Attachment 2

Geotechnical Material Properties

Golder Associates	**SUBJECT:** **Estimation of Ash Pond Materials Properties** **Project Number:** **1520347** **Project Name:** **Bremo Ash Pond Closure, Bremo Bluff, VA** **Prepared by:** JGM **Checked by:** PDP **Date:** Oct 2015 **Reviewed by:** GLH

Objective

Based on available field and laboratory data and accepted correlations and relationships, develop strength and consolidation parameters for the in-situ Coal Combustion Residual (CCR) material, dike soils, and natural soils at the East Ash Pond (EAP), North Ash Pond (NAP) and West Ash Pond (WAP) located at Bremo Power Station, Bremo Bluff, Virginia.

Method

Strength and consolidation parameters are selected based on laboratory testing (CU Triaxial, Direct Shear, Plasticity, Proctor Compaction, Sieve, Permeability, etc.), in-situ testing (CPT, SPT, Vane Shear Testing), and various correlations to testing (Mesri and Shahien Plasticity correlations, plasticity correlations, etc.). Explanation of parameter selection can be found the in following pages.

Typical Values and Terminology

Fine Grained Soils

Consistency	Field Identification	Undrained Shear Strength (kPa)	
Very Soft	Extrudes between fingers when squeezed	0	12
Soft	Molded by light finger pressure	12	25
Firm	Molded by strong finger pressure	25	50
Stiff	Indented by thumb	50	100
Very Stiff	Indented by thumbnail	100	200
Hard	Difficult to indent with thumbnail	> 200	

Coarse Grained Soils

Density	Field Identification	Dr (%)	ϕ' (Deg)
Very Loose	Easily penetrated with shovel handle	<20	< 29
Loose	Easily penetrated with 1/2 inch rebar pushed by hand. Easily excavated with hand shovel.	20 - 40	29 - 30
Compact	Easily penetrated with 1/2 inch rebar driven by 5 lb. hammer. Difficult to excavate with hand shovel.	40 - 60	30 - 36
Dense	Penetrated 1 foot with driven rebar. Must be loosened with pick to hand excavate.	60 - 80	36 - 41
Very Dense	Penetrated only a few inches with driven rebar. Very difficult to excavate even with pick.	> 80	> 41

D_r (%) = Relative Density = $(e_{max} - e) / (e_{max} - e_{min})$ * 100%.

ϕ' (Deg) = Effective Friction Angle, from Peck, Hanson, and Thornburn (1974).

SUMMARY OF ESTIMATED PROPERTIES

The material properties, as shown in the table below are selected as representative values for the materials for use in slope stability and settlement analyses.

Strength parameters are based on extensive CPT-based correlations for peak effective friction angle, laboratory shear strength test results, and plasticity correlations to fully-softened shear strength.

Consolidation parameters were estimated by employing the Strain-energy method and results from laboratory 1-D oedometer consolidation tests on the ash material.

The following table summarizes the selected geotechnical material properties

Golder Associates	**SUBJECT:** **Estimation of Ash Pond Materials Properties** **Project Number:** **1520347** **Project Name:** **Bremo Ash Pond Closure, Bremo Bluff, VA** **Prepared by:** JGM **Checked by:** PDP **Date:** Oct 2015 **Reviewed by:** GLH

Summary of Geotechnical Strength Properties East, North and West Ash Ponds					
Material	***Total Unit Weight (pcf)***	***Strength Properties***			
		Peak φ' (°)	**Cohesion (psf)**	**Su (tsf)**	
Uncompacted CCR	90	28	0	0.5	
Compacted CCR	110	34	0	1.5	
Dike Fill Soils- NAP	125	0 - 40 ft: 31 > 40 ft: 28	75	2.0	
Dike Fill Soils- EAP and WAP	125	0 - 20 ft: 31 > 20 ft: 28	75	1.5	
Alluvium	115	28	50	1.0	
Residuum	125	28	50	1.5	
Clay Liner (EAP vertical expansion)	125	26	50	0.25	
Disintegrated Rock	140	31	1000	50	

Summary of CCR Consolidation Properties				
OCR	**Cc,ε (strain)**	**Cr,ε (strain)**	**Cv (ft2/day)**	**Cα,ε (strain)**
2.5	*0.18*	0.024	3.2	0.003

References

FHWA (1998), Training Course in Geotechnical and Foundation Engineering - Rock Slopes, Publication No. FHWA HI-99-007

Golder Associates 2015, Draft 30% Design Geotechnical Data Report, May 2015

Mesri, G. and Shahien, M. (2003) "Residual Shear Strength Mobilized in First-Time Slope Failures,", JGGE, 129, 1, 12-31.

Gregg Drilling, "Guide to Cone Penetration Testing", 6th Edition 2015.

Objective

Develop strength and consoildiation parameters for the in-situ Coal Combustion Residual (CCR) material at the East Ash Pond (EAP) and North Ash Pond (NAP) based on field and laboratory data and accepted correlations and relationships.

CCR Material Properties:

Basic Properties

Basic properties for the CCR were evaluated based on laboratory testing, summarized in the table below.

For stability and settlement analyses, a saturated unit weight of 90 pcf was selected for uncompacted CCR, and a saturated unit weight of 110 pcf was selected for compacted CCR. The representative uncompacted CCR unit weight is based on two criteria plotted in the following pages: (1) the unit weights calculated from water contents of samples below the water table in the EAP and NAP and (2) unit weights directly measured from Shelby tube samples. The selected compacted CCR unit weight is based on the four proctor tests and the upper bound of saturated unit weights calculated from water contents of samples below the water table in the EAP and NAP. Other laboratory tests were used to determine strength and compressibility properties described below.

Summary of Geotechnical Testing Data - Basic Properties
CCR - All Ponds

Primary Laboratory Tests						
Property		***No. of Data Points (Borings)***	**Min**	**Max**	**Avg**	**Med**
Depth Range (ft)		-	1	80	30	30
Water Content (%)		61 (7)	21	163	82	79
Gravel (> 4.75 mm) (%)		15 (6)	0	0	0	0
Sand (%)			3	52	25	23
Fines (< 0.075 mm) (%)			49	97	75	77
Specific Gravity		10 (3)	2.06	2.21	2.12	2.10
Liquid Limit (LL) (%)		5 (2)	NP			
Plastic Limit (PL) (%)						
Plasticity Index (PI)						
Non Plastic Results		5	5 of 5			
pH		3 (3)	8.5	8.7	8.6	8.6
Resistivity (ohm-cm)		3 (3)	2400	5100	3570	3200
Standard Proctor Test Depth Range (ft)		0 – 10 ft				
Max Dry Density (pcf)		4 (4)	53	82	67	65
Optimum Moisture (%)			28.6	50	41.7	44.1
Saturated Unit Weight (pcf)	Directly Measured	12 (4)	48	96	79	83
	Calculated	37 (5)	78	112	91	88
	Both	49 (5)	48	112	88	88

Selected Representative Unit Weights (pcf)	
Uncompacted, Saturated	90
Compacted, Saturated	110

Strength Data

Strength parameters for the CCR were evaluated based on in-situ and laboratory testing, summarized in the table below. A single set of strength parameters were selected for CCR in both the EAP and NAP due to their similar behavior during testing. A crust with increased strength is apparent in the upper 5-10 ft of the CCR layers. Crusts and other stronger layers can form when the CCR desicates or is compacted. Since the crust does not represent the strength of the majority of CCR, strengths of the crust zones were less influential in the selection of representative CCR strength parameters.

Drained friction angles of 28 and 34 degrees were selected for the uncompacted and compacted CCR, respectively. The selected uncompacted CCR friction angle is based on the average correlated friction angle from CPT (30.5°) and is close to the post-peak friction angle obtained from direct shear testing (31.8°). Peak strengths from lab testing indicate appropriate conservativism of the selected friction angle for stability analyses. Although correlated CPT friction angles in the compacted CCR average 42.7°, 34° was selected as a practicle upper limit. For the drained condition and the vertical stress range tested (1 - 4 ksf), the CCR is best modeled without a cohesion parameter, according to results from direct shear and triaxial tests.

Undrained strengths (Su) of 0.5 tsf and 1.5 tsf were selected for the uncompacted and compacted CCR based on the correlated CPT values and Vane Shear Test results (plotted in the following pages).

In some cases, CCR is susceptible to liquefaction. For more information on liquefaction analyses, refer to the calculation package in the appendix titled "Liquefaction Assessment of north and East Ash Ponds".

Summary of Geotechnical Strength Data
East and North Ash Ponds

CCR- Uncompacted

	Property	*No. of Data Points (Borings)*	*Min*	*Max*	*Avg*	*Median*
Drilling	*SPT N (bpf)*	49 (6)	0	11	1.5	1
	φ' (°) (Meyerhof)	-	#N/A	35.3	27.5	27.5
	φ' (°) (Peck et al.)	-	#N/A	30.3	27.0	27.0
CPT Interpreted	*Peak φ' (°)*	17215 (36)	2.2	47.2	30.5	30.5
	Su (tsf)		0.0	4.0	0.8	0.6
	SPT N_{60} (bpf)		1	45.0	5.0	4.0
	Norm. CPT Tip (Qtn)		0.0	490.6	25.6	14.8
Vane Shear Test	*Peak Su (tsf)*	8 (4)	0.5	3.9	1.9	1.6
	Residual Su (tsf)	7 (4)	0.1	2.5	0.6	0.3

Lab Test		*Strength Type*	*ϕ (deg)*	*c (psf)*
Direct Shear	EB-02 UD-01 33-35 ft	*Peak Effective*	34.7	0
		Post-Peak Effective	31.8	0
CU Triaxial	NB-02 UD-02 53.5 - 55.5 ft	*Peak Effective*	37.4	0
		Peak Total	26.9	0

CCR- Compacted

	Property	*No. of Data Points (Borings)*	*Min*	*Max*	*Avg*	*Median*
Drilling	*SPT N (bpf)*	3 (1)	22	34	27	24
	φ' (°) (Meyerhof)	-	38	41.0	39.3	38.5
	φ' (°) (Peck et al.)	-	33.6	37	35.1	34.2
CPT Interpreted	*Peak φ' (°)*	960 (5)	33.7	47.0	42.7	43.3
	Su (tsf)		1.9	4.0	3.0	2.9
	SPT N_{60} (bpf)		10	66	34	36
	Norm. CPT Tip (Qtn)		28.8	467.4	215.0	215.9

Selected Strength Parameters		
Uncompacted	ϕ' (deg)	28
	c' (psf)	0
	Su (tsf)	0.5
Compacted	ϕ' (deg)	34
	c' (psf)	0
	Su (tsf)	1.5

Summary of Consolidation Parameters

Consolidation parameters were assessed from six (6) 1-D oedometer tests, CPT correlations, and pore pressure dissipation tests. All strain dependent values (Cc, Cr, Cα) are presented in strain instead of void ratio.

The selected OCR and Coefficients of Consolidation (Cc), Recompression (Cr), Secondary Compression (Cα), and Time Rate of Consolidation (Cv) are averaged from the oedometer tests. The selected shear wave velocity profile was developed from CPT correlations. Correlation data are presented in the following graphs

Summary of Consolidation Data - CCR- Uncompacted

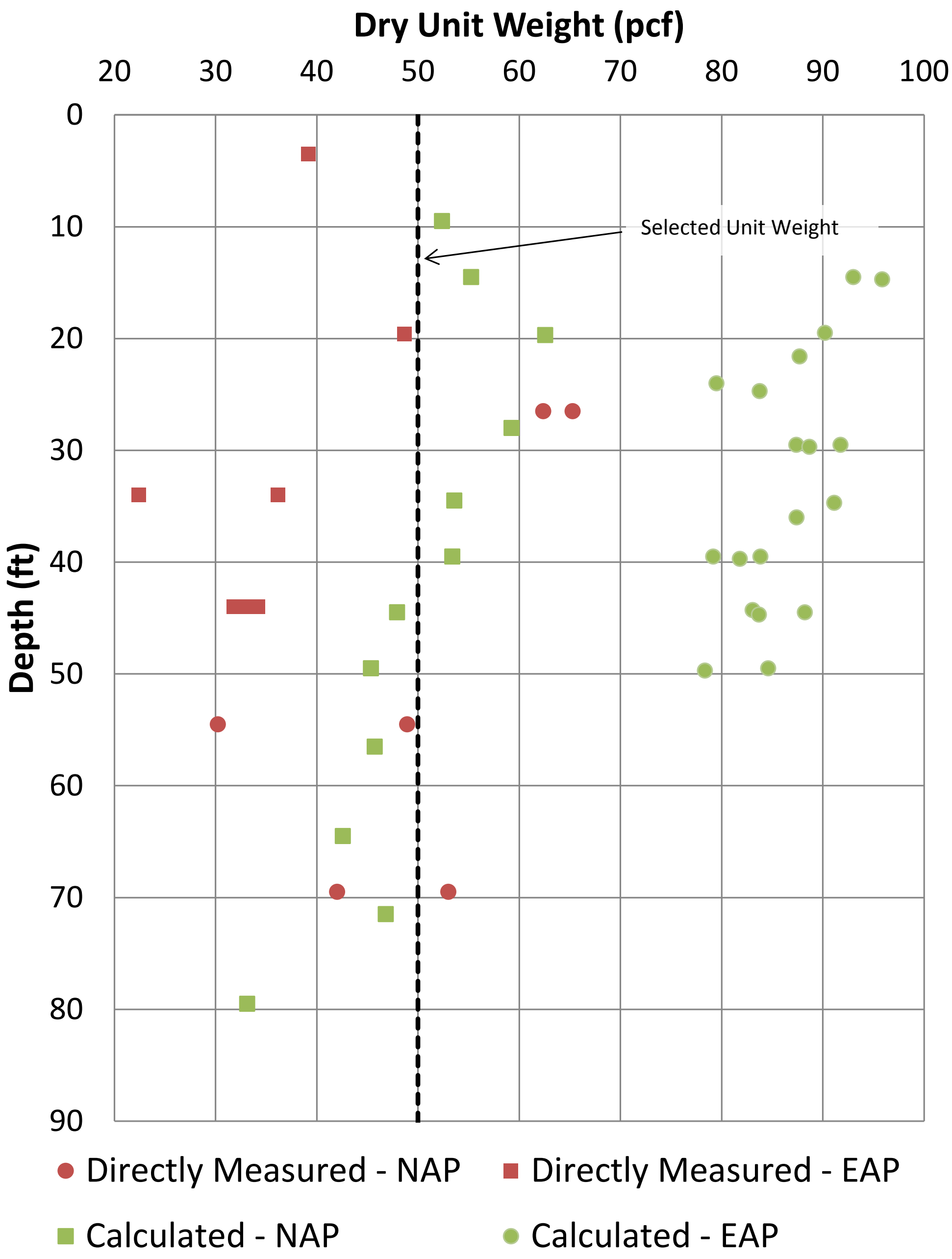
1-D Oedometer Tests (Lab)						
Sample ID & Depth (ft)	***OCR***	***Cc, ε (strain)***	***Cr, ε (strain)***	***Cc/Cr***	***Cv (ft^2/day)***	***C α, ε * (strain)***
EB-02 UD-01 33-35 ft	2.4	0.130	0.027	4.8	2.64	0.0026
EB-02 UD-02 43-45 ft	2.0	0.143	0.028	5.1	3.15	0.0029
EB-02 UD-02 43-45 ft (24 hr)	3.0	0.231	0.029	8.0	2.35	0.0032
NB-02 UD-01 25.5-27.5 ft	3.2	0.049	0.015	3.3	3.98	0.0009
NB-02 UD-02 53.5-55.5 ft	3.0	0.326	0.022	14.8	2.67	0.0031
NB-02 UD-03 68.5-70.5 ft	3.2	0.191	0.026	7.3	4.32	0.0018

Summary of Tests and Correlations						
Property		***No. of Data Points (Borings)***	***Min***	***Max***	***Avg***	***Median***
CPT Interpreted	*OCR*	12315 (36)	1.0	10	4.5	4.1
	Vs (ft/s^2)	17207 (36)	0	1267	429	418
	Ch (ft^2/day) (PPD tests)	99 (18)	7	230	134	133
Lab	*Cv (ft^2/day)*	6 (3)	2.35	4.32	3.19	2.91
Cα Correlation (0.04*Cc) (Terzaghi 96)		6 (3)	0.0020	0.0130	0.0071	0.0067

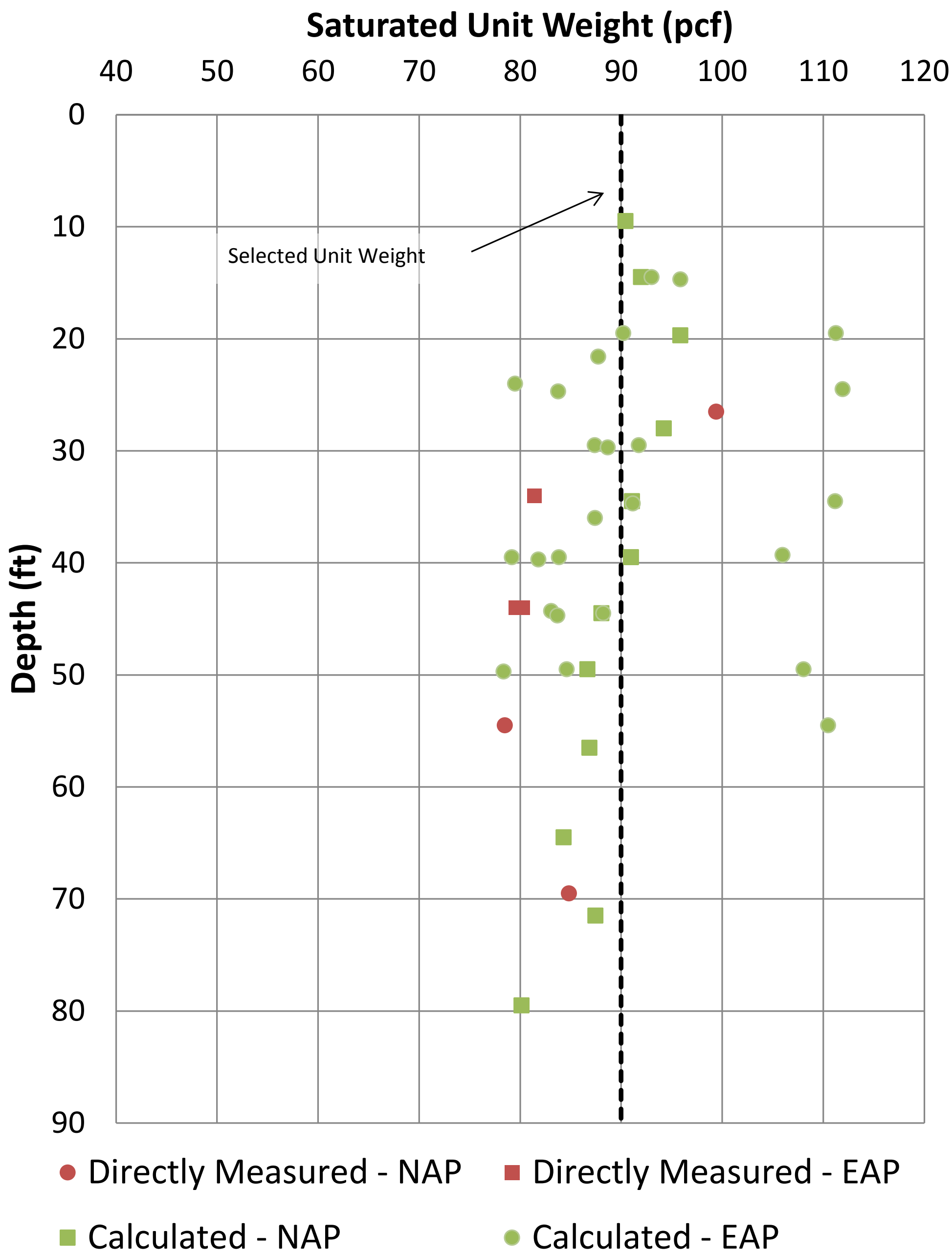
* Lab Cα calculated for a vertical stress of 16 ksf

Selected Consolidation Parameters	
Over Consolidation Ratio (OCR)	2.5
Coefficient of Consolidation,Strain (Cc,ε)	0.180
Coefficient of Recompression, Strain (Cr,ε)	0.024
Coefficient of Secondary Compression, Strain (Cα,ε)	0.0030
Time Rate of Consolidation Coefficient (Cv) (ft^2/day)	3.2
Time Rate of Horizontal Consolidation (Ch) (ft^2/day)	134
Shear Wave Velocity (Vs) (ft/s)	Vs = 200 + 4*depth[ft]

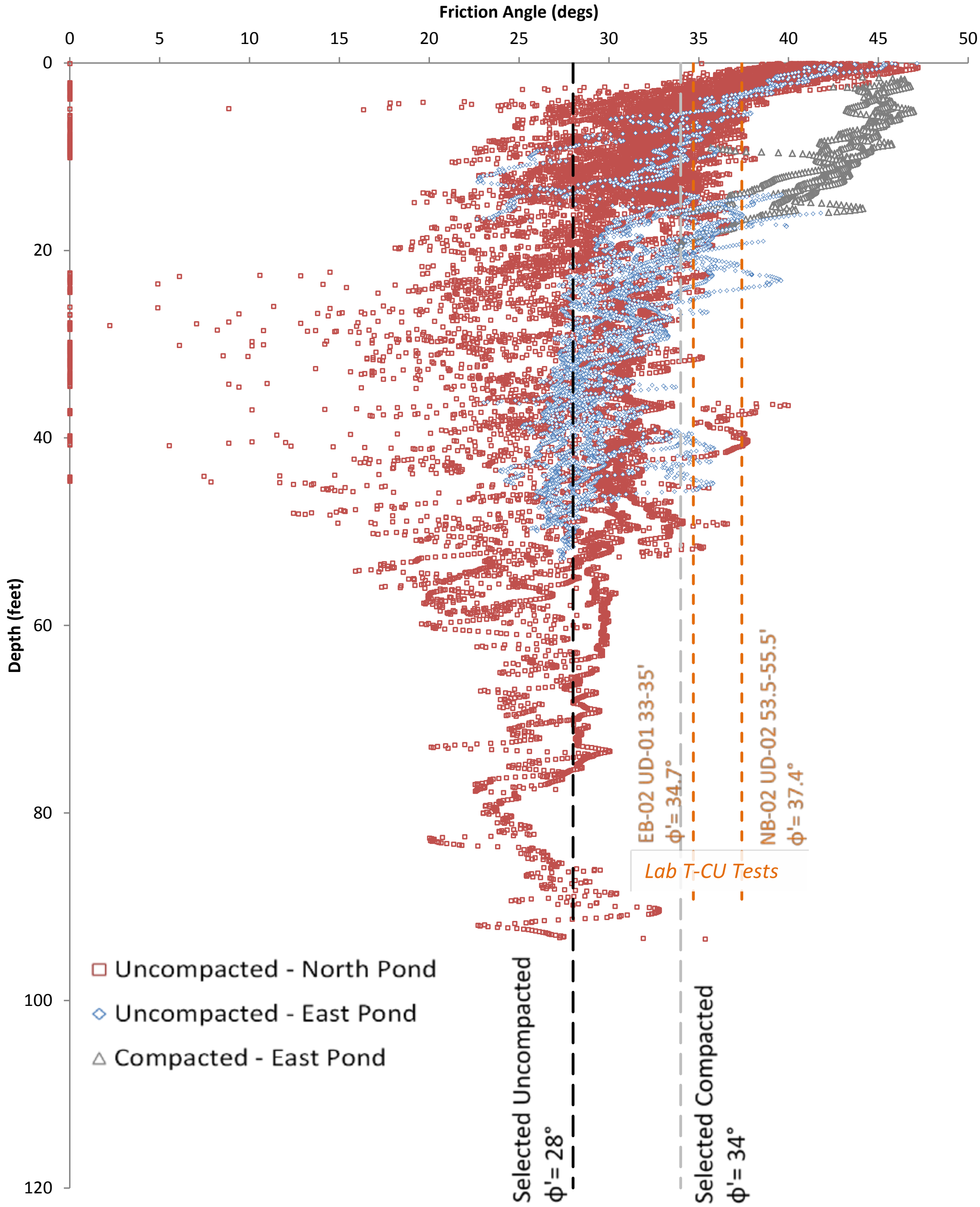
CCR Dry Unit Weight - NAP & EAP



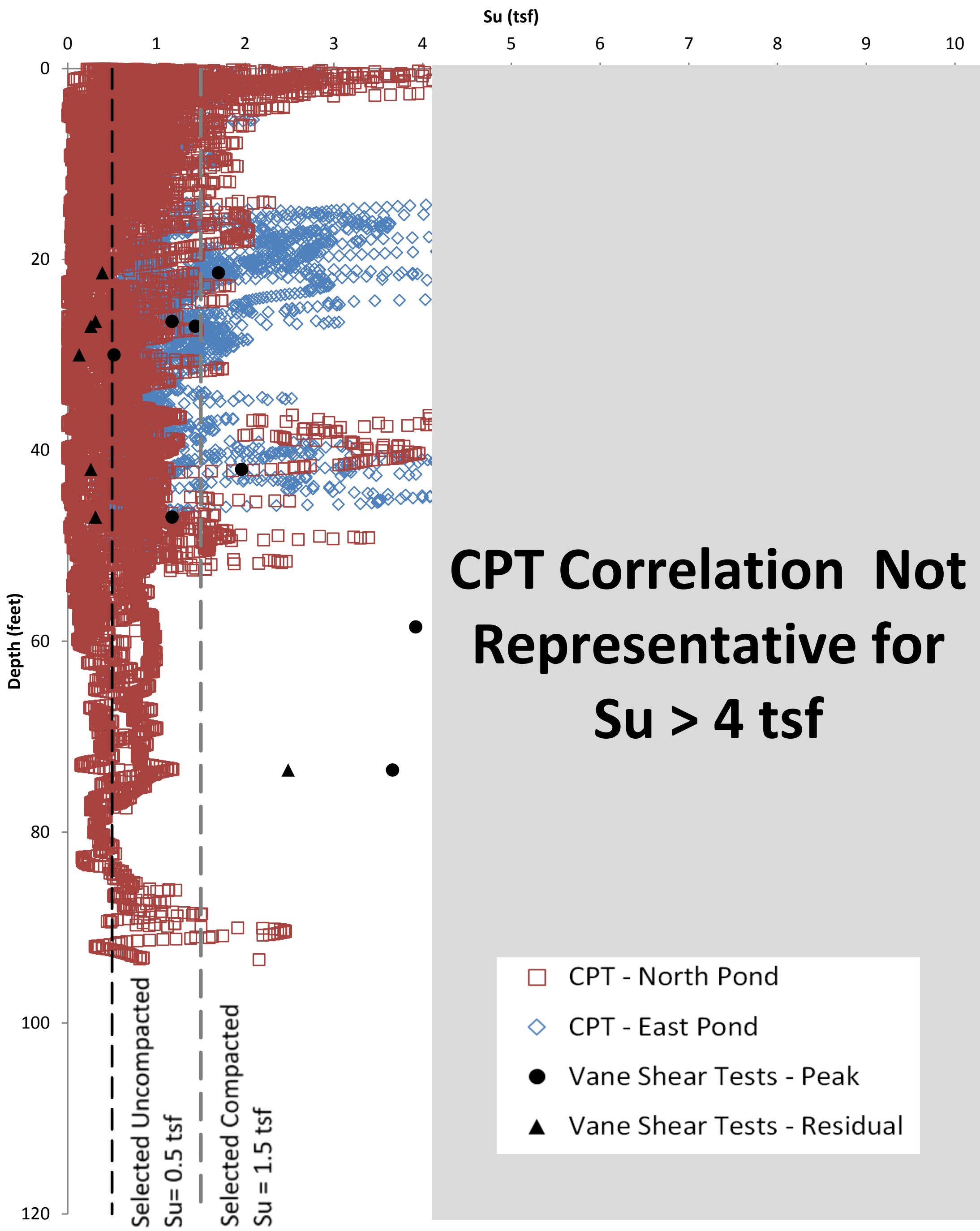
CCR Saturated Unit Weight - NAP & EAP



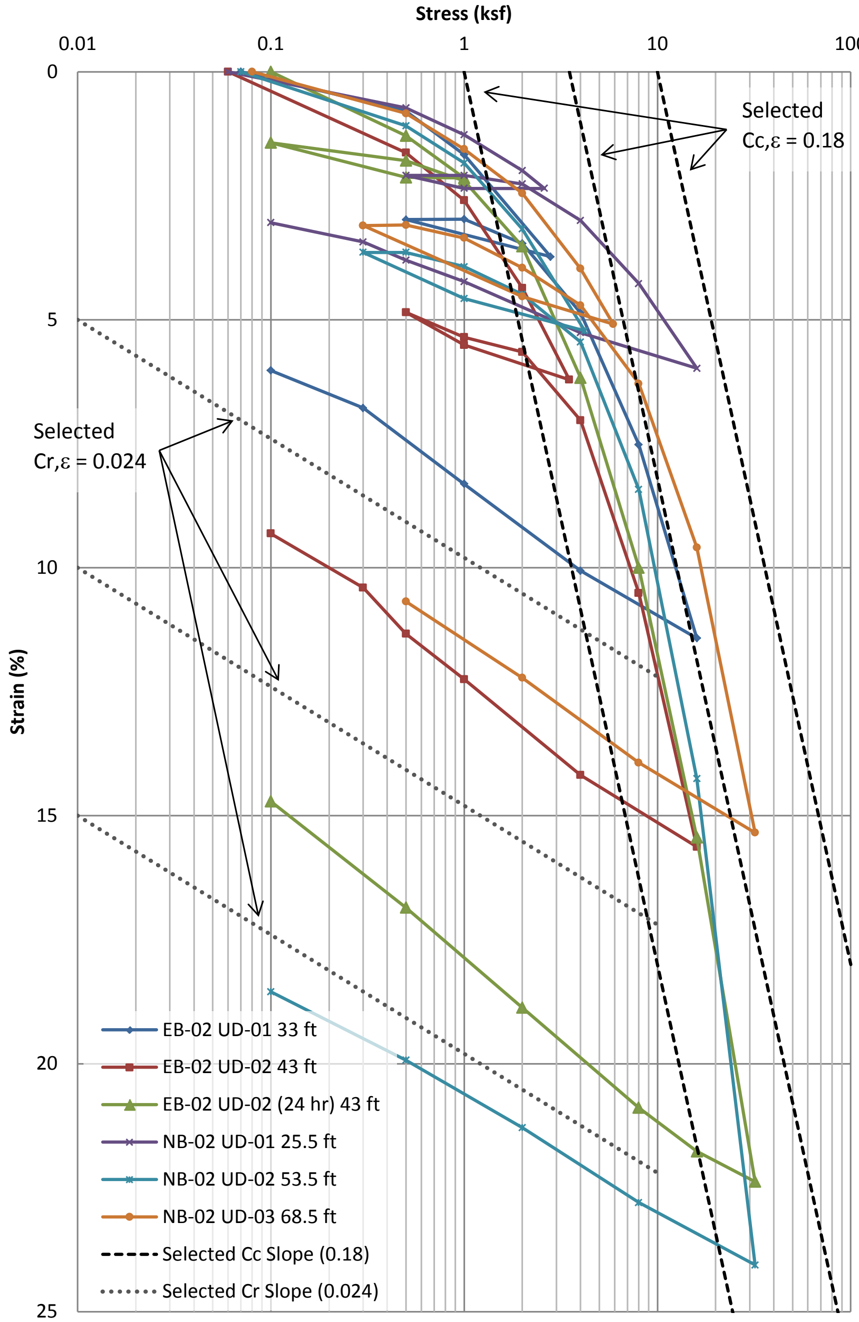
CCR Peak Phi-CPT & Lab Based

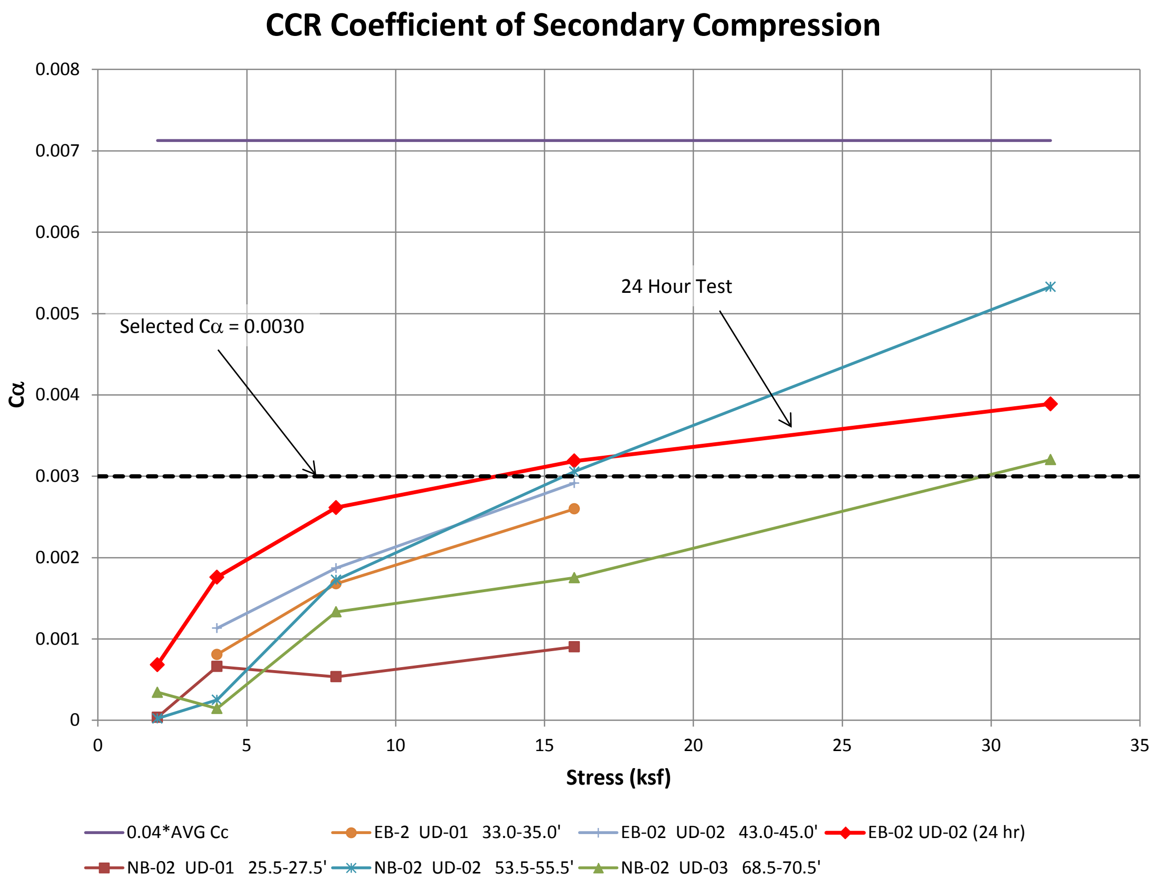


CCR Undrained Shear Strength (Su) -CPT Based

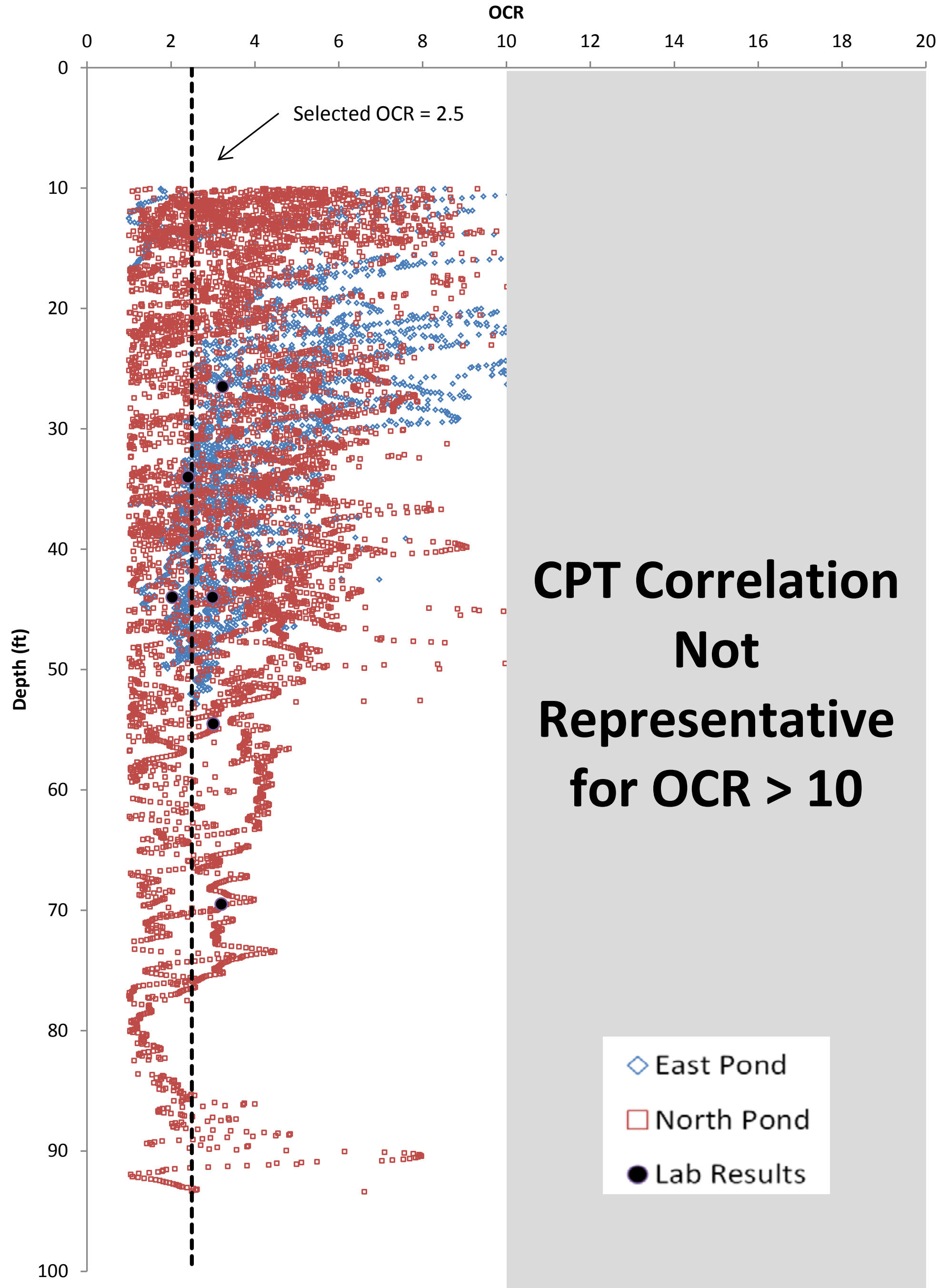


CCR Primary Consolidation Parameters - Lab

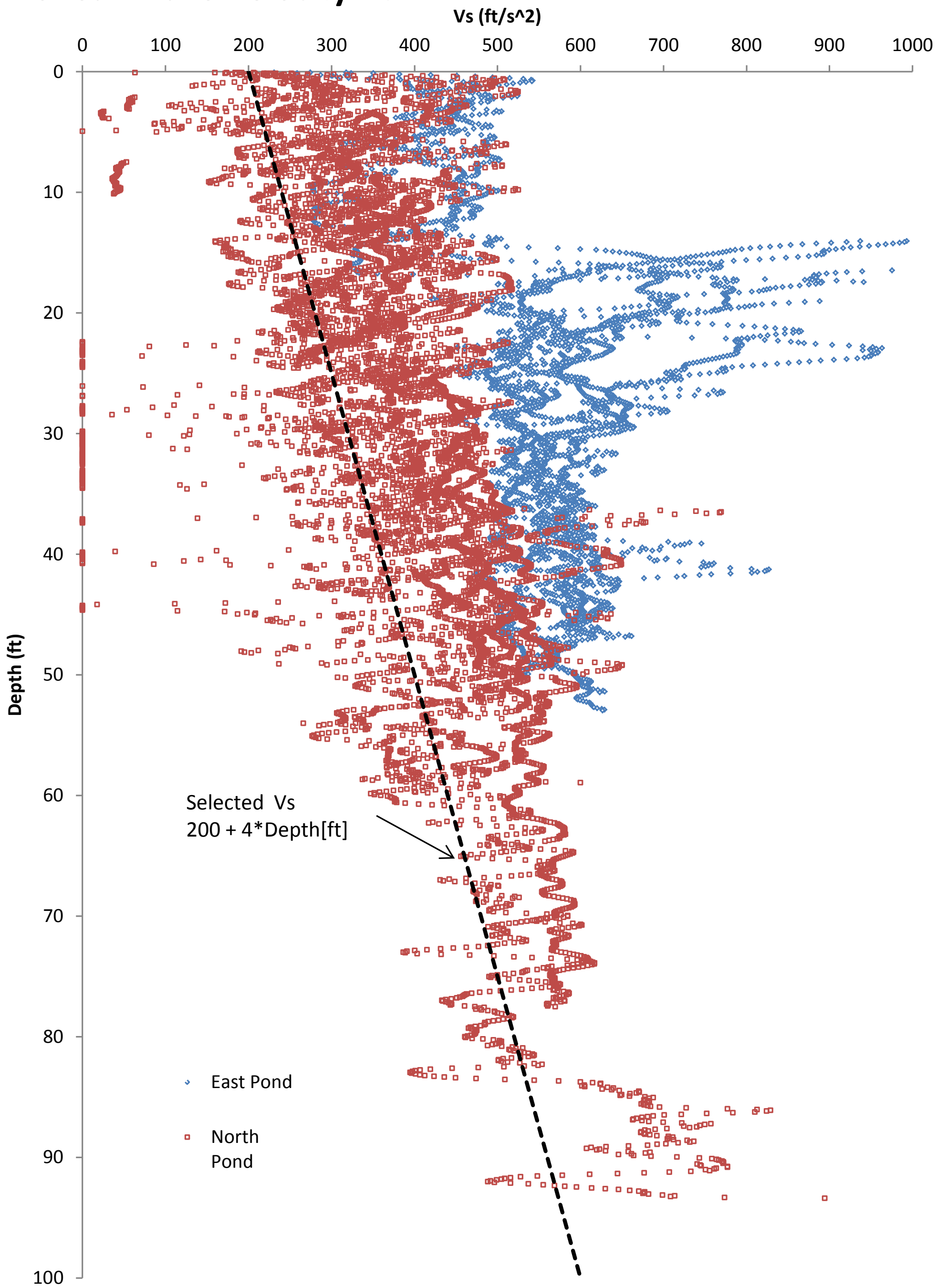



CCR Coefficient of Secondary Compression
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Cα
24 Hour Test
Selected Cα = 0.0030
0
5
10
15
20
25
30
35
Stress (ksf)
0.04*AVG Cc
EB-2 UD-01 33.0-35.0'
EB-02 UD-02 43.0-45.0'
EB-02 UD-02 (24 hr)
NB-02 UD-01 25.5-27.5'
NB-02 UD-02 53.5-55.5'
NB-02 UD-03 68.5-70.5'

CCR OCR - CPT + Lab



CCR Shear Wave Velocity - CPT



Objective

Develop strength parameters for the Dike Fill material at the East Ash Pond (EAP) and West Ash Pond (WAP) based on field and laboratory test results and accepted correlations and relationships.

Dike Fill Material Properties:

East and West Ash Pond Dikes

Basic properties for the EAP and WAP dike fill were evaluated based on laboratory testing and CPT correlations, summarized in the table below.

For stability and settlement analyses, a unit weight of 125 pcf was selected for the dike fill based on two criteria: (1) the unit weights correlated to CPT measurements and (2) unit weights directly measured from Shelby tube samples.

Other laboratory tests were used to determine strength and compressibility properties described below.

Summary of Geotechnical Testing Data - Basic Properties
East and West Ash Pond Dikes

Property		No. of Data Points (Borings)	Min	Max	Avg	Med
Primary Laboratory Tests - East Ash Pond						
Depth Range (ft)		-	9	49.6	22.3	17.0
Water Content (%)		8 (6)	12	30	24	24
Gravel (> 4.75 mm) (%)		5 (5)	0	5.9	1.2	0.0
Sand (%)		5 (5)	4.8	48.9	25.9	27.4
Fines (< 0.075 mm) (%)		6 (6)	51.1	95.2	74.1	74.9
Specific Gravity		2 (2)	2.71	2.76	2.74	2.74
Liquid Limit (LL) (%)		8 (6)	19	44	33	32
Plastic Limit (PL) (%)		8 (6)	15	33	22	22
Plasticity Index (PI)		8 (6)	4	18	11	11
Non Plastic Results		1	1 of 8			
Unit Weight (pcf)	Lab	2 (2)	125.8	126.3	126	126
	CPT interpreted	586 (1)	106	132	121	122
Primary Laboratory Tests - West Ash Pond						
Depth Range (ft)		-	9.5	34.5	22.3	22.9
Water Content (%)		6 (2)	22	26	24	23
Gravel (> 4.75 mm) (%)		2 (1)	0	0.2	0.1	0.1
Sand (%)		2 (1)	10.5	32.1	21.3	21.3
Fines (< 0.075 mm) (%)		4 (2)	58.8	89.5	74.7	75.3
Specific Gravity		1 (1)	2.72	2.72	2.72	2.72
Liquid Limit (LL) (%)		5 (2)	28	41	34	35
Plastic Limit (PL) (%)		5 (2)	19	25	22	23
Plasticity Index (PI)		5 (2)	8	17	11	11
Non Plastic Results		0	0 of 5			
Unit Weight (pcf)	Lab	1 (1)	127	127	127	127
	CPT interpreted	890 (4)	103	128	120	120

Selected Total Unit Weight (pcf)	
East Dike Fill	125
West Dike Fill	125

Strength Data

Strength parameters for the dike fill were evaluated based on in-situ and laboratory testing, summarized in the table below. A single set of strength parameters were selected for dike fill in both the EAP and WAP due to their similar origin (according to construction documents, both were constructed from alluvial sandy silts and clays underlying the CCR ponds) and similar behavior during laboratory and in-situ testing.

Laboratory and in-situ testing show two zones of drained strengths. The upper 20 feet contains material of higher strength, and a drained effective friction angle of 31° and cohesion of 50 psf were selected for the upper 20 feet. For depths greater than 20 ft, a reduced friction angle of 28° was selected. These values are based on CPT correlation, laboratory testing, and plasticity correlations plotted in the following pages.

Undrained strengths (Su) vary less with depth than drained strengths, so an undrained strength of 1.5 tsf was selected for all depths.

Summary of Geotechnical Strength Data East & West Pond Dikes						
	Property	***No. of Data Points (Borings)***	***Min***	***Max***	***Avg***	***Median***
East Ash Pond Dike Fill Soils						
Drilling	*SPT N (bpf)*	39 (6)	2	18	8	8
	φ' (°) (Meyerhof)		28.3	37.0	33.3	33.3
	φ' (°) (Peck et al.)		27.3	32.4	29.3	29.3
CPT Interpreted	*Peak φ' (°)*	586 (1)	23.1	47.1	33.4	31.9
	Su (tsf)		0.4	4.0	1.8	1.7
	SPT N_{60} (bpf)		6	41	12.5	12
	Norm. CPT Tip (Qtn)		3	481	49	20
Mesri and Shahien Correlations	*Fully Softened Strength*	7 (6)	Calculated Strength Based on Plasticity (mean PI = 11)			
	c' (psf)		46	111	77	77
	$(\phi'_{fs})_{tan}$		28.4	32.8	30.3	29.6
West Ash Pond Dike Fill Soils						
Drilling	*SPT N (bpf)*	9 (2)	4	25	13.4	12
	φ' (°) (Meyerhof)		30.0	38.8	35.8	35.5
	φ' (°) (Peck et al.)		28.0	34.5	30.9	30.6
CPT Interpreted	*Peak φ' (°)*	890 (4)	27	47.5	36.6	35.8
	Su (tsf)		0.4	4.0	1.9	1.9
	SPT N_{60} (bpf)		3	19	10.1	10
	Norm. CPT Tip (Qtn)		7	522	74	45
Mesri and Shahien Correlations	*Fully Softened Strength*	5 (2)	Calculated Strength Based on Plasticity (mean PI = 11)			
	c' (psf)		63	121	86	77
	$(\phi'_{fs})_{tan}$		28.4	31.7	30.2	29.6

Laboratory Tests

Lab Test			***Effective***		***Total***	
			ϕ (deg)	***c (psf)***	***ϕ (deg)***	***c (psf)***
CU Triaxial	EAP Dikes	GB-2 UD-01 8-10 ft	*28.3*	*245*	20.1	288
		GB-3 UD-01 16-18 ft	*26.4*	*86*	17.7	144
	WAP Dikes	WB-01 UD-01 20.5-22 ft	*28.3*	*101*	23.2	0

EAP & WAP Dike Fill Soils Material Strength Properties (EAP & WAP)			
Project Number:	**1520347**		
Project Name:	**Bremo Ash Pond Closure, Bremo Bluff, VA**		
Prepared by:	JGM	*Checked by:*	PDP
Date:	Oct 2015	*Reviewed by:*	GLH

Selected Strength Parameters EAP/WAP Fill		
0 - 20 ft	ϕ' (deg)	31
	c' (psf)	50
	Su (tsf)	1.5
> 20 ft	ϕ' (deg)	28
	c' (psf)	50
	Su (tsf)	1.5

Objective

Develop strength parameters for the Dike Fill material at the North Ash Pond (NAP) located at Bremo Power Station, Bremo Bluff, Virginia.

Dike Fill Material Properties:

North Ash Pond Dikes

Basic properties for the EAP and WAP dike fill were evaluated based on laboratory testing and CPT correlations, summarized in the table below.

For stability and settlement analyses, a unit weight of 125 pcf was selected for the dike fill. This selection is based on CPT correlations and Golder's experience.

Other laboratory tests were used to determine strength and compressibility properties described below.

Summary of Geotechnical Testing Data - Basic Properties
North Ash Pond Dikes

Property		No. Tests (Borings)	Min	Max	Avg	Med
Primary Laboratory Tests						
Depth Range (ft)		(4)	9.5	109.6	57.9	59.5
Water Content (%)		9 (2)	14	29	22	21
Gravel (> 4.75 mm) (%)		9 (2)	0	8	3	2
Sand (%)		9 (2)	47	67	59	62
Fines (< 0.075 mm) (%)		9 (2)	30	53	38	36
Specific Gravity		0	-	-	-	-
Liquid Limit (LL) (%)		4 (2)	32	46	39	38
Plastic Limit (PL) (%)		4 (2)	26	35	30	30
Plasticity Index (PI)		4 (2)	3	16	9	8
Non Plastic Results		0	0 of 4			
Unit Weight (pcf)	Lab	No Tubes Collected Due to Dense Fill and Gravel Inclusions				
	CPT interpreted	3235 (4)	104	137	128	128

Selected Total Unit Weight (pcf)	
North Dike Fill	125

Strength Data

Strength parameters for the dike fill were evaluated based on in-situ and laboratory testing, summarized in the table below.

Laboratory and in-situ testing show two zones of drained strengths. The upper 40 feet contains material of higher strength, and a drained effective friction angle of 31° and cohesion of 50 psf were selected for the upper 40 feet. For depths greater than 40 ft, a reduced friction angle of 28° was selected. These values are based on CPT correlation, laboratory testing, and plasticity correlations plotted in the following pages.

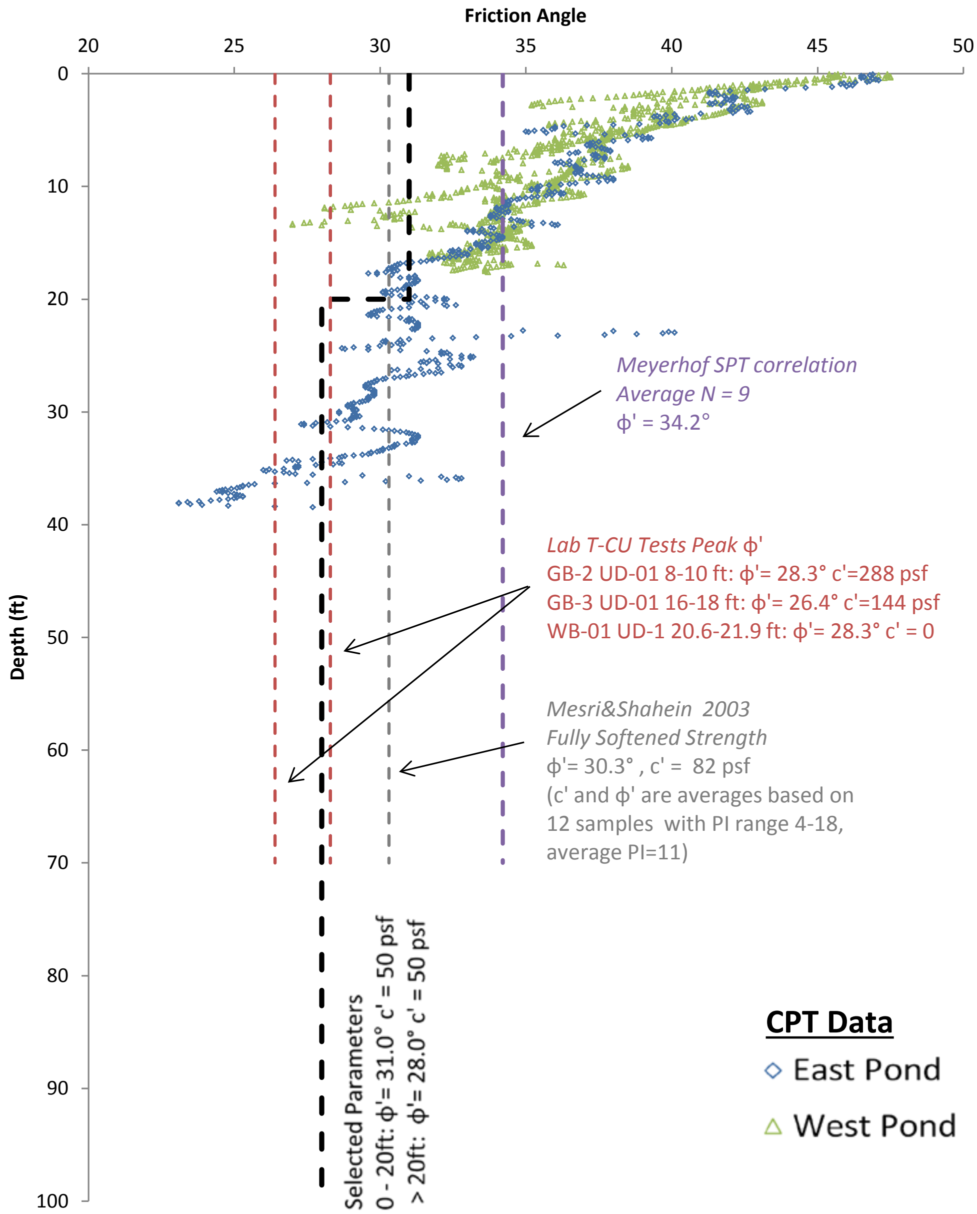
Undrained strengths (Su) vary less with depth than drained strengths, so an undrained strength of 2.0 tsf was selected for all depths.

Summary of Geotechnical Strength Data
North Ash Pond Dikes

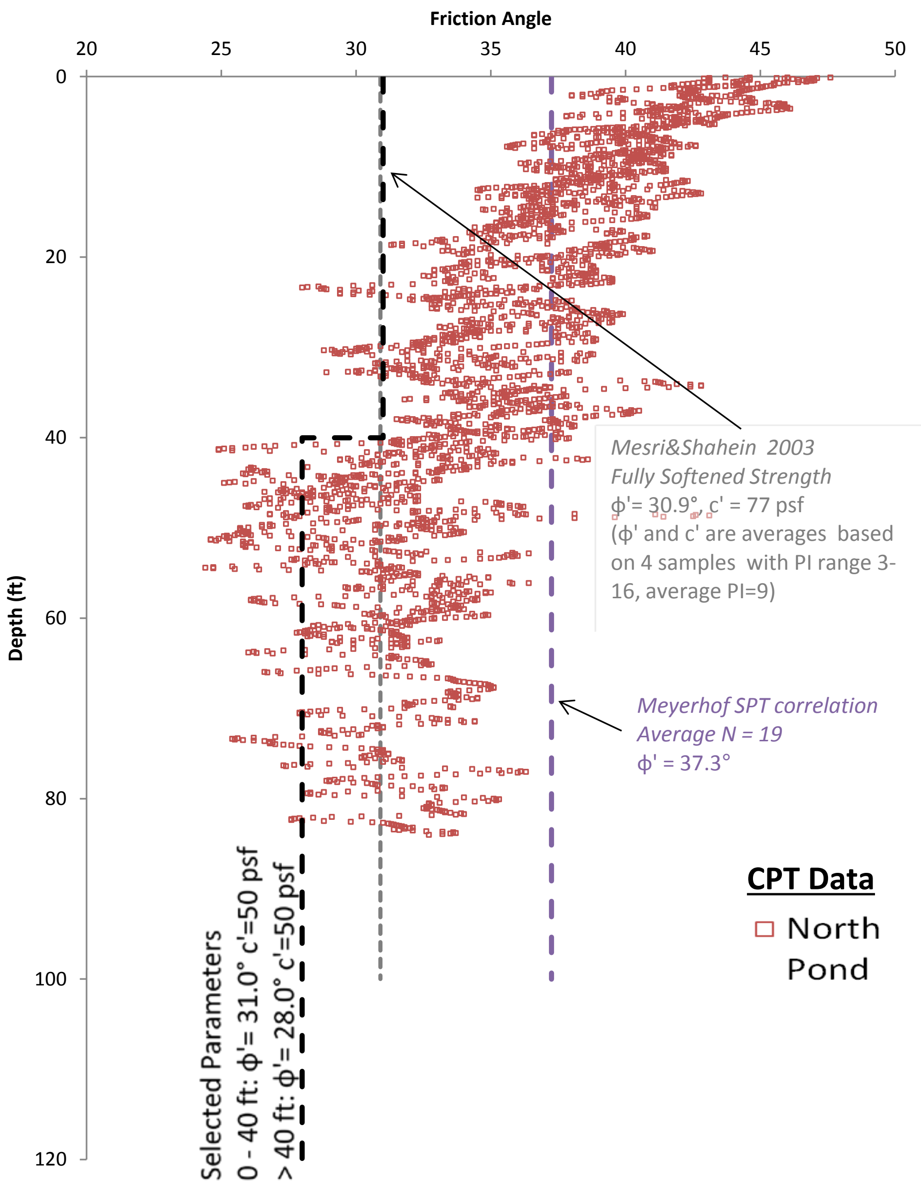
Property		***No. of Data Points (Borings)***	***Min***	***Max***	***Avg***	***Median***
North Dike Fill Soils						
Drilling	*SPT N (bpf)*	46 (2)	7	31	19	18
	φ' (°) (Meyerhof)		32.5	40.3	37.3	37.0
	φ' (°) (Peck et al.)		29.0	36.3	32.7	32.4
CPT Interpreted	*Peak φ' (°)*	3235 (4)	24.4	47.6	35.5	35
	Su (tsf)		0.7	4.0	2.7	2.8
	SPT N_{60} (bpf)		2	100	27.2	25
	Norm. CPT Tip (Qtn)		4	529	64	39
Mesri and Shahien Correlations	*Fully Softened*	4 (2)	Calculated Strength Based on Plasticity (mean PI = 9)			
	c' (psf)		46	121	79	75
	$(\phi'_{fs})_{tan}$		28.4	32.8	30.9	31.2

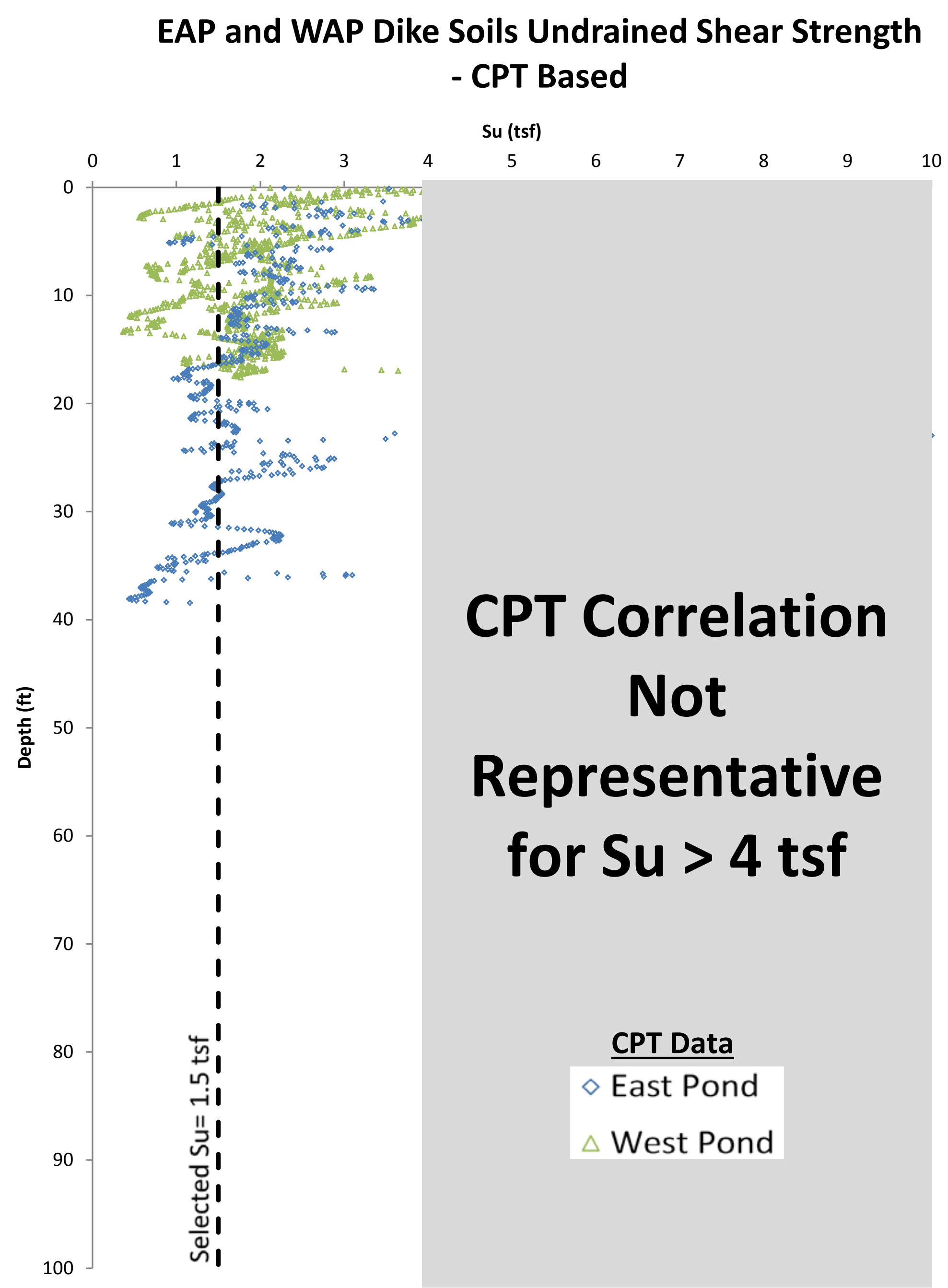
Selected Strength Parameters NAP Fill		
0 - 40 ft	ϕ' (deg)	31
	c' (psf)	50
	Su (tsf)	2.0
> 40 ft	ϕ' (deg)	28
	c' (psf)	50
	Su (tsf)	2.0

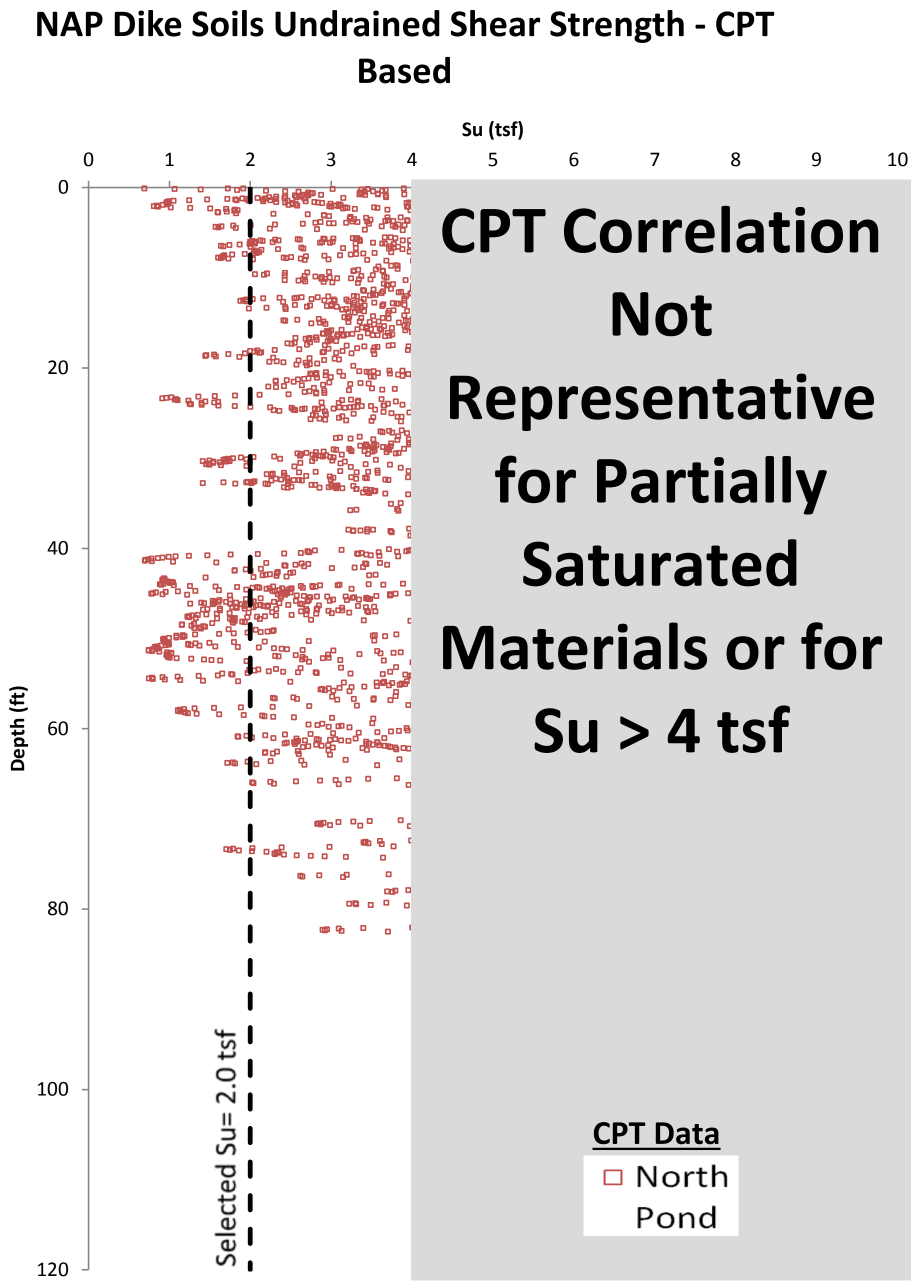
East and West Pond Dike Soils Peak Phi - CPT & Lab Based



North Pond Dike Soils Peak Phi- CPT & Lab Based




EAP and WAP Dike Soils Undrained Shear Strength
- CPT Based
Su (tsf)
0
1
2
3
4
5
6
7
8
9
10
Depth (ft)
0
10
20
30
40
50
60
70
80
90
100
Selected Su= 1.5 tsf
CPT Correlation Not Representative for Su > 4 tsf
CPT Data
East Pond
West Pond


NAP Dike Soils Undrained Shear Strength - CPT Based
Su (tsf)
0
1
2
3
4
5
6
7
8
9
10
Depth (ft)
0
20
40
60
80
100
120
CPT Correlation Not Representative for Partially Saturated Materials or for Su > 4 tsf
Selected Su= 2.0 tsf
CPT Data
North Pond

Objective

Determine strength parameters for the Alluvium material at the East, West and North Ash Ponds located at Bremo Power Station, Bremo Bluff, Virginia.

Alluvium Material Properties:

Basic properties for the alluvium were evaluated based on field observation and CPT correlations.

For stability and settlement analyses, a unit weight of 115 pcf was selected for the alluvium based on unit weights correlated to CPT measurements.

The alluvial material was not sampled sufficiently for laboratory testing.

Summary of Geotechnical Testing Data - Basic Properties Alluvium						
Property		**No. Tests (Soundings)**	**Min**	**Max**	**Avg**	**Med**
Unit Weight (pcf)	CPT interpreted	2907 (19)	90	140	118	116

Selected Total Unit Weight (pcf)	
Alluvium	115

Strength Data

Strength parameters for the alluivum were evaluated based on in-situ and laboratory testing, summarized in the table below.

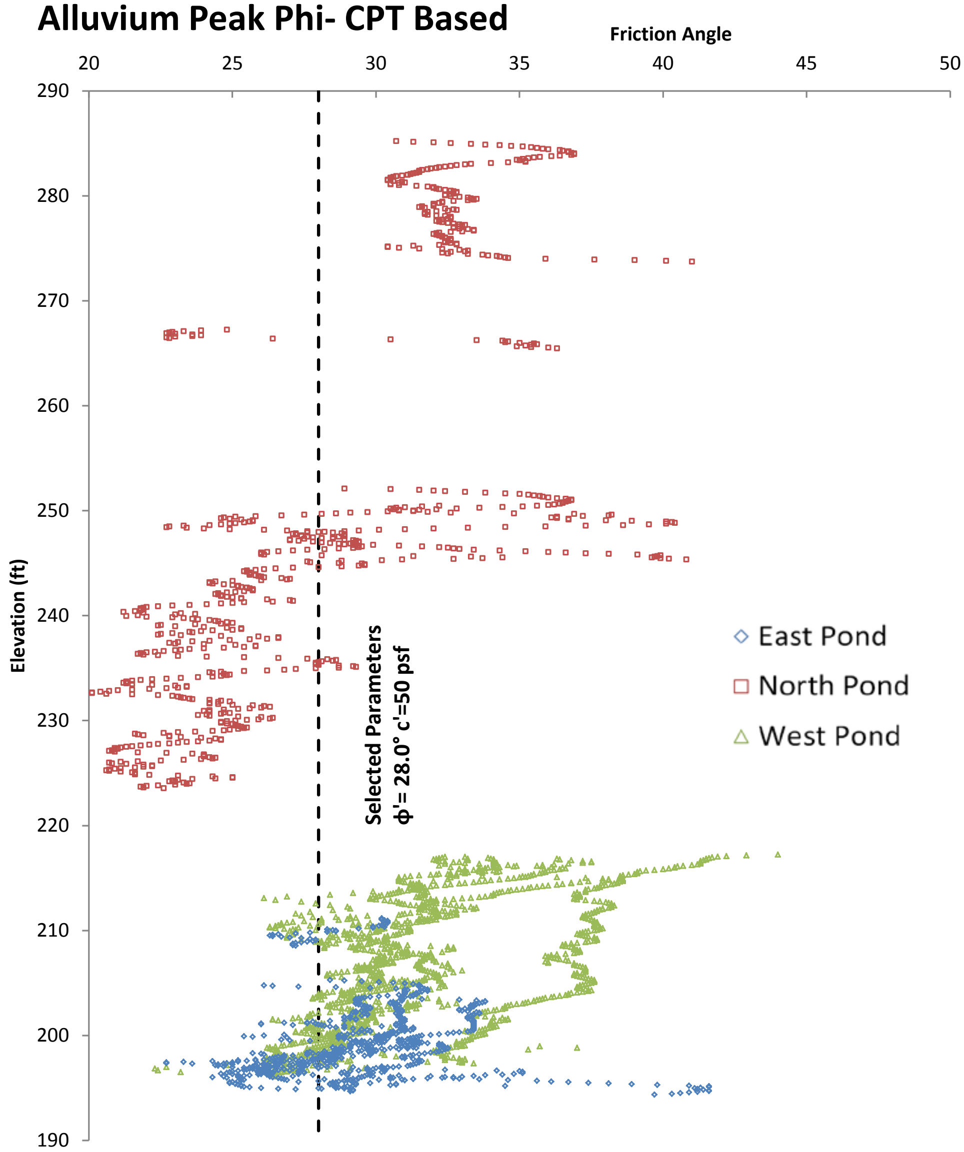
A drained friction angle of 28° with a cohesion of 50 psf was selected for the alluvium material. These values are based on in-situ testing (CPT and SPT correlation). Strength correlations are plotted in the following pages.

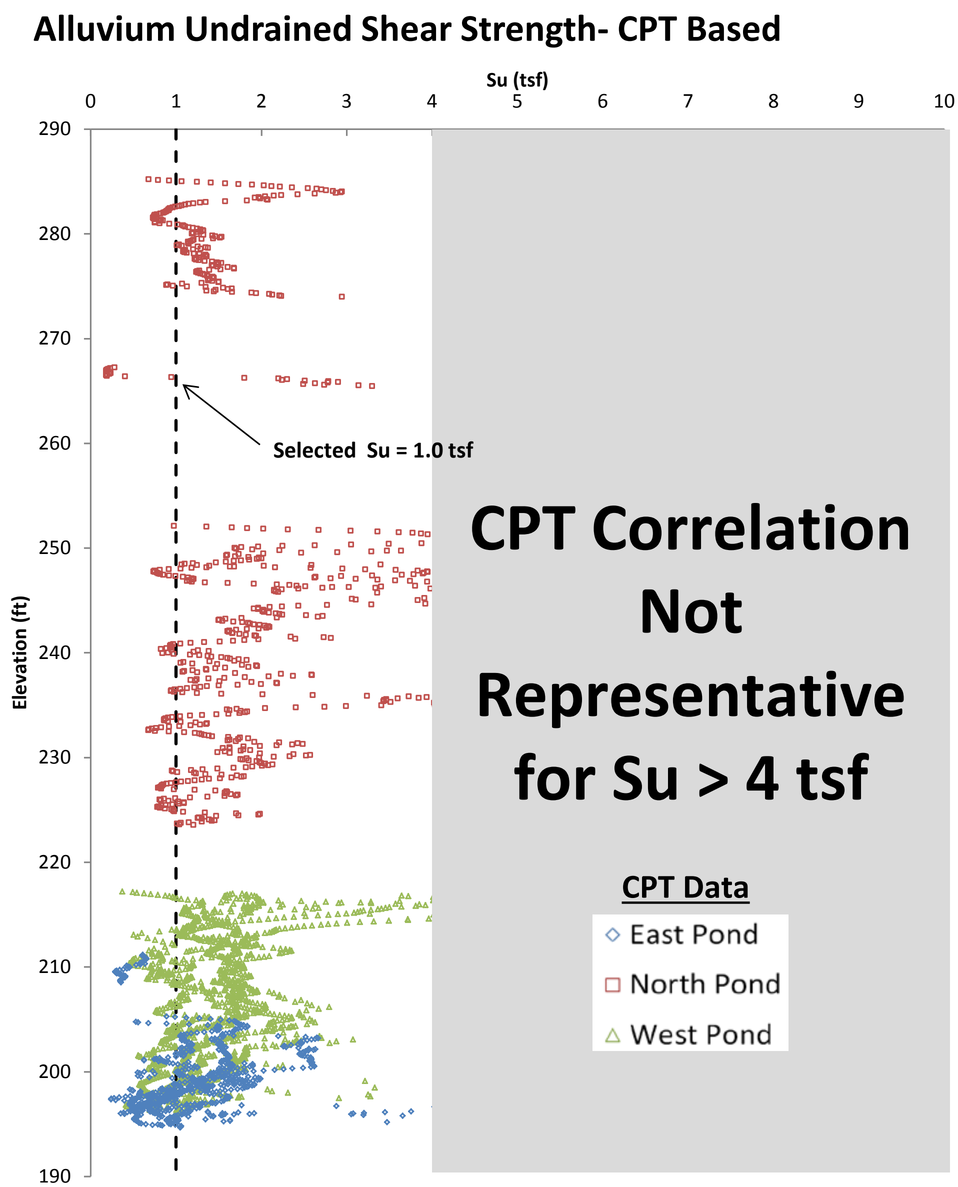
An undrained strength of 1.0 tsf was selected for all depths based on in-situ testing (CPT correlation).

Summary of Geotechnical Strength Data Alluvium						
Property		***No. of Data Points (Borings)***	***Min***	***Max***	***Avg***	***Median***
North Dike Fill Soils						
Drilling	*SPT N (bpf)*	21 (12)	0	15	7	8
	φ' (°) (Meyerhof)		#N/A	36.3	32.5	33.3
	φ' (°) (Peck et al.)		#N/A	31.5	29.0	29.3
CPT Interpreted	*Peak φ' (°)*	2907 (19)	20.1	44.0	30.4	30.1
	Su (tsf)		0.2	10	1.7	1.4
	SPT N_{60} (bpf)		2	70	13	11
	Norm. CPT Tip (Qtn)		1.7	253.2	20.7	13.6

Selected Strength Parameters		
Alluvium	ϕ' (deg)	28
	c' (psf)	50
	Su (tsf)	1.0

Alluvium Peak Phi- CPT Based




Alluvium Undrained Shear Strength- CPT Based
Su (tsf)
0
1
2
3
4
5
6
7
8
9
10
290
280
270
260
250
240
230
220
210
200
190
Elevation (ft)
Selected Su = 1.0 tsf
CPT Correlation Not Representative for Su > 4 tsf
CPT Data
East Pond
North Pond
West Pond

Objective

Determine strength parameters for the Residuum material at the East, West, and North Ash Ponds located at Bremo Power Stataion, Bremo Bluff, Virginia.

Residuum Material Properties:

All Ash Ponds

Basic properties for the Residuum were evaluated based on laboratory testing and CPT correlations and are summarized in the table below.

For stability and settlement analyses, a unit weight of 125 pcf was selected for the residuum. This selection is based on CPT correlations.

Other laboratory tests used to determine strength and compressibility properties are described below.

Summary of Geotechnical Testing Data - Basic Properties Residuum						
Property		**No. Tests (Borings)**	**Min**	**Max**	**Avg**	**Med**
Primary Laboratory Tests						
Depth Range (ft)		-	84.2	114.5	99.3	99.3
Water Content (%)		2 (2)	7	28	17	17
Gravel (> 4.75 mm) (%)		1 (1)	2	2	2	2
Sand (%)		1 (1)	39	39	39	39
Fines (< 0.075 mm) (%)		1 (1)	59	59	59	59
Specific Gravity		0	-	-	-	-
Liquid Limit (LL) (%)		1 (1)	43	2	2	2
Plastic Limit (PL) (%)		1 (1)	28	28	28	28
Plasticity Index (PI)		1 (1)	15	15	15	15
Non Plastic Results		0	0 of 1			
Unit Weight (pcf)	Lab	No Shebly Tubes Aquired in Alluvium				
	CPT interpreted	1721 (7)	107	140	126	125

Selected Total Unit Weight (pcf)	
Residuum	125

CPT Interpreted Data

Strength parameters for the residuum were evaluated based on in-situ and laboratory testing, summarized in the table below.

A drained friction angle of 28° with a cohesion of 50 psf was selected for the residuum material. These values are based on in-situ testing (CPT and SPT correlation) and plasticity correlation from laboratory tests. Strength correlations are plotted in the following pages.

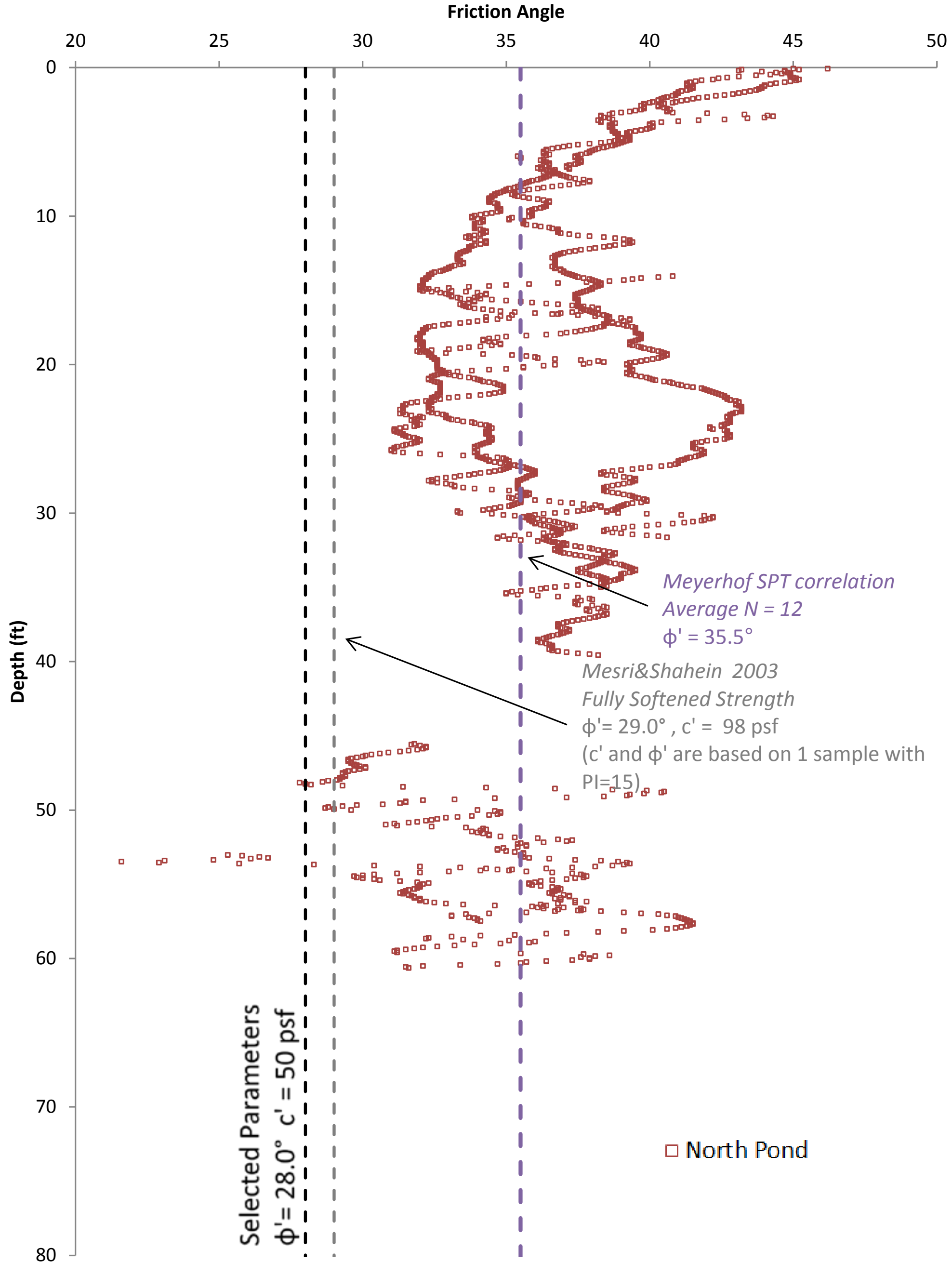
An undrained strength of 2.0 tsf was selected for all depths based on in-situ testing (CPT correlation).

