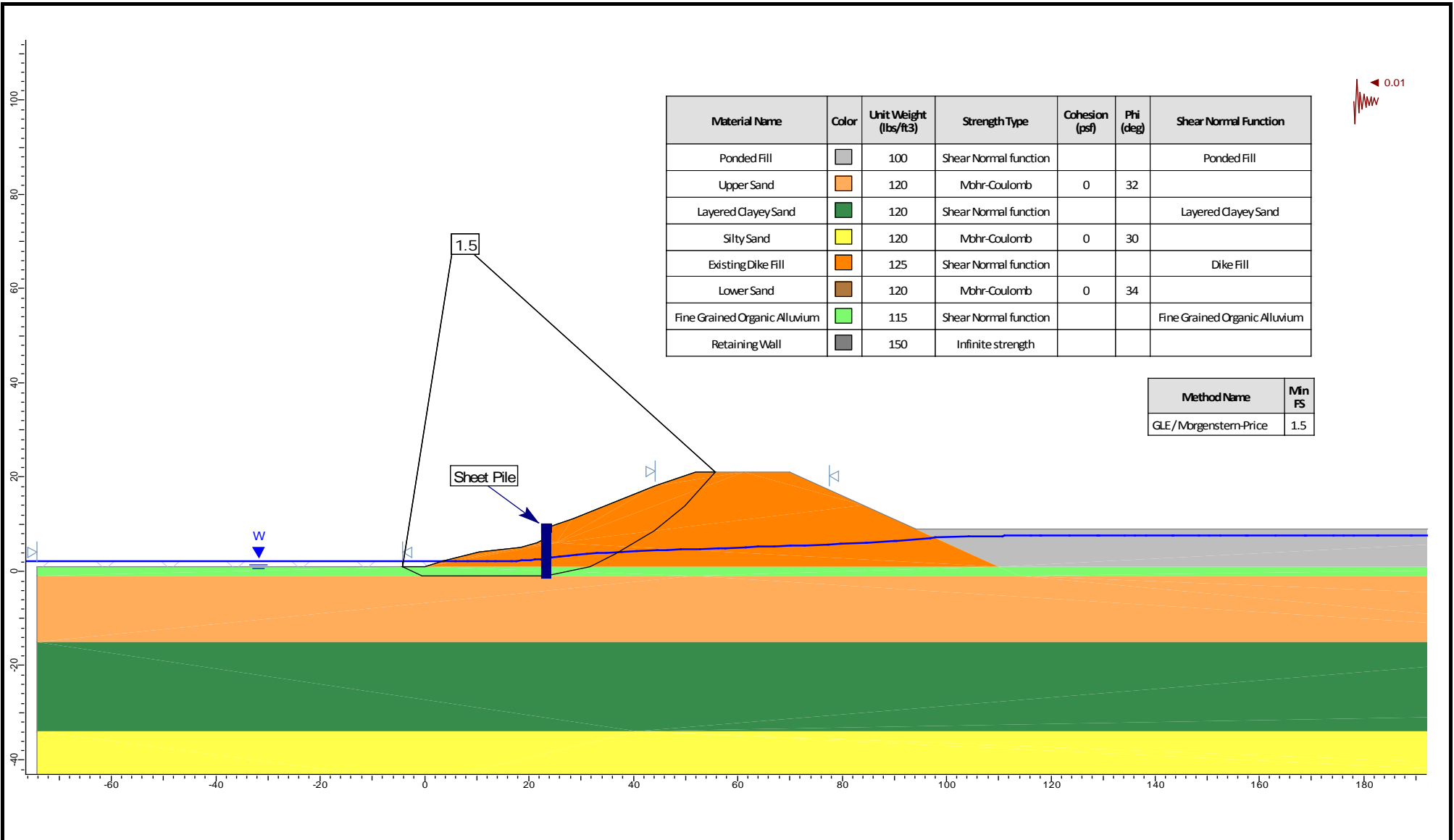
Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function
Ponded Fill	Grey	100	Shear Normal function			Ponded Fill
Upper Sand	Orange	120	Mohr-Coulomb	0	32	
Layered Clayey Sand	Green	120	Shear Normal function			Layered Clayey Sand
Silty Sand	Yellow	120	Mohr-Coulomb	0	30	
Existing Dike Fill	Dark Orange	125	Shear Normal function			Dike Fill
Lower Sand	Brown	120	Mohr-Coulomb	0	34	
Lower Silty Sand	Light Yellow	120	Mohr-Coulomb	0	34	
Fine Grained Organic Alluvium	Light Green	115	Shear Normal function			Fine Grained Organic Alluvium

Method Name	Min FS
GLE/Morgenstern-Price	1.7

	SCALE AS SHOWN	PROJECT	CEC BAP - Inactive Pond Demonstration	
	DATE 3/14/2018	TITLE	Section D-D Seismic screening	
	MADE BY LJ			
CAD -	CHECK JGM	CLIENT	Dominion Energy	
FILE STABILITY	REVIEW GLH	FIGURE		
PROJECT No. 1300193	REV. 0			



	SCALE	AS SHOWN	PROJECT	CEC BAP - Inactive Pond Demonstration	
	DATE	3/14/2018	TITLE	Section E-E Seismic screening	
	MADE BY	LJ			
CAD	-				
FILE	STABILITY	CHECK	JGM	CLIENT	Dominion Energy
PROJECT No.	1300193	REVIEW	GLH	FIGURE	



SCALE AS SHOWN
 DATE 3/14/2018
 MADE BY LJ
 CAD -

PROJECT **CEC BAP - Inactive Pond Demonstration**
 TITLE **Section F-F
 Seismic screening**

FILE STABILITY
 PROJECT No. 1300193 REV. 0

CHECK JGM
 REVIEW GLH

CLIENT **Dominion Energy**

FIGURE **B - 18**

ATTACHMENT 1

Material Properties Calculation Package

Date:	February 13, 2018	Made by:	G. Martin
Project No.:	1300193	Checked by:	L. Jin
Site Name:	Chesapeake Energy Center – BAP	Reviewed by:	G. Hebelner
Subject	MATERIAL PROPERTIES PACKAGE		

1.0 OBJECTIVE

The objective of this package is to characterize the material properties of the ash and soil materials found at Dominion Energy’s Chesapeake Energy Center (CEC) in Chesapeake, VA. Specifically, Golder assessed the dike soils, foundation soils, and impounded materials at the Bottom Ash Pond (BAP) at CEC to support stability and liquefaction analyses of the dikes. Eight units were identified to represent these materials (one for dike fill, one for impounded material, and six for foundation soils):

- Dike Fill Soils
- Poned Fill (Impounded materials)
- Foundation Materials
 - Fine Grained Organic Alluvium
 - Upper Sand
 - Layered Clayey Sand
 - Silty Sand
 - Lower Sand
 - Lower Silty Sand

2.0 METHODOLOGY

Material properties used in the analyses were evaluated based on geotechnical data available from the following sources:

- Schnabel Engineering’s 2010 report titled “Geotechnical Engineering Study, Chesapeake Energy Center, Stability Evaluation of the Bottom Ash Pond and Sedimentation Pond Dikes”
- Schnabel Engineering’s 2011 report titled “Geotechnical Engineering Study, Chesapeake Energy Center, Phase 1 Evaluation of Perimeter Dikes of the Columbia Gas Property and Dry Ash Landfill”
- Golder geotechnical explorations completed in 2016 and 2017.

These sources are discussed in greater detail in the following sections

CALCULATIONS

Page 2 of 5

Project No.:	1300193	Made by:	G. Martin
Site Name:	CEC – BAP Inactive Pond Demonstration	Checked by:	L. Jin
Date:	2/13/18	Reviewed by:	G. Hebel

2.1 Schnabel Engineering Reports

Schnabel Engineering (Schnabel) completed a stability assessment of dikes surrounding the BAP in February 2010 and a stability assessment of the dikes surrounding the ash landfill (located adjacent to the north side of the BAP) in July 2011. These reports include borehole drilling data in the dikes surrounding the BAP and the ash landfill to the north. Schnabel completed two consolidated-undrained (CU) triaxial tests as part of their 2010 efforts. One CU test was performed on the dike soils of the BAP (noted as Fine-Grained Embankment Fill, Stratum A2 in the Schnabel report), and the other CU test tested the silty sand foundation soils (identified as Coarse-Grained Norfolk Formation, Stratum C).

Schnabel categorized the site materials into six groups in their 2010 report and added a seventh in the 2011 report to model the landfilled ash. For each group, Schnabel provided total and effective strengths and unit weights. Golder grouped soils similarly to Schnabel, but further divided two of Schnabel's foundation groups after analyzing additional cone penetration test (CPT) data completed by Golder in 2016 and 2017. Golder also modeled the dike fill soils as a single group, whereas Schnabel divided these soils into a fine-grained and coarse-grained portion. Golder found the delineation between fine and coarse grained soils in the dike fill to be variable, so Golder conservatively modeled all the dike fill materials as fine-grained.

2.2 Golder Geotechnical Explorations

Golder completed two rounds of cone penetration tests (CPTs) to provide further characterization of the materials and around the BAP. The first round was conducted by ConeTec on November 21 and 22 of 2016, and ConeTec completed the second round on December 21 and 22 of 2017. Table 3 lists general information and latitude and longitude of the CPTs.

CALCULATIONS

Page 3 of 5

Project No.:	1300193	Made by:	G. Martin
Site Name:	CEC – BAP Inactive Pond Demonstration	Checked by:	L. Jin
Date:	2/13/18	Reviewed by:	G. Hebler

Table 1: Golder CPT Locations and Testing Notes

Sounding ID	Date	Total Depth (ft)	Latitude (deg)	Longitude (deg)	Surface Elevation (ft-msl)	Testing Notes
CPT-BAP-01	2016-11-21	72.2	36.76120	-76.30125	20.7	
CPT-BAP-02	2016-11-21	62.3	36.76138	-76.30128	19.9	
CPT-BAP-03	2016-11-21	79.9	36.76204	-76.30100	18.0	
CPT-BAP-04	2016-11-21	101.7	36.76217	-76.30238	26.9	Seismic CPT
CPT-BAP-05	2016-11-22	78.7	36.76215	-76.30151	26.1	
CPT-BAP-06	2016-11-22	75.5	36.76245	-76.30105	26.7	
CPT-BAP-07	2016-11-22	59.1	36.76153	-76.30222	18.0	
CPT-BAP-08	2016-11-22	59.1	36.76118	-76.30208	19.5	
CPT-BAP-09	2016-11-22	95.1	36.76245	-76.30082	21.2	
CPT-BAP-10	2017-12-21	72.0	36.76162	-76.30082	20.0	
CPT-BAP-11	2017-12-21	101.7	36.76146	-76.30336	20.0	Seismic CPT
CPT-BAP-12	2017-12-22	55.7	36.76242	-76.30440	20.0	
CPT-BAP-13	2017-12-22	65.6	36.76380	-76.30440	20.0	
CPT-BAP-14	2017-12-22	65.6	36.76295	-76.30467	20.0	Seismic CPT

Notes:

1. Phreatic surface depth determined from representative pore pressure dissipation tests. Hydrostatically increasing water pressures were used for interpretation tables.
2. Latitude/ Longitude- WGS 84. Coordinates were taken with handheld GPS and should be considered approximate.
3. Elevations are referenced to the existing ground/pond surface at the time of testing.

CALCULATIONS

Page 4 of 5

Project No.:	1300193	Made by:	G. Martin
Site Name:	CEC – BAP Inactive Pond Demonstration	Checked by:	L. Jin
Date:	2/13/18	Reviewed by:	G. Hebel

From the CPT data and the geotechnical data available in the Schnabel reports, Golder developed strength properties for use in slope stability analyses. Variation in the dike fills makes delineation of fine-grained and coarse-grained portions ambiguous, so Golder has treated the entire dike as fine-grained to be conservative. Also, Golder spilt foundation soils which Schnabel identified as part of the Norfolk and Yorktown formations into four groups based on CPT data: Layered Clayey Sand, Silty Sand, Lower Sand, and Lower Silty Sand. Golder added a “Ponded Fill” material to model the impounded material in the BAP. Ultimately, Golder grouped soils into eight layers:

- Dike Fill Soils
- Ponded Fill (Impounded materials)
- Foundation Materials
 - Fine Grained Organic Alluvium
 - Upper Sand
 - Layered Clayey Sand
 - Silty Sand
 - Lower Sand
 - Lower Silty Sand

Logs of the CPT data with these layers identified available in the pages following this text. CPT logs present the tip, sleeve, and pore pressure measurements with depth and the correlated shear strength values.

3.0 SELECTED MATERIAL PROPERTIES

Golder selected strength parameters and unit weights for use in stability analyses based on data available in Schnabel’s reports and CPT data collected during Golder’s geotechnical explorations. Golder found the majority of values presented in Schnabel’s reports to be consistent with CPT data, so Golder used the Schnabel values for most materials. However, the following modifications were made to the values presented by Schnabel:

- All dike fill was modeled as a single unit due to variation within dikes. The fine-grained dike fill properties were used for the entire dike fill.
- The undrained strength of fine grained organic alluvium was modeled with a stress-dependent component to account for a wider range of overburden stresses.
- The drained strength of the Upper Sand was slightly increased to be more consistent with CPT data.
- Golder assigned the ponded fill strength based on CPT data and experience with similar materials at other sites.

CALCULATIONS

Page 5 of 5

Project No.:	1300193	Made by:	G. Martin
Site Name:	CEC – BAP Inactive Pond Demonstration	Checked by:	L. Jin
Date:	2/13/18	Reviewed by:	G. Hebel

The selected properties used for stability analyses are listed in Table 4. Also, the selected strengths are plotted on the attached CPT logs with the values correlated from CPT data.

Table 2: Selected Material Properties for Use in Slope Stability Analysis

Material	Drained Strength		Undrained Strength			Unit Weight (pcf)
	ϕ' (degrees)	c' (psf)	Su/ $\sigma'v$	Minimum Su (psf)	Su (Constant, psf)	
Dike Fill	26	100	N/A	N/A	1,500	125
Ponded Fill	20	100	0.22	400	N/A	100
Fine Grained Organic Alluvium	20	100	0.22	400	N/A	115
Upper Sand	32	0	N/A	N/A	N/A	120
Layered Clayey Sand	28	100	0.5	N/A	N/A	120
Silty Sand	30	0	N/A	N/A	N/A	120
Lower Sand	34	0	N/A	N/A	N/A	120
Lower Silty Sand	34	0	N/A	N/A	N/A	120

4.0 REFERENCES

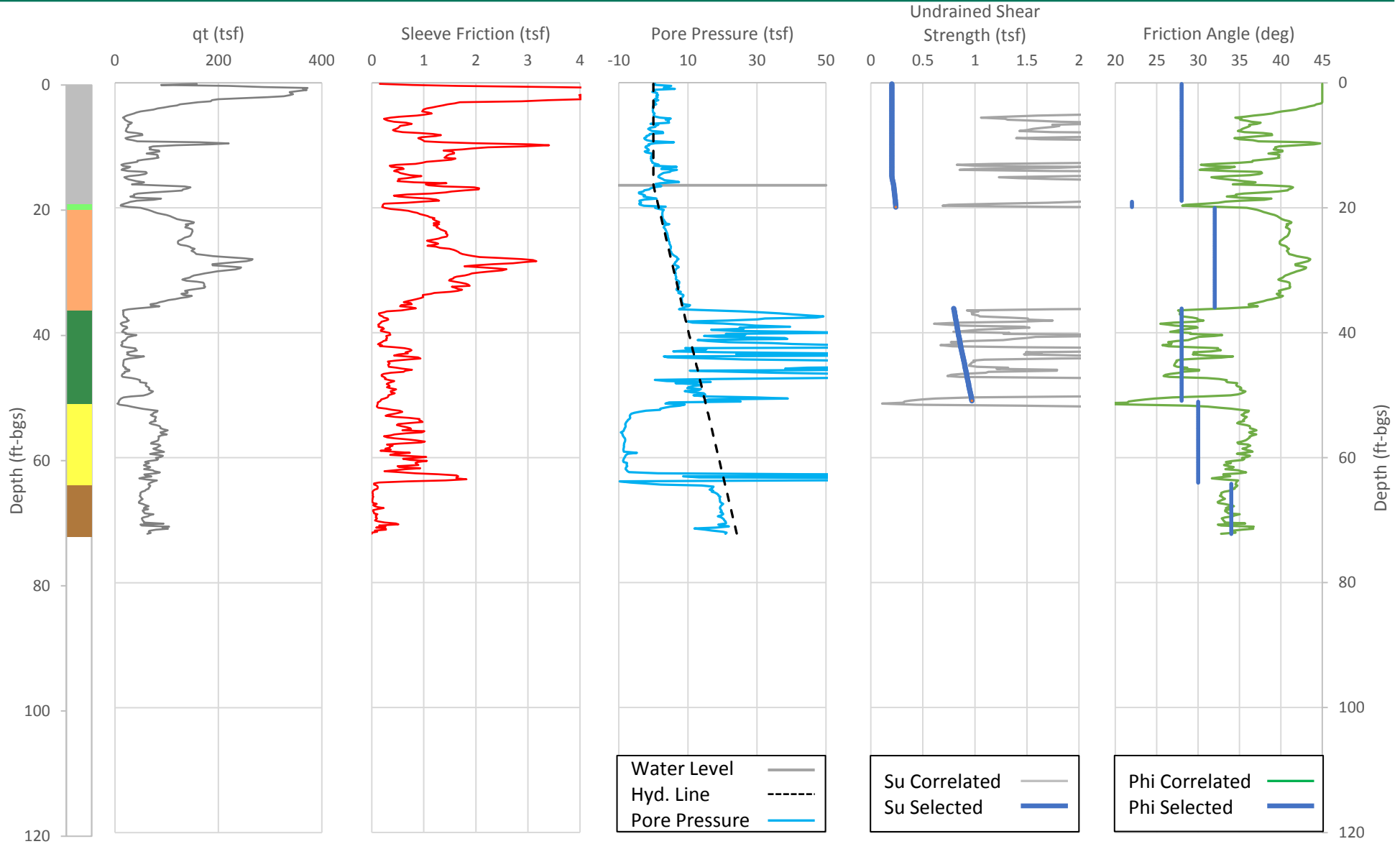
Schnabel Engineering (2010). "Geotechnical Engineering Study, Chesapeake Energy Center, Stability Evaluation of the Bottom Ash Pond and Sedimentation Pond Dikes." February 5, 2010.

