TVA Calculation Package

Page: 01 of 168

Title Lateral Expansion (Cell 4) Ash Stacking

Location Description: *(Optional)* Lateral Expansion (Cell 4)	**Total Pages:** *(including appendices & attachments)*

Calculation ID *(All parts required to form a unique ID)*:

Org Code	**Location/ Plant Code**	**Branch Code**	**Alphanumeric Part =** Discipline Code (1) + Type Code (1) + "X" + Unit Field (3) + Sys Code (3) + Year (4) + Sequence No. (4)
FPG	KIF	FES	CDX00030020110001

NOTE: When referencing the calculation ID, include all parts without spaces or dashes between them.

Unit(s), Spill gate(s), or Voltages (PSO):	**Key Nouns (For CTS/CCRIS):**
000	CTS

Applicable Design Document(s):	**Rev**	**RIMS/EDMS Accession Number** *(Optional)*
	R0	
	R	
UNID System(s):	**R**	
000	**R**	

	R0	**R**	**R**	**R**
DCN, PCN, NA	RDP-0114-A			
Prepared: Sign➔				
Print Name				
Checked: Sign➔				
Print Name				
	These calculations contain unverified assumption(s) that must be verified later? ☐ Yes ☒ No These calculations contain special requirements and/or limiting conditions? ☐ Yes ☒ No			
Approved: Sign➔				
Print Name				
Approval Date				
	These calculations contain a design output attachment? ☐ Yes ☒ No			
Revision Applicability	☐ Entire calc	☐ Entire calc ☐ Selected pgs	☐ Entire calc ☐ Selected pgs	☐ Entire calc ☐ Selected pgs
	Computer output Microfiche generated? ☐ Yes ☒ No Number: _____			

Purpose of the Calculation: See Title

Abstract:

☒ Electronically file and return calculation to Calculation Library.
☐ Electronically file and return calculation _____ Address: _____

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TVA Calculation Coversheet
CTS Input Form

Preparer	Preparer Login ID	Date
Checker	**Checker Login ID**	**Date**

Update Code: ☐ Add ☐ Change ☐ Delete ☐ Rename ☐ Supersede ☐ Duplicate ☐ Verify

The following section applies if a calculation is being renamed, superseded, or has a duplicate.

	Org Code	Plant	Branch	Number	Cur Rev	New Rev
Current Calc ID:						

The following section applies to all calculations.

Calc ID:	FPG	KIF	FES	CDX00030020110001	0	0

Firm: *(TVA or Contractor)* Contractor - Stantec Consulting Services

Cross-References

A/C/D	Xref Code	Type	Org Code	Plant	Branch	Number	Rev

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TVA Calculation Record of Revision

Calculation Identifier: FPGKIFFESCDX00030020110001

Title Lateral Expansion (Cell 4) Ash Stacking

Revision No.	Description of Revision
Rev 0	These calculations are to support the Lateral Expansion (Cell 4) Ash Stacking project.

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TVA Computer File Storage Information Sheet

Calculation Identifier: FPGKIFFESCDX00030020110001 **Rev.** 0 **Plant:** KIF

Subject: These calculations are to support the Lateral Expansion (Cell 4) Ash Stacking project.

Software Name:	1.) SEDCAD 4, Build 2000.09.07	2.) Slope/W 2007	**Revision Level:**
Vendor Name:	1.) Civil Software Design	2.) Geo-Slope Intl Ltd	
Address:	1.) P.O. Box 706, Ames, IA 50010	2.) 1400,633 6th Avenue SW, Calgary, AB, Canada T2P-2Y5	

Executable Files

☒ No TVA developed **executable files** were used in this calculation.

Comments:

☐ TVA developed **executable files** used in this calculation have been stored electronically and sufficient identifying information is provided below for each executable file. *(Any retrieved file requires re-verification of its contents before use.)*

Input Files

☒ Electronic storage of the **input files** for this calculation is not required.