Summary of Geotechnical Strength Data
North Ash Pond Dikes

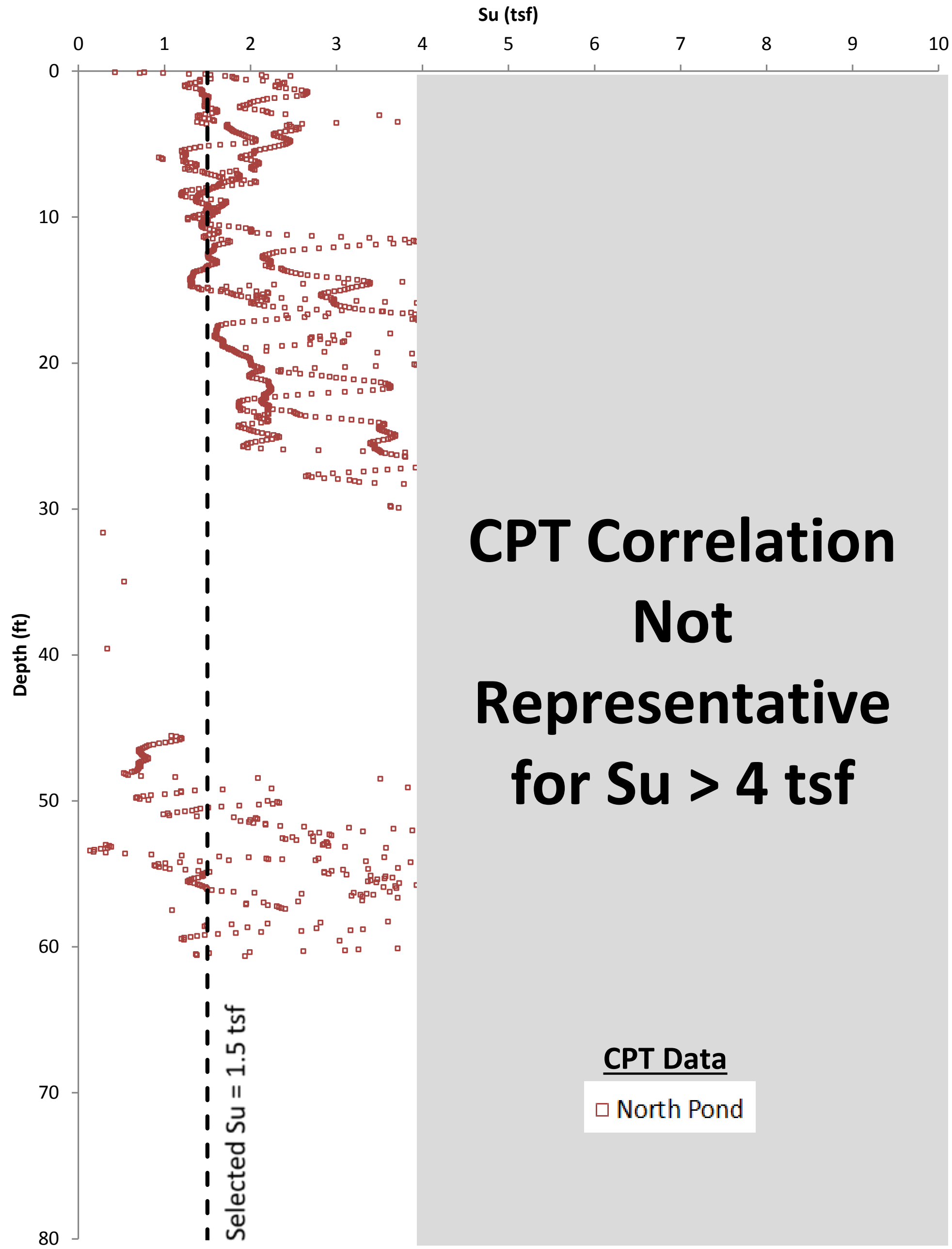
Property		No. of Data Points (Borings)	Min	Max	Avg	Median
North Dike Fill Soils						
Drilling	*SPT N (bpf)*	3 (3)	4	26	12	7
	φ' (°) (Meyerhof)		30.0	39.0	35.5	32.5
	φ' (°) (Peck et al.)		28.0	34.8	30.6	29.0
CPT Interpreted	*Peak φ' (°)*	1721 (7)	21.6	46.2	36.4	36.4
	Su (tsf)		0.1	10.0	4.1	2.9
	SPT N60 (bpf)		2	58	21	16
	Qtn		2.3	397.3	65.2	51.3
Mesri and Shahien Correlations	*Fully Softened*	1 (1)	(mean PI = 15)			
	c' (psf)		98	98	98	98
	$(\phi'_{fs})_{tan}$		29.0	29.0	29.0	29.0

Selected Strength Parameters		
Residuum	ϕ' (deg)	28
	c' (psf)	50
	Su (tsf)	1.5

Residuum Peak Phi- CPT Based



Residuum Undrained Shear Strength - CPT Based



Objective

Determine strength parameters for the clay liner material in the extension section of the East Ash Pond located at Bremo Power Station, Bremo Bluff, Virginia.

Clay Liner Material Properties:

Basic properties for the clay liner found in the vertical expansion of the East Ash Pond were evaluated based on field observation and CPT correlations.

For stability and settlement analyses, a unit weight of 125 pcf was selected for the clay liner based on unit weights of similar materials found onsite and Golder's experience.

The clay liner material was not sampled sufficiently for laboratory testing.

Selected Total Unit Weight (pcf)	
Clay Liner	125

Strength Data

Strength parameters for the clay liner were evaluated based on in-situ CPT testing, summarized in the table below.

A drained friction angle of 26° with a cohesion of 50 psf was selected for the clay liner material.

An undrained strength of 0.25 tsf was selected for all depths based on in-situ testing (CPT correlation).

Summary of Geotechnical Strength Data Clay Liner						
Property		***No. of Data Points (Borings)***	***Min***	***Max***	***Avg***	***Median***
North Dike Fill Soils						
CPT Interpreted	*Peak φ' (°)*	2907 (19)	23.7	29.5	26.1	26.1
	Su (tsf)		0.17	0.55	0.29	0.27
	SPT N_{60} (bpf)		2	4	3	3
	Norm. CPT Tip (Qtn)		3.6	12.0	6.3	5.9

Selected Strength Parameters		
Existing Clay Liner in EAP	ϕ' (deg)	26
	c' (psf)	50
	Su (tsf)	0.25

Attachment 3

Liquefaction Analyses

Date:	8/14/15	**Made by:**	Aaron Geiger
Project No.:	1520347	**Checked by:**	Sal Romero
Subject:	Liquefaction Assessment for North and East Ash Ponds	**Reviewed by:**	Gregory Hebeler
Project Short Title:	**DOMINION / BREMO ASH POND CLOSURES / VA**		

1.0 OBJECTIVE

Perform liquefaction analyses for coal combustion residuals (CCR) storage ponds at Bremo Power Station (Bremo) based upon cone penetrometer test (CPT) data.

2.0 METHODOLOGY

CPTs were performed as part of Golder's 2015 geotechnical investigation. The factor of safety against liquefaction was determined using the procedure discussed during the 1996 and 1998 NCEER/NSF Workshop on liquefaction evaluation (Youd et al 2001). The ratio of the cyclic stress ratio (CSR) to the cyclic resistance ratio (CRR) gives the factor of safety against liquefaction. FS values less than 1.2 are considered to liquefy during a given seismic event per the EPA CCR Rule.

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 ground acceleration (PGA), 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

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

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

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

$$r_d = 0.50 \quad for\ z > 30\ m$$

where z is the depth in meters.

2.1.1 Peak Ground Acceleration (a_{max}) from Attenuation Relationships

The 2008 USGS seismic hazard maps represent the ground motions at a site based on the probabilistic analysis of all sources contributing to the hazard at the site. A probabilistic seismic hazard (PSH) deaggregation analysis at the site is shown on Figure 1 for the 2% probability of exceedance in 50 years (USGS 2008). The deaggregation shows the contribution of earthquake magnitude and distance to the seismic hazard. An earthquake with a magnitude of 5.64 at a distance of 30.5 km represents the mean contributor for the 2% probability of exceedance in 50 years (return period = 2475 years).

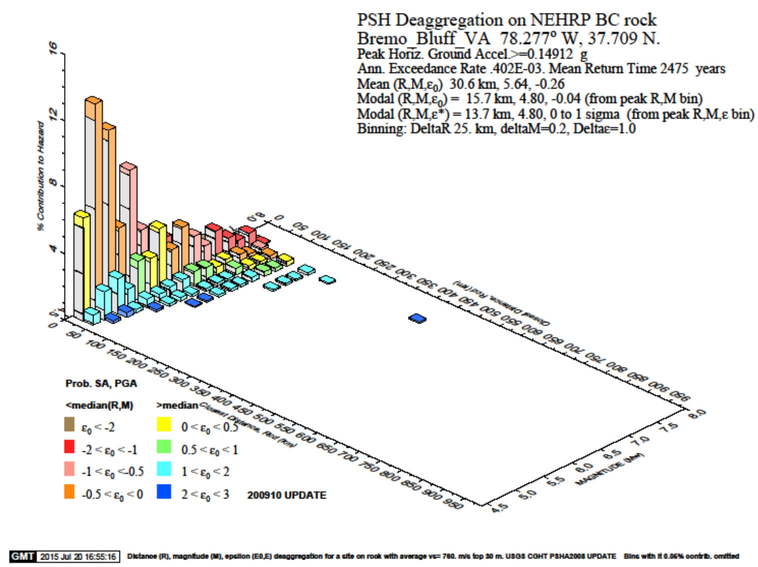


Figure 1-2008 USGS Seismic Hazard Deaggregation, 2% Probability of Exceedance in 50 years

The ground motion at the site was determined from the relationship developed by Atkinson and Boore (2006) for the Eastern United States as given by:

$$\log PGA = c_1 + c_2 M + c_3 M^2 + (c_4 + c_5 M) f_1 + (c_6 + c_7 M) f_2 + (c_8 + c_9 M) f_0 + c_{10} R_{cd} + S$$

where

$f_0 = \max(\log(R_0/R_{cd}), 0)$

$f_1 = \min(\log R_{cd}, \log R_1)$

$f_2 = \max(\log(R_{cd}/R_2), 0)$

$R_0=10$, $R_1=70$, $R_2=140$, R_{cd}=Closest Distance to Fault, M=Moment Magnitude

S=Site Amplification Factor (See below)

The following table presents the coefficients used to obtain the PGA, based on the NEHRP BC Boundary (Vs30=760m/s):

Table 1-Coefficients for Use in the Atkinson and Boore (2008) Method

c_1	5.23E-01
c_2	9.69E-01
c_3	-6.20E-02
c_4	-2.44E+00
c_5	1.47E-01
c_6	-2.34E+00
c_7	1.91E-01
c_8	-8.70E-02
c_9	-8.29E-02
c_{10}	-6.30E-04

The site amplification factor S is calculated based on the weighted average shear wave velocity in the upper 30 meters of soil and rock (V_{s30}). The following equations and constants were used in determining S for each earthquake in the deaggregation.

$$S = \log\{\exp[b_{lin} \ln(V_{s30}/V_{ref}) + b_{nl} \ln\left(\frac{60}{100}\right)\}$$, where $PGA_{BC} <= 60\ cm/s^2$

$$S = \log\{\exp[b_{lin} \ln(V_{s30}/V_{ref}) + b_{nl} \ln\left(\frac{PGA_{BC}}{100}\right)\}$$, where $PGA_{BC} > 60\ cm/s^2$

$$b_{nl} = b_1\ for\ V_{s30} \leq v_1$$

$$b_{nl} = (b_1 - b_2) \ln \frac{\frac{V_{30}}{v_2}}{\ln\left(\frac{v_1}{v_2}\right)} + b_2,\ for\ v_1 < V_{s30} \leq v_2$$

$$b_{nl} = b_2 \ln \frac{\frac{V_{30}}{V_{ref}}}{\ln\left(\frac{v_2}{V_{ref}}\right)},\ for\ v_2 < V_{s30} \leq V_{ref}$$

$$b_{nl} = 0\ for\ V_{s30} > V_{ref}$$

$$V_{ref} = 760, v_1 = 180, v_2 = 300$$

$$For\ PGA, b_{lin} = -0.361, b_1 = -0.641, b_2 = -0.144$$

$$V_{s30} = \frac{\sum d}{\sum \frac{d_i}{V_{si}}}$$

where PGA_{BC} is the peak ground acceleration for the BC Boundary (assumes S=0).

Most CPTs refused on partially weathered rock before they reached the 30-meter mark. Therefore, a velocity of 1350 ft/s (approximately 411 m/s) was assumed for the remainder of the 30-meter profile, which is typical for bedrock material.

Golder selected the mean moment magnitude from the 2008 USGS Seismic Hazard Map for 2% in 50 years. For the selected amax, Golder used an average of the calculated amax values, which take amplification into account. This was done for 4 selected CPTs. Two CPTs represented the East Ash Pond and two CPTs represented the North Ash Pond. The selected parameters are presented in the following table.

Table 2: Summary of Earthquake Parameters for Selected Bremo CPTs

CPT-ID	Ash Pond	Moment Magnitude (M)	Peak Ground Acceleration (PGA or a_{max})
NC-10	North	5.6	0.109
NC-12	North		0.068
EC-07	East		0.065
EC-10	East		0.062

Note: NC-10 was pushed for 30 m (100 ft); The remaining three refused on rock before reaching 30 m (100 ft).

2.2 CRR Determination

The CRR is calculated based on CPT data. The CRR for an earthquake magnitude (M) of 7.5 is given as the following (Robertson and Wride 1998):

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

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

where $(q_{c1N})_{cs}$ is the clean sand cone penetration resistance normalized to approximately 100 kPa (1 atm).

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

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

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

where C_Q is the normalizing factor for cone penetration resistance, Pa is 1 atmosphere of pressure or 100 kPa, 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 exponent n is:

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

where

$$I_c = [(3.47 - logQ_t)^2 + (1.22 + logF_r)^2]^{0.5}$$

$$Q_{tn} = \left[\frac{q_c - \sigma_{vo}}{P_a}\right]\left[\left(\frac{P_a}{\sigma'_{vo}}\right)^n\right]$$

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

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

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

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

and K_c was assumed to be 1.371. The assumption for Kc is based on Ic=2.05, which is the boundary between soil behavior type zones 5 and 6 (sandy mixtures and clean to silty sands, respectively) as presented by Robertson & Wride (1998).

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

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

The magnitude scaling factors are based on Idriss as presented in Youd et al. (2001) and equal to

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

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 (i.e., every recorded CPT depth reading within each of the evaluated soundings). The calculations of CSR and CRR for the 4 CPTs are attached

3.0 LIQUEFIED UNDRAINED SHEAR STRENGTH

Two methods to estimate the magnitude of the undrained shear strength of liquefied materials [termed the residual or liquefied shear strength (s_r or $s_{u(liq)}$)] have been proposed as a function of the CPT tip resistance. Robertson (2010) uses the normalized cone penetration resistance corrected to a clean sand ($Q_{tn,cs}$) whereas Olson and Stark (2003) uses the cone penetration resistance corrected for overburden stress (q_{c1}).

Robertson (2010) estimated the liquefied undrained shear strength ratio ($s_{u(liq)}/\sigma'_{vo}$) as a function of the normalized cone penetration resistance corrected to an equivalent clean sand

$$\frac{s_{u(liq)}}{\sigma'_v} = \frac{0.02199 - 0.0003124Q_{tn,cs}}{1 - 0.02676Q_{tn,cs} + 0.0001783\left(Q_{tn,cs}\right)^2}$$

and is valid for $Q_{tn,cs} \leq 70$. Robertson (2010) observed materials are not susceptible to strength loss for $Q_{tn,cs} > 70$.

Olson and Stark (2003) developed $s_{u(liq)}/\sigma'_{vo}$ from CPT data by back-analyzing a series of known flow failures and is defined as

$$\frac{s_{u(liq)}}{\sigma'_v} = 0.03 + 0.0143(q_{c1}) \pm 0.03 \;\; for\ q_{c1} \leq 6.5MPa$$

where q_{c1} is in MPa and is approximately given by

$$q_{c1} \approx q_c C_N$$

The liquefied undrained shear strength ratios for the 2015 Bremo CPTs were calculated and are presented in the attached CPT plots. The average liquefied strength ratio for 2015 CPTs is 0.04, which is an average of the Robertson ratio and the Olson and Stark ratio.

For material that is subject to liquefy, the liquefied (residual) undrained shear strength ratio should be used in slope stability analyses to evaluate the factor of safety for slope stability if the material liquefies.

4.0 CONCLUSIONS

Table 3 summarizes the calculated factors of safety against liquefaction for the evaluated CPTs across each of the evaluated earthquake scenarios considered.

Table 3 – Summary of Liquefaction Analyses

Scenario	Calculated Liquefaction Factor of Safety <1.2?
NC-10	**YES**
NC-12	**NO**
EC-07	**NO**
EC-10	**NO**

The results presented in the attached CPT plots and summarized in Table 3 show that the North Ash Pond is most likely to liquefy in a seismic event and the East Pond is unlikely to liquefy. As a result, the slope stability analysis for the North Ash Pond includes scenarios where liquefaction occurs and uses a liquefied undrained shear strength ratio of 0.04 as calculated from the CPT correlations.

5.0 ATTACHMENTS

CPT Liquefaction Analysis Plots for NC-10, NC-12, EC-07, and EC-10

6.0 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.

Golder Associates Inc., (2015) Draft 30% Design Geotechnical Data Report, May 2015.

Olson, Scott M. and Timothy D. Stark (2003) "Yield Strength Ratio and Liquefaction Analysis of Slopes and Embankments," *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 129, No. 8, pp. 727-737.

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.

Robertson, P.K. (2010) "Evaluation of Flow Liquefaction and Liquefied Strength Using the Cone Penetration Test," *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 136, No. 6, pp. 842-853.

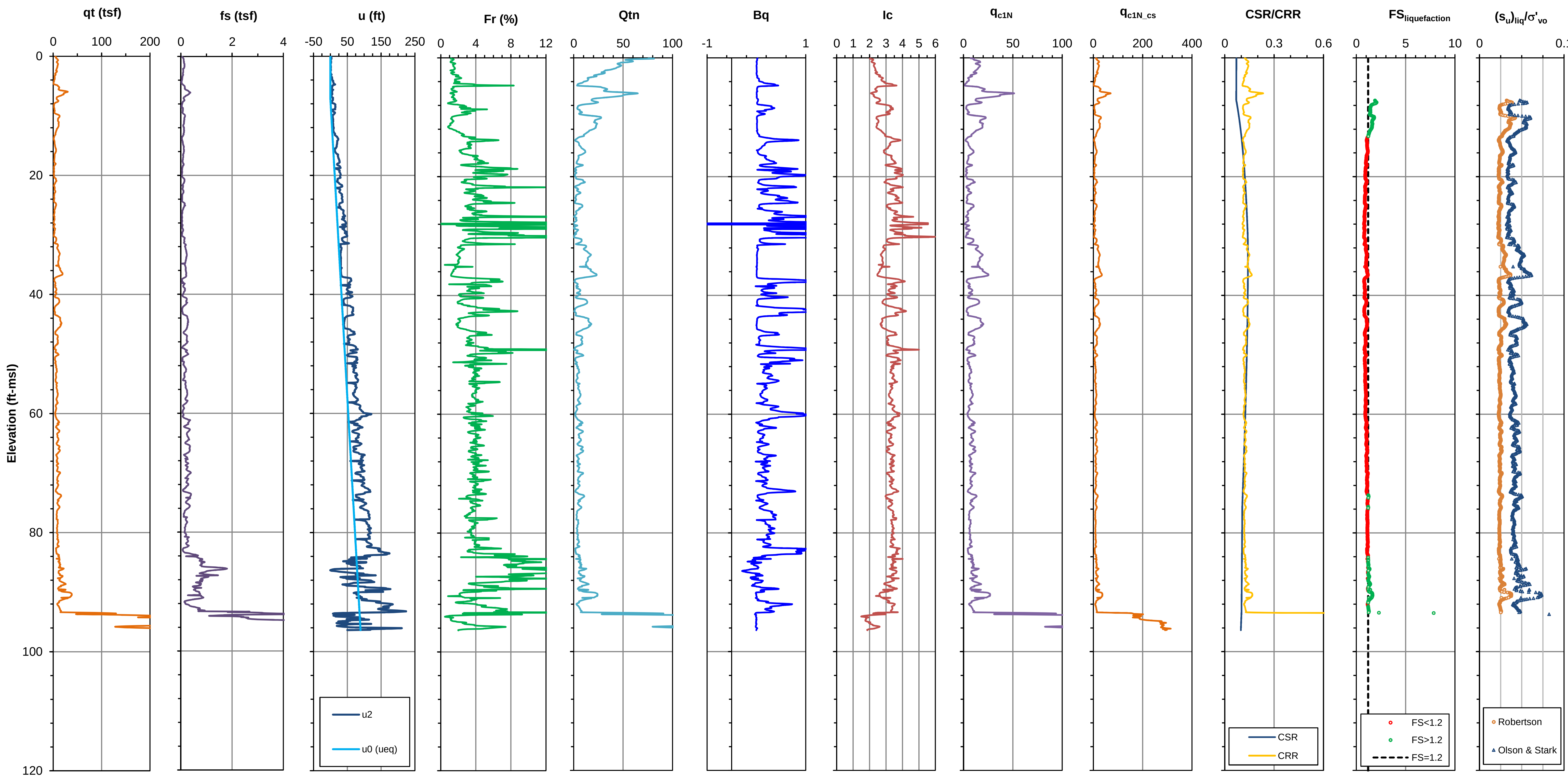
US Environmental Protection Agency (2015), "Final Rule: Disposal of Coal Combustion Residuals From Electric Utilities," 40 CFR Parts 257 and 261. Federal Register Vol. 80, No. 74

Youd, T.L., I.M. Idriss, Ronald D. Andrus, Ignacio Arango, Gonzalo Castro, John T. Christian, Ricardo Dobry, W.D. Liam Finn, Leslie F. Harder Jr., Mary Ellen Hynes, Kenji Ishihara, Joseph P. Koester, Sam S.C. Liao, William F. Marcuson III, Geoffrey R. Martin, James K. Mitchell, Yoshiharu Moriwaki, Maurice S. Power, Peter K. Robertson, Raymond B. Seed, Kenneth H. Stokoe II (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*, 127(10), pp. 817-833.

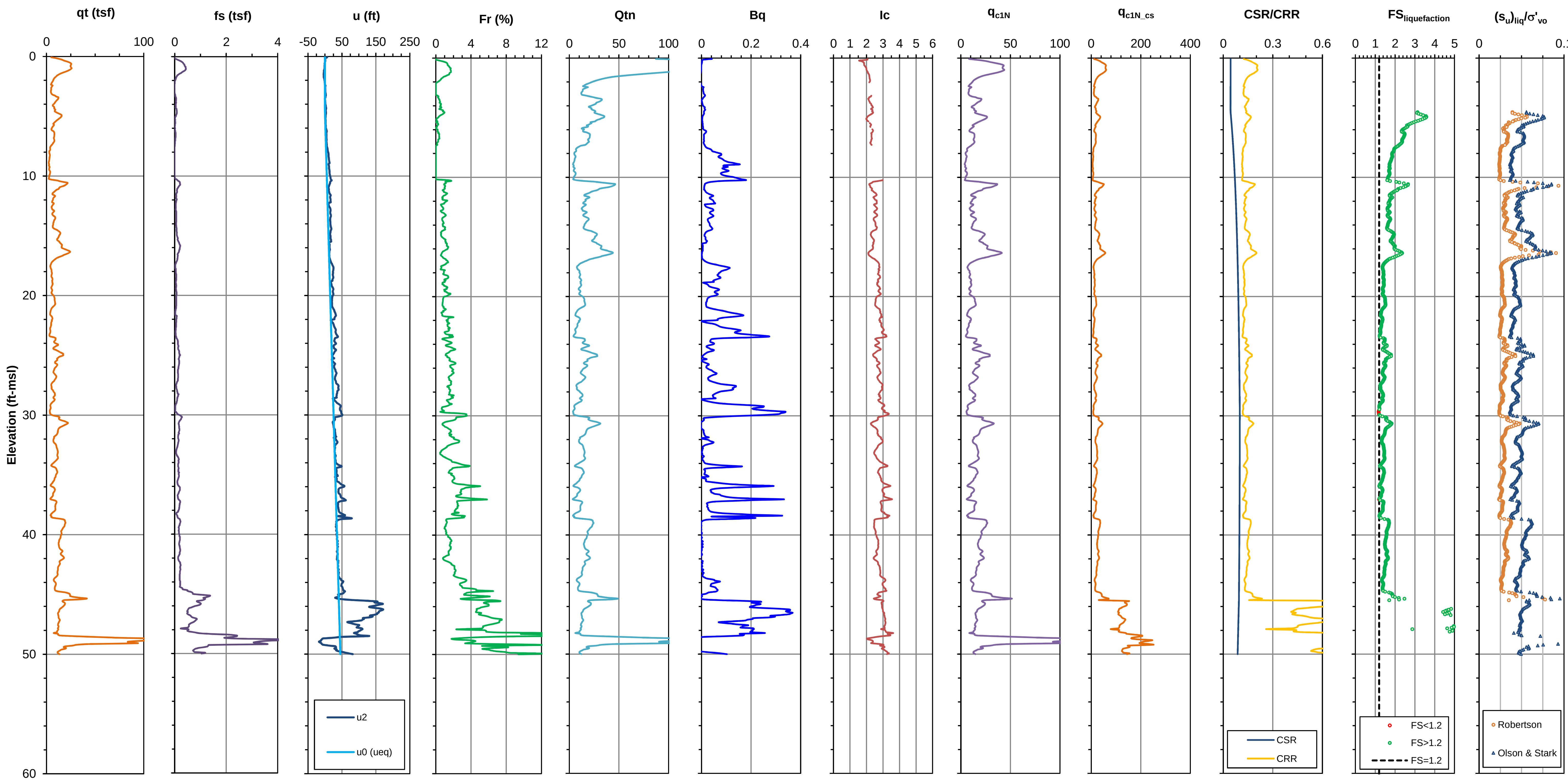
2008 USGS National Seismic Hazard Map; http://earthquake.usgs.gov/hazards/products/conterminous/2008/maps/

Test Date:	3/23/2015	**Project:**	Bremo CCR Pond Closu	**Test Type:**	CPTU	**Water Table:**	7.1 ft	**Design Earthquake**	
Test ID:	NC-10	**Location:**	Bremo Bluff, VA	**Device:**	10 cm^2, Type 2 filter	**Golder Eng:**	JGM	**Magnitude:**	5.6
Latitude:	37.70826	**Client:**	Dominion	**Standard:**	ASTM D5778	**Check**	SR/AJG	**a_{max}:**	0.109 g
Longitude:	-78.27867	**Proj No.:**	1520347	**Push Co.:**	Mid Atlantic Drilling	**Review:**	GLH		
Elevation:	325.6 ft	**Termination:**	CPT Refusal	**Operator:**	Corey Robinson	**Max Depth:**	96.4 ft		

Golder Associates



Test Date:	3/24/2015	**Project:**	Bremo CCR Pond Closu	**Test Type:**	CPTU	**Water Table:**	4.5 ft	**Design Earthquake**	
Test ID:	NC-12	**Location:**	Bremo Bluff, VA	**Device:**	10 cm^2, Type 2 filter	**Golder Eng:**	JGM	**Magnitude:**	5.6
Latitude:	37.71026	**Client:**	Dominion	**Standard:**	ASTM D5778	**Check**	SR/AJG	**a_{max}:**	0.068 g
Longitude:	-78.27565	**Proj No.:**	1520347	**Push Co.:**	Mid Atlantic Drilling	**Review:**	GLH		
Elevation:	332.4 ft	**Termination:**	CPT Refusal	**Operator:**	Corey Robinson	**Max Depth:**	50.0 ft		



Test Date: 3/18/2015
Test ID: EC-07
Latitude: N 37.70699
Longitude: W 78.28271
Elevation: 247.9 ft

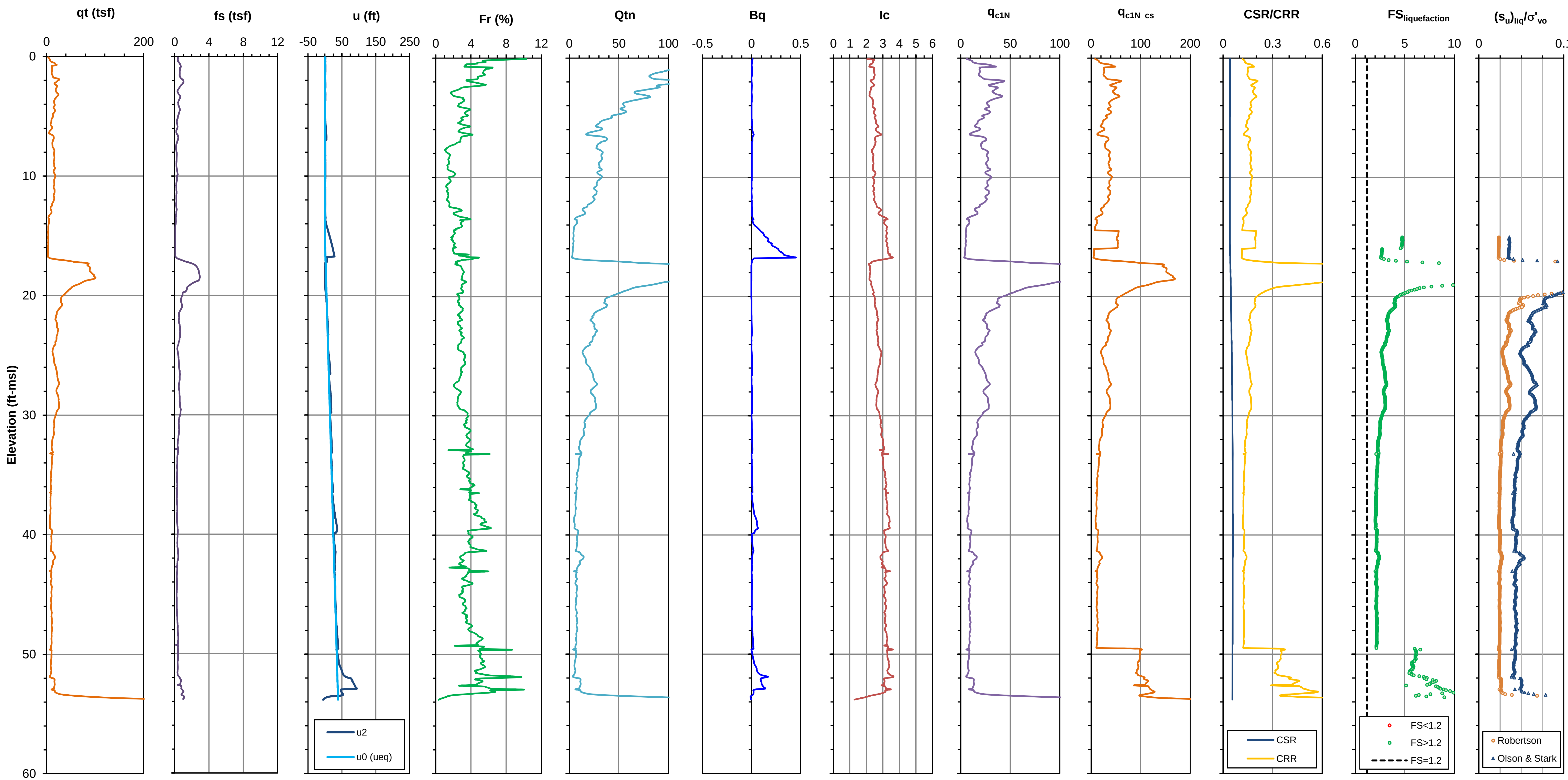
Project: Bremo CCR Pond Closure
Location: Bremo Bluff, VA
Client: Dominion
Proj No.: 1520347
Termination: CPT Refusal

Test Type: CPTU
Device: 10 cm^2, Type 2 filter
Standard: ASTM D5778
Push Co.: Mid Atlantic Drillers
Operator: Corey Robinson

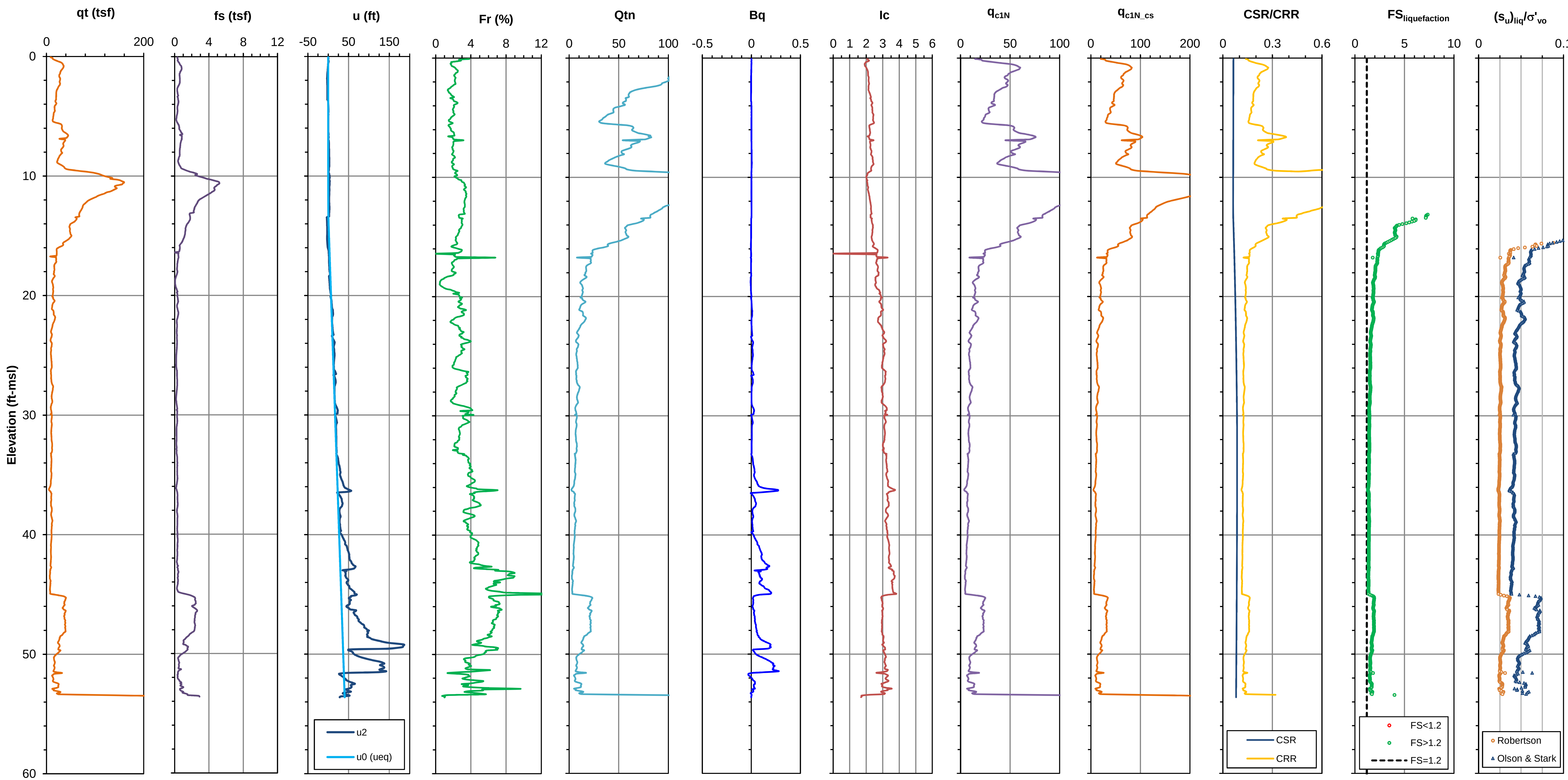
Water Table: 15.0 ft
Golder Eng: JGM
Check SR/AJG
Review: GLH
Max Depth: 53.8 ft

Design Earthquake
Magnitude: 5.6
a_{max}: 0.065 g

Golder Associates



Test Date:	3/18/2015	**Project:**	Bremo CCR Pond Closu	**Test Type:**	CPTU	**Water Table:**	13.1 ft	**Design Earthquake**	
Test ID:	EC-10	**Location:**	Bremo Bluff, VA	**Device:**	10 cm^2, Type 2 filter	**Golder Eng:**	JGM	**Magnitude:**	5.6
Latitude:	N 37.70560	**Client:**	Dominion	**Standard:**	ASTM D5778	**Check**	SR/AJG	**a_{max}:**	0.062 g
Longitude:	W 78.28039	**Proj No.:**	1520347	**Push Co.:**	Mid Atlantic Drilling	**Review:**	GLH		
Elevation:	248.5 ft	**Termination:**	CPT Refusal	**Operator:**	Corey Robinson	**Max Depth:**	53.6 ft		



Attachment 4

Global Stability Analyses

East Ash Pond Slope Stability

North Ash Pond Slope Stability

West Ash Pond Slope Stability

CALCULATIONS

Date:	October 2015	**Made by:**	G. Martin
Project No.:	1520347	**Checked by:**	PDP
Subject:	Slope Stability Analysis - Ash Ponds	**Reviewed by:**	GLH
Short Title:	CCR Pond Closure - Bremo Bluff Power Station, Stability Analysis		

1.0 OBJECTIVE

Slope stability analyses are conducted for embankments (dikes) impounding the West Ash Pond (WAP), East Ash Pond (EAP), and North Ash Pond (NAP) at Dominion's Bremo Power Station located at Bremo Bluff, VA. Multiple cross sections identified as critical areas are evaluated.

2.0 METHODOLOGY

Dike geometry for the model was developed based on the proposed design grades (Golder 2015), 2015 LiDAR topography, historic drawings, historic topographic maps, and geotechnical site investigation results.

Stability analyses were completed using the computer program SLIDE 6.0 Version 6.036 (2015). SLIDE computes potential failure surfaces using a general limit equilibrium (GLE) method developed by Morgenstern and Price (Abramson et al., 2002). The method is based on the principle of limit equilibrium (i.e., 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). A "grid", circular failure surface search-method was used in this study. For these iterations, safety factors in excess of 1.0 indicate stability, and those less than 1.0 indicate a potential for instability. Shallow surfaces (< 5 ft) were not considered in the global analysis (see veneer calculations).

2.1 Material Properties

In March 2015, Golder conducted a geotechnical site exploration of the West (WAP), East (EAP), and North (NAP) Ash Ponds and their embankments. Embankment stratigraphy was estimated based on subsurface data and site reconnaissance. Details of the exploration can be found in Golder's 2015 Geotechnical Data Report. From the results of Golder's investigation and previous investigations, properties were selected for the soils and CCR found onsite and are presented in the table below. Details of material property determination are included in the Material Property Calculation Package (Appendix A).

Table 1: Summary of Geotechnical Strength Properties

Summary of Geotechnical Strength Properties East, North and West Ash Ponds				
Material	***Total Unit Weight (pcf)***	***Strength Properties***		
		Peak φ' (°)	**Cohesion (psf)**	**Su (tsf)**
Uncompacted CCR	90	28	0	0.5
Compacted CCR	110	34	0	1.5
Liquefied CCR	90	N/A	N/A	0.04*Vertical Stress
Dike Fill Soils- NAP	125	0 - 40 ft: 31 > 40 ft: 28	50	2.0
Dike Fill Soils- EAP and WAP	125	0 - 20 ft: 31 > 20 ft: 28	50	1.5
Alluvium	115	28	50	1.0
Degraded Alluvium	115	N/A	N/A	0.25
Residuum	125	28	50	1.5
Clay Liner (EAP vertical expansion)	125	26	50	0.25
Disintegrated Rock	140	31	1000	50

2.2 Stability Cases

Critical slopes along two (2) sections in the WAP, four (4) sections in the EAP, and three (3) sections in the NAP were analyzed for six (6) stability scenarios:

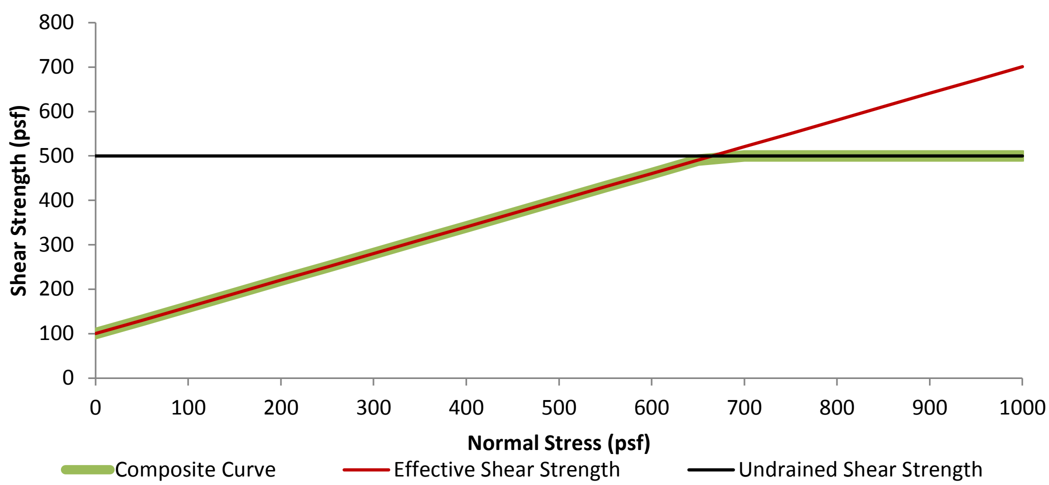
(A) Existing Conditions (Pre-closure)
(B) Closure Design Grades with long term, steady state conditions and maximum water level
(C) Closure Design Grades with long term, steady state conditions and design water level
(D) Closure Design Grades with short term conditions (undrained) and maximum water level
(E) Closure Design Grades with seismic loading and maximum water level
(F) Closure Design Grades with seismic loading and design water level.

Additionally, select slopes in the NAP were analyzed for stability in the case that susceptible CCR liquefies during a seismic event. Three (3) sections in the NAP were analyzed for 2 stability scenarios:

(A) Closure Design Grades with water level at the liner
(B) Closure Design Grades and a compacted CCR/Fill wedge with water level at the liner

For analyses with long term conditions, long-term effective strength material properties were used. For short-term conditions, the undrained strength was used for the alluvium, and composite curves were used for all other materials. Composite curves were developed for each material by taking the minimum of the effective shear strength and the undrained shear strength for a given normal stress (see below for illustration). For seismic loading conditions, 80% of the undrained strength was used for the alluvium, and for all other materials, a composite curve was developed by taking the minimum of 80% of the undrained shear strength and the effective strength for a given normal stress.

Stability for the design cases of the West Ash Pond was assessed with a degraded alluvial layer below the current ash pond areas. This degraded alluvium conservatively accounts for changes that may have occurred over time below the ash pond from dredging operations, changing water level conditions, and changing loading conditions.



2.3 Seismic Analysis

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). The seismic coefficient is estimated from the peak ground acceleration (PGA) expected at the site. The PGA is based on the 2008 USGS seismic hazard maps with a 2% probability of exceedance in 50 years (2475-year return period). Based on the 2008 USGS seismic hazard maps, the PGA at Bremo Power Station is 0.14g for a 2% probability of exceedance in 50 years as defined in greater detail in Appendix C to the geotechnical report. Hynes-Griffin and Franklin (1984) recommend using a seismic coefficient equal to 0.5xPGA with a 20% shear strength reduction, where the shear strength is based on a composite of the total and the average of the total and effective shear strength envelopes.

2.4 Post-seismic Liquefaction Analysis

The closure is designed to protect the channels around the perimeter of the closure from the potential for lateral spreading (flow of material laterally in sloped areas). It is recommended that all CCR within 15 ft of lined channels in the North Ash Pond be compacted or replaced with new fill prior to liner placement to stabilize the closure condition in the event of future saturation and potential for liquefaction of loose CCR during the design (2475 year) basis earthquake. The water levels in these analyses are considered very conservative, with evaluations considering unlikely cases where the water level exists just below the liner at some point in the future. This condition is not expected and is considered very conservative.

The following assumptions were made in our analysis:

- The proposed soil fill, proposed compacted CCR fill, and existing compacted-CCR are all calculated to be non-liquefiable for the design event
- Hydraulically placed, uncompacted CCR in the North Ash Pond is liquefiable for the design event when saturated.
- Post-liquefied CCR can be modeled with a vertical effective strength ratio of 0.04, based on CPT correlations.

If liquefaction does occur after an earthquake event, there may be some risk of isolated pockets of movement to the interior portions of the cover that are not estimated to cause cover failure. While we believe this scenario is very low risk due to the expected drying of the ash over time preventing liquefaction, we recommend a detailed inspection of the closure be performed after an earthquake event to assess the performance.

For further discussion of liquefiable materials and post-liquefied strengths, refer to Appendix C.

CALCULATIONS

Date:	October 2015	**Made by:**	G. Martin
Project No.:	1520347	**Checked by:**	PDP
Subject:	Slope Stability Analysis - Ash Ponds	**Reviewed by:**	GLH
Short Title:	CCR Pond Closure - Bremo Bluff Power Station, Stability Analysis		

3.0 RESULTS

Table 2 shows the results of each analysis completed. This analysis confirms earlier analysis conducted for the EAP (Golder 2014) which revealed sections of the EAP to be marginally stable in the long-term. While some sections of the ash pond do not meet required factors of safety for closure in their current configuration, the proposed design grades bring all sections into compliance.

Table 2: Summary of Geotechnical Stability Analyses

		A	B	C	D	E	F
	Grading	Existing	Design	Design	Design	Design	Design
	Type	Steady-State	Steady-State	Steady-State	Undrained	Seismic	Seismic
	Water Level	Existing	Max	Design	Max	Max	Design
	Required FS	N / A	1.5	1.5	1.5	1.2	1.2
Figure	**Section**	**Factors of Safety - West Ash Pond**					
WP-3	WP-C, West, Right	N/A	**1.7**	N/A	**1.8**	**1.2**	N/A
WP-4	WP-C, East, Left	**2.3**	**2.1**	N/A	**2.2**	**1.8**	N/A
WP-5	WP-C, East, Right	**1.6**	**1.6**	N/A	**1.6**	**1.4**	N/A
WP-6	WP-E, South, Left	**1.4**	**1.6**	N/A	**1.6**	**1.4**	N/A
WP-7	WP-E, South, Right	**1.2**	**2.1**	N/A	**2.2**	**1.8**	N/A
WP-8	WP-E, North, Left	**2.1**	**2.0**	N/A	**2.4**	**1.9**	N/A
WP-9	WP-E, North, Right	**1.7**	**1.7**	N/A	**1.7**	**1.5**	N/A
Figure	**Section**	**Factors of Safety - East Ash Pond**					
EP-4	EP-B, South	**1.2**	**1.9**	***2.0***	**1.8**	**1.2**	**1.2**
EP-5	EP-B, North	**N/A**	***1.9***	**2.1**	***2.0***	**1.3**	**1.3**
EP-6	EP-D, South	**1.3**	***1.7***	**2.0**	***2.0***	**1.3**	**1.3**
EP-7	EP-D, North	**2.4**	**1.8**	**2.1**	**2.1**	**1.7**	**1.7**
EP-8	EP-G, West	**1.2**	**1.5**	**1.8**	**1.8**	**1.5**	**1.5**
EP-9	EP-G, East	**1.3**	**1.5**	**1.8**	**1.9**	**1.4**	**1.4**
EP-10	EP-H, South	**1.3**	**1.8**	**2.1**	**2.1**	**1.7**	**1.7**
EP-11	EP-I, South, Left	**1.3**	**1.7**	N/A	**1.9**	**1.6**	N/A
EP-12	EP-I, South, Right	**2.1**	**1.7**	N/A	**2.0**	**1.6**	N/A
Figure	**Section**	**Factors of Safety - North Ash Pond**					
NP-2	NP-B, South, Left	**1.6**	**1.6**	**1.6**	**1.6**	**1.3**	**1.3**
NP-3	NP-B, South, Right	**2.1**	***2.2***	**2.2**	**2.2**	**1.7**	**1.7**
NP-4	NP-H, East	**1.7**	**2.1**	**2.0**	**2.0**	**1.7**	**1.7**

Date:	October 2015	**Made by:**	G. Martin
Project No.:	1520347	**Checked by:**	PDP
Subject:	Slope Stability Analysis - Ash Ponds	**Reviewed by:**	GLH
Short Title:	CCR Pond Closure - Bremo Bluff Power Station, Stability Analysis		

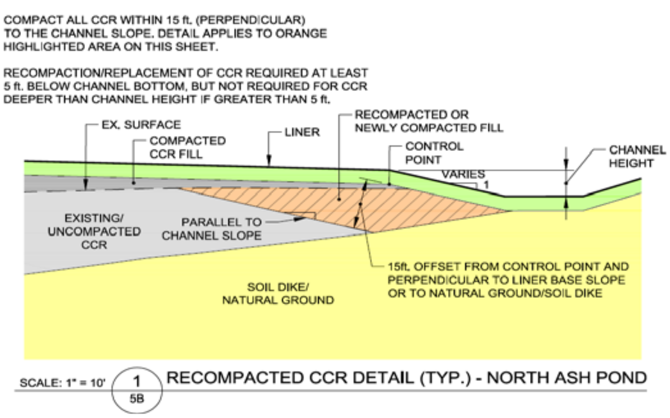
Table 3 below shows the results of the post-seismic liquefaction analyses. The analyses demonstrate that a wedge of compacted CCR or new fill is required at the channels to prevent lateral spreading in the case of liquefaction (as outlined on drawing GD-5B and shown in the detail below Table 3). The last analysis in the below table demonstrates that the North Ash Pond Dam remains stable and well above the required factor of safety even if full liquefaction of the ash in the NAP were to occur.

Table 3: Summary of post-seismic liquefaction analyses

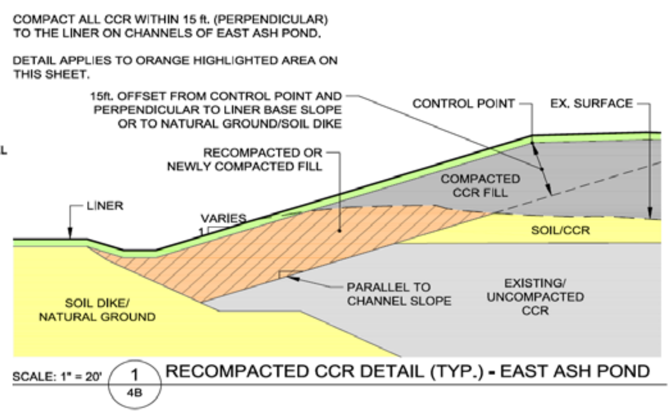
		A	**B**
	Compacted CCR/Fill	No	Yes
	Type	Liquefaction	Liquefaction
	Water Level	At Liner	At Liner
	Required FS	1.2	1.2
Figure	**Section**	**Factors of Safety - North Ash Pond**	
NP-5	NP-B, South	**0.2**	**1.2**
NP-6	NP-D, West	**0.2**	***2.5***
NP-7	NP-D, East	**0.5**	***3.6***
NP-8	NP-B, South, Left	**N/A**	***1.6***

Similar to the north pond, the perimeter of the EAP closure requires that the perimeter materials under the proposed final cover be either compacted fill, natural ground, or compacted ash within a 15 foot zone parallel to the final cover such that sufficient strength and control of the materials is provided to limit movements during and following the design earthquake scenario. The schematic below (from Figure GD-4B) illustrates this recommendation which is necessary for the east pond areas to achieve the required factors of safety with respect to global stability.

North Ash Pond Drainage Channel Preparation Detail



East Ash Pond Perimeter Preparation Detail



4.0 Conclusion

While the existing configuration of the ash ponds does not meet closure requirements, changes presented in the proposed closure design remediate deficiencies and bring all ponds into compliance with required factors of safety regarding the scenarios presented above.

5.0 References

Abramson, L.W., T.S. Lee, S. Sharma, and G.M. Boyce (2002), Slope Stability and Stabilization Methods, 2nd edition, John Wiley & Sons, New York.

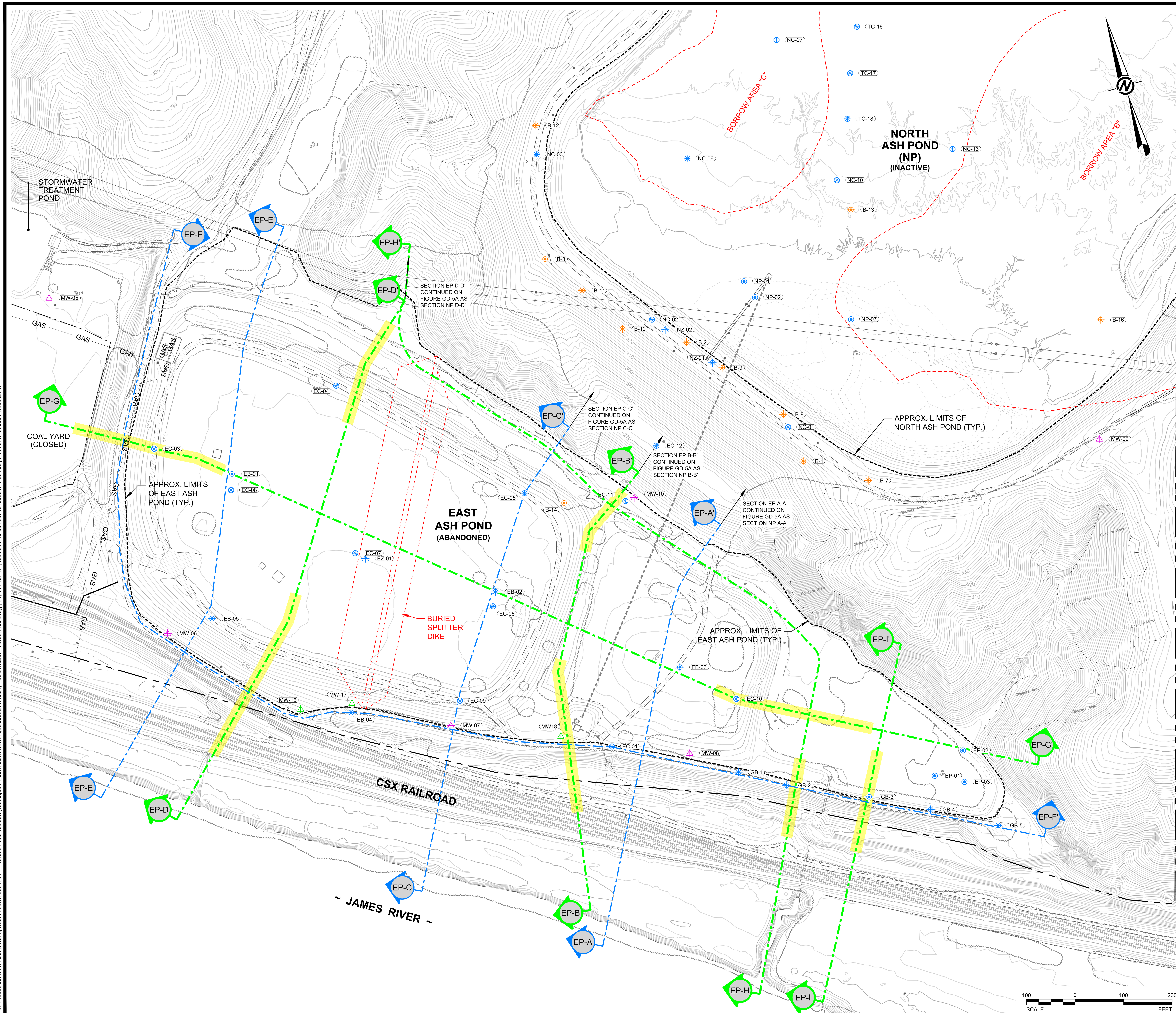
Golder Associates (2015). Geotechnical Material Properties Calculation Package. August 2015.

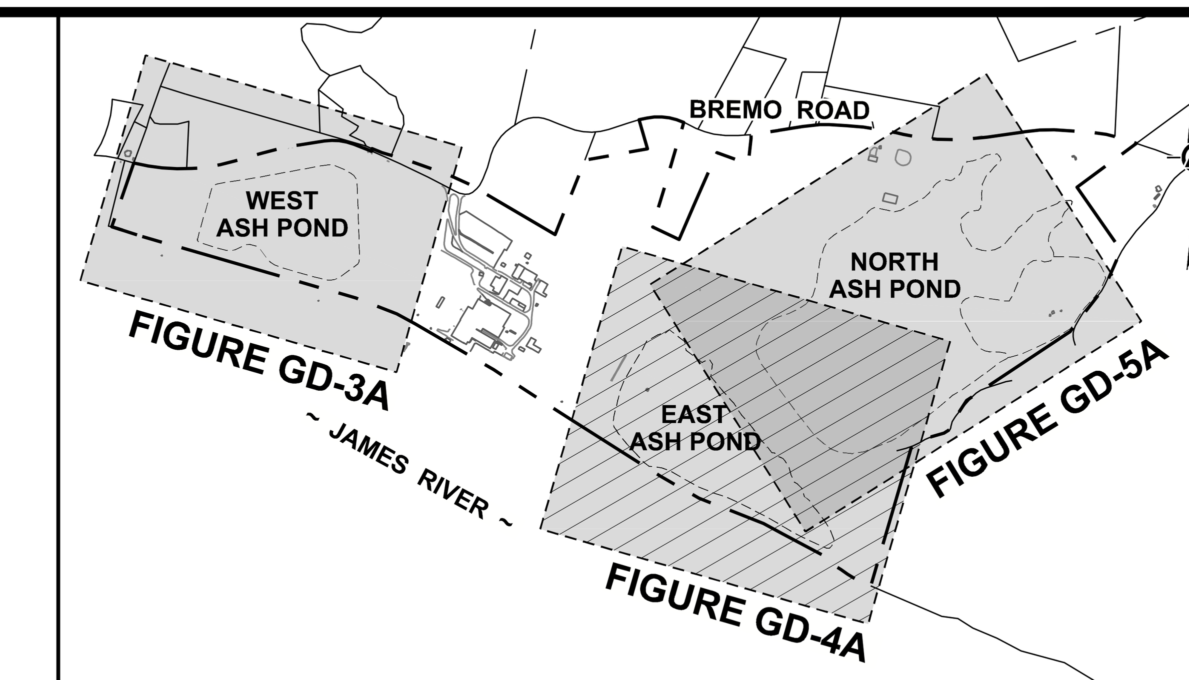
Golder Associates (2015). Bremo CCR Pond Closure Geotechnical Data Report. May 2015.

Hynes-Griffin, M.E. and Franklin, A.G. (1984), Rationalizing the Seismic Coefficient Method, Final Report (July), Misc Paper GL-84-13, Dept. of the Army, US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Rocscience (2015), SLIDE Version 6.036.

2008 USGS National Seismic Hazard Map; http://earthquake.usgs.gov/hazards/products/conterminous/2008/maps/





SITE KEY

NOT TO SCALE

LEGEND

- DOMINION PROPERTY BOUNDARY
- ADJACENT PROPERTY BOUNDARY
- APPROXIMATE LIMITS OF EXISTING ASH PONDS
- EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS)
- EXISTING BATHYMETRIC SURFACE CONTOURS (2' INTERVALS)
- DESIGN SURFACE CONTOURS (2' INTERVALS)
- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING RAILROAD
- CREEK CENTERLINE
- EXISTING TREE LINE
- EXISTING FENCE
- GAS — EXISTING GAS LINE
- DENOTES AREAS OF TOPOGRAPHY THAT DO NOT MEET MINIMUM ACCURACY STANDARDS FOR AERIAL SURVEYING
- SCHNABEL BORING (1982)
- SCHNABEL BORING (2010)
- GES MONITORING WELL (2013)
- HALEY AND ALDRICH BORING (2015)
- GOLDER BORING (2014 / 2015)
- GOLDER PIEZOMETER (2015)
- GOLDER CONE PENETRATION TEST (CPT)(2015)
- GOLDER PROBE HOLE (2015)
- GOLDER HAND AUGER (2015)
- EP-A — GEOTECHNICAL SECTIONS (SEE GOLDER 2015 GEOTECH DATA REPORT)
- EP-B — SLOPE STABILITY SECTIONS
- SLOPE STABILITY FIGURE LOCATIONS - SEE APPENDIX D

REFERENCES

1. AERIAL TOPOGRAPHIC SURVEY PREPARED BY McKENZIE SNYDER, INC., DATE OF AERIAL PHOTO: 01/16/15 [CONTROL PREPARED BY H&B SURVEYING & MAPPING (H&B)].

2. BATHYMETRIC SURVEYS PREPARED BY H&B, SURVEYS PERFORMED IN FEBRUARY 2015.

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW

PROJECT
DOMINION
BREMO POWER STATION
CCR IMPOUNDMENT CLOSURE
FLUVANNA COUNTY, VIRGINIA

TITLE
EXISTING CONDITIONS GEOTECHNICAL EXPLORATION PLAN (EAST POND)

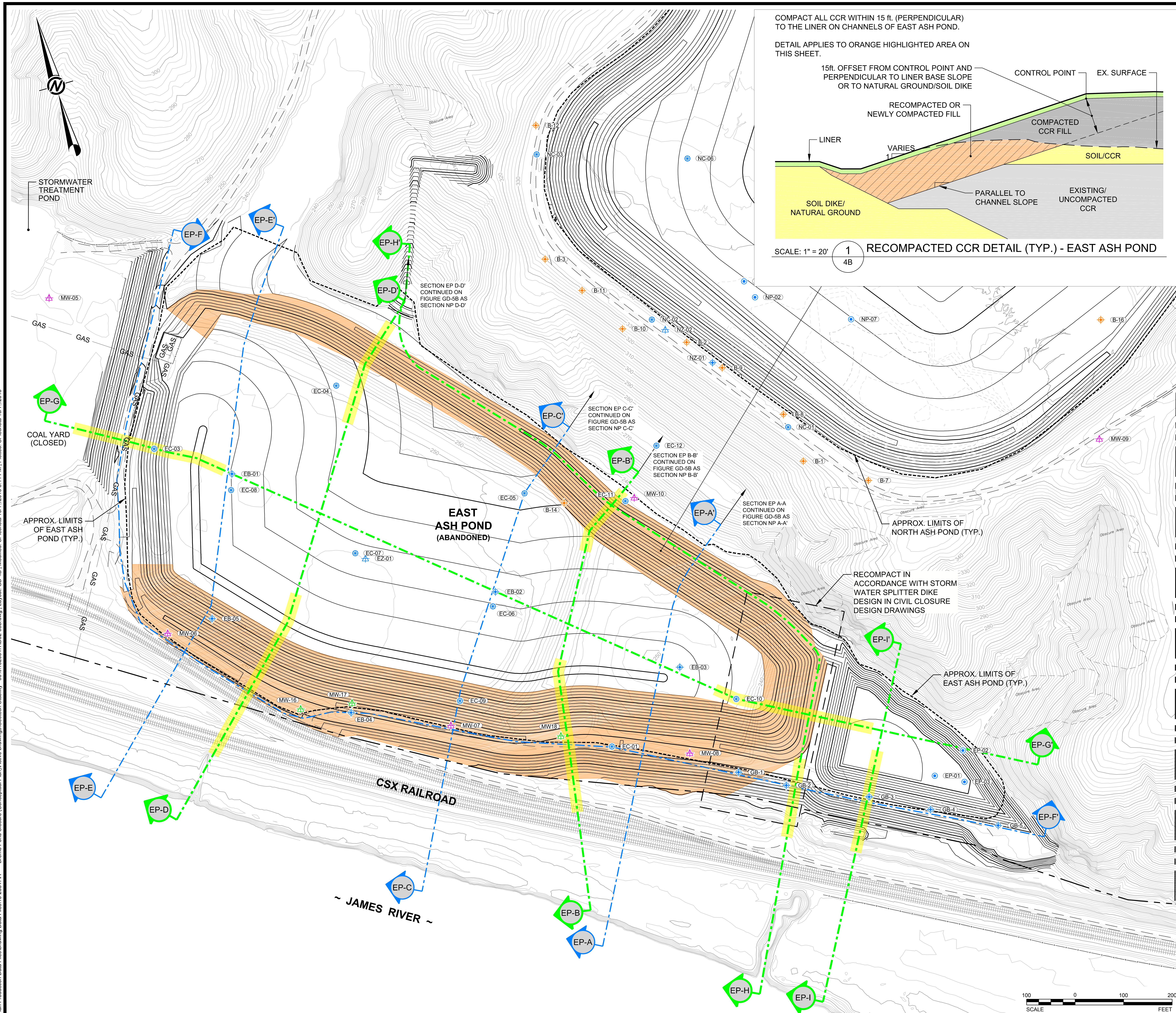
PROJECT No.		15-20347
DESIGN	-	-
CADD	SEP	10/15/15
CHECK	JGM	10/15/15
REVIEW	GLH	10/15/15

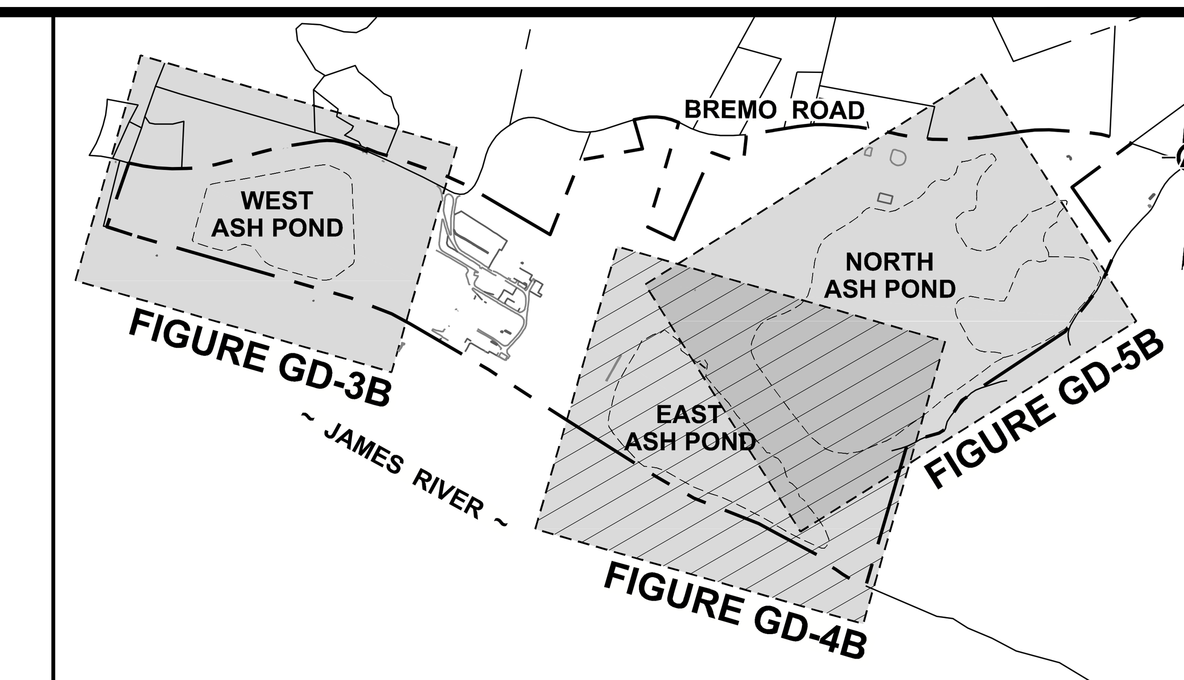
FILE No. 1520347AD03A-05A
SCALE AS SHOWN

Golder Associates

FIGURE GD-4A

G:\Plan Production Data Files\Drawing Data Files\15-20347\A - Bremo Pond Closure (Conceptual Plan)\Active Drawings\Geotech Stability - 90%\1520347AD03A-05A.dwg | Layout: GD-4A | Modified: SPlechota 10/09/2015 7:29 AM | Plotted: SPlechota 10/09/2015





SITE KEY

NOT TO SCALE

LEGEND

- DOMINION PROPERTY BOUNDARY
- ADJACENT PROPERTY BOUNDARY
- APPROXIMATE LIMITS OF EXISTING ASH PONDS
- EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS)
- EXISTING BATHYMETRIC SURFACE CONTOURS (2' INTERVALS)
- DESIGN SURFACE CONTOURS (2' INTERVALS)
- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING RAILROAD
- CREEK CENTERLINE
- EXISTING TREE LINE
- EXISTING FENCE
- EXISTING GAS LINE
- DENOTES AREAS OF TOPOGRAPHY THAT DO NOT MEET MINIMUM ACCURACY STANDARDS FOR AERIAL SURVEYING
- SCHNABEL BORING (1982)
- SCHNABEL BORING (2010)
- GES MONITORING WELL (2013)
- HALEY AND ALDRICH BORING (2015)
- GOLDER BORING (2014 / 2015)
- GOLDER PIEZOMETER (2015)
- GOLDER CONE PENETRATION TEST (CPT)(2015)
- GOLDER PROBE HOLE (2015)
- GOLDER HAND AUGER (2015)
- GEOTECHNICAL SECTIONS (SEE GOLDER 2015 GEOTECH DATA REPORT)
- SLOPE STABILITY SECTIONS
- SLOPE STABILITY FIGURE LOCATIONS - SEE APPENDIX D

REFERENCES

1. AERIAL TOPOGRAPHIC SURVEY PREPARED BY McKENZIE SNYDER, INC., DATE OF AERIAL PHOTO: 01/16/15 [CONTROL PREPARED BY H&B SURVEYING & MAPPING (H&B)].
2. BATHYMETRIC SURVEYS PREPARED BY H&B, SURVEYS PERFORMED IN FEBRUARY 2015.

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW

PROJECT

DOMINION
BREMO POWER STATION
CCR IMPOUNDMENT CLOSURE
FLUVANNA COUNTY, VIRGINIA

TITLE

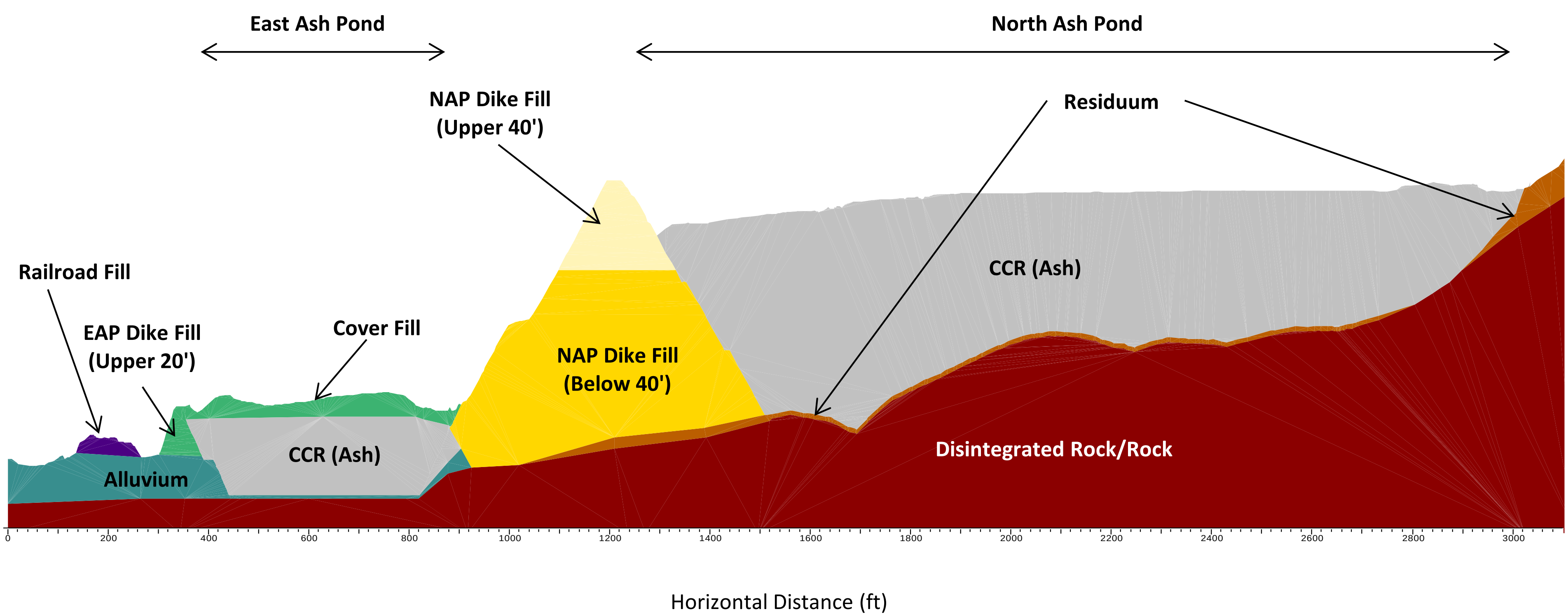
DESIGN GRADES GEOTECHNICAL STABILITY PLAN (EAST POND)

PROJECT No.		15-20347	FILE No.	1520347AD02-05B
DESIGN	-	-	SCALE	AS SHOWN
CADD	SEP	10/15/15		
CHECK	JGM	10/15/15	FIGURE GD-4B	
REVIEW	GLH	10/15/15		

Golder Associates

EP-B & NP-B Schematic

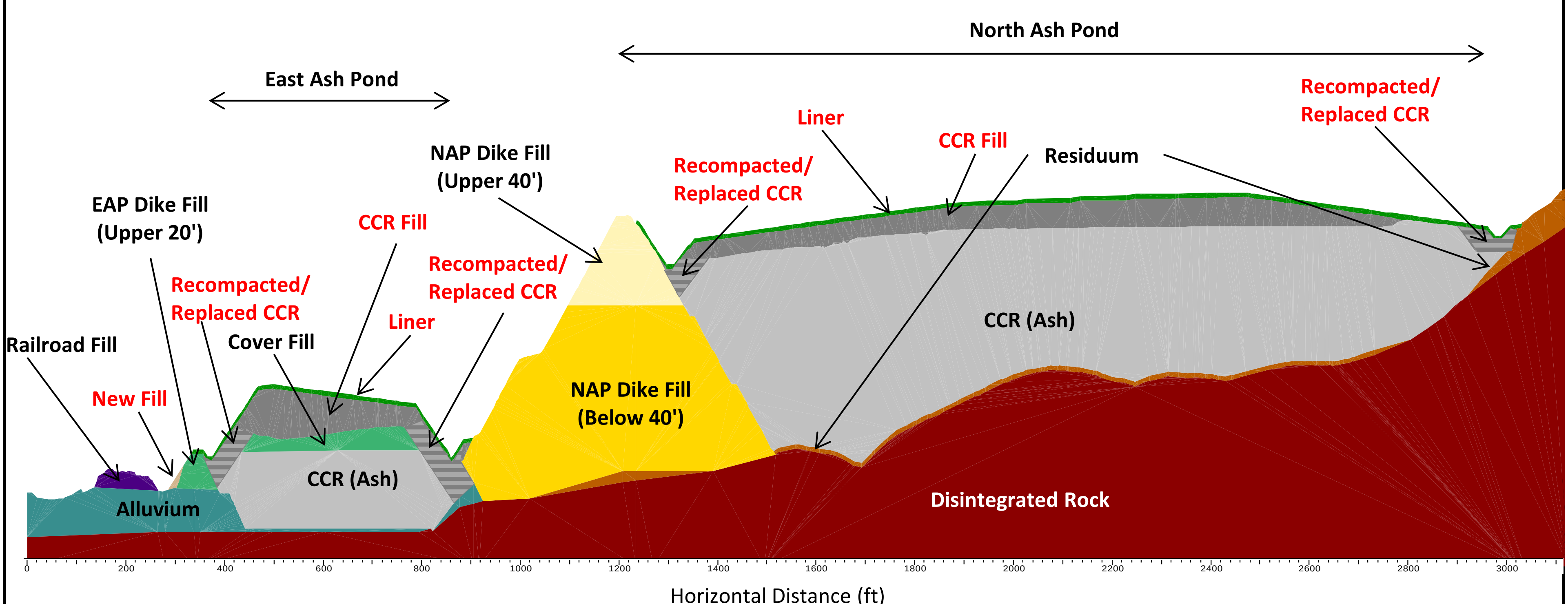
5 x Vertical Exaggeration



Golder Associates	SCALE	As Shown	EAP and NAP Section B	
	DATE	Oct-30-2015	Bremo Bluff Power Station Schematic Existing Case	
	MADE BY	JGM		
	CHECK	PDP		
	REVIEW	GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 1A
PROJECT No. 1520347 — REV. 0				

EP-B & NP-B Schematic

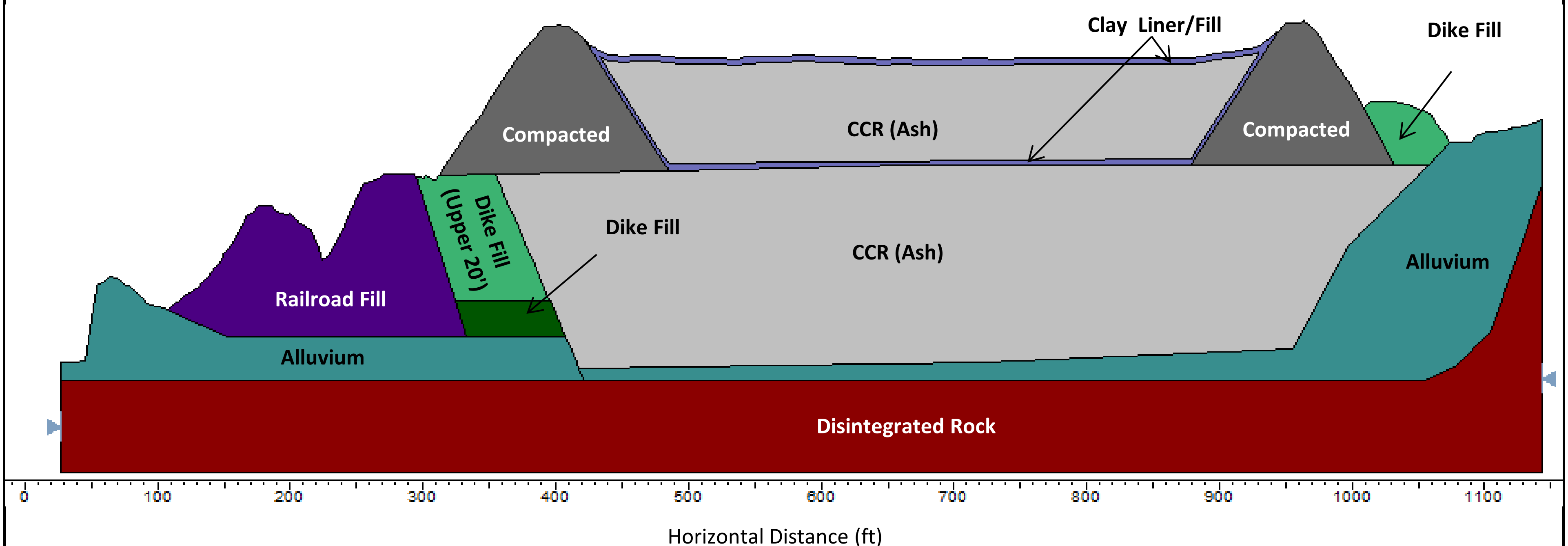
5 x Vertical Exaggeration



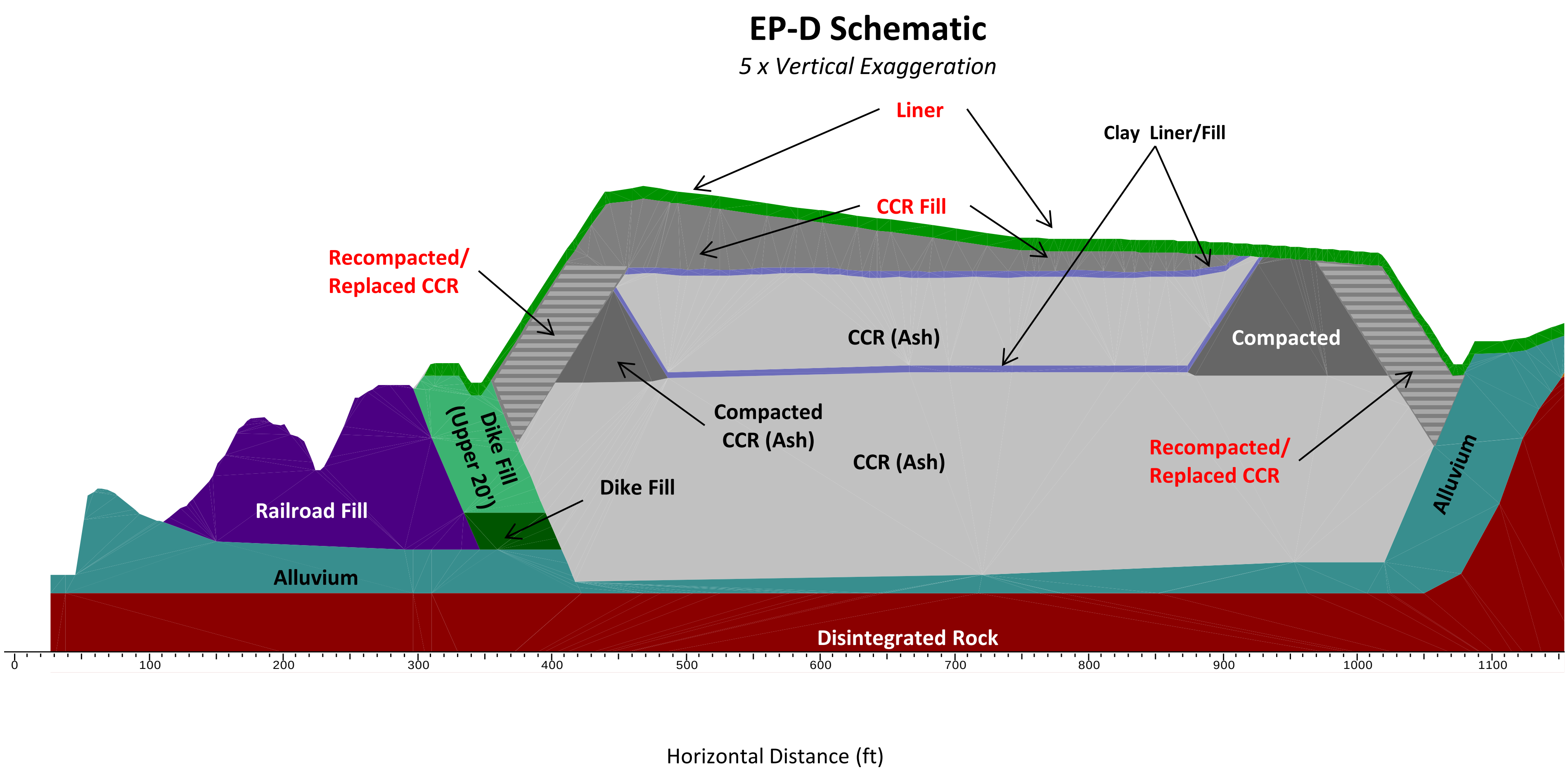
Golder Associates	SCALE	As Shown	**EAP and NAP Section B**
	DATE	Oct-30-2015	**Bremo Bluff Power Station** **Schematic** **Design Case**
	MADE BY	JGM	
	CHECK	PDP	
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**
PROJECT No. 1520347 REV. 0			Figure **1B**