Schnabel Engineering (2011). "Geotechnical Engineering Study, Chesapeake Energy Center, Phase 1 Evaluation of Perimeter Dikes of the Columbia Gas Property and Dry Ash Landfill." July 18, 2011.

Test ID: CPT-BAP-01
GS Elev. (ft-msl): 20.0
Test Depth (ft): 72.2

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 16.4

Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy

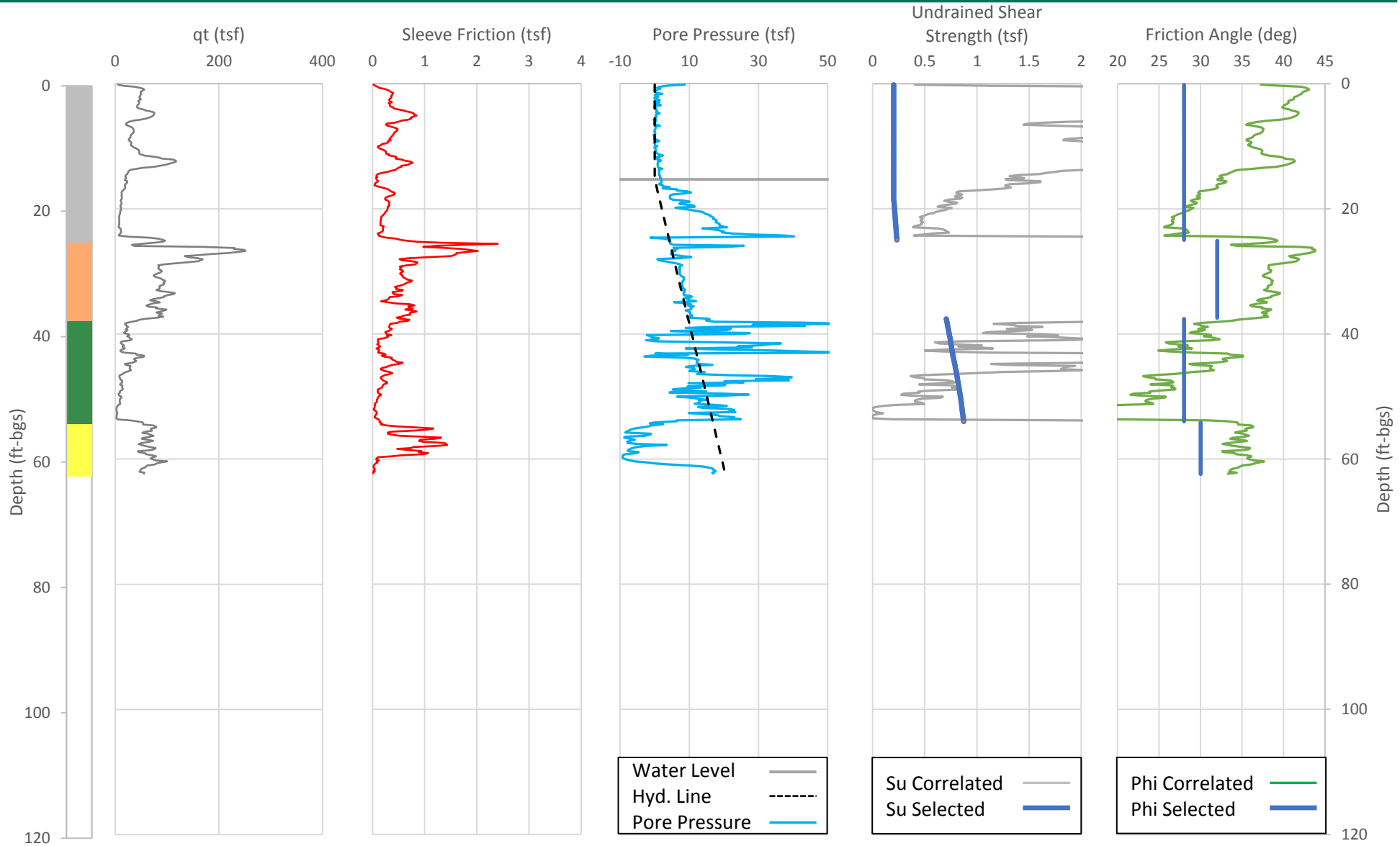


- | | | | |
|---------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ponded Fill | Layered Clayey Sand | Existing Dike Fill | Lower Silty Sand |
| Upper Sand | Silty Sand | Lower Sand | Fine Grained Organic Alluvium |

Test ID: CPT-BAP-02
GS Elev. (ft-msl): 20.0
Test Depth (ft): 62.3

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 15.3

Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy

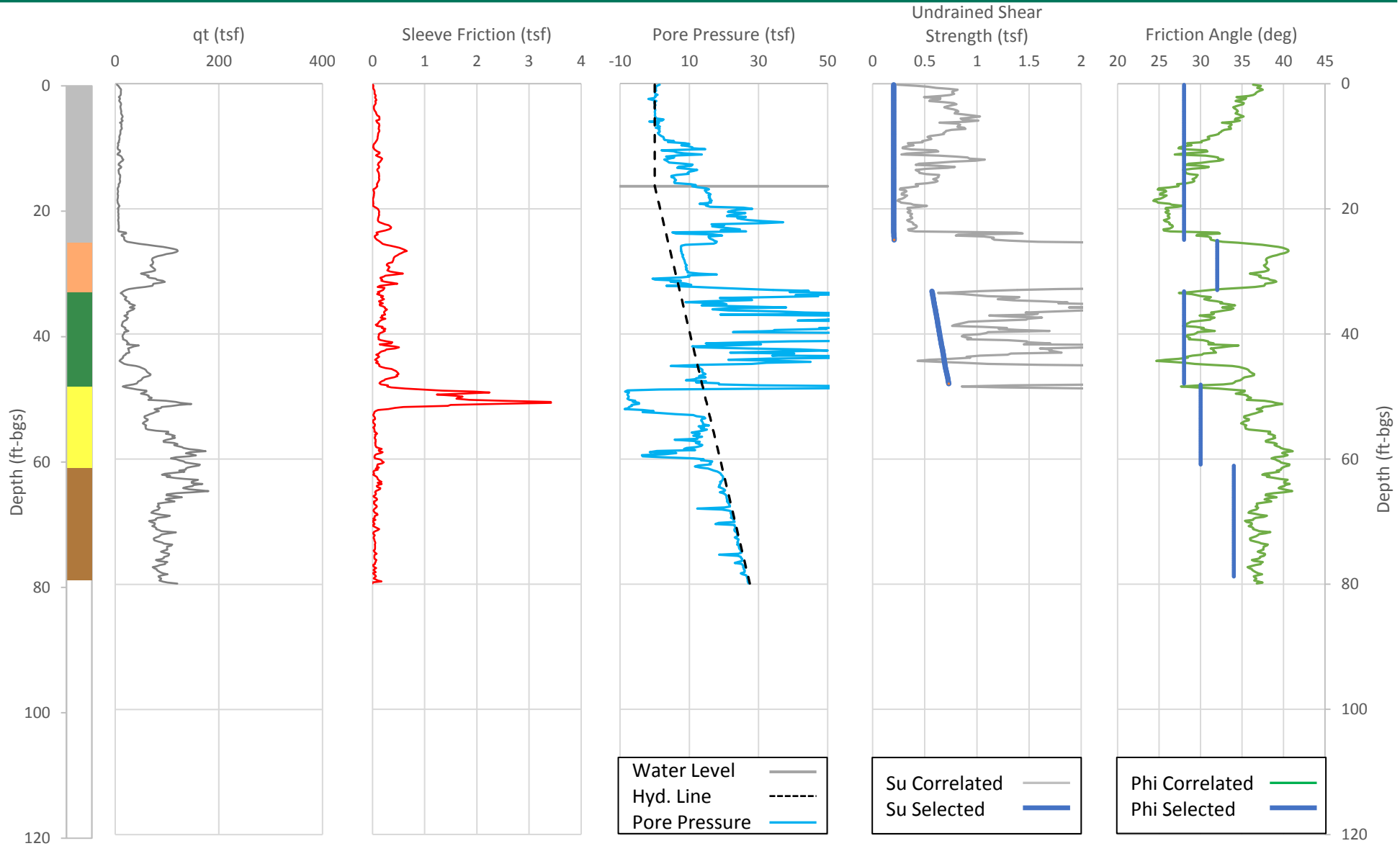


- Ponedged Fill
- Layered Clayey Sand
- Existing Dike Fill
- Lower Silty Sand
- Upper Sand
- Silty Sand
- Lower Sand
- Fine Grained Organic Alluvium

Test ID: CPT-BAP-03
GS Elev. (ft-msl): 18.0
Test Depth (ft): 79.9

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 16.4

Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy

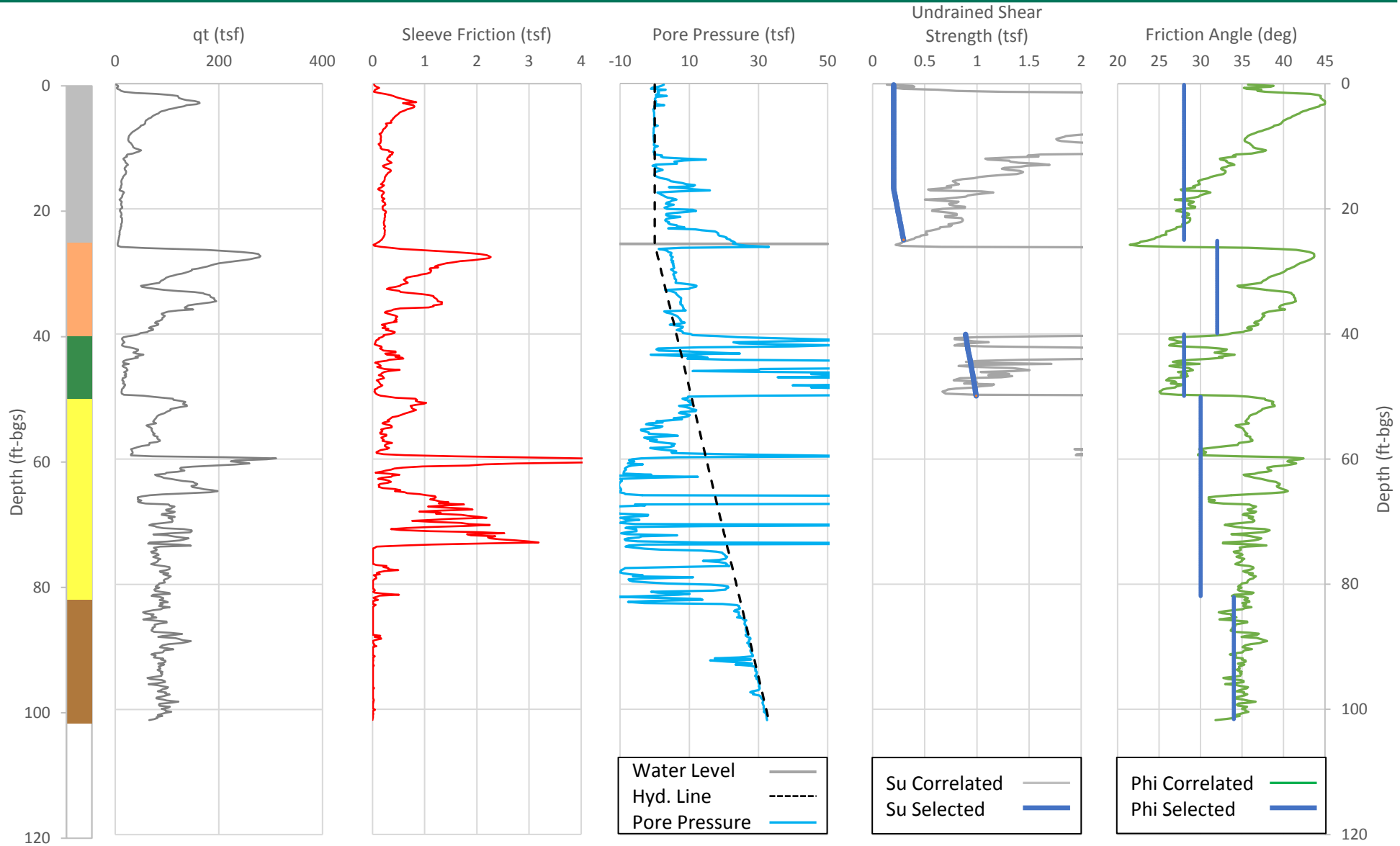


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| Ponded Fill | Layered Clayey Sand | Existing Dike Fill | Lower Silty Sand |
| Upper Sand | Silty Sand | Lower Sand | Fine Grained Organic Alluvium |