Comments:

☐ **Input files** for this calculation have been stored electronically and sufficient identifying information is provided below for each input file. *(Any retrieved file requires re-verification of its contents before use.)*

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TVA Calculation Table of Contents

Calculation Identifier: FPGKIFFESCDX00030020110001 **Revision:** 0

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Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Lateral Expansion (Cell 4)** **Ash Stacking**

Document Control Number	RDP-0114-A
Calculation Package	FPGKIFFESCDX00030020110001

Stantec

Exhibit 01
SEDCAD – Ditch No. 5 Watershed

Purpose:

- Determine the peak flow associated with the 25 year-24 hour storm event. (12.1)
- Size the ditch to convey said flow without overtopping.
- Check ditch hydraulics for shear and armor appropriately.
- Meet Section 12 of the Design Basis Criteria Dredge Cell Closure, Kingston Fossil Plant

Methods:

- Use SECAD4 Build 2000.09.07 to model peak flows using TR-55 emulator. (12.3)
- Use precipitation event from NOAA-14. (12.4)
- Use SECAD to model velocities for determination of ditch lining protection. (12.4)

Results:

- Armor Ditch 5 at confluence with flumes.
- Trapezoidal ditch resists scouring sufficiently elsewhere with vegetation
- Flat slopes with trapezoidal configuration convey sufficient flow. Challenge will be in construction.

*Numbers in parentheses references Sections of Design Basis Criteria

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: DEH	*Reviewed by: TC*
Revisions:	

DRAFT

KIF Lateral Expansion

Ditch No.5 Watershed

DRAFT

Darrell Herron

Stantec Consulting Services Inc
1409 N. Forbes Road
Lexington, KY 40511

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 24 hr
Rainfall Depth:	5.470 inches

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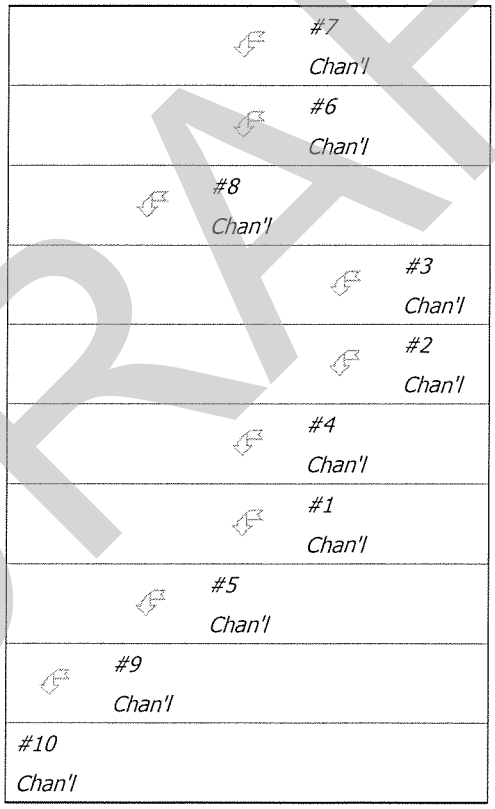
Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#1	==>	#5	0.060	0.256	V-Ditch portion Ditch 5
Channel	#2	==>	#4	0.000	0.000	F-8 western watershed
Channel	#3	==>	#4	0.000	0.000	F-8 eastern watershed
Channel	#4	==>	#5	0.000	0.000	head of Flume 8
Channel	#5	==>	#9	0.237	0.163	trapezoidal segment d-7
Channel	#6	==>	#8	0.000	0.000	F-9 western
Channel	#7	==>	#8	0.000	0.000	F-9 eastern
Channel	#8	==>	#9	0.000	0.000	head of Flume 9
Channel	#9	==>	#10	0.115	0.163	Ditch 7
Channel	#10	==>	End	0.000	0.000	End Ditch 10



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	6. Grassed waterway	1.44	5.60	390.00	1.79	0.060

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Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	**Muskingum K:**					**0.060**
#5	6. Grassed waterway	0.30	2.12	700.00	0.82	0.237
#5	**Muskingum K:**					**0.237**
#9	6. Grassed waterway	0.30	1.03	340.00	0.82	0.115
#9	**Muskingum K:**					**0.115**