EP-D Schematic

5 x Vertical Exaggeration



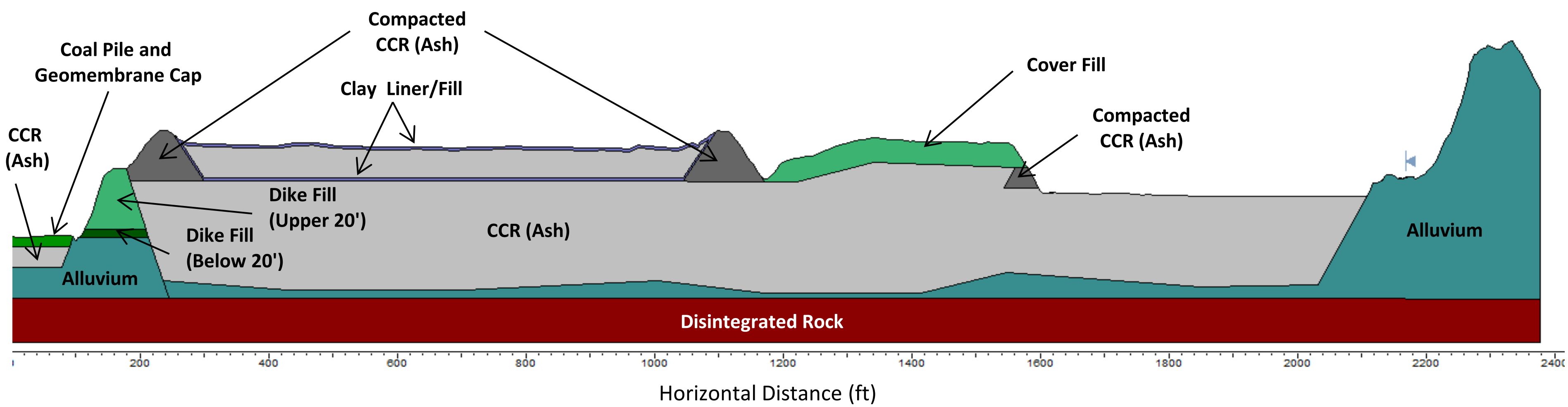
Golder Associates	SCALE As Shown	EAP Section D	
	DATE Oct-30-2015	Bremo Bluff Power Station Schematic Existing Case	
	MADE BY NES		
	CHECK JGM		
	REVIEW GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 2A
PROJECT No. 1520347 REV. 0			



Golder Associates	SCALE As Shown	**EAP Section D**	
	DATE Oct-30-2015	**Bremo Bluff Power Station Schematic Design Case**	
	MADE BY JGM		
	CHECK PDP		
	REVIEW GLH	**Dominion Bremo Bluff Power Station Ash Pond Closure Project**	Figure **2B**
PROJECT No. 1520347 / REV. 0			

EP-G Schematic

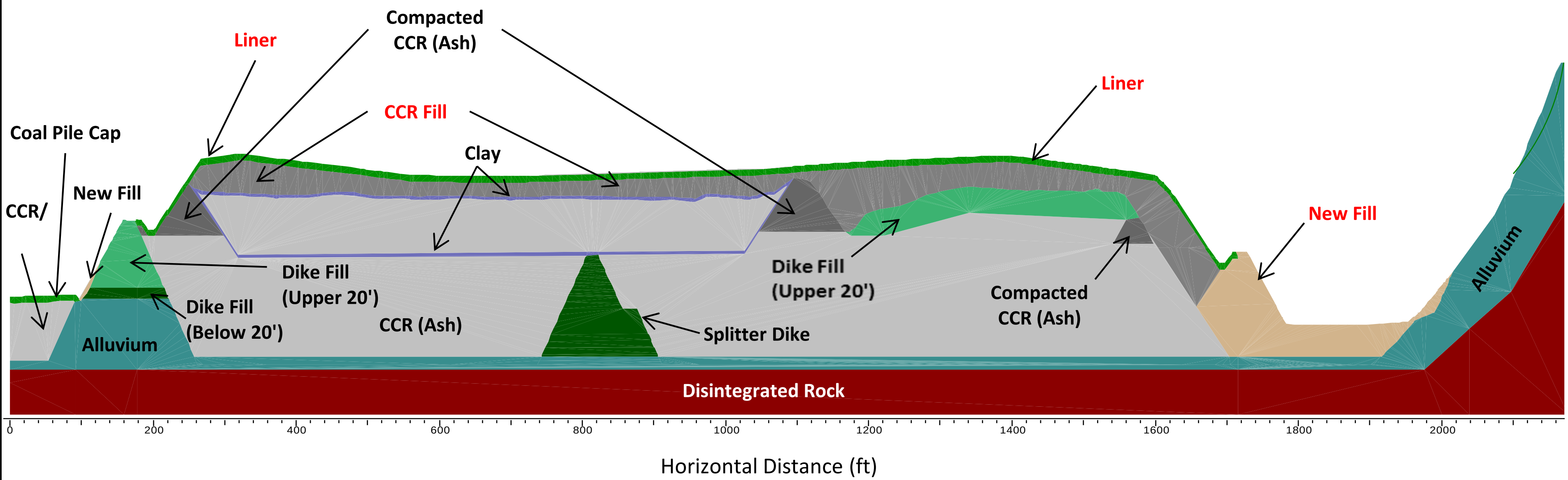
5 x Vertical Exaggeration



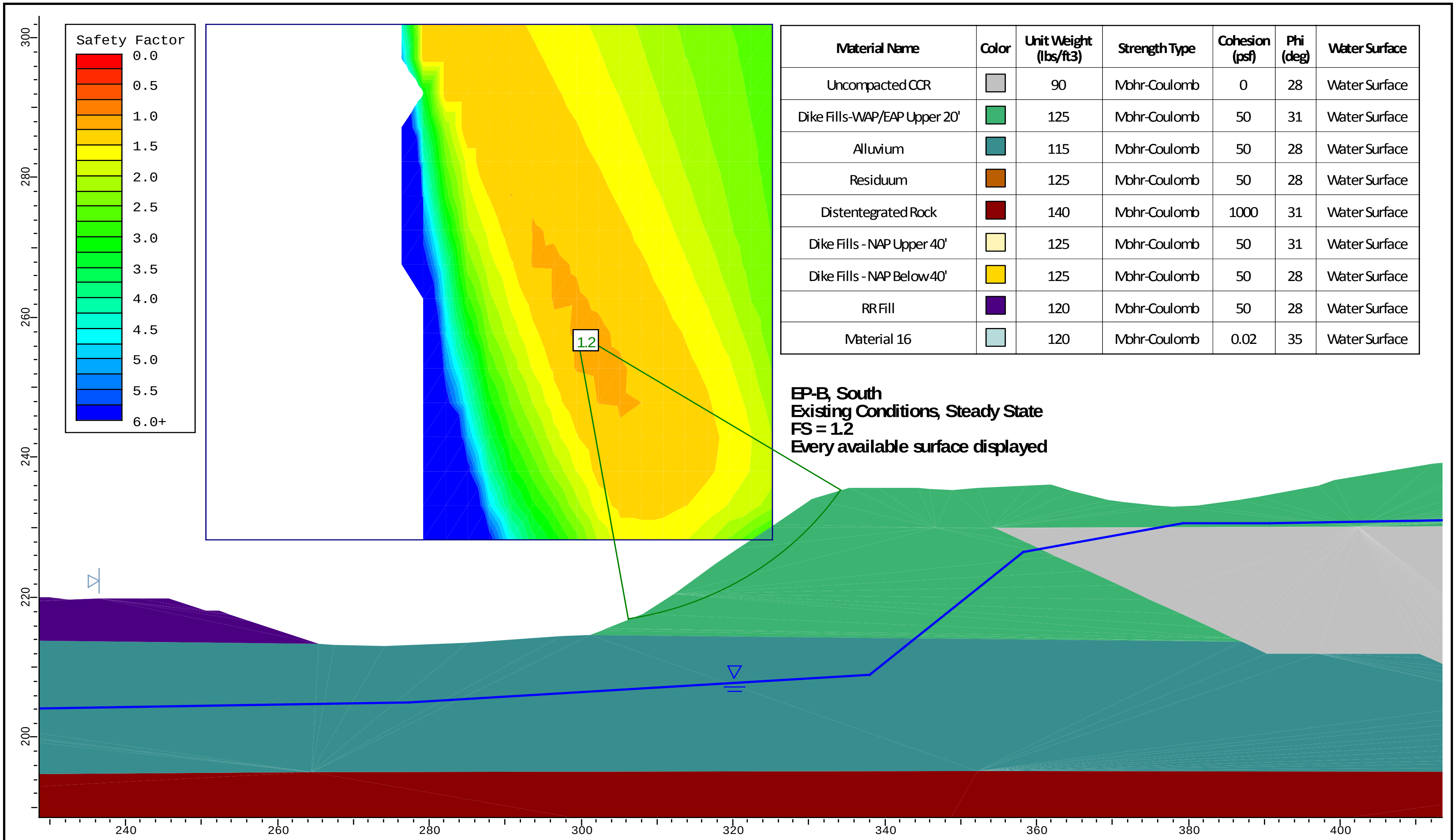
	SCALE	As Shown	**EAP Section G**
	DATE	Oct-30-2015	**Bremo Bluff Power Station** **Schematic** **Existing Case**
	MADE BY	JGM	
	CHECK	PDP	
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**
PROJECT No. 1520347	REV. 0		Figure **3A**

EP-G Schematic

5 x Vertical Exaggeration



Golder Associates	SCALE: As Shown	EAP Section G	
	DATE: Oct-30-2015	Bremo Bluff Power Station Schematic Design Case	
	MADE BY: JGM		
	CHECK: PDP		
	REVIEW: GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 3B
PROJECT No. 1520347 — REV. 0			



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Residuum		125	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface
Dike Fills - NAP Upper 40'		125	Mohr-Coulomb	50	31	Water Surface
Dike Fills - NAP Below 40'		125	Mohr-Coulomb	50	28	Water Surface
RR Fill		120	Mohr-Coulomb	50	28	Water Surface
Material 16		120	Mohr-Coulomb	0.02	35	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	JGM
CHECK	MGP
REVIEW	PDP

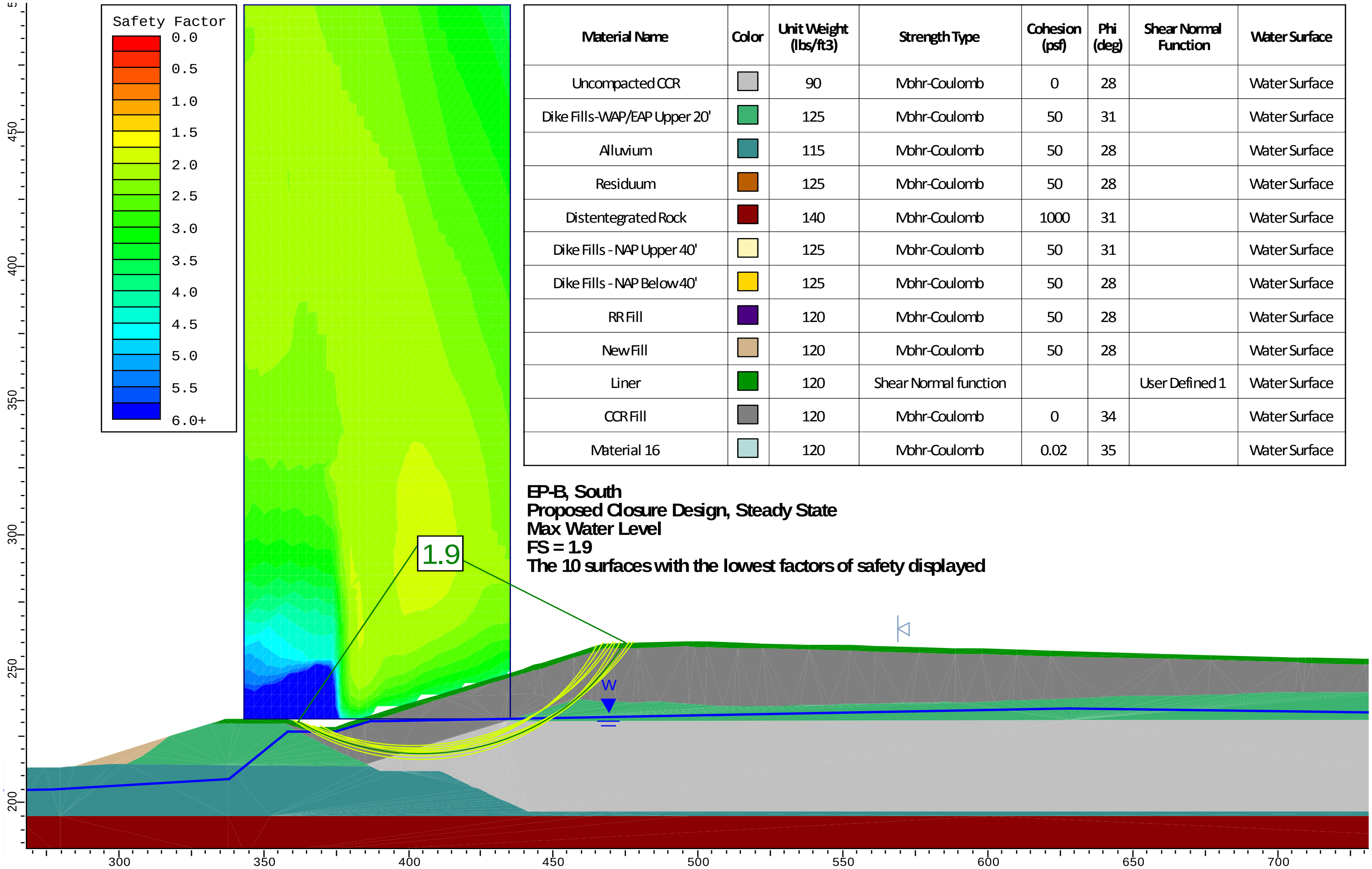
EAP Section B - South

Bremo Bluff Power Station
Slope Stability Analysis
Existing Conditions, Steady State

PROJECT No. 1520347 REV. 0

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **4A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Dike Fills - NAP Upper 40'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills - NAP Below 40'		125	Mohr-Coulomb	50	28		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface
Material 16		120	Mohr-Coulomb	0.02	35		Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

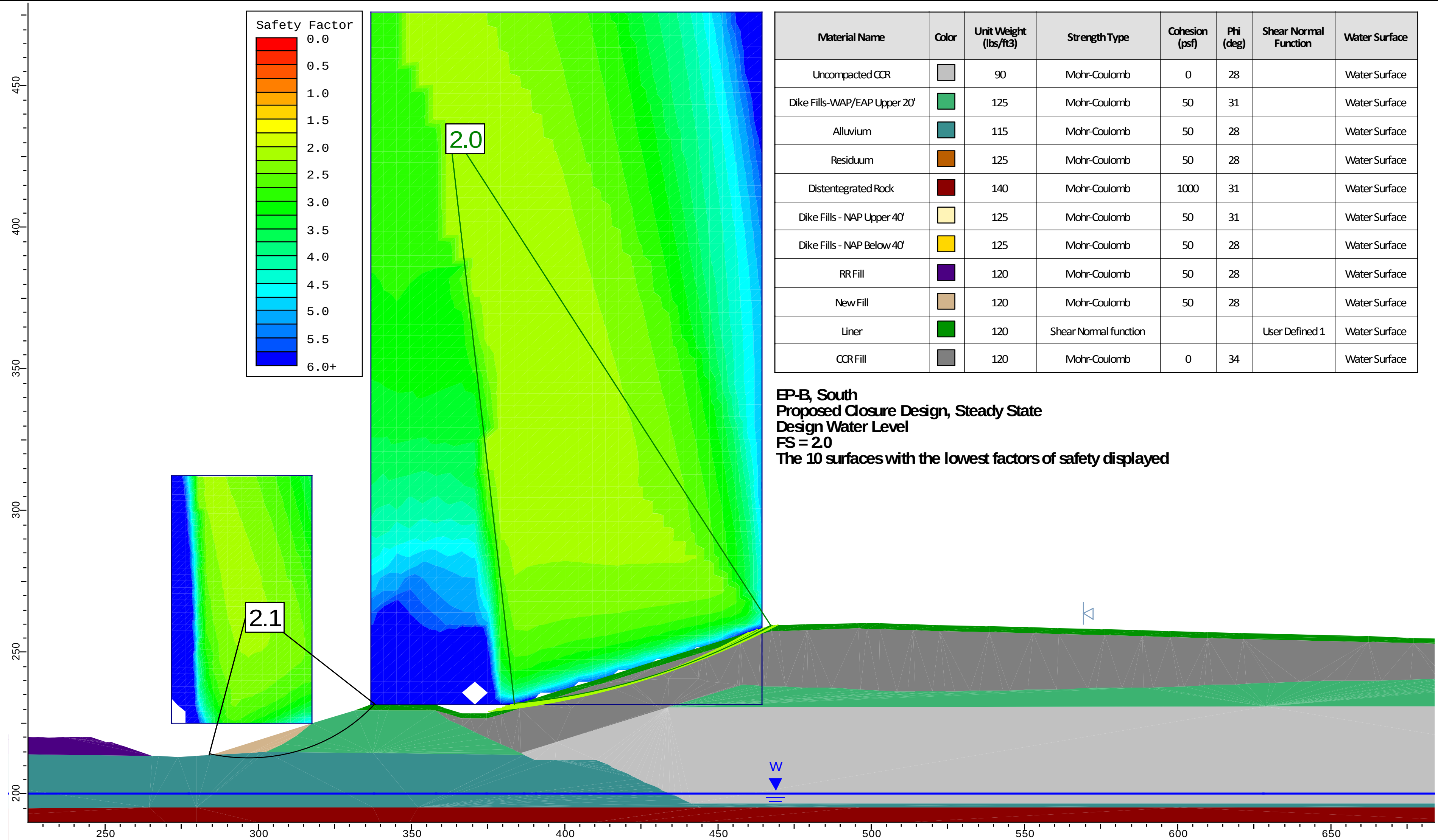
PROJECT No. 1520347 REV. 0

EAP Section B - South

Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

Dominion Bremo Bluff Power Station
Closure Ash Pond Project

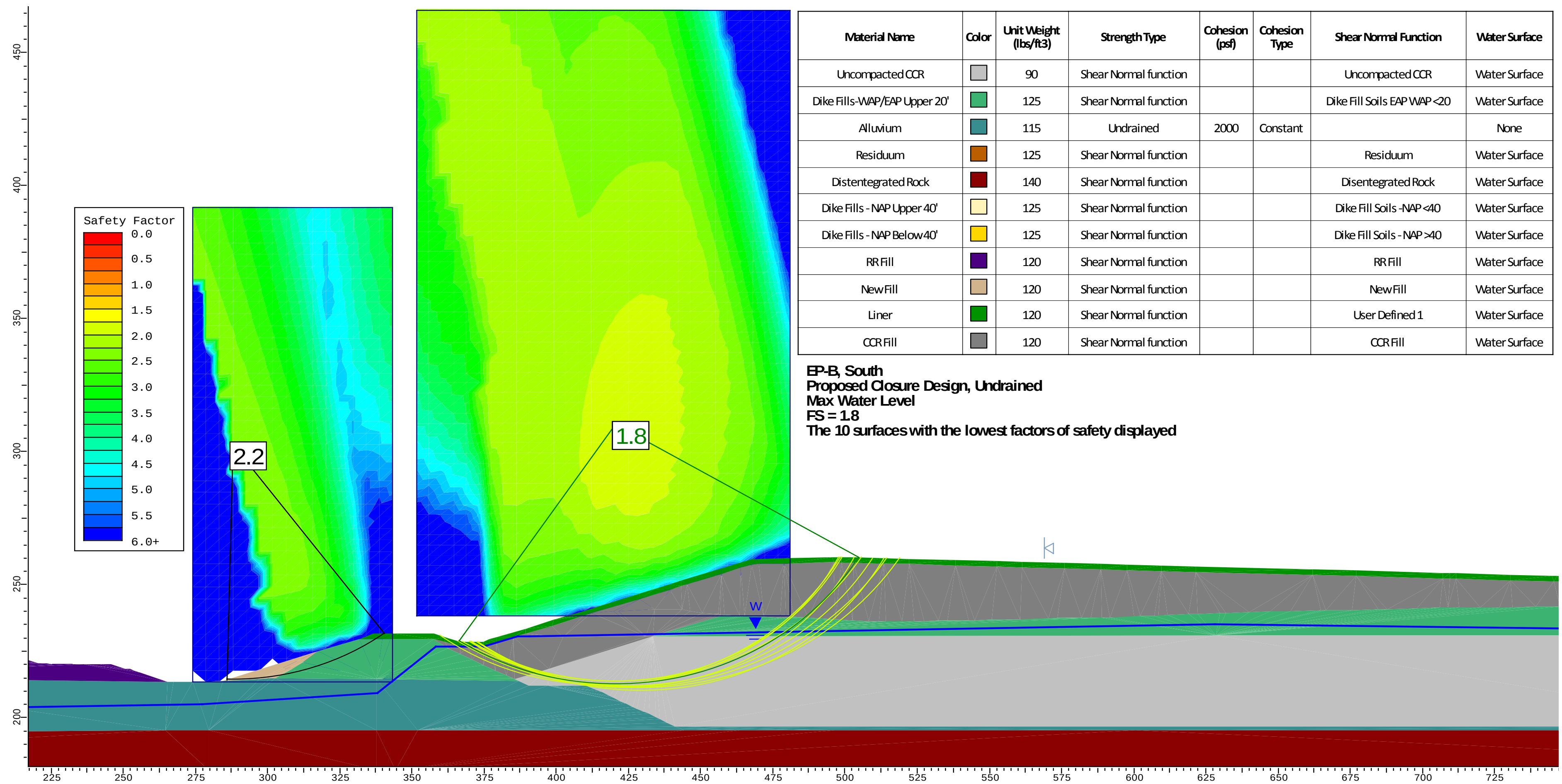
Figure **4B**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Dike Fills - NAP Upper 40'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills - NAP Below 40'		125	Mohr-Coulomb	50	28		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

EP-B, South
Proposed Closure Design, Steady State
Design Water Level
FS = 2.0
The 10 surfaces with the lowest factors of safety displayed

Golder Associates	SCALE As Shown	**EAP Section B - South**
	DATE Oct-30-2015	**Slope Stability Analysis**
	MADE BY MGP	**Proposed Closure Design**
	CHECK JGM	**Steady State, Design Water Level**
	REVIEW PDP	**Dominion Bremo Bluff Power Station**
PROJECT No. 1520347 REV. 0		**Ash Pond Closure Project** — Figure **4C**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40	Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

EP-B, South
Proposed Closure Design, Undrained
Max Water Level
FS = 1.8
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

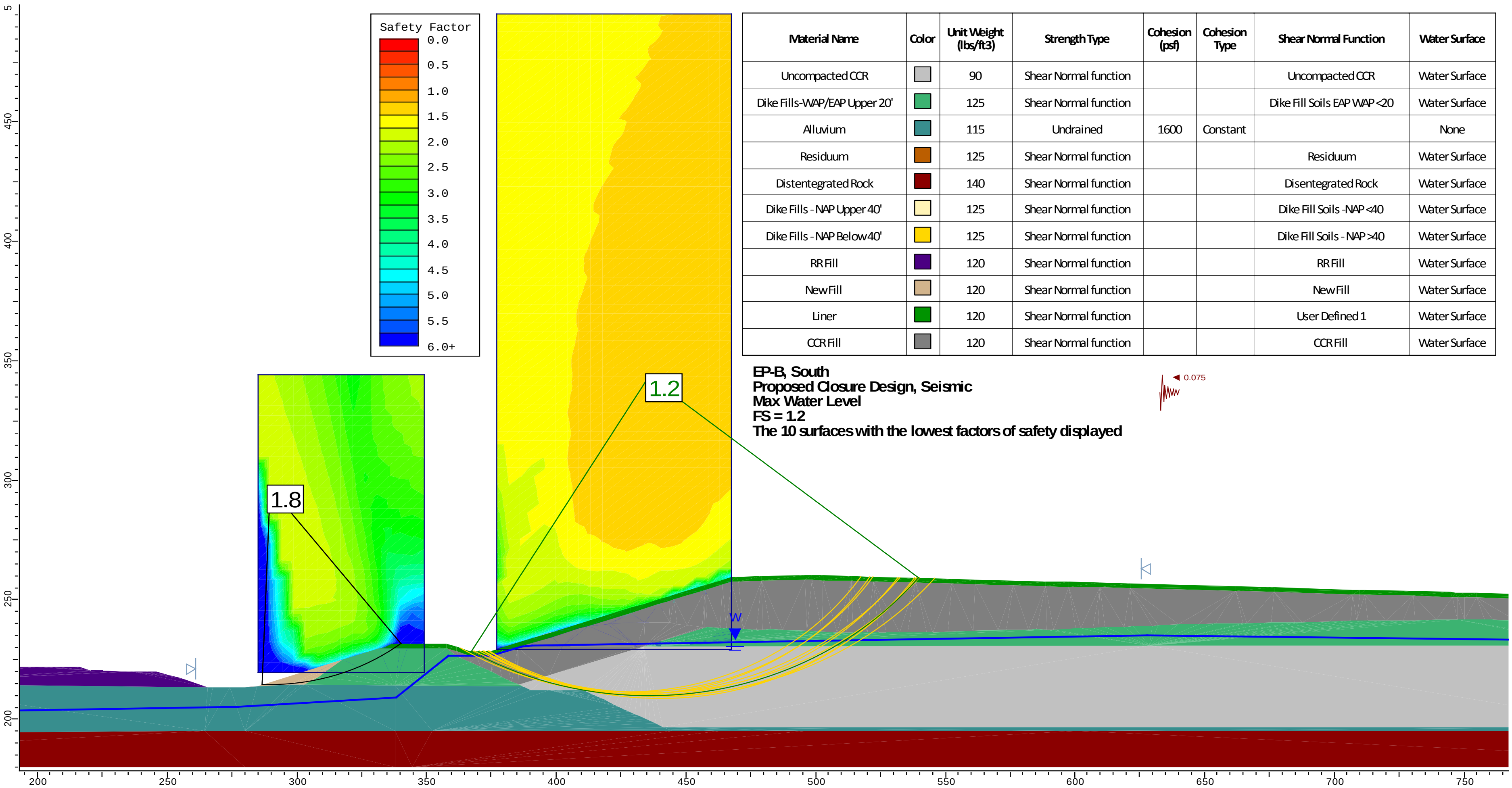
EAP Section B - South

Slope Stability Analysis
Proposed Closure Design
Undrained, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **4D**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40	Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

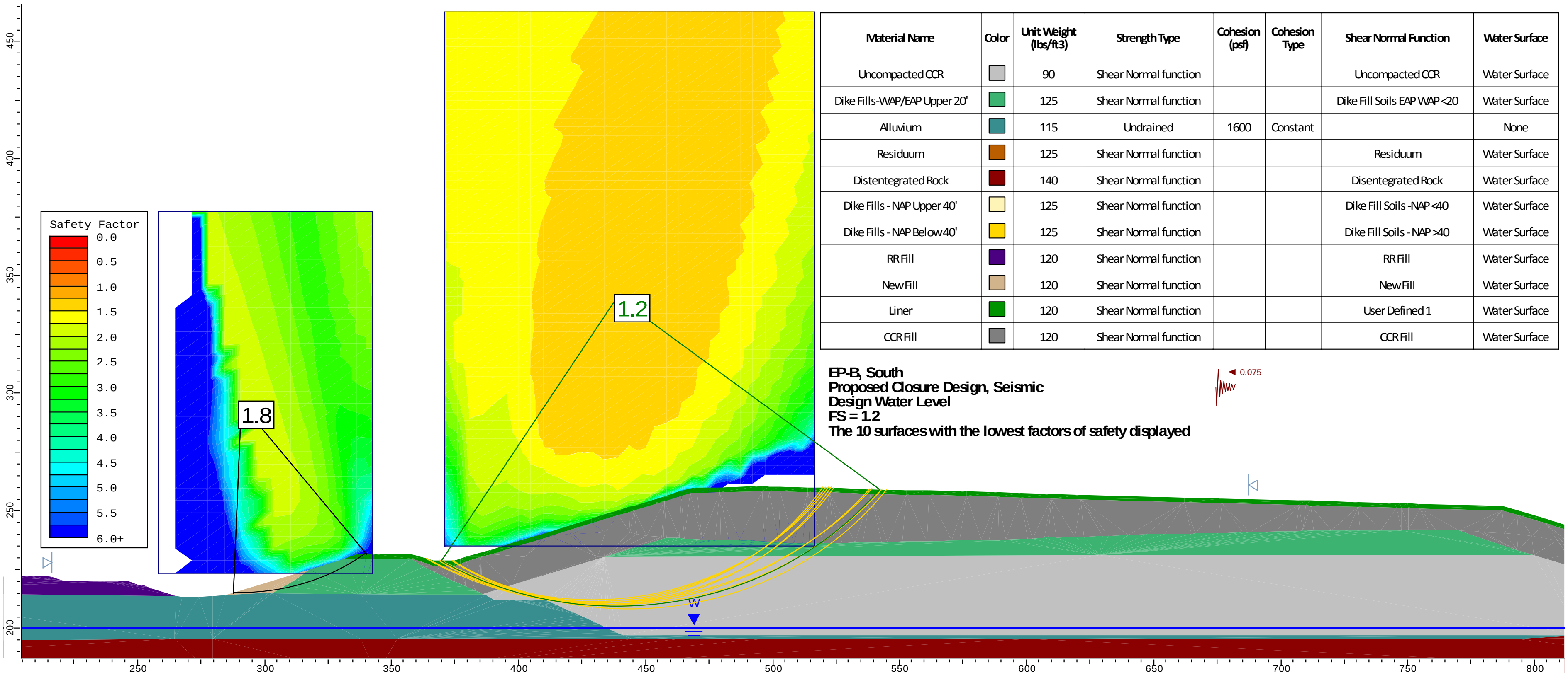
PROJECT No. 1520347 REV. 0

EAP Section B - South

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **4E**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40	Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

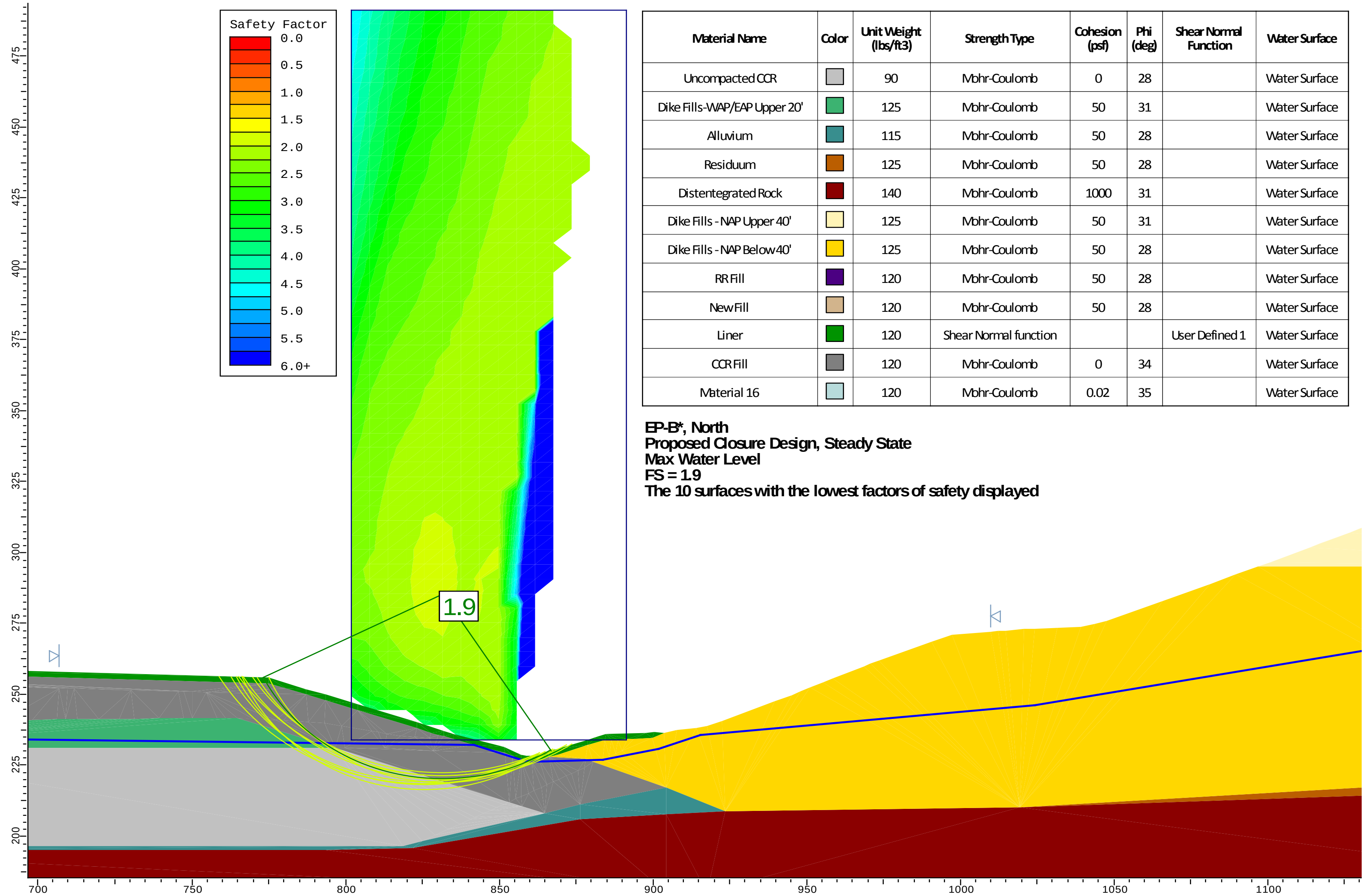
EP-B, South
Proposed Closure Design, Seismic
Design Water Level
FS = 1.2
The 10 surfaces with the lowest factors of safety displayed

Golder Associates	SCALE: As Shown	**EAP Section B - South**	
	DATE: Oct-30-2015	**Slope Stability Analysis Proposed Closure Design Seismic, Design Water Level**	
	MADE BY: MGP		
	CHECK: JGM		
	REVIEW: PDP	**Dominion Bremo Bluff Power Station Ash Pond Closure Project**	Figure **4F**
PROJECT No. 1520347 REV. 0			

Not Applicable
No Existing Slope to Analyze

SCALE	As Shown	**EAP Section B - North**	
DATE	Oct-30-2015	**Bremo Bluff Power Station** **Slope Stability Analysis** **Existing Conditions, Steady State Analysis**	
MADE BY	JGM		
CHECK	MGP		
REVIEW	PDP	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **5A**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Dike Fills - NAP Upper 40'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills - NAP Below 40'		125	Mohr-Coulomb	50	28		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface
Material 16		120	Mohr-Coulomb	0.02	35		Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

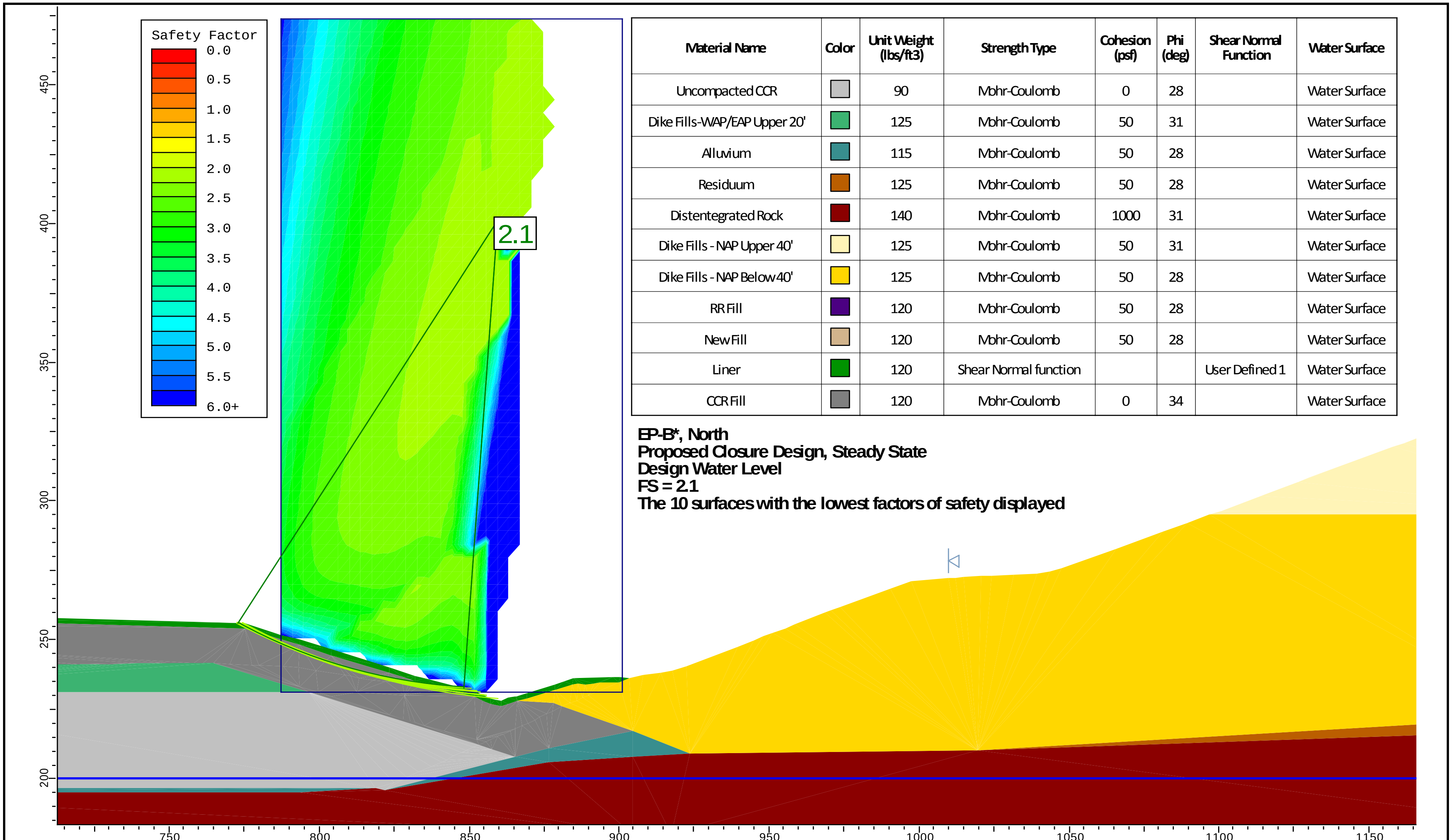
EAP Section B* - North

Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

Dominion Bremo Bluff Power Station
Closure Ash Pond Project

Figure **5B**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Dike Fills - NAP Upper 40'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills - NAP Below 40'		125	Mohr-Coulomb	50	28		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

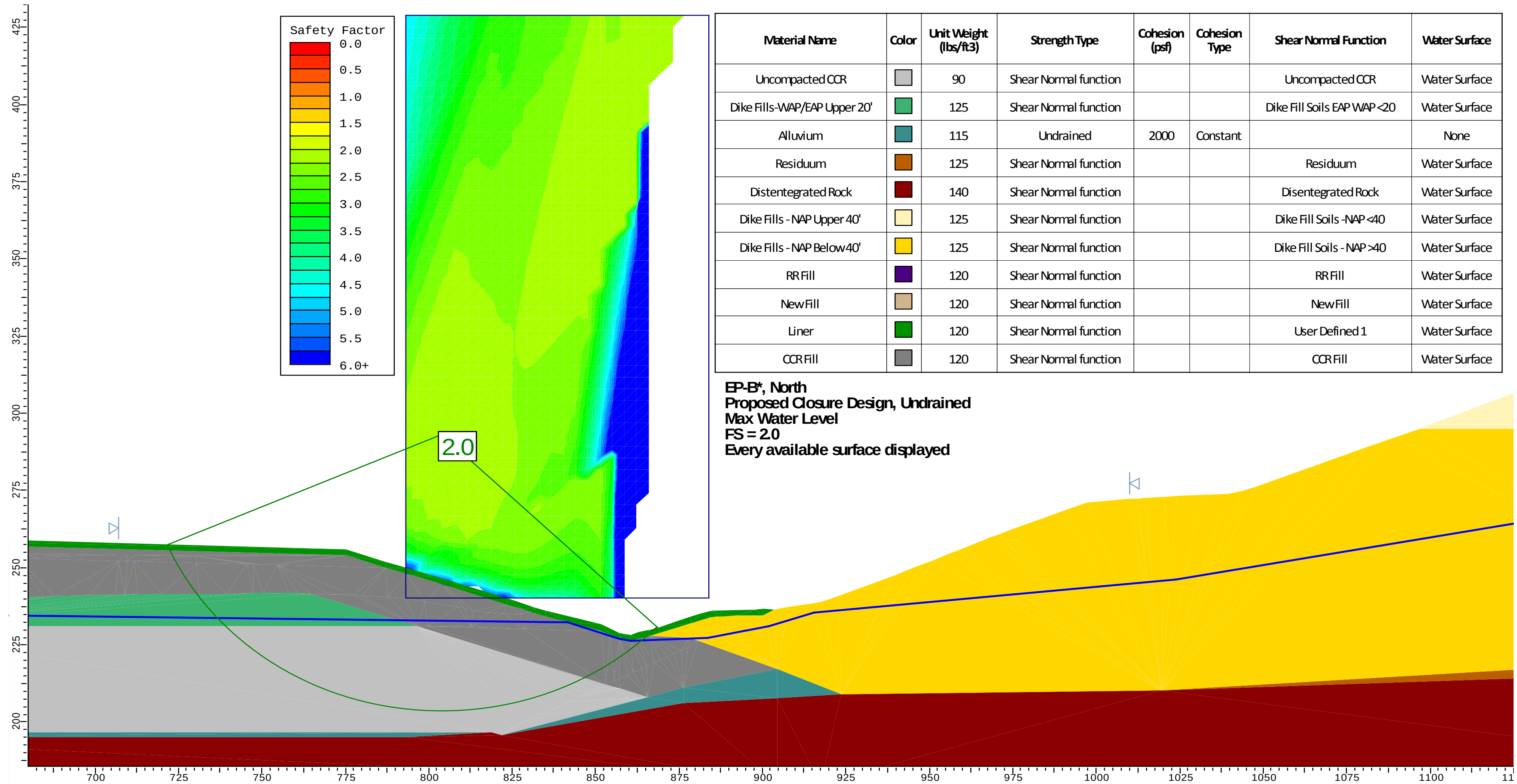
EAP Section B* - North

Slope Stability Analysis
Proposed Closure Design
Steady State, Design Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **5C**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40	Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

EP-B*, North
Proposed Closure Design, Undrained
Max Water Level
FS = 2.0
Every available surface displayed

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

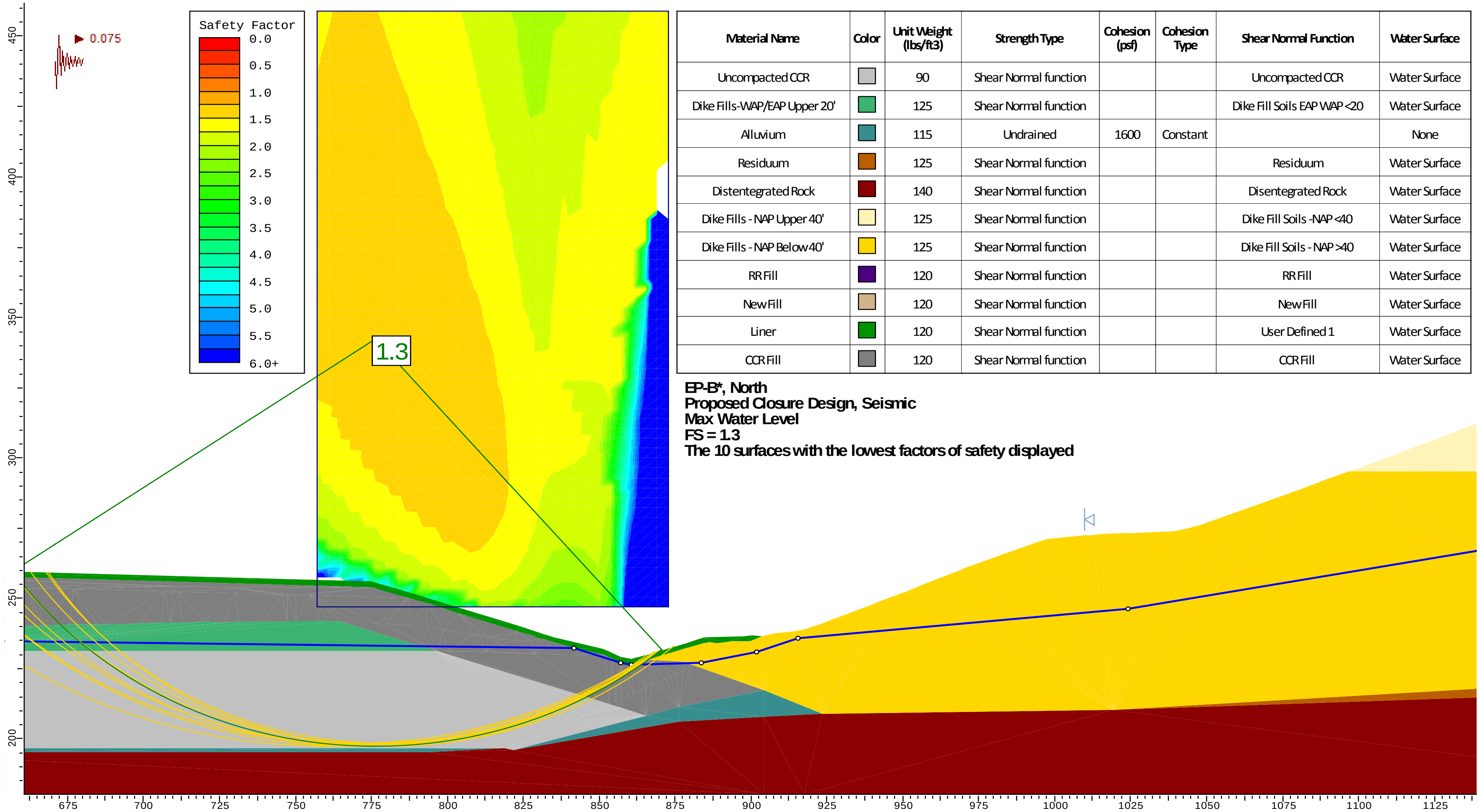
EAP Section B* - North

Slope Stability Analysis
Proposed Closure Design
Undrained, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **5D**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40	Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

EP-B*, North
Proposed Closure Design, Seismic
Max Water Level
FS = 1.3
The 10 surfaces with the lowest factors of safety displayed

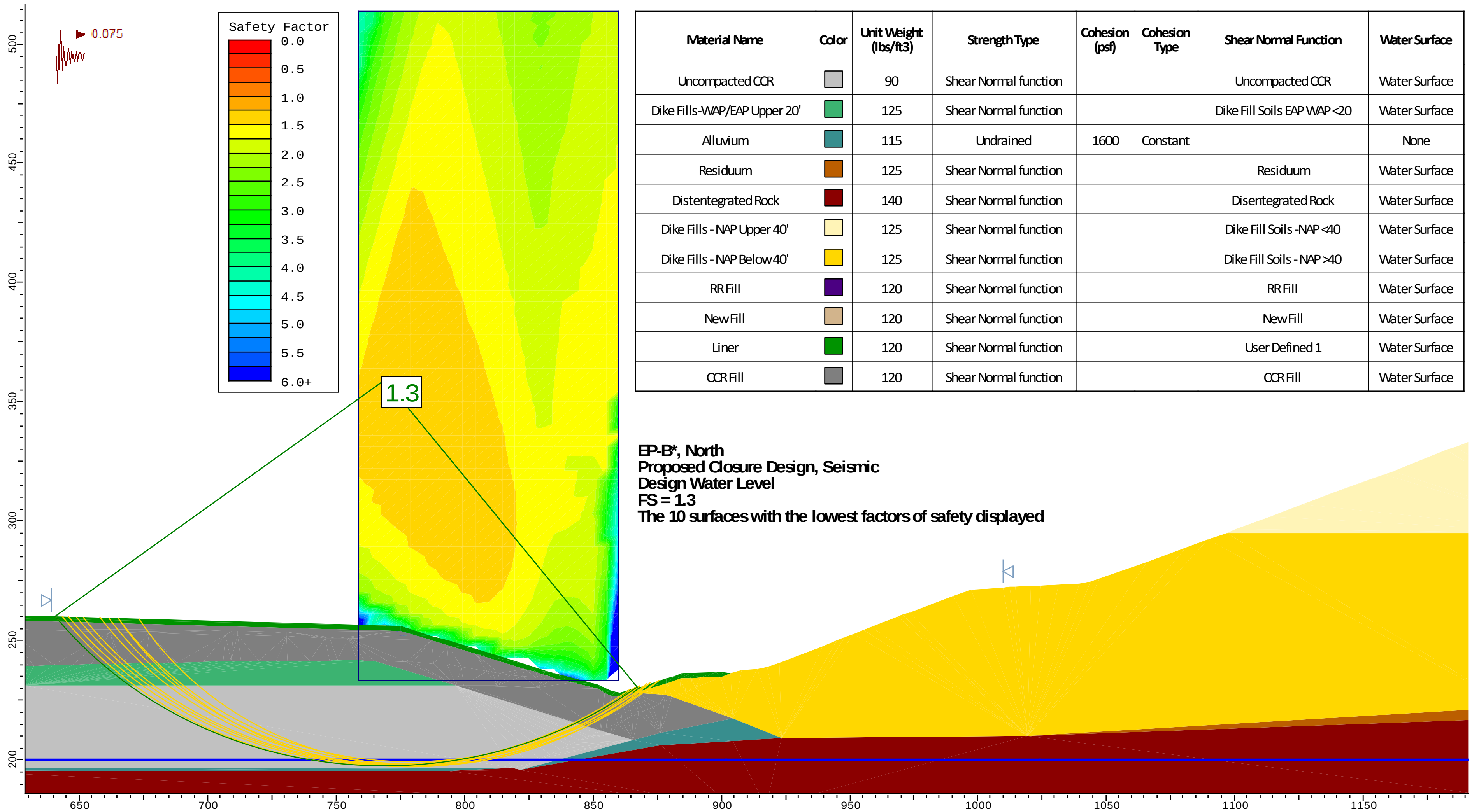
Golder Associates	SCALE	As Shown
	DATE	Oct-30-2015
	MADE BY	MGP
	CHECK	JGM
	REVIEW	PDP
PROJECT No. 1520347	REV. 0	

EAP Section B* - North

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **5E**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40	Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

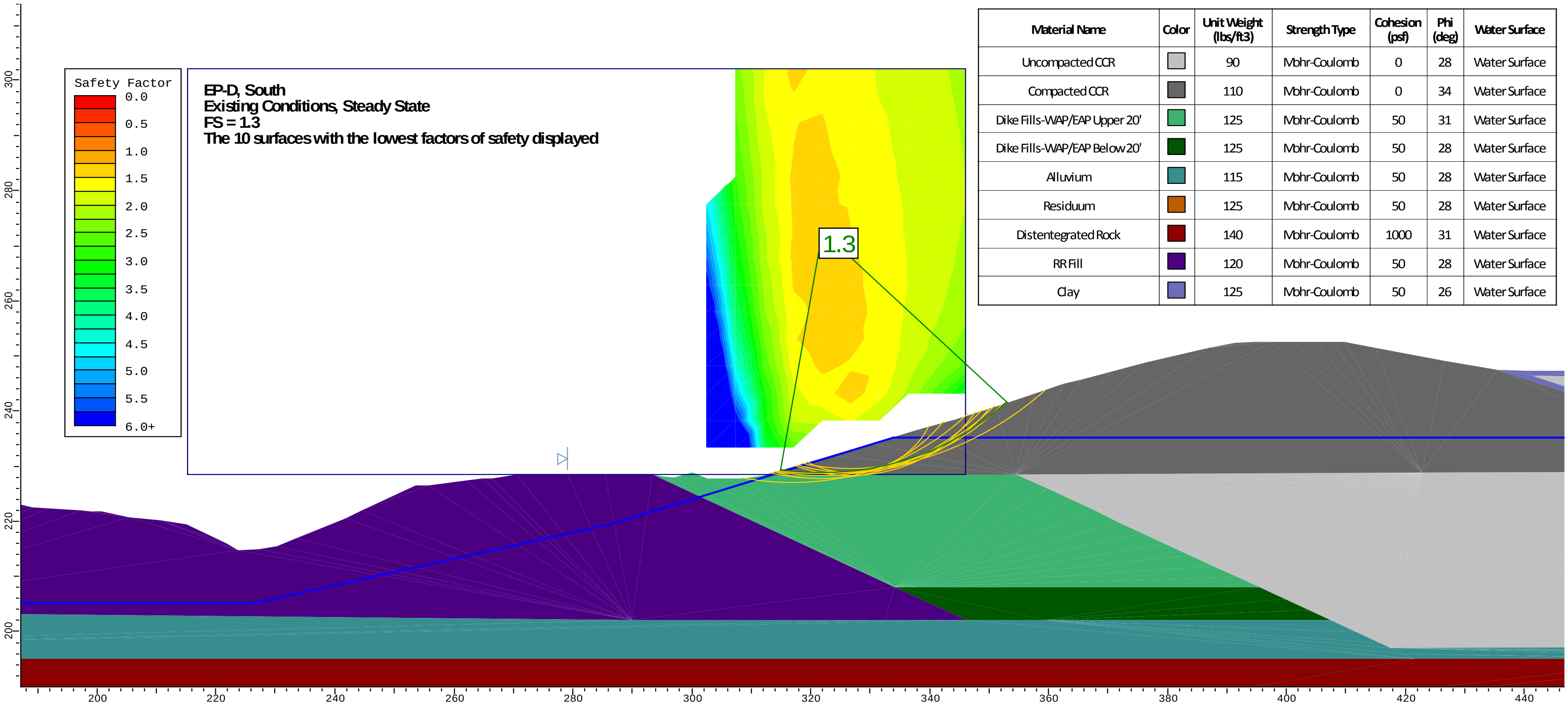
PROJECT No. 1520347 REV. 0

EAP Section B* - North

Slope Stability Analysis
Proposed Closure Design
Seismic, Design Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **4F**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Residuum		125	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface
RR Fill		120	Mohr-Coulomb	50	28	Water Surface
Clay		125	Mohr-Coulomb	50	26	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	JGM
CHECK	MGP
REVIEW	PDP

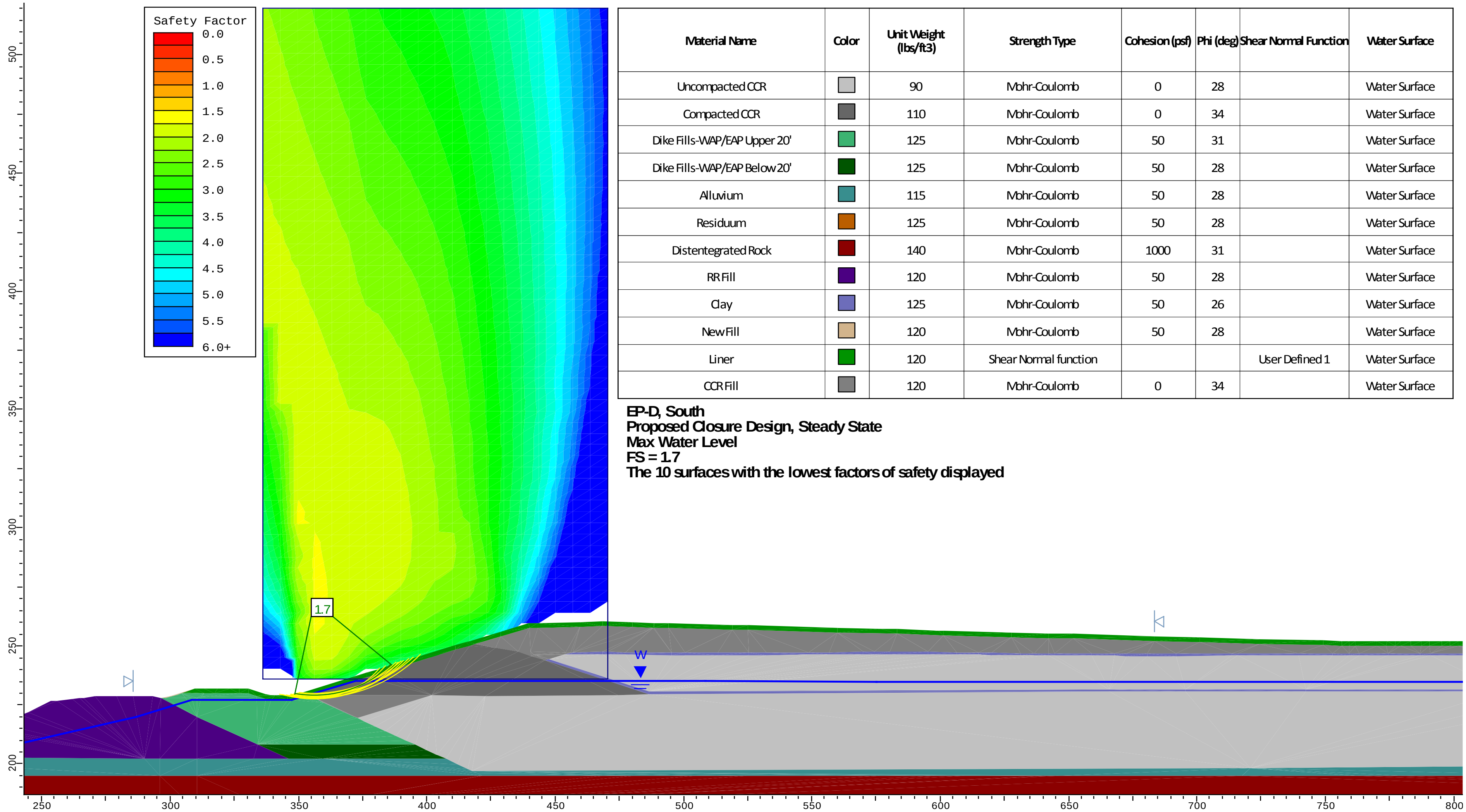
PROJECT No. 1520347 REV. 0

EAP Section D - South

Bremo Bluff Power Station
Slope Stability Analysis
Existing Conditions, Steady State

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **6A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
Clay		125	Mohr-Coulomb	50	26		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

EP-D, South
Proposed Closure Design, Steady State
Max Water Level
FS = 1.7
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

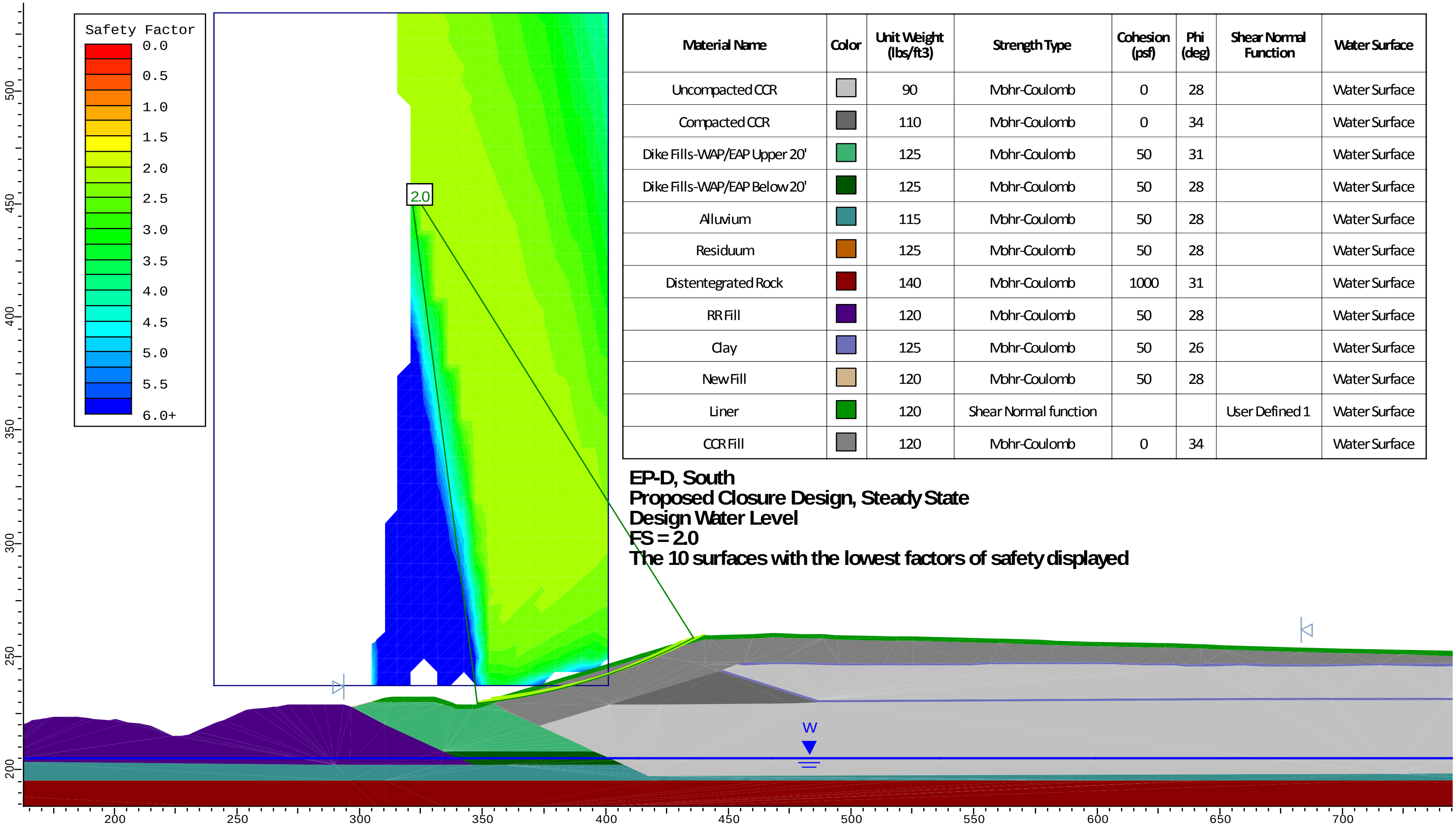
PROJECT No. 1520347 REV. 0

EAP Section D - South

Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **6B**



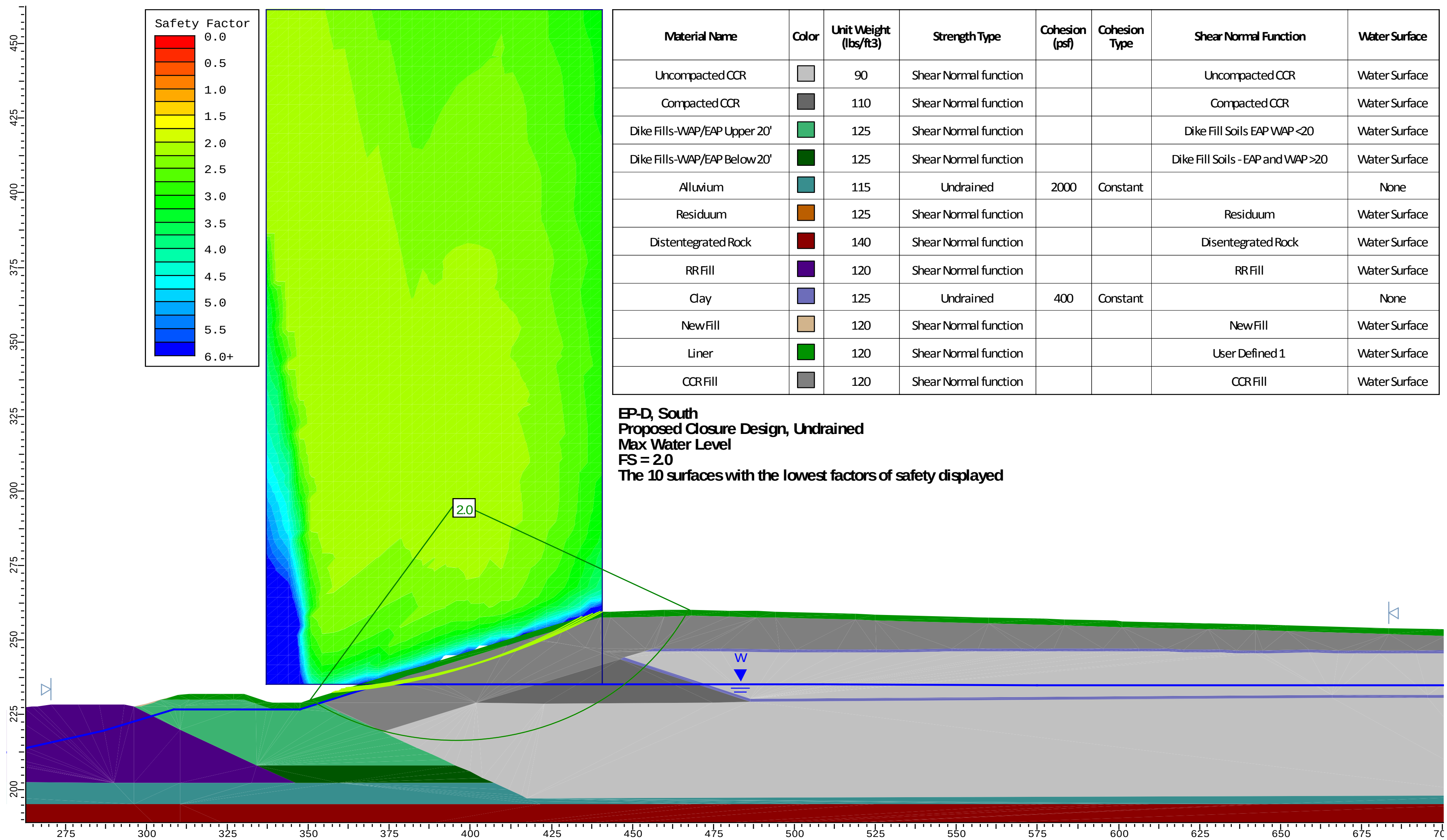
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
Clay		125	Mohr-Coulomb	50	26		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

EP-D, South
Proposed Closure Design, Steady State
Design Water Level
FS = 2.0
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown	**EAP Section D - South**	
DATE	Oct-30-2015	**Slope Stability Analysis**	
MADE BY	MGP	**Proposed Closure Design**	
CHECK	JGM	**Steady State, Design Water Level**	
REVIEW	PDP	**Dominion Bremo Bluff Power Station**	Figure
		Ash Pond Closure Project	**6C**

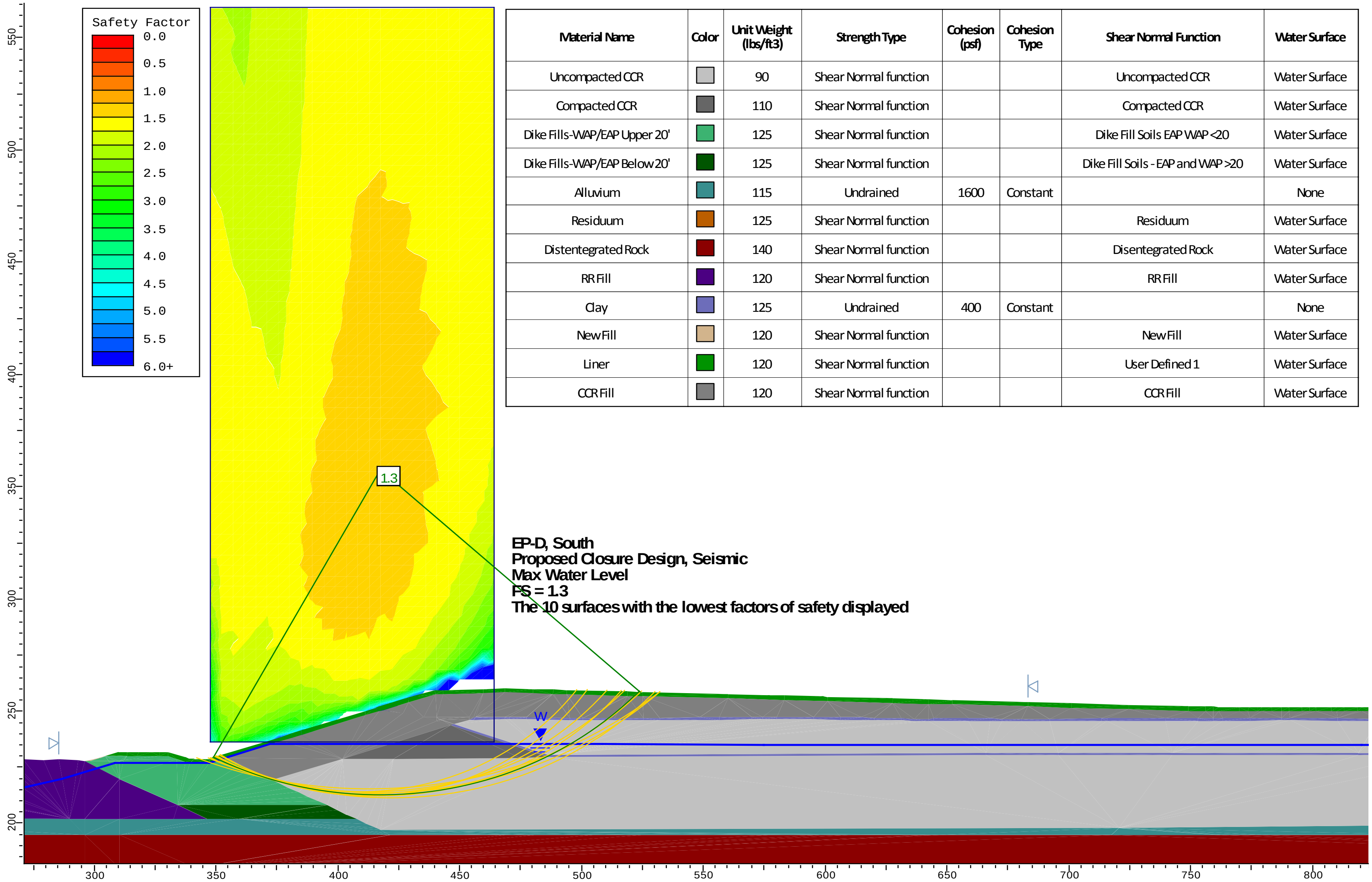
PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
Clay		125	Undrained	400	Constant		None
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

EP-D, South
Proposed Closure Design, Undrained
Max Water Level
FS = 2.0
The 10 surfaces with the lowest factors of safety displayed

Golder Associates	SCALE: As Shown	**EAP Section D - South**	
	DATE: Oct-30-2015	**Slope Stability Analysis Proposed Closure Design Undrained, Max Water Level**	
	MADE BY: MGP		
	CHECK: JGM		
	REVIEW: PDP	**Dominion Bremo Bluff Power Station Ash Pond Closure Project**	Figure **6D**
PROJECT No. 1520347 / REV. 0			



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
Clay		125	Undrained	400	Constant		None
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

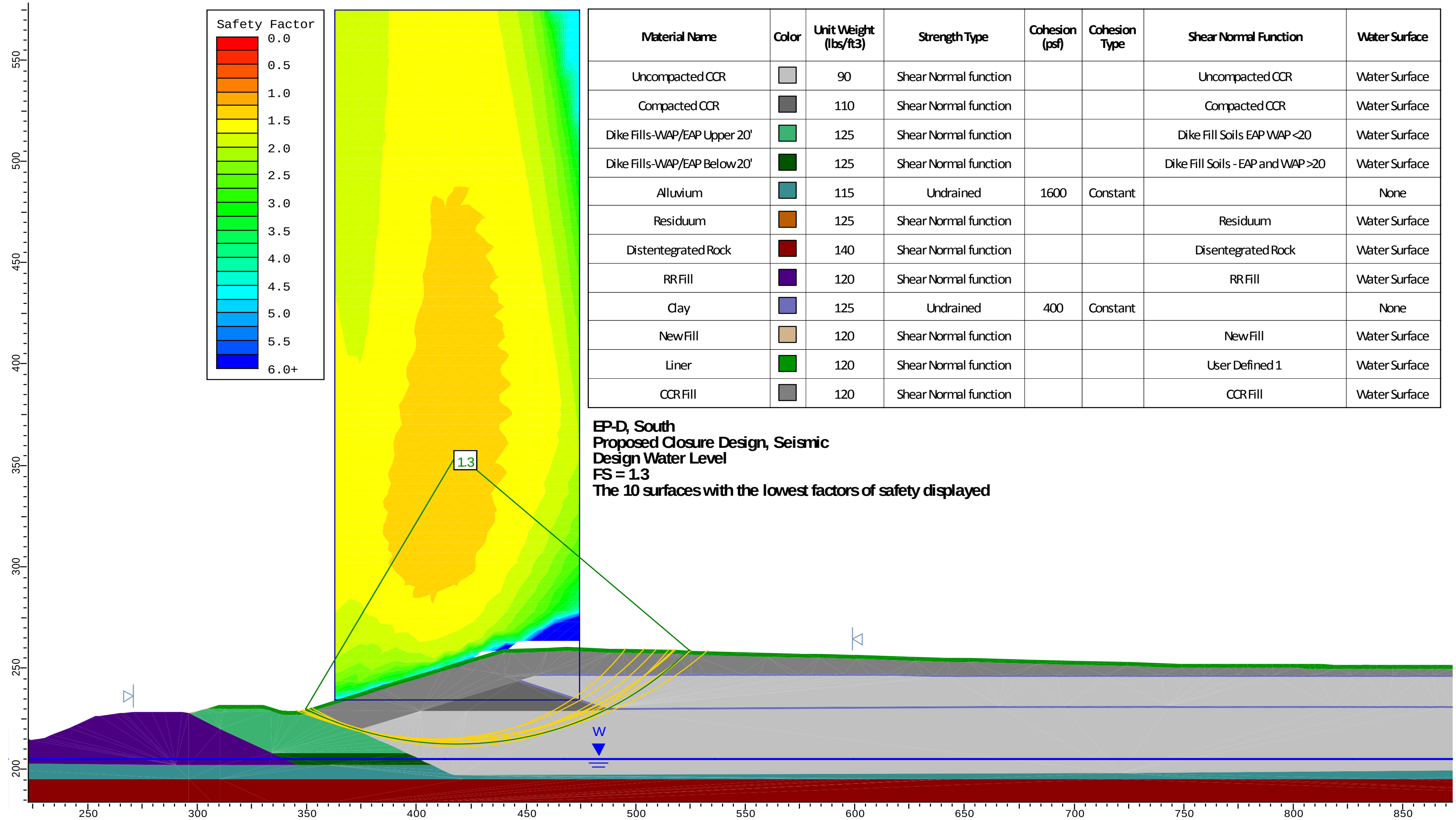
EAP Section D - South

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **6E**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
Clay		125	Undrained	400	Constant		None
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

EP-D, South
Proposed Closure Design, Seismic
Design Water Level
FS = 1.3
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

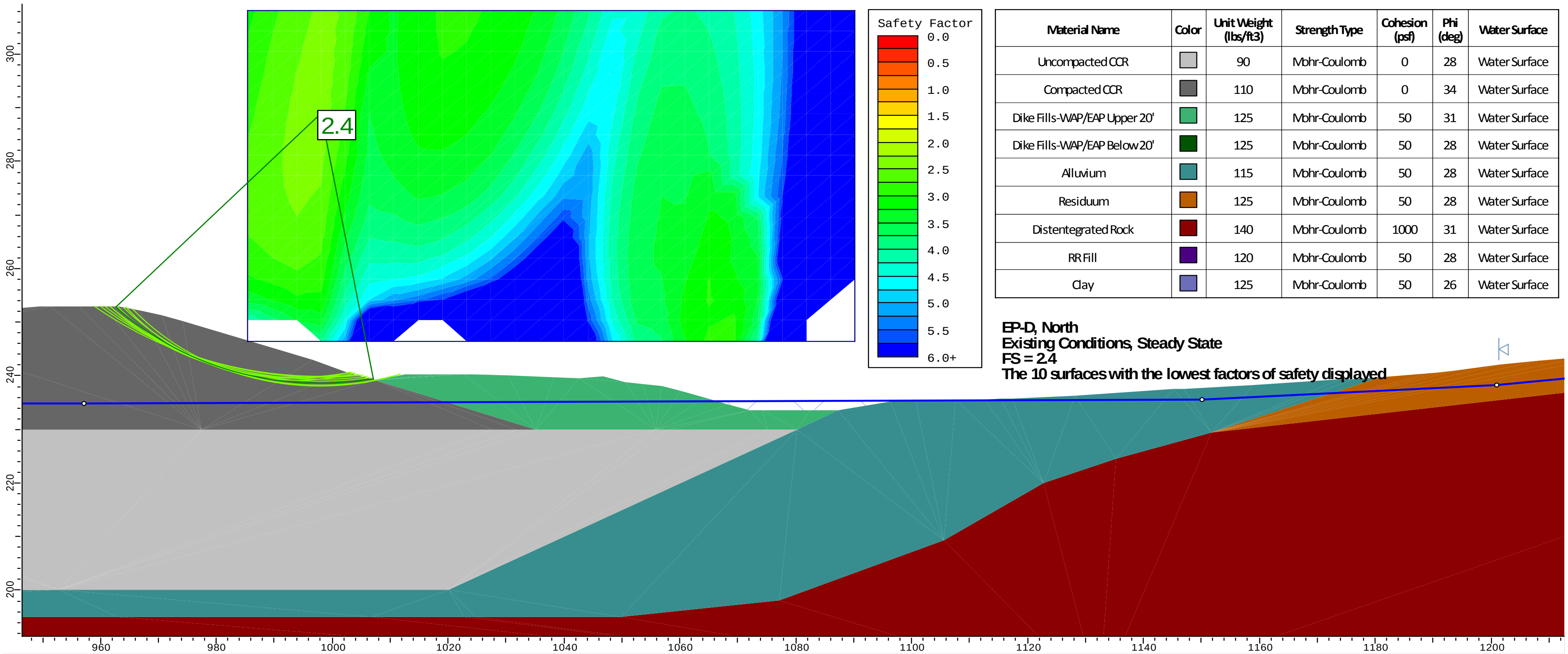
PROJECT No. 1520347 REV. 0

EAP Section D - South

Slope Stability Analysis
Proposed Closure Design
Seismic, Design Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **6F**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Residuum		125	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface
RR Fill		120	Mohr-Coulomb	50	28	Water Surface
Clay		125	Mohr-Coulomb	50	26	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	JGM
CHECK	MGP
REVIEW	PDP

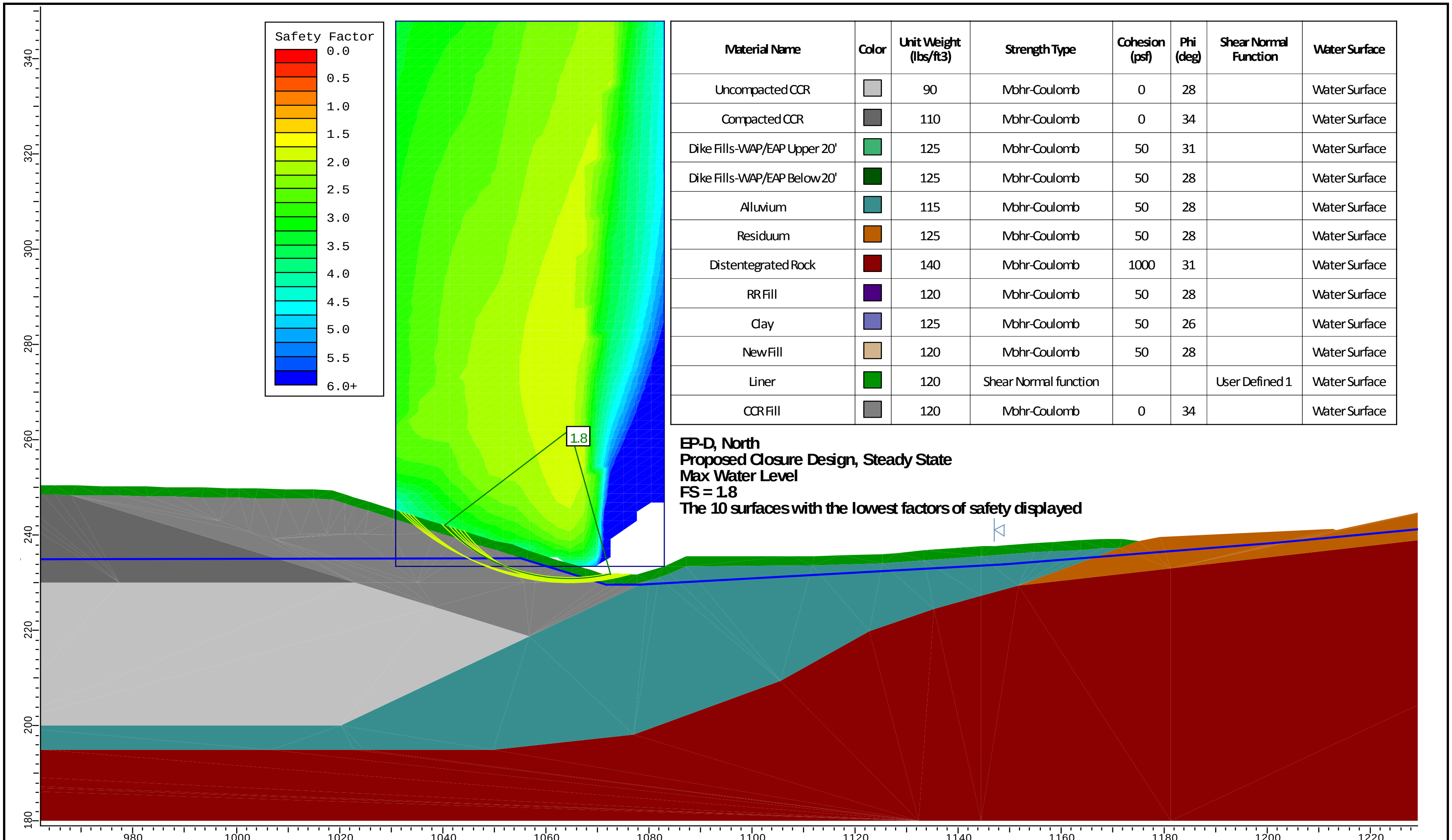
PROJECT No. 1520347 REV. 0

EAP Section D - North

Bremo Bluff Power Station
Slope Stability Analysis
Existing Conditions, Steady State

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **7A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
Clay		125	Mohr-Coulomb	50	26		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