Test ID: CPT-BAP-04
GS Elev. (ft-msl): 25.0
Test Depth (ft): 101.7

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 25.6

Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy

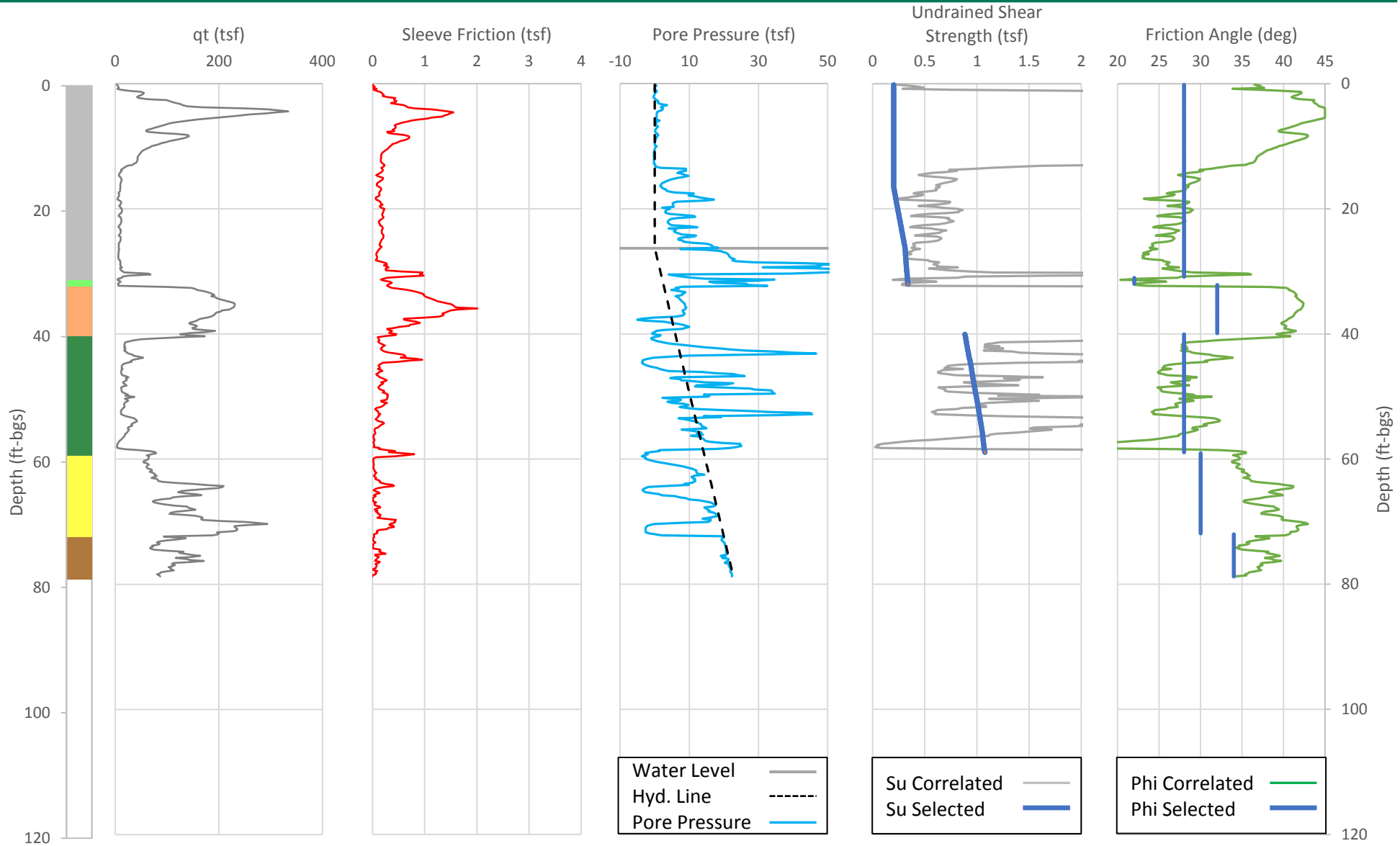


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| Ponded Fill | Layered Clayey Sand | Existing Dike Fill | Lower Silty Sand |
| Upper Sand | Silty Sand | Lower Sand | Fine Grained Organic Alluvium |

Test ID: CPT-BAP-05
GS Elev. (ft-msl): 25.0
Test Depth (ft): 78.7

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 26.3

Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy

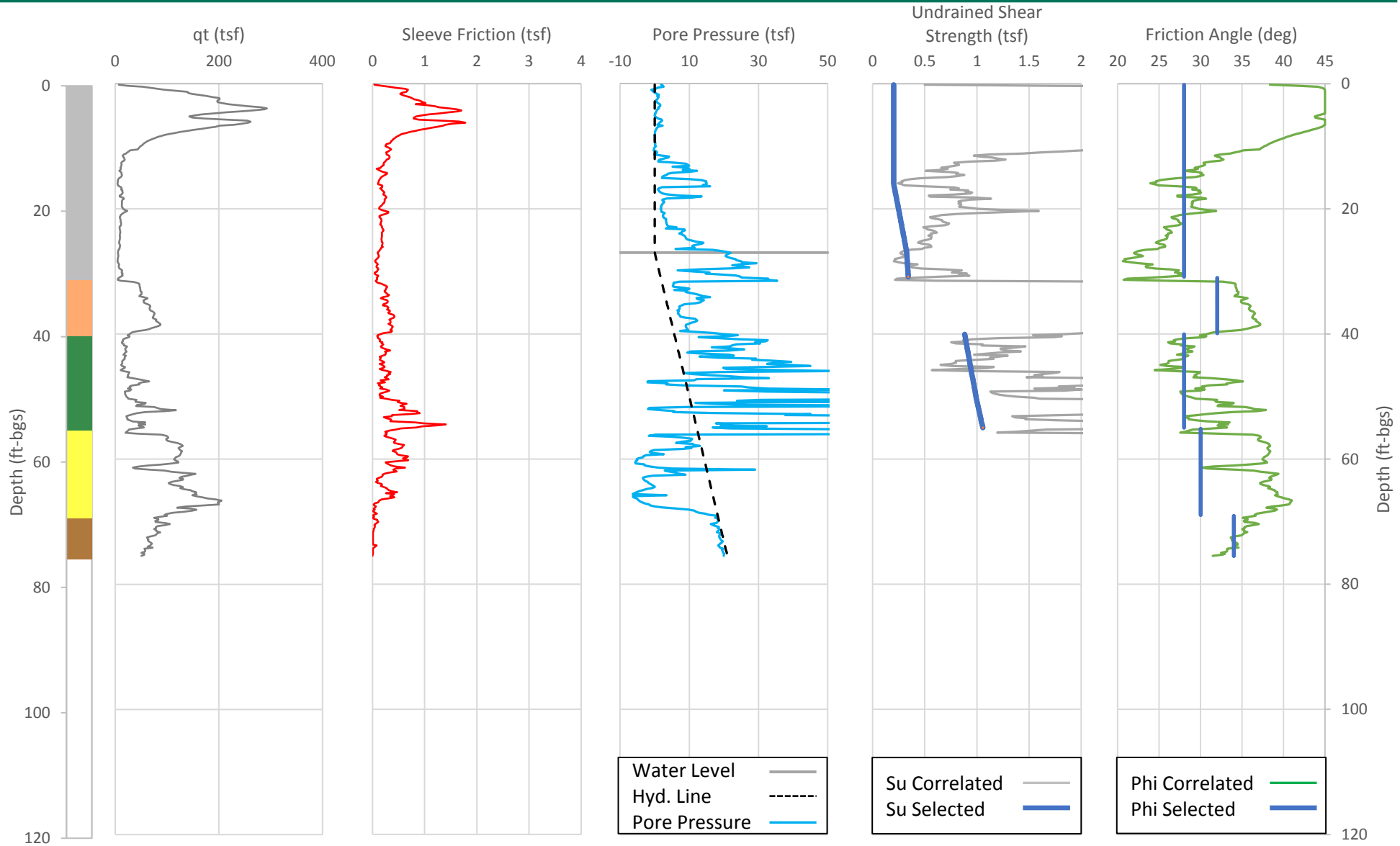


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| Ponded Fill | Layered Clayey Sand | Existing Dike Fill | Lower Silty Sand |
| Upper Sand | Silty Sand | Lower Sand | Fine Grained Organic Alluvium |

Test ID: CPT-BAP-06
GS Elev. (ft-msl): 25.0
Test Depth (ft): 75.5

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 27.0

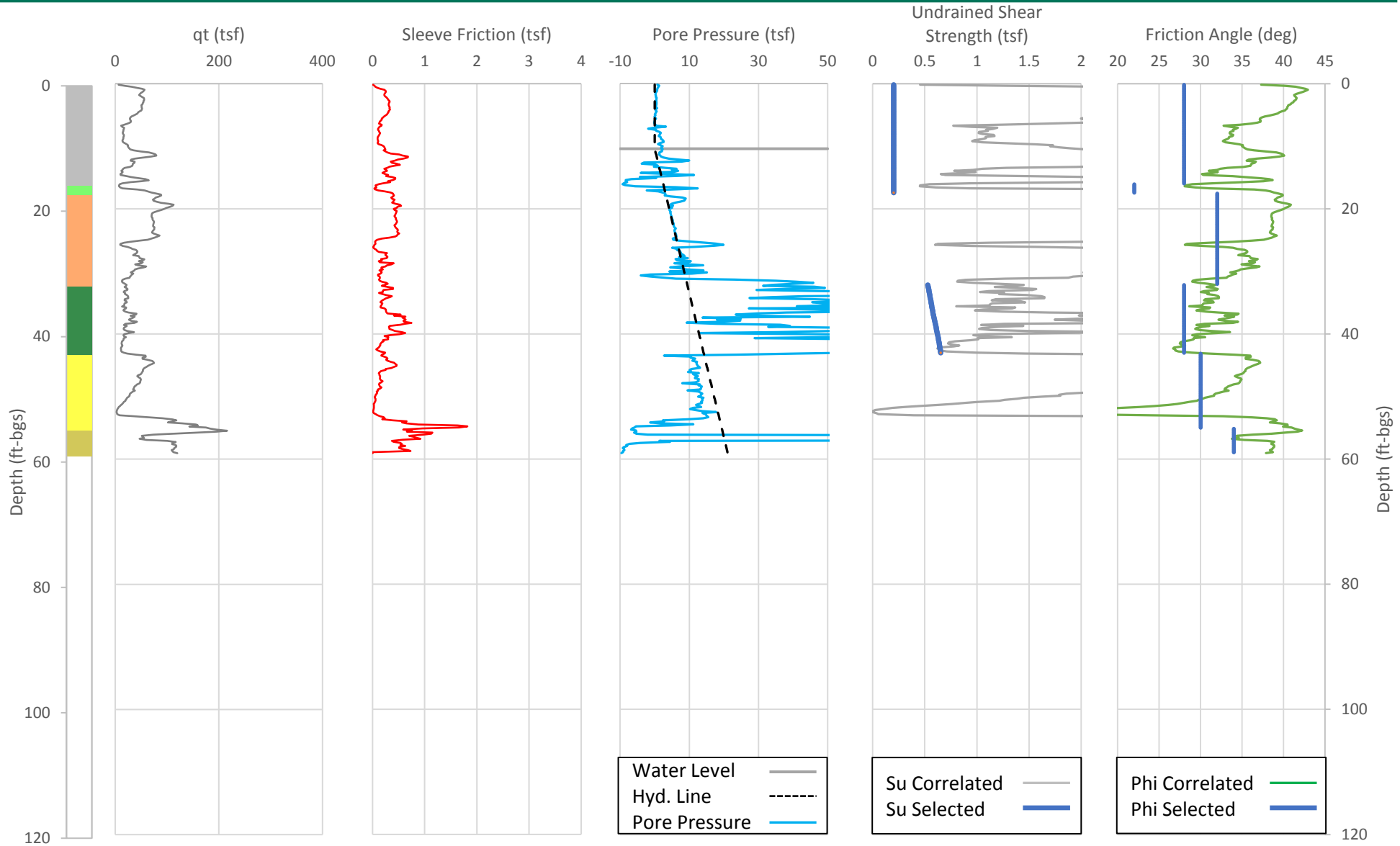
Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy



Test ID: CPT-BAP-07
GS Elev. (ft-msl): 17.5
Test Depth (ft): 59.1

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 10.4

Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy

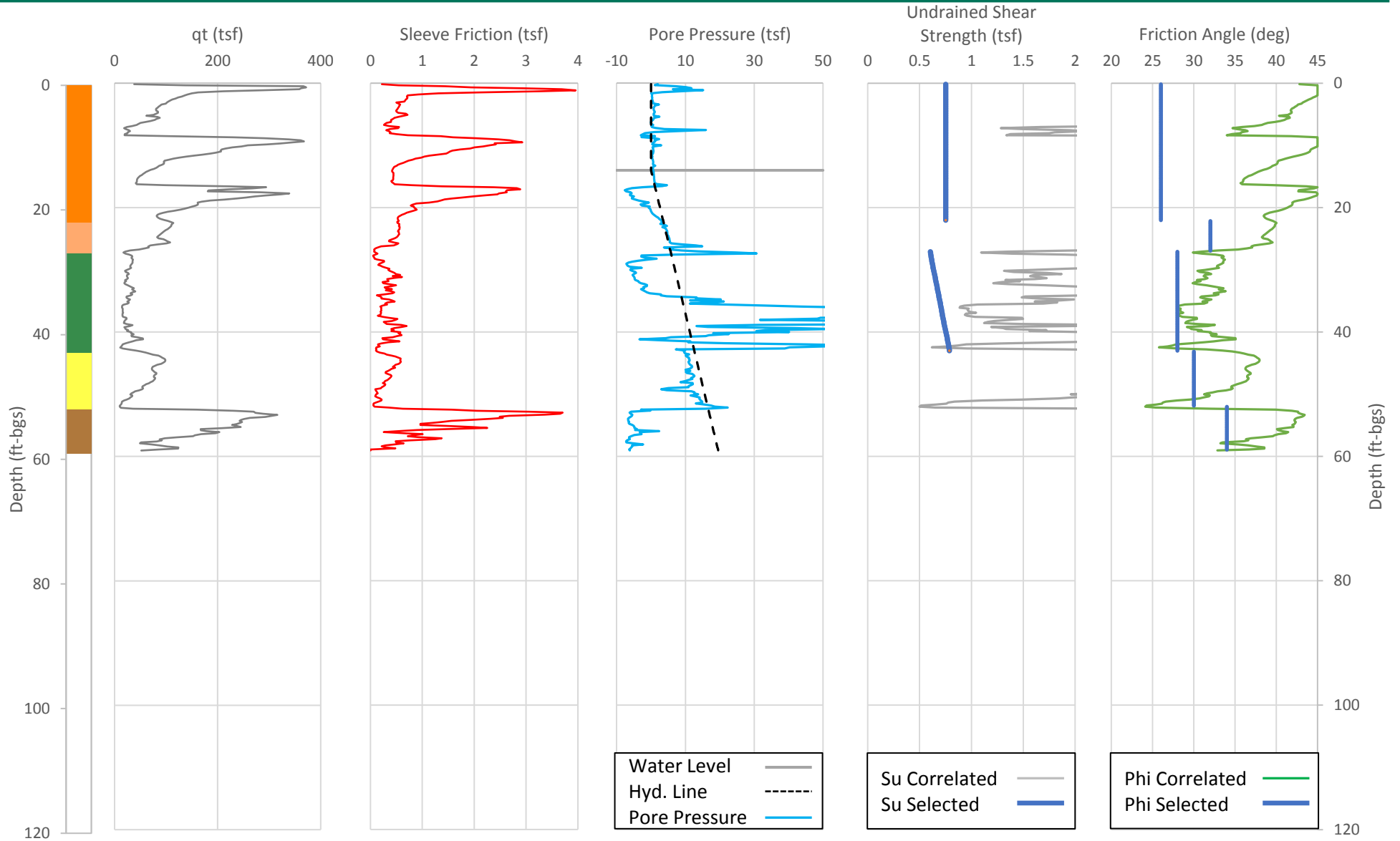


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|---------------|---------------------|--------------------|-------------------------------|
| Ponedged Fill | Layered Clayey Sand | Existing Dike Fill | Lower Silty Sand |
| Upper Sand | Silty Sand | Lower Sand | Fine Grained Organic Alluvium |

Test ID: CPT-BAP-08
GS Elev. (ft-msl): 20.0
Test Depth (ft): 59.1

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 14.0

Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy

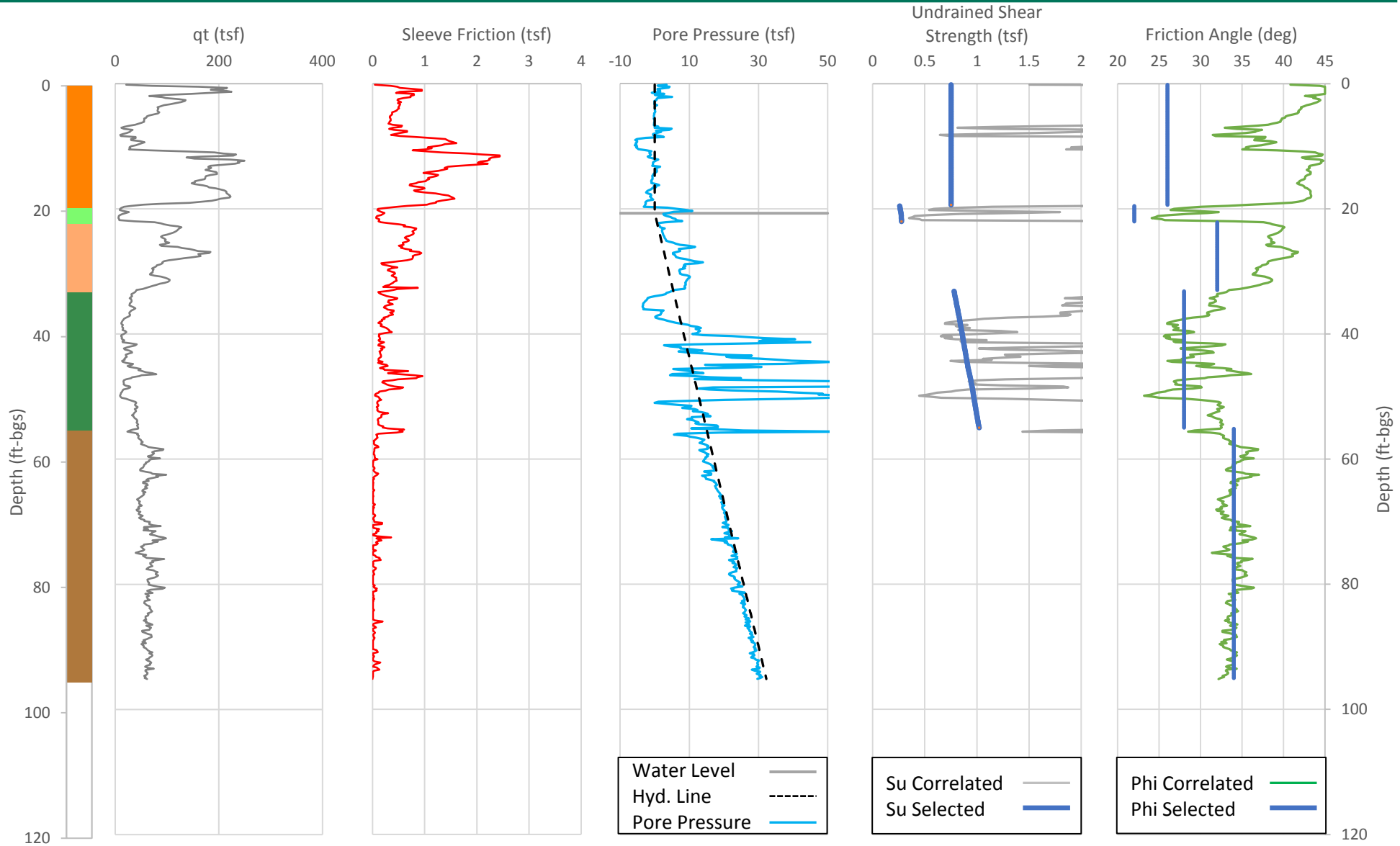


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| Ponded Fill | Layered Clayey Sand | Existing Dike Fill | Lower Silty Sand |
| Upper Sand | Silty Sand | Lower Sand | Fine Grained Organic Alluvium |