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#7	2.370	2.370	8.49	0.77
#6	4.610	4.610	16.29	1.50
#8	0.000	6.980	24.72	2.27
#3	4.600	4.600	16.25	1.50
#2	1.400	1.400	5.10	0.46
#4	0.001	6.001	21.29	1.95
#1	2.220	2.220	8.24	0.72
#5	4.050	12.271	44.01	4.00
#9	5.460	24.711	81.55	8.05
#10	2.420	27.131	80.10	8.84

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Structure Detail:

Structure #7 (Vegetated Channel)

F-9 eastern

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.0:1	6.0:1	1.0	D, B				4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	8.49 cfs		8.49 cfs	
Depth:	1.00 ft		1.61 ft	
Top Width:	11.95 ft		19.36 ft	
Velocity:	1.43 fps		0.54 fps	
X-Section Area:	5.95 sq ft		15.61 sq ft	
Hydraulic Radius:	0.491		0.796	
Froude Number:	0.36		0.11	
Roughness Coefficient:	0.0650		0.2350	

Structure #6 (Vegetated Channel)

F-9 western

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.0:1	6.0:1	1.0	D, B				4.0

Vegetated Channel Results:

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	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	16.29 cfs		16.29 cfs	
Depth:	1.21 ft		1.86 ft	
Top Width:	14.48 ft		22.36 ft	
Velocity:	1.86 fps		0.78 fps	
X-Section Area:	8.74 sq ft		20.83 sq ft	
Hydraulic Radius:	0.595		0.919	
Froude Number:	0.42		0.14	
Roughness Coefficient:	0.0565		0.1799	

Structure #8 (Riprap Channel)

head of Flume 9

Trapezoidal Riprap Channel Inputs:

Material: Riprap

Bottom Width (ft)}	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
8.00	6.0:1	6.0:1	16.7			

Riprap Channel Results:

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	24.72 cfs	
Depth:	0.40 ft	
Top Width:	12.79 ft	
Velocity:	5.96 fps	
X-Section Area:	4.15 sq ft	
Hydraulic Radius:	0.323	
Froude Number:	1.84	
Manning's n:	0.0480	
Dmin:	2.00 in	
D50:	3.00 in	
Dmax:	4.50 in	

Structure #3 (Vegetated Channel)

F-8 eastern watershed

Triangular Vegetated Channel Inputs:

DRAFT

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.0:1	6.0:1	1.0	D, B				4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	16.25 cfs		16.25 cfs	
Depth:	1.21 ft		1.86 ft	
Top Width:	14.47 ft		22.34 ft	
Velocity:	1.86 fps		0.78 fps	
X-Section Area:	8.73 sq ft		20.80 sq ft	
Hydraulic Radius:	0.595		0.918	
Froude Number:	0.42		0.14	
Roughness Coefficient:	0.0565		0.1800	

Structure #2 (Vegetated Channel)

F-8 western watershed

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.0:1	6.0:1	1.0	D, B				4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	5.10 cfs		5.10 cfs	
Depth:	0.86 ft		1.44 ft	
Top Width:	10.30 ft		17.29 ft	
Velocity:	1.15 fps		0.41 fps	
X-Section Area:	4.42 sq ft		12.46 sq ft	
Hydraulic Radius:	0.423		0.711	
Froude Number:	0.31		0.09	
Roughness Coefficient:	0.0726		0.2895	

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Structure #4 (Riprap Channel)

head of Flume 8

Trapezoidal Riprap Channel Inputs:

Material: Riprap

Bottom Width (ft)}	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
8.00	6.0:1	6.0:1	16.7			

Riprap Channel Results:

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	21.29 cfs	
Depth:	0.37 ft	
Top Width:	12.46 ft	
Velocity:	5.60 fps	
X-Section Area:	3.80 sq ft	
Hydraulic Radius:	0.303	
Froude Number:	1.79	
Manning's n:	0.0490	
Dmin:	2.00 in	
D50:	3.00 in	
Dmax:	4.50 in	

Structure #1 (Riprap Channel)

V-Ditch portion Ditch 5

Trapezoidal Riprap Channel Inputs:

Material: Riprap

Bottom Width (ft)}	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
0.00	6.0:1	6.0:1	1.0			

Riprap Channel Results:

PADER Method - Mild Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	8.24 cfs	

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	w/o Freeboard	w/ Freeboard
Depth:	0.74 ft	
Top Width:	8.84 ft	
Velocity:	2.53 fps	
X-Section Area:	3.26 sq ft	
Hydraulic Radius:	0.363	
Froude Number:	0.73	
Manning's n:	0.0300	
Dmin:	1.00 in	
D50:	1.50 in	
Dmax:	3.00 in	

Structure #5 (Vegetated Channel)

trapezoidal segment d-7

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
20.00	6.0:1	6.0:1	1.5	D, B				4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	44.01 cfs		44.01 cfs	
Depth:	0.71 ft		1.22 ft	
Top Width:	28.56 ft		34.62 ft	
Velocity:	2.54 fps		1.32 fps	
X-Section Area:	17.31 sq ft		33.26 sq ft	
Hydraulic Radius:	0.604		0.955	
Froude Number:	0.58		0.24	
Roughness Coefficient:	0.0512		0.1336	

Structure #9 (Vegetated Channel)

Ditch 7

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

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Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
20.00	6.0:1	6.0:1	0.3	D, B				4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	81.55 cfs		81.55 cfs	
Depth:	1.48 ft		2.39 ft	
Top Width:	37.75 ft		48.69 ft	
Velocity:	1.91 fps		0.99 fps	
X-Section Area:	42.71 sq ft		82.12 sq ft	
Hydraulic Radius:	1.124		1.673	
Froude Number:	0.32		0.13	
Roughness Coefficient:	0.0462		0.1157	

Structure #10 (Vegetated Channel)

End Ditch 10

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
20.00	6.0:1	6.0:1	0.3	D, B				4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	80.10 cfs		80.10 cfs	
Depth:	1.47 ft		2.38 ft	
Top Width:	37.62 ft		48.54 ft	
Velocity:	1.89 fps		0.98 fps	
X-Section Area:	42.29 sq ft		81.49 sq ft	
Hydraulic Radius:	1.117		1.665	
Froude Number:	0.31		0.13	
Roughness Coefficient:	0.0464		0.1166	

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#7	1	2.370	0.206	0.000	0.000	86.000	TR55	8.49	0.772
	Σ	**2.370**						**8.49**	**0.772**
#6	1	4.610	0.227	0.000	0.000	86.000	TR55	16.29	1.501
	Σ	**4.610**						**16.29**	**1.501**
#8	1	0.000	0.000	0.000	0.000	86.000	TR55	0.00	0.000
	Σ	**6.980**						**24.72**	**2.273**
#3	1	4.600	0.227	0.000	0.000	86.000	TR55	16.25	1.498
	Σ	**4.600**						**16.25**	**1.498**
#2	1	1.400	0.168	0.000	0.000	86.000	TR55	5.10	0.456
	Σ	**1.400**						**5.10**	**0.456**
#4	1	0.001	0.000	0.000	0.000	86.000	TR55	0.00	0.000
	Σ	**6.001**						**21.29**	**1.954**
#1	1	2.220	0.070	0.000	0.000	86.000	TR55	8.24	0.723
	Σ	**2.220**						**8.24**	**0.723**
#5	1	4.050	0.115	0.000	0.000	86.000	TR55	15.04	1.319
	Σ	**12.271**						**44.01**	**3.996**
#9	1	5.460	0.184	0.000	0.000	86.000	TR55	19.61	1.778
	Σ	**24.711**						**81.55**	**8.047**
#10	1	2.420	0.104	0.000	0.000	86.000	TR55	8.99	0.788
	Σ	**27.131**						**80.10**	**8.835**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	3.53	6.00	170.00	1.870	0.025
		7. Paved area and small upland gullies	1.14	4.00	350.00	2.150	0.045
#1	**1**	**Time of Concentration:**					**0.070**
#2	1	5. Nearly bare and untilled, and alluvial valley fans	1.00	4.10	410.00	1.000	0.113
		6. Grassed waterway	1.00	3.00	300.00	1.500	0.055
#2	**1**	**Time of Concentration:**					**0.168**