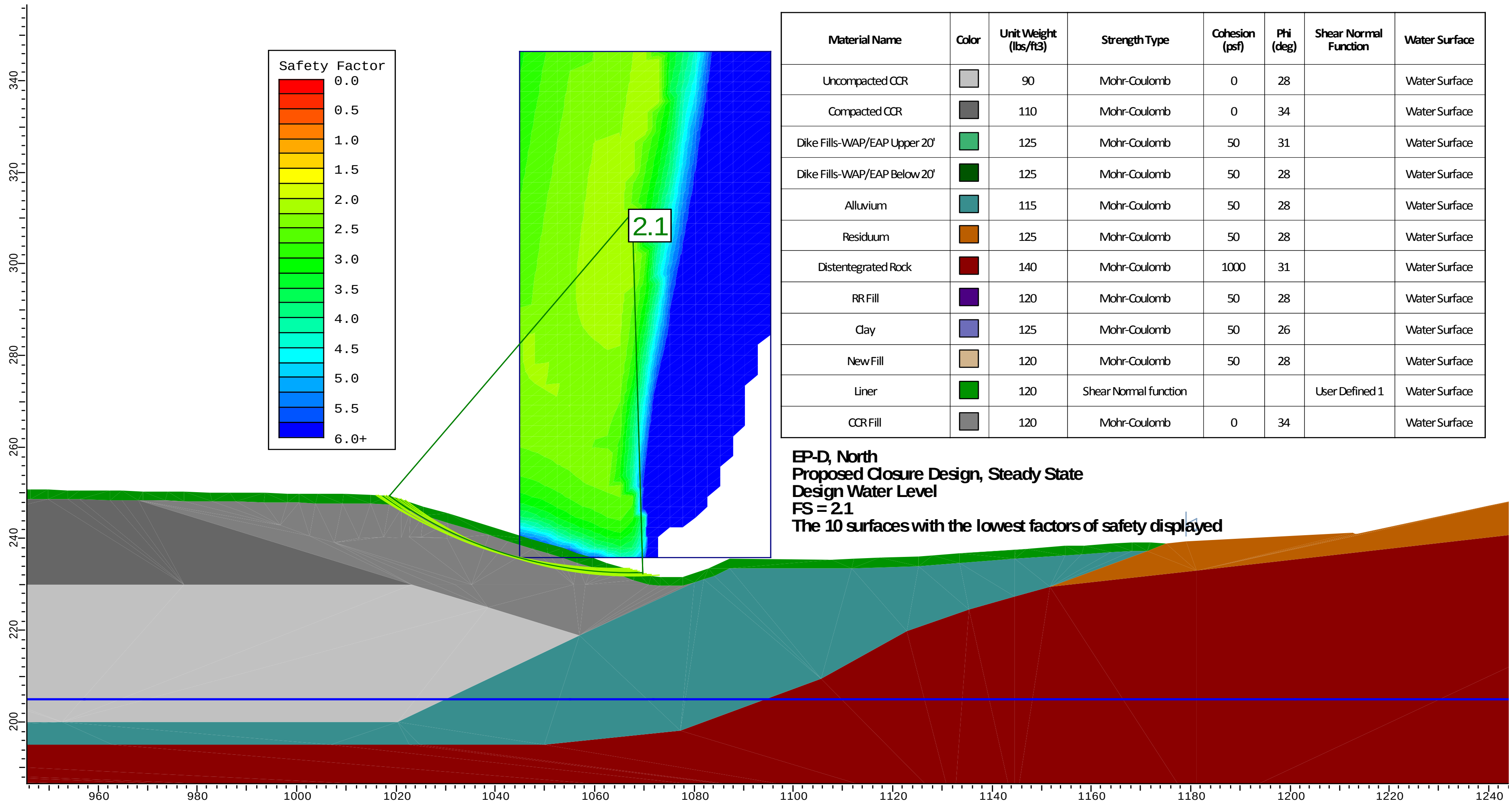
EAP Section D - North

Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **7B**

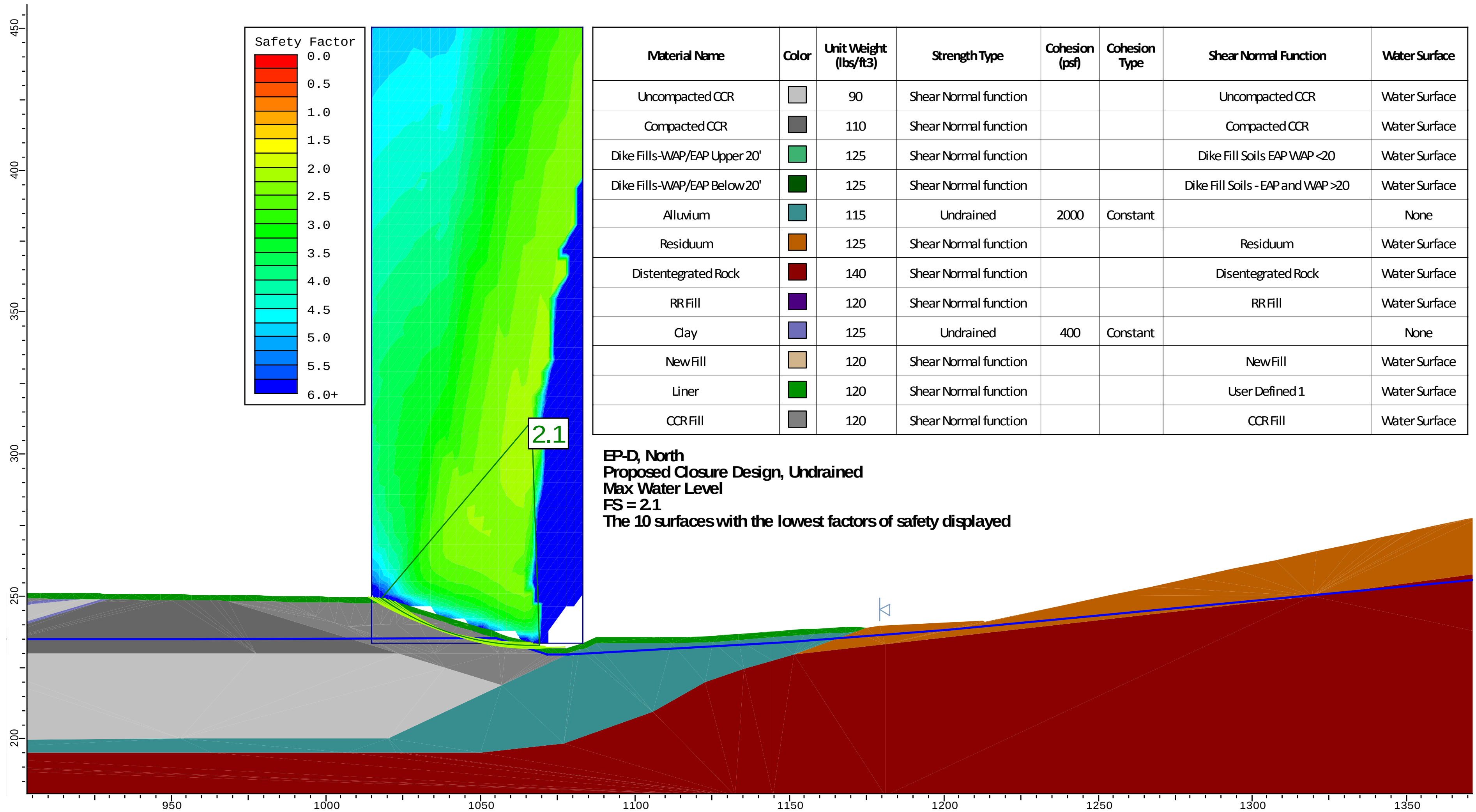
PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
Clay		125	Mohr-Coulomb	50	26		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

EP-D, North
Proposed Closure Design, Steady State
Design Water Level
FS = 2.1
The 10 surfaces with the lowest factors of safety displayed

Golder Associates	SCALE: As Shown	**EAP Section D - North**	
	DATE: Oct-30-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Design Water Level**	
	MADE BY: MGP		
	CHECK: JGM		
PROJECT No. 1520347 / REV. 0	REVIEW: PDP	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **7C**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
Clay		125	Undrained	400	Constant		None
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

PROJECT No. 1520347 REV. 0

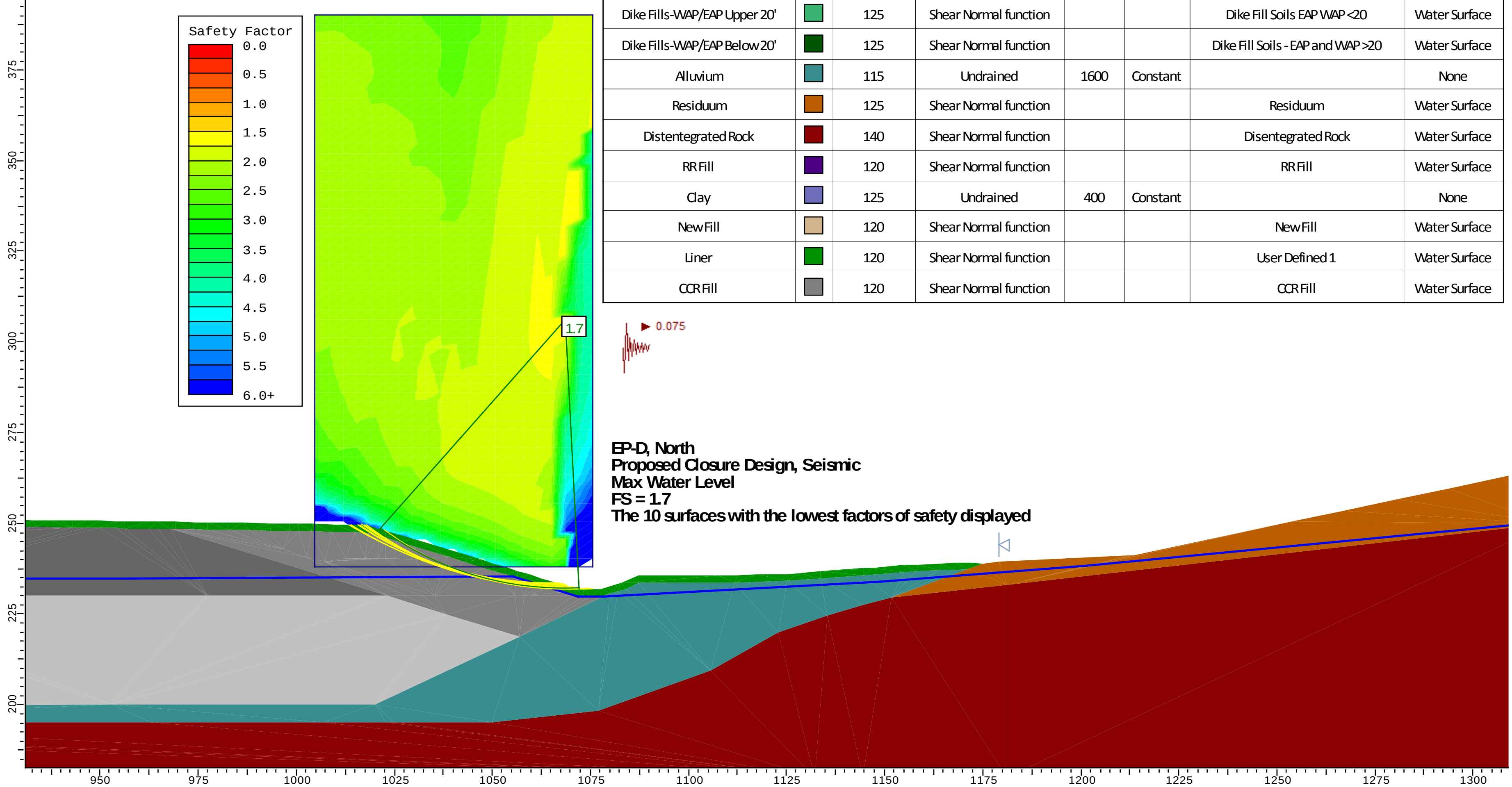
EAP Section D - North

Slope Stability Analysis
Proposed Closure Design
Undrained, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **7D**

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
Clay		125	Undrained	400	Constant		None
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface



Golder Associates

SCALE As Shown

DATE Oct-30-2015

MADE BY MGP

CHECK JGM

REVIEW PDP

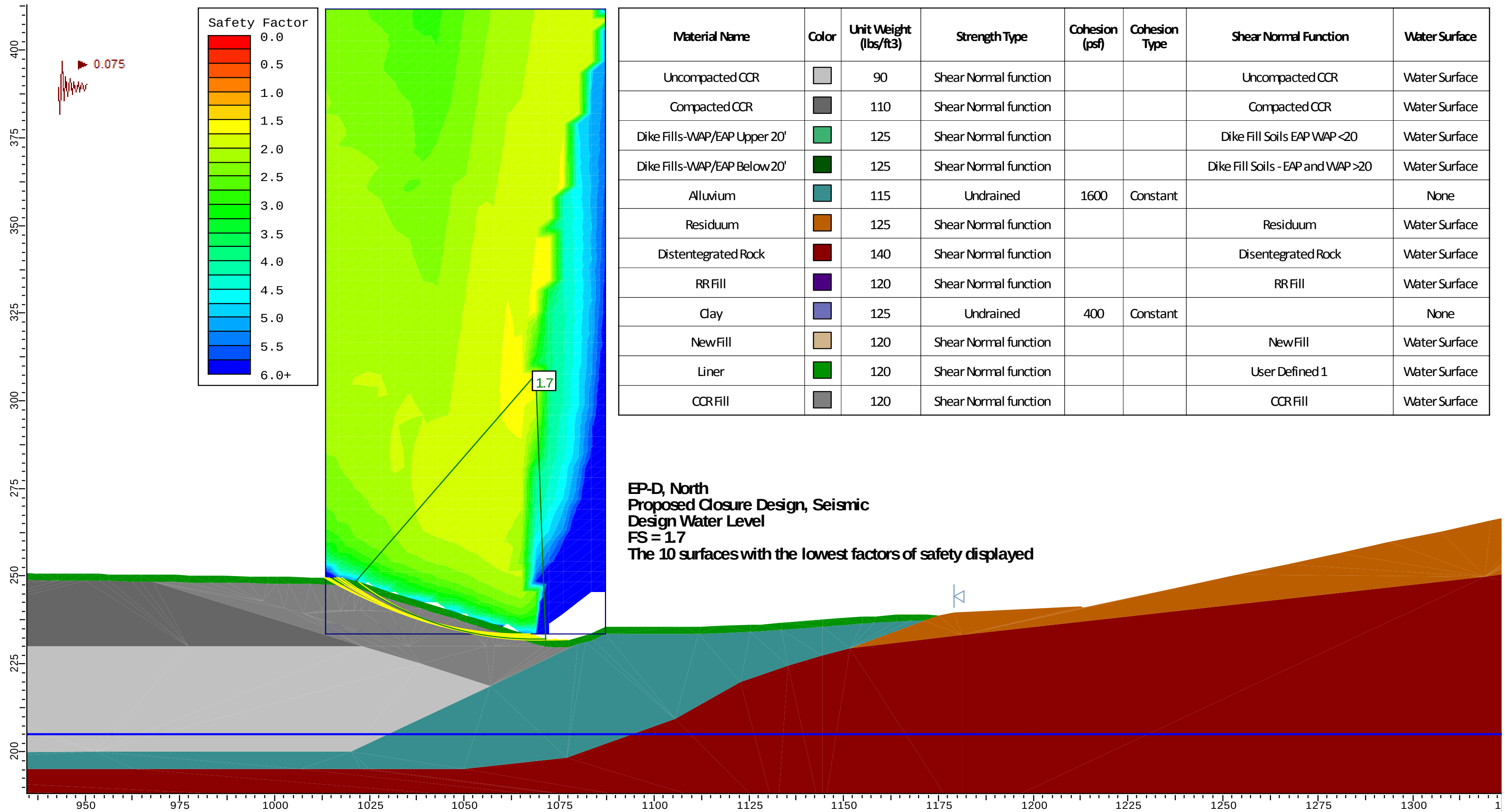
PROJECT No. 1520347 REV. 0

EAP Section D - North

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **7E**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
Clay		125	Undrained	400	Constant		None
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

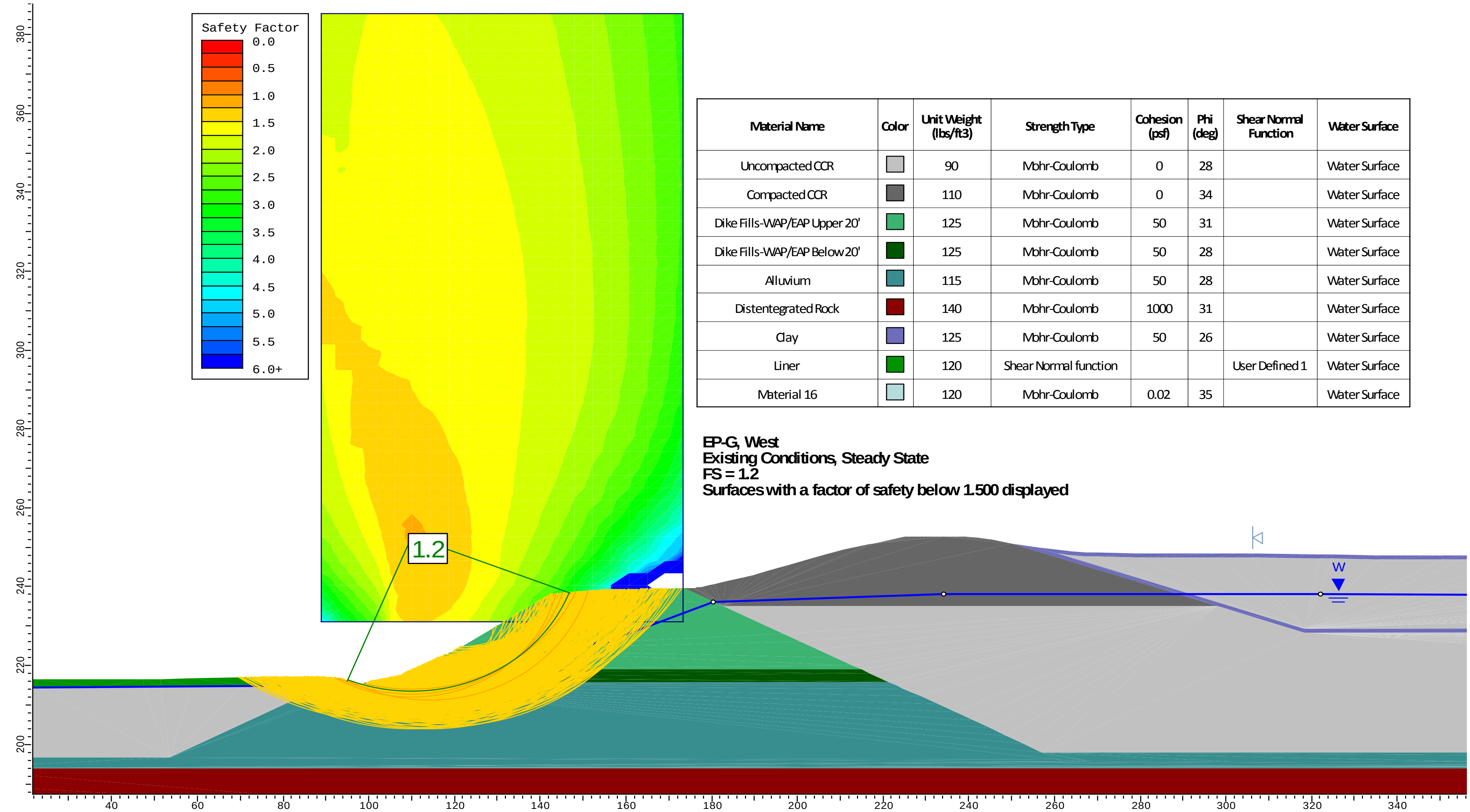
PROJECT No. 1520347 REV. 0

EAP Section D - North

Slope Stability Analysis
Proposed Closure Design
Seismic, Design Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **7F**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Clay		125	Mohr-Coulomb	50	26		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
Material 16		120	Mohr-Coulomb	0.02	35		Water Surface

EP-G, West
Existing Conditions, Steady State
FS = 1.2
Surfaces with a factor of safety below 1.500 displayed

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	JGM
CHECK	MGP
REVIEW	PDP

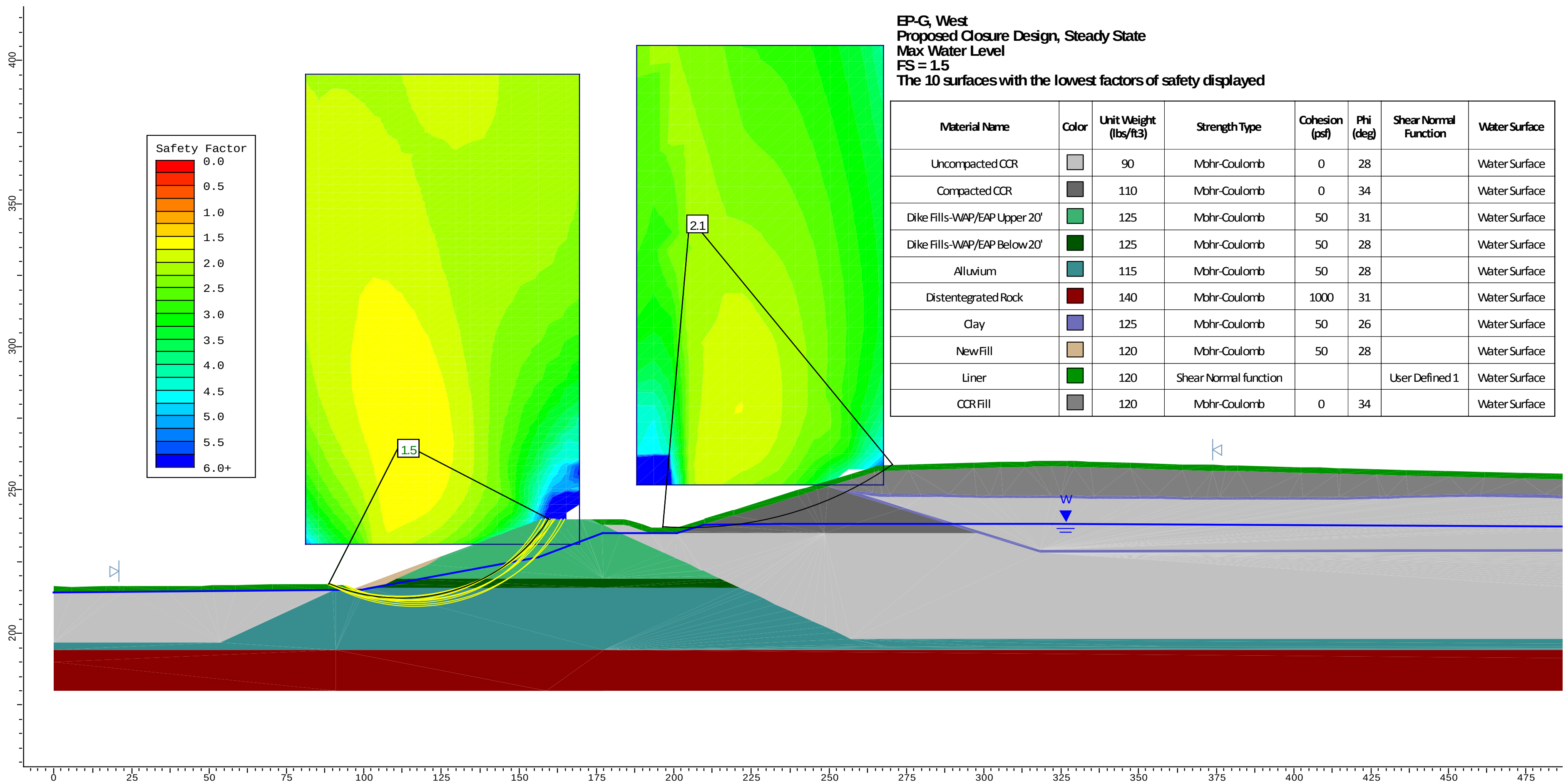
EAP Section G - West

Bremo Bluff Power Station
Slope Stability Analysis
Existing Conditions, Steady State

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **8A**

PROJECT No. 1520347 REV. 0



EP-G, West
Proposed Closure Design, Steady State
Max Water Level
FS = 1.5
The 10 surfaces with the lowest factors of safety displayed

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Clay		125	Mohr-Coulomb	50	26		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

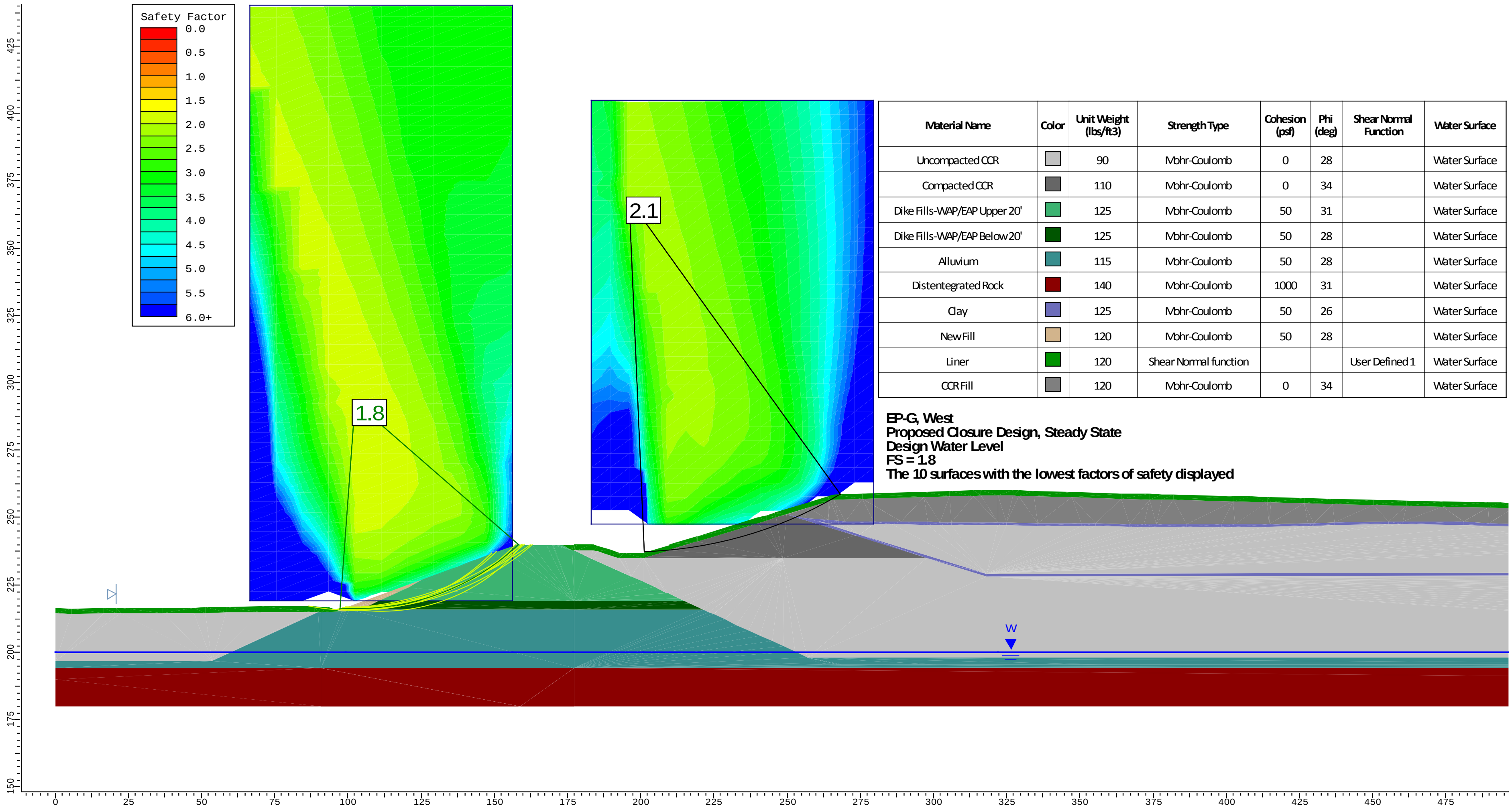
PROJECT No. 1520347 REV. 0

EAP Section G - West

Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **8B**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Clay		125	Mohr-Coulomb	50	26		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

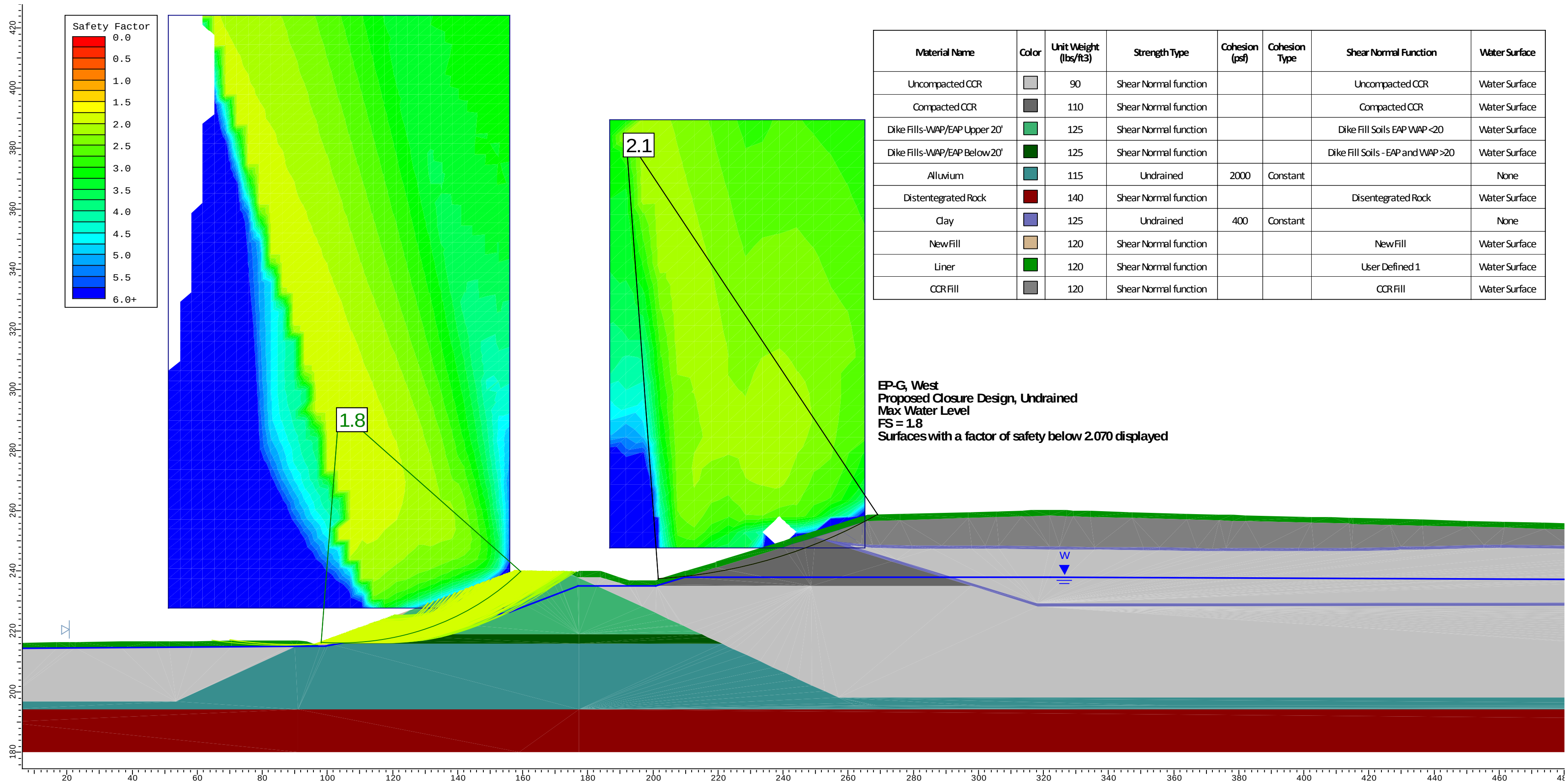
EAP Section G - West

Slope Stability Analysis
Proposed Closure Design
Steady State, Design Water Level

PROJECT No. 1520347 REV. 0

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **8C**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Clay		125	Undrained	400	Constant		None
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

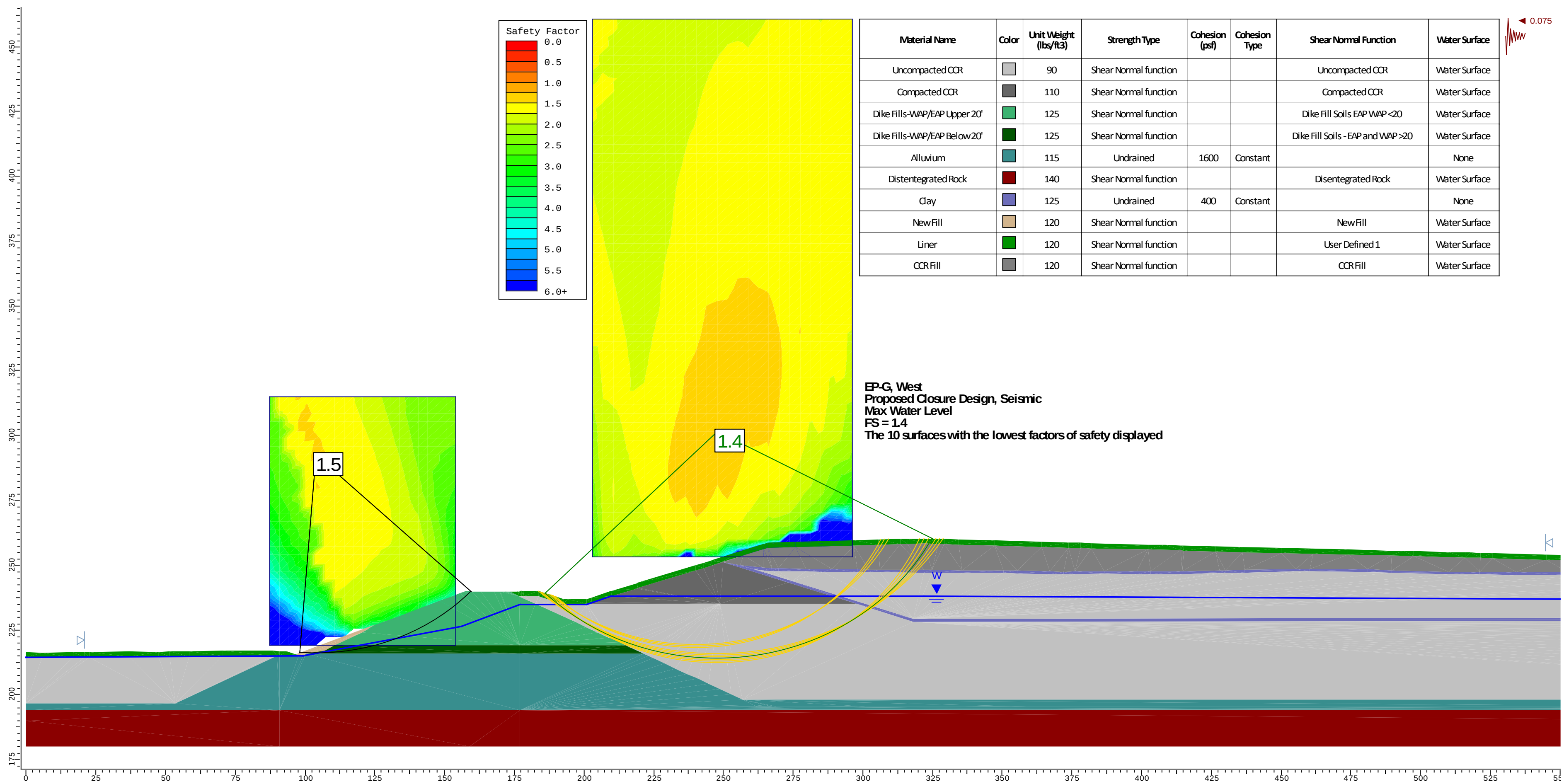
EAP Section G - West

Slope Stability Analysis
Proposed Closure Design
Undrained, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **8D**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Clay		125	Undrained	400	Constant		None
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

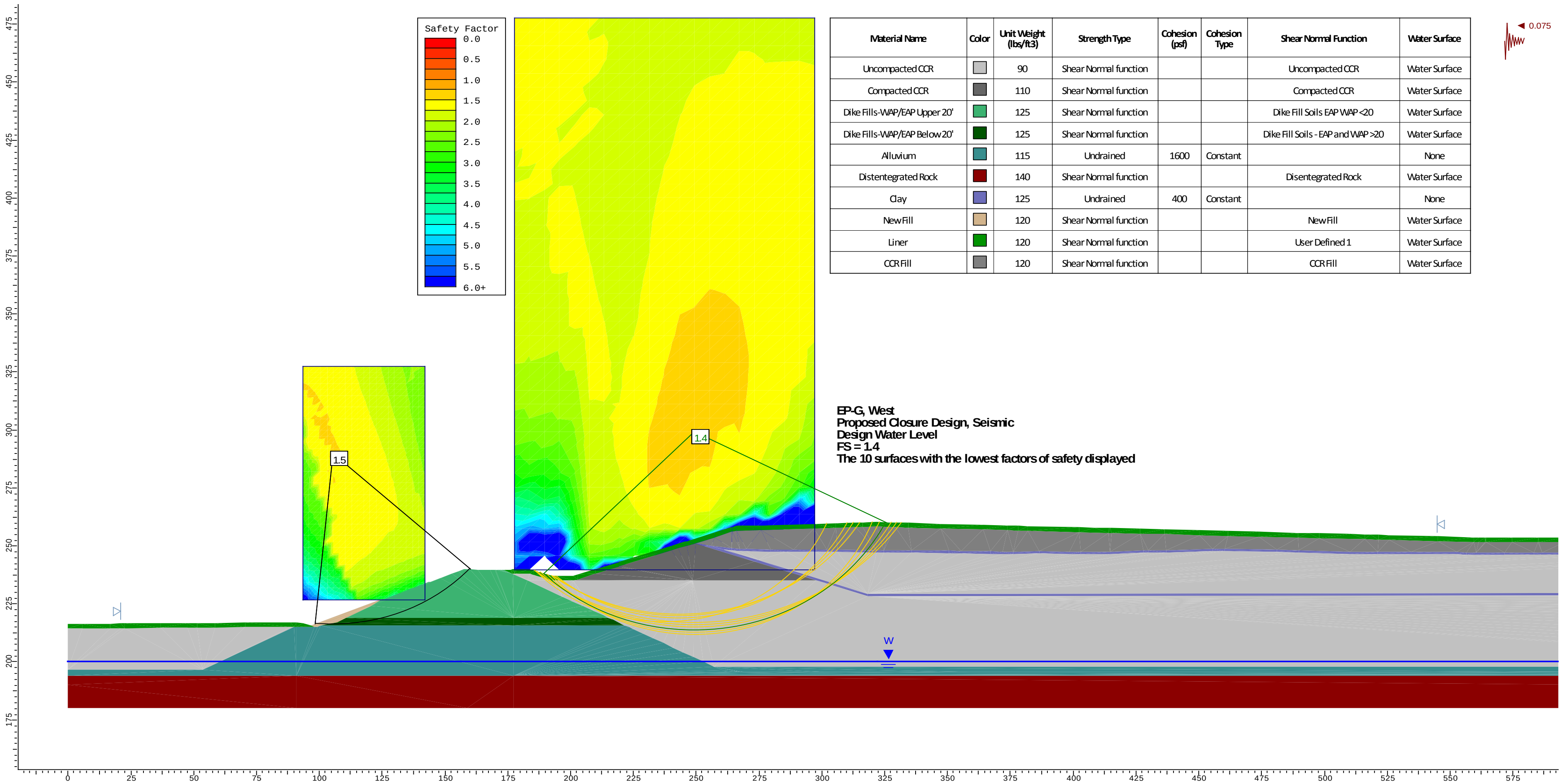
PROJECT No. 1520347 REV. 0

EAP Section G - West

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **8E**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Clay		125	Undrained	400	Constant		None
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

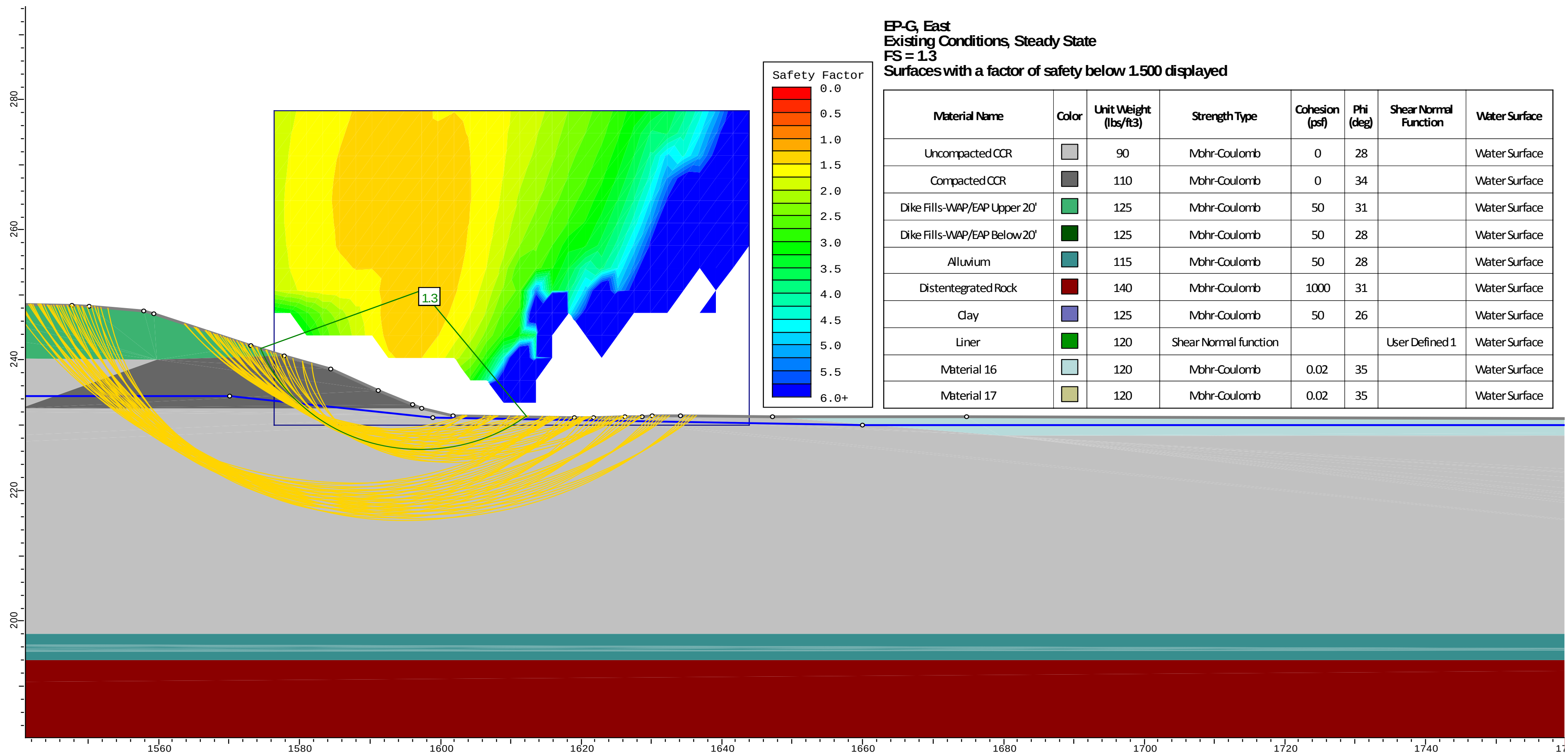
EAP Section G - West

Slope Stability Analysis
Proposed Closure Design
Seismic, Design Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **8F**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Clay		125	Mohr-Coulomb	50	26		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
Material 16		120	Mohr-Coulomb	0.02	35		Water Surface
Material 17		120	Mohr-Coulomb	0.02	35		Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	JGM
CHECK	MGP
REVIEW	PDP

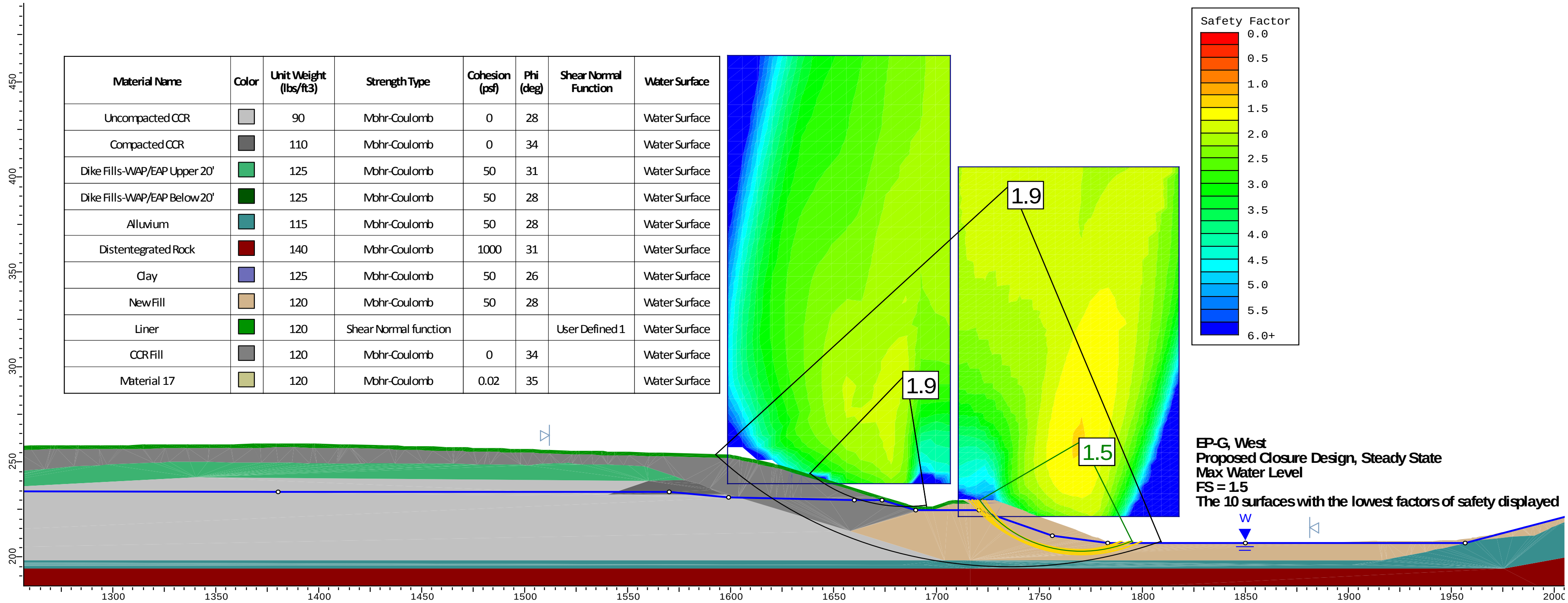
EAP Section G - East

Bremo Bluff Power Station
Slope Stability Analysis
Existing Conditions, Steady State

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **9A**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Clay		125	Mohr-Coulomb	50	26		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface
Material 17		120	Mohr-Coulomb	0.02	35		Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

PROJECT No. 1520347 REV. 0

EAP Section G - East

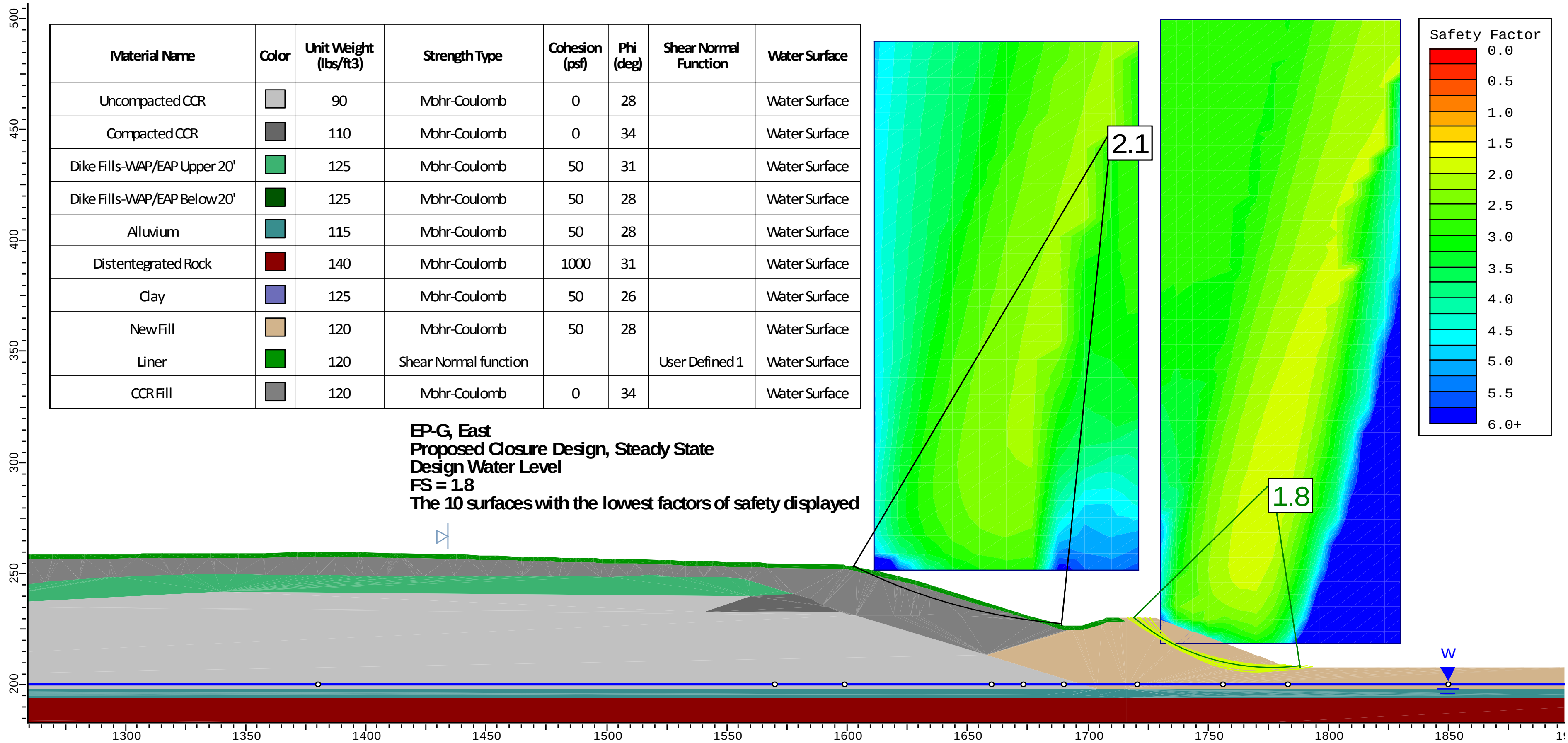
Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

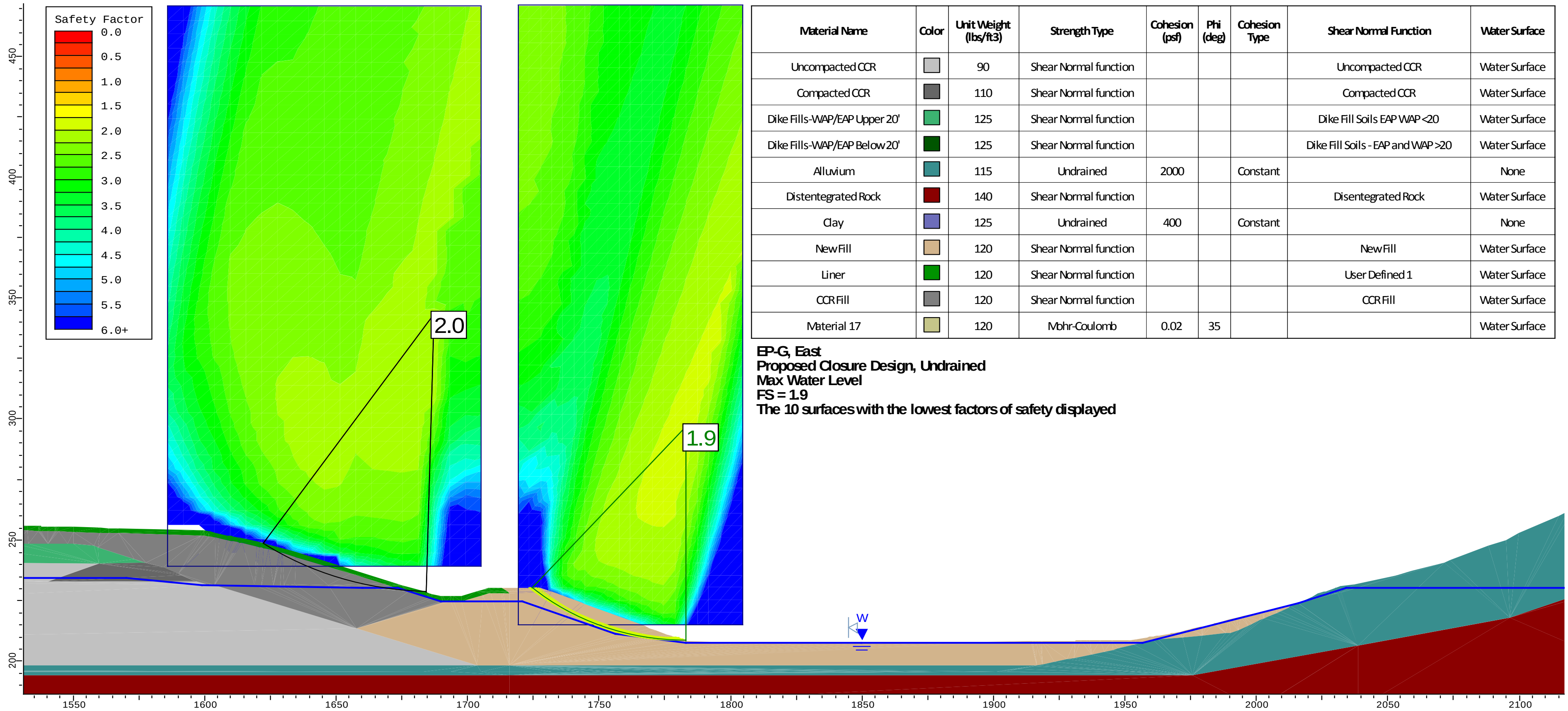
Figure **9B**

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Clay		125	Mohr-Coulomb	50	26		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

EP-G, East
Proposed Closure Design, Steady State
Design Water Level
FS = 1.8
The 10 surfaces with the lowest factors of safety displayed



Golder Associates	SCALE As Shown	**EAP Section G - East**	
	DATE Oct-30-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Design Water Level**	
	MADE BY MGP		
	CHECK JGM		
	REVIEW PDP	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **9C**
PROJECT No. 1520347 REV. 0			



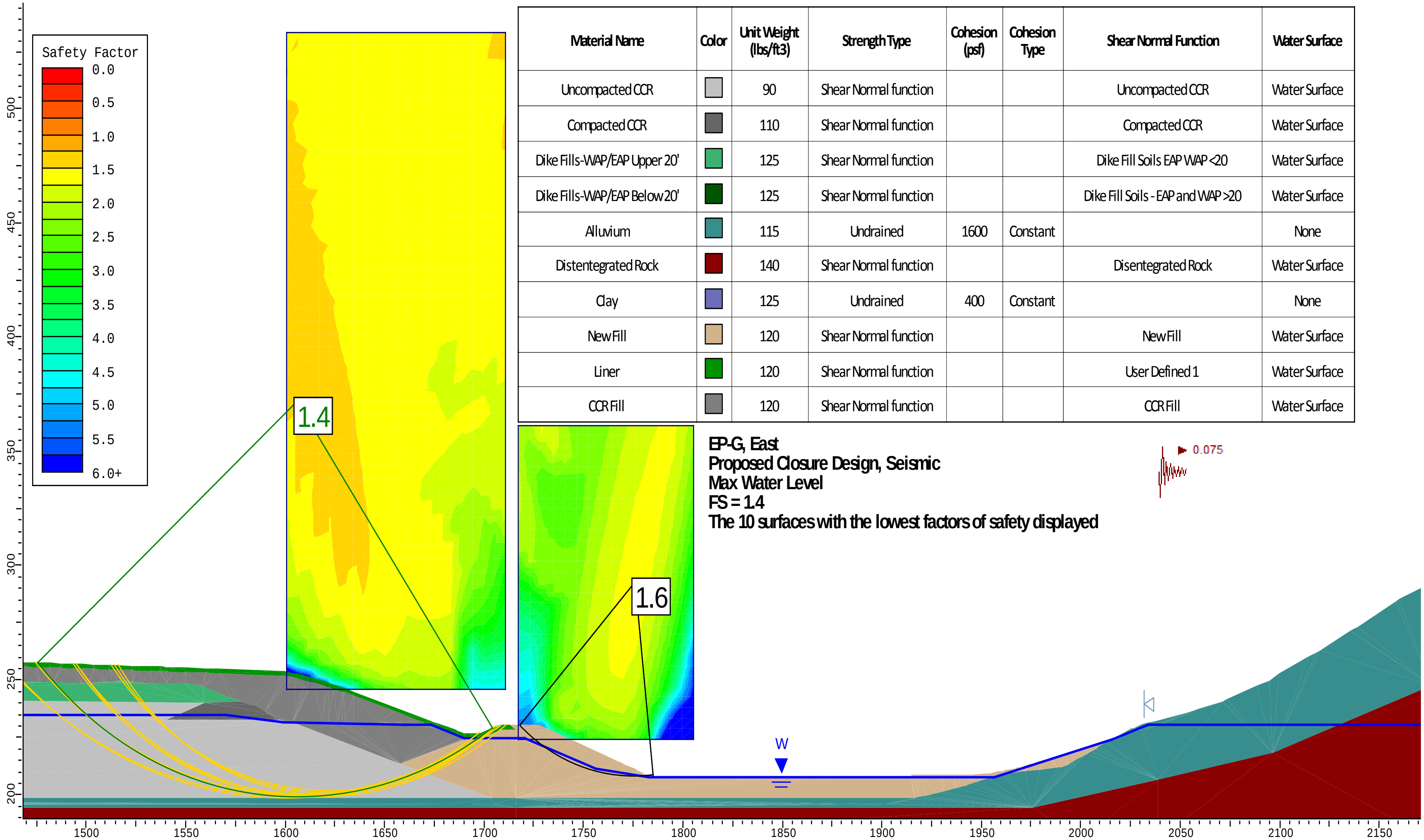
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function				Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function				Compacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function				Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function				Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	2000		Constant		None
Distentegrated Rock		140	Shear Normal function				Disentegrated Rock	Water Surface
Clay		125	Undrained	400		Constant		None
New Fill		120	Shear Normal function				New Fill	Water Surface
Liner		120	Shear Normal function				User Defined 1	Water Surface
CCR Fill		120	Shear Normal function				CCR Fill	Water Surface
Material 17		120	Mohr-Coulomb	0.02	35			Water Surface

EP-G, East
Proposed Closure Design, Undrained
Max Water Level
FS = 1.9
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown	**EAP Section G - East**	
DATE	Oct-30-2015	**Slope Stability Analysis Proposed Closure Design Undrained, Max Water Level**	
MADE BY	GPM		
CHECK	JGM		
REVIEW	PDP	**Dominion Bremo Bluff Power Station Ash Pond Closure Project**	Figure **9D**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Clay		125	Undrained	400	Constant		None
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

EAP Section G - East

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

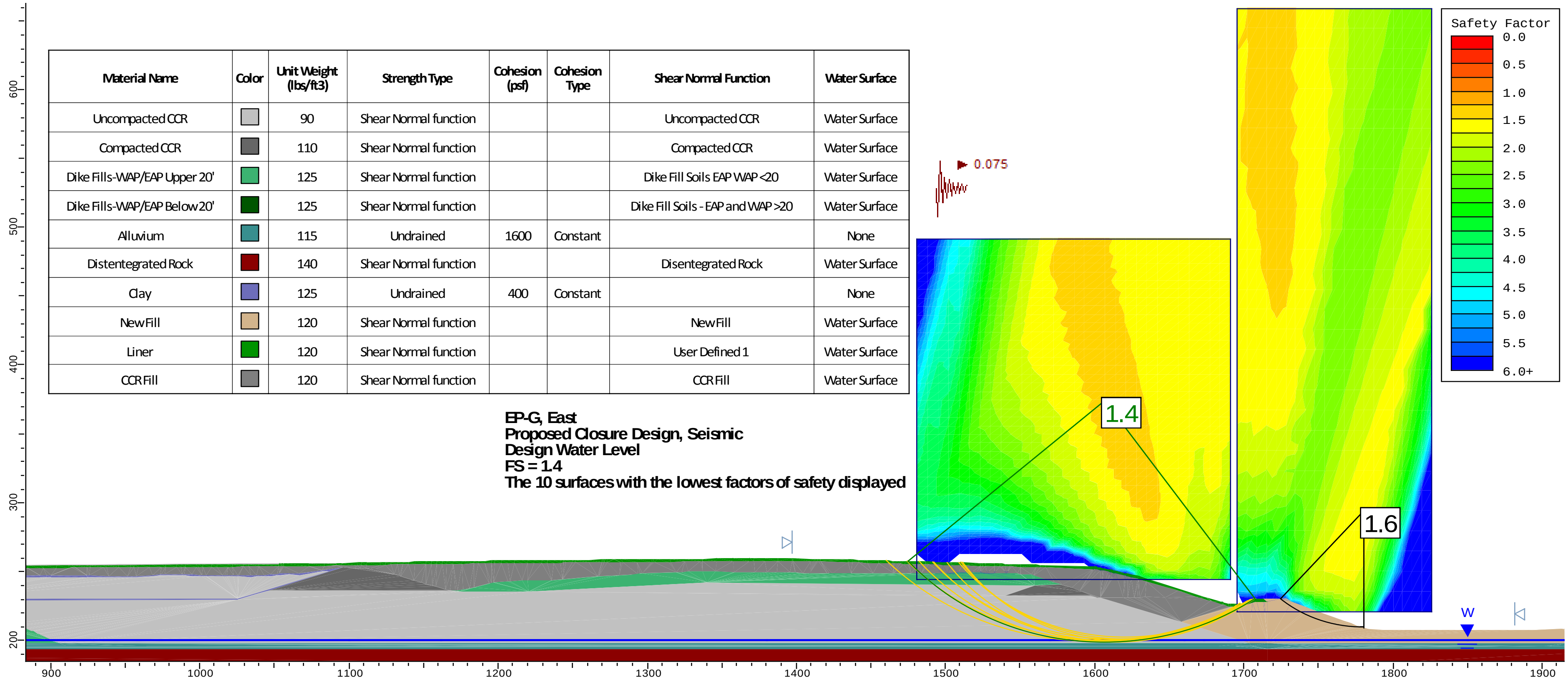
Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **9E**

PROJECT No. 1520347 REV. 0

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Clay		125	Undrained	400	Constant		None
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

EP-G, East
Proposed Closure Design, Seismic
Design Water Level
FS = 1.4
The 10 surfaces with the lowest factors of safety displayed



SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

Golder Associates

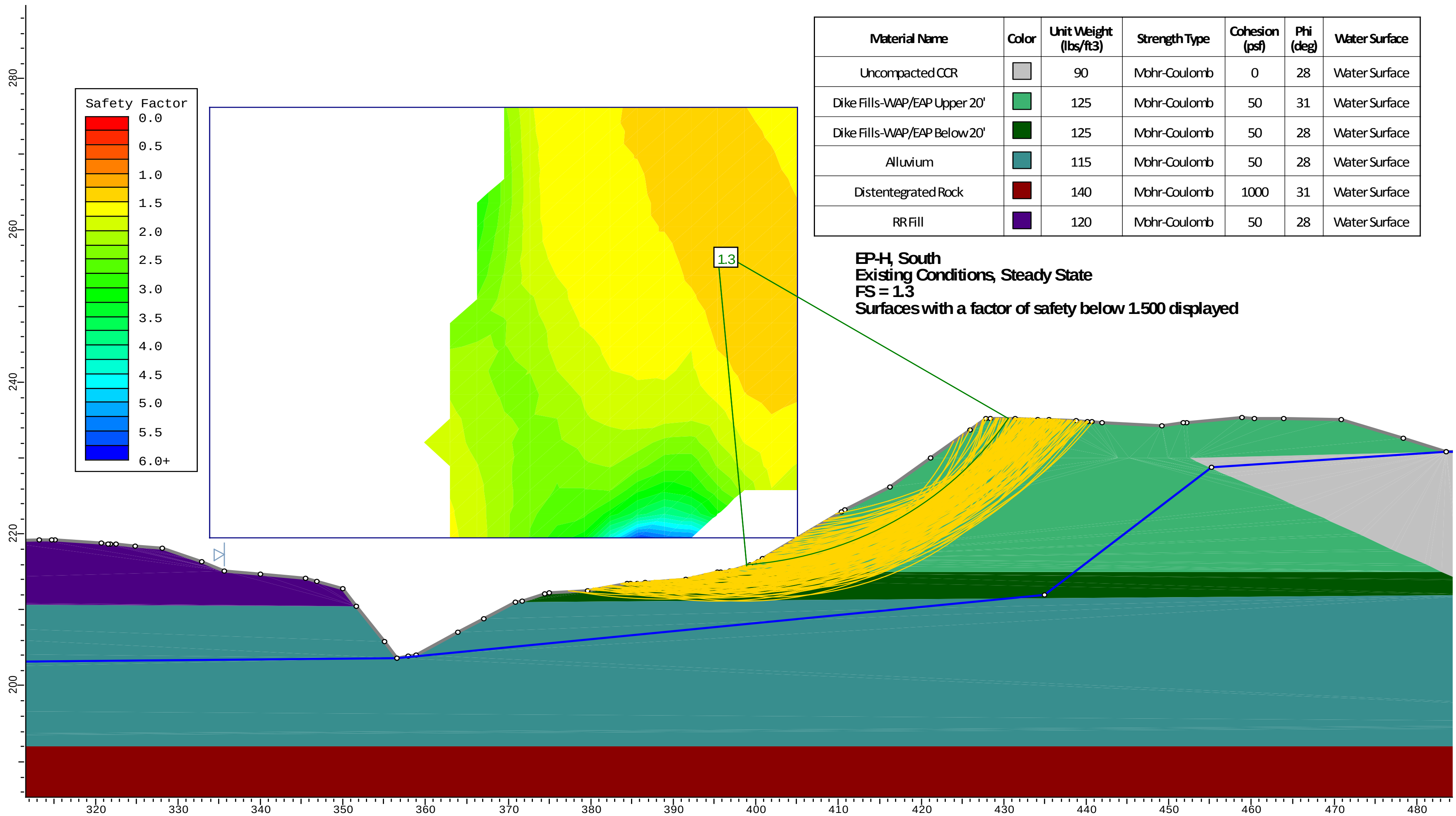
PROJECT No. 1520347 REV. 0

EAP Section G - East

Slope Stability Analysis
Proposed Closure Design
Seismic, Design Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **9F**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface
RR Fill		120	Mohr-Coulomb	50	28	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

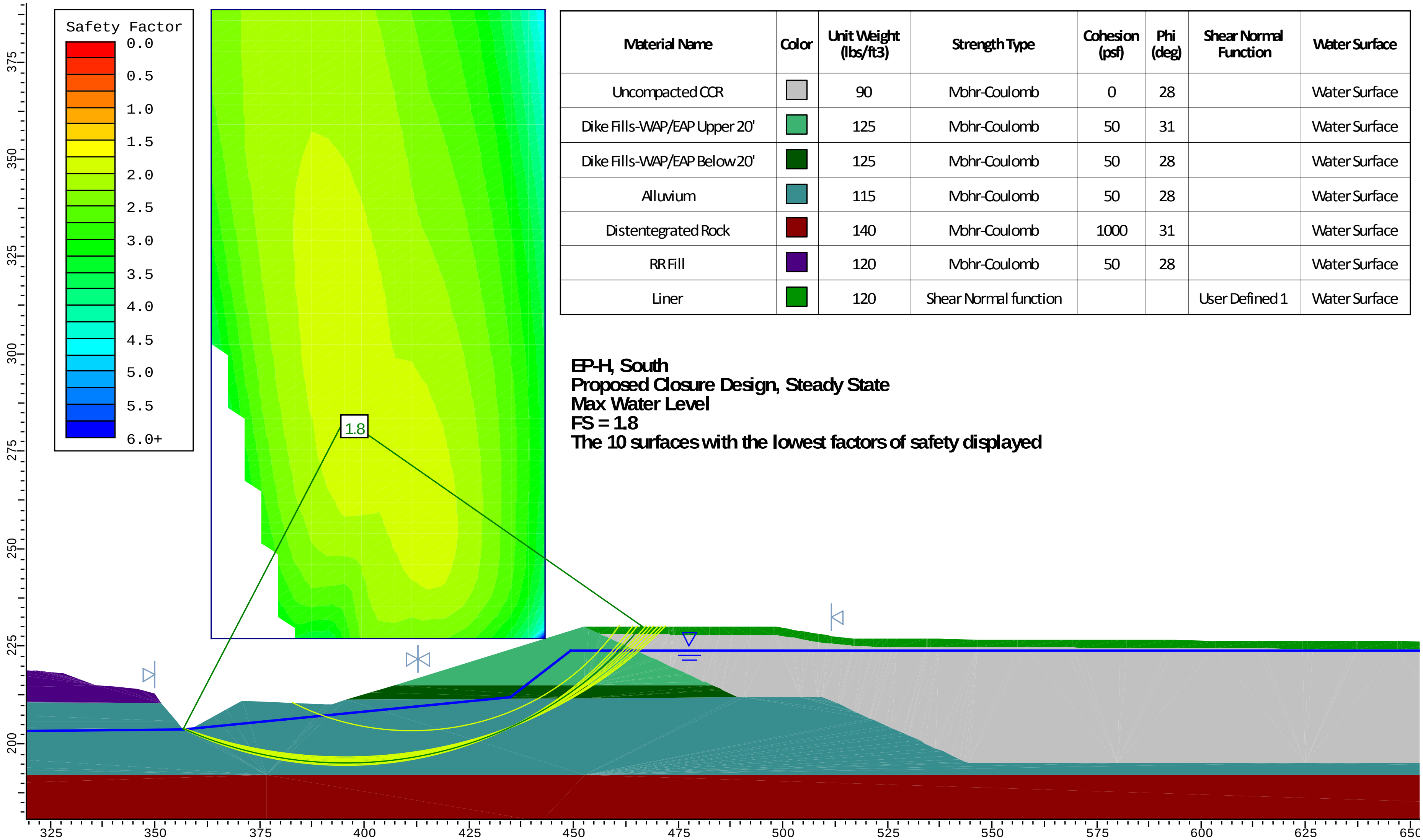
PROJECT No. 1520347 REV. 0

EAP Section H - South

Bremo Bluff Power Station
Slope Stability Analysis
Existing Conditions, Steady State

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **10A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

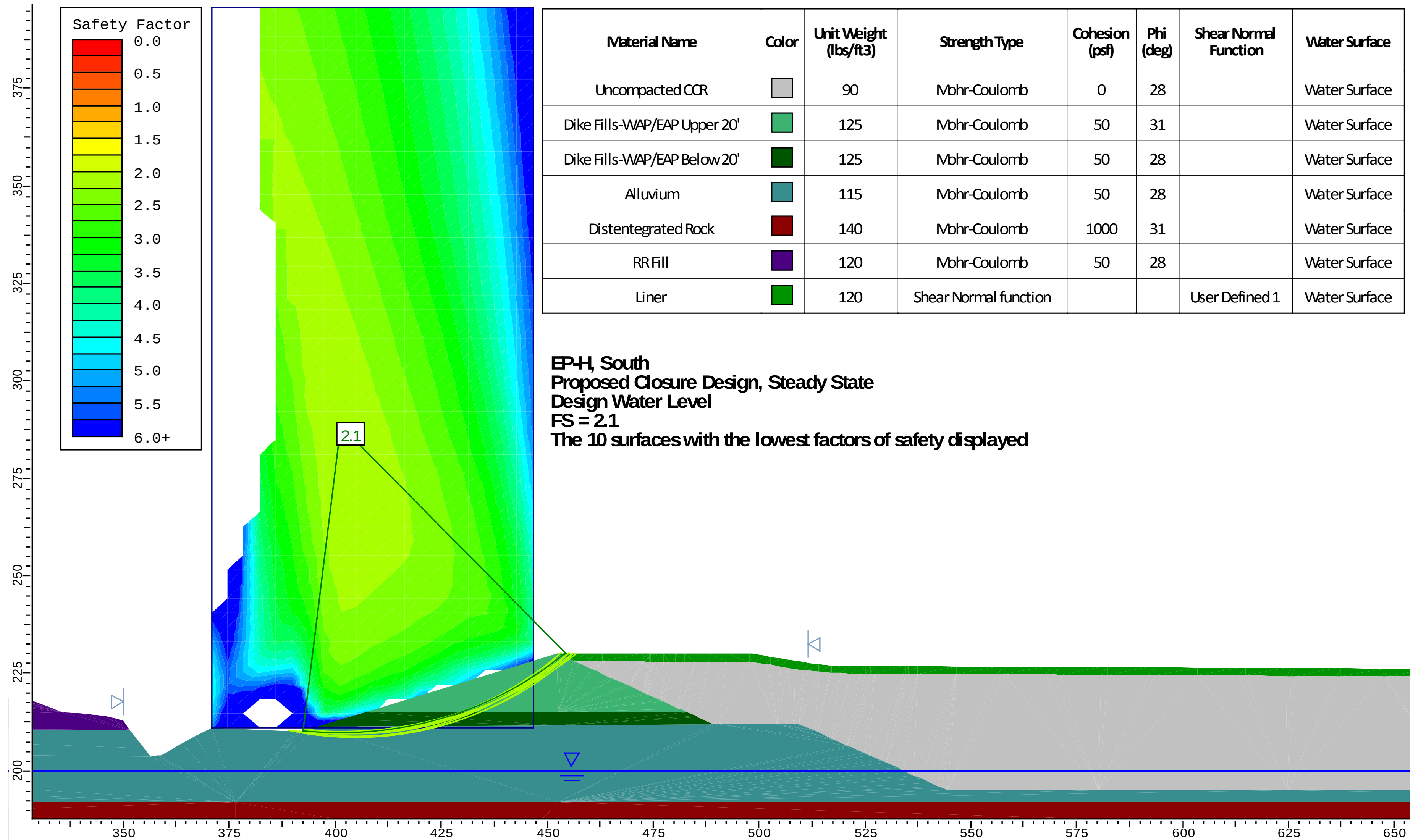
EAP Section H - South

Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **10B**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills-WAP/EAP Below 20'		125	Mohr-Coulomb	50	28		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface

EP-H, South
Proposed Closure Design, Steady State
Design Water Level
FS = 2.1
The 10 surfaces with the lowest factors of safety displayed

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

Golder Associates

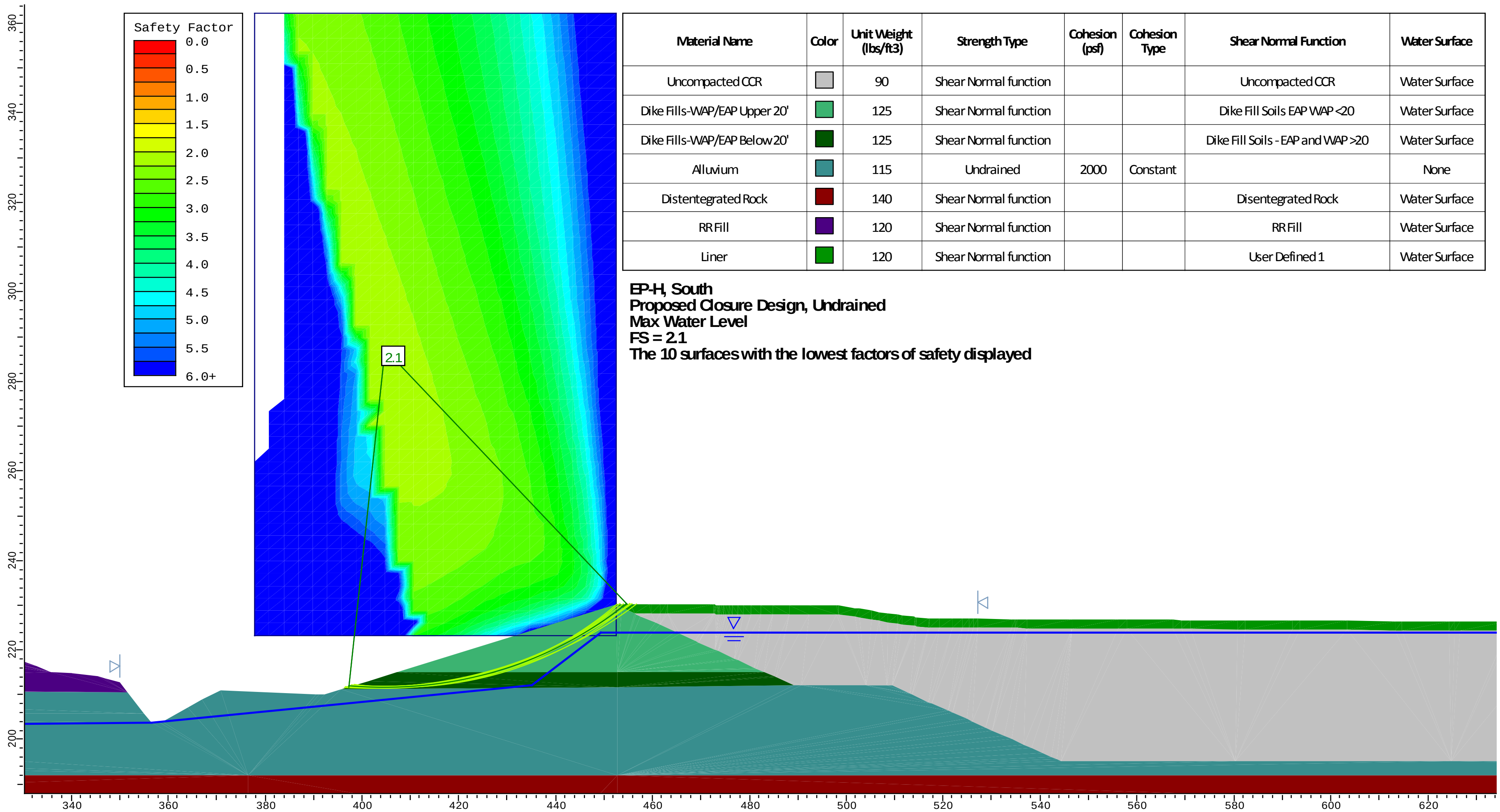
PROJECT No. 1520347 REV. 0

EAP Section H - South

Slope Stability Analysis
Proposed Closure Design
Steady State, Design Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **10C**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface

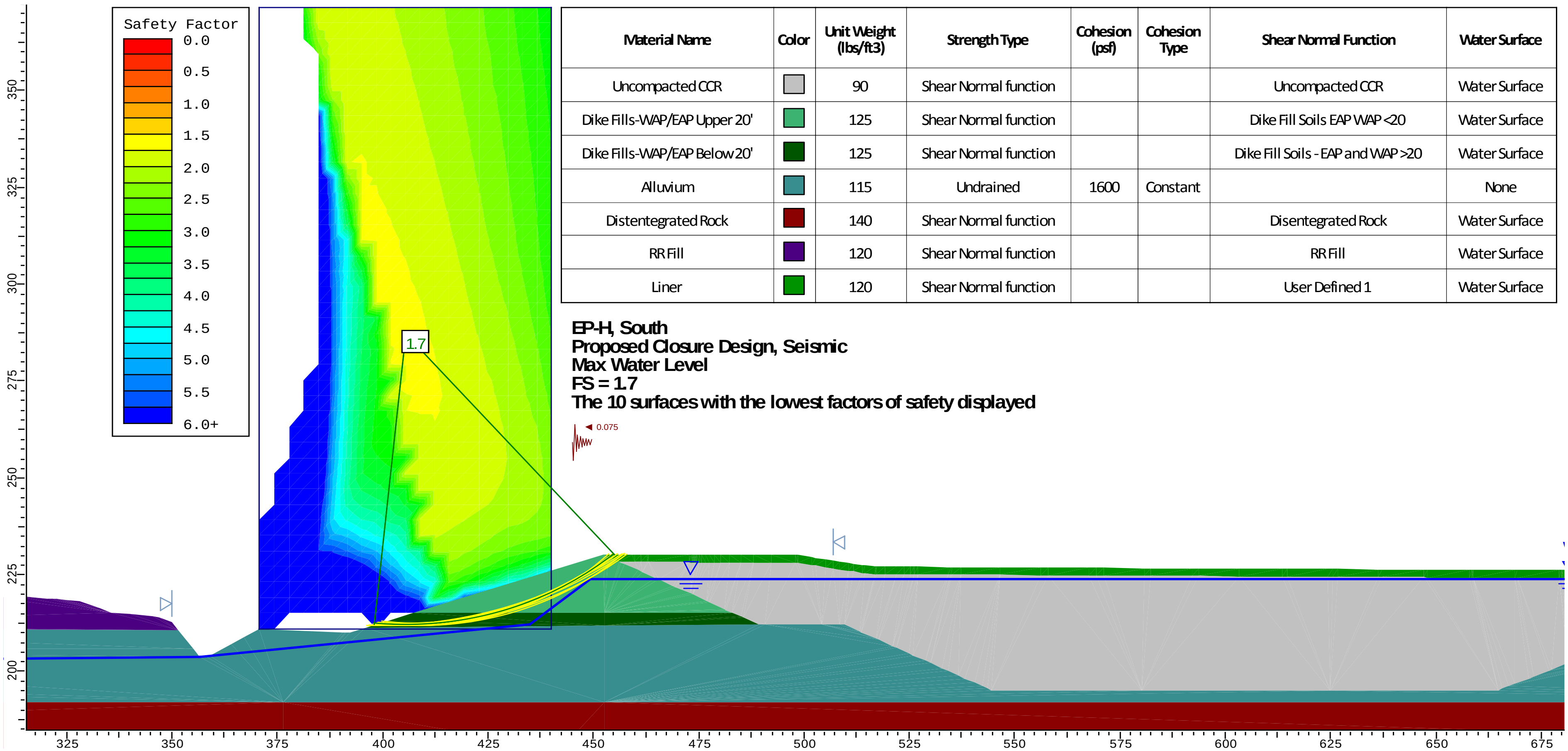
EP-H, South
Proposed Closure Design, Undrained
Max Water Level
FS = 2.1
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown	**EAP Section H - South**	
DATE	Oct-30-2015	**Slope Stability Analysis Proposed Closure Design Undrained, Max Water Level**	
MADE BY	MGP		
CHECK	JGM		
REVIEW	PDP	**Dominion Bremo Bluff Power Station Ash Pond Closure Project**	Figure **10D**

PROJECT No. 1520347 REV. 0

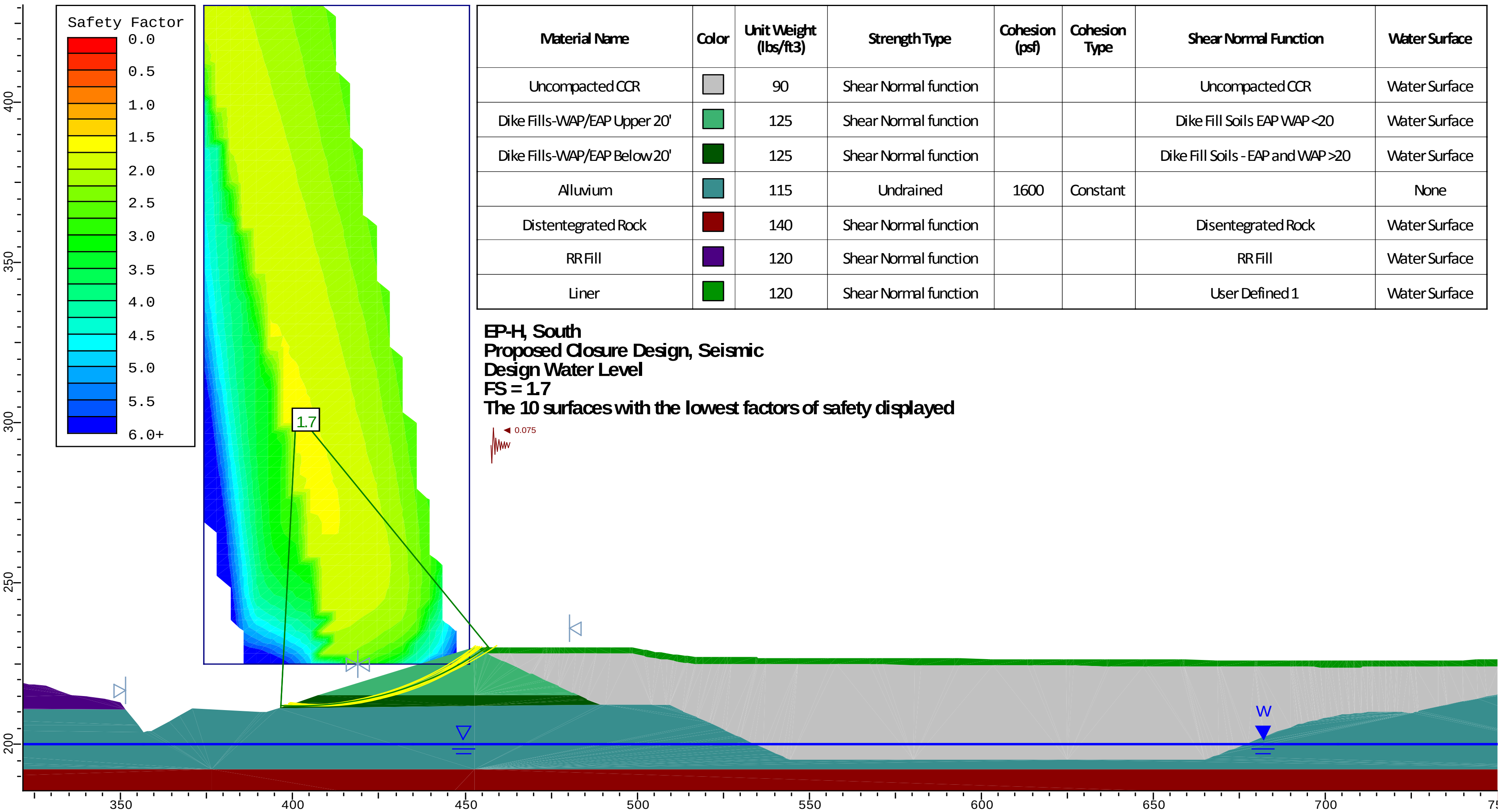
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface



Golder Associates

SCALE	As Shown	**EAP Section H - South**	
DATE	Oct-30-2015	**Slope Stability Analysis** **Proposed Closure Design** **Seismic, Max Water Level**	
MADE BY	MGP		
CHECK	JGM		
REVIEW	PDP	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **10E**

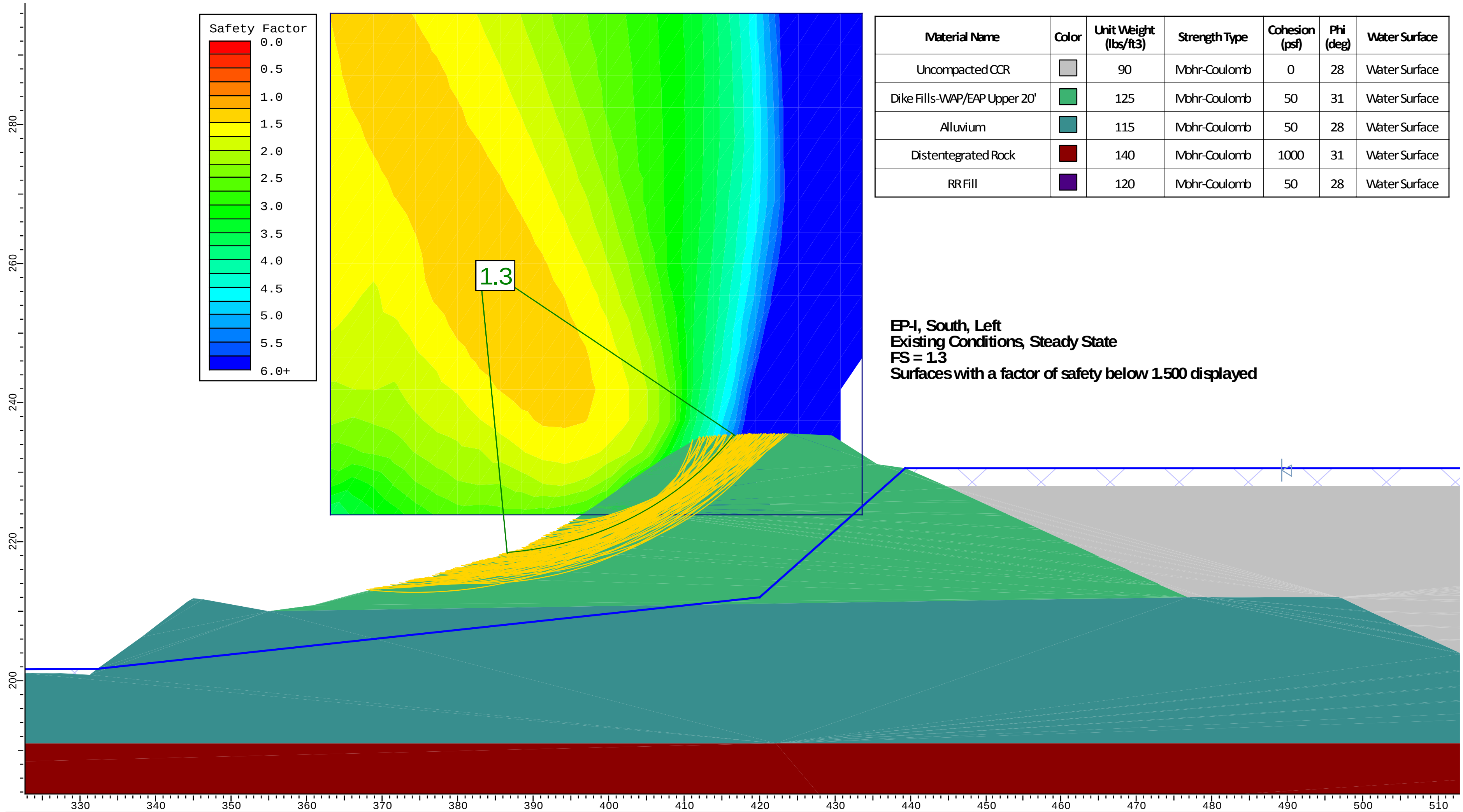
PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface

EP-H, South
Proposed Closure Design, Seismic
Design Water Level
FS = 1.7
The 10 surfaces with the lowest factors of safety displayed

Golder Associates	SCALE: As Shown	**EAP Section H - South**	
	DATE: Oct-30-2015	**Slope Stability Analysis** **Proposed Closure Design** **Seismic, Design Water Level**	
	MADE BY: MGP		
	CHECK: JGM		
	REVIEW: PDP	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **10F**
PROJECT No. 1520347 REV. 0			



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface
RR Fill		120	Mohr-Coulomb	50	28	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

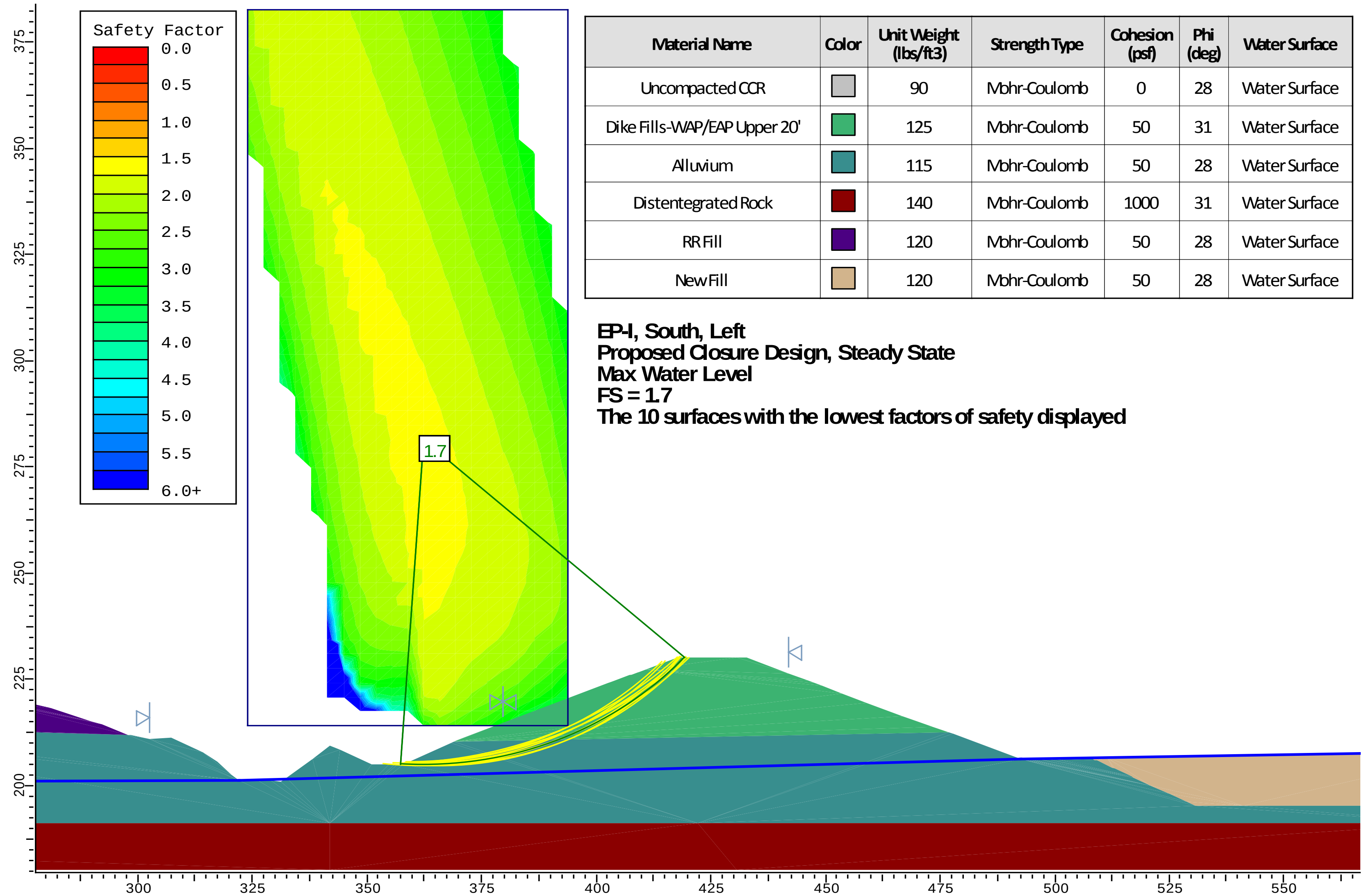
PROJECT No. 1520347 REV. 0

EAP Section I - South, Left

Bremo Bluff Power Station
Slope Stability Analysis
Existing Conditions, Steady State

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **11A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface
RR Fill		120	Mohr-Coulomb	50	28	Water Surface
New Fill		120	Mohr-Coulomb	50	28	Water Surface

EP-I, South, Left
Proposed Closure Design, Steady State
Max Water Level
FS = 1.7
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

EAP Section I - South, Left

Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

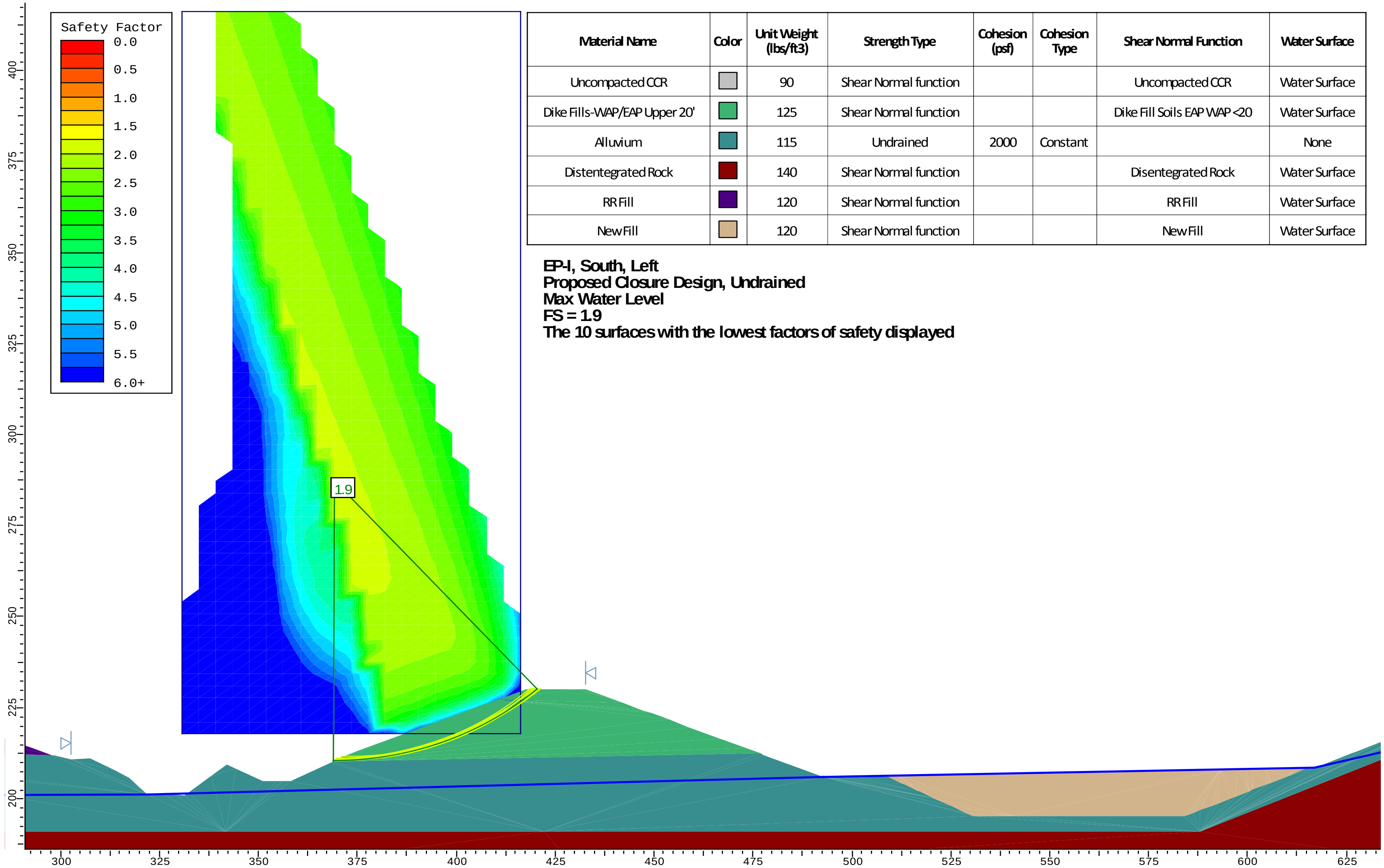
Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **11B**

PROJECT No. 1520347 REV. 0

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 11B

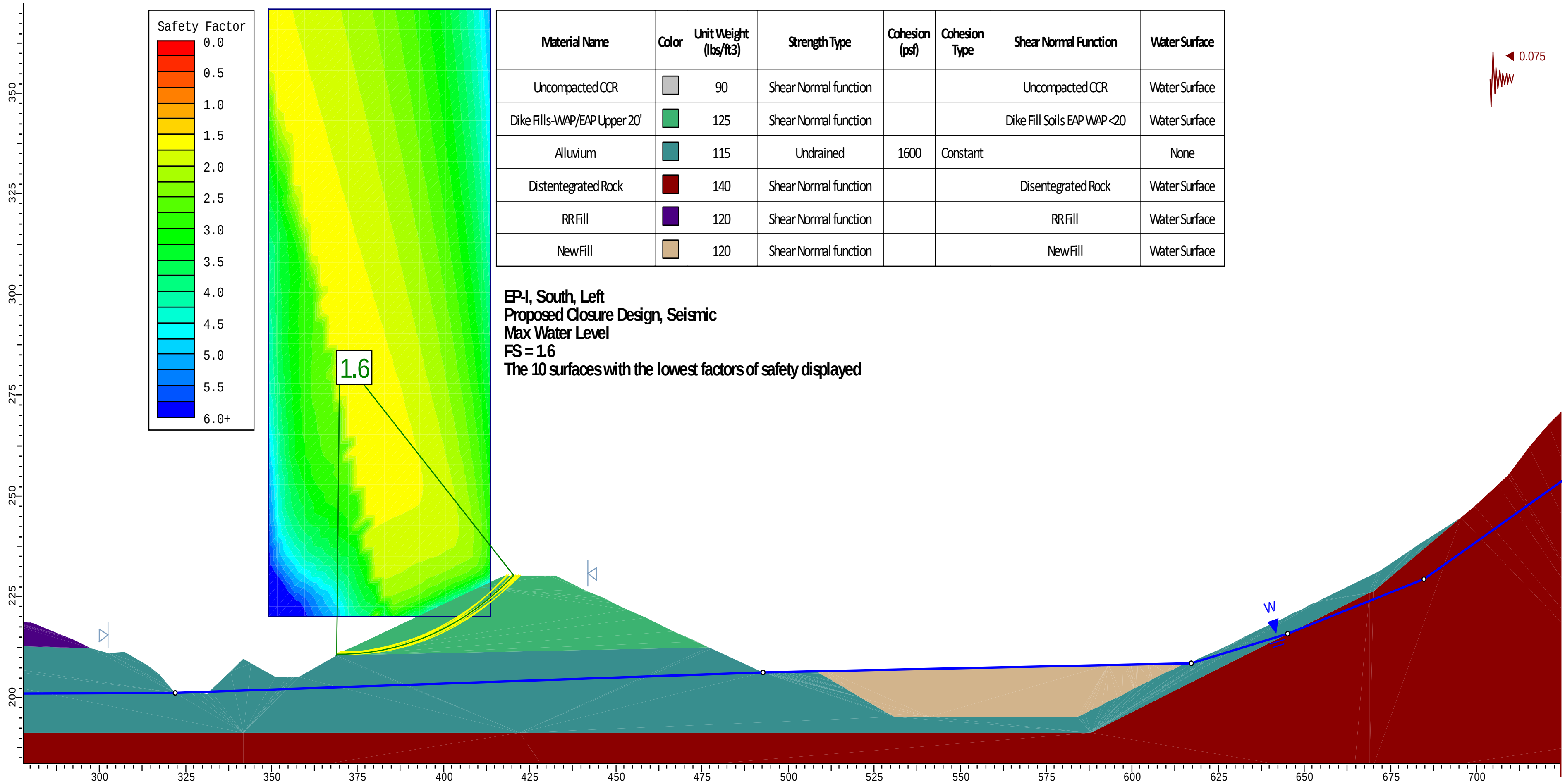
Golder Associates	SCALE	As Shown	**EAP Section I - South, Left**	
	DATE	Oct-30-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Design Water Level**	
	MADE BY	MGP		
	CHECK	JGM		
	REVIEW	PDP	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **11C**
PROJECT No. 1520347	REV. 0				



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface

EP-I, South, Left
Proposed Closure Design, Undrained
Max Water Level
FS = 1.9
The 10 surfaces with the lowest factors of safety displayed

Golder Associates	SCALE: As Shown	**EAP Section I - South, Left**	
	DATE: Oct-30-2015	**Slope Stability Analysis** **Proposed Closure Design** **Undrained, Max Water Level**	
	MADE BY: MGP		
	CHECK: JGM		
	REVIEW: PDP	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **11D**
PROJECT No. 1520347 / REV. 0			



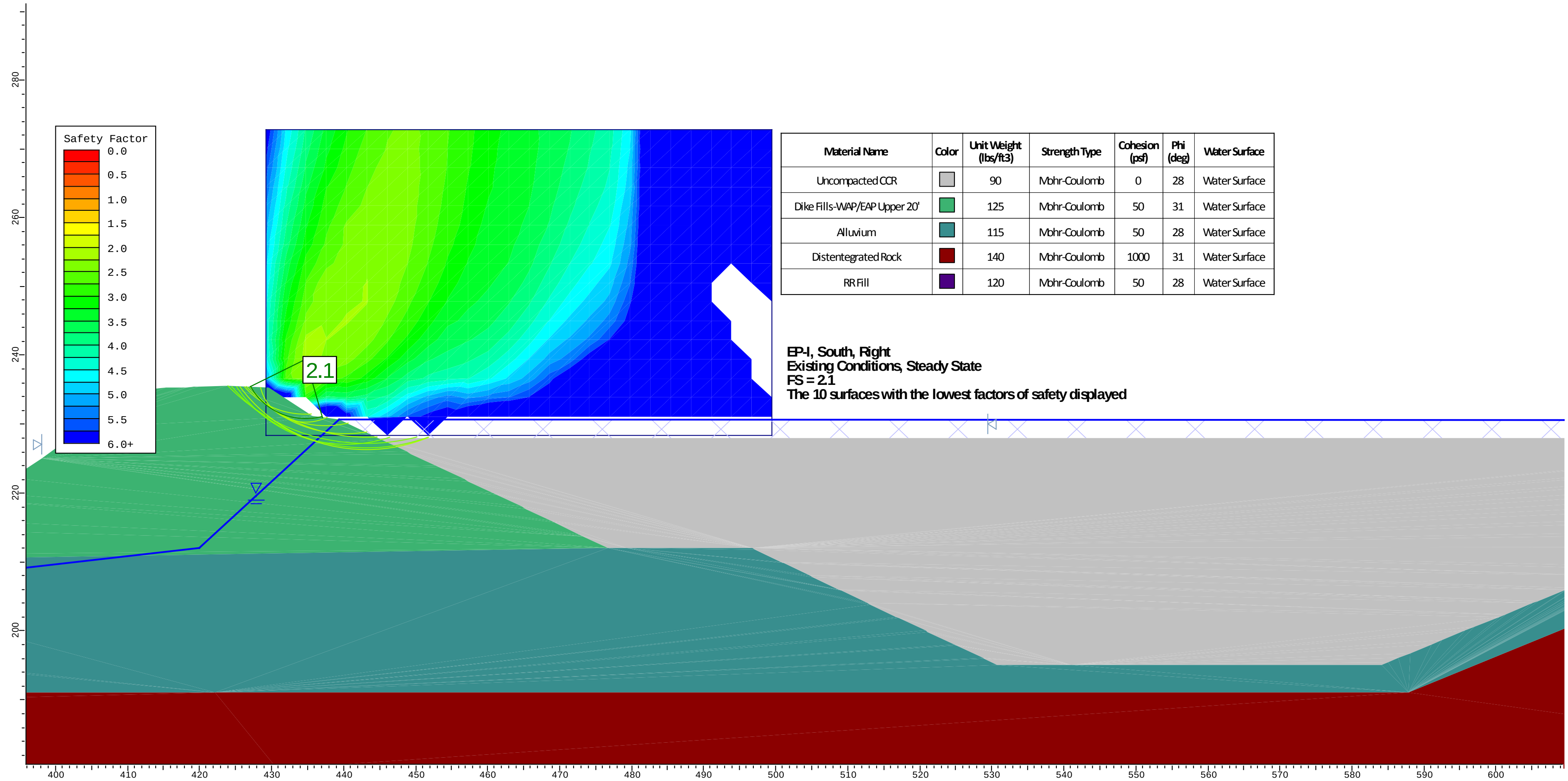
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface

EP-I, South, Left
Proposed Closure Design, Seismic
Max Water Level
FS = 1.6
The 10 surfaces with the lowest factors of safety displayed

Golder Associates	SCALE: As Shown	**EAP Section I - South, Left**
	DATE: Oct-30-2015	**Slope Stability Analysis**
	MADE BY: MGP	**Proposed Closure Design**
	CHECK: JGM	**Seismic, Max Water Level**
	REVIEW: PDP	**Dominion Bremo Bluff Power Station** / **Ash Pond Closure Project**
PROJECT No. 1520347 / REV. 0		Figure **11E**

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 11E

Golder Associates	SCALE	As Shown	**EAP Section I - South, Left**	
	DATE	Oct-30-2015	**Slope Stability Analysis Proposed Closure Design Seismic, Design Water Level**	
	MADE BY	MGP		
	CHECK	JGM		
	REVIEW	PDP	**Dominion Bremo Bluff Power Station Ash Pond Closure Project**	Figure **11F**
PROJECT No. 1520347 REV. 0				



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface
RR Fill		120	Mohr-Coulomb	50	28	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

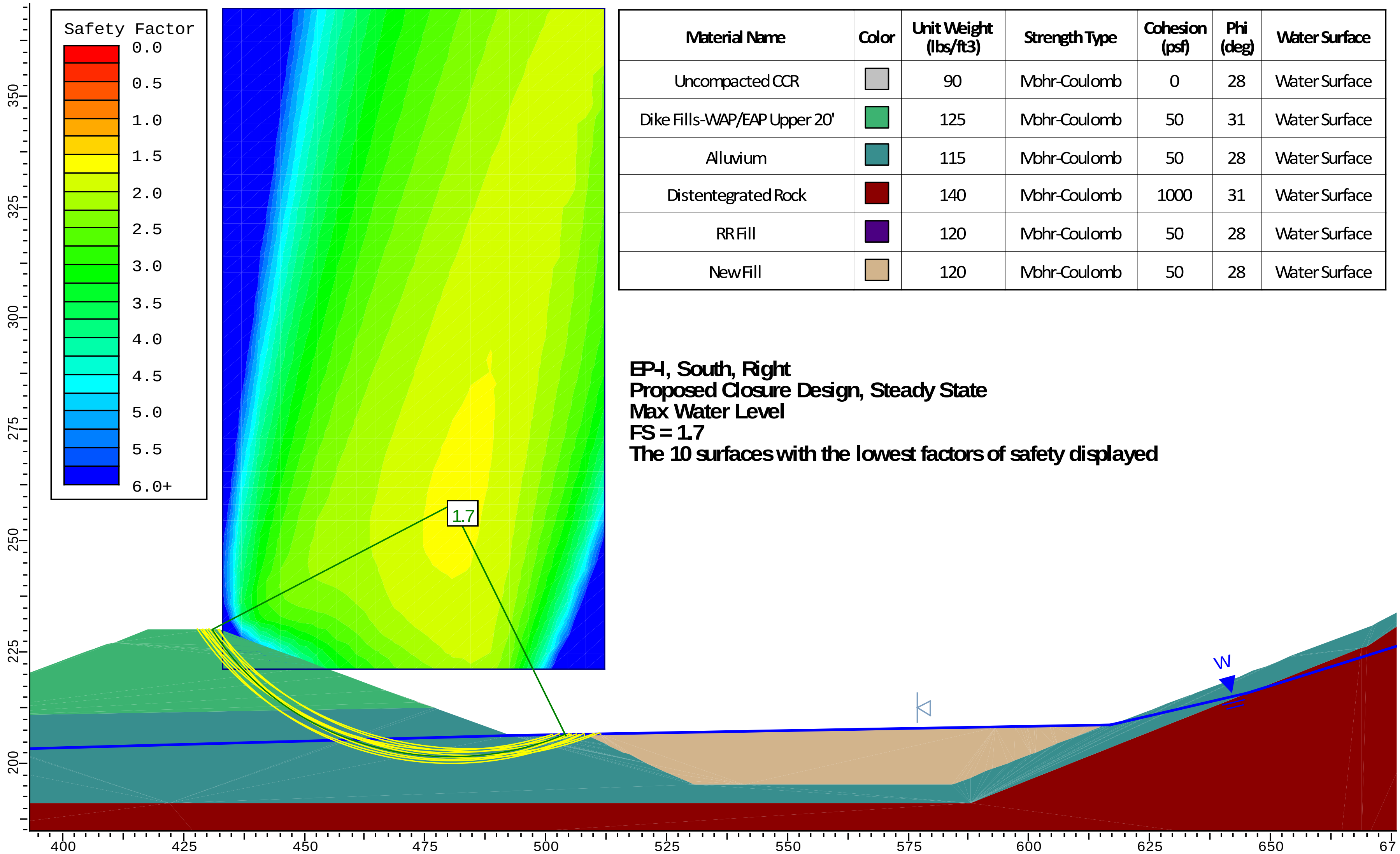
EAP Section I - South, Right

Bremo Bluff Power Station
Slope Stability Analysis
Existing Conditions, Steady State

PROJECT No. 1520347 REV. 0

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **12A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface
RR Fill		120	Mohr-Coulomb	50	28	Water Surface
New Fill		120	Mohr-Coulomb	50	28	Water Surface

EP-I, South, Right
Proposed Closure Design, Steady State
Max Water Level
FS = 1.7
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

EAP Section H - South

Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

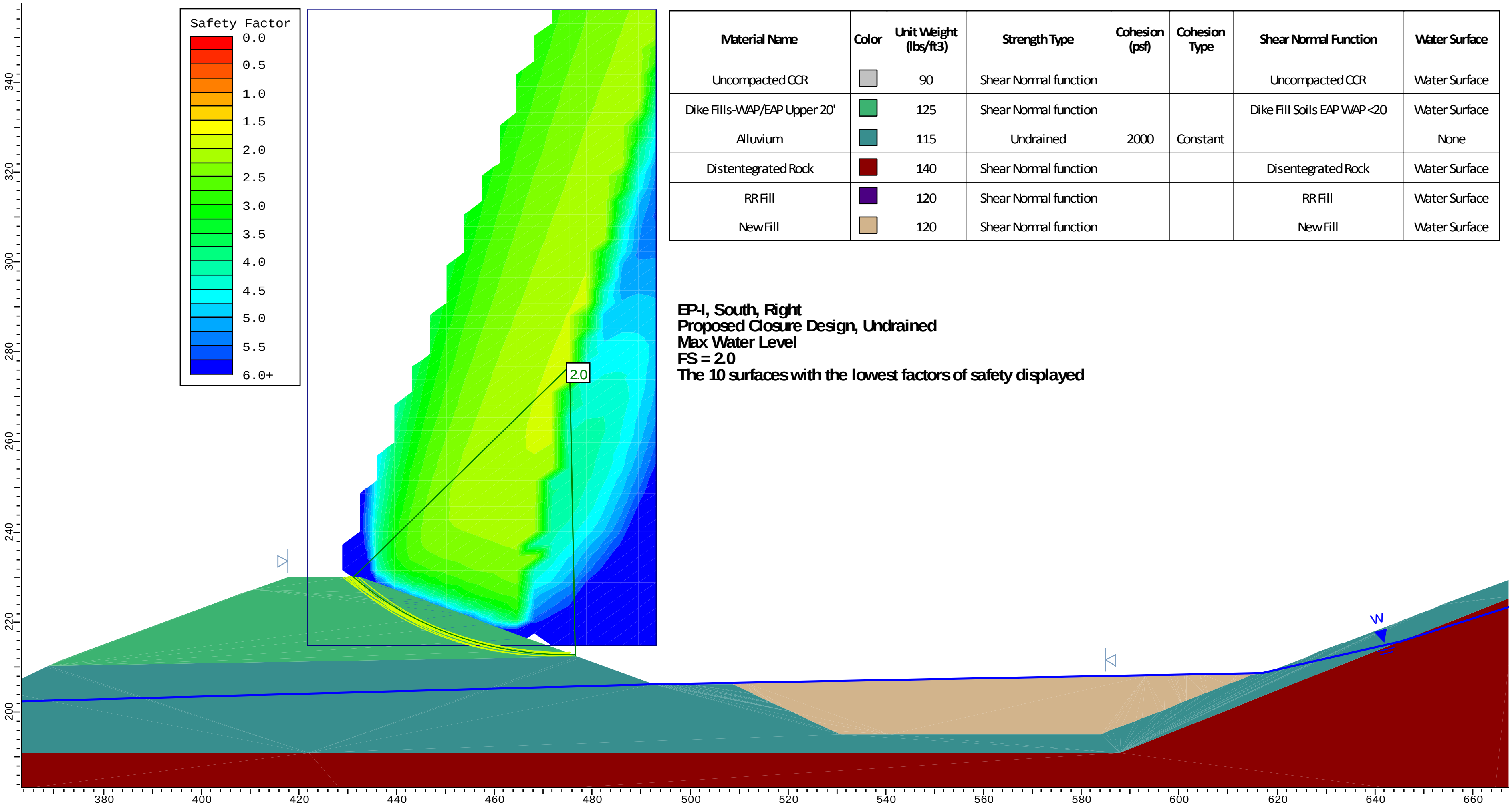
Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **11B**

PROJECT No. 1520347 REV. 0

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 12B

Golder Associates	SCALE As Shown	**EAP Section I - South, Right**	
	DATE Oct-30-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Design Water Level**	
	MADE BY MGP		
	CHECK JGM		
	REVIEW PDP	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **12C**
PROJECT No. 1520347 REV. 0			



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

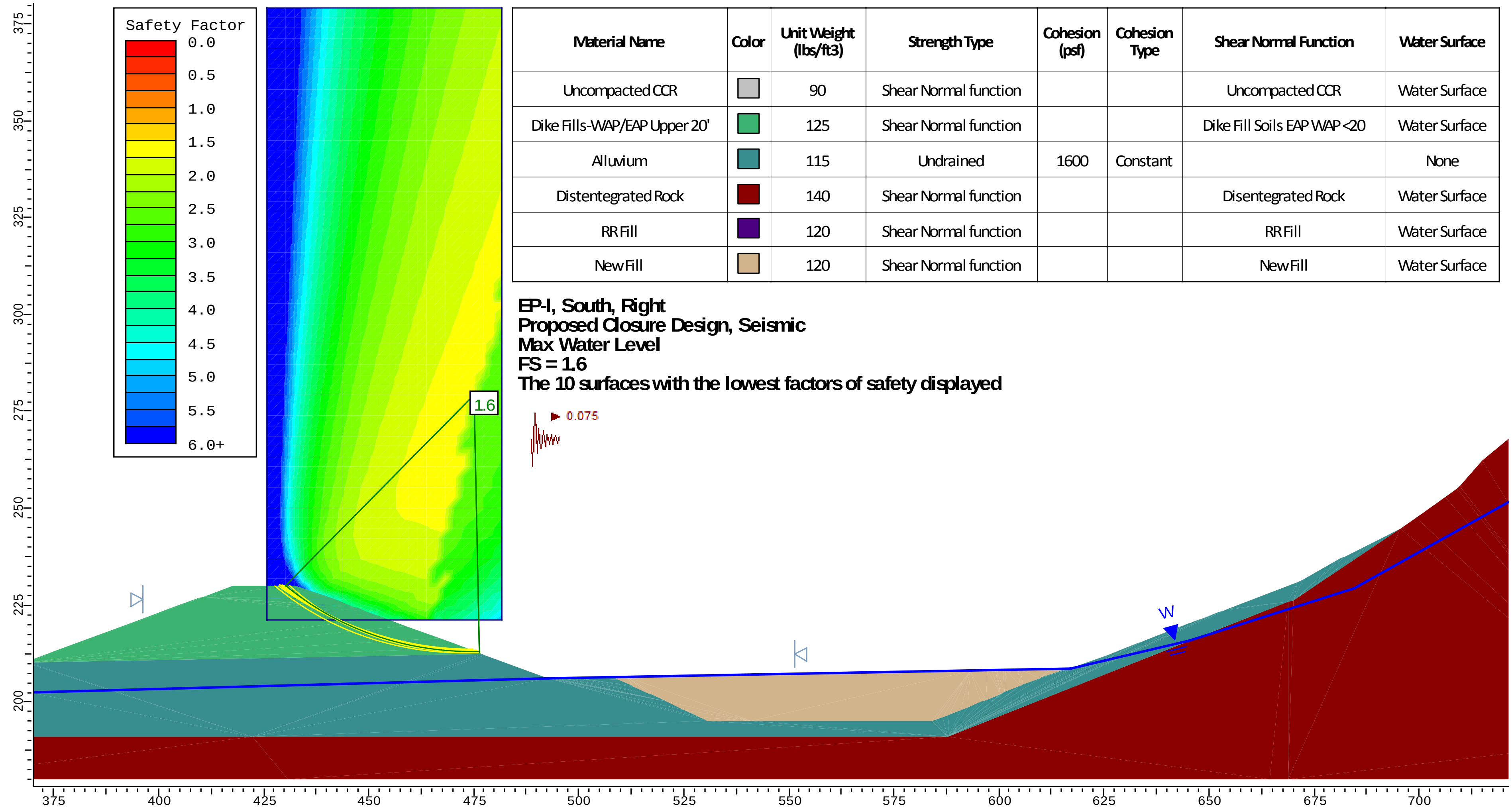
EAP Section I - South, Right

Slope Stability Analysis
Proposed Closure Design
Undrained, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **12D**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	PDP

EAP Section I - South, Right

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **12E**

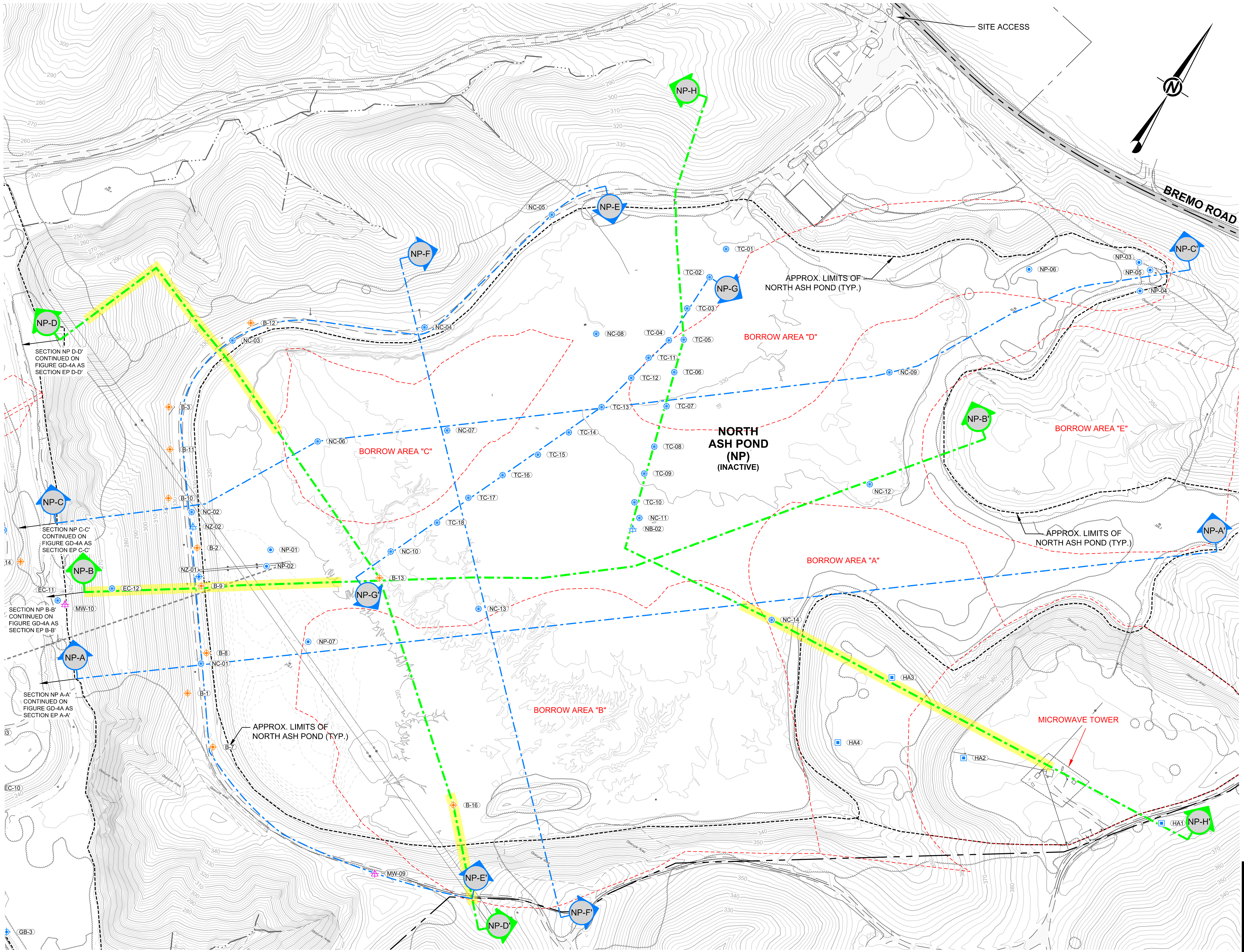
PROJECT No. 1520347 REV. 0

Not Applicable

Design Water Level Is Same as Max Water Level

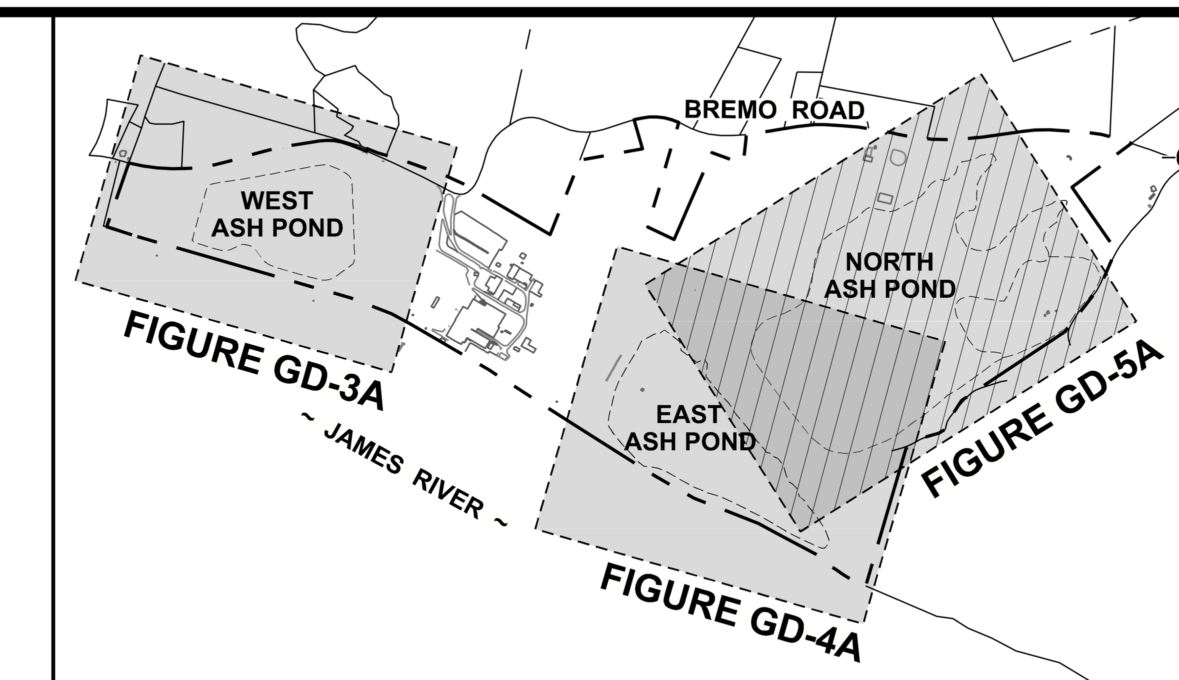
See Figure 12E

SCALE	As Shown	**EAP Section I - South, Right**	
DATE	Oct-30-2015	**Slope Stability Analysis Proposed Closure Design Seismic, Design Water Level**	
MADE BY	MGP		
CHECK	JGM		
REVIEW	PDP	**Dominion Bremo Bluff Power Station Ash Pond Closure Project**	Figure **12F**
PROJECT No. 1520347	REV. 0		



SITE KEY

NOT TO SCALE



LEGEND

- DOMINION PROPERTY BOUNDARY
- ADJACENT PROPERTY BOUNDARY
- APPROXIMATE LIMITS OF EXISTING ASH PONDS
- EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS)
- EXISTING BATHYMETRIC SURFACE CONTOURS (2' INTERVALS)
- DESIGN SURFACE CONTOURS (2' INTERVALS)
- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING RAILROAD
- CREEK CENTERLINE
- EXISTING TREE LINE
- EXISTING FENCE
- EXISTING GAS LINE
- DENOTES AREAS OF TOPOGRAPHY THAT DO NOT MEET MINIMUM ACCURACY STANDARDS FOR AERIAL SURVEYING
- SCHNABEL BORING (1982)
- SCHNABEL BORING (2010)
- GES MONITORING WELL (2013)
- HALEY AND ALDRICH BORING (2015)
- GOLDER BORING (2014 / 2015)
- GOLDER PIEZOMETER (2015)
- GOLDER CONE PENETRATION TEST (CPT)(2015)
- GOLDER PROBE HOLE (2015)
- GOLDER HAND AUGER (2015)
- EP-A — GEOTECHNICAL SECTIONS (SEE GOLDER 2015 GEOTECH DATA REPORT)
- EP-B — SLOPE STABILITY SECTIONS
- SLOPE STABILITY FIGURE LOCATIONS - SEE APPENDIX D

REFERENCES

1. AERIAL TOPOGRAPHIC SURVEY PREPARED BY McKENZIE SNYDER, INC., DATE OF AERIAL PHOTO: 01/16/15 [CONTROL PREPARED BY H&B SURVEYING & MAPPING (H&B)].
2. BATHYMETRIC SURVEYS PREPARED BY H&B, SURVEYS PERFORMED IN FEBRUARY 2015.

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW

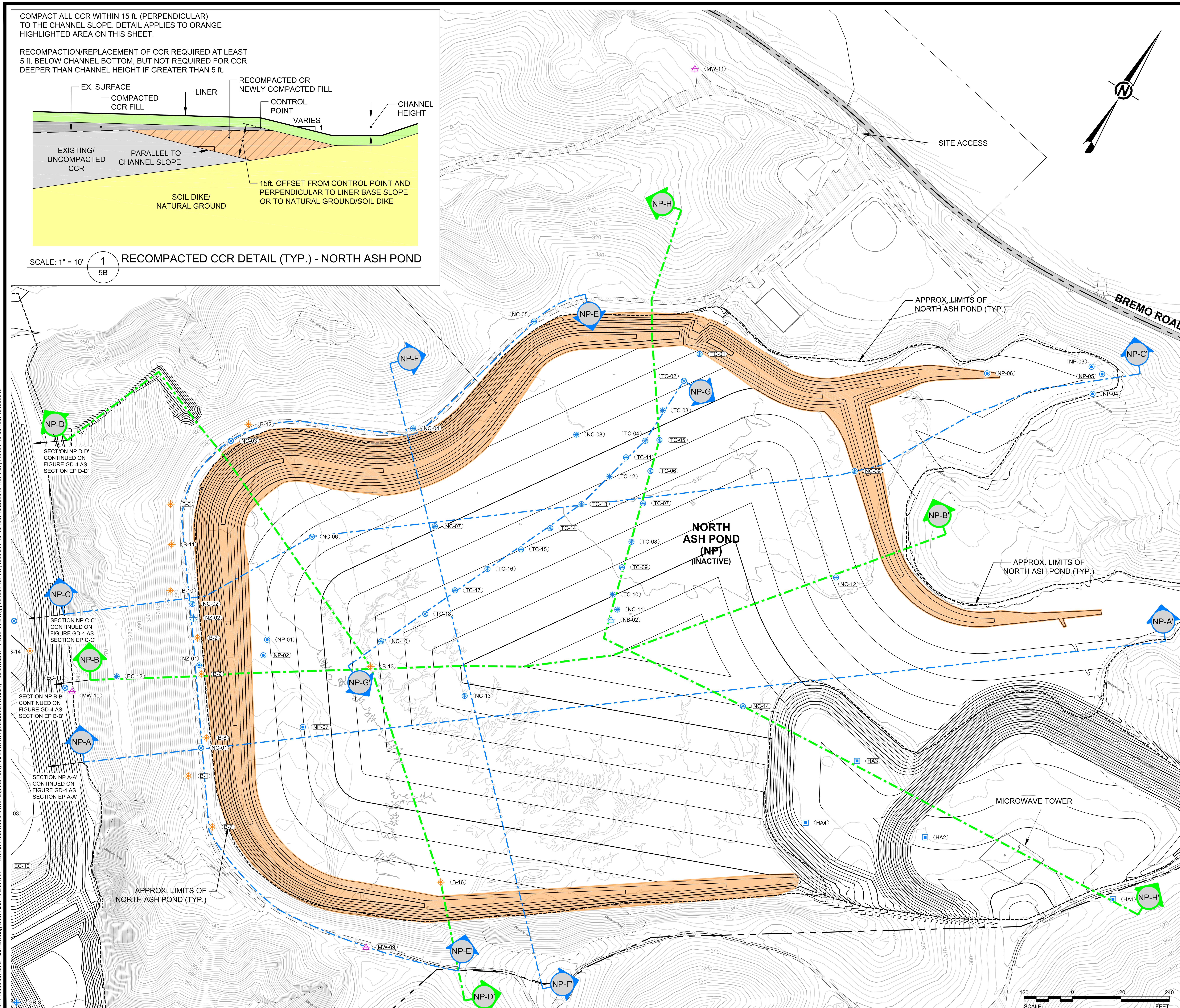
PROJECT
DOMINION
BREMO POWER STATION
CCR IMPOUNDMENT CLOSURE
FLUVANNA COUNTY, VIRGINIA

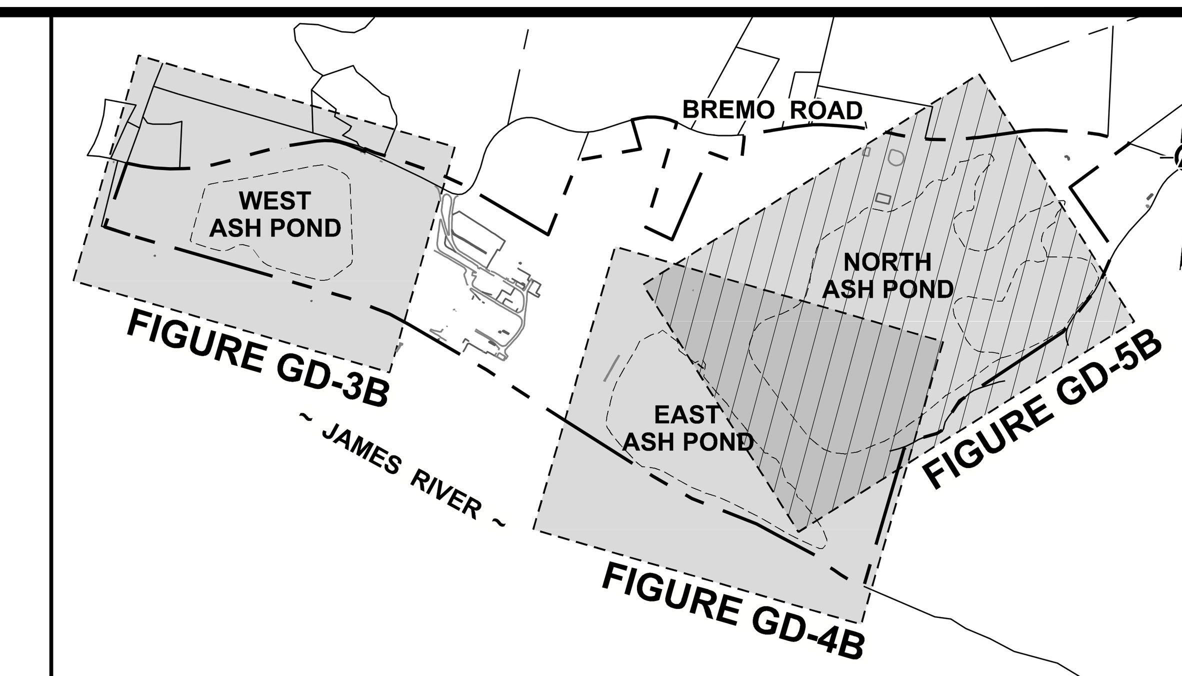
TITLE
EXISTING CONDITIONS GEOTECHNICAL EXPLORATION PLAN (NORTH POND)

PROJECT No.		15-20347	FILE No.	1520347AD03A-05A
DESIGN	-	-	SCALE	AS SHOWN
CADD	SEP	10/15/15		
CHECK	JGM	10/15/15		
REVIEW	GLH	10/15/15		

Golder Associates

FIGURE GD-5A





SITE KEY

NOT TO SCALE

LEGEND

- DOMINION PROPERTY BOUNDARY
- ADJACENT PROPERTY BOUNDARY
- APPROXIMATE LIMITS OF EXISTING ASH PONDS
- EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS)
- EXISTING BATHYMETRIC SURFACE CONTOURS (2' INTERVALS)
- DESIGN SURFACE CONTOURS (2' INTERVALS)
- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING RAILROAD
- CREEK CENTERLINE
- EXISTING TREE LINE
- EXISTING FENCE
- EXISTING GAS LINE
- DENOTES AREAS OF TOPOGRAPHY THAT DO NOT MEET MINIMUM ACCURACY STANDARDS FOR AERIAL SURVEYING
- SCHNABEL BORING (1982)
- SCHNABEL BORING (2010)
- GES MONITORING WELL (2013)
- HALEY AND ALDRICH BORING (2015)
- GOLDER BORING (2014 / 2015)
- GOLDER PIEZOMETER (2015)
- GOLDER CONE PENETRATION TEST (CPT)(2015)
- GOLDER PROBE HOLE (2015)
- GOLDER HAND AUGER (2015)
- EP-A: GEOTECHNICAL SECTIONS (SEE GOLDER 2015 GEOTECH DATA REPORT)
- EP-B: SLOPE STABILITY SECTIONS
- SLOPE STABILITY FIGURE LOCATIONS - SEE APPENDIX D

REFERENCES

1. AERIAL TOPOGRAPHIC SURVEY PREPARED BY McKENZIE SNYDER, INC., DATE OF AERIAL PHOTO: 01/16/15 [CONTROL PREPARED BY H&B SURVEYING & MAPPING (H&B)].
2. BATHYMETRIC SURVEYS PREPARED BY H&B, SURVEYS PERFORMED IN FEBRUARY 2015.

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW

PROJECT

DOMINION
BREMO POWER STATION
CCR IMPOUNDMENT CLOSURE
FLUVANNA COUNTY, VIRGINIA

TITLE

DESIGN GRADES GEOTECHNICAL STABILITY PLAN (NORTH POND)

PROJECT No.		15-20347	FILE No.	1520347AD02-05B
DESIGN	-	-	SCALE	AS SHOWN
CADD	SEP	10/15/15		
CHECK	JGM	10/15/15		
REVIEW	GLH	10/15/15		

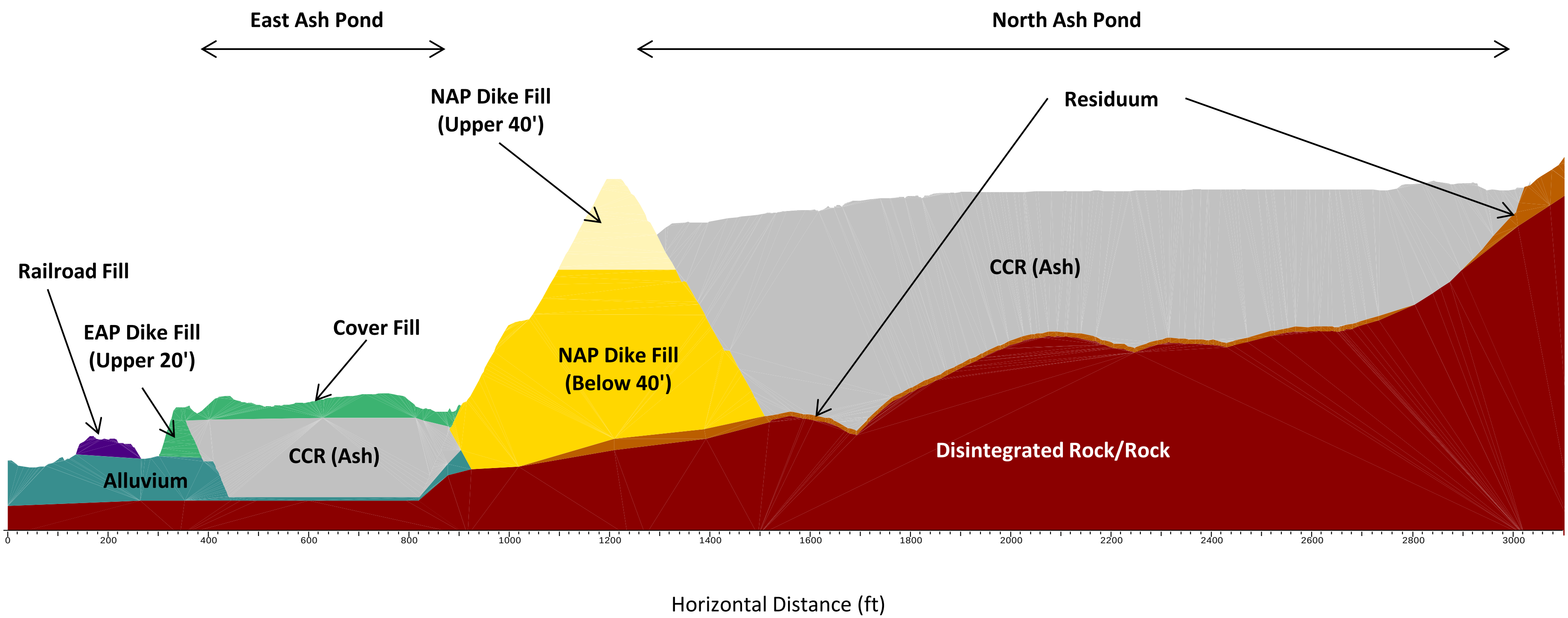
Golder Associates

FIGURE GD-5B

G:\Plan Production Data Files\Drawing Data Files\15-20347\A - Bremo Pond Closure (Conceptual Plan)\Active Drawings\Geotech Stability - 90%\1520347AD02-05B.dwg | Layout: GD-5B | Modified: SPlechota 10/23/2015 7:57 AM | Plotted: SPlechota 10/30/2015

EP-B & NP-B Schematic

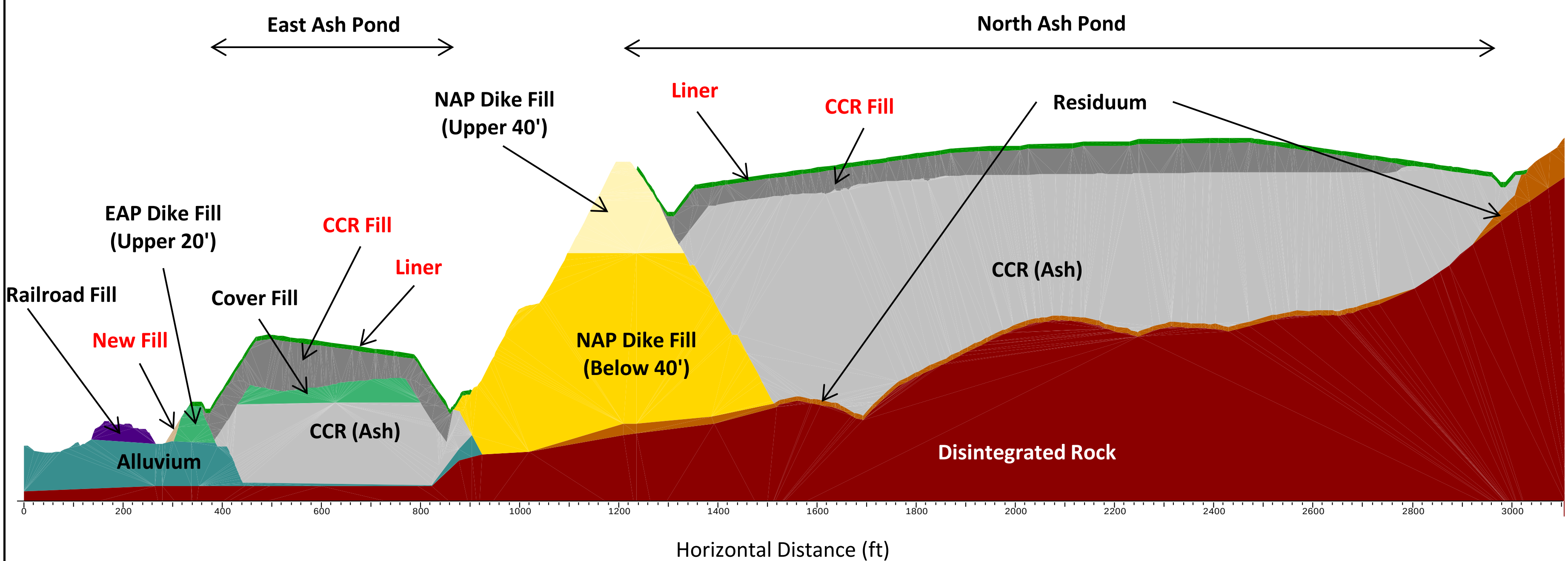
5 x Vertical Exaggeration



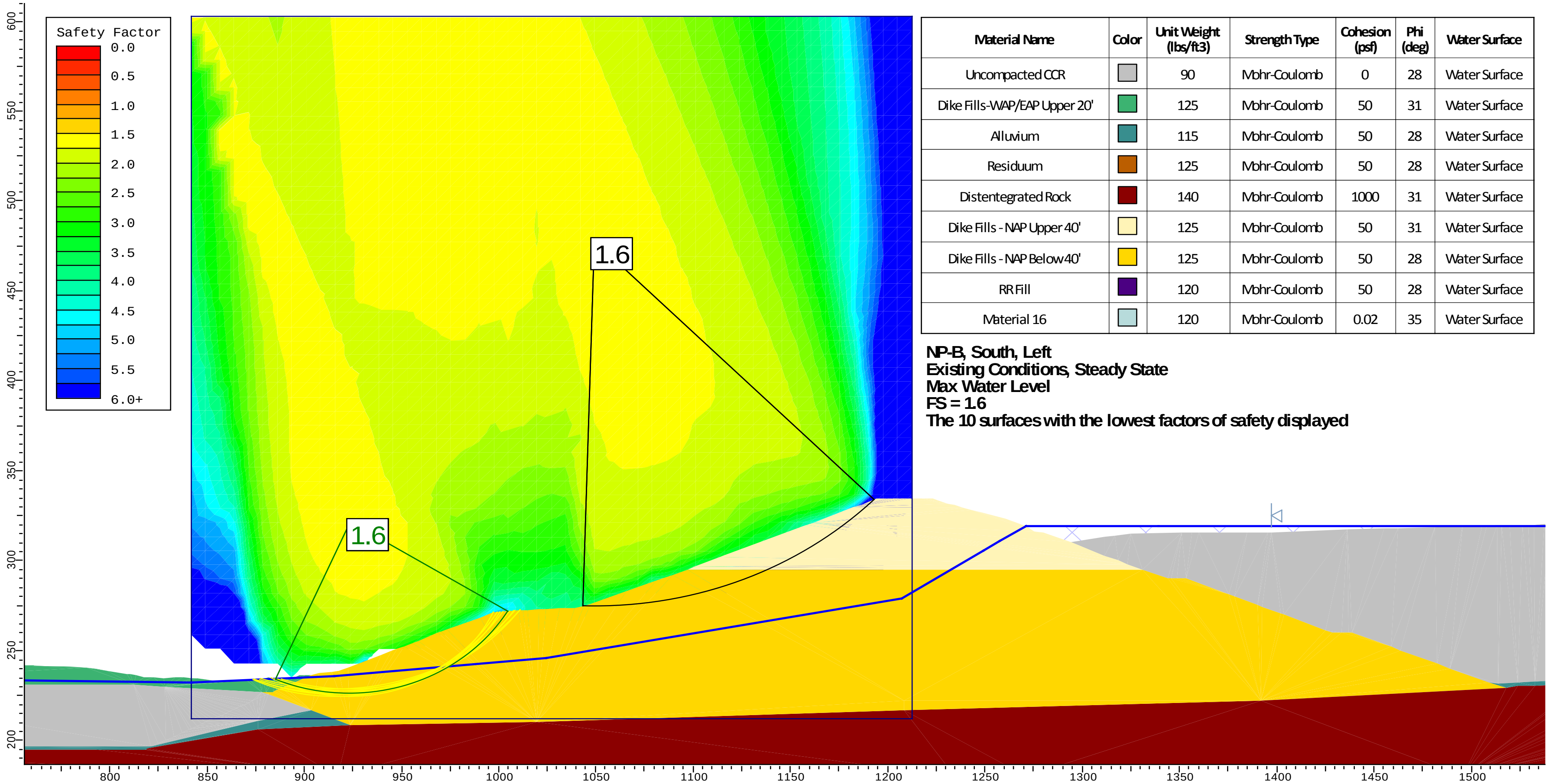
Golder Associates	SCALE: As Shown	**EAP and NAP Section B**	
	DATE: Oct-30-2015	**Bremo Bluff Power Station** **Schematic** **Existing Case**	
	MADE BY: JGM		
	CHECK: GLH		
	REVIEW: GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **1A**
PROJECT No. 1520347 / REV. 0			

EP-B & NP-B Schematic

5 x Vertical Exaggeration



Golder Associates	SCALE As Shown	EAP and NAP Section B	
	DATE Oct-30-2015	Bremo Bluff Power Station Schematic Design Case	
	MADE BY JGM		
	CHECK GLH		
	REVIEW GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 1B
PROJECT No. 1520347 REV. 0			



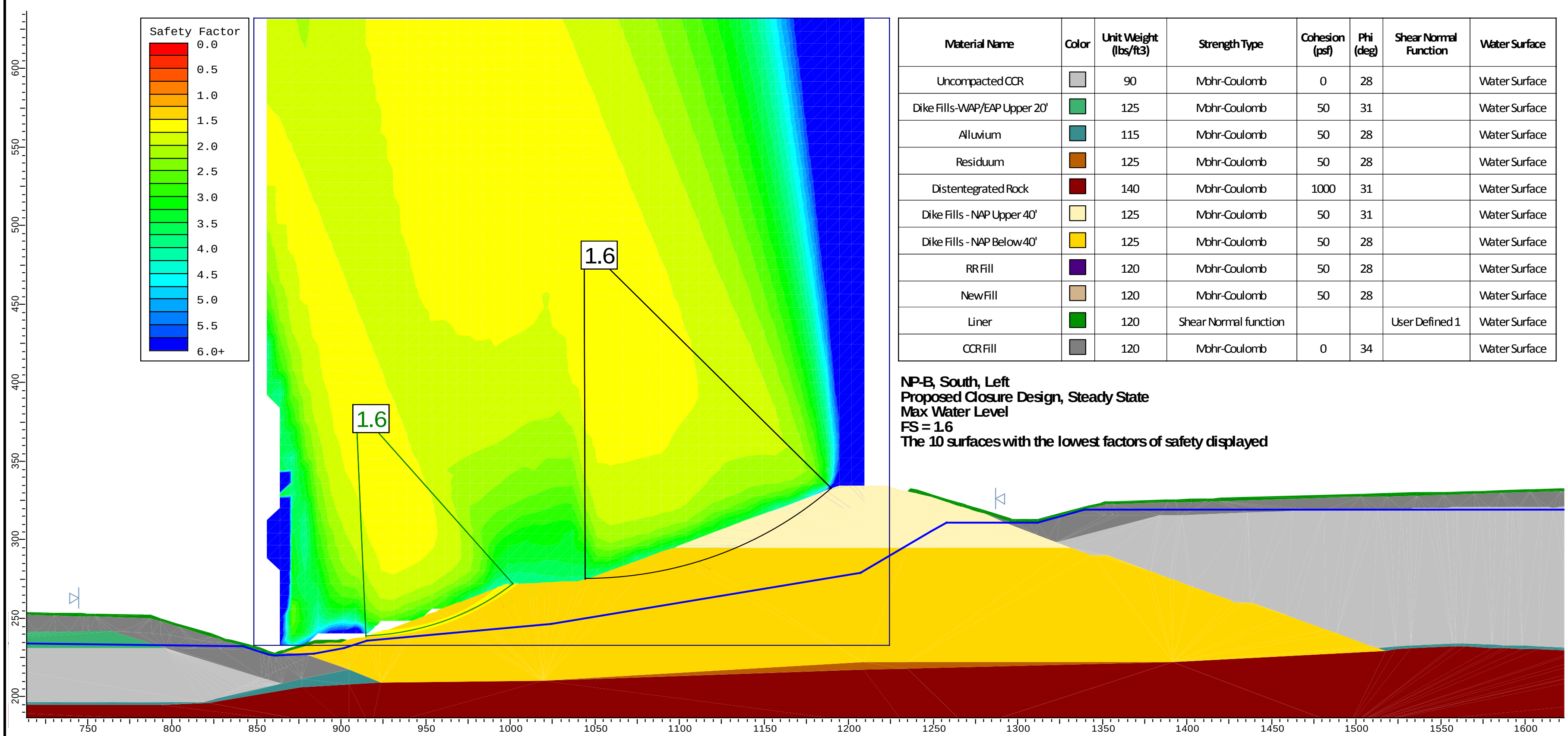
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Residuum		125	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface
Dike Fills - NAP Upper 40'		125	Mohr-Coulomb	50	31	Water Surface
Dike Fills - NAP Below 40'		125	Mohr-Coulomb	50	28	Water Surface
RR Fill		120	Mohr-Coulomb	50	28	Water Surface
Material 16		120	Mohr-Coulomb	0.02	35	Water Surface

NP-B, South, Left
Existing Conditions, Steady State
Max Water Level
FS = 1.6
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown	**NAP Section B - South - Left**
DATE	Oct-30-2015	**Bremo Bluff Power Station**
MADE BY	MGP	**Slope Stability Analysis**
CHECK	JGM	**Existing Conditions, Drained Analysis**
REVIEW	GLH	**Dominion Bremo Bluff Power Station**
PROJECT No. 1520347	REV. 0	**Ash Pond Closure Project**

Figure **2A**



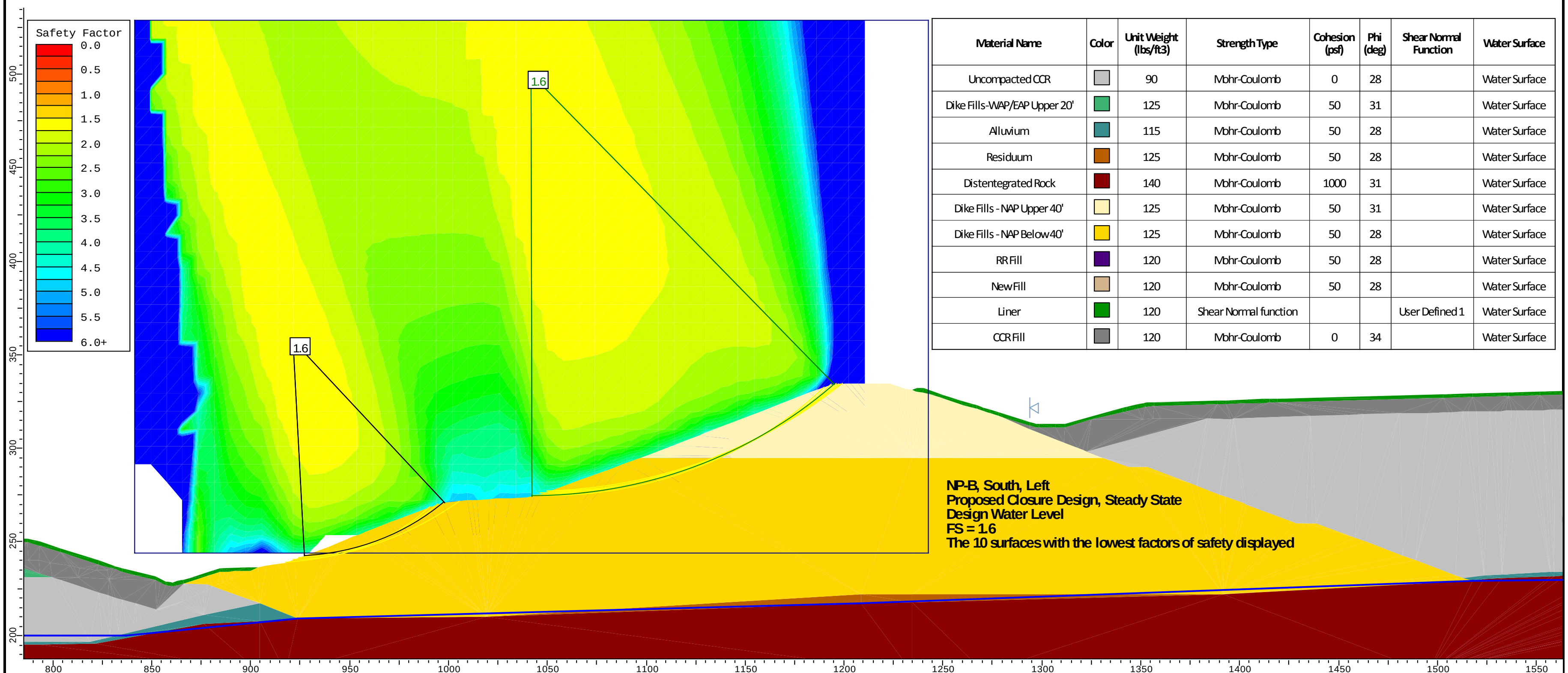
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Dike Fills - NAP Upper 40'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills - NAP Below 40'		125	Mohr-Coulomb	50	28		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

NP-B, South, Left
Proposed Closure Design, Steady State
Max Water Level
FS = 1.6
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown	**NAP Section B - South - Left**	
DATE	Oct-30-2015	**Slope Stability Analysis Proposed Closure Design Steady State, Max Water Level**	
MADE BY	MGP		
CHECK	JGM		
REVIEW	GLH	**Dominion Bremo Bluff Power Station Ash Pond Closure Project**	Figure **2B**

PROJECT No. 1520347 REV. 0

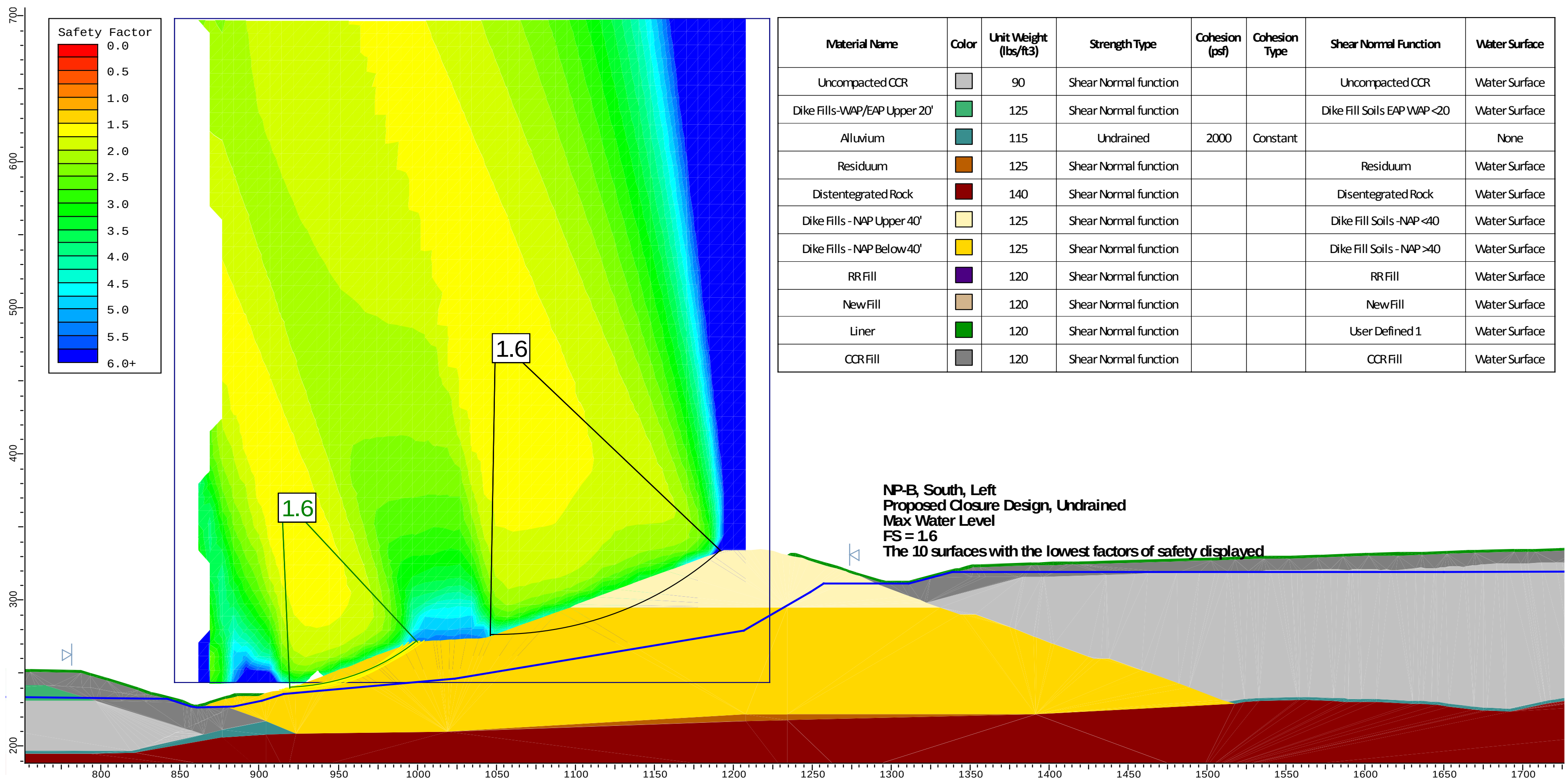


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Dike Fills - NAP Upper 40'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills - NAP Below 40'		125	Mohr-Coulomb	50	28		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

Golder Associates

SCALE	As Shown	**NAP Section B - South - Left**	
DATE	Oct-30-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Design Water Level**	
MADE BY	MGP		
CHECK	JGM		
REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **2C**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40	Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

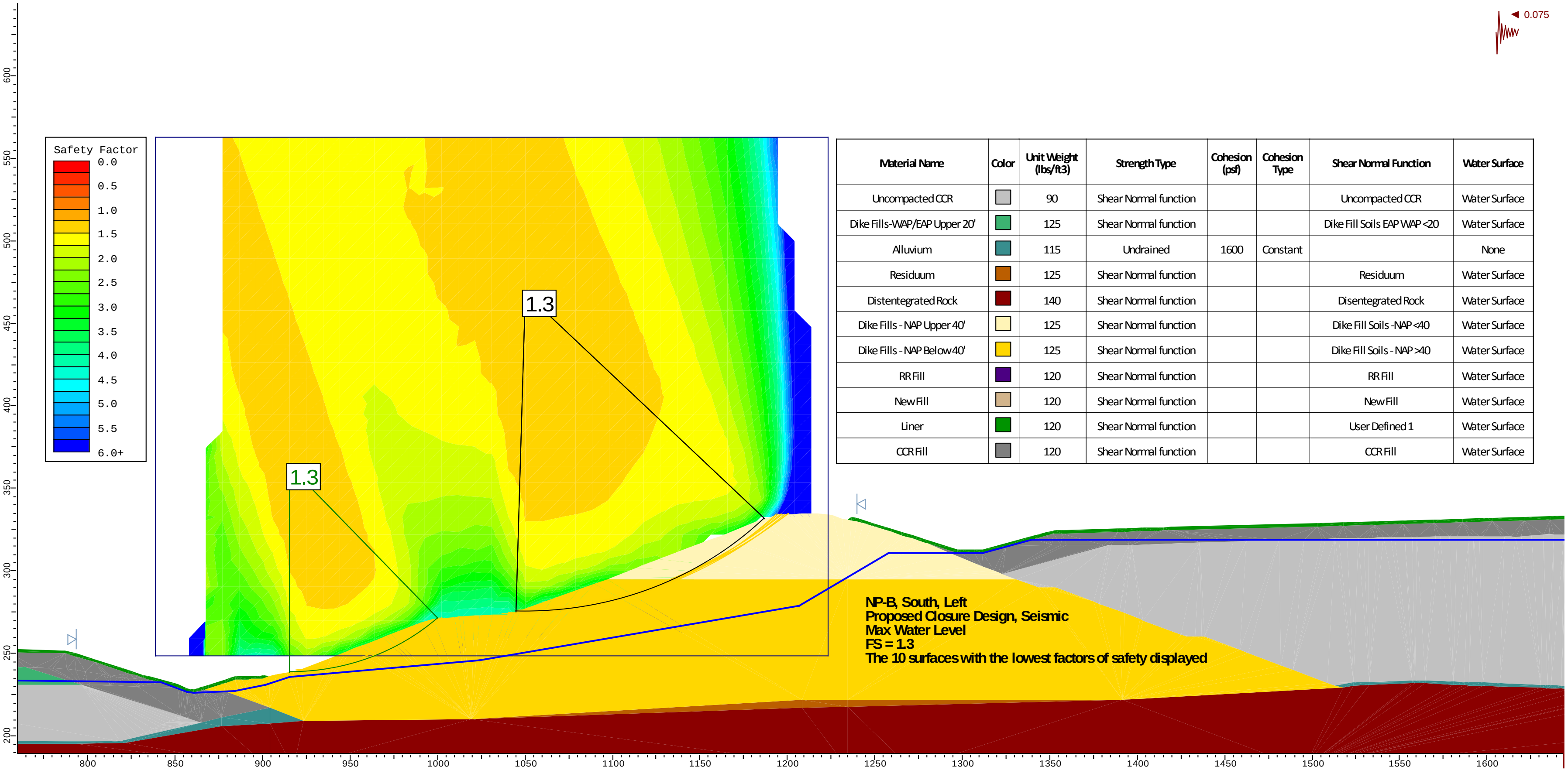
NAP Section B - South - Left

Slope Stability Analysis
Proposed Closure Design
Undrained, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **2D**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40	Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

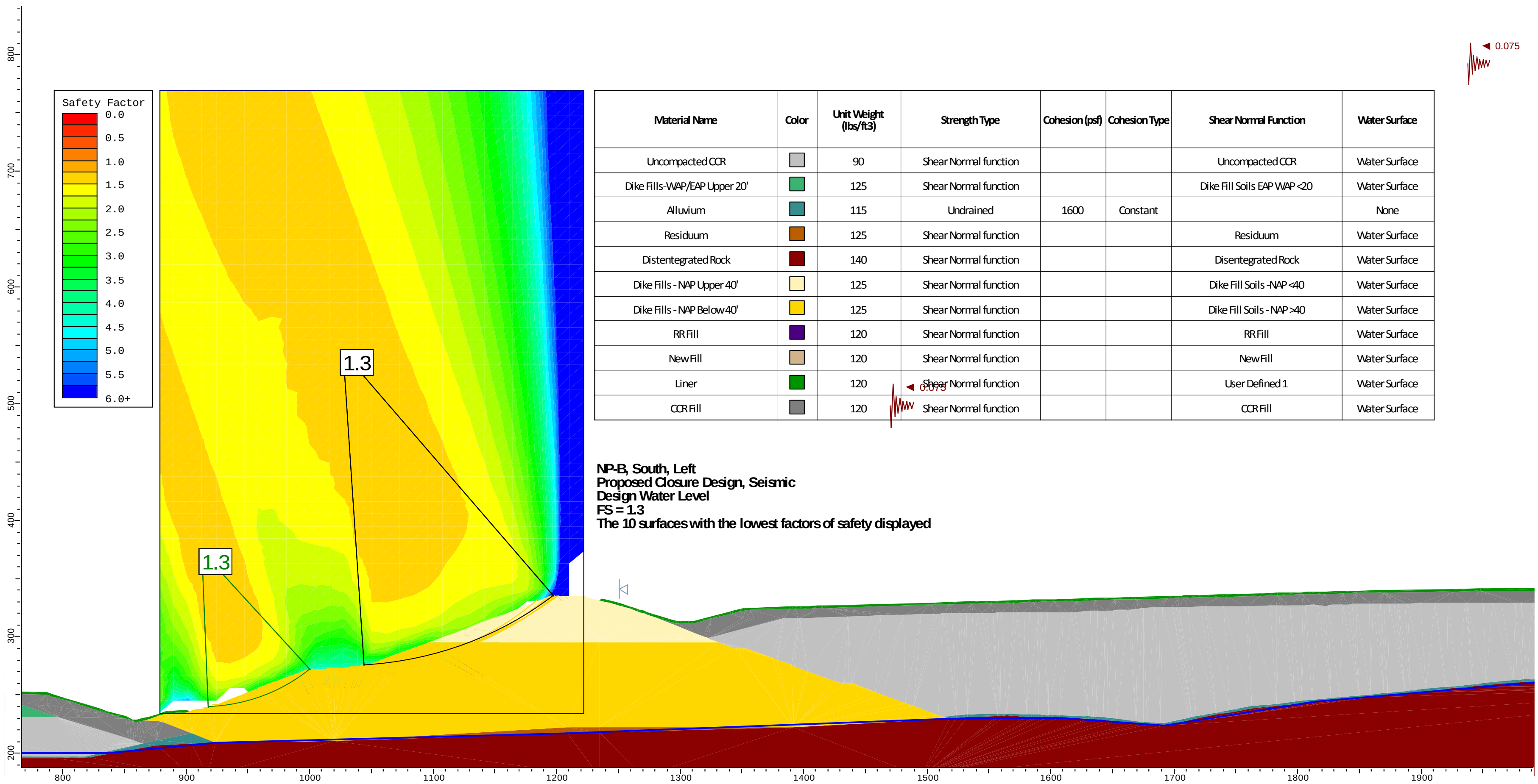
NAP Section B - South - Left

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

PROJECT No. 1520347 REV. 0

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **2E**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40	Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