Test ID: CPT-BAP-09
GS Elev. (ft-msl): 20.0
Test Depth (ft): 95.1

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 20.7

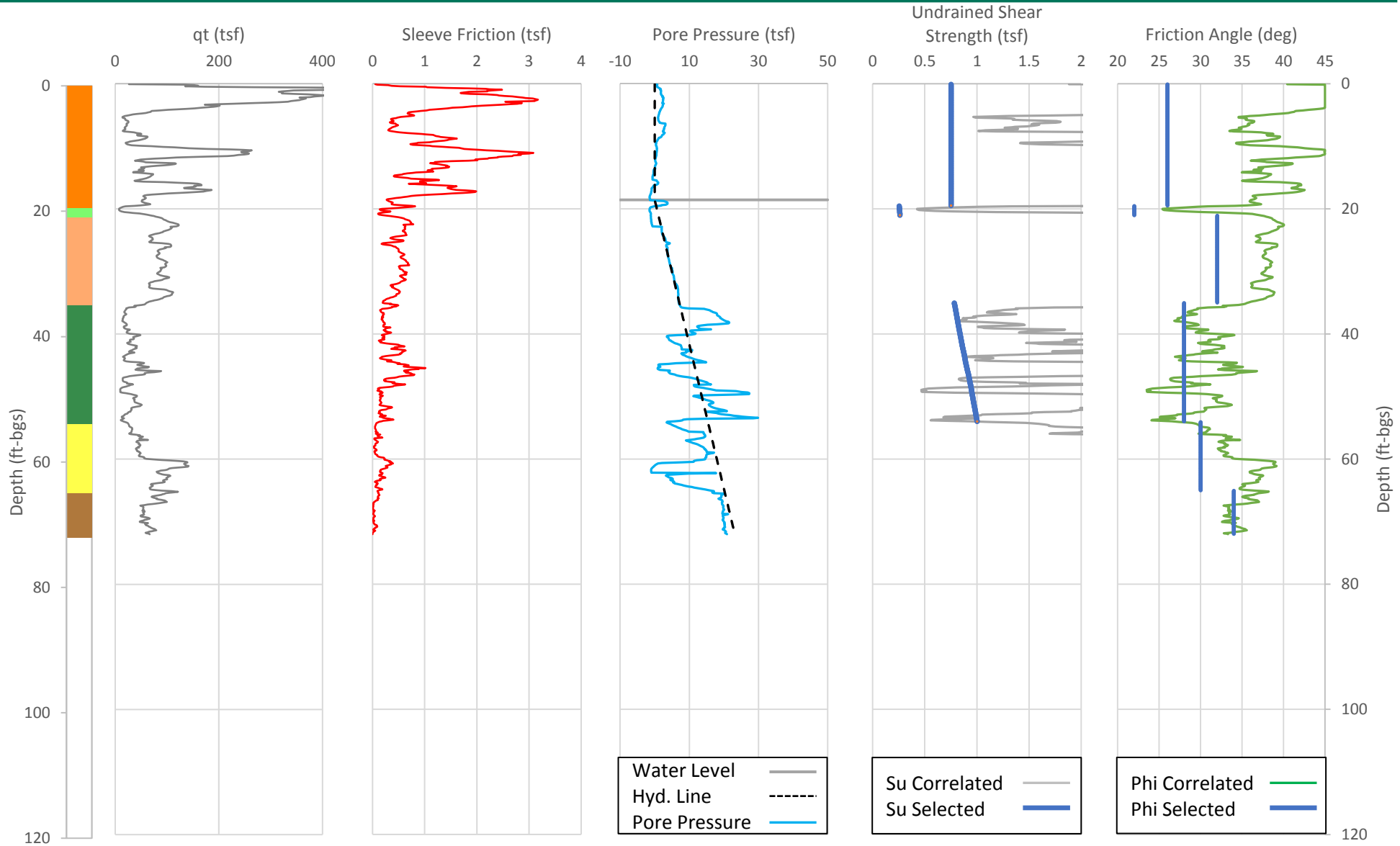
Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy



Test ID: CPT-BAP-10
GS Elev. (ft-msl): 20.0
Test Depth (ft): 72.0

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 18.6

Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy

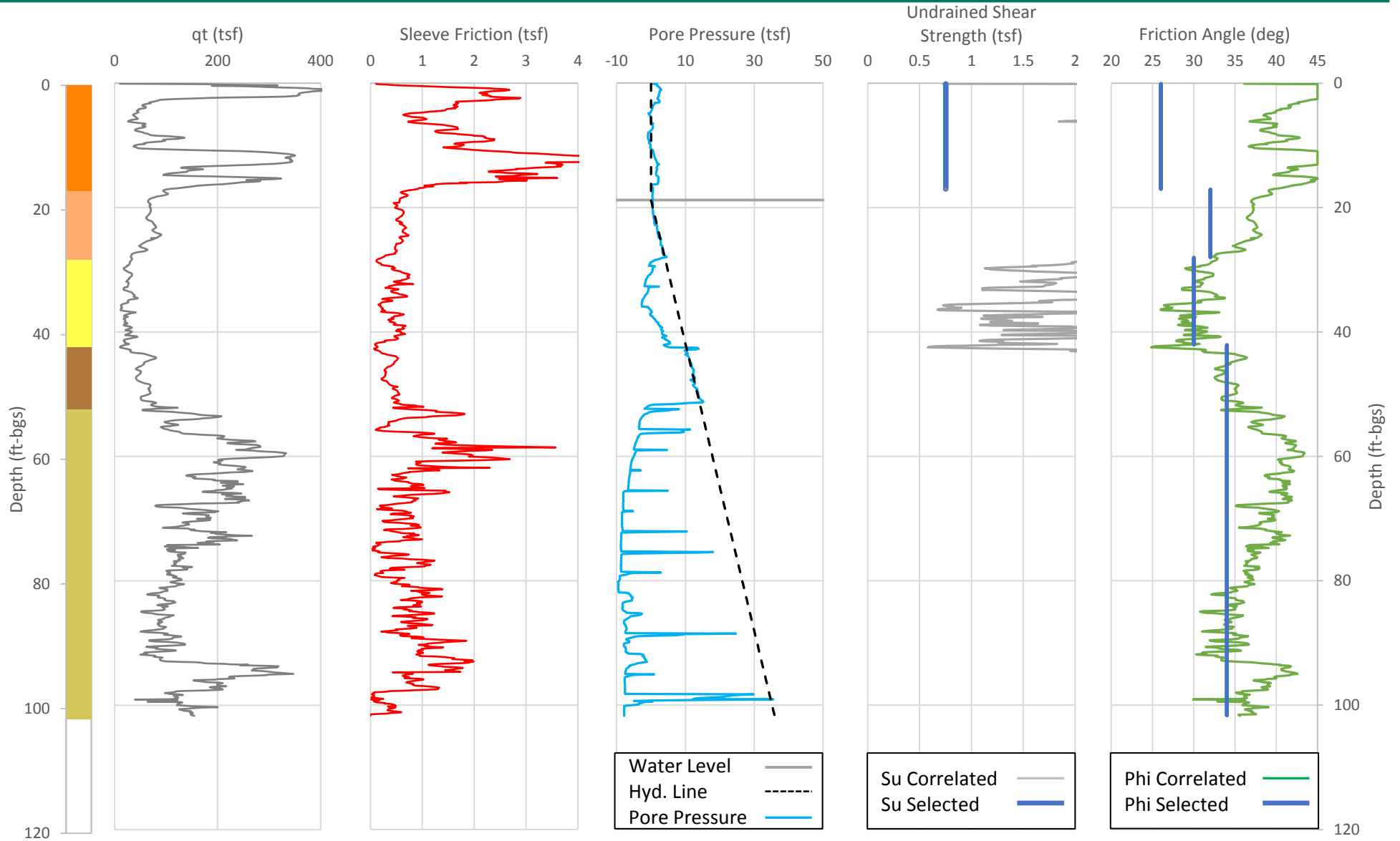


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| Ponded Fill | Layered Clayey Sand | Existing Dike Fill | Lower Silty Sand |
| Upper Sand | Silty Sand | Lower Sand | Fine Grained Organic Alluvium |

Test ID: CPT-BAP-11
GS Elev. (ft-msl): 20.0
Test Depth (ft): 101.7

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 18.8

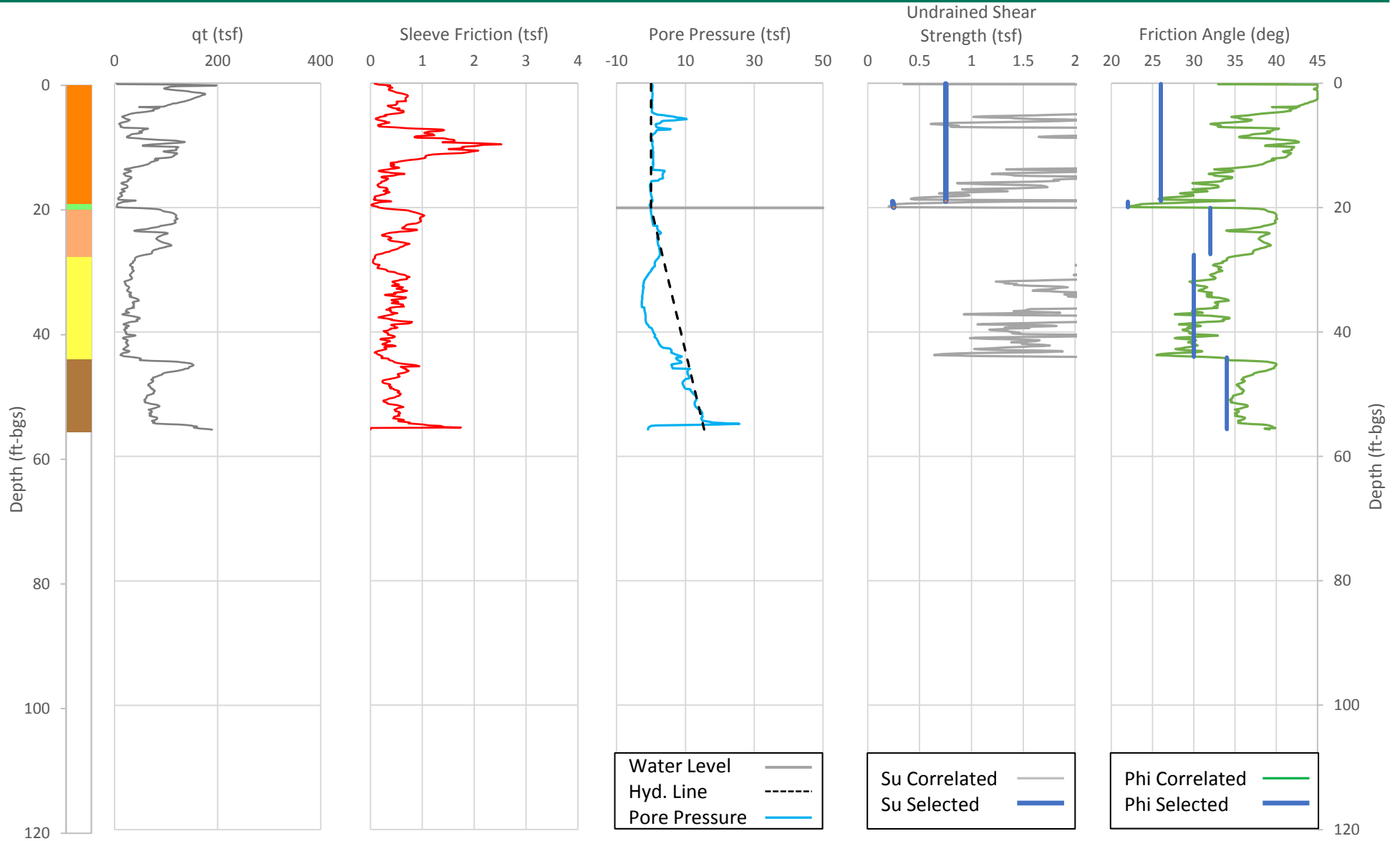
Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy



Test ID: CPT-BAP-12
GS Elev. (ft-msl): 20.0
Test Depth (ft): 55.7

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 20.0

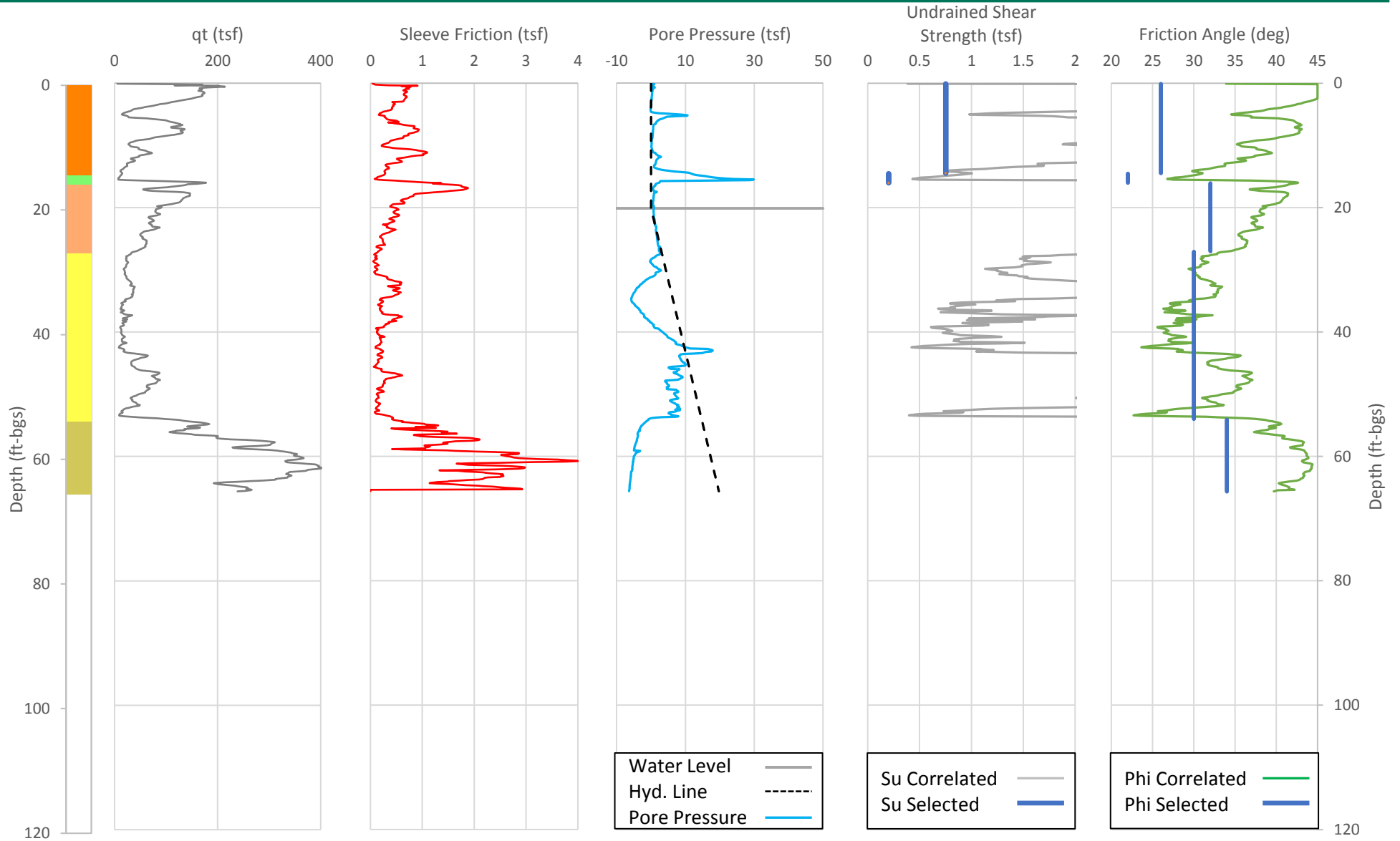
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Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy



Test ID: CPT-BAP-13
GS Elev. (ft-msl): 20.0
Test Depth (ft): 65.6

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 20.1

Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy

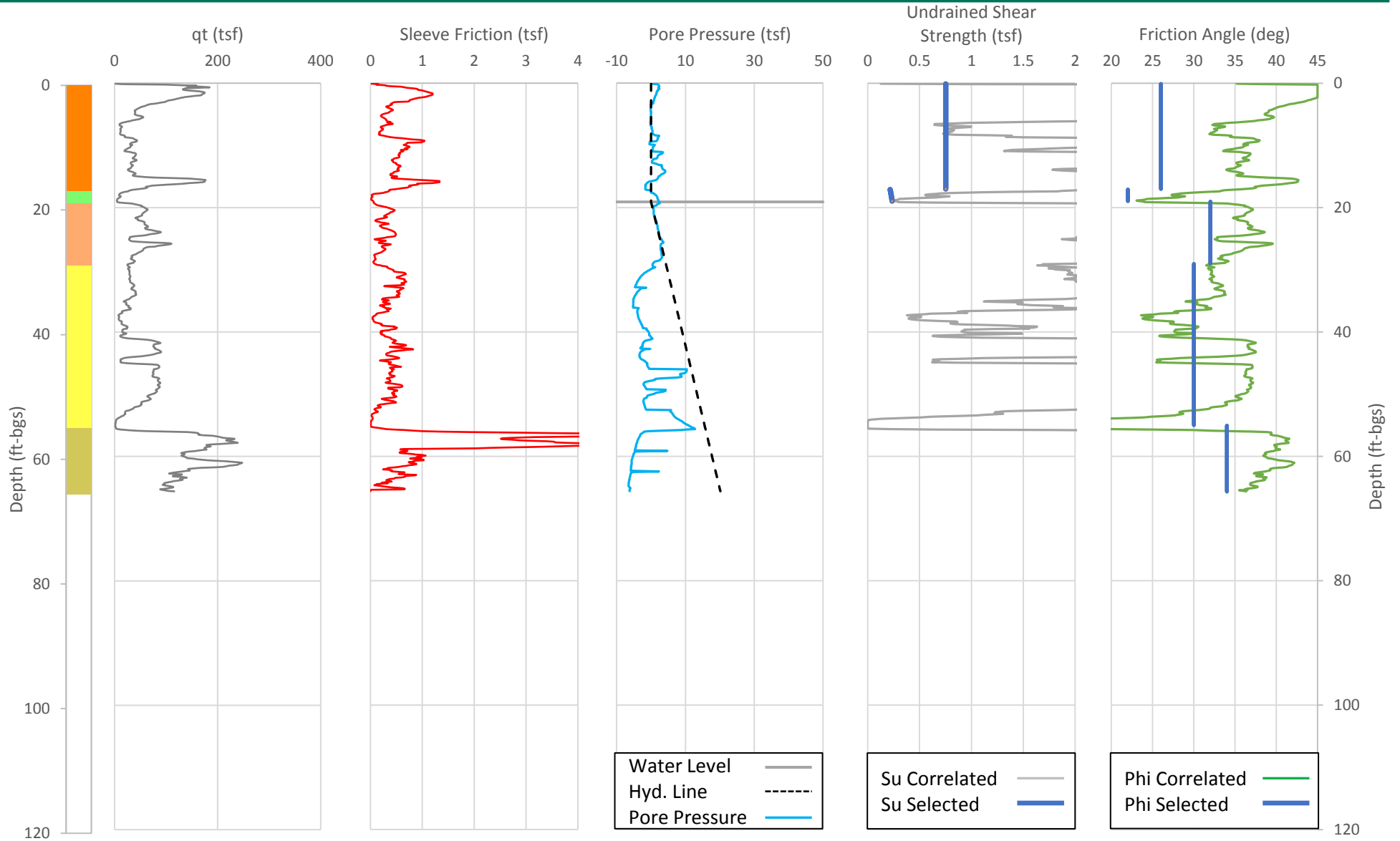


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| Ponded Fill | Layered Clayey Sand | Existing Dike Fill | Lower Silty Sand |
| Upper Sand | Silty Sand | Lower Sand | Fine Grained Organic Alluvium |

Test ID: CPT-BAP-14
GS Elev. (ft-msl): 20.0
Test Depth (ft): 65.6

CPT Rig Type: Truck
Location: CEC BAP Dikes
Groundwater Depth (ft-bgs): 19.1

Project #: 130-0193
Project Name: BAP - Inactive Pond Demo.
Client: Dominion Energy



- Ponedged Fill
- Layered Clayey Sand
- Existing Dike Fill
- Lower Silty Sand
- Upper Sand
- Silty Sand
- Lower Sand
- Fine Grained Organic Alluvium

ATTACHMENT 2

Seismic Hazard Calculation Package

Date:	January 9, 2018	Made by:	L. Jin
Project No.:	130-0193	Checked by:	G. Martin
Subject:	Seismic Hazard Assessment	Reviewed by:	G. Hebeler
Project:	CHESEPEAKE ENERGY CENTER – DOMNINION ENERGY		

1.0 OBJECTIVE

This calculation package identifies and summarizes the seismic hazard at the project site located nominally at 76.302°W and 36.762°N. The seismic hazard is necessary for geotechnical design evaluations of stability under earthquake loading and liquefaction susceptibility.

2.0 SEISMIC HAZARD SUMMARY

For ash pond closures, the United State Environmental Protection Agency's (USEPA) CCR Rule has specified seismic analyses be completed for a seismic event with a 2% probability of exceedance in 50 years (2% / 50yr), equivalent to a return period of approximately 2,500 years, based on the United States Geological Survey (USGS) seismic hazard maps. The USGS has provided online tools associated with this hazard for its 2014 seismic hazard model (SHM). The sections below detail the use of these tools to obtain seismic hazard data for use in analyses.

2.1 Peak Ground and Spectral Acceleration

The peak ground acceleration (PGA) and spectral ground accelerations (S_a) corresponding to a range of spectral periods are necessary for many engineering analyses including slope stability analysis and liquefaction analysis. For a 2% PE in 50 years of the 2014 SHM, The USGS provides a reference PGA and spectral accelerations corresponding to a reference site on the border between the National Earthquake Reductions Hazard Program (NEHRP) site classes B and C with an average shear wave velocity in the upper 30 m (V_{s30}) of 760 m/s. These reference accelerations are often referenced with a BC subscript (e.g. PGA_{BC}) and can be scaled as appropriate to match site conditions and analysis input requirements. Figure 1 below shows the project site on the 2014 USGS seismic hazard map for PGA_{BC} , and Figure 2 displays the uniform hazard response spectrum curve, which plots the reference spectral acceleration, or ground motion, for various spectral periods. The uniform hazard response spectrum curve is presented in tabular form in Table 1.

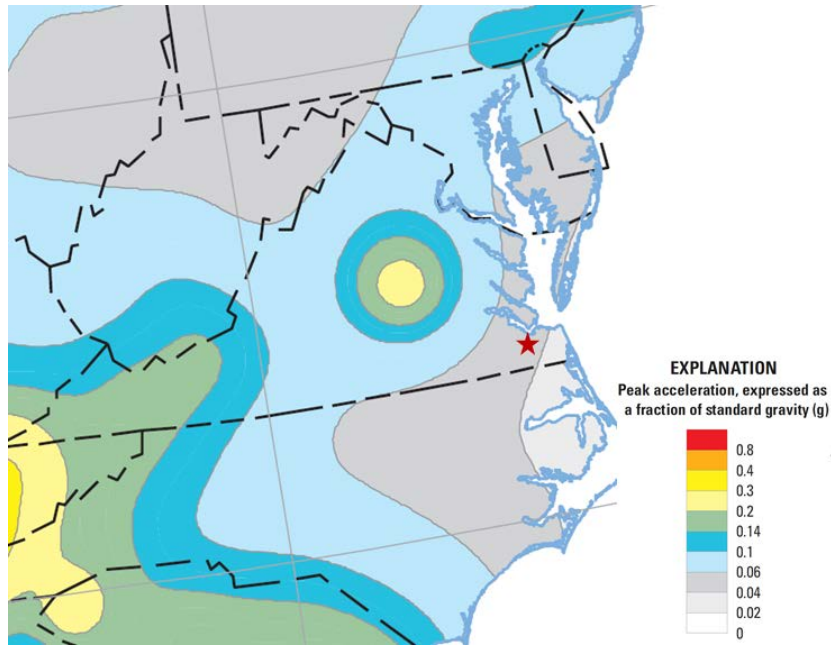


Figure 1: PGA_{BC} for the 2% PE in 50 years at the project site (red star). (USGS 2014).

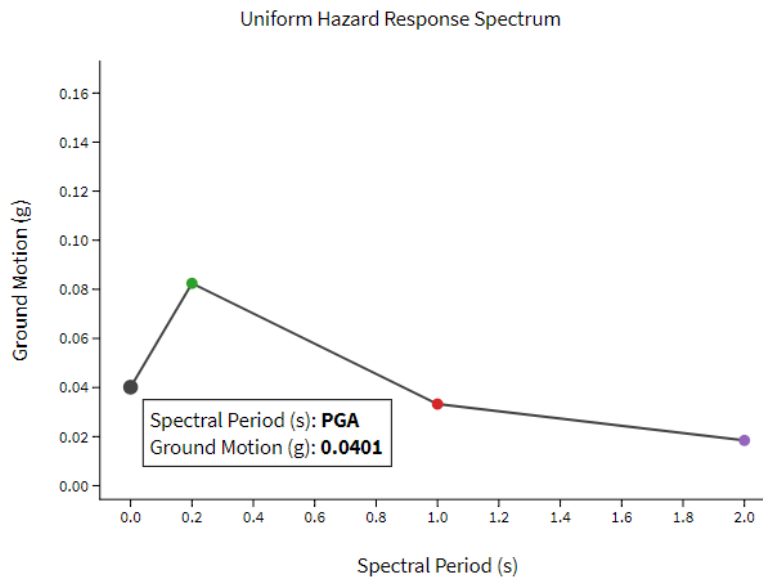


Figure 2: Uniform Hazard Response Spectrum for the 2% PE in 50 years Seismic Hazard at the Project Site (USGS 2014).

Table 1: Reference site (BC) PGA and Spectral Acceleration for the 2% PE in 50 year Seismic Hazard at the Project Site (USGS 2014).

Spectral Period (s)	Acceleration, BC (g)
0 (PGA)	0.0401
0.2	0.0824
1.0	0.0332
2.0	0.0184

2.2 Seismic Hazard Deaggregation

The seismic hazard is compiled from multiple predictive models which consider many seismic sources of varying combinations of earthquake magnitude and distance from the project site. For each magnitude and distance pair, models predict the resulting accelerations and activity rates for the project site. The results of these predictive models are aggregated to produce the seismic hazard model for specified return periods. The seismic hazard model can be deaggregated to obtain the contribution to hazard percentage of magnitude and distance combinations. This information is necessary for analyzes requiring earthquake magnitude (e.g. liquefaction susceptibility) or distance. Figure 3 below displays a deaggregation plot of the PGA_{BC} at the project site for a 2% PE in 50 years with descriptive statistics available through the USGS online tools.

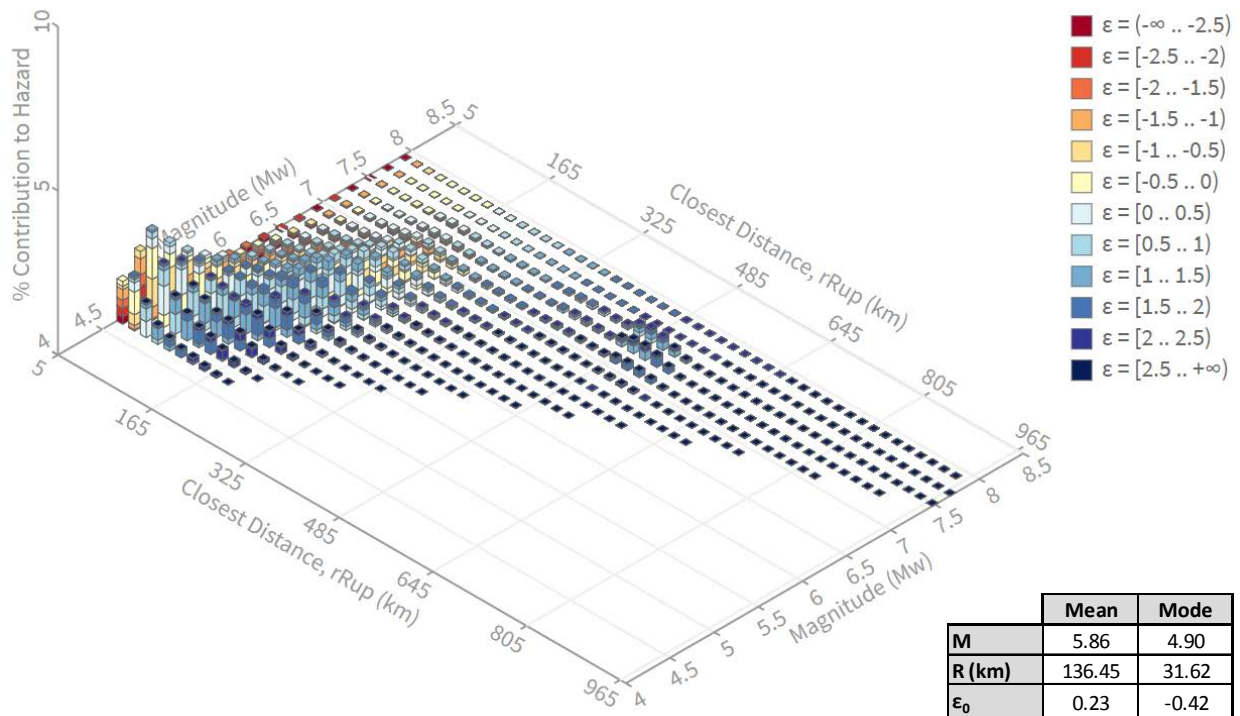


Figure 3: Deaggregation Plot of the PGA_{BC} at the Project Site for a 2% PE in 50 Years

3.0 DESIGN EARTHQUAKE MAGNITUDE

Some seismic analysis methods require a design earthquake magnitude as an input. One such analysis is the liquefaction screening method. Based on its application in the liquefaction screening, a design earthquake magnitude of 5.68 was selected. Additional details on the design earthquake magnitude are available in the Liquefaction Assessment Calculation Package. This design earthquake magnitude was used in other analyses requiring a design magnitude for consistency.

4.0 PSEUDOSTATIC COEFFICIENT

For slope stability analyses, Golder used the Bray and Travasarou (2009) screening method which models the seismic loading using a pseudostatic coefficient (k). This section details the calculation of the pseudostatic coefficient for the project site. Details on the slope stability analysis are available in a separate calculation package.