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Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#3	1	5. Nearly bare and untilled, and alluvial valley fans	1.00	5.90	590.00	1.000	0.163
		6. Grassed waterway	1.00	3.50	350.00	1.500	0.064
#3	**1**	**Time of Concentration:**					**0.227**
#5	1	5. Nearly bare and untilled, and alluvial valley fans	3.48	8.00	230.00	1.860	0.034
		6. Grassed waterway	0.50	1.55	310.00	1.060	0.081
#5	**1**	**Time of Concentration:**					**0.115**
#6	1	5. Nearly bare and untilled, and alluvial valley fans	1.00	5.90	590.00	1.000	0.163
		6. Grassed waterway	1.00	3.50	350.00	1.500	0.064
#6	**1**	**Time of Concentration:**					**0.227**
#7	1	5. Nearly bare and untilled, and alluvial valley fans	1.00	5.25	525.00	1.000	0.145
		6. Grassed waterway	1.00	3.30	330.00	1.500	0.061
#7	**1**	**Time of Concentration:**					**0.206**
#9	1	5. Nearly bare and untilled, and alluvial valley fans	1.00	2.00	200.00	1.000	0.055
		6. Grassed waterway	1.00	7.00	700.00	1.500	0.129
#9	**1**	**Time of Concentration:**					**0.184**
#10	1	5. Nearly bare and untilled, and alluvial valley fans	1.00	1.59	160.00	1.000	0.044
		5. Nearly bare and untilled, and alluvial valley fans	16.66	4.16	25.00	4.080	0.001
		6. Grassed waterway	1.00	3.19	320.00	1.500	0.059
#10	**1**	**Time of Concentration:**					**0.104**

DRAFT

Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Lateral Expansion (Cell 4)** **Ash Stacking**

Document Control Number	RDP-0114-A
Calculation Package	FPGKIFFESCDX00030020110001

Stantec

Exhibit 02
SEDCAD – Ditch No. 6 Watershed

Purpose:

- Determine the peak flow associated with the 25 year-24 hour storm event. (12.1)
- Size the ditch to convey said flow without overtopping.
- Check ditch hydraulics for shear and armor appropriately.
- Meet Section 12 of the Design Basis Criteria Dredge Cell Closure, Kingston Fossil Plant

Methods:

- Use SECAD4 Build 2000.09.07 to model peak flows using TR-55 emulator. (12.3)
- Use precipitation event from NOAA-14. (12.4)
- Use SECAD to model velocities for determination of ditch lining protection. (12.4)

Results:

- Armor Ditch 6 at segment with 10% slope.
- V- ditch resists scouring sufficiently elsewhere with vegetation.
- V-Ditch conveys sufficient flow.

*Numbers in parentheses references Sections of Design Basis Criteria

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: DEH	*Reviewed by: TC*
Revisions:	

DRAFT

KIF Lateral Expansion

Ditch No.6 Watershed

DRAFT

Darrell Herron

Stantec Consulting Services Inc
1409 N Forbes Road
Lexington, KY 40511

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 24 hr
Rainfall Depth:	5.470 inches

DRAFT

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#1	==>	End	0.000	0.000	Ditch No. 6

#1
Chan'l

DRAFT

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	2.240	2.240	8.32	0.73

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Structure Detail:

Structure #1 (Riprap Channel)

Ditch No. 6

Triangular Riprap Channel Inputs:

Material: Riprap

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
6.0:1	6.0:1	11.0			

Riprap Channel Results:

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	8.32 cfs	
Depth:	0.54 ft	
Top Width:	6.48 ft	
Velocity:	4.76 fps	
X-Section Area:	1.75 sq ft	
Hydraulic Radius:	0.266	
Froude Number:	1.61	
Manning's n:	0.0430	
Dmin:	2.00 in	
D50:	3.00 in	
Dmax:	4.50 in	

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	2.240	0.063	0.000	0.000	86.000	TR55	8.32	0.729
	Σ	**2.240**						**8.32**	**0.729**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	8.57	3.00	35.00	2.920	0.003
		8. Large gullies, diversions, and low flowing streams	1.98	18.00	910.00	4.210	0.060
#1	**1**	**Time of Concentration:**					**0.063**