Golder Associates

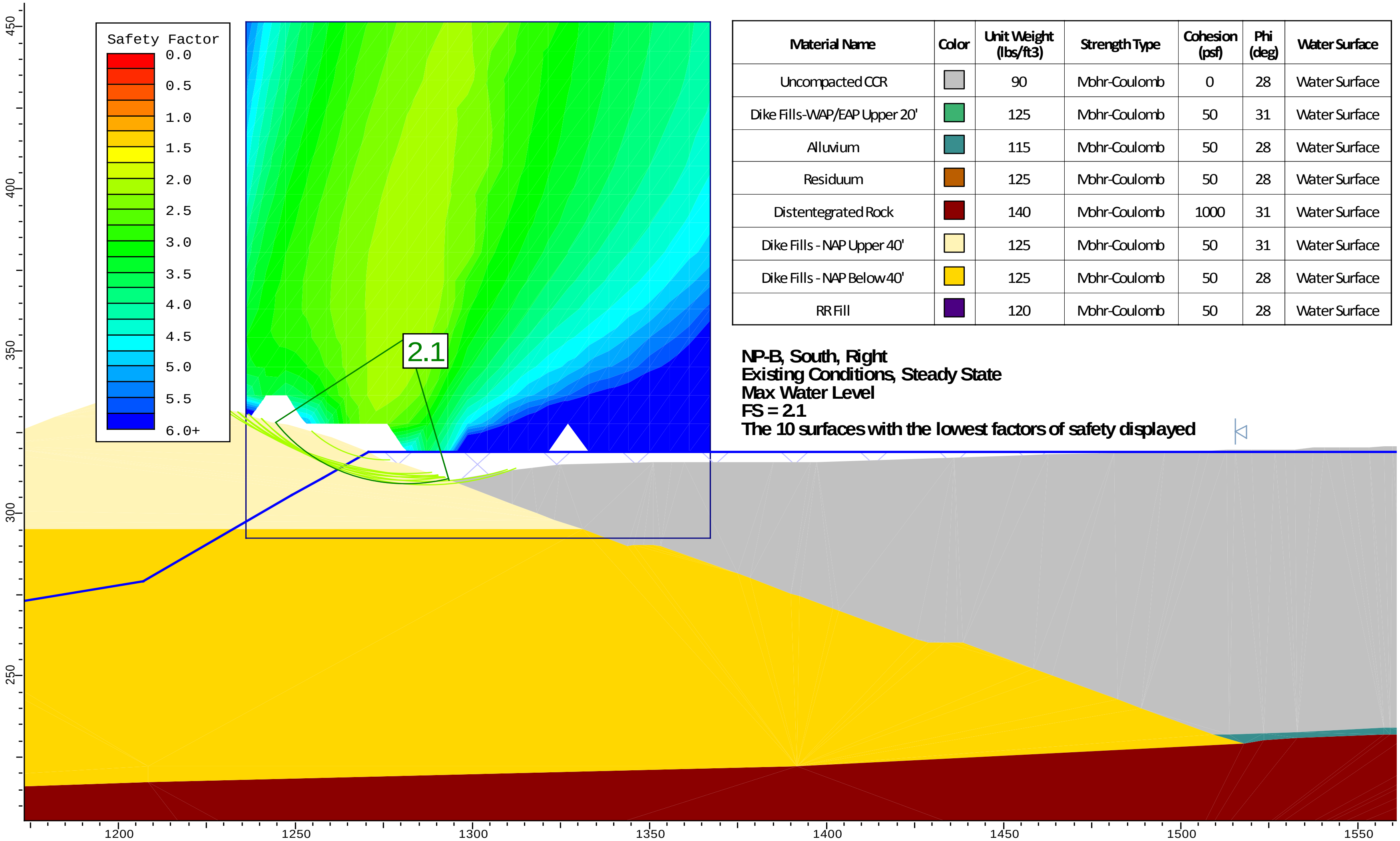
NAP Section B - South - Left

Slope Stability Analysis
Proposed Closure Design
Seismic, Design Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **2F**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Residuum		125	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface
Dike Fills - NAP Upper 40'		125	Mohr-Coulomb	50	31	Water Surface
Dike Fills - NAP Below 40'		125	Mohr-Coulomb	50	28	Water Surface
RR Fill		120	Mohr-Coulomb	50	28	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

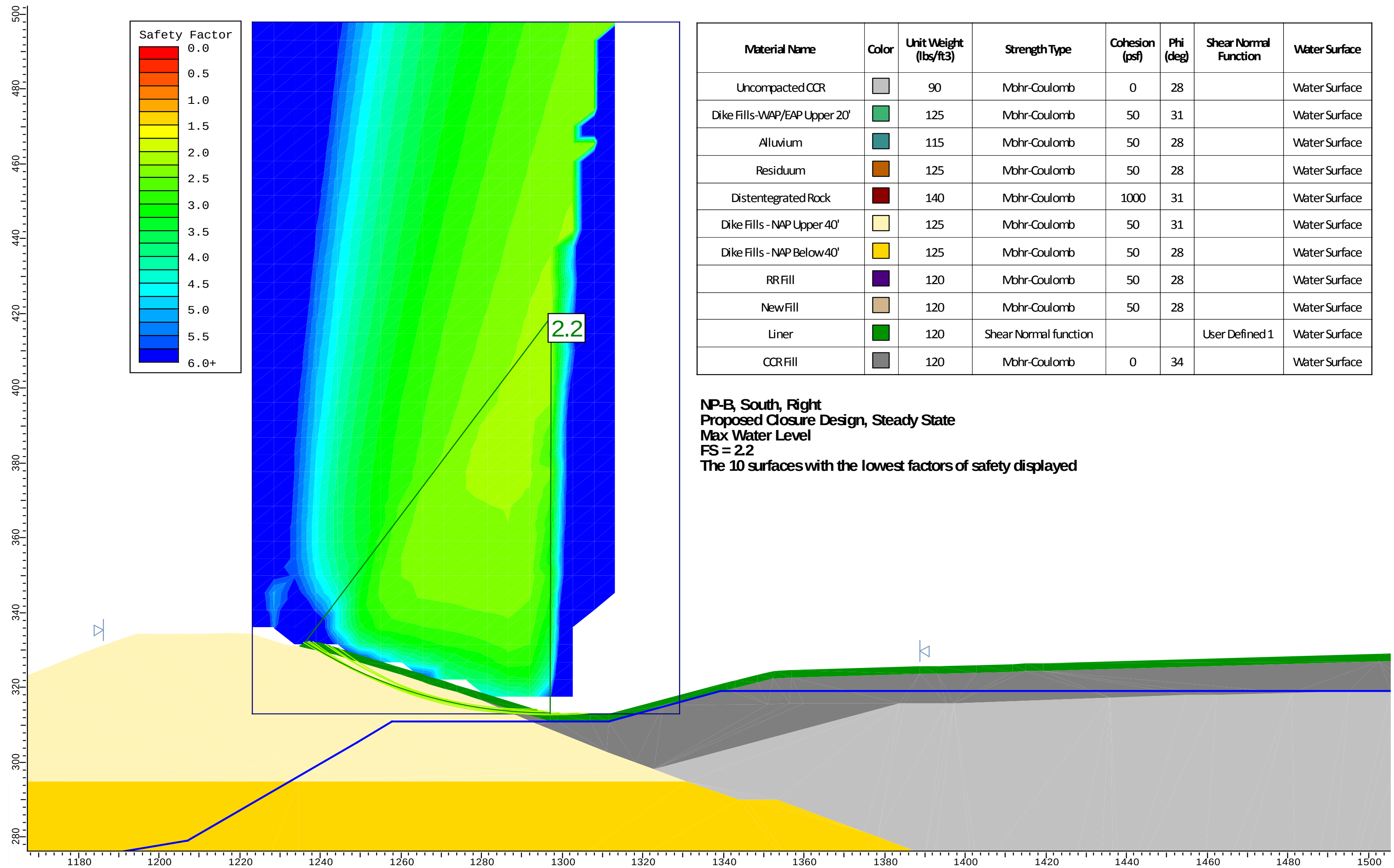
NAP Section B - South - Right

Bremo Bluff Power Station
Slope Stability Analysis
Existing Conditions, Drained Analysis

PROJECT No. 1520347 REV. 0

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

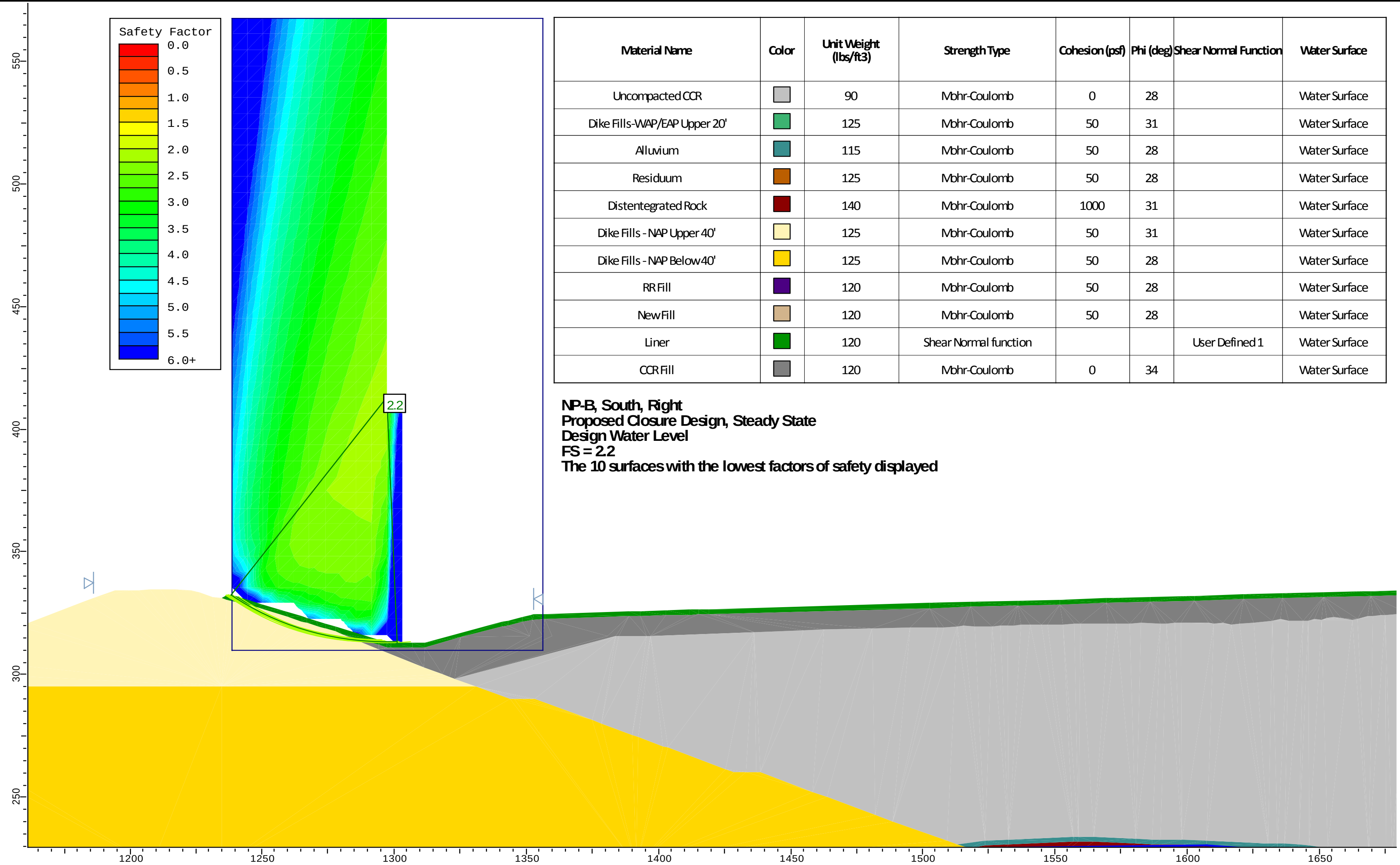
Figure **3A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Dike Fills - NAP Upper 40'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills - NAP Below 40'		125	Mohr-Coulomb	50	28		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

NP-B, South, Right
Proposed Closure Design, Steady State
Max Water Level
FS = 2.2
The 10 surfaces with the lowest factors of safety displayed

Golder Associates	SCALE: As Shown	**NAP Section B - South - Right**	
	DATE: Oct-30-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Max Water Level**	
	MADE BY: MGP		
	CHECK: JGM		
	REVIEW: GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **3B**
PROJECT No. 1520347 / REV. 0			



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Dike Fills - NAP Upper 40'		125	Mohr-Coulomb	50	31		Water Surface
Dike Fills - NAP Below 40'		125	Mohr-Coulomb	50	28		Water Surface
RR Fill		120	Mohr-Coulomb	50	28		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

NP-B, South, Right
Proposed Closure Design, Steady State
Design Water Level
FS = 2.2
The 10 surfaces with the lowest factors of safety displayed

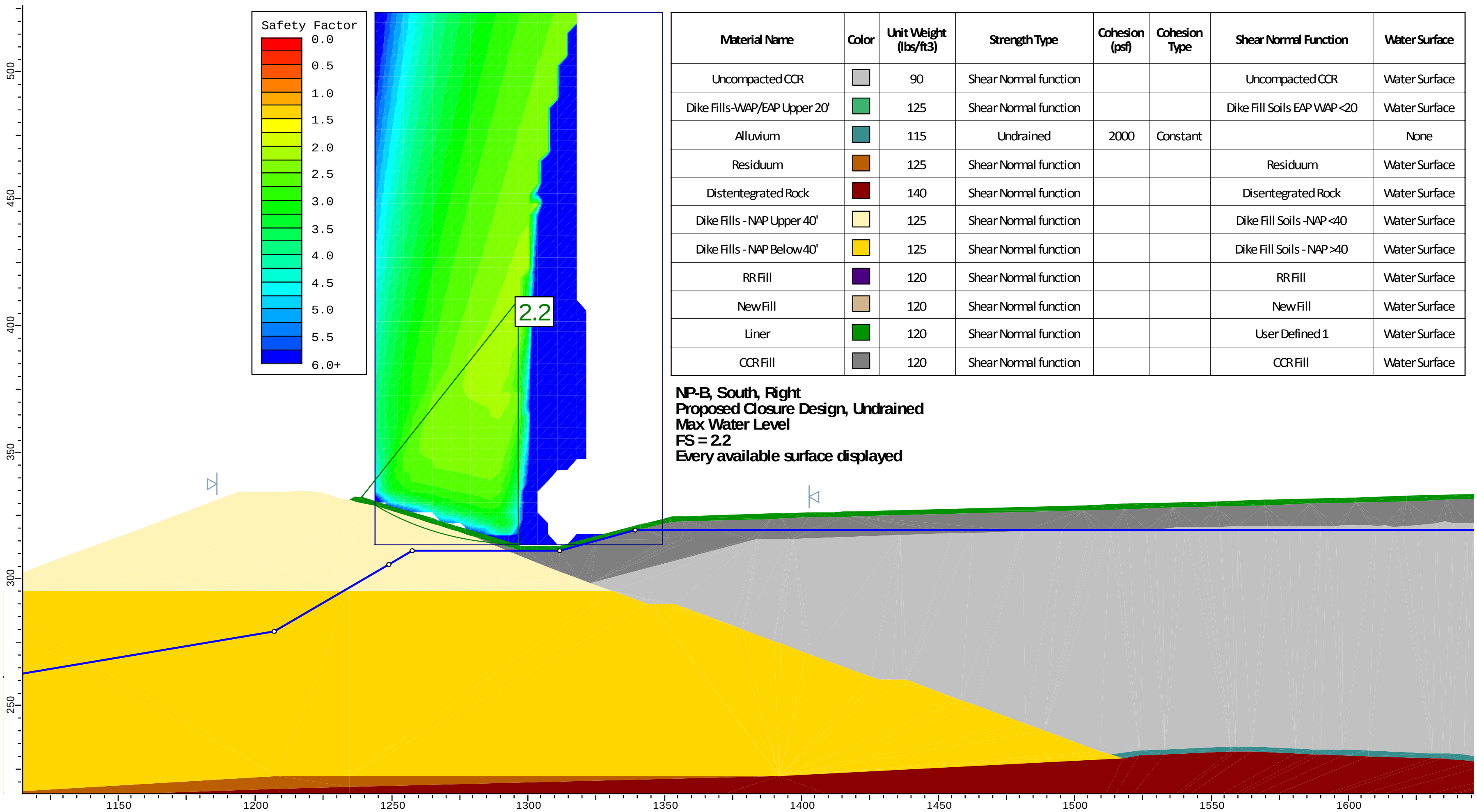
Golder Associates

SCALE	As Shown	**NAP Section B - South - Right**	
DATE	Oct-30-2015	**Slope Stability Analysis Proposed Closure Design Steady State, Design Water Level**	
MADE BY	MGP		
CHECK	JGM		
REVIEW	GLH	**Dominion Bremo Bluff Power Station Ash Pond Closure Project**	Figure **3C**

PROJECT No. 1520347 REV. 0

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40	Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

NP-B, South, Right
Proposed Closure Design, Undrained
Max Water Level
FS = 2.2
Every available surface displayed



Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

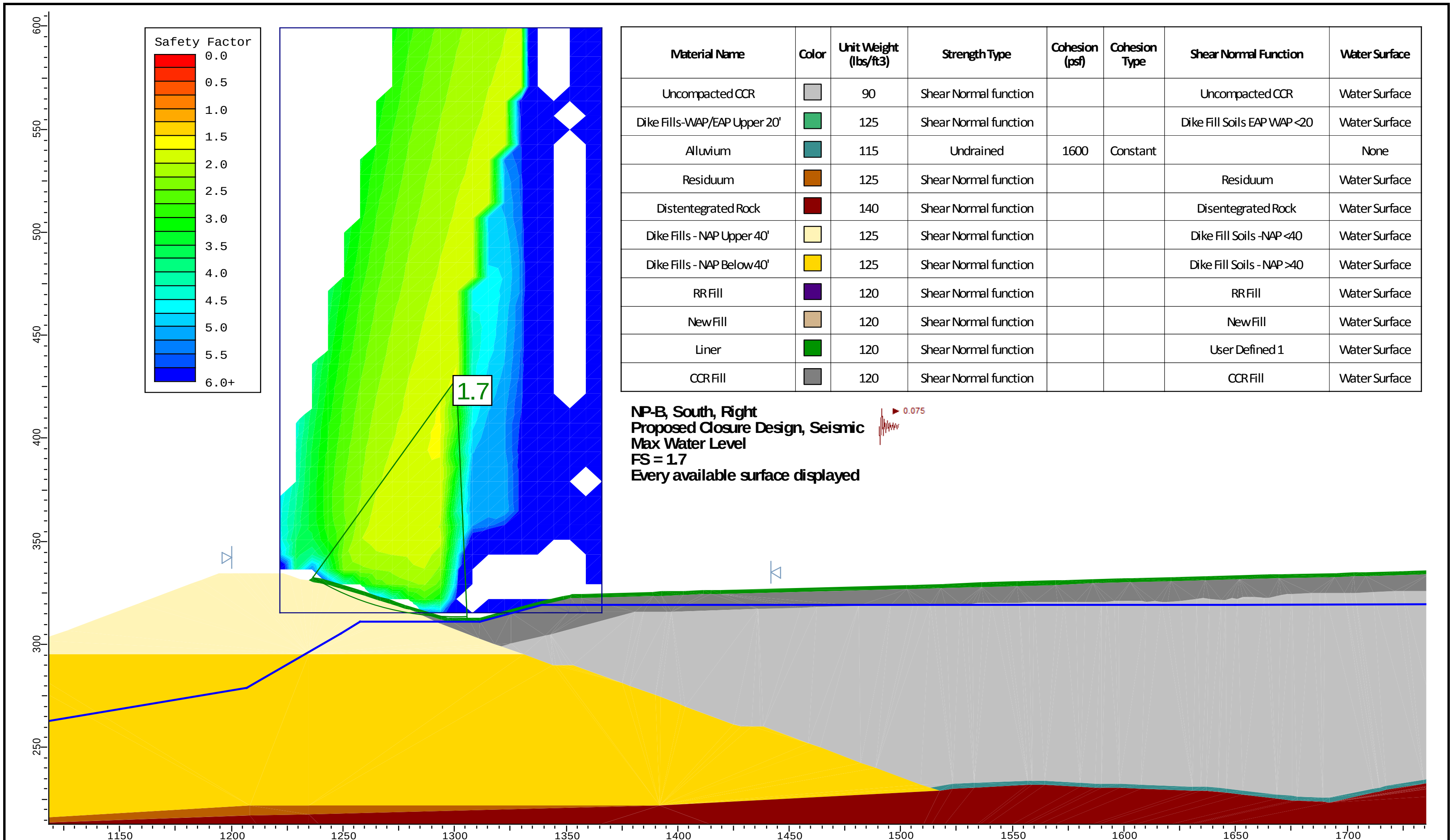
PROJECT No. 1520347 REV. 0

NAP Section B - South - Right

Slope Stability Analysis
Proposed Closure Design
Undrained, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **3D**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40	Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

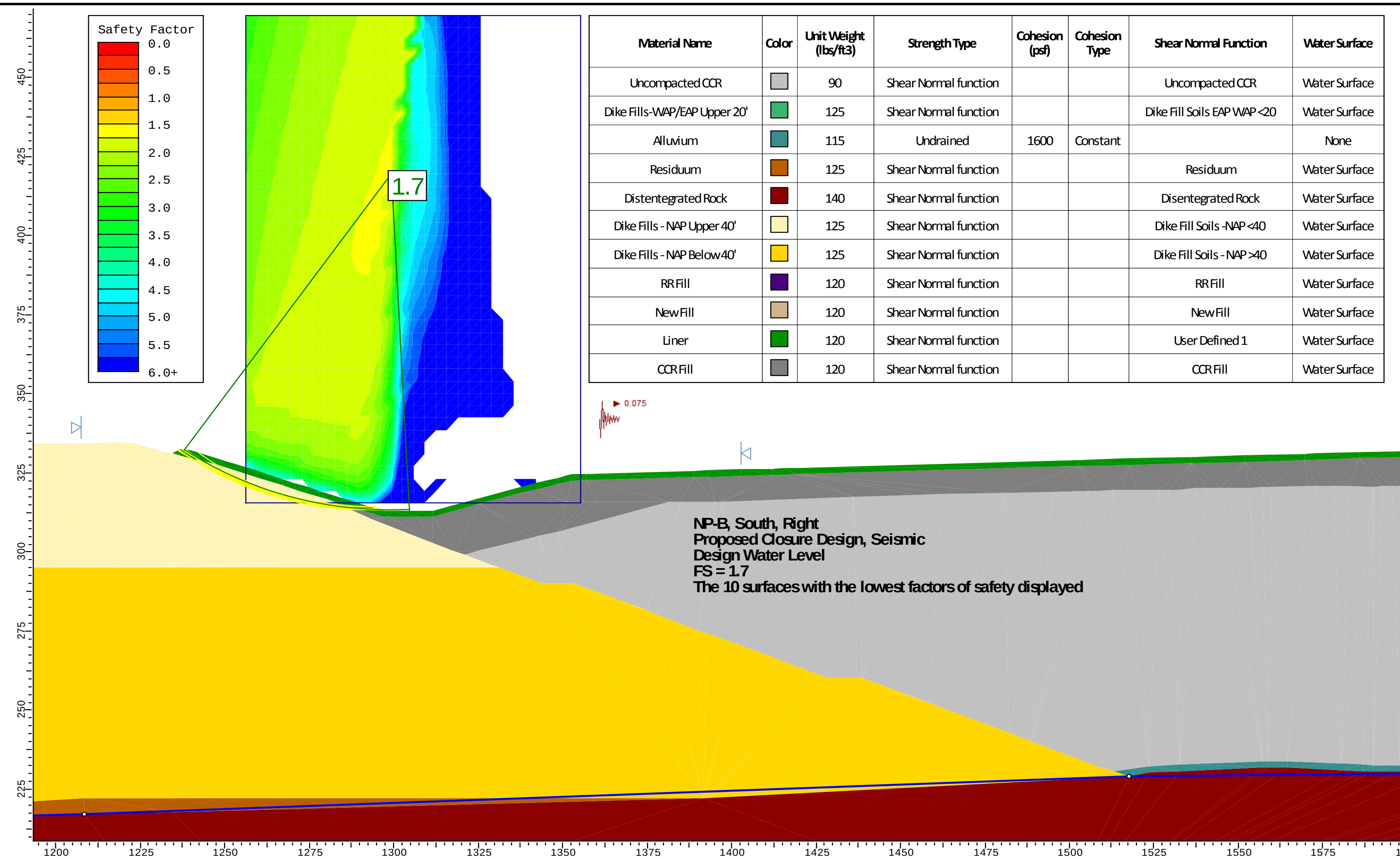
PROJECT No. 1520347 REV. 0

NAP Section B - South - Right

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **3E**

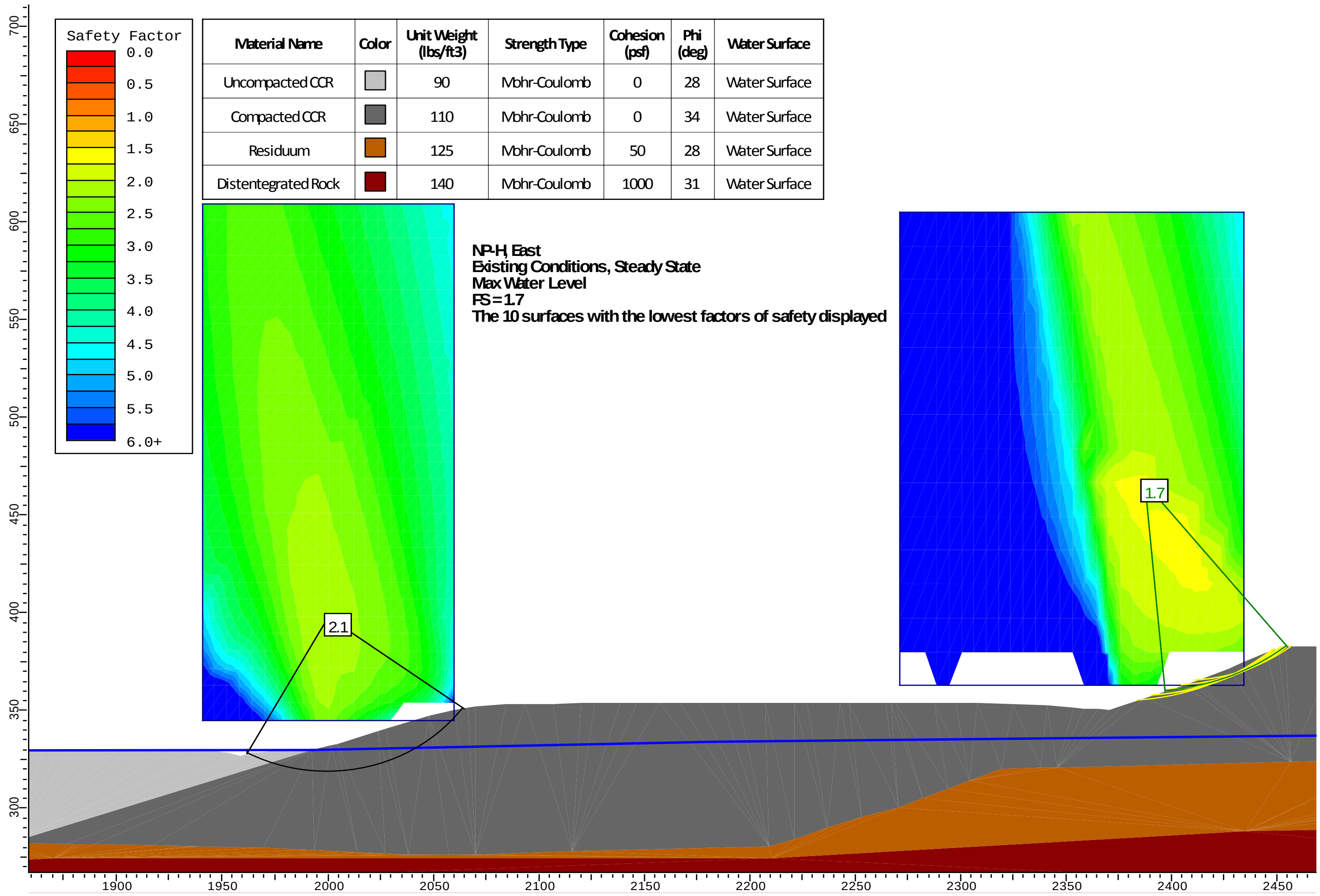


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Residuum		125	Shear Normal function			Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40	Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils -NAP >40	Water Surface
RR Fill		120	Shear Normal function			RR Fill	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Shear Normal function			CCR Fill	Water Surface

Golder Associates

SCALE	As Shown	**NAP Section B - South - Right**
DATE	Oct-30-2015	**Slope Stability Analysis**
MADE BY	MGP	**Proposed Closure Design**
CHECK	JGM	**Seismic, Design Water Level**
REVIEW	GLH	**Dominion Bremo Bluff Power Station**
PROJECT No. 1520347	REV. 0	**Ash Pond Closure Project**

Figure **3F**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34	Water Surface
Residuum		125	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

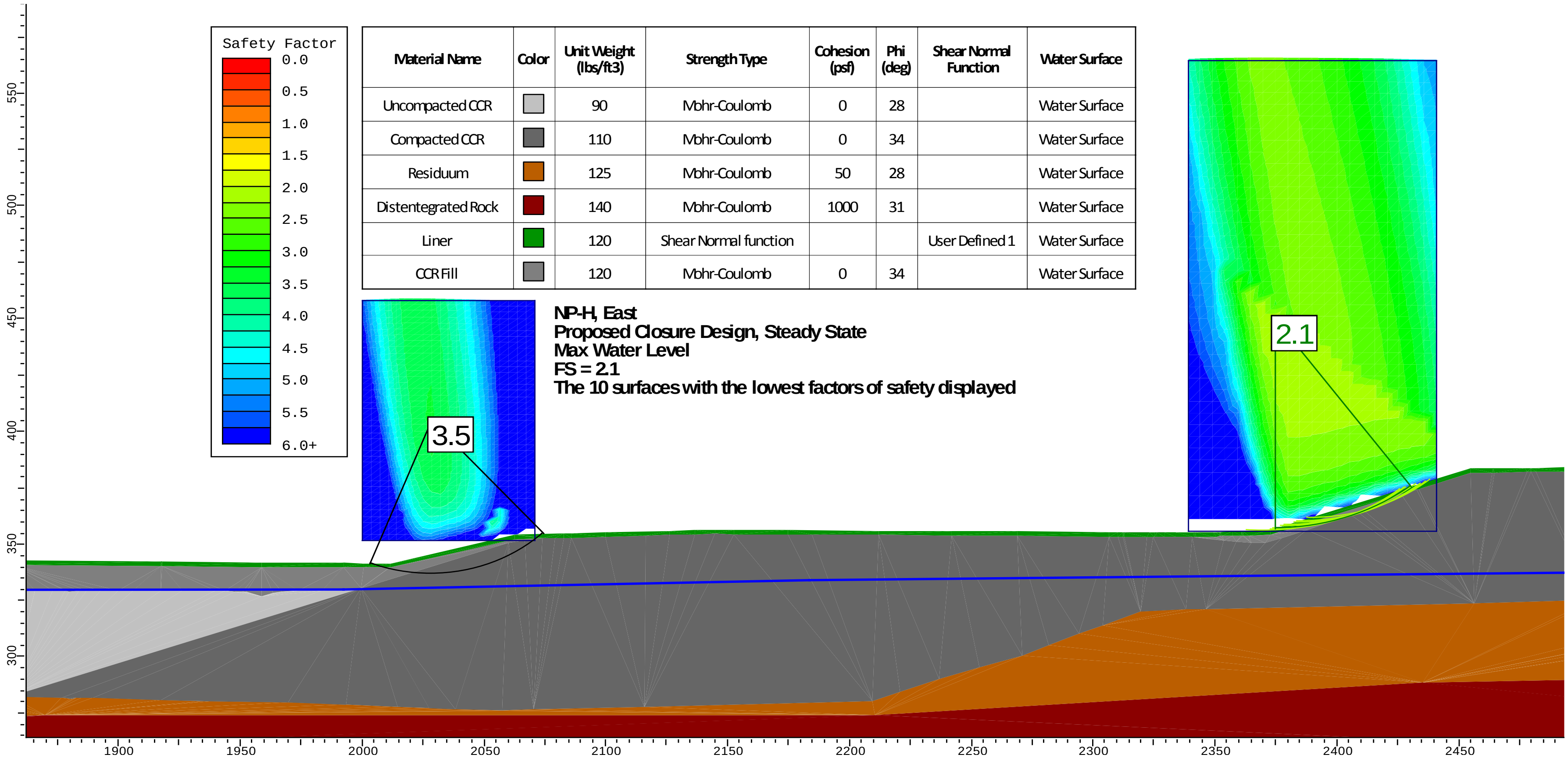
NAP Section H - East

Bremo Bluff Power Station
Slope Stability Analysis
Existing Conditions, Drained Analysis

PROJECT No. 1520347 REV. 0

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **4A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

PROJECT No. 1520347 REV. 0

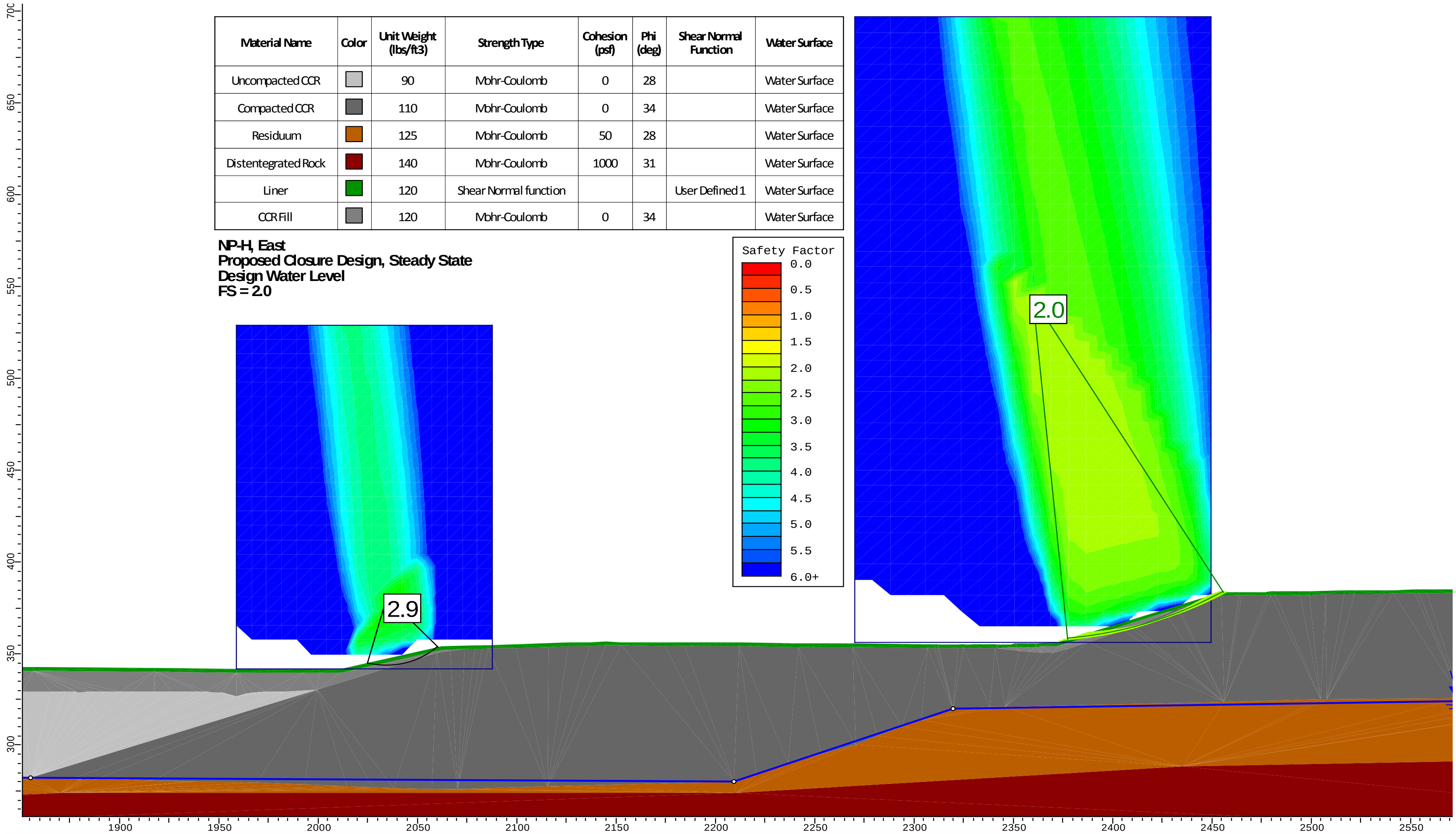
NAP Section H - East

Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

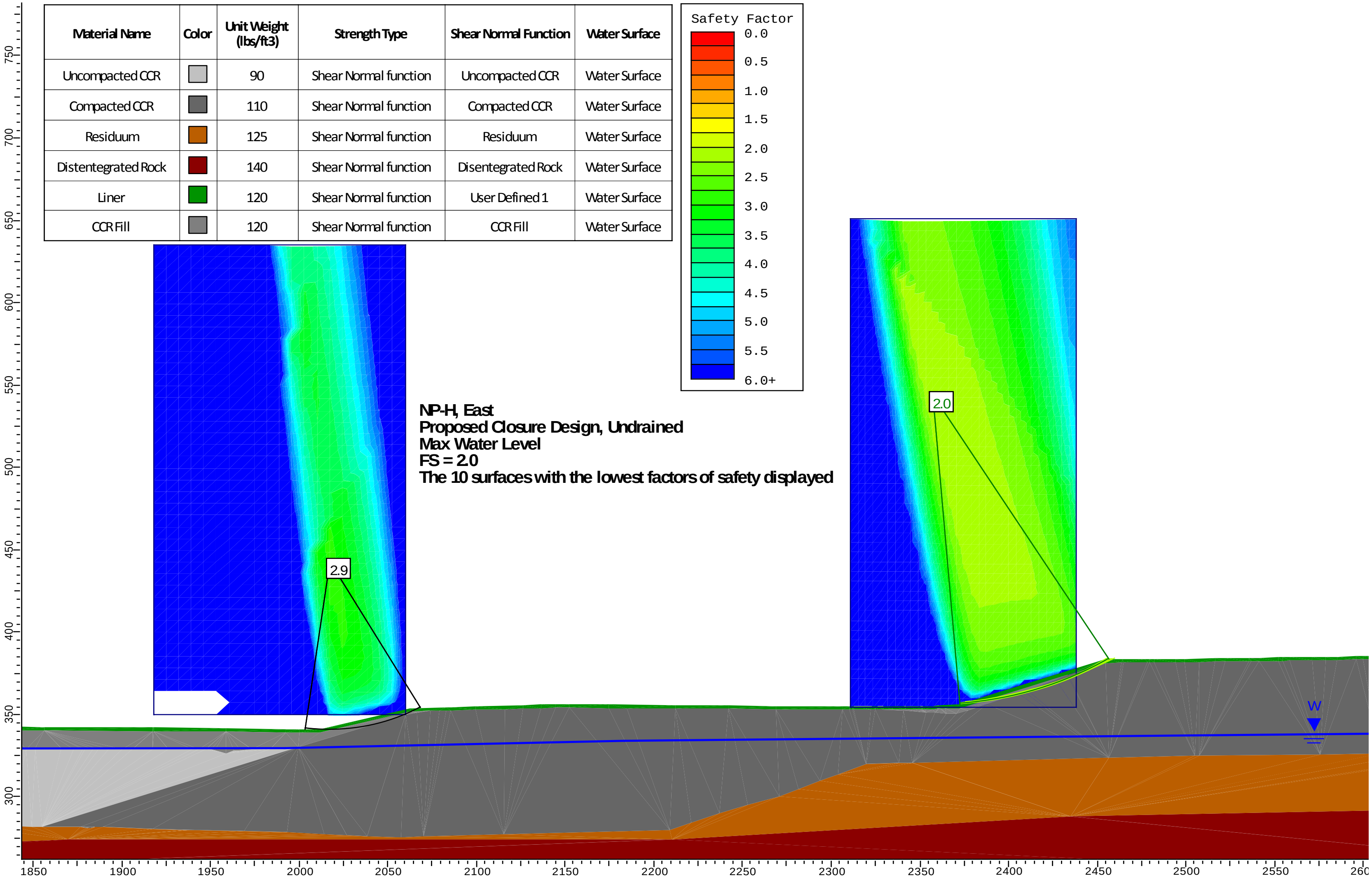
Figure **4B**

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28		Water Surface
Compacted CCR		110	Mohr-Coulomb	0	34		Water Surface
Residuum		125	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
Liner		120	Shear Normal function			User Defined 1	Water Surface
CCR Fill		120	Mohr-Coulomb	0	34		Water Surface



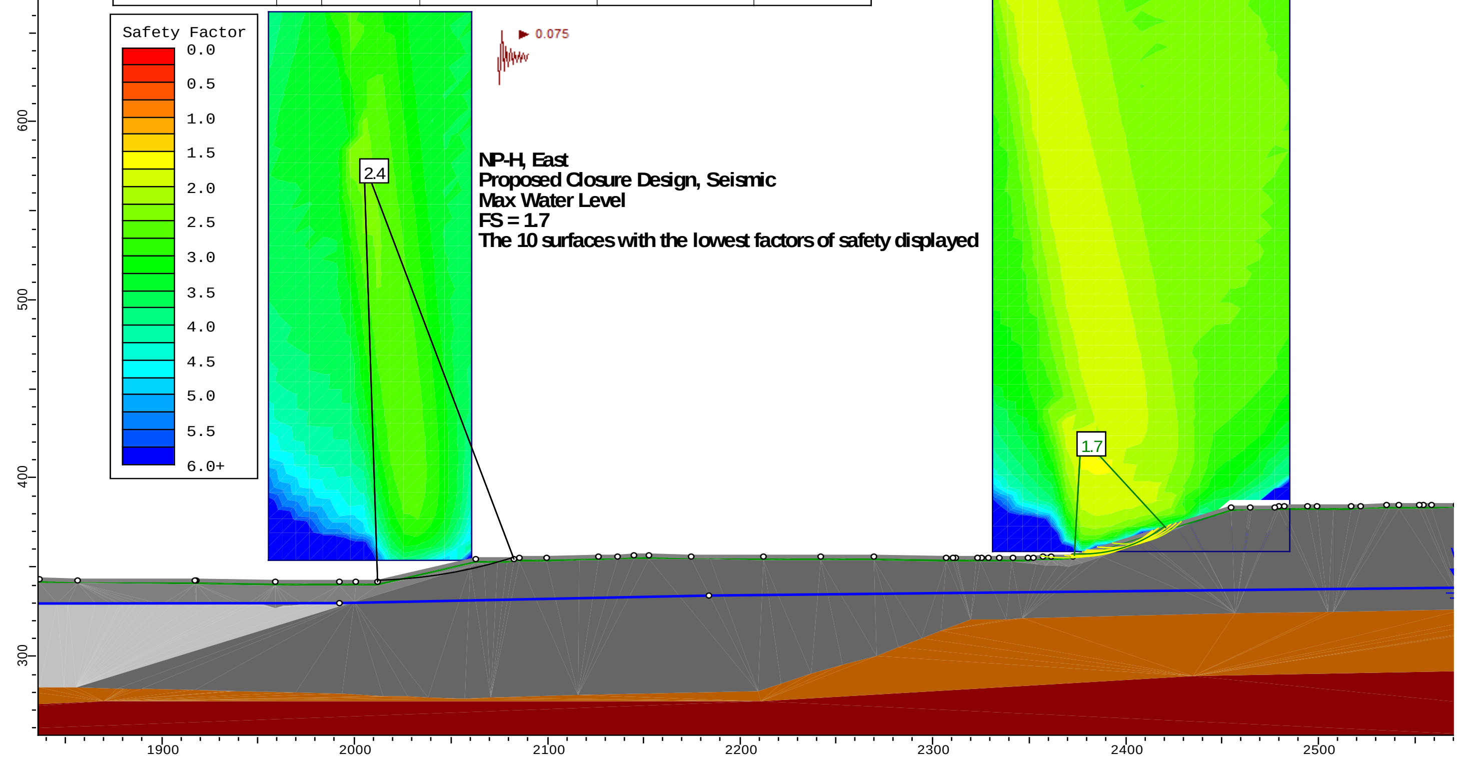
Golder Associates	SCALE: As Shown	NAP Section H - East	
	DATE: Oct-30-2015	Slope Stability Analysis Proposed Closure Design Steady State, Design Water Level	
	MADE BY: MGP		
	CHECK: JGM		
	REVIEW: GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 4C
PROJECT No. 1520347 / REV. 0			

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function	Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function	Compacted CCR	Water Surface
Residuum		125	Shear Normal function	Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function	Disentegrated Rock	Water Surface
Liner		120	Shear Normal function	User Defined 1	Water Surface
CCR Fill		120	Shear Normal function	CCR Fill	Water Surface

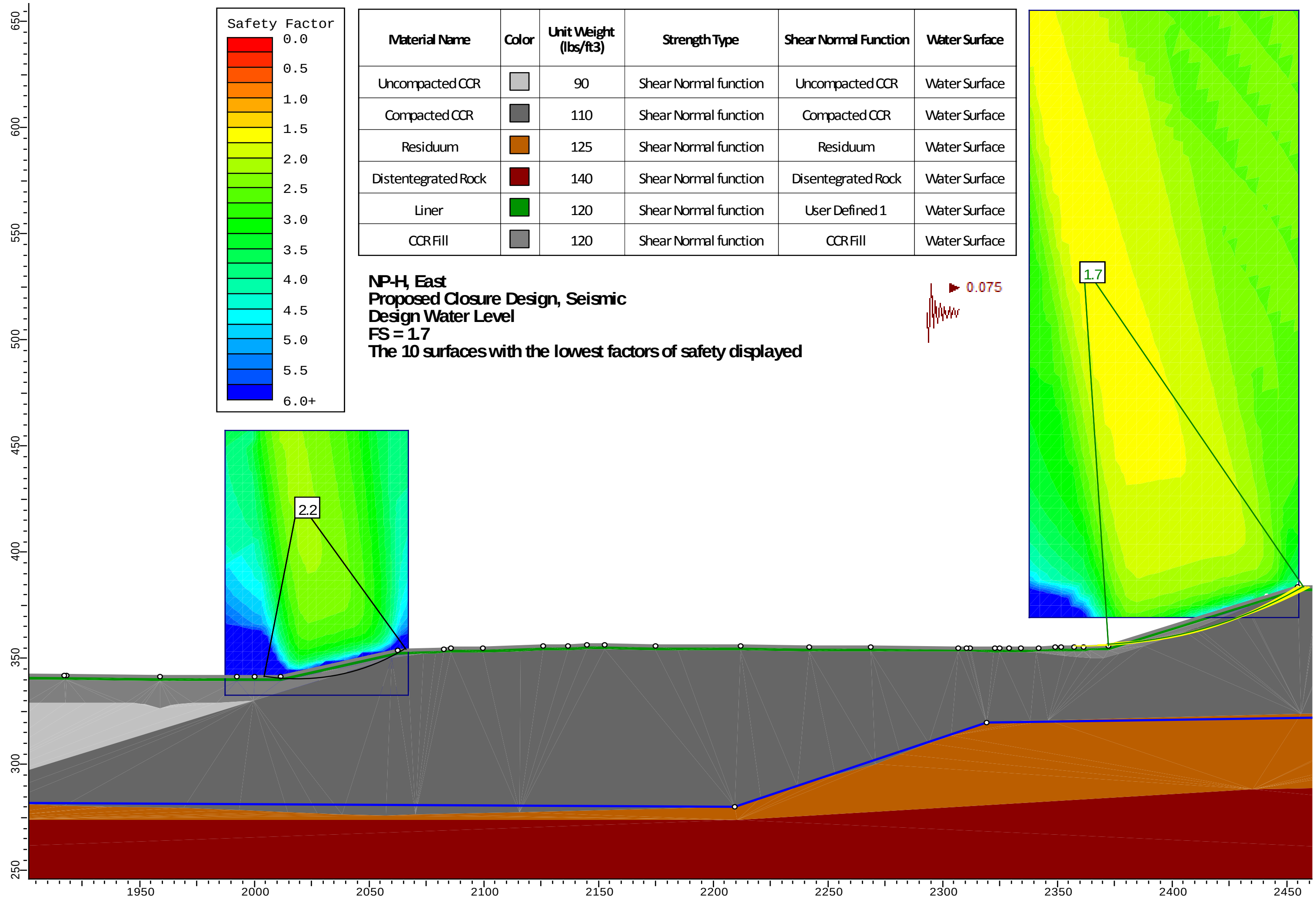


Golder Associates	SCALE: As Shown	**NAP Section H - East**	
	DATE: Oct-30-2015	**Slope Stability Analysis** **Proposed Closure Design** **Undrained, Max Water Level**	
	MADE BY: MGP		
	CHECK: JGM		
	REVIEW: GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **4D**
PROJECT No. 1520347 / REV. 0			

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function	Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function	Compacted CCR	Water Surface
Residuum		125	Shear Normal function	Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function	Disentegrated Rock	Water Surface
Liner		120	Shear Normal function	User Defined 1	Water Surface
CCR Fill		120	Shear Normal function	CCR Fill	Water Surface



Golder Associates	SCALE: As Shown	**NAP Section H - East**	
	DATE: Oct-30-2015	**Slope Stability Analysis** **Proposed Closure Design** **Seismic, Max Water Level**	
	MADE BY: MGP		
	CHECK: JGM		
	REVIEW: GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **4E**
PROJECT No. 1520347 / REV. 0			



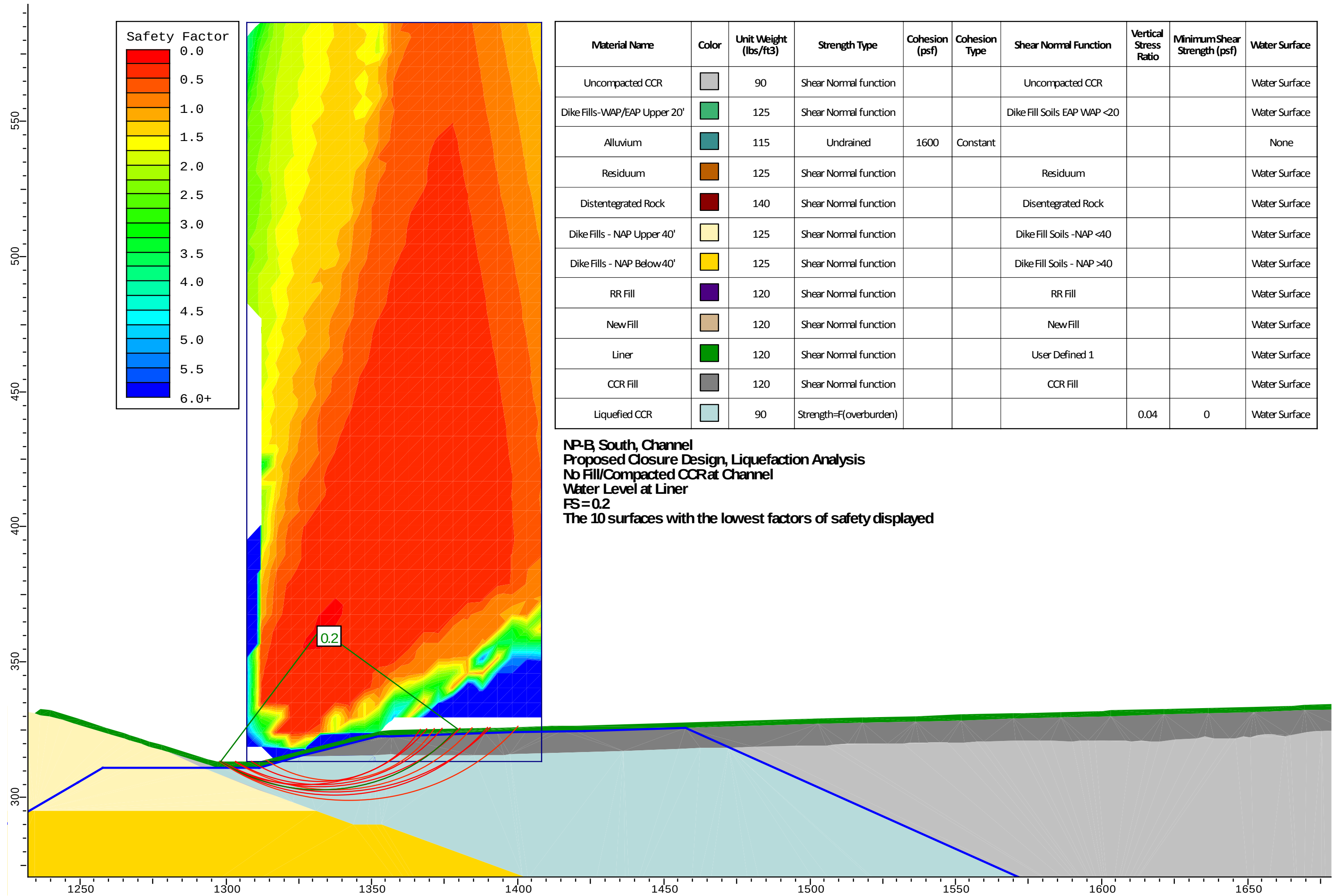
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear Normal Function	Water Surface
Uncompacted CCR		90	Shear Normal function	Uncompacted CCR	Water Surface
Compacted CCR		110	Shear Normal function	Compacted CCR	Water Surface
Residuum		125	Shear Normal function	Residuum	Water Surface
Distentegrated Rock		140	Shear Normal function	Disentegrated Rock	Water Surface
Liner		120	Shear Normal function	User Defined 1	Water Surface
CCR Fill		120	Shear Normal function	CCR Fill	Water Surface

NP-H, East
Proposed Closure Design, Seismic
Design Water Level
FS = 1.7
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown	**NAP Section H - East**	
DATE	Oct-30-2015	**Slope Stability Analysis** **Proposed Closure Design** **Seismic, Design Water Level**	
MADE BY	MGP		
CHECK	JGM		
REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **4F**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR			Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20			Water Surface
Alluvium		115	Undrained	1600	Constant				None
Residuum		125	Shear Normal function			Residuum			Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock			Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40			Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40			Water Surface
RR Fill		120	Shear Normal function			RR Fill			Water Surface
New Fill		120	Shear Normal function			New Fill			Water Surface
Liner		120	Shear Normal function			User Defined 1			Water Surface
CCR Fill		120	Shear Normal function			CCR Fill			Water Surface
Liquefied CCR		90	Strength=F(overburden)				0.04	0	Water Surface

NP-B, South, Channel
Proposed Closure Design, Liquefaction Analysis
No Fill/Compacted CCR at Channel
Water Level at Liner
FS=0.2
The 10 surfaces with the lowest factors of safety displayed

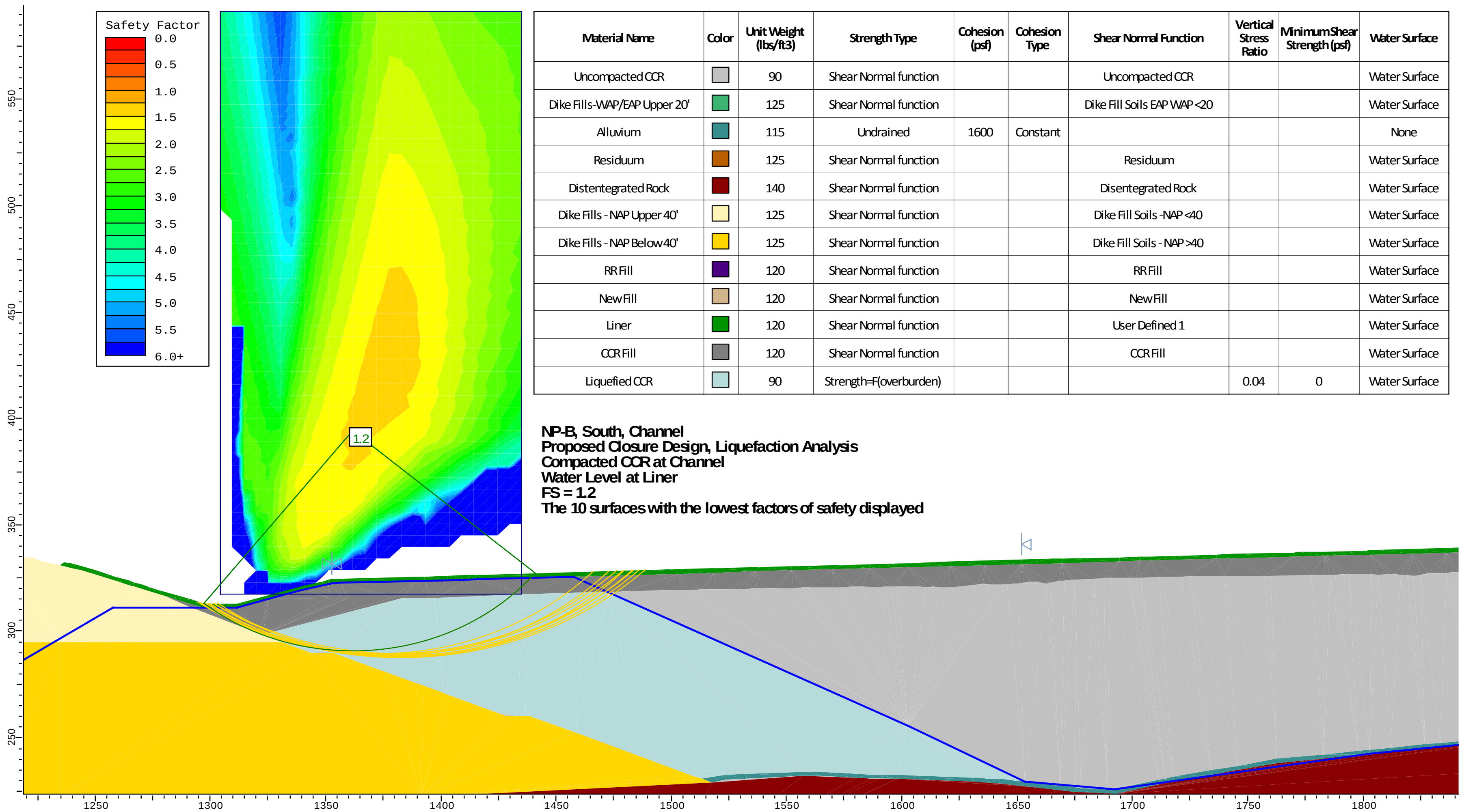
Golder Associates

SCALE	As Shown	**NAP Section B - South, Channel**
DATE	Oct-30-2015	**Bremo Bluff Power Station**
MADE BY	MGP	**Proposed Closure Design - No Fill/Compacted CCR at Channel**
CHECK	JGM	**Liquifaction Analysis, Water Level at Liner**
REVIEW	GLH	**Dominion Bremo Bluff Power Station**

Ash Pond Closure Project

PROJECT No. 1520347 REV. 0

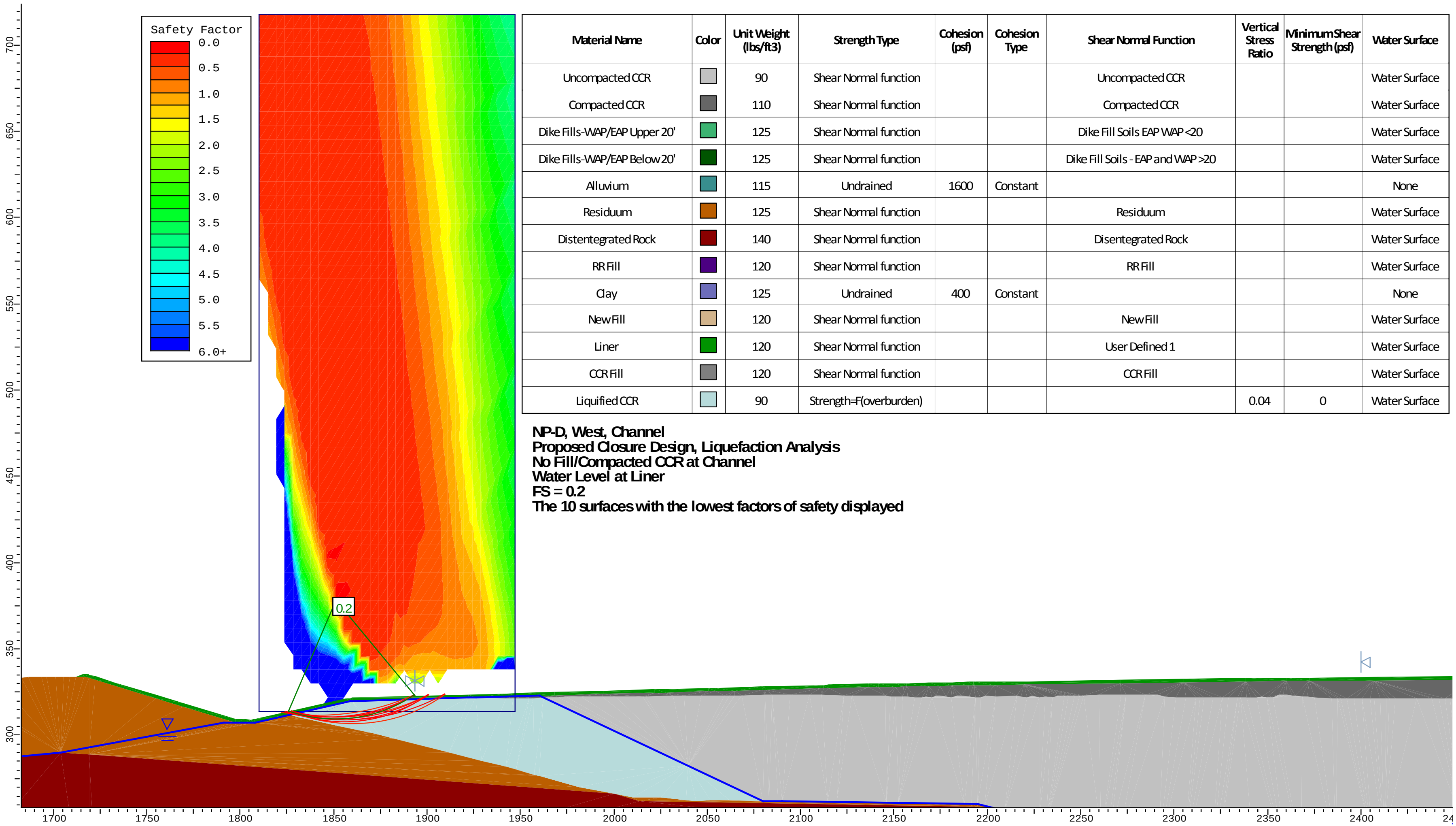
Figure **5A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR			Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20			Water Surface
Alluvium		115	Undrained	1600	Constant				None
Residuum		125	Shear Normal function			Residuum			Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock			Water Surface
Dike Fills - NAP Upper 40'		125	Shear Normal function			Dike Fill Soils -NAP <40			Water Surface
Dike Fills - NAP Below 40'		125	Shear Normal function			Dike Fill Soils - NAP >40			Water Surface
RR Fill		120	Shear Normal function			RR Fill			Water Surface
New Fill		120	Shear Normal function			New Fill			Water Surface
Liner		120	Shear Normal function			User Defined 1			Water Surface
CCR Fill		120	Shear Normal function			CCR Fill			Water Surface
Liquefied CCR		90	Strength=F(overburden)				0.04	0	Water Surface

NP-B, South, Channel
Proposed Closure Design, Liquefaction Analysis
Compacted CCR at Channel
Water Level at Liner
FS = 1.2
The 10 surfaces with the lowest factors of safety displayed

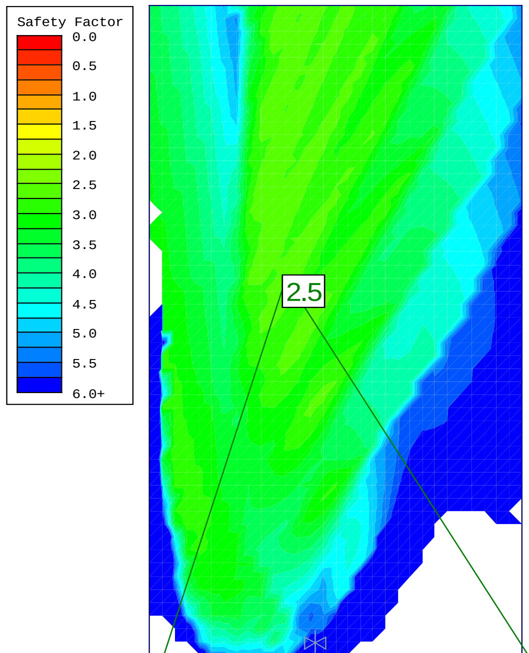
Golder Associates	SCALE: As Shown	**NAP Section B - South, Channel**	
	DATE: Oct-30-2015	**Bremo Bluff Power Station** **Proposed Closure Design - Compacted CCR at Channel** **Liquifaction Analysis, Water Level at Liner**	
	MADE BY: MGP		
	CHECK: JGM		
	REVIEW: GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **5B**
PROJECT No. 1520347 / REV. 0			



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR			Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR			Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20			Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20			Water Surface
Alluvium		115	Undrained	1600	Constant				None
Residuum		125	Shear Normal function			Residuum			Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock			Water Surface
RR Fill		120	Shear Normal function			RR Fill			Water Surface
Clay		125	Undrained	400	Constant				None
New Fill		120	Shear Normal function			New Fill			Water Surface
Liner		120	Shear Normal function			User Defined 1			Water Surface
CCR Fill		120	Shear Normal function			CCR Fill			Water Surface
Liquified CCR		90	Strength=F(overburden)				0.04	0	Water Surface

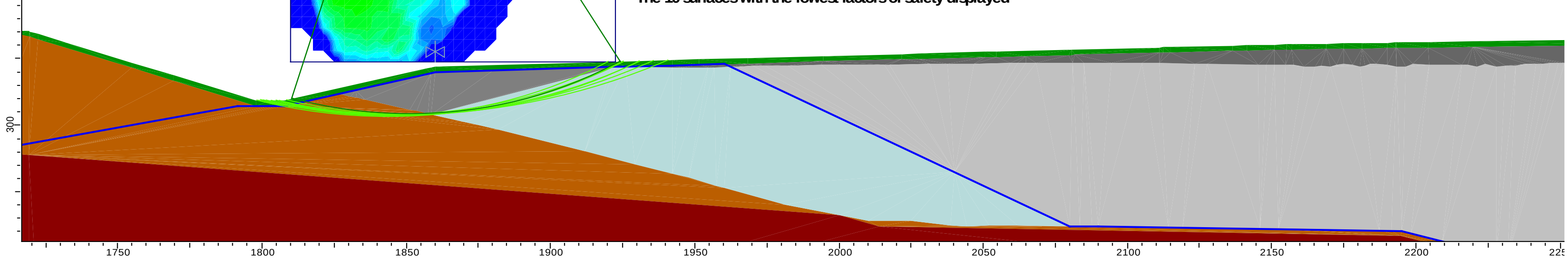
NP-D, West, Channel
Proposed Closure Design, Liquefaction Analysis
No Fill/Compacted CCR at Channel
Water Level at Liner
FS = 0.2
The 10 surfaces with the lowest factors of safety displayed

Golder Associates	SCALE	As Shown	**NAP Section D - West, Channel**
	DATE	Oct-30-2015	**Bremo Bluff Power Station** **Proposed Closure Design - No Fill/Compacted CCR at Channel** **Liquifaction Analysis, Water Level at Liner**
	MADE BY	MGP	
	CHECK	JGM	
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**
PROJECT No. 1520347	REV. 0		Figure **6A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR			Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR			Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20			Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20			Water Surface
Alluvium		115	Undrained	1600	Constant				None
Residuum		125	Shear Normal function			Residuum			Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock			Water Surface
RR Fill		120	Shear Normal function			RR Fill			Water Surface
Clay		125	Undrained	400	Constant				None
New Fill		120	Shear Normal function			New Fill			Water Surface
Liner		120	Shear Normal function			User Defined 1			Water Surface
CCR Fill		120	Shear Normal function			CCR Fill			Water Surface
Liquified CCR		90	Strength=F(overburden)				0.04	0	Water Surface

NP-D, East, Channel
Proposed Closure Design, Liquefaction Analysis
Compacted CCR at Channel
Water Level at Liner
FS = 2.5
The 10 surfaces with the lowest factors of safety displayed



Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

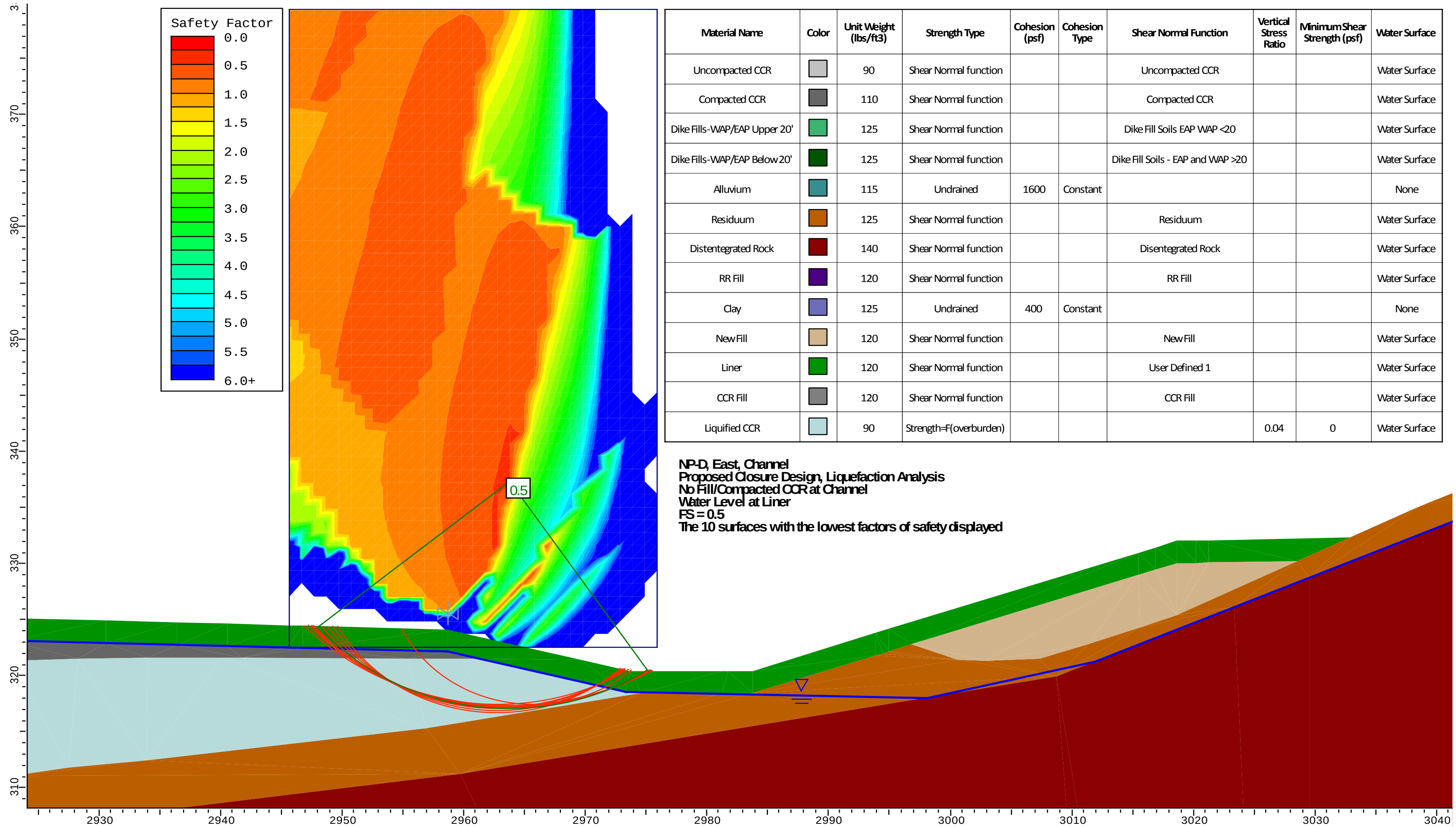
PROJECT No. 1520347 REV. 0

NAP Section D - West, Channel

Bremo Bluff Power Station
Proposed Closure Design - Compacted CCR at Channel
Liquifaction Analysis, Water Level at Liner

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **6B**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR			Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR			Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20			Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20			Water Surface
Alluvium		115	Undrained	1600	Constant				None
Residuum		125	Shear Normal function			Residuum			Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock			Water Surface
RR Fill		120	Shear Normal function			RR Fill			Water Surface
Clay		125	Undrained	400	Constant				None
New Fill		120	Shear Normal function			New Fill			Water Surface
Liner		120	Shear Normal function			User Defined 1			Water Surface
CCR Fill		120	Shear Normal function			CCR Fill			Water Surface
Liquified CCR		90	Strength=F(overburden)				0.04	0	Water Surface

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

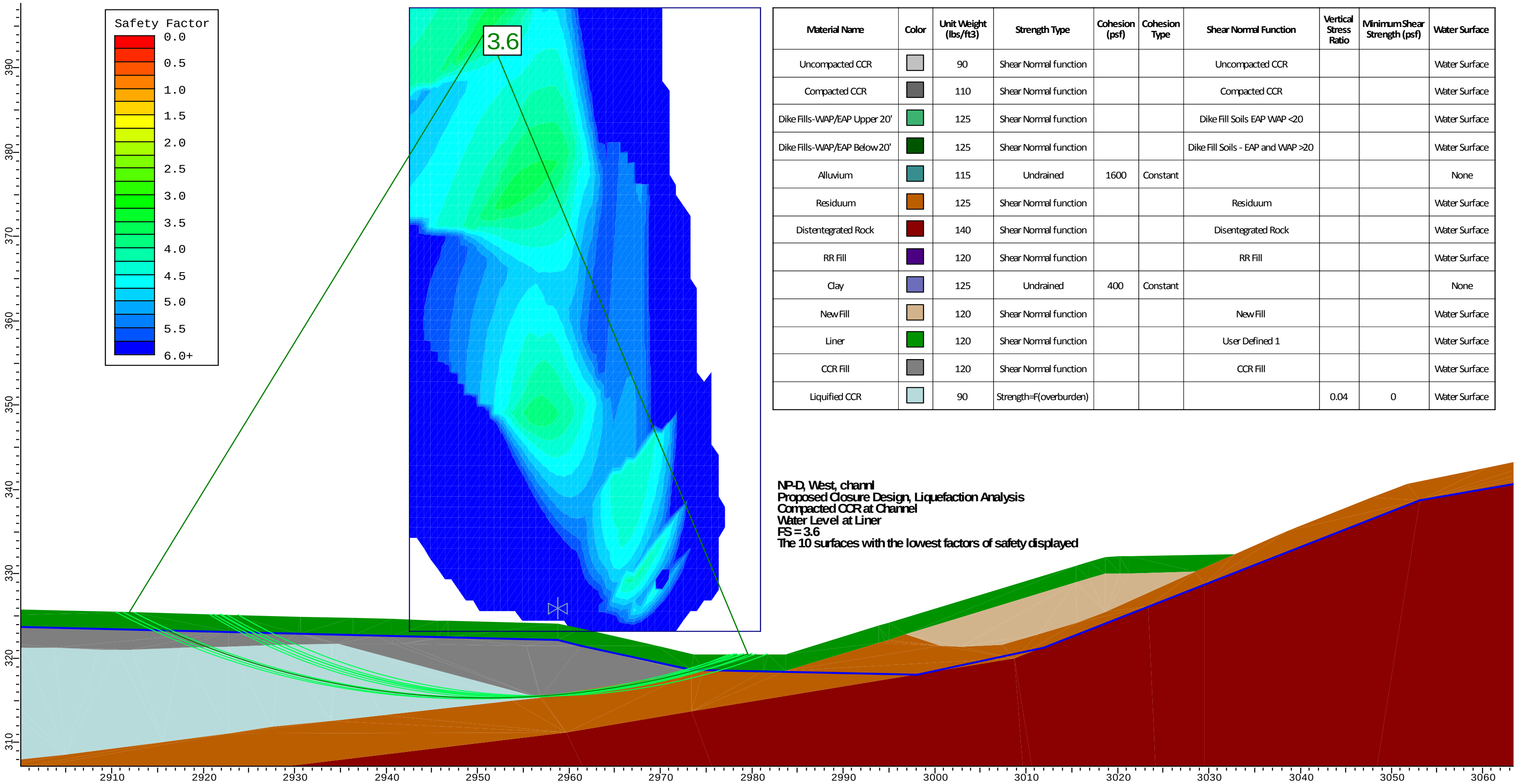
PROJECT No. 1520347 REV. 0

NAP Section D - East, Channel

Bremo Bluff Power Station
Proposed Closure Design - No Fill/Compacted CCR at Channel
Liquifaction Analysis, Water Level at Liner

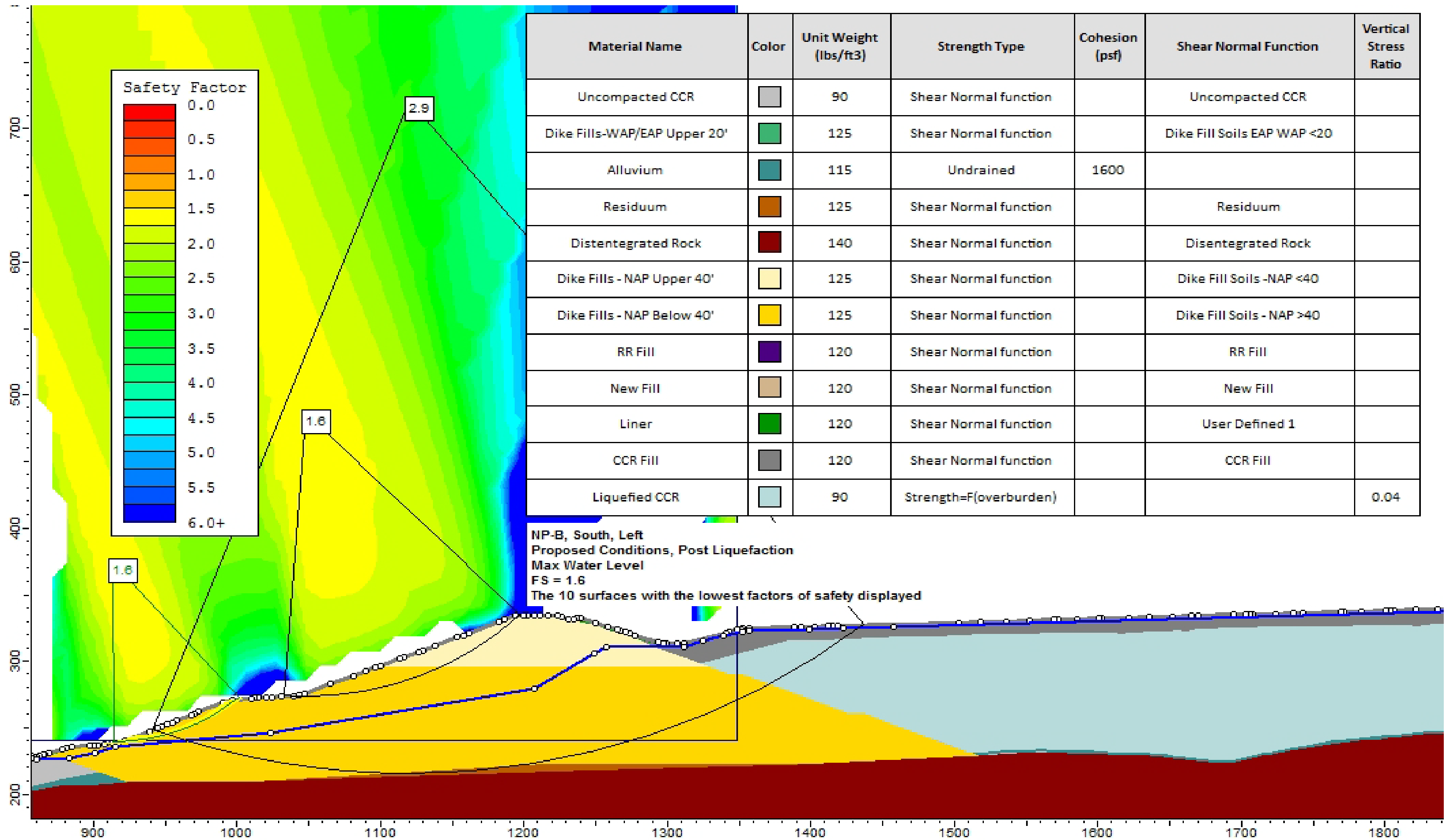
Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **7A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface
Uncompacted CCR		90	Shear Normal function			Uncompacted CCR			Water Surface
Compacted CCR		110	Shear Normal function			Compacted CCR			Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20			Water Surface
Dike Fills-WAP/EAP Below 20'		125	Shear Normal function			Dike Fill Soils - EAP and WAP >20			Water Surface
Alluvium		115	Undrained	1600	Constant				None
Residuum		125	Shear Normal function			Residuum			Water Surface
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock			Water Surface
RR Fill		120	Shear Normal function			RR Fill			Water Surface
Clay		125	Undrained	400	Constant				None
New Fill		120	Shear Normal function			New Fill			Water Surface
Liner		120	Shear Normal function			User Defined 1			Water Surface
CCR Fill		120	Shear Normal function			CCR Fill			Water Surface
Liquified CCR		90	Strength=F(overburden)				0.04	0	Water Surface

Golder Associates	SCALE As Shown	NAP Section D - East, Channel	
	DATE Oct-30-2015	Bremo Bluff Power Station Proposed Closure Design - Compacted CCR at Channel Liquifaction Analysis, Water Level at Liner	
	MADE BY MGP		
	CHECK JGM		
	REVIEW GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 7B
PROJECT No. 1520347 REV. 0			



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Shear Normal Function	Vertical Stress Ratio
Uncompacted CCR		90	Shear Normal function		Uncompacted CCR	
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function		Dike Fill Soils EAP WAP <20	
Alluvium		115	Undrained	1600		
Residuum		125	Shear Normal function		Residuum	
Distentegrated Rock		140	Shear Normal function		Disentegrated Rock	
Dike Fills - NAP Upper 40'		125	Shear Normal function		Dike Fill Soils -NAP <40	
Dike Fills - NAP Below 40'		125	Shear Normal function		Dike Fill Soils - NAP >40	
RR Fill		120	Shear Normal function		RR Fill	
New Fill		120	Shear Normal function		New Fill	
Liner		120	Shear Normal function		User Defined 1	
CCR Fill		120	Shear Normal function		CCR Fill	
Liquefied CCR		90	Strength=F(overburden)			0.04

Golder Associates

SCALE	As Shown
DATE	Oct-30-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

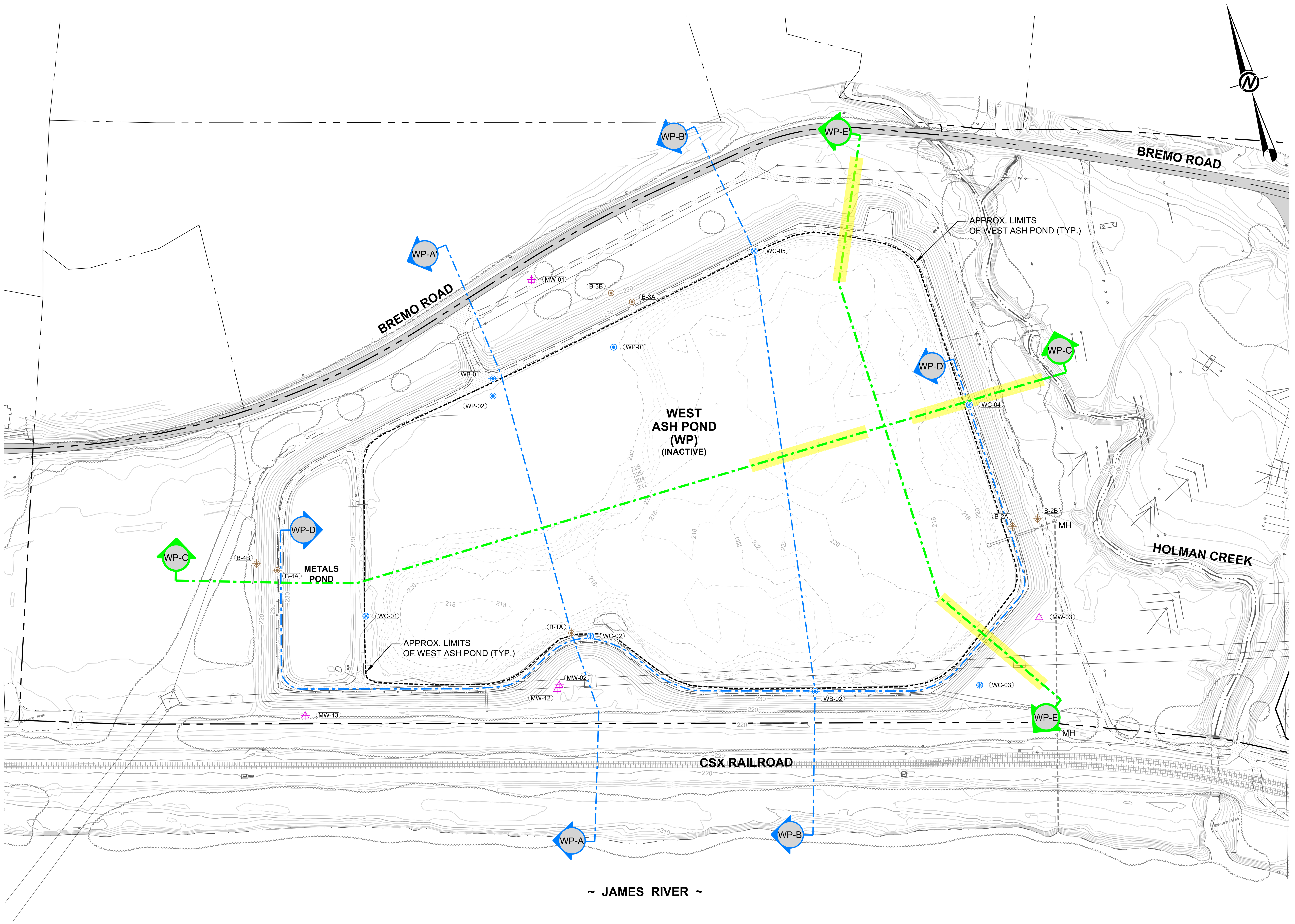
NAP Section B - South, Liquefaction Scenario

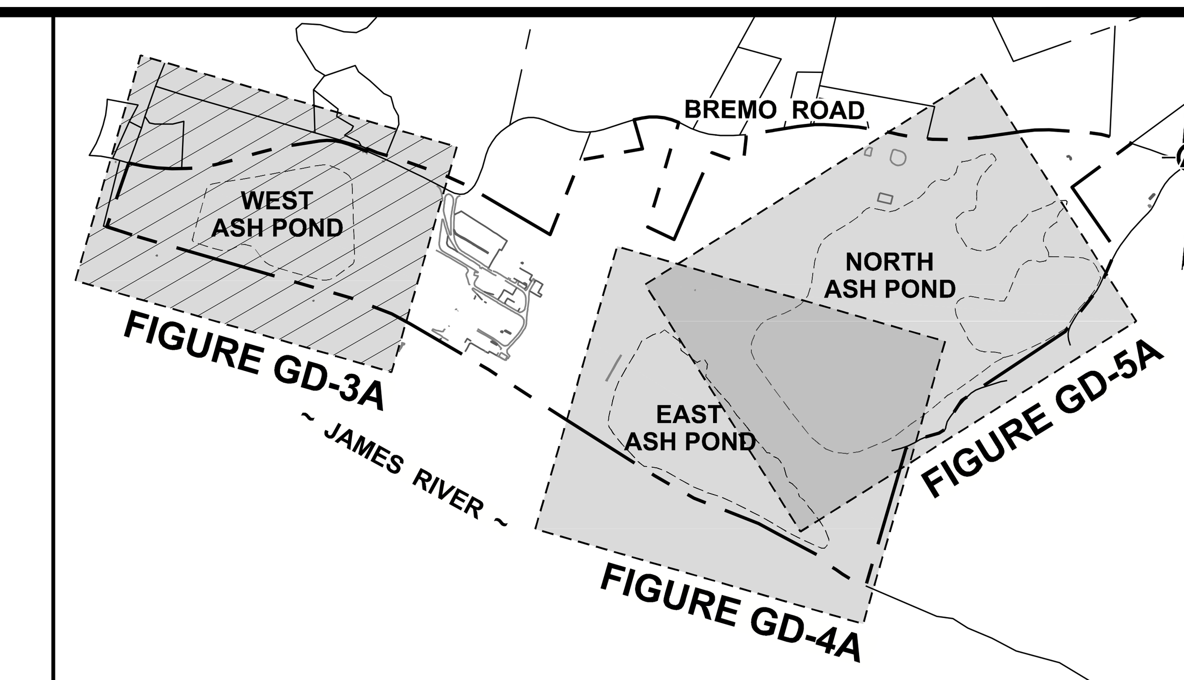
Bremo Bluff Power Station
Proposed Closure Design - Post Liquefaction Check
Liquifaction Analysis, Water Level at Liner

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **8B**

PROJECT No. 1520347 REV. 0





SITE KEY

NOT TO SCALE

LEGEND

- DOMINION PROPERTY BOUNDARY
- ADJACENT PROPERTY BOUNDARY
- APPROXIMATE LIMITS OF EXISTING ASH PONDS
- EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS)
- EXISTING BATHYMETRIC SURFACE CONTOURS (2' INTERVALS)
- DESIGN SURFACE CONTOURS (2' INTERVALS)
- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING RAILROAD
- CREEK CENTERLINE
- EXISTING TREE LINE
- EXISTING FENCE
- GAS — EXISTING GAS LINE
- DENOTES AREAS OF TOPOGRAPHY THAT DO NOT MEET MINIMUM ACCURACY STANDARDS FOR AERIAL SURVEYING
- SCHNABEL BORING (1982)
- SCHNABEL BORING (2010)
- GES MONITORING WELL (2013)
- HALEY AND ALDRICH BORING (2015)
- GOLDER BORING (2014 / 2015)
- GOLDER PIEZOMETER (2015)
- GOLDER CONE PENETRATION TEST (CPT)(2015)
- GOLDER PROBE HOLE (2015)
- GOLDER HAND AUGER (2015)
- EP-A — GEOTECHNICAL SECTIONS (SEE GOLDER 2015 GEOTECH DATA REPORT)
- EP-B — SLOPE STABILITY SECTIONS
- SLOPE STABILITY FIGURE LOCATIONS - SEE APPENDIX D

REFERENCES

1. AERIAL TOPOGRAPHIC SURVEY PREPARED BY McKENZIE SNYDER, INC., DATE OF AERIAL PHOTO: 01/16/15 [CONTROL PREPARED BY H&B SURVEYING & MAPPING (H&B)].