Stability under seismic conditions is calculated using the pseudo-static method to model horizontal seismic forces as the product of a seismic coefficient (k) and the weight of the sliding mass (vertical seismic forces are typically neglected). Bray and Travasarou (2009) proposed screening methodology to determine the seismic coefficient k based on the degraded period of the sliding mass and an allowable seismic displacement threshold. The screening method includes an equation to calculate the pseudostatic coefficient for periods of 0.2 and 0.5 seconds, which encompasses the range of typical slope periods. A period of 0.2 s is more conservative, so for this analysis, Golder used the equation associated with a period of 0.2 s and an allowable seismic displacement of 15 cm:

$$k_{15\text{ cm}} = (0.036M_w - 0.004)S_a - 0.030 > 0.0, \text{ for } S_a = S_a(T = 0.2\text{ s}) < 2.0\text{ g}$$

Where, $k_{15\text{ cm}}$ = pseudostatic coefficient

M_w = Design Earthquake Magnitude

S_a = Spectral acceleration at the base of the sliding mass

As noted in Section 2.1, the BC spectral acceleration at a period of 0.2 s is 0.0824. This value is multiplied by an amplification factor to obtain the acceleration at the base of the sliding mass. Golder used an amplification factor of 1.6 as prescribed by the international building code (IBC 2012) for a site class D. The project site was classified as D according to the representative shear wave velocity in the upper 30 meters or 100 feet (V_{s30}). Details on the site V_{s30} are available in the Liquefaction Assessment Calculation Package. Thus, the spectral acceleration used in the above equation is 0.132g.

Using a design magnitude of 5.68 and spectral acceleration of 0.132g, the calculated pseudostatic coefficient is nearly zero for an allowable seismic displacement of 15 cm due to the low seismic hazard. In an effort to demonstrate an acceptable factor of safety in slope stability analyses, Golder conservatively

used the coefficient for an allowable displacement of two inches (5 cm) as described with the equation below:

$$k_{5\text{ cm}} = (0.040M_w + 0.120)S_a - 0.034 > 0 \text{ for } S_a = S_a(T = 0.2\text{ s}) < 2.0\text{ g}$$

This equation yields a pseudostatic coefficient of 0.01g, which was used for seismic stability demonstrations.

5.0 REFERENCE

Bray, J.D., and Travararou, T. 2009. Pseudostatic Coefficient for Use in Simplified Seismic Slope Stability Evaluation. *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 135, No. 9: pp. 1336-1340.

United States Geologic Survey, Unified Hazard Tool. <https://earthquake.usgs.gov/hazards/interactive/>. Accessed January 9, 2018.

ATTACHMENT 3

Liquefaction Assessment Calculation Package

Date:	February 5 th 2018	Made by:	G. Martin
Project No.:	1300193	Checked by:	L. Jin
Subject:	Liquefaction Assessment	Reviewed by:	G. Hebelar
Project:	CHESAPEAKE ENERGY CENTER INACTIVE POND DEMONSTRATION		

1.0 OBJECTIVE

The objective of this calculation is to assess the liquefaction potential of the foundation soils and surrounding dikes of the bottom ash pond (BAP) at Dominion Energy's Chesapeake Energy Center (CEC). This assessment is a screening-level assessment performed according to the simplified procedure, as described in Youd et al. (2001). Cone Penetration Test (CPT) data was used to estimate the soil properties for this assessment. A variation from the procedure was performed based on an updated method of incorporating CPT data into the liquefaction assessment (Robertson, 2009).

Factors of safety against liquefaction were calculated for eight CPT soundings pushed in the dikes surrounding the BAP (CPT-BAP-01 and CPT-BAP-08 through -14)

2.0 LIQUEFACTION ASSESSMENT METHODOLOGY

Seismically-induced liquefaction susceptibility was evaluated using the National Center for Earthquake Engineering Research (NCEER) simplified procedure with CPT data (Youd et al., 2001). The simplified procedure is an empirical method used to calculate the factor of safety against liquefaction. The factor of safety is defined as a ratio of the cyclic resistance ratio (CRR) to the cyclic stress ratio (CSR). The CRR is a measure of a soils' resistance to liquefaction and was estimated using CPT data. The CSR is a measure of the seismic demand on the soil and was estimated using seismic hazard assessment resources provided by the United States Geologic Survey (USGS) as described in Golder's Seismic Hazard Assessment package.

2.1 CSR Determination

The CSR is defined as:

$$CSR = \frac{\tau_{ave}}{\sigma'_v} = 0.65 \left(\frac{a_{max}}{g} \right) \left(\frac{\sigma_v}{\sigma'_v} \right) r_d$$

where a_{max} is the peak horizontal acceleration at the ground surface, g is the acceleration due to gravity, σ_v is the total vertical overburden stress, σ'_v is the effective vertical overburden stress, and r_d is a depth-dependent stress reduction factor defined as:

$$r_d = 1.0 - 0.00765z \quad \text{for } z \leq 9.15 \text{ m}$$

$$r_d = 1.174 - 0.0267z \quad \text{for } 9.15 \text{ m} < z \leq 23 \text{ m}$$

$$r_d = 0.744 - 0.008z \quad \text{for } 23 \text{ m} < z \leq 30 \text{ m}$$

$$r_d = 0.50 \quad \text{for } z > 30 \text{ m}$$

where z is the depth in meters (m).

The site reference peak ground acceleration (PGA,BC) discussed in Golder's Seismic Hazard Assessment package was used to calculate acceleration at the ground surface (a_{\max}). To obtain a representative a_{\max} , the PGA,BC was multiplied by an amplification factor calculated from the average shear wave velocity in the upper 30 meters (V_{s30}). The shear wave velocity was measured in two CPTs (CPT-BAP-11 and CPT-BAP-14), and a representative shear wave velocity was derived from these measurements. Figure 1 below shows the measured shear wave velocities and the representative shear wave velocity profile. The V_{s30} was calculated from the representative profile to be 840 ft/s.

An amplification factor was calculated using the site response term from the Atkinson and Boore (2006) publication on earthquake ground-motion prediction equations for Eastern North America. The International Building Code (IBC) also provides amplification factors for structures. While these factors may not be directly applicable due to the different responses of earthen dams and buildings to seismic loads, the amplification factor was calculated using this alternative method as a check on the Atkinson and Boore method.

The amplification factors were calculated to be 1.72 using the Atkinson and Boore method, and 1.69 using the IBC method. Golder selected an amplification factor of 1.7.

a_{\max} was thus calculated to be $0.040g \times 1.7 = 0.068g$ for a 2,475 year return period.

This a_{\max} value was used to calculate CSR.

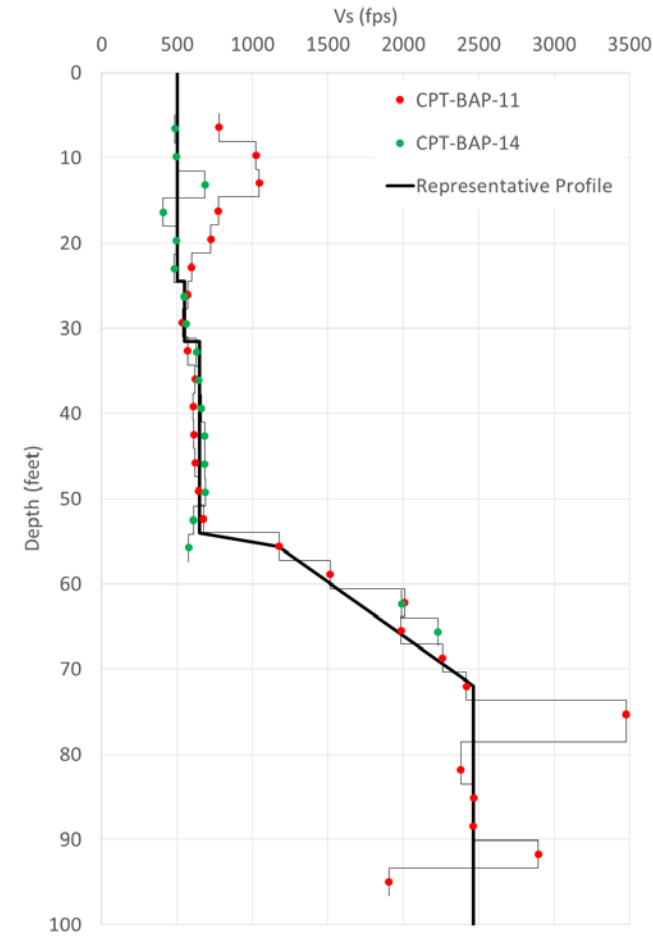


Figure 1: Shear Wave Velocity Measurements and Selected Profile

2.2 CRR Determination

The second major step in assessing the liquefaction susceptibility using the simplified approach is to estimate the CRR. Robertson and Wride (1998) developed the procedure for calculating CRR from the CPT as a function of the “clean sand” cone penetration resistance normalized to 1 atmosphere (atm; approximately 100 kilopascals; kPa) and given as $(q_{c1N})_{cs}$. The CRR is based on an earthquake magnitude of 7.5 and a magnitude scaling factor (MSF) adjusts the CRR for magnitudes other than 7.5.

The CRR for an earthquake magnitude (M) of 7.5 is given as:

$$(q_{c1N})_{cs} < 50 \quad CRR_{7.5} = 0.833 \left[\frac{(q_{c1N})_{cs}}{1000} \right] + 0.05$$

$$50 \leq (q_{c1N})_{cs} < 160 \quad CRR_{7.5} = 93 \left[\frac{(q_{c1N})_{cs}}{1000} \right]^3 + 0.08$$

where $(q_{c1N})_{cs}$ is the clean sand cone penetration resistance normalized to 1 atm (approximately 100 kPa or 1 ton per square foot; tsf).

The tip resistance (q_c) is normalized to obtain q_{c1N} as:

$$q_{c1N} = C_Q \left(\frac{q_c}{P_a} \right)$$

$$C_Q = \left(\frac{P_a}{\sigma'_{vo}} \right)^n$$

where C_Q is the normalizing factor for cone penetration resistance, P_a is 1 atm of pressure, n is an exponent that is dependent on the soil type, and q_c is the cone tip penetration resistance (q_c is replaced by q_t the cone tip resistance corrected for geometric impacts of the pore pressure measurement in all instances).

The method adopted in this assessment calculates the exponent, n , according to a method developed by Robertson (2009) and represents a small modification from the standard NCEER approach. The exponent, n , is calculated as:

$$n = 0.381I_c + 0.05 \left(\frac{\sigma'_{vo}}{P_a} \right) - 0.15 \leq 1.0$$

where

$$I_c = [(3.47 - \log Q_{t1})^2 + (1.22 + \log F_r)^2]^{0.5}$$

$$Q_{t1} = \left[\frac{q_c - \sigma_{vo}}{\sigma'_{vo}} \right]$$

$$F_r = \left[\frac{f_s}{q_c - \sigma_{vo}} \right] \times 100\%$$

2.2.1 Clean Sand Equivalent Cone Penetration Resistance $(q_{c1N})_{cs}$

According to the NCEER approach, the presence of fines affects the liquefaction resistance of soils. A correction factor, K_c , is applied to the normalized penetration resistance (q_{c1N}) to determine the clean sand equivalent $(q_{c1N})_{cs}$ where

$$(q_{c1N})_{cs} = K_c q_{c1N}$$

$$\text{for } I_c \leq 1.64 \quad K_c = 1.0$$

$$\text{for } I_c > 1.64 \quad K_c = -0.403I_c^4 + 5.581I_c^3 - 21.63I_c^2 + 33.75I_c - 17.88$$

2.2.2 Magnitude Scaling Factor (MSF)

The magnitude scaling factor (MSF) adjusts the CRR for magnitudes other than 7.5 (Youd et al. 2001) where the factor of safety against liquefaction is calculated as

$$FS = \frac{CRR_{7.5}}{CSR} \times MSF$$

A number of different MSF values are discussed in the NCEER approach. The MSF values used in this assessment are the revised Idriss values (which are considered a lower bound set of values), and are calculated as:

$$MSF = \frac{10^{2.24}}{M^{2.56}}$$

A probabilistic seismic hazard analysis was used to estimate the PGA, but such an analysis includes the aggregate contributions of all possible combinations of magnitude and distance from all sources, all weighted by their relative likelihoods of occurrence (Kramer, 2008). However, the simplified approach requires the selection of a single earthquake magnitude. Since liquefaction is sensitive to ground motion duration, which is correlated to earthquake magnitude, this selection is an important issue in liquefaction assessments.

The selection of either the mean or modal magnitude produces inconsistent risks of liquefaction because the relationship between duration (represented by magnitude) and liquefaction potential is non-linear. Kramer (2008) suggests that the best way to handle this issue is to perform liquefaction calculations for all magnitudes and to weight the results according to the relative contribution of each magnitude.

Golder has implemented this approach by recognizing that the MSF is the only term in the simplified approach that is affected by the magnitude selection. Golder calculated a weighted-average MSF (weighted by the relative contribution of each magnitude) and then calculated the magnitude corresponding to that MSF.

Golder calculated the earthquake magnitude to be 5.68. This value is less than the mean magnitude (5.86), and is greater than the modal magnitude (4.90).

2.3 Factor of Safety Against Liquefaction

The factor of safety was calculated as:

$$FS = \frac{CRR_{7.5}}{CSR} \times MSF$$

The factor of safety was calculated for each CPT reading (every recorded CPT depth reading). The liquefaction output and factors of safety are presented in Attachment 1.

3.0 RESULTS AND CONCLUSIONS

The USEPA's 2015 Final Rule on the Disposal of Coal Combustion Residuals (CCR, EPA Rule) specify a required factor of safety of 1.2 against liquefaction for pond impoundment structures in section § 257.73(e)(iv). The dikes impounding the BAP at CEC meet this requirement as all calculated factors of safety against liquefaction for both dike and foundation materials are in excess of 1.2 for all eight CPT soundings analyzed.

4.0 REFERENCES

Atkinson, G.M. and D.M. Boore (2006) "Earthquake Ground-Motion Prediction Equations for Eastern North America," *Bulletin of the Seismological Society of America*, Vol. 96, No. 6, pp. 2181-2205.

Kramer, S.L. (2008). "Evaluation of Liquefaction Hazards in Washington State" Final Research report WA-RD 668.1, December 2008.

Robertson, P.K. and C.E. (Fear) Wride (1998) "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test," *Canadian Geotechnical Journal*, Vol. 35, pp. 442-459.

Youd, T.L. et al. (2001). "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF workshops on Evaluation of Liquefaction Resistance of Soils", *Journal of Geotechnical and Geoenvironmental Engineering*, vol. 127, No. 4, April 2001.