2. BATHYMETRIC SURVEYS PREPARED BY H&B, SURVEYS PERFORMED IN FEBRUARY 2015.

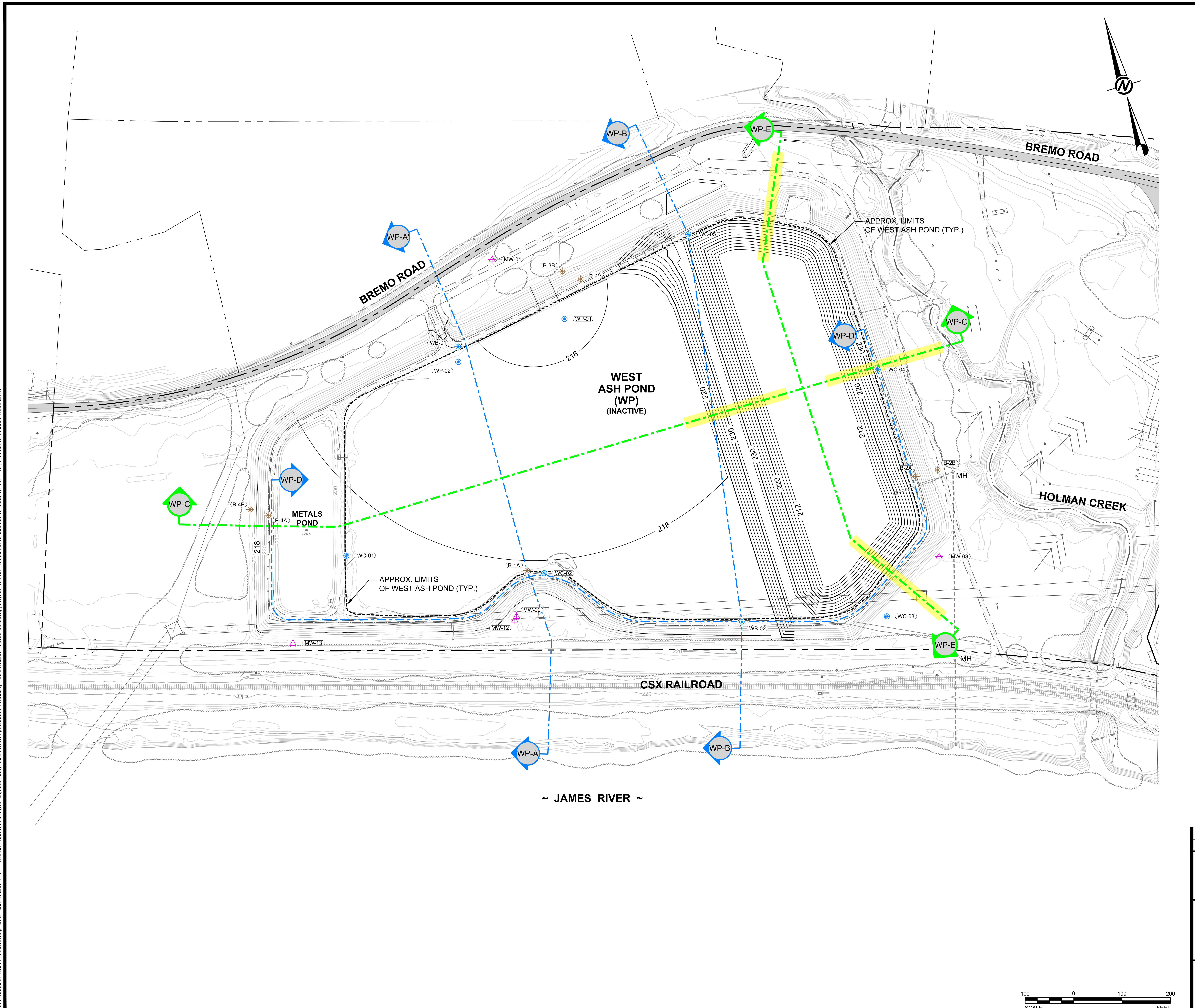
REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW

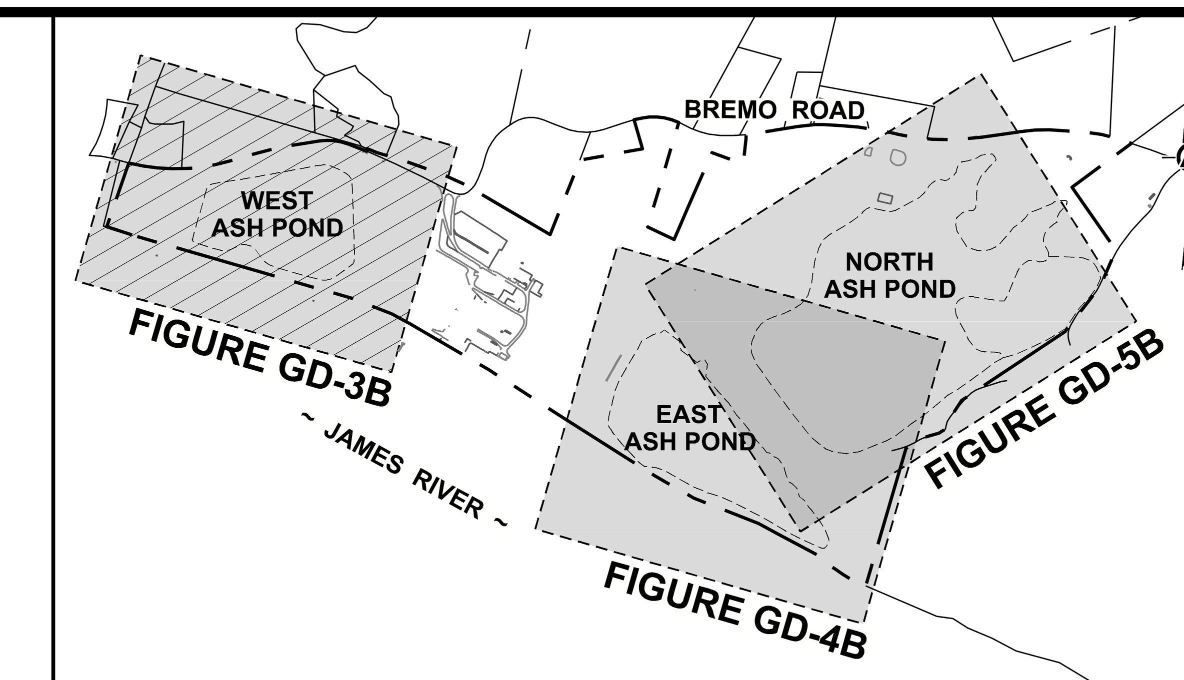
PROJECT
DOMINION
BREMO POWER STATION
CCR IMPOUNDMENT CLOSURE
FLUVANNA COUNTY, VIRGINIA

TITLE
EXISTING CONDITIONS GEOTECHNICAL EXPLORATION PLAN (WEST POND)

Golder Associates

PROJECT No.		15-20347	FILE No.	1520347AD03A-05A
DESIGN	-	-	SCALE	AS SHOWN
CADD	SEP	10/15/15	FIGURE GD-3A	
CHECK	JGM	10/15/15		
REVIEW	GLH	10/15/15		





SITE KEY

NOT TO SCALE

LEGEND

- DOMINION PROPERTY BOUNDARY
- ADJACENT PROPERTY BOUNDARY
- APPROXIMATE LIMITS OF EXISTING ASH PONDS
- EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS)
- EXISTING BATHYMETRIC SURFACE CONTOURS (2' INTERVALS)
- DESIGN SURFACE CONTOURS (2' INTERVALS)
- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING RAILROAD
- CREEK CENTERLINE
- EXISTING TREE LINE
- EXISTING FENCE
- GAS — EXISTING GAS LINE
- DENOTES AREAS OF TOPOGRAPHY THAT DO NOT MEET MINIMUM ACCURACY STANDARDS FOR AERIAL SURVEYING
- SCHNABEL BORING (1982)
- SCHNABEL BORING (2010)
- GES MONITORING WELL (2013)
- HALEY AND ALDRICH BORING (2015)
- GOLDER BORING (2014 / 2015)
- GOLDER PIEZOMETER (2015)
- GOLDER CONE PENETRATION TEST (CPT)(2015)
- GOLDER PROBE HOLE (2015)
- GOLDER HAND AUGER (2015)
- EP-A — GEOTECHNICAL SECTIONS (SEE GOLDER 2015 GEOTECH DATA REPORT)
- EP-B — SLOPE STABILITY SECTIONS
- SLOPE STABILITY FIGURE LOCATIONS - SEE APPENDIX D

REFERENCES

1. AERIAL TOPOGRAPHIC SURVEY PREPARED BY McKENZIE SNYDER, INC., DATE OF AERIAL PHOTO: 01/16/15 [CONTROL PREPARED BY H&B SURVEYING & MAPPING (H&B)].
2. BATHYMETRIC SURVEYS PREPARED BY H&B, SURVEYS PERFORMED IN FEBRUARY 2015.

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW

PROJECT
DOMINION
BREMO POWER STATION
CCR IMPOUNDMENT CLOSURE
FLUVANNA COUNTY, VIRGINIA

TITLE
DESIGN GRADES GEOTECHNICAL STABILITY PLAN (WEST POND)

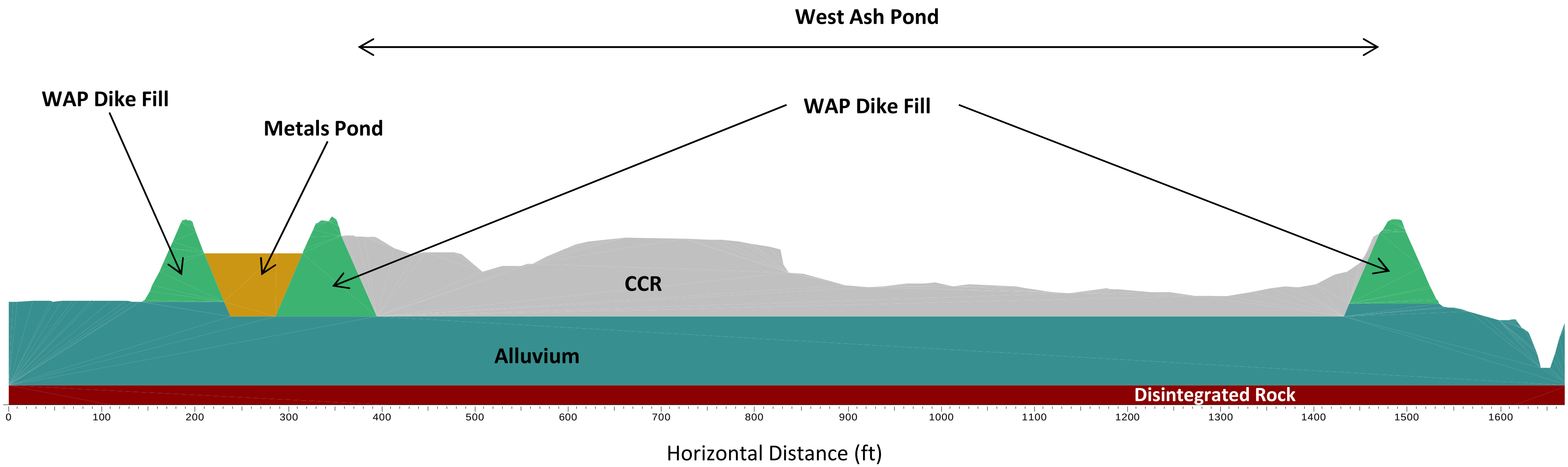
Golder Associates

PROJECT No.		15-20347	FILE No.	1520347AD02-05B
DESIGN	-	-	SCALE	AS SHOWN
CADD	SEP	10/15/15	FIGURE GD-3B	
CHECK	JGM	10/15/15		
REVIEW	GLH	10/15/15		

G:\Plan Production Data Files\Drawing Data Files\15-20347\A - Bremo Pond Closure (Conceptual Plan)\Active Drawings\Geotech Stability - 90%\1520347AD02-05B.dwg | Layout: GD-3B | Modified: SPechota 10/08/2015 3:04 PM | Plotted: SPechota 10/08/2015

WP-C Schematic (Existing)

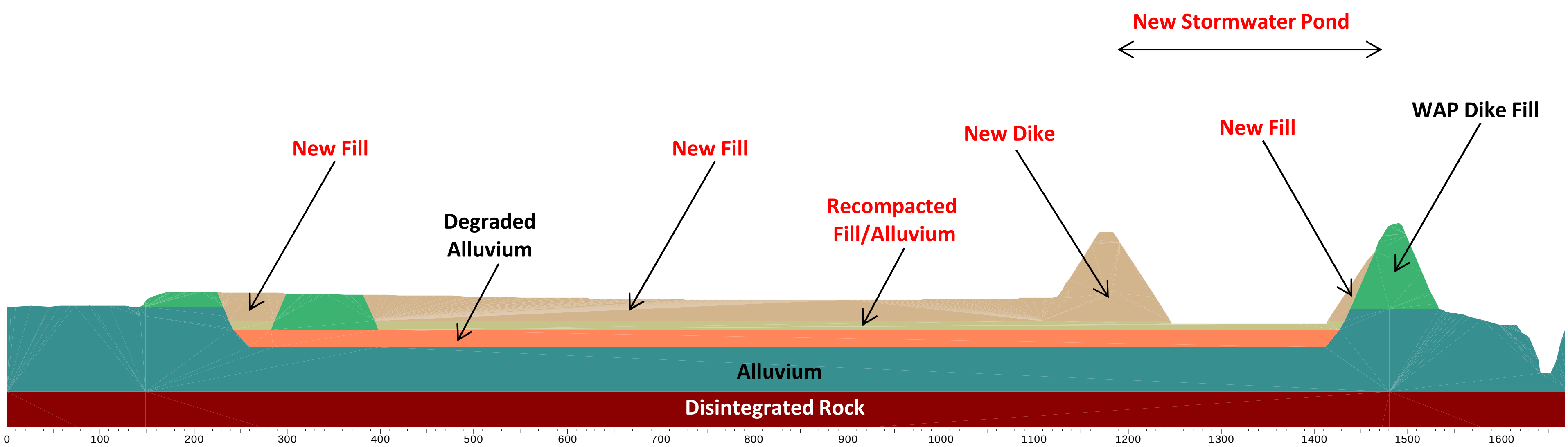
5 x Vertical Exaggeration



Golder Associates	SCALE As Shown	**WAP Section C**	
	DATE Oct-21-2015	**Bremo Bluff Power Station** **Schematic** **Existing Case**	
	MADE BY JGM		
	CHECK GLH		
	REVIEW GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **1A**
PROJECT No. 1520347 REV. 0			

WP-C Schematic (Proposed Design)

5 x Vertical Exaggeration

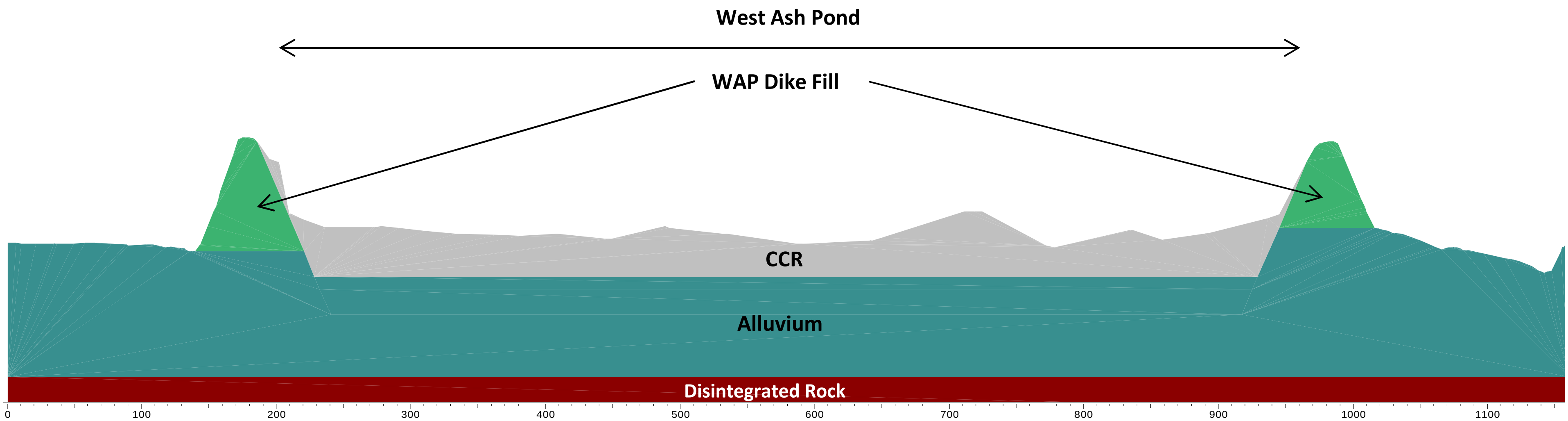


Horizontal Distance (ft)

Golder Associates	SCALE As Shown	WAP Section C	
	DATE Oct-21-2015	Bremo Bluff Power Station Schematic Design Case	
	MADE BY JGM		
	CHECK GLH		
	REVIEW GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 1B
PROJECT No. 1520347 REV. 0			

WP-E Schematic (Existing)

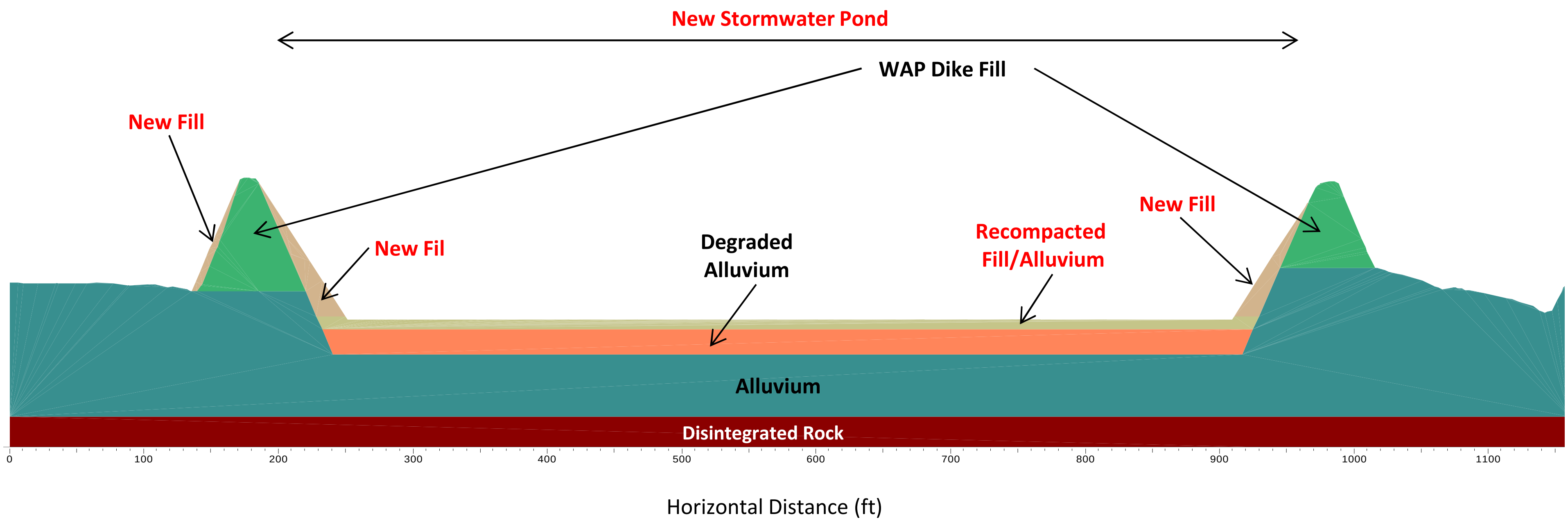
5 x Vertical Exaggeration



Golder Associates	SCALE	As Shown	WAP Section E	
	DATE	Oct-21-2015	Bremo Bluff Power Station Schematic Existing Case	
	MADE BY	JGM		
	CHECK	GLH		
	REVIEW	GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 1A
PROJECT No. 1520347	REV. 0			

WP-E Schematic (Proposed Design)

5 x Vertical Exaggeration

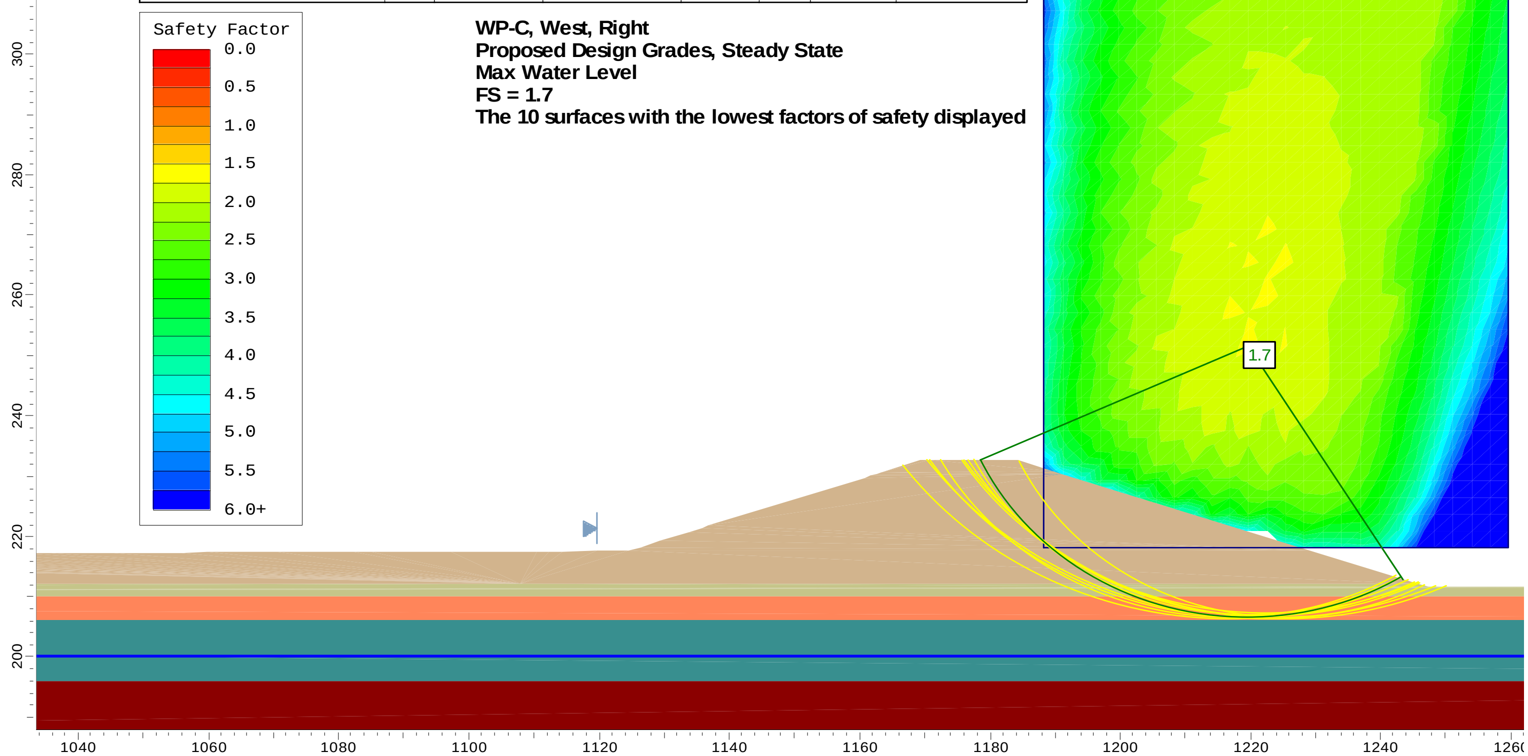


Golder Associates	SCALE As Shown	**EAP and NAP Section B**	
	DATE Oct-21-2015	**Bremo Bluff Power Station** **Schematic** **Design Case**	
	MADE BY JGM		
	CHECK GLH		
	REVIEW GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **1B**
PROJECT No. 1520347 / REV. 0			

Not Applicable
No Existing Slope to Analyze

Golder Associates	SCALE As Shown	**WAP Section C - West, Right**	
	DATE Oct-21-2015	**Bremo Bluff Power Station** **Slope Stability Analysis** **Existing Conditions, Steady State**	
	MADE BY MGP		
	CHECK JGM		
	REVIEW GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **3A**
PROJECT No. 1520347 REV. 0			

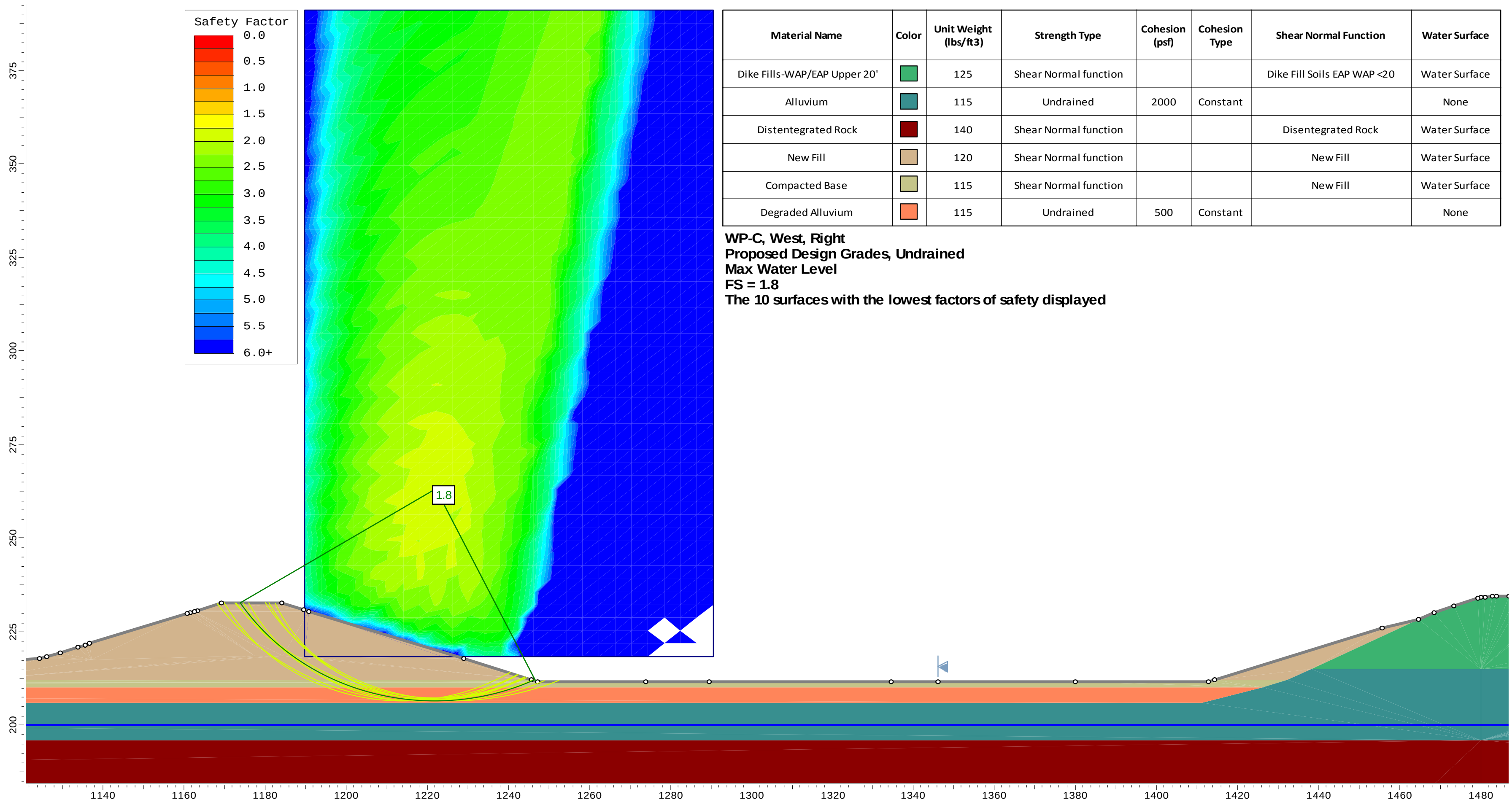
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Compacted fill		115	Mohr-Coulomb	50	28		Water Surface
Degraded Alluvium		115	Undrained	500		Constant	None



Golder Associates	SCALE As Shown	WAP Section C - West, Right	
	DATE Oct-21-2015	Slope Stability Analysis Proposed Closure Design Steady State, Max Water Level	
	MADE BY MGP		
	CHECK JGM		
	REVIEW GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 3B
PROJECT No. 1520347 REV. 0			

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 3B

Golder Associates	SCALE	As Shown	**WAP Section C - West, Right**	
	DATE	Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Design Water Level**	
	MADE BY	MGP		
	CHECK	JGM		
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **3C**
PROJECT No. 1520347 / REV. 0				



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Base		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	500	Constant		None

WP-C, West, Right
Proposed Design Grades, Undrained
Max Water Level
FS = 1.8
The 10 surfaces with the lowest factors of safety displayed

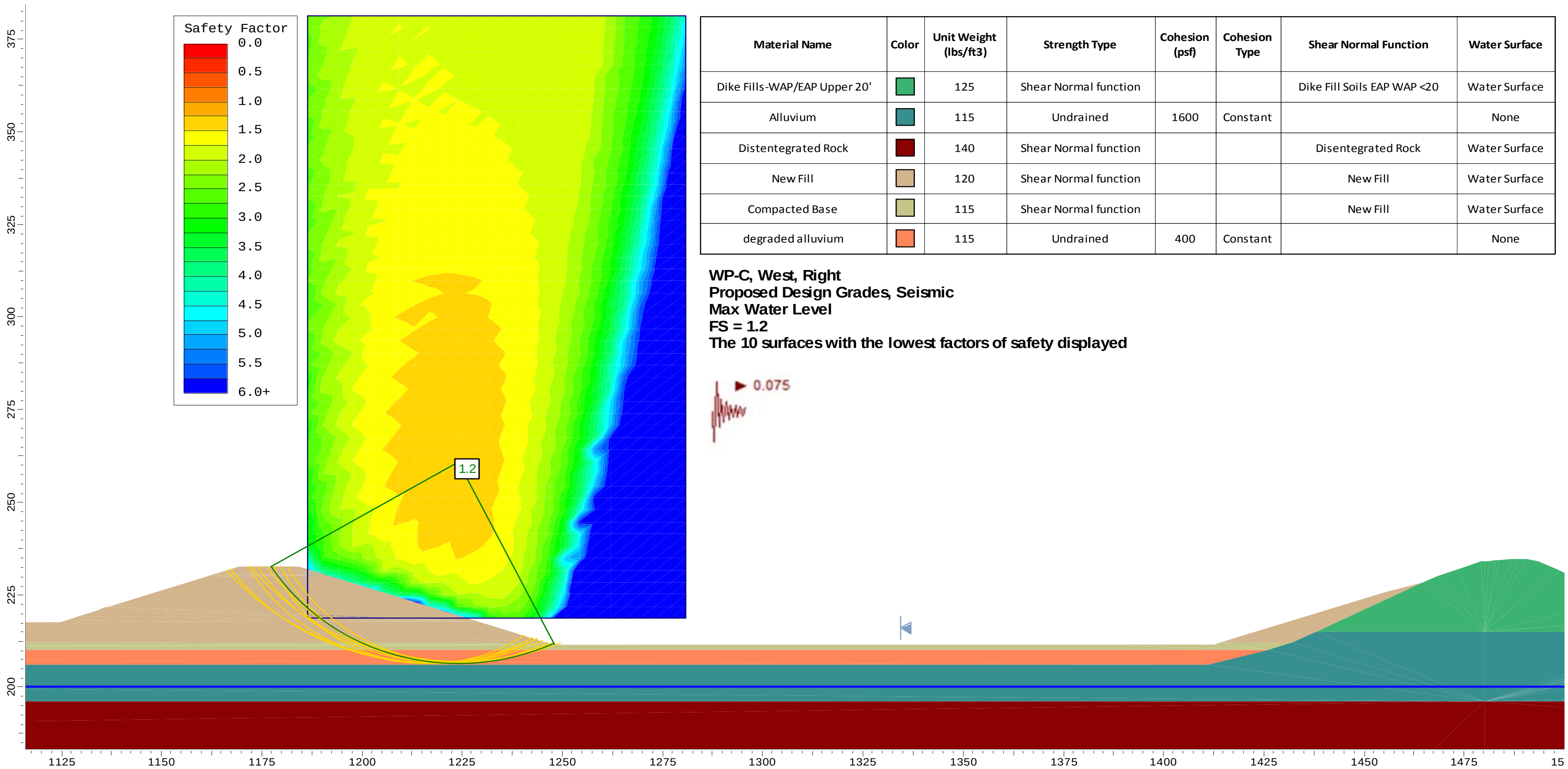
Golder Associates	SCALE	As Shown
	DATE	Oct-21-2015
	MADE BY	MGP
	CHECK	JGM
	REVIEW	GLH
PROJECT No. 1520347	REV. 0	

WAP Section C - West, Right

Slope Stability Analysis
Proposed Closure Design
Undrained, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **3D**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Base		115	Shear Normal function			New Fill	Water Surface
degraded alluvium		115	Undrained	400	Constant		None

WP-C, West, Right
Proposed Design Grades, Seismic
Max Water Level
FS = 1.2
The 10 surfaces with the lowest factors of safety displayed

SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

WAP Section C - West, Right

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

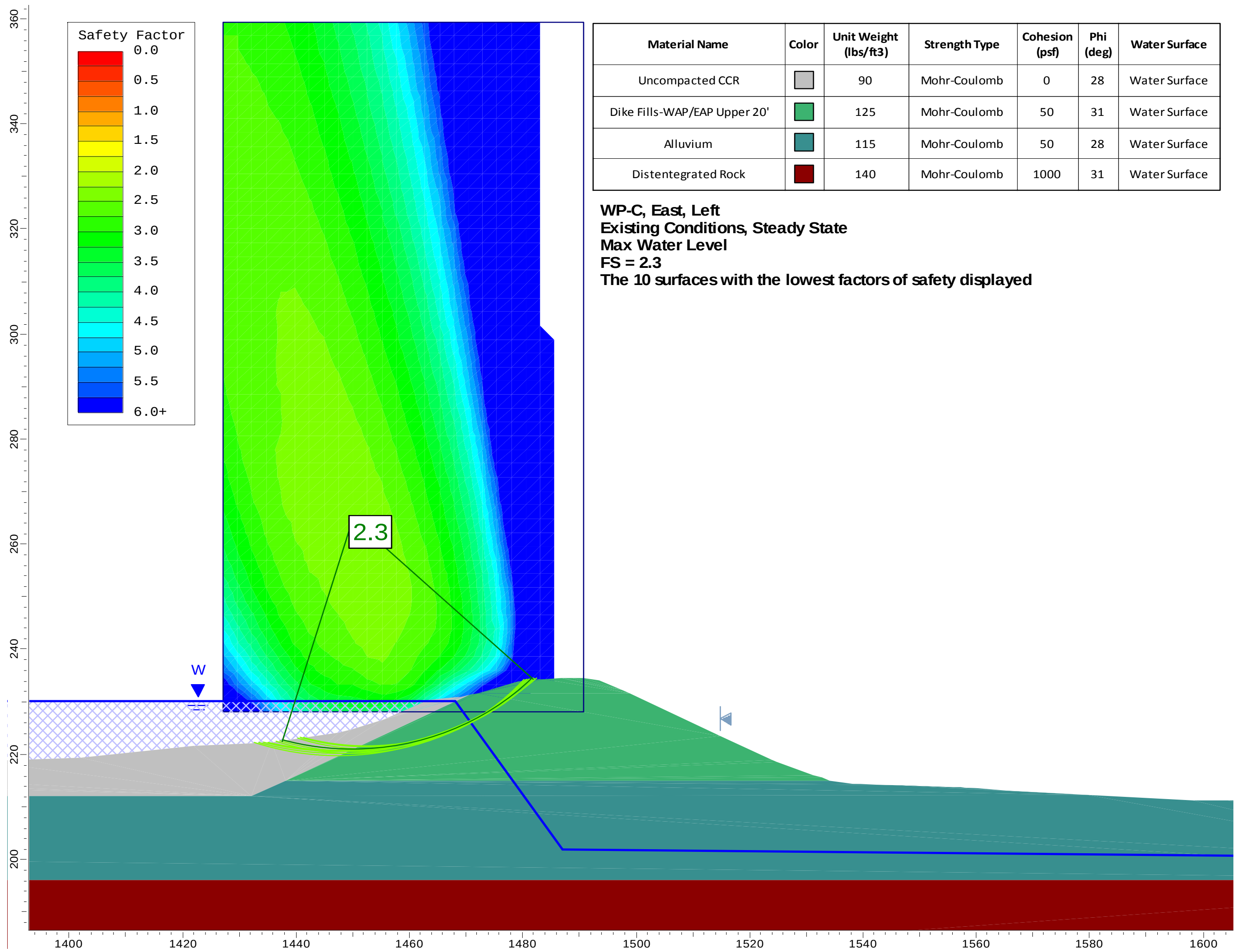
Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **3E**

PROJECT No. 1520347 REV. 0

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 3E

Golder Associates	SCALE	As Shown	**WAP Section C - West, Right**		
	DATE	Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Seismic, Design Water Level**		
	MADE BY	MGP			
	CHECK	JGM			
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure	**3F**
PROJECT No. 1520347	REV. 0				



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface

WP-C, East, Left
Existing Conditions, Steady State
Max Water Level
FS = 2.3
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

PROJECT No. 1520347 REV. 0

WAP Section C - East, Left

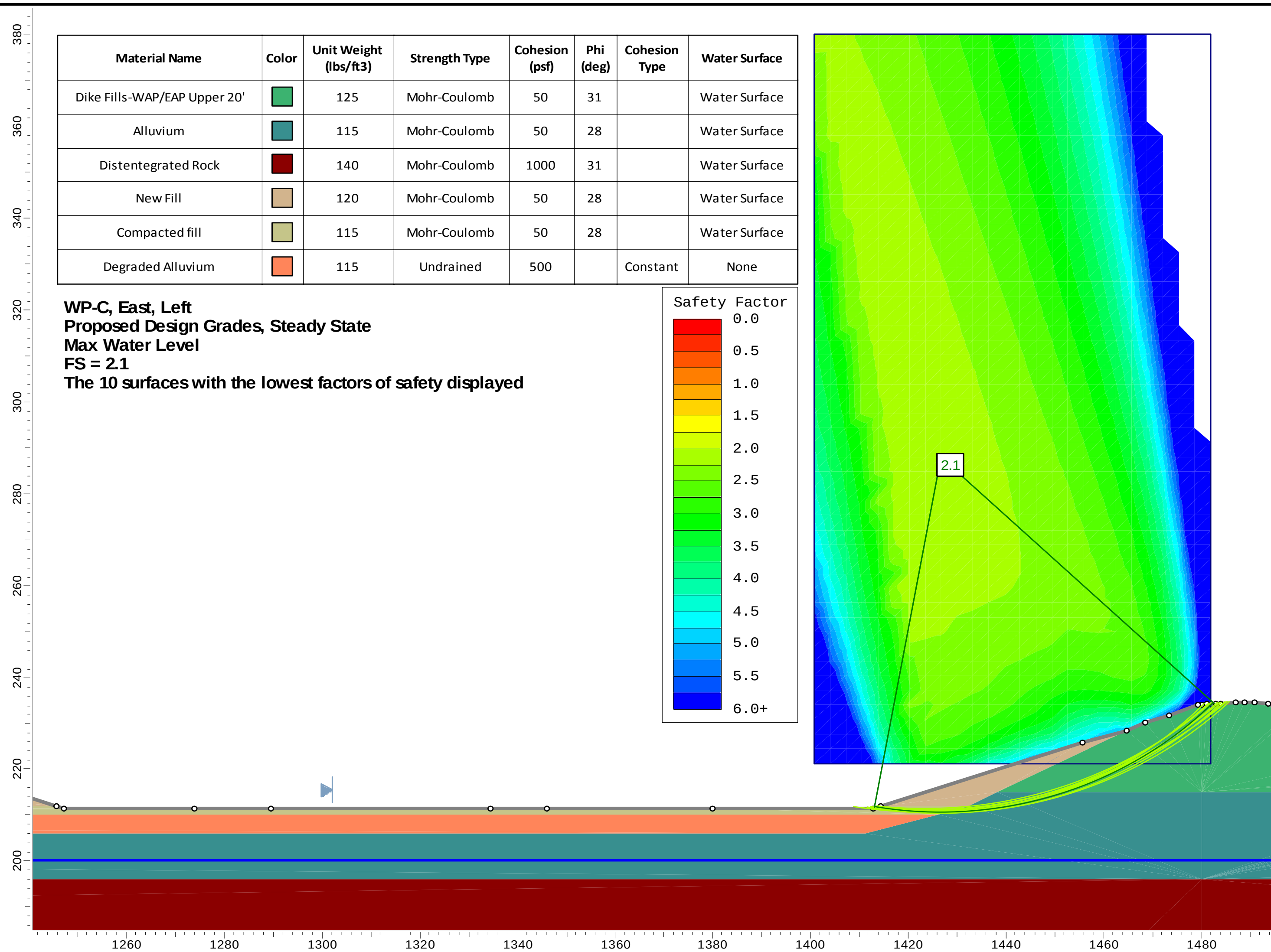
Bremo Bluff Power Station
Slope Stability Analysis
Existing Conditions, Steady State

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **4A**

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Compacted fill		115	Mohr-Coulomb	50	28		Water Surface
Degraded Alluvium		115	Undrained	500		Constant	None

WP-C, East, Left
Proposed Design Grades, Steady State
Max Water Level
FS = 2.1
The 10 surfaces with the lowest factors of safety displayed

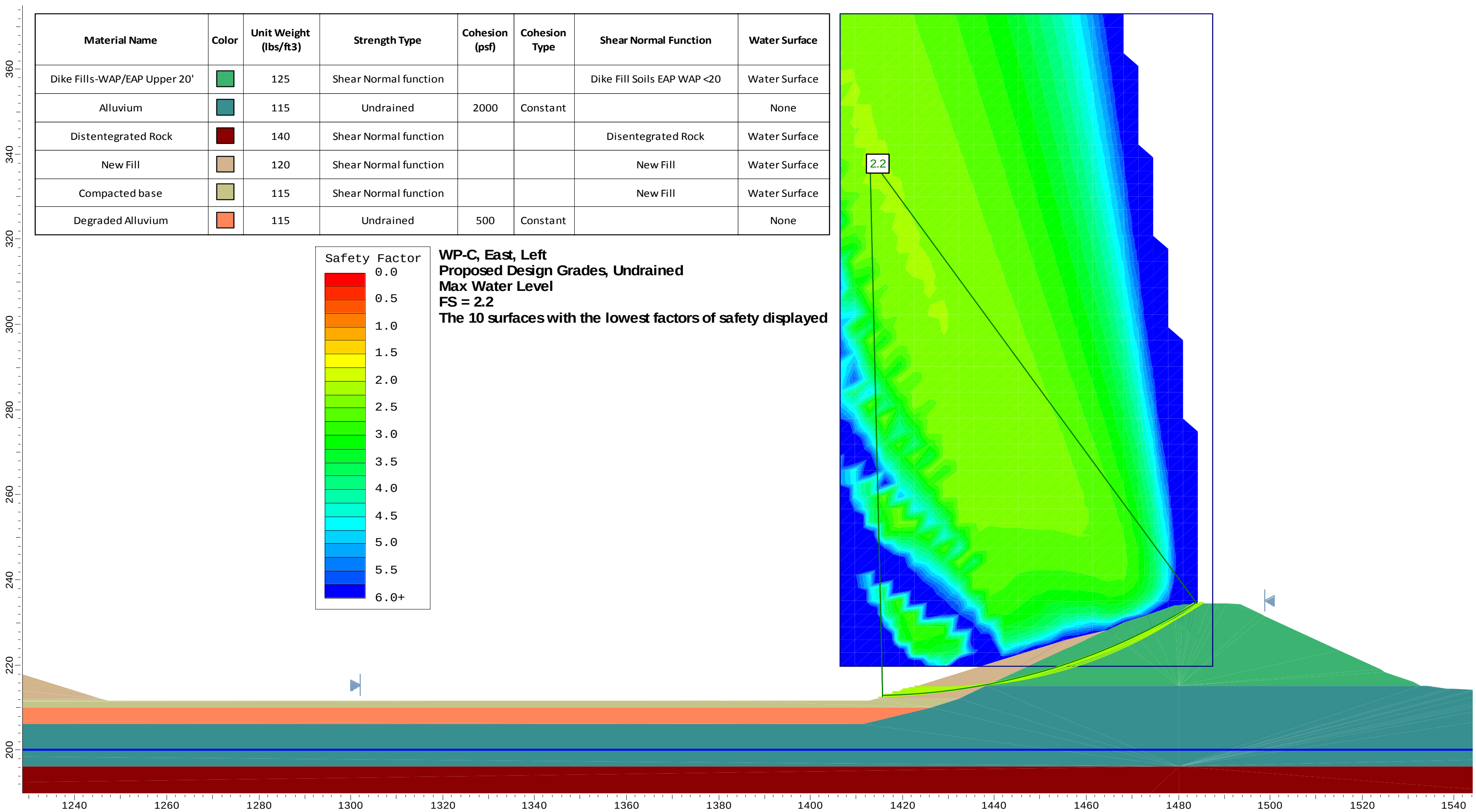


Golder Associates	SCALE: As Shown	**WAP Section C - East, Left**
	DATE: Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Max Water Level**
	MADE BY: MGP	
	CHECK: GLH	
	REVIEW:	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**
PROJECT No. 1520347 REV. 0		Figure **4B**

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 4B

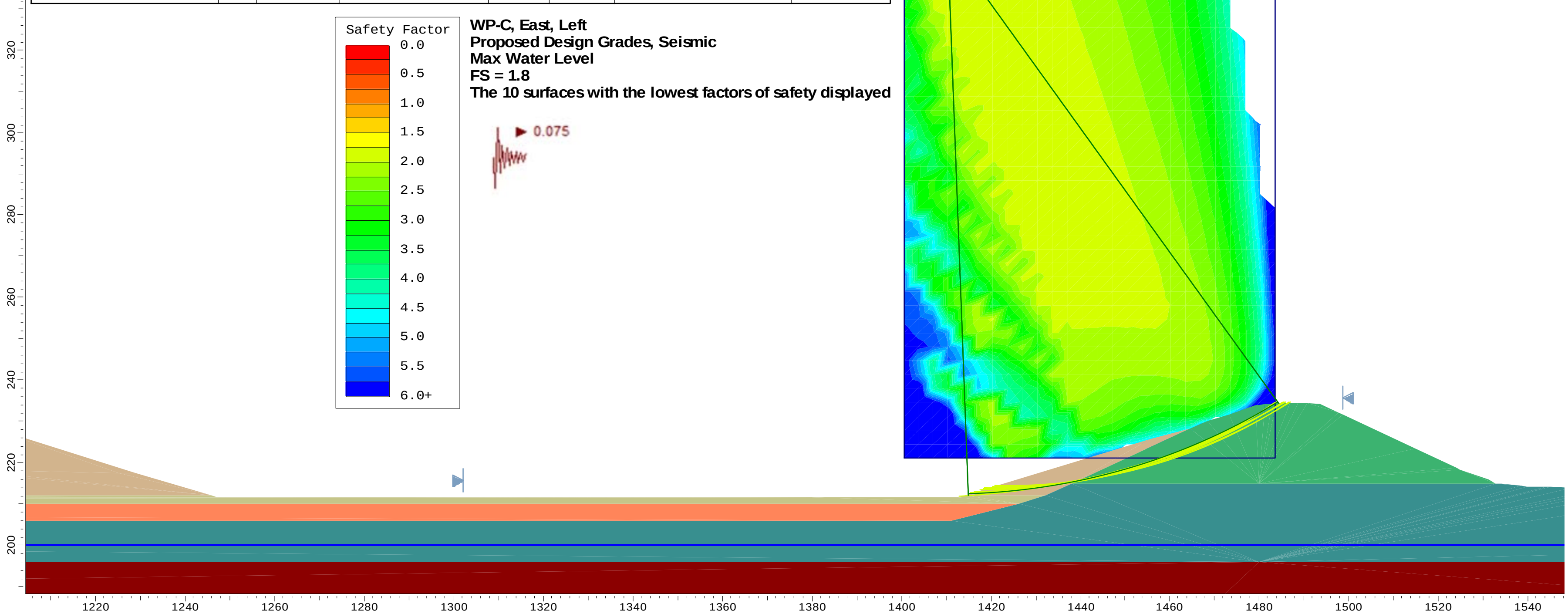
Golder Associates	SCALE	As Shown	**WAP Section C - East, Left**	
	DATE	Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Design Water Level**	
	MADE BY	MGP		
	CHECK	JGM		
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **4C**
PROJECT No. 1520347 / REV. 0				

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted base		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	500	Constant		None



Golder Associates	SCALE As Shown	WAP Section C - East, Left	
	DATE Oct-21-2015	Slope Stability Analysis Proposed Closure Design Undrained, Max Water Level	
	MADE BY MGP		
	CHECK JGM		
	REVIEW GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 4D
PROJECT No. 1520347 REV. 0			

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Base		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	400	Constant		None



Golder Associates

SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

WAP Section C - East, Left

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

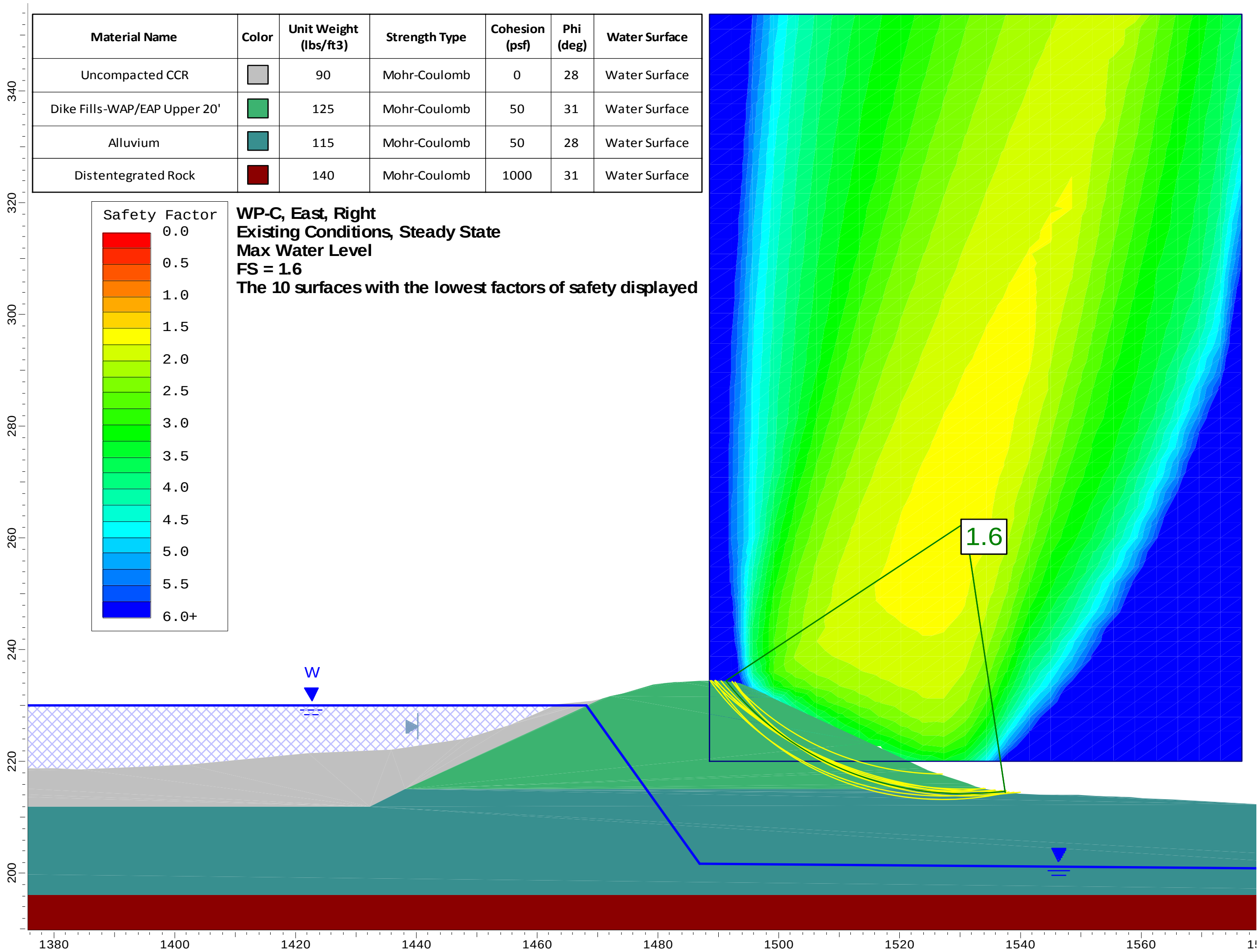
Figure **4E**

PROJECT No. 1520347 REV. 0

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 4E

Golder Associates	SCALE	As Shown	**WAP Section C - East, Left**	
	DATE	Oct-21-2015	**Slope Stability Analysis Proposed Closure Design Seismic, Design Water Level**	
	MADE BY	MGP		
	CHECK	JGM		
	REVIEW	GLH	**Dominion Bremo Bluff Power Station Ash Pond Closure Project**	Figure **4F**
PROJECT No. 1520347 REV. 0				

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface



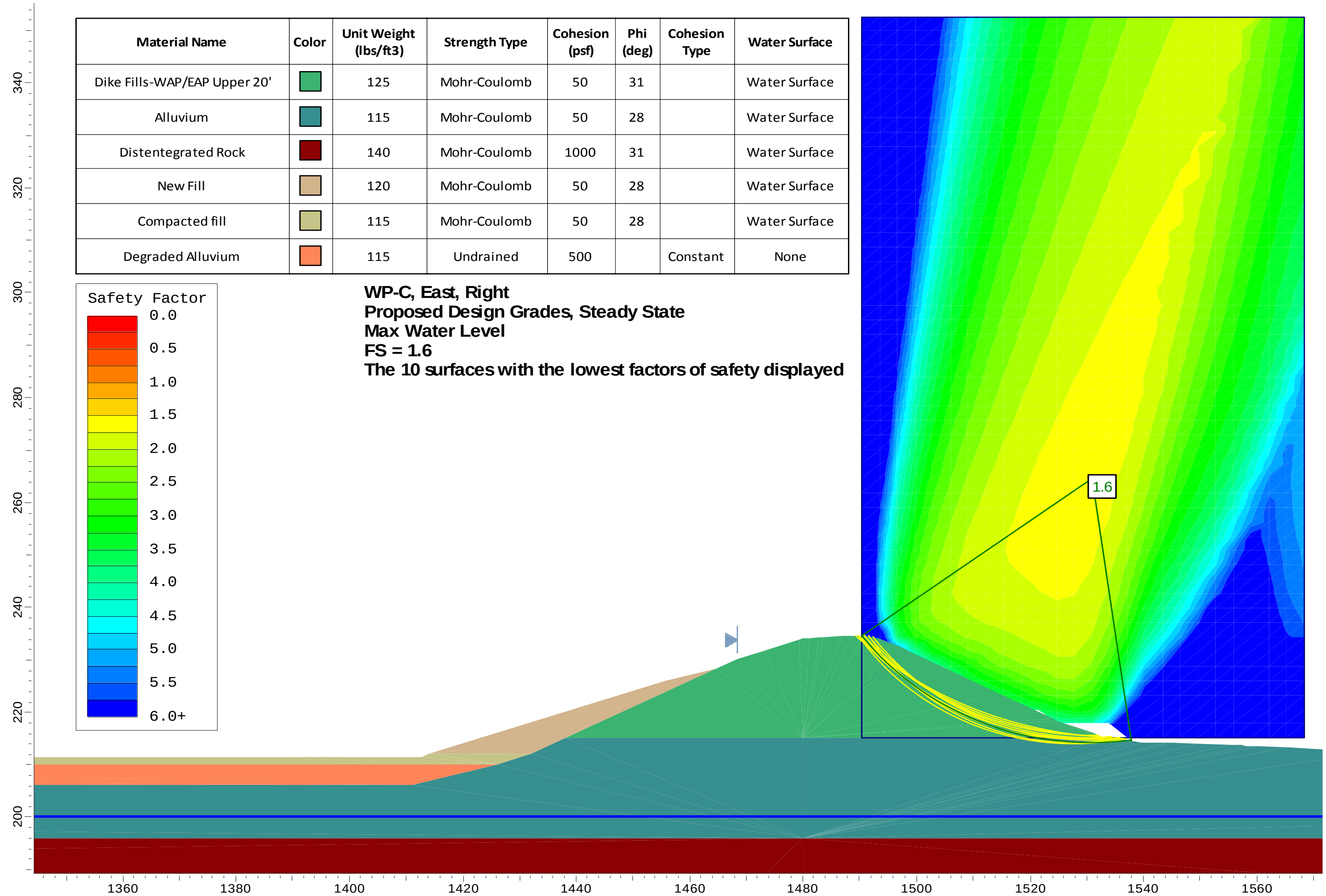
SCALE	As Shown	**WAP Section C - East, Right**
DATE	Oct-21-2015	**Bremo Bluff Power Station** **Slope Stability Analysis** **Existing Conditions, Steady State**
MADE BY	MGP	
CHECK	JGM	
REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**

Golder Associates

PROJECT No. 1520347 REV. 0

Figure **5A**

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Compacted fill		115	Mohr-Coulomb	50	28		Water Surface
Degraded Alluvium		115	Undrained	500		Constant	None



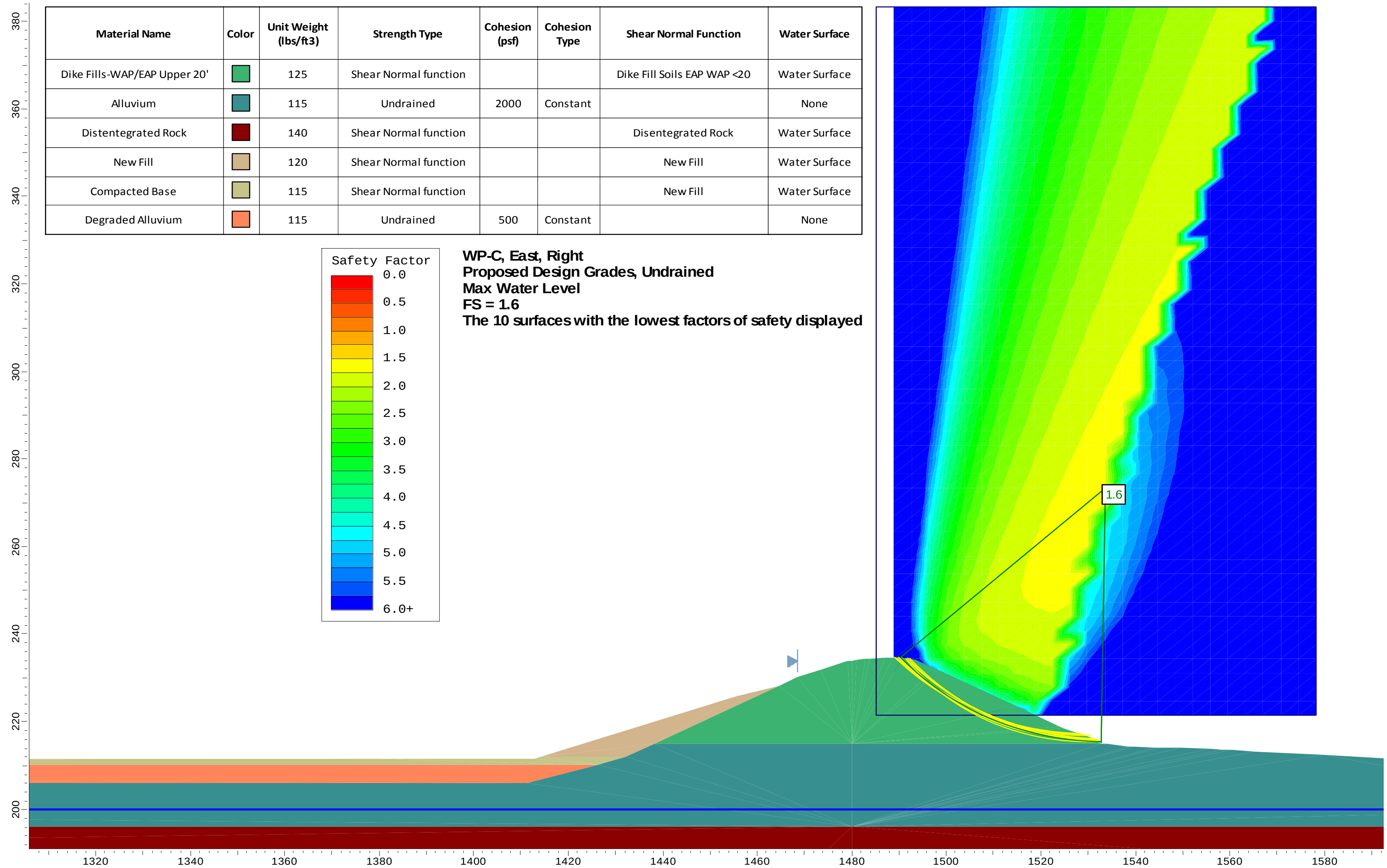
Golder Associates

SCALE	As Shown	WAP Section C - East, Right	
DATE	Oct-21-2015	Slope Stability Analysis Proposed Closure Design Steady State, Max Water Level	
MADE BY	MGP		
CHECK	JGM		
REVIEW	GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 5B
PROJECT No. 1520347	REV. 0		

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 5B

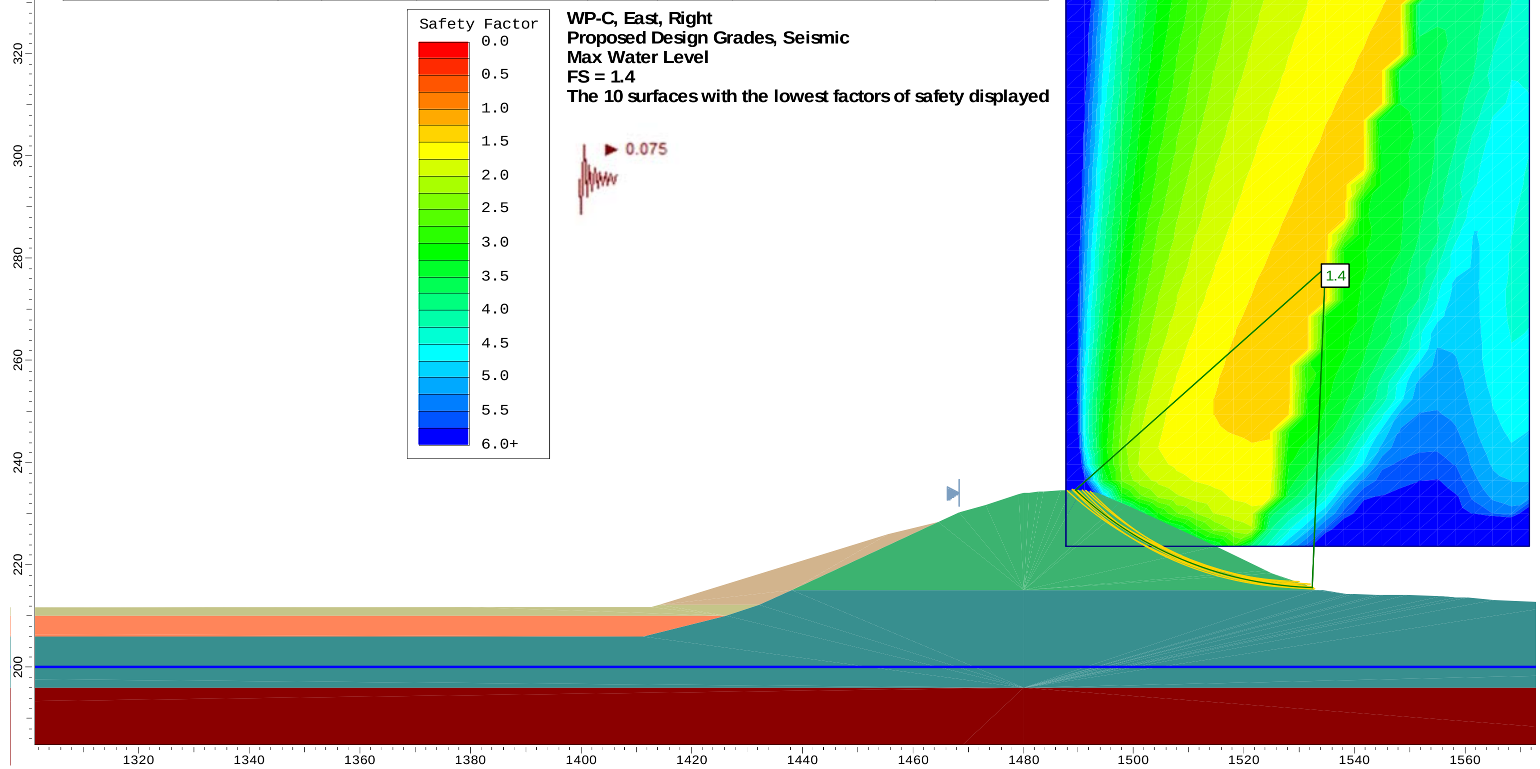
Golder Associates	SCALE	As Shown	**WAP Section C - East, Right**		
	DATE	Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Design Water Level**		
	MADE BY	MGP			
	CHECK	JGM			
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure	**5C**
PROJECT No. 1520347	REV. 0				

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Base		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	500	Constant		None



Golder Associates	SCALE As Shown	WAP Section C - East, Right	
	DATE Oct-21-2015	Slope Stability Analysis Proposed Closure Design Undrained, Max Water Level	
	MADE BY MGP		
	CHECK JGM		
	REVIEW GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 5D
PROJECT No. 1520347 REV. 0			

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Base		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	400	Constant		None



Golder Associates

SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

WAP Section C - East, Right

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

PROJECT No. 1520347 REV. 0

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

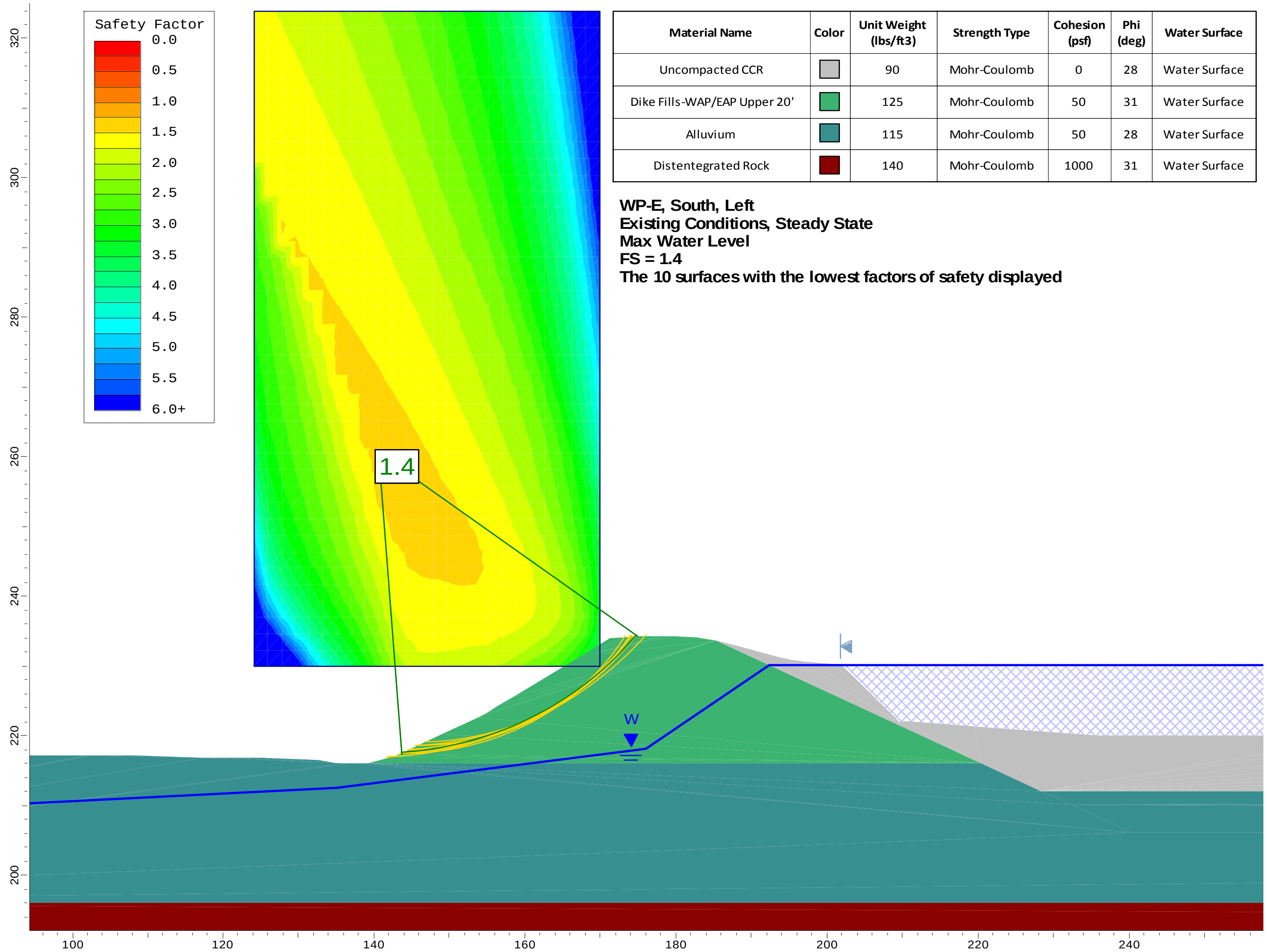
Figure **5E**

Not Applicable

Design Water Level Is Same as Max Water Level

See Figure 5E

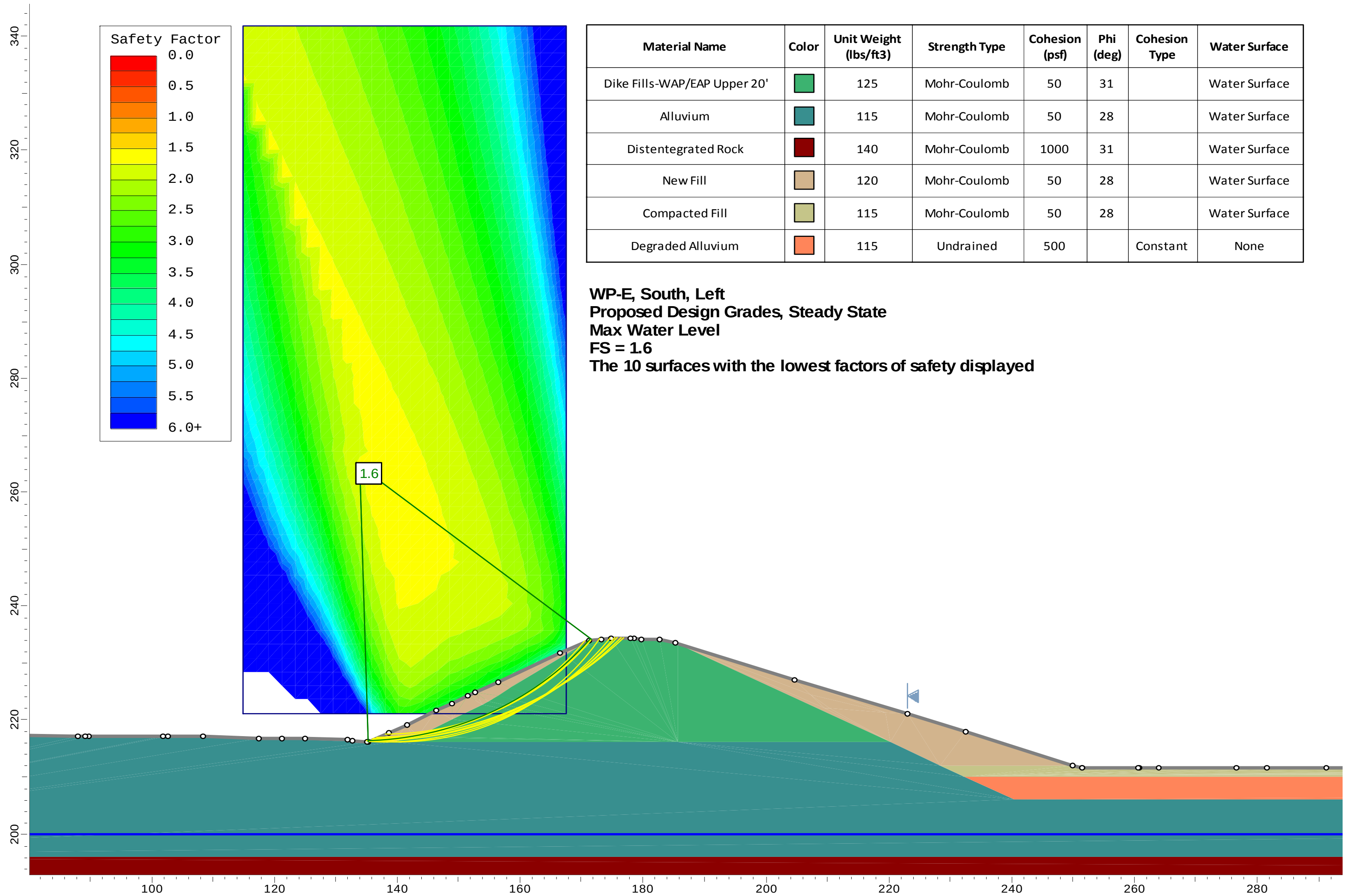
Golder Associates	SCALE	As Shown	**WAP Section C - East, Right**	
	DATE	Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Seismic, Design Water Level**	
	MADE BY	MGP		
	CHECK	JGM		
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **5F**
PROJECT No. 1520347 / REV. 0				



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface

WP-E, South, Left
Existing Conditions, Steady State
Max Water Level
FS = 1.4
The 10 surfaces with the lowest factors of safety displayed

Golder Associates	SCALE	As Shown	**WAP Section E - South, Left**
	DATE	Oct-21-2015	**Bremo Bluff Power Station**
	MADE BY	MGP	**Slope Stability Analysis**
	CHECK	JGM	**Existing Conditions, Steady State**
	REVIEW	GLH	**Dominion Bremo Bluff Power Station**
PROJECT No. 1520347	REV. 0		**Ash Pond Closure Project** — Figure **6A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Compacted Fill		115	Mohr-Coulomb	50	28		Water Surface
Degraded Alluvium		115	Undrained	500		Constant	None

WP-E, South, Left
Proposed Design Grades, Steady State
Max Water Level
FS = 1.6
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

WAP Section E - South, Left

Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

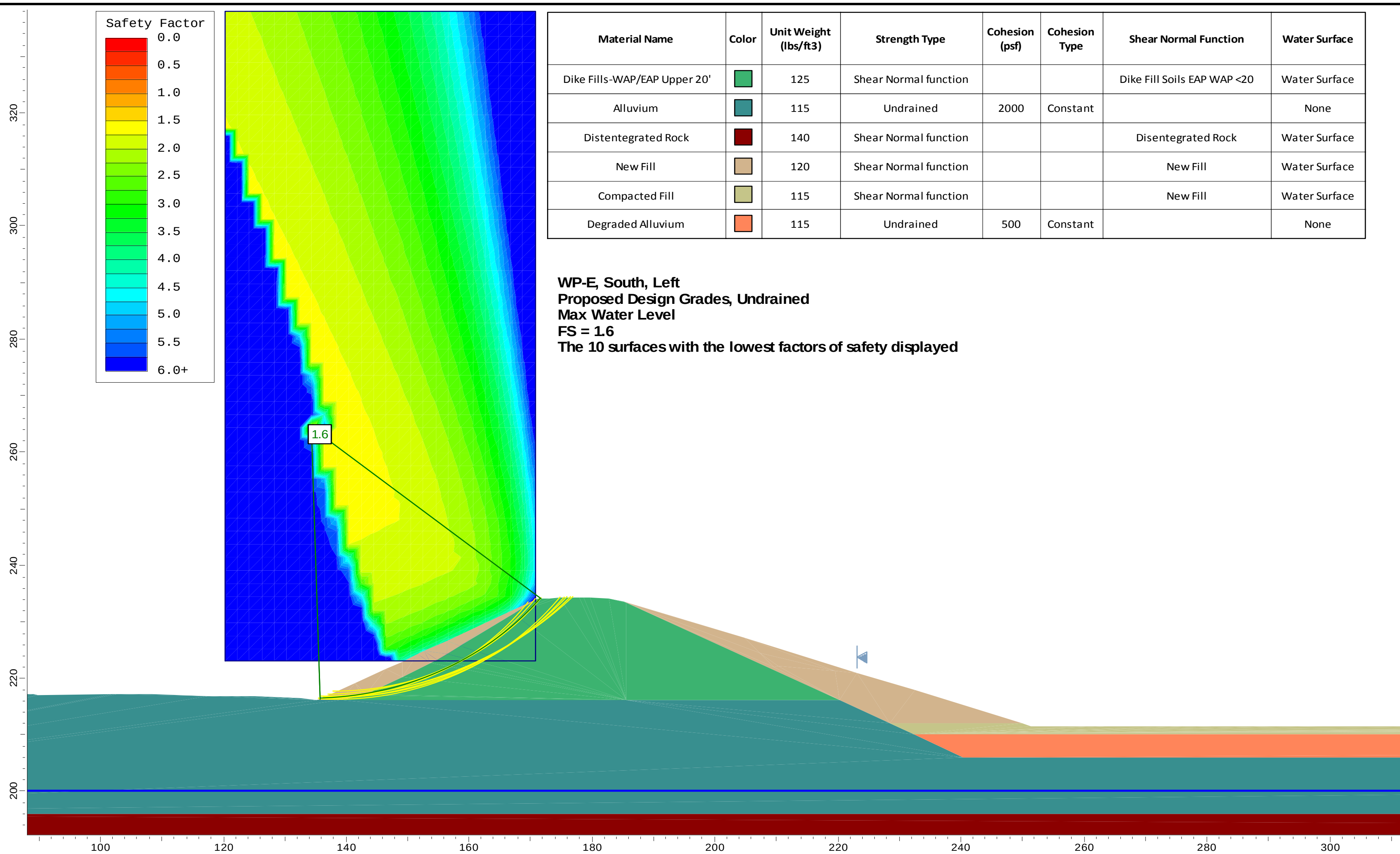
PROJECT No. 1520347 REV. 0

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **6B**

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 6B

	SCALE	As Shown	**WAP Section E - South, Left**		
	DATE	Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Design Water Level**		
	MADE BY	MGP			
	CHECK	JGM			
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure	**6C**
PROJECT No. 1520347	REV. 0				



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Fill		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	500	Constant		None

WP-E, South, Left
Proposed Design Grades, Undrained
Max Water Level
FS = 1.6
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

PROJECT No. 1520347 REV. 0

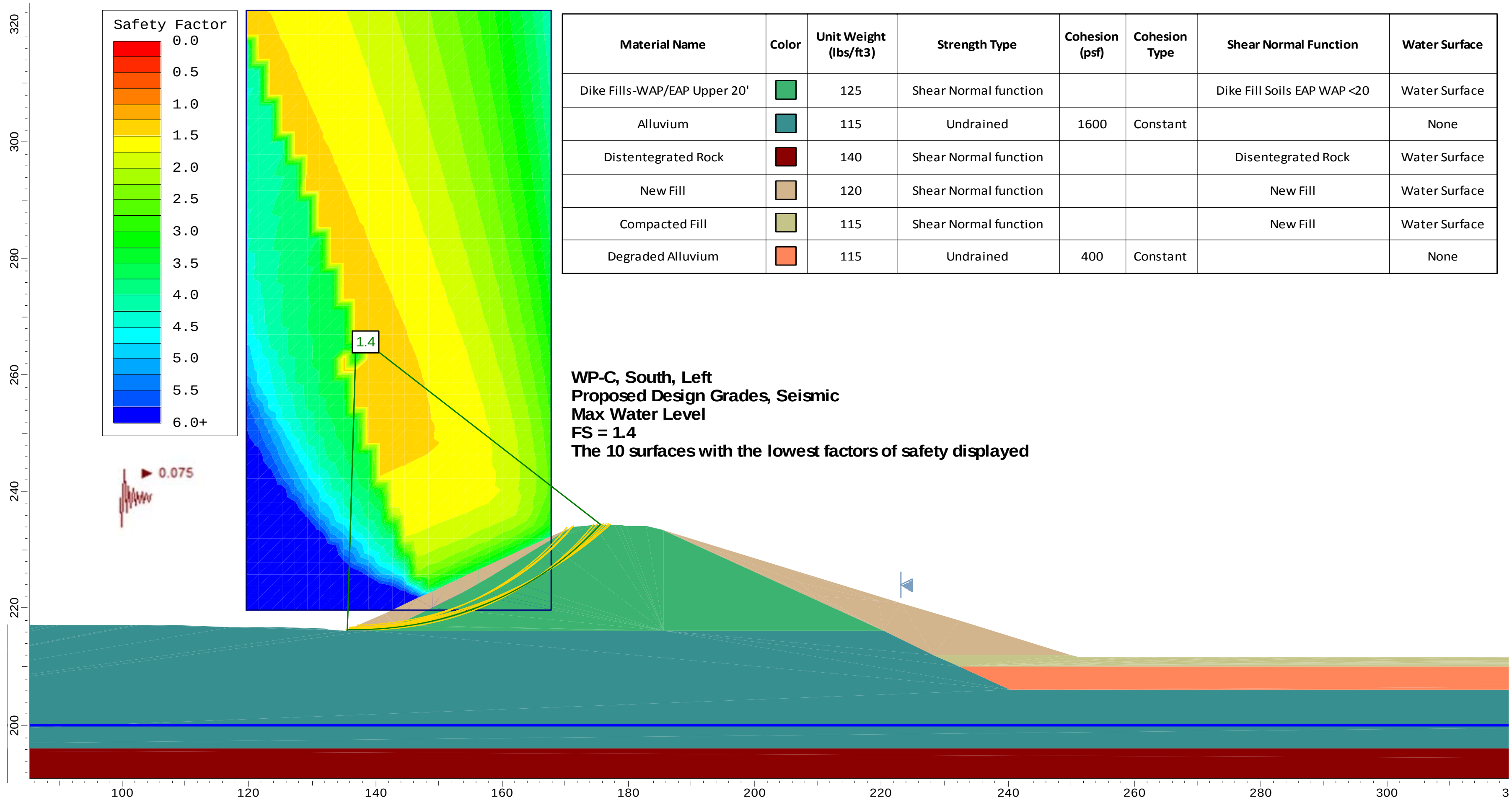
WAP Section E - South, Left

Slope Stability Analysis
Proposed Closure Design
Undrained, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **6D**

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Fill		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	400	Constant		None



SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

Golder Associates

PROJECT No. 1520347 REV. 0

WAP Section E - South, Left

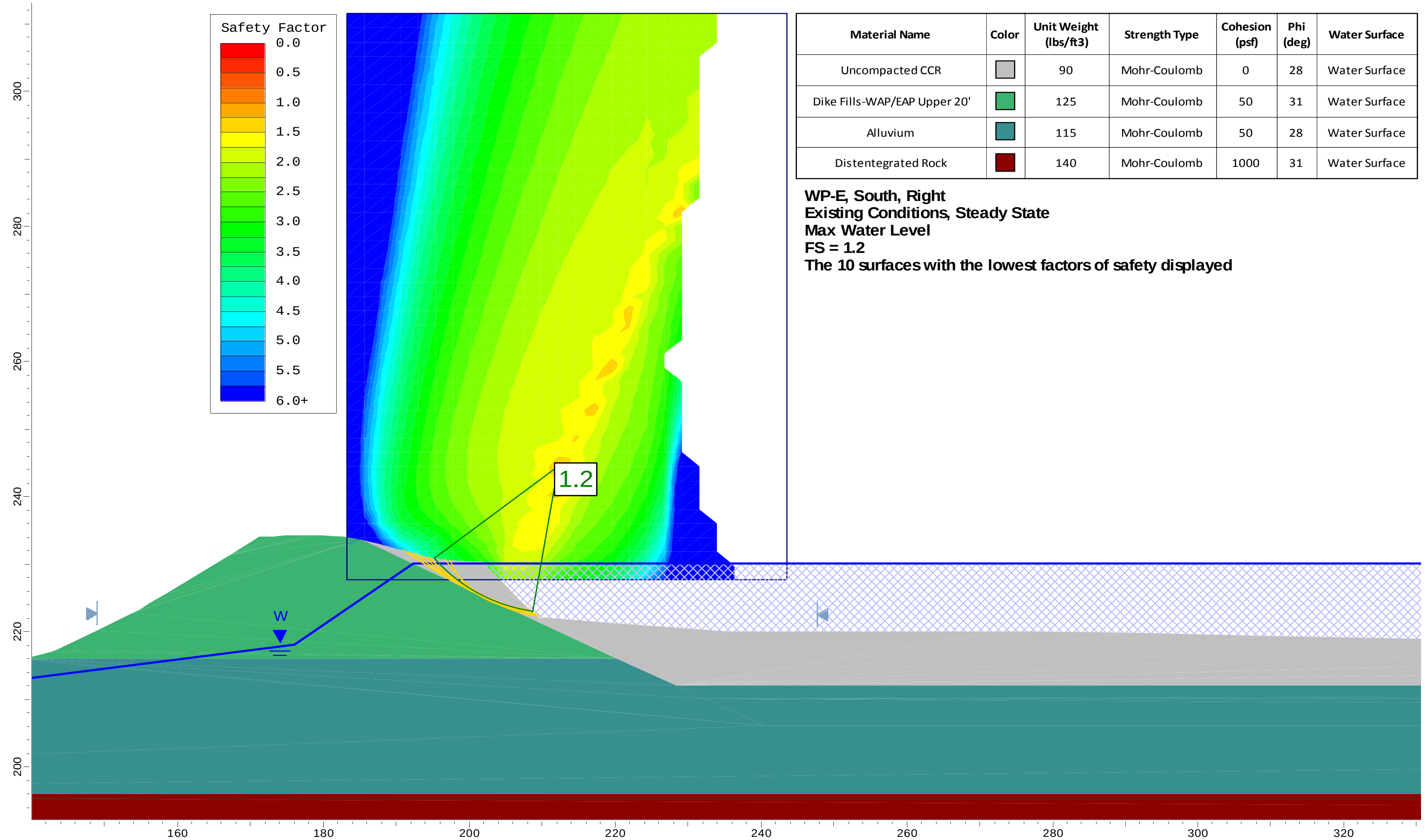
Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **6E**

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 6E

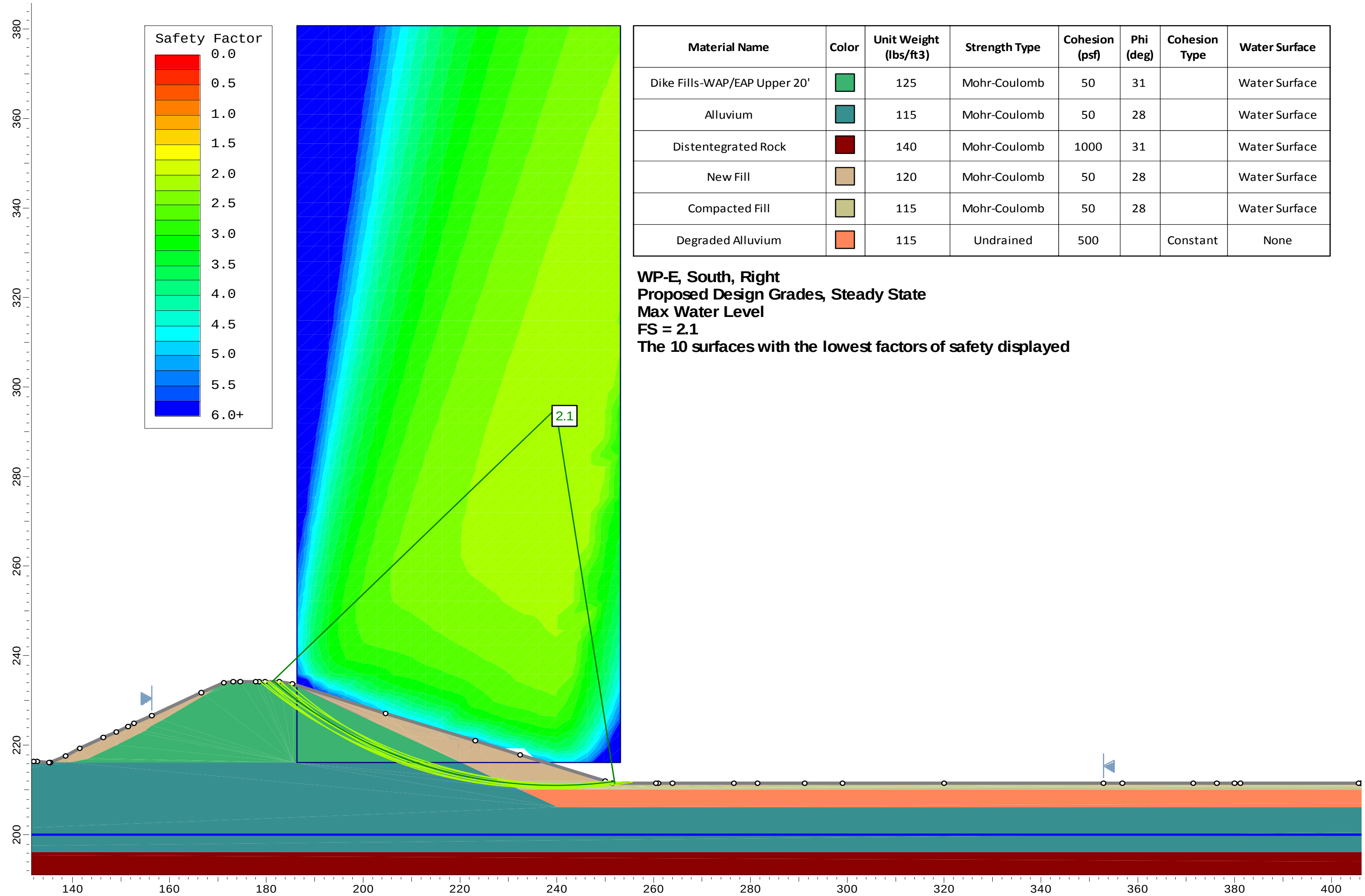
Golder Associates	SCALE	As Shown	**WAP Section E - South, Left**		
	DATE	Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Seismic, Design Water Level**		
	MADE BY	MGP			
	CHECK	JGM			
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure	**6F**
PROJECT No. 1520347	REV. 0				



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface

WP-E, South, Right
Existing Conditions, Steady State
Max Water Level
FS = 1.2
The 10 surfaces with the lowest factors of safety displayed

Golder Associates	SCALE As Shown	**WAP Section E - South, Right**	
	DATE Oct-21-2015	**Bremo Bluff Power Station** **Slope Stability Analysis** **Existing Conditions, Steady State**	
	MADE BY MGP		
	CHECK JGM		
	REVIEW GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **7A**
PROJECT No. 1520347 REV. 0			



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Compacted Fill		115	Mohr-Coulomb	50	28		Water Surface
Degraded Alluvium		115	Undrained	500		Constant	None

WP-E, South, Right
Proposed Design Grades, Steady State
Max Water Level
FS = 2.1
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

WAP Section E - South, Right

Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

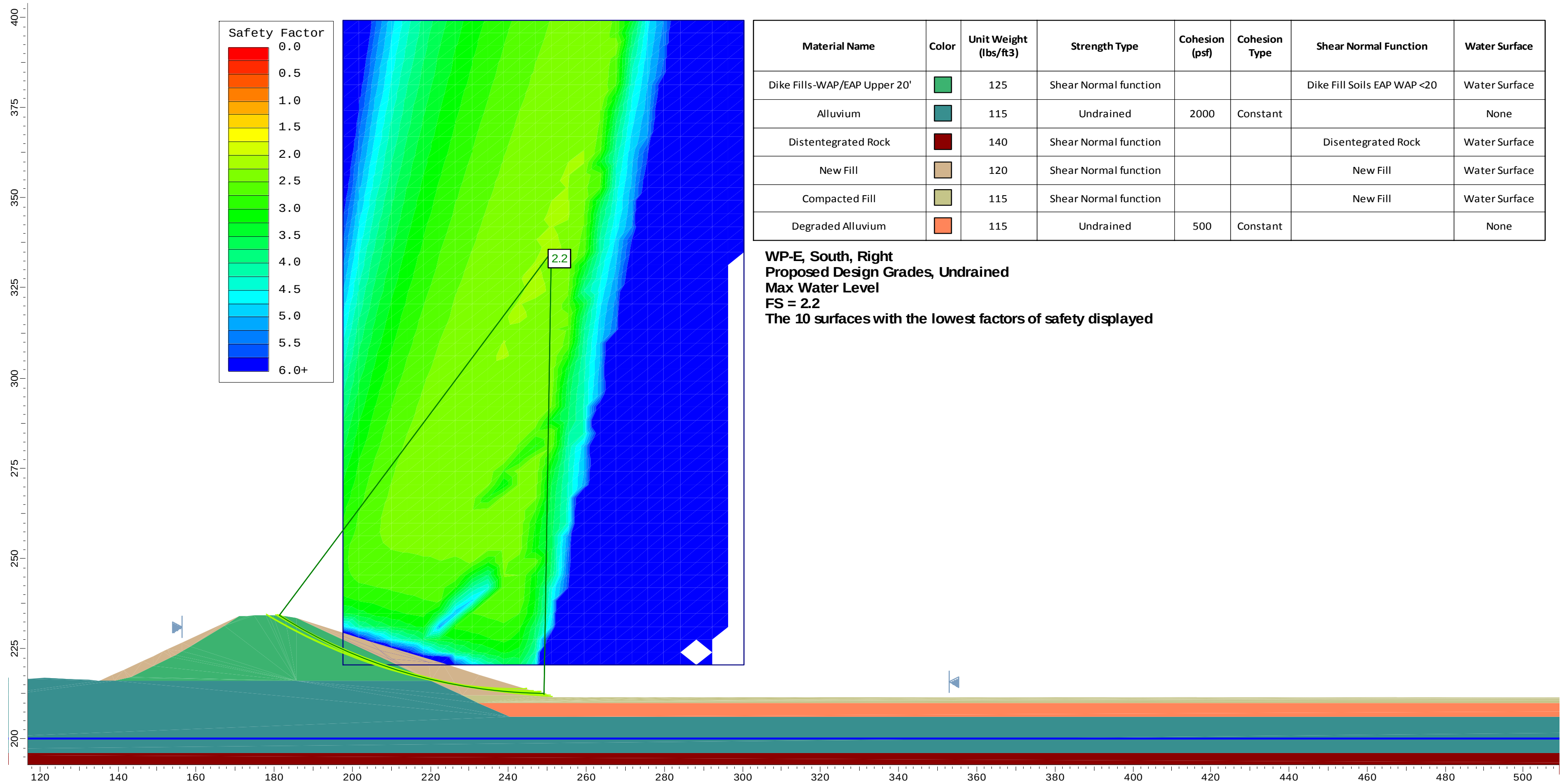
Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **7B**

PROJECT No. 1520347 REV. 0

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 7B

Golder Associates	SCALE	As Shown	**WAP Section E - South, Right**	
	DATE	Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Design Water Level**	
	MADE BY	MGP		
	CHECK	JGM		
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **7C**
PROJECT No. 1520347 REV. 0				



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Fill		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	500	Constant		None

WP-E, South, Right
Proposed Design Grades, Undrained
Max Water Level
FS = 2.2
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

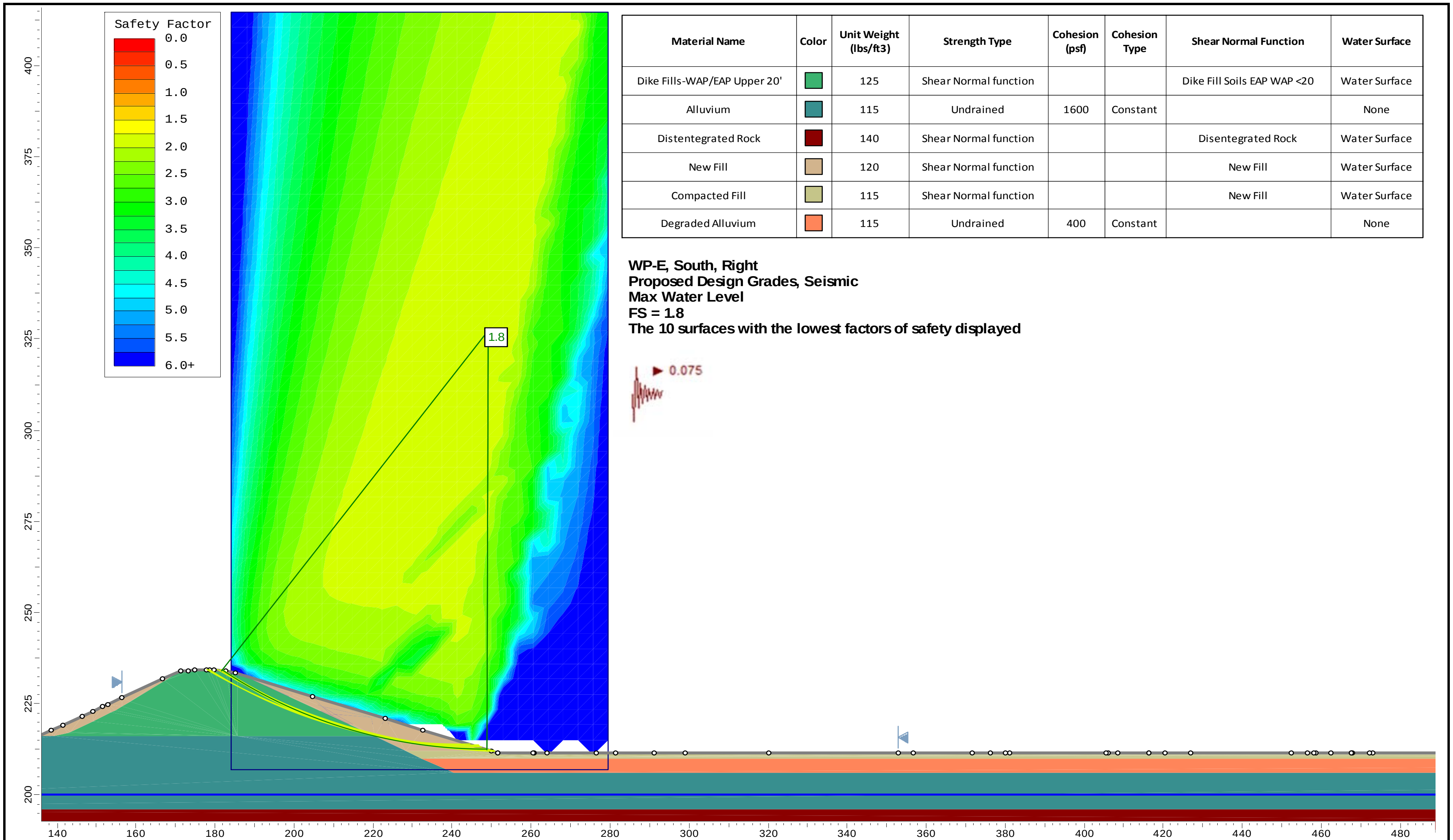
WAP Section E - South, Right

Slope Stability Analysis
Proposed Closure Design
Undrained, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **7D**

PROJECT No. 1520347 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Fill		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	400	Constant		None

WP-E, South, Right
Proposed Design Grades, Seismic
Max Water Level
FS = 1.8
The 10 surfaces with the lowest factors of safety displayed

Golder Associates

SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

PROJECT No. 1520347 REV. 0

WAP Section E - South, Right

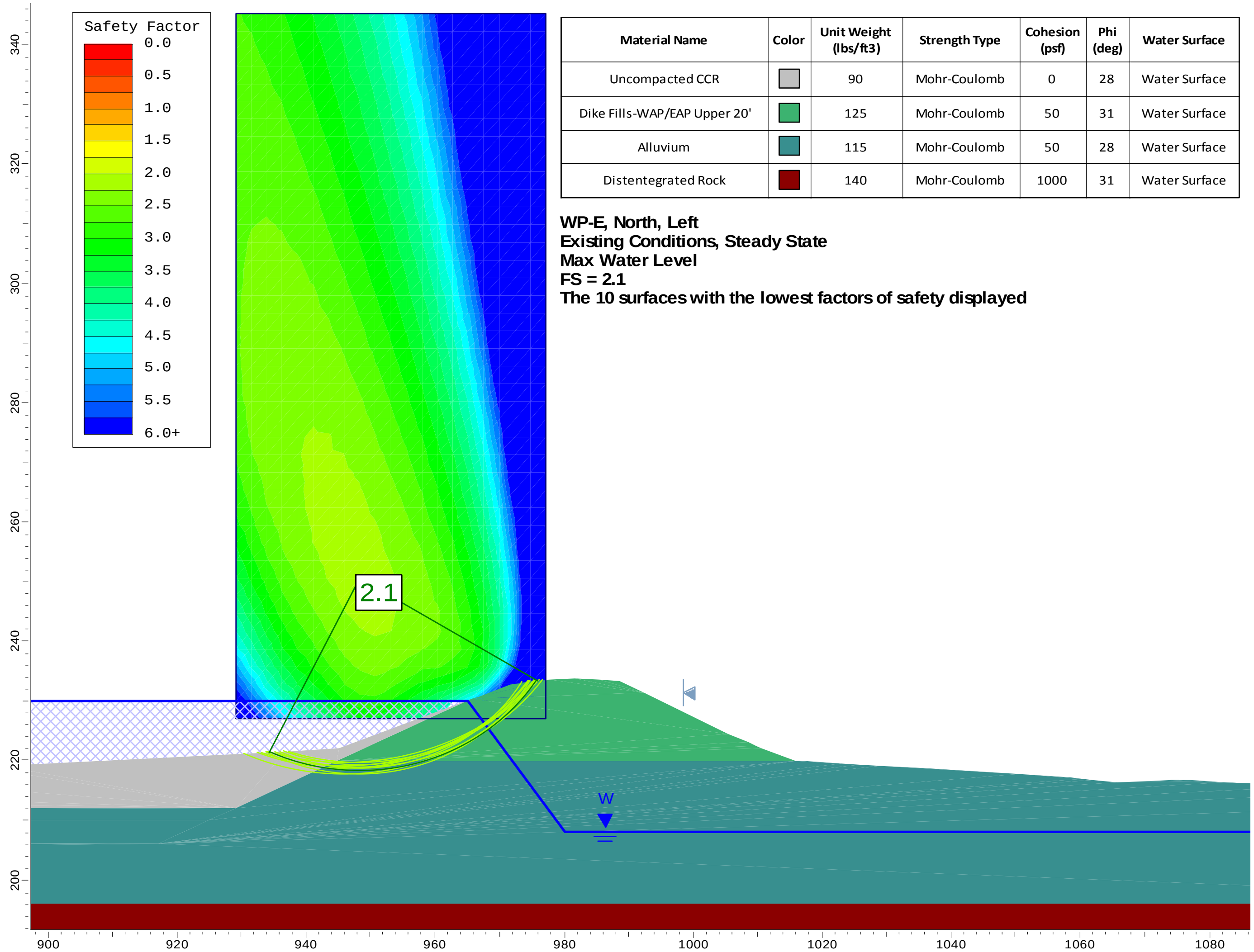
Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **7E**

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 7E

Golder Associates	SCALE	As Shown	**WAP Section E - South, Right**	
	DATE	Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Seismic, Design Water Level**	
	MADE BY	MGP		
	CHECK	JGM		
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **7F**
PROJECT No. 1520347 · REV. 0				

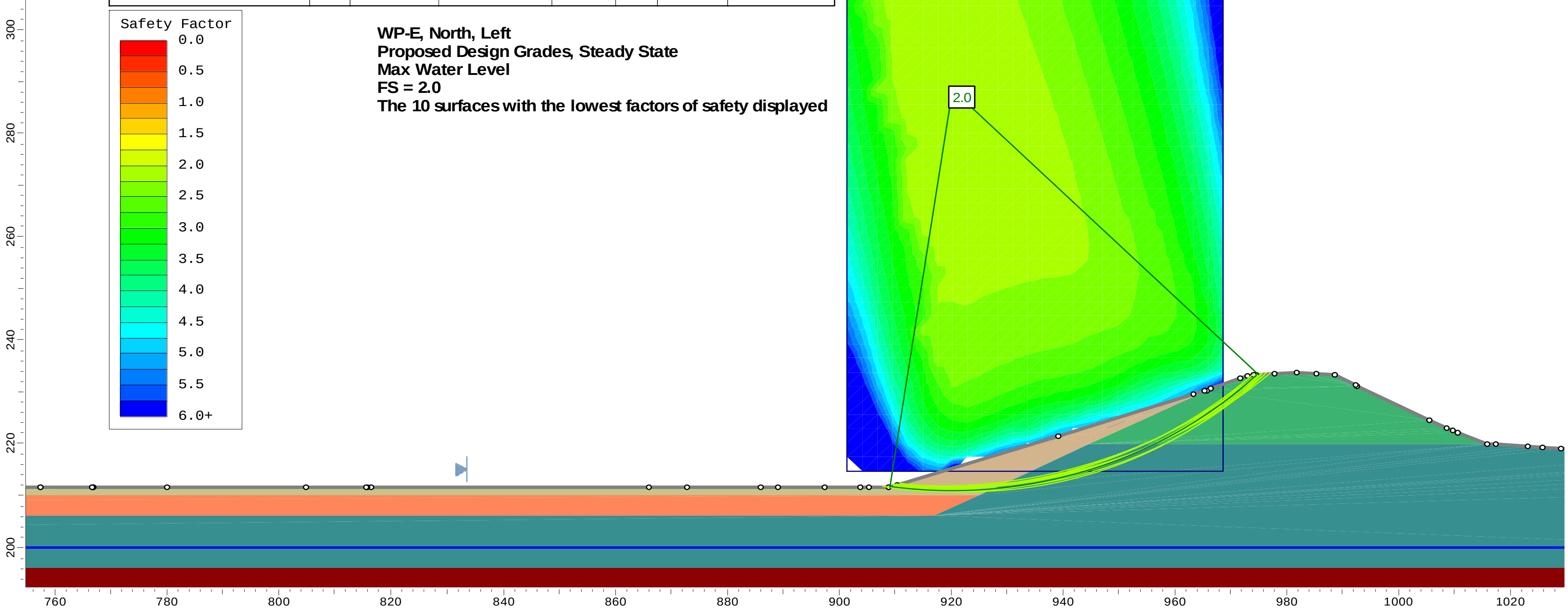


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface

WP-E, North, Left
Existing Conditions, Steady State
Max Water Level
FS = 2.1
The 10 surfaces with the lowest factors of safety displayed

Golder Associates	SCALE As Shown	**WAP Section E - North, Left**	
	DATE Oct-21-2015	**Bremo Bluff Power Station** **Slope Stability Analysis** **Existing Conditions, Steady State**	
	MADE BY MGP		
	CHECK JGM		
	REVIEW GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **8A**
PROJECT No. 1520347 REV. 0			

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Compacted Fill		115	Mohr-Coulomb	50	28		Water Surface
Degraded Alluvium		115	Undrained	500		Constant	None



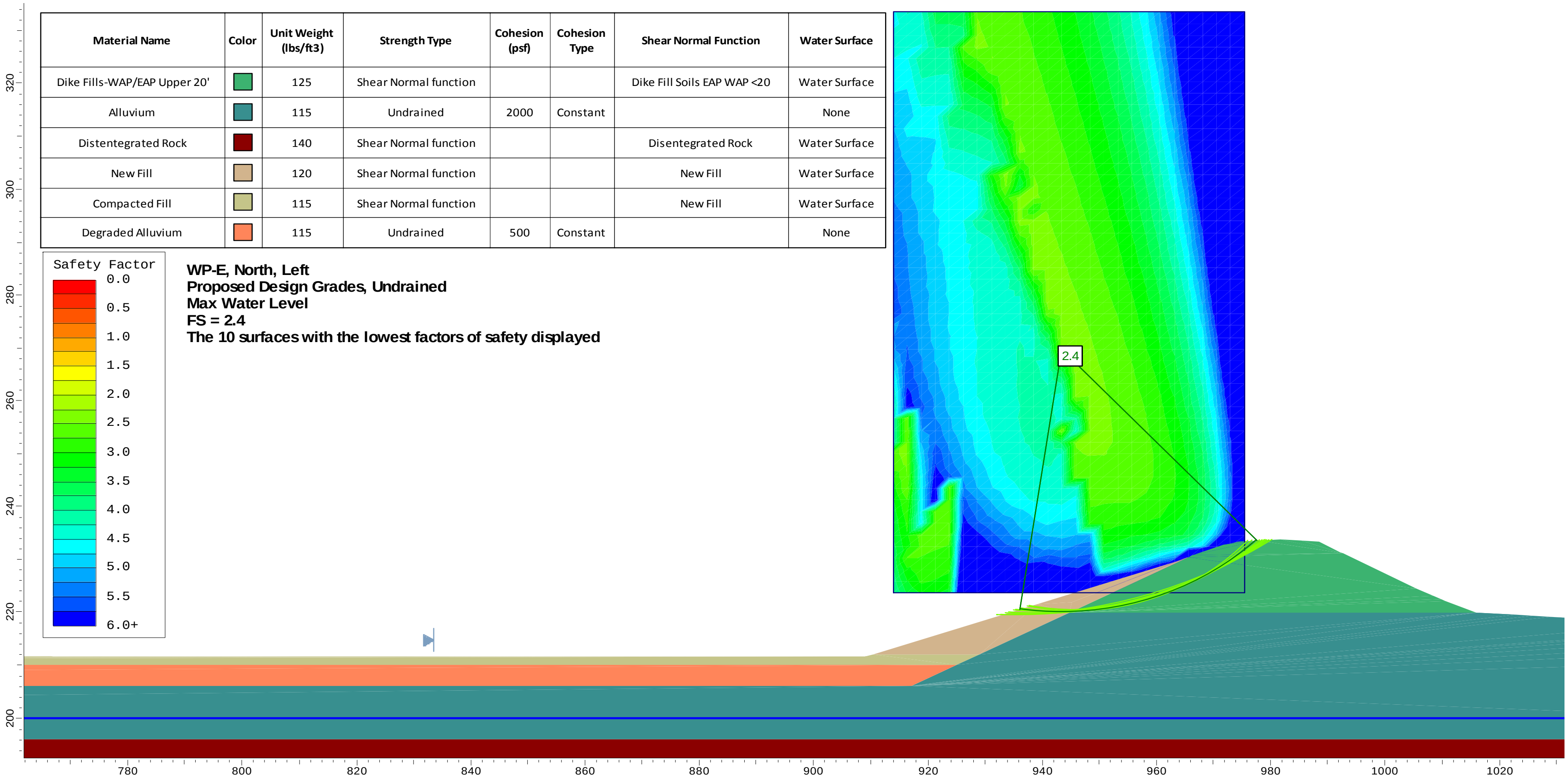
Golder Associates	SCALE: As Shown	**WAP Section E - North, Left**	
	DATE: Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Max Water Level**	
	MADE BY: MGP		
	CHECK: JGM		
	REVIEW: GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **8B**
PROJECT No. 1520347 / REV. 0			

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 8B

Golder Associates	SCALE	As Shown	**WAP Section E - North, Left**	
	DATE	Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Design Water Level**	
	MADE BY	MGP		
	CHECK	JGM		
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **8C**
PROJECT No. 1520347 REV. 0				

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Fill		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	500	Constant		None

WP-E, North, Left
Proposed Design Grades, Undrained
Max Water Level
FS = 2.4
The 10 surfaces with the lowest factors of safety displayed



SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

Golder Associates

WAP Section E - North, Left

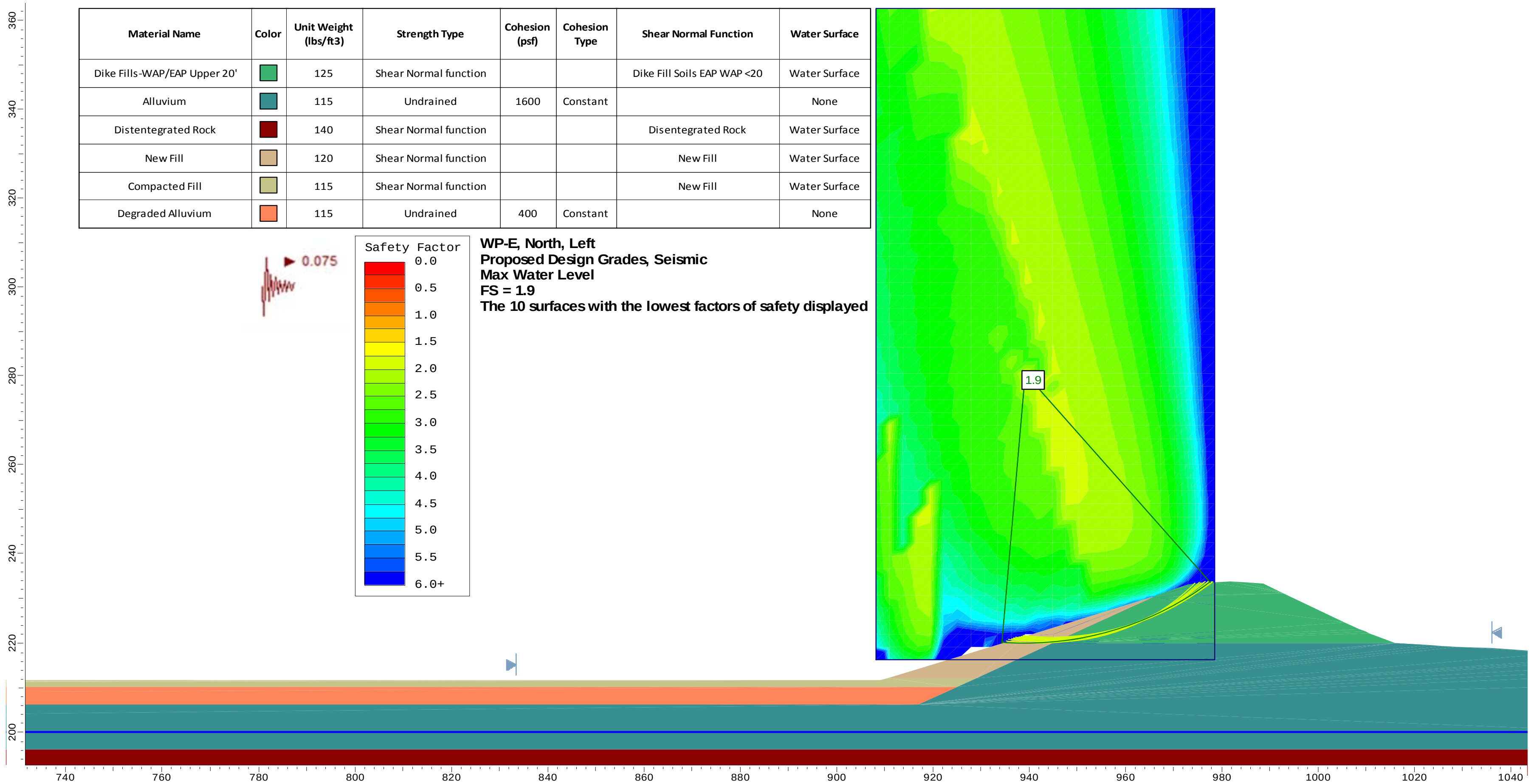
Slope Stability Analysis
Proposed Closure Design
Undrained, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **8D**

PROJECT No. 1520347 REV. 0

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Fill		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	400	Constant		None



Golder Associates

SCALE	As Shown	**WAP Section E - North, Left**
DATE	Oct-21-2015	**Slope Stability Analysis**
MADE BY	MGP	**Proposed Closure Design**
CHECK	JGM	**Seismic, Max Water Level**
REVIEW	GLH	**Dominion Bremo Bluff Power Station**
PROJECT No. 1520347	REV. 0	**Ash Pond Closure Project**

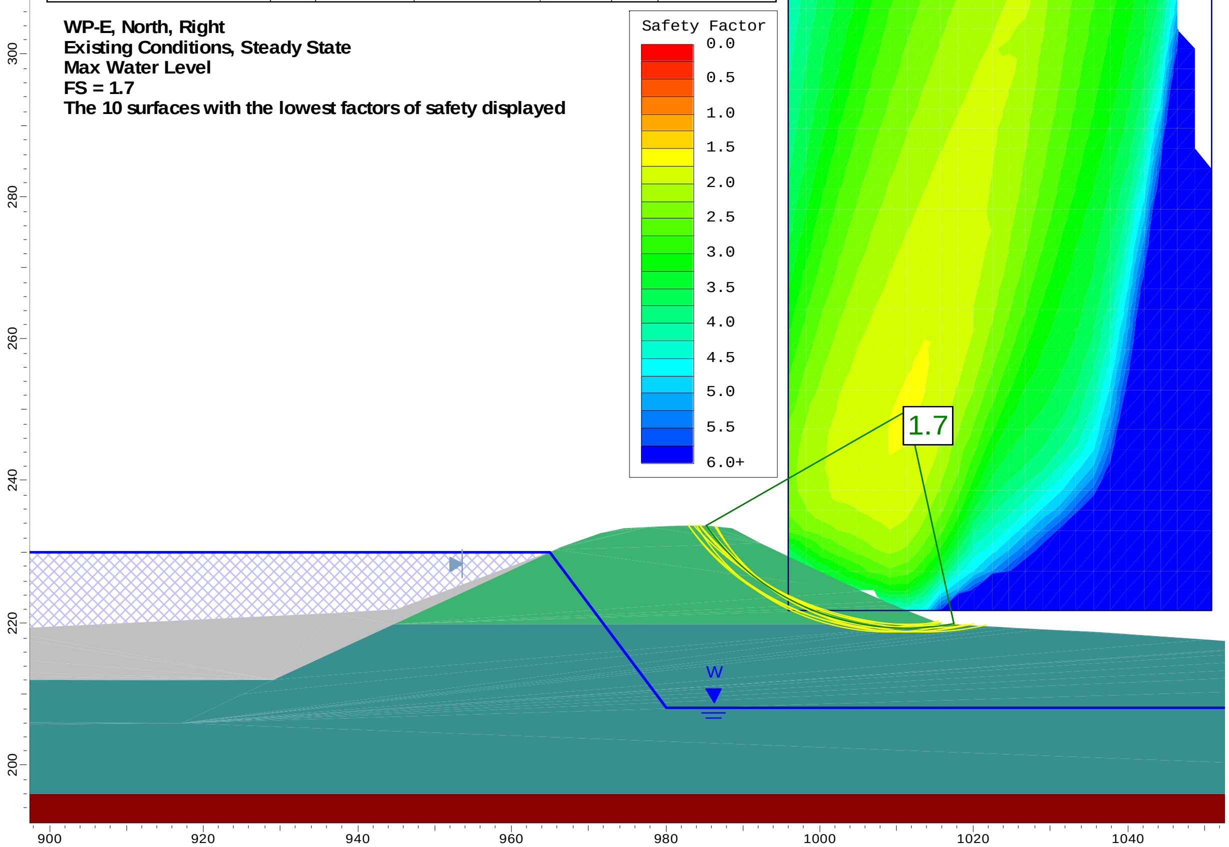
Figure **8E**

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 8E

Golder Associates	SCALE As Shown	**WAP Section E - North, Left**	
	DATE Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Seismic, Design Water Level**	
	MADE BY MGP		
	CHECK JGM		
	REVIEW GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **8F**
PROJECT No. 1520347 REV. 0			

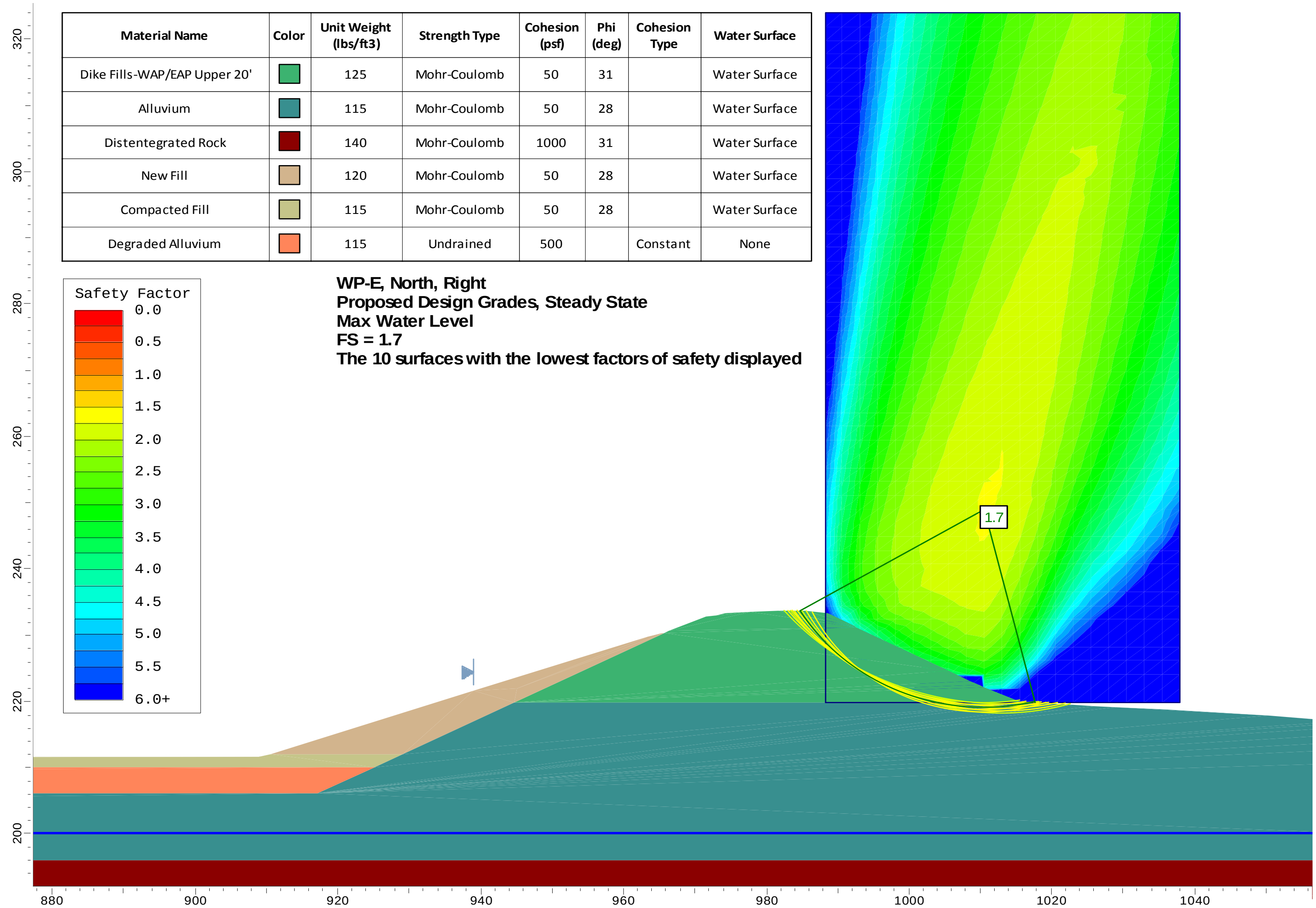
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Uncompacted CCR		90	Mohr-Coulomb	0	28	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31	Water Surface
Alluvium		115	Mohr-Coulomb	50	28	Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31	Water Surface

WP-E, North, Right
Existing Conditions, Steady State
Max Water Level
FS = 1.7
The 10 surfaces with the lowest factors of safety displayed



Golder Associates	SCALE	As Shown	**WAP Section E - North, Right**
	DATE	Oct-21-2015	**Bremo Bluff Power Station** **Slope Stability Analysis** **Existing Conditions, Steady State**
	MADE BY	MGP	
	CHECK	JGM	
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**
PROJECT No. 1520347 / REV. 0			Figure **9A**

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Mohr-Coulomb	50	31		Water Surface
Alluvium		115	Mohr-Coulomb	50	28		Water Surface
Distentegrated Rock		140	Mohr-Coulomb	1000	31		Water Surface
New Fill		120	Mohr-Coulomb	50	28		Water Surface
Compacted Fill		115	Mohr-Coulomb	50	28		Water Surface
Degraded Alluvium		115	Undrained	500		Constant	None



Golder Associates

SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	GLH
REVIEW	

WAP Section E - North, Right

Slope Stability Analysis
Proposed Closure Design
Steady State, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

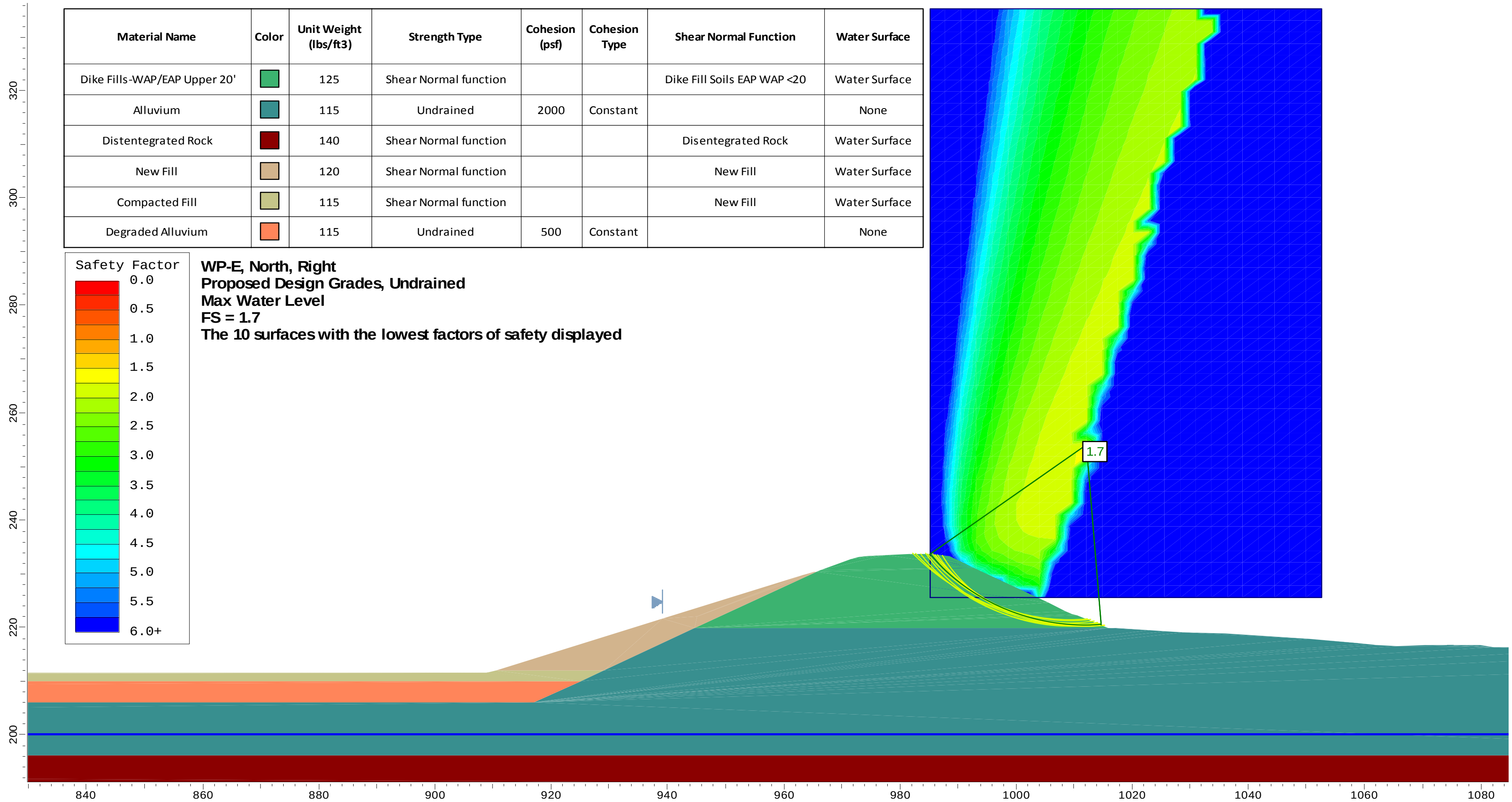
Figure **9B**

PROJECT No. 1520347 REV. 0

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 9B

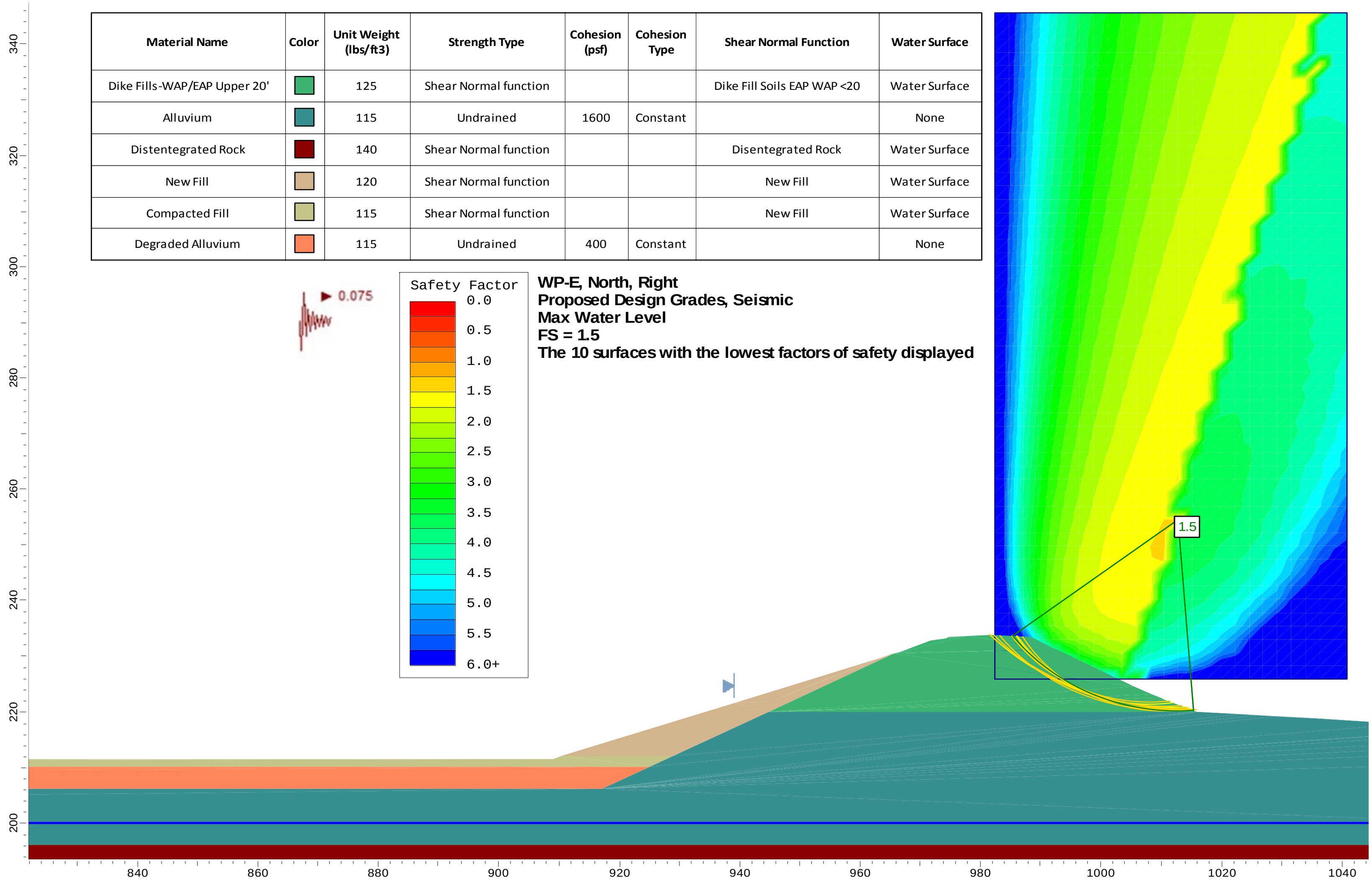
Golder Associates	SCALE	As Shown	**WAP Section E - North, Right**	
	DATE	Oct-21-2015	**Slope Stability Analysis** **Proposed Closure Design** **Steady State, Design Water Level**	
	MADE BY	MGP		
	CHECK	JGM		
	REVIEW	GLH	**Dominion Bremo Bluff Power Station** **Ash Pond Closure Project**	Figure **9C**
PROJECT No. 1520347 REV. 0				

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	2000	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Fill		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	500	Constant		None



Golder Associates	SCALE As Shown	WAP Section E - North, Right	
	DATE Oct-21-2015	Slope Stability Analysis Proposed Closure Design Undrained, Max Water Level	
	MADE BY MGP		
	CHECK JGM		
	REVIEW GLH	Dominion Bremo Bluff Power Station Ash Pond Closure Project	Figure 9D
PROJECT No. 1520347 REV. 0			

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Cohesion Type	Shear Normal Function	Water Surface
Dike Fills-WAP/EAP Upper 20'		125	Shear Normal function			Dike Fill Soils EAP WAP <20	Water Surface
Alluvium		115	Undrained	1600	Constant		None
Distentegrated Rock		140	Shear Normal function			Disentegrated Rock	Water Surface
New Fill		120	Shear Normal function			New Fill	Water Surface
Compacted Fill		115	Shear Normal function			New Fill	Water Surface
Degraded Alluvium		115	Undrained	400	Constant		None



SCALE	As Shown
DATE	Oct-21-2015
MADE BY	MGP
CHECK	JGM
REVIEW	GLH

Golder Associates

PROJECT No. 1520347 REV. 0

WAP Section E - North, Right

Slope Stability Analysis
Proposed Closure Design
Seismic, Max Water Level

Dominion Bremo Bluff Power Station
Ash Pond Closure Project

Figure **9E**

Not Applicable
Design Water Level Is Same as Max Water Level
See Figure 9E

Golder Associates	SCALE	As Shown	**WAP Section E - North, Right**	
	DATE	Oct-21-2015	**Slope Stability Analysis Proposed Closure Design Seismic, Design Water Level**	
	MADE BY	MGP		
	CHECK	JGM		
	REVIEW	GLH	**Dominion Bremo Bluff Power Station Ash Pond Closure Project**	Figure **9F**
PROJECT No. 1520347 REV. 0				

Attachment 5

Geotechnical Settlement Analyses

CALCULATIONS

Date:	October 2015	**Made by:**	J Grant Martin
Project No.	1520347	**Checked by**	PDP
Short Name:	Bremo Power Station Ash Pond Closure	**Reviewed by:**	GLH
Subject	**SETTLEMENT ANALYSIS OF EAST AND NORTH ASH PONDS**		

1.0 OBJECTIVE

Settlement analyses were completed to check closure cap design grades for grade reversals caused by settlement of ash.

2.0 METHODOLOGY

Since ash in the ash ponds is much more compressible than the underlying piedmont soils, only the ash is considered in the settlement calculations.

Ash differs from typical soils in that its unit weight is much lower (typ. ~50 pcf, dried) and it often exhibits anywhere from light to significant cementation. Laboratory tests used for traditional consolidation theory analysis (i.e. oedometer 1-D consolidation tests) often fail to capture cementation effects because sample transportation and preparation for laboratory testing often disturb fragile cementation that is lost or does not have time to reform before testing begins. Settlement analyses using laboratory test results can over-predict settlement where cementation is present in-situ but is either lost during transport or is not accounted for in lab tests. Cone Penetration Testing (CPT) tip stresses and densities with depth obtained from Golder's March 2015 geotechnical investigation (Golder 2015) imply cementation within both the North Ash Pond (NAP) and East Ash Pond (EAP).

Additionally, uncertainty exists in the drainage behavior of each individual ash pond over the long term, there is long history showing that impoundments containing fine-grained materials (e.g. mine tailings, ash, etc.) tend to dry from both the top down and bottom up. The lower drained and partially saturated zone that is formed near the base of ash ponds often creates a capillary break which impedes subsequent drainage flows downward through the zone. Since the ash in EAP and NAP is predominantly fine sand to silt sized, an unsaturated zone with a capillary break is likely to form for some period after closure, trending slowly towards complete drainage over time.

Settlement analyses were completed by calculating settlement at discrete locations within the pond spaced on a 5 ft grid. Settlement analysis results were used to create isopach maps and post-settlement surfaces of the proposed final design grades. To account for ash cementation and uncertainties in pond

Project No.:	1520347	Made by:	J Grant Martin
Site Name:	Bremo Power Station	Checked by:	PDP
Date:	August 2015	Reviewed by:	GLH

drainage, two sets of analyses were completed for settlement in both the EAP and the NAP to yield **predicted** and **conservative** settlement estimates.

2.1 Predicted Settlement Analysis

The predicted settlement analyses models the settlement of the ash considering the known light cementation that exists within the ash using elastic theory. Elastic theory was applied using properties developed from in-situ (CPT) tests was applied to calculate predicted settlement at each discrete settlement location within the pond. Using elastic theory, a settlement can be calculated from a change in stress over a given thickness using a constrained modulus of elasticity (M).

$$S = H * \frac{\Delta\sigma'}{M}$$

Where S = Settlement
H = Layer thickness
$\Delta\sigma'$ = Change in effective stress
M = Constrained modulus of elasticity

The constrained modulus of elasticity was calculated from correlated shear wave velocities from in-situ CPT measurements through the following relationships.

$$M = \frac{2 * G * (1 - \nu)}{1 - 2 * \nu}$$

Where M = Constrained modulus of elasticity
G = Shear Modulus
ν = Poisson's ratio (0.45 for nearly saturated soils)

$$G = G_0 * \left(\frac{G}{G_0}\right)$$

Where G = Shear Modulus
G_0 = Initial Small Strain Shear Modulus
$\frac{G}{G_0}$ = Degradation coefficient from backbone curve (0.15)

$$G_0 = \rho * V_s^2$$

Where G_0 = Initial Small Strain Shear Modulus
ρ = Density of material ($\frac{90\ pcf}{32.2 \frac{ft}{s^2}}$ for ash)
V_s = Shear wave velocity

Project No.:	1520347	Made by:	J Grant Martin
Site Name:	Bremo Power Station	Checked by:	PDP
Date:	August 2015	Reviewed by:	GLH

According to shear modulus backbone curves developed by Seed and Idriss (1970) and Darendeli and Stokoe (2001), the shear modulus is degraded to less than 20% of the initial small strain shear modulus at large strains (Shear strains > 10^{-2}). Therefore, the shear modulus was degraded to 15% of the initial small strain modulus for settlement analysis.

The shear wave velocity developed from CPT correlations (see Appendix A: Material Properties Package for details) varies with depth in the ash from 200 ft/s at the surface to 600 ft/s at 100 ft below the ground surface. To account for varying V_s (and thus, varying M) with depth, the settlement calculation was applied in 1 ft layers and summed for a total settlement at each settlement point location.

For initial effective stress calculations in the NAP, the ash was assumed to be initially saturated to either 5 ft below the ground surface elevation or the elevation of free water in the south part of the pond (El. 320 ft), whichever was greater. In the EAP, the ash was assumed to be initially saturated to the elevation of free water in the EAP (El. 230 ft) because the water level varies little in EAP. For final effective stress calculations in the predicted settlement analysis, the proposed final design grades were used to calculate areas of cut and fill within the pond. Fill areas were assumed to be filled with material having a unit weight similar to the current soil dike fills around the ponds (125 pcf). A partially drained condition with the upper 15 ft and bottom 15 ft of the pond becoming unsaturated was used for the predicted analysis.

2.2 Conservative Settlement Analysis

The conservative settlement calculation analyses ignored the known impact of cementation on ash deflection. Traditional consolidation theory with material properties developed from laboratory testing was applied to obtain a conservative settlement prediction at each discrete settlement location within the pond. This settlement prediction represents settlement 10 years after draining of the pond. The following equations were used to calculate primary settlement in 1 ft layers, then summed for total primary settlement (Das 2007).

$$S_p = H * C'_c * \log\left(\frac{\sigma_f}{\sigma_i}\right) \; for \; \sigma_f < \sigma_p$$

$$S_p = H * \left(C'_c * \log\left(\frac{\sigma_p}{\sigma_i}\right) + C'_r * \log\left(\frac{\sigma_f}{\sigma_p}\right)\right) \; for \; \sigma_i < \sigma_p < \sigma_f$$

$$S_p = H * C'_r * \log\left(\frac{\sigma_f}{\sigma_i}\right) \; for \; \sigma_p < \sigma_i$$

Project No.:	1520347	Made by:	J Grant Martin
Site Name:	Bremo Power Station	Checked by:	PDP
Date:	August 2015	Reviewed by:	GLH

Where S_p = Primary settlement
H = Thickness of layer
C'_c = Coefficient of consolidation (strain)
C'_r = Coefficient of recompression (strain)
σ_i = initial effective stress
σ_f = final effective stress
σ_p = preconsolidation pressure

For each settlement location, a time estimate for completion of 95% of primary consolidation was calculated using the following equation (Das 2007).

$$t_{95} = \frac{T_v * H_{total}}{C_v}$$

Where t_{95} = Time for completion of 95% of primary consolidation
T_v = Coefficient for 95% of primary consolidation
H_{total} = Total height of ash
C'_v = Time rate coefficient (strain)

For settlement points which completed 95% of primary consolidation within 10 years, the secondary settlement was calculated from the end of 95% of primary consolidation to 10 years using the following equation (Das 2007).

$$S_s = H_{total} * C'_\alpha * \log\left(\frac{10\ yrs}{t_{95}}\right)$$

Where S_s = Secondary consolidation
t_{95} = Time for completion of 95% of primary consolidation (years)
H_{total} = Total height of ash
C'_α = Coefficient of secondary consolidation (strain)

Total settlement after 10 years is calculated with the following formula.

$$S_t = S_p + S_s$$

Where S_t = Total consolidation
S_p = Primary consolidation
S_s = Secondary consolidation

For initial effective stress calculations in the NAP, the ash was assumed to be initially saturated to either 5 ft below the ground surface elevation or the elevation of free water in the south part of the pond (El. 320 ft), whichever was greater. In the EAP, the ash was assumed to be initially saturated to the elevation of free water in the EAP (El. 230 ft) because the water level varies little in EAP. For final effective stress calculations in the conservative settlement analysis, the proposed design grades were used to calculate areas of cut and fill within the pond. Fill areas were assumed to be filled with material having a unit

Project No.:	1520347	Made by:	J Grant Martin
Site Name:	Bremo Power Station	Checked by:	PDP
Date:	August 2015	Reviewed by:	GLH

weight similar to the existing soil dike fills around the ponds (125 pcf). A fully drained condition of the pond was assumed for the conservative analysis.

2.3 Material Properties

The material properties presented below were used for settlement analyses. Details on these properties can be found in Appendix A: Material Properties Package.

Summary of CCR Consolidation Properties					
Unit Weight (pcf)	***OCR***	**Cc,ε (strain)**	**Cr,ε (strain)**	**Cv (ft2/day)**	**Cα,ε (strain)**
90	*2.5*	*0.18*	0.024	3.2	0.003

3.0 RESULTS

The settlement analysis results for the NAP and EAP can be found in Figures GD-6A to GD-9B. The table below summarizes each figure.

ASH POND	FIGURE NUMBER	FIGURE TITLE
EAST	GD-6A	Predicted Settlement Isopachs
	GD-6B	Predicted Post-Settlement Surface
	GD-7A	Conservative Settlement Isopachs
	GD-7B	Conservative Post Settlement Surface
NORTH	GD-8A	Predicted Settlement Isopachs
	GD-8B	Predicted Post-Settlement Surface
	GD-9A	Conservative Settlement Isopachs
	GD-9B	Conservative Post Settlement Surface

Project No.:	1520347	Made by:	J Grant Martin
Site Name:	Bremo Power Station	Checked by:	PDP
Date:	August 2015	Reviewed by:	GLH

In the predicted case, both the north and east ash ponds are expected to experience post cap construction settlements of less than 0.4 ft. As for the conservative case, parts of the east pond may experience settlements up to 3.5 ft, while some parts of the north pond could settle up to 6.0 ft.

4.0 CONCLUSIONS

The ash pond surfaces were adjusted for predicted and conservative settlements. These predicted settlement surfaces were then used to check the design grades for minimum slope and grade reversal requirements. The grades before and after settlement are shown on the figures for comparison. Some more significant changes in grade are seen in the conservative cases. However, the post-settlement grades are considered sufficient to maintain drainage paths and channels and do not adversely affect the stability of the slopes. As the figures indicate, the grades are expected to change very little for the predicted settlement cases as the closure cover grades were designed to limit post construction settlement of critical features by placing the drainage channels away from the areas of high settlement.

5.0 REFERENCES

Das, Braja M. (2006) Principles of Geotechnical Engineering. Sixth Edition.

Golder Associates Inc., (2015) “Draft 30% Design Geotechnical Data Report,” May 2015.

Golder Associates Inc., (2015) “Geotechnical Material Property Calculation Package,” August 2015.

Attachment 6

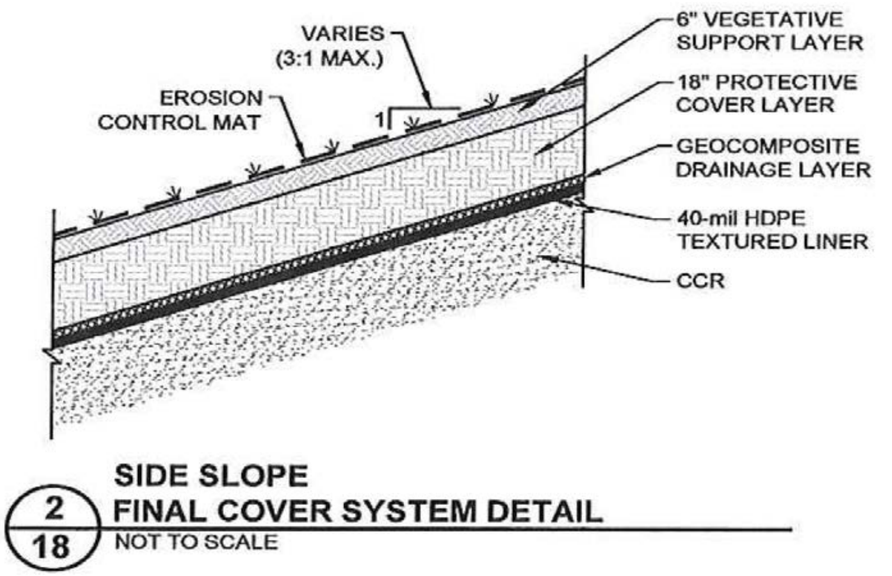
Veneer Stability Analyses

SUBJECT:	Stability of Cover System - Veneer Stability				
Job No. 1520347		Made by	JGM	Sheet	1 of 8
Ref. :	Dominion/Bremo Power Station/VA	Checked	WRP	Date	10/9/2015
		Reviewed	GLH		

OBJECTIVE:

Analyze the stability of the final closure cover system for use on the existing coal ash ponds at the Bremo Power Station.
Use design strength parameters and analyze for conditions with and without seepage forces.

GEOMETRY:



GOLDER RECOMMENDED FACTORS OF SAFETY FOR LANDFILL FINAL COVER

Shear Strength	During Construction (Short term)	Long Term
Design	1.1	1.5, 1.1 [a]

[a] Recommended factor of safety with seepage forces included

If the calculated factors of safety based on the final cover conditions are higher than the recommended factors of safety for landfill final cover, the stability of the final cover meets the requirement.

Based on Proposed Cover Grades (Figure 1, attached):
Top Elevation of Cover
Approximate Toe Elevation :

Slope is 3 H:1V

Material Properties (ref. 1 and 4)

Material	c (psf)	c_a (psf)	ϕ (°)	δ (°)	γ (pcf)	Thickness (ft)
Cover soil (CS) [(1)]	50	-	28	-	120	2.00
CS/GC/GM/Ash [(2)]	-	0	-	24	-	0.03

(1) Based off Material Properties for Bremo Closure (2015)

(2) Used low range of values for: internal soil strength, and of interfaces from unpublished Golder Lab Interface Shear test data for low normal stress - conservative.

Where: c = Cohesion of the cover soil

c_a = Adhesion between cover soil of the active wedge and the geomembrane

δ = Interface friction angle between cover soil and geomembrane

f = Friction Angle of cover soil

γ = Unit weight of the cover soil

Slope Angle = β (°) = 18.4

Slope Height = 30.0 ft (H)

CALCULATIONS:

LONG TERM VENEER STABILITY based on Koerner/Soong Method (page 487 to 490, ref. 2)

Using the Koerner/Soong Method, the factor of safety is calculated using the following equation (Eq. 13.9, ref. 2)

$$FS = \frac{-b \pm (b^2 - 4 \times a \times c)^{0.5}}{2 \times a}$$

Where:

$a = (W_a - N_a \text{ x } \cos\beta) \cos\beta$

$b = -[(W_a - N_a \text{ x } \cos\beta) \text{ x } \sin\beta \tan f + (N_a \text{ x } \tan\delta + C_a) \text{ x } \sin\beta \text{ x } \cos\beta + (C + W_p \text{ x } \tan f) \text{ x } \sin\beta]$

$c = (N_a \text{ x } \tan\delta + C_a) \text{ x } \sin^2\beta \text{ x } \tan f$

$W_a = \gamma \text{ x } h^2 \text{ x } (L/h - 1/\sin\beta - \tan\beta / 2)$

$N_a = W_a \text{ x } \cos\beta$

$C_a = c_a \text{ x } (L - h/\sin\beta)$

$W_p = (\gamma \text{ x } h^2) / \sin 2\beta$

$C = c \text{ x } h / \sin\beta$

Where:

W_a = Total weight of the active wedge

N_a = Effective force normal to the failure plane of the active wedge

C_a = Adhesive force between cover soil of the active wedge and the geomembrane

W_p = Total weight of the passive wedge
C = Cohesive force along the failure plane of the passive wedge
γ = Unit Weight of protective cover soil
h = Thickness of cover soil
β = Slope Angle
L = Length of slope measured along the geosynthetic interface
c = Cohesion of the cover soil
c_a = Adhesion between cover soil of the active wedge and the geomembrane
δ = Interface friction angle between cover soil and geomembrane
f = Friction Angle of cover soil

Where:

h = Thickness of Cover (ft) = 2.00
β = Cover Slope Angle (°) = 18.4
H_{max} = Maximum height = 30.0 feet
L= 94.9 feet

Since h and L are known for **LONG-TERM Conditions,** solve for the FS:

W_a (lbs/ft) = 21,171
N_a (lbs/ft) = 20,084
C_a (lbs/ft) = 89 x c_a

W_p (lbs/ft) = 800
C (lbs/ft) = 316

(W_a - N_a x cos β) = 2,117
(C + W_p x tan f) = 742

cos β = 0.95
sin β = 0.32
sin β x tan f = 0.17
$\sin^2$ β x tan f = 0.05
sin β x cos β = 0.30
tan f = 0.53

a= 2008.4

- b= 590.5 0.30

c = × 0.05

Solve for FS with different combinations of δ an c_a:

δ (°)	c_a (psf)	tan δ	C_a (lbs/ft)	(N_a x tan δ + C_a)	b	c	$(b^2 - 4ac)^{0.5}$	Factor of Safety
24.00	*0*	*0.4*	*0*	*8,942*	*-3,273*	*475*	*2625.5*	*1.5*

SHORT TERM CONDITIONS (***Dozer on the slope without acceleration)***

Veneer Stability based on Koerner/Soong Method (page 490-497, ref. 2)

$$FS = \frac{-b \pm (b^2 - 4 \times a \times c)^{0.5}}{2 \times a}$$

Where:

$a = (W_{a+e} - N_{a+e} \times \cos\beta) \cos\beta$

$b = -[(W_{a+e} - N_{a+e} \times \cos\beta) \times \sin\beta \times \tan f + (N_{a+e} \times \tan\delta + C_a) \times \sin\beta \times \cos\beta + (C + W_p \times \tan f) \times \sin\beta]$

$c = (N_{a+e} \times \tan\delta + C_a) \times \sin^2\beta \times \tan f)$

$W_a = \gamma \times h^2 \times (L/h - 1/\sin\beta - \tan\beta / 2)$

W_e = Equipment Weight, see below

$W_{a+e} = W_a + W_e$

$N_{a+e} = W_{a+e} \times \cos\beta$

$C_a = c_a \times (L - h/\sin\beta)$

$W_p = (\gamma \times h^2) / \sin 2\beta$

$C = c \times h / \sin\beta$

The definitions of all the parameters are as same as those in long term FS calculation except W_e, W_{a+e}, and N_{a+e}

For SHORT-Term Conditions, look at 6 inches of soil being placed up slope with a Low Ground Pressure Dozer

$L_{short\ term}$=	94.9	ft
$h_{short\ term}$=	0.50	ft
f =	28.00	degrees
c =	50.00	psf
$\gamma_{soil\ cover}$ =	120.00	pcf

Determination of W_e (See dozer specifications from manufacturer, ref. 3):

Width of Dozer Track = 3.00 ft
Contact Area = 64.26 sq.ft.
Ground Pressure = 4.8 psi
Influence factor (I) = 0.95 (obtained from Figure 13.7, page 493, ref. 2)
Ground Pressure at Geosynthetics = 652.4 psf
Length of Dozer Track = 10.7 ft

W_e= 6987 lbs/ft

W_a+W_e (lbs/ft) = 12,580
N_{a+e} (lbs/ft) = 11,934
C_a (lbs/ft) = 93 x c_a

W_p (lbs/ft) = 50
C (lbs/ft) = 79

(W_{a+e} - N_{a+e} x cos β) = 1,258
(C + W_p x tan f) = 106
cos β = 0.95
sin β = 0.32
sin β x tan f = 0.17
sin^2 β x tan f = 0.05
sin β x cos β = 0.30
tan f = 0.53

a= 1193.4
- b= 244.9 0.30
c = 0.05

Solve for FS :

δ (°)	c_a (psf)	tan δ	C_a (lbs/ft)	(N_{a+e} x tan δ + C_a)	b	c	$(b^2 - 4ac)^{0.5}$	Factor of Safety
24.00	*0.00*	*0.4*	0.00	*5,313*	*-1,839*	*283*	*1,426*	*1.4*

SEEPAGE BUILD-UP CONDITION

Veneer Stability based on Koerner/Soong Method (page 501-508, ref. 2)

$$FS = \frac{-b \pm (b^2 - 4 \times a \times c)^{0.5}}{2 \times a}$$

Where:

a = W_a sin β cos β + U_H x (1 - $\cos^2$β)

b = -[Wp x tan f + W_a x ($\sin^2$ β x tan f + $\cos^2$β x tan δ) - U_{AN} x cos β x tan δ - U_{PN} x tan f + U_H x sin β x cos β x (tan f - tan δ)]

c = (W_a x cos β - U_{AN} + U_H x sin β) x sin β x tan δ x tan f)

U_{AN} = $γ_w$ x h_w x (H - 0.5 x h_w x cos β) / tan β

U_H = 0.5 x $γ_w$ x h_w^2

U_{PN} = 0.5 x $γ_w$ x h_w^2 / tan β

W_a = 0.5 x [γ x (h - h_w) x (2 x H x cos β - h - h_w) + $γ_{sat}$ x h_w x (2 x H x cos β - h_w)] / (sin β x cos β)

W_p = 0.5 x [γ x (h^2 - h_w^2) + $γ_{sat}$ x h_w^2] / (sin β x cos β)

U_H = Resultant of the pore water pressures acting on lateral side of the active wedge or passive wedge

U_{PN} = Resultant of the pore water pressures acting on bottom of the passive wedge

U_{AN} = Resultant of the pore water pressures acting on bottom of the active wedge

h = Thickness of the soil layer

h_w = Depth of seepage water in the soil layer (perpendicular to the slope)

$γ_w$ = Unit weight of water

γ = Moisture unit weight of the soil layer

$γ_{sat}$ = Saturated unit weight of the soil layer

Other parameters are same as in the above calculations

γ_w = 62.4 lb/ft^3

h_w = 10.00 inches

H = 30.0 ft

γ_{sat} = 130 lb/ft^3 (Assumed)

U_{AN} = 4618 lbs/ft

U_H = 21.67 lbs/ft

U_{PN} = 65.00 lbs/ft

W_a = 22747 lbs/ft

W_p = 812 lbs/ft

Wp x tan f =	432	$\sin^2 \beta$ x tan f =	0.05
U_{PN} x tan f =	34.56	$\sin \beta$ =	0.32
U_H x sin β x cos β =	6.5000	tan f =	0.53
		$\cos^2 \beta$ =	0.90
		$\cos \beta$ =	0.95

a = 6826

- b= 1610 16084.8172

c = 2853.1

δ (°)	c_a (psf)	tan δ	b	c	$(b^2 - 4ac)^{0.5}$	Factor of Safety
24.0	*0.0*	*0.445*	*-8,771*	*1,270*	*6500*	*1.1*

SUMMARY OF RESULTS

CASE ANALYZED	REQUIRED FACTOR OF SAFETY	CALCULATED FACTOR OF SAFETY	MEETS REQUIREMENT
Long Term using Design Shear Strength	1.5	1.5	Yes
Short Term using Design Shear Strength - Dozer on Slope	1.1	1.4	Yes
Seepage Analysis	1.1	1.1	Yes

Therefore, the stability of the final cover meets the recommended factors of safety provided the cover drainage layer maintains a maximum fluid head condition of no greater than 18 inches above the liner. As such, the cover drainage layer should be designed to maintain this condition.

References:

1. Geotechnical Material Properties Calculation Package, Golder Associates, August 2015

2. Qian, X., Koerner, R. M., Gray, D. H., Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, New Jersey, US, 2002.

3. Dozer Specifications from Manufacturer

4. Golder Associates Inc., Unpublished Database of Direct Shear Laboratory Results.