5.0 ATTACHMENTS

Attachment 1 - Liquefaction Factor of Safety Results

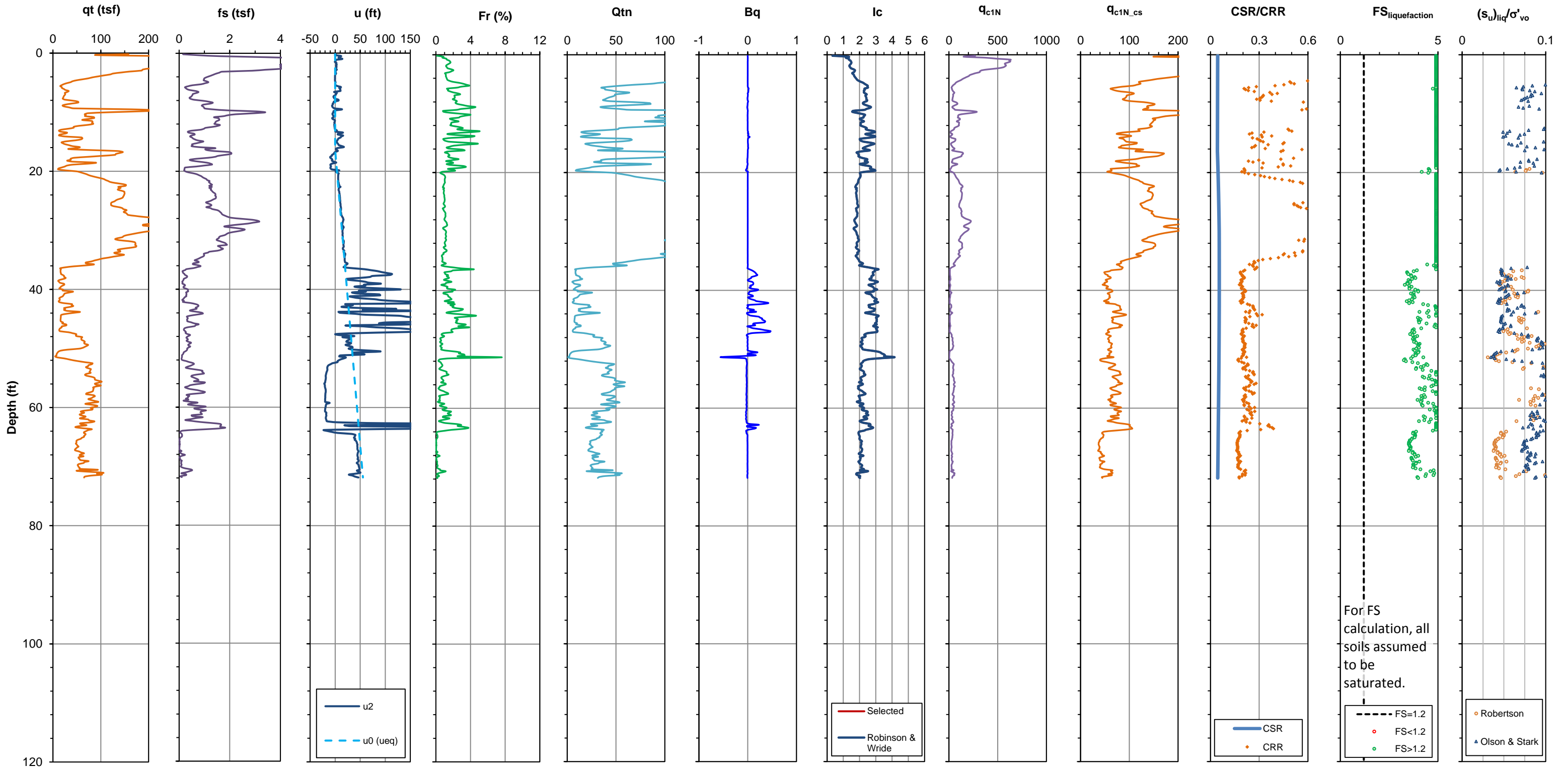
Test Date: 11/21/2016
Test ID: CPT-BAP-01
Latitude: 36.76120
Longitude: -76.30125
Elevation: 20.7 ft

Project: CEC - Inactive Demo.
Location: Chesapeake, VA
Client: Dominion Energy
Proj No.: 1300193
Termination: 71.9 ft-bgs

Test Type: CPTU
Device: 10 cm², Type 2 filter
Standard: ASTM D5778
Push Co.: ConeTec
Operator: ConeTec

Water Table: 16.4 ft
Golder Eng: L. Jin
Check: G. Martin
Review: G. Hebel

2% PE in 50 years Seismic Hazard
Magnitude: 5.68
a_{max}: 0.068 g



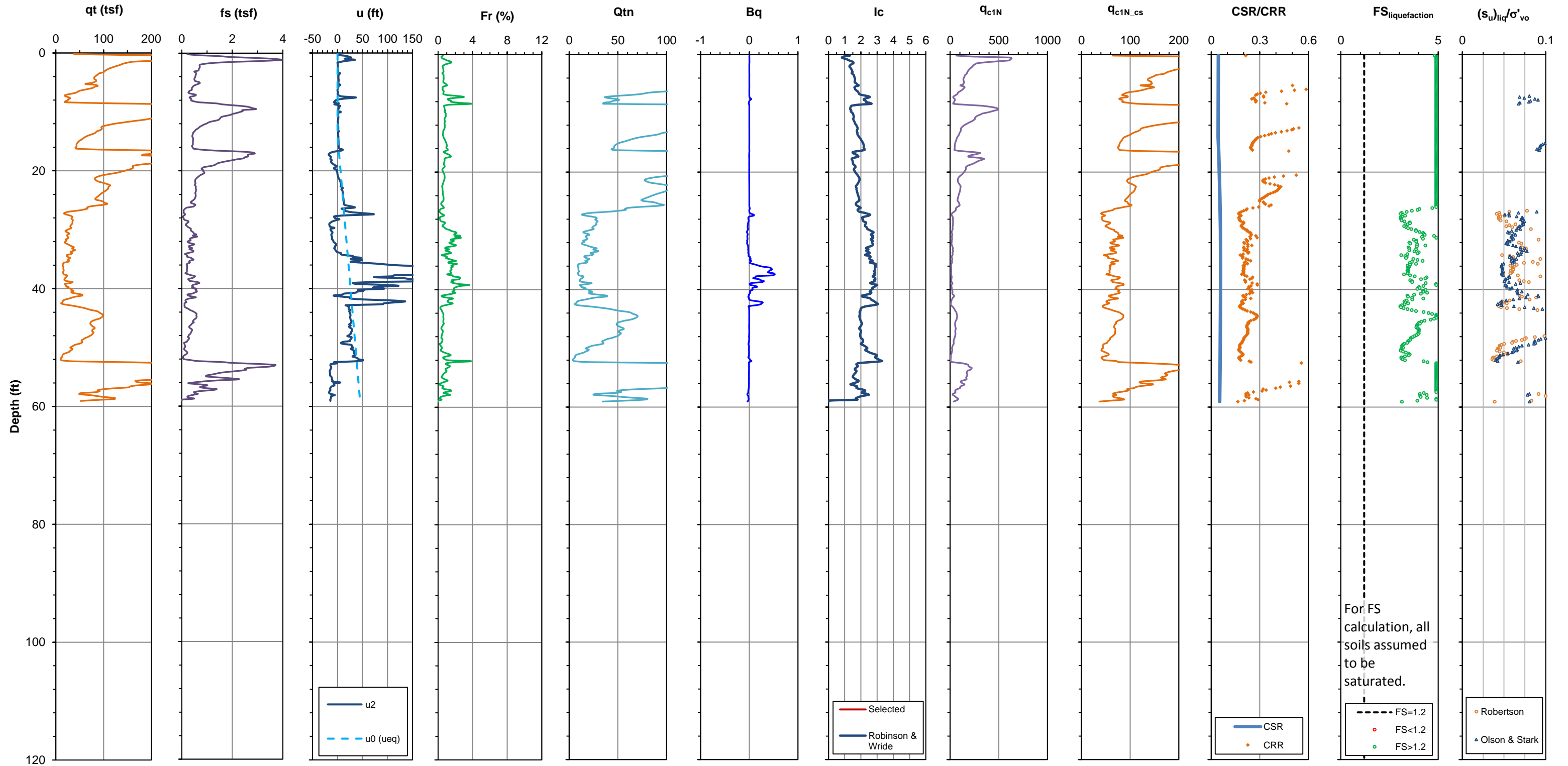
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Test ID: CPT-BAP-08
Latitude: 36.76118
Longitude: -76.30208
Elevation: 19.5 ft

Project: CEC - Inactive Demo.
Location: Chesapeake, VA
Client: Dominion Energy
Proj No.: 1300193
Termination: 71.9 ft-bgs

Test Type: CPTU
Device: 10 cm², Type 2 filter
Standard: ASTM D5778
Push Co.: ConeTec
Operator: ConeTec

Water Table: 14.0 ft
Golder Eng: L. Jin
Check: G. Martin
Review: G. Hebel

2% PE in 50 years Seismic Hazard
Magnitude: 5.68
a_{max}: 0.068 g



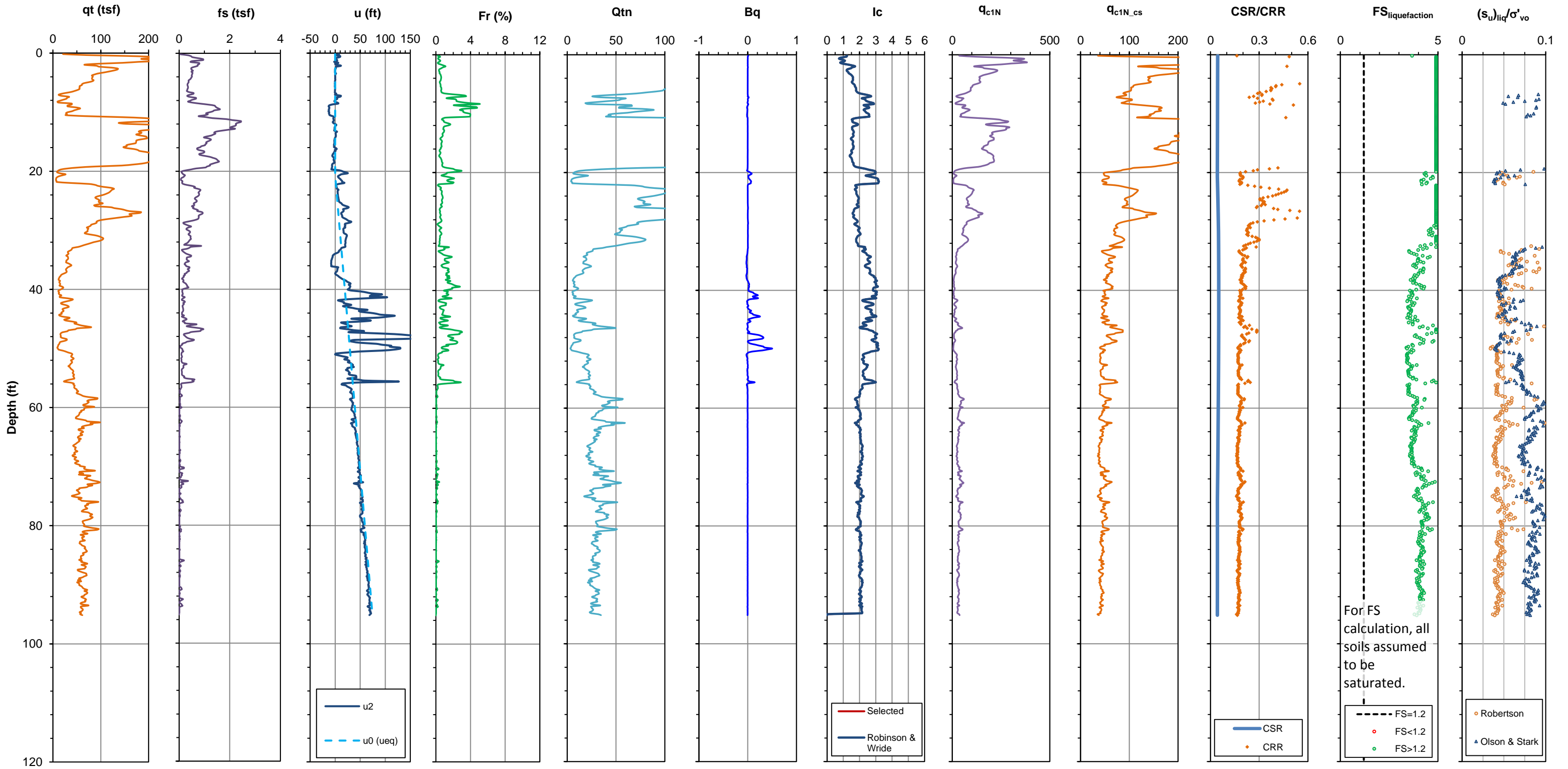
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Project: CEC - Inactive Demo.
Location: Chesapeake, VA
Client: Dominion Energy
Proj No.: 1300193
Termination: 71.9 ft-bgs

Test Type: CPTU
Device: 10 cm², Type 2 filter
Standard: ASTM D5778
Push Co.: ConeTec
Operator: ConeTec

Water Table: 20.7 ft
Golder Eng: L. Jin
Check: G. Martin
Review: G. Hebel

2% PE in 50 years Seismic Hazard
Magnitude: 5.68
a_{max}: 0.068 g



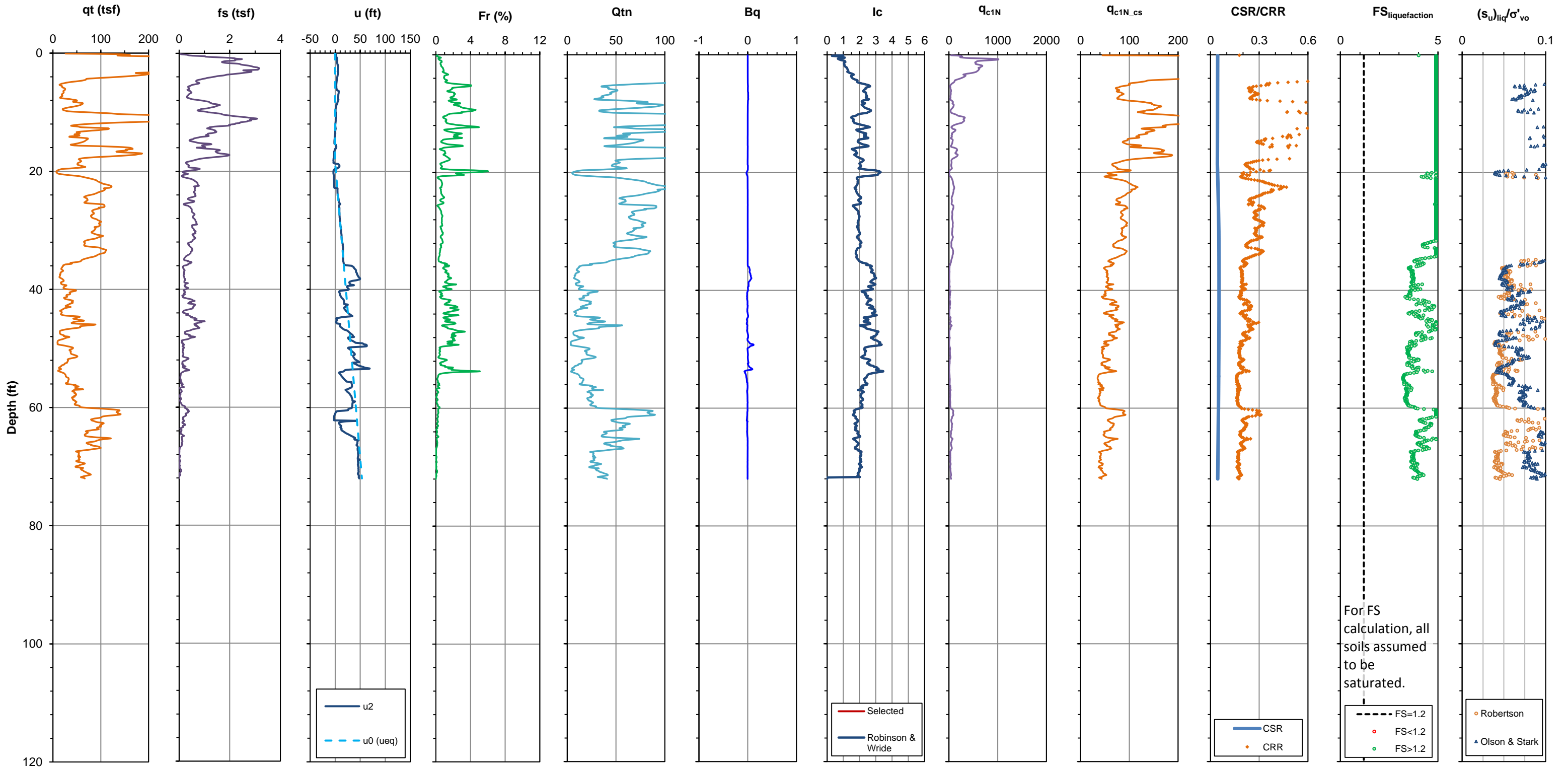
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Latitude: 36.76162
Longitude: -76.30082
Elevation: 20.0 ft

Project: CEC - Inactive Demo.
Location: Chesapeake, VA
Client: Dominion Energy
Proj No.: 1300193
Termination: 71.9 ft-bgs

Test Type: CPTU
Device: 10 cm², Type 2 filter
Standard: ASTM D5778
Push Co.: ConeTec
Operator: ConeTec

Water Table: 18.6 ft
Golder Eng: L. Jin
Check: G. Martin
Review: G. Hebel

2% PE in 50 years Seismic Hazard
Magnitude: 5.68
a_{max}: 0.068 g



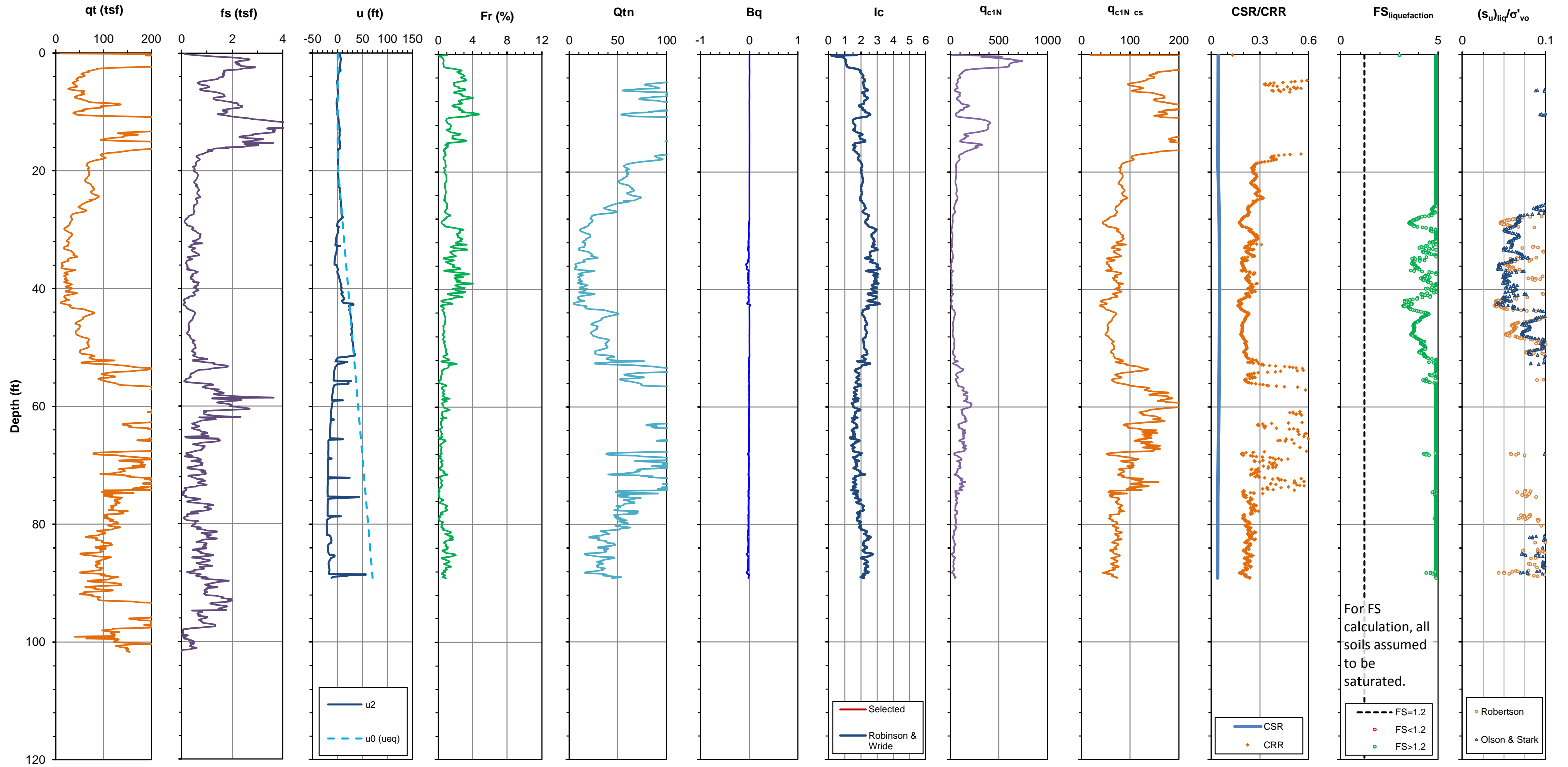
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Elevation: 20.0 ft

Project: CEC - Inactive Demo.
Location: Chesapeake, VA
Client: Dominion Energy
Proj No.: 1300193
Termination: 71.9 ft-bgs

Test Type: CPTU
Device: 10 cm², Type 2 filter
Standard: ASTM D5778
Push Co.: ConeTec
Operator: ConeTec

Water Table: 18.8 ft
Golder Eng: L. Jin
Check: G. Martin
Review: G. Hebel

2% PE in 50 years Seismic Hazard
Magnitude: 5.68
a_{max}: 0.068 g



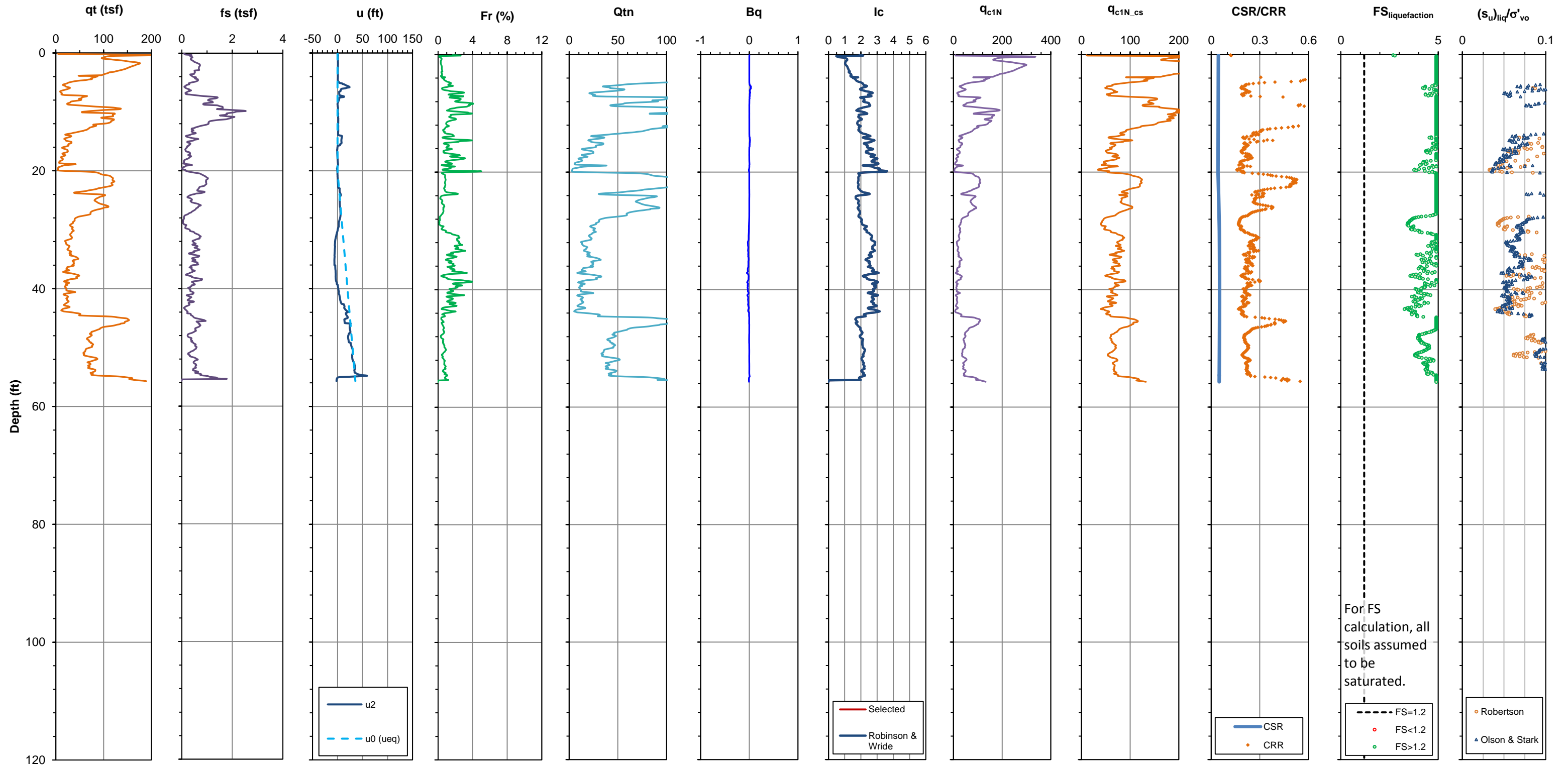
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Elevation: 20.0 ft

Project: CEC - Inactive Demo.
Location: Chesapeake, VA
Client: Dominion Energy
Proj No.: 1300193
Termination: 71.9 ft-bgs

Test Type: CPTU
Device: 10 cm², Type 2 filter
Standard: ASTM D5778
Push Co.: ConeTec
Operator: ConeTec

Water Table: 20.0 ft
Golder Eng: L. Jin
Check: G. Martin
Review: G. Hebel

2% PE in 50 years Seismic Hazard
Magnitude: 5.68
a_{max}: 0.068 g



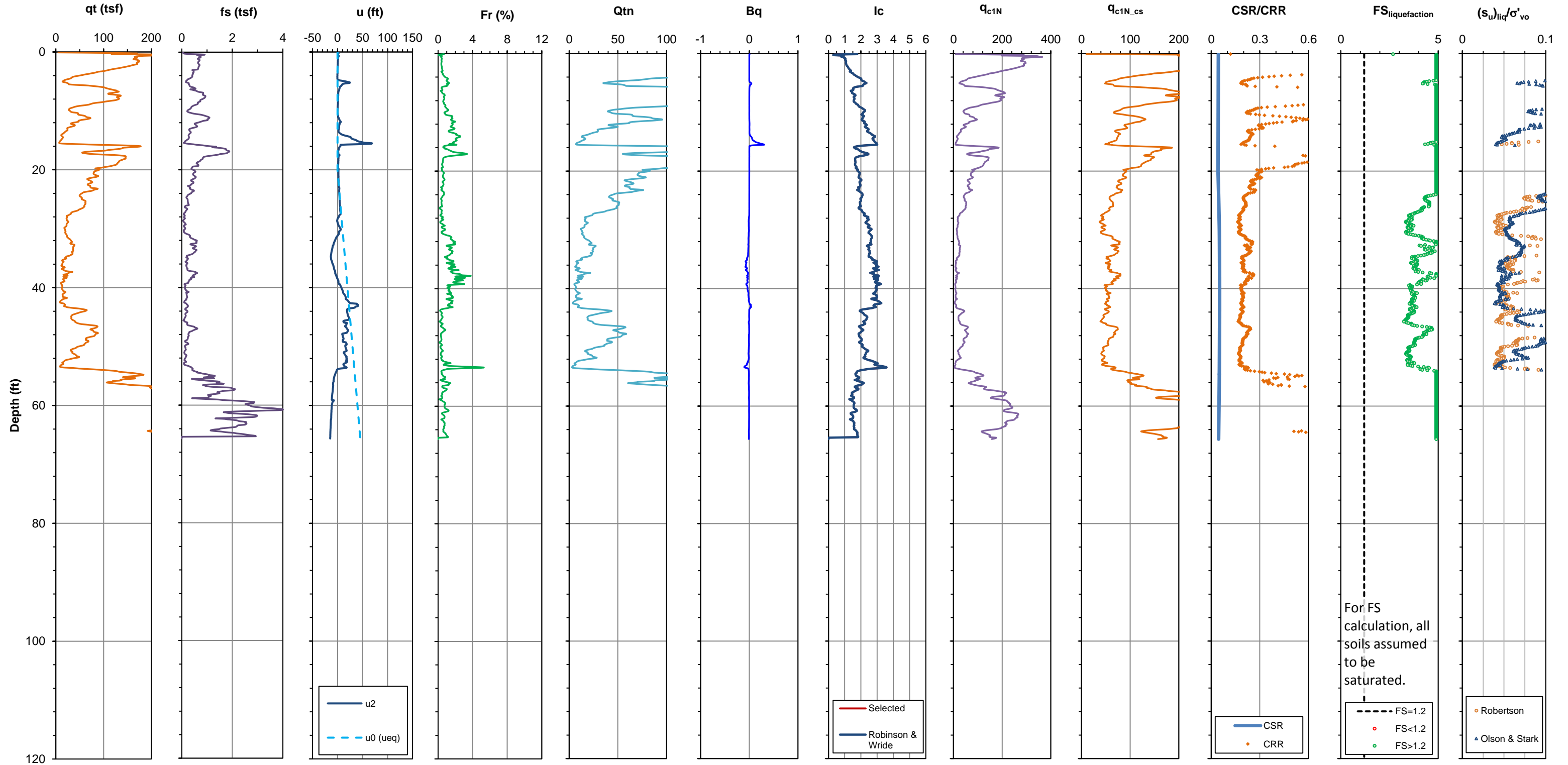
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Project: CEC - Inactive Demo.
Location: Chesapeake, VA
Client: Dominion Energy
Proj No.: 1300193
Termination: 71.9 ft-bgs

Test Type: CPTU
Device: 10 cm², Type 2 filter
Standard: ASTM D5778
Push Co.: ConeTec
Operator: ConeTec

Water Table: 20.1 ft
Golder Eng: L. Jin
Check: G. Martin
Review: G. Hebel

2% PE in 50 years Seismic Hazard
Magnitude: 5.68
a_{max}: 0.068 g



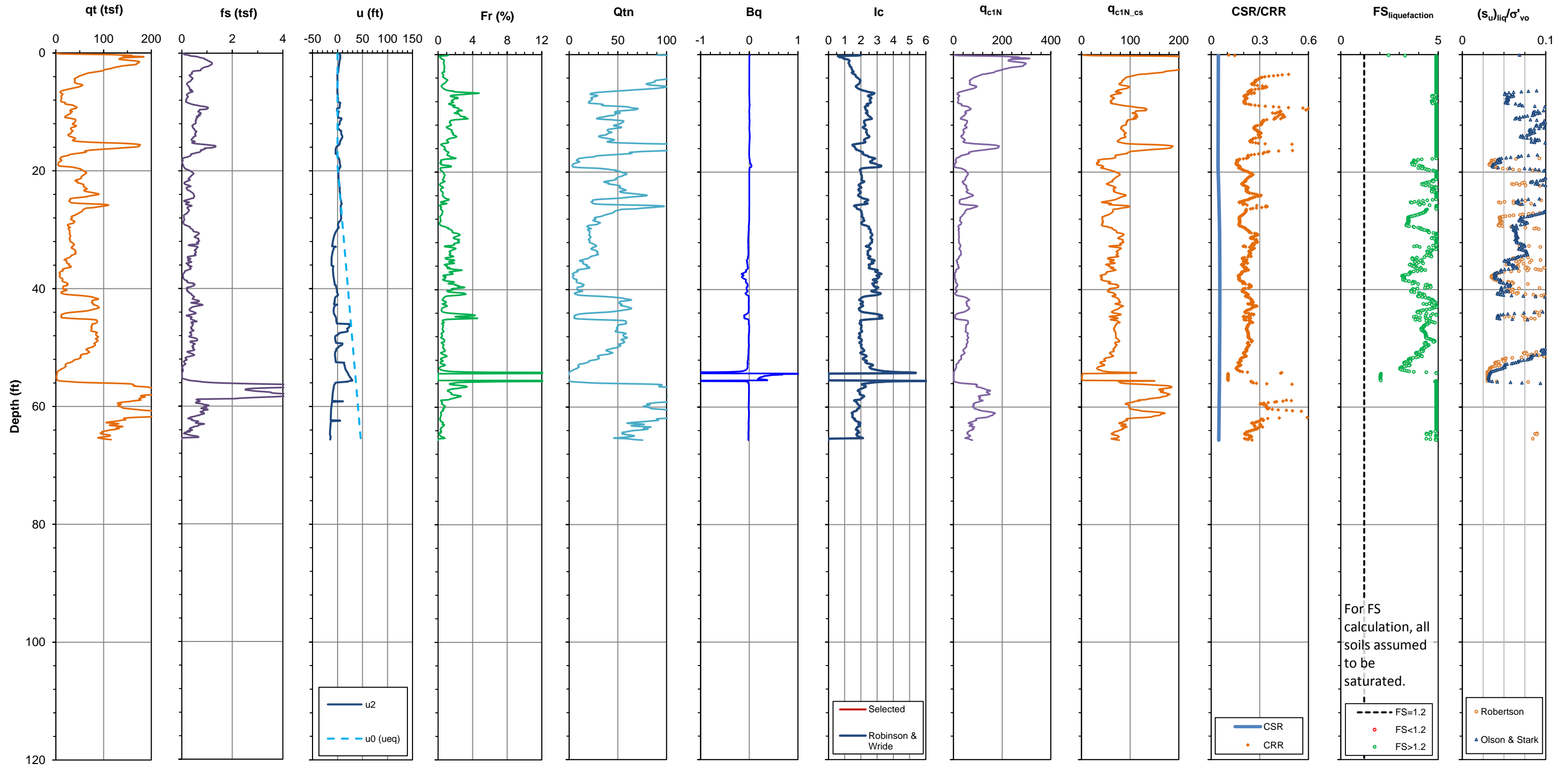
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Test ID: CPT-BAP-14
Latitude: 36.76295
Longitude: -76.30467
Elevation: 20.0 ft

Project: CEC - Inactive Demo.
Location: Chesapeake, VA
Client: Dominion Energy
Proj No.: 1300193
Termination: 71.9 ft-bgs

Test Type: CPTU
Device: 10 cm², Type 2 filter
Standard: ASTM D5778
Push Co.: ConeTec
Operator: ConeTec

Water Table: 19.1 ft
Golder Eng: L. Jin
Check: G. Martin
Review: G. Hebel

2% PE in 50 years Seismic Hazard
Magnitude: 5.68
a_{max}: 0.068 g



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