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Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Lateral Expansion (Cell 4)** **Ash Stacking**

Document Control Number	RDP-0114-A
Calculation Package	FPGKIFFESCDX00030020110001

Stantec

Exhibit 03
SEDCAD – Flume 10 Watershed

Purpose:

- Determine the peak flow associated with the 25 year-24 hour storm event. (12.1)
- Size the ditch to convey said flow without overtopping.
- Check ditch hydraulics for shear and armor appropriately.
- Meet Section 12 of the Design Basis Criteria Dredge Cell Closure, Kingston Fossil Plant

Methods:

- Use SECAD4 Build 2000.09.07 to model peak flows using TR-55 emulator. (12.3)
- Use precipitation event from NOAA-14. (12.4)
- Use SECAD to model velocities for determination of ditch lining protection. (12.4)

Results:

- Armor flume with TDOT A-3 Machined Riprap.
- Armor confluence with Ditch 5.
- Trapezoidal Ditch conveys sufficient flow.

*Numbers in parentheses references Sections of Design Basis Criteria

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: DEH	*Reviewed by: TC*
Revisions:	

DRAFT

KIF-Lateral Expansion

Flume 10 Watershed

DRAFT

Darrell Herron

Stantec Consulting Services Inc
1409 N. Forbes Road
Lexington, KY 40511

General Information

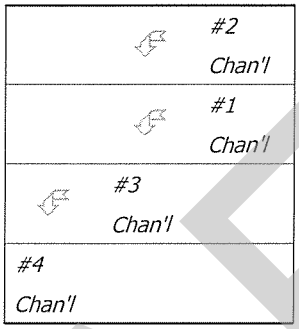
Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 24 hr
Rainfall Depth:	5.470 inches

DRAFT

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#1	==>	#3	0.000	0.000	north watershed
Channel	#2	==>	#3	0.000	0.000	south watershed
Channel	#3	==>	#4	0.002	0.439	head of flume
Channel	#4	==>	End	0.000	0.000	flume at discharge



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#3	8. Large gullies, diversions, and low flowing streams	16.67	15.00	90.00	12.24	0.002
#3	**Muskingum K:**					**0.002**

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#2	1.880	1.880	6.75	0.61
#1	2.830	2.830	9.70	0.92
#3	0.000	4.710	16.37	1.53
#4	0.000	4.710	16.37	1.53

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Structure Detail:

Structure #2 (Vegetated Channel)

south watershed

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.0:1	6.0:1	1.0	D, B				4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	6.75 cfs		6.75 cfs	
Depth:	0.93 ft		1.53 ft	
Top Width:	11.17 ft		18.40 ft	
Velocity:	1.30 fps		0.48 fps	
X-Section Area:	5.20 sq ft		14.10 sq ft	
Hydraulic Radius:	0.459		0.756	
Froude Number:	0.34		0.10	
Roughness Coefficient:	0.0683		0.2582	

Structure #1 (Vegetated Channel)

north watershed

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.0:1	6.0:1	1.0	D, B				4.0

Vegetated Channel Results:

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	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	9.70 cfs		9.70 cfs	
Depth:	1.04 ft		1.66 ft	
Top Width:	12.43 ft		19.93 ft	
Velocity:	1.51 fps		0.59 fps	
X-Section Area:	6.44 sq ft		16.55 sq ft	
Hydraulic Radius:	0.511		0.819	
Froude Number:	0.37		0.11	
Roughness Coefficient:	0.0632		0.2225	

Structure #3 (Riprap Channel)

head of flume

Trapezoidal Riprap Channel Inputs:

Material: Riprap

Bottom Width (ft)}	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
8.00	6.0:1	6.0:1	16.7			

Riprap Channel Results:

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	16.37 cfs	
Depth:	0.33 ft	
Top Width:	11.93 ft	
Velocity:	5.01 fps	
X-Section Area:	3.26 sq ft	
Hydraulic Radius:	0.272	
Froude Number:	1.69	
Manning's n:	0.0510	
Dmin:	2.00 in	
D50:	3.00 in	
Dmax:	4.50 in	

Structure #4 (Riprap Channel)

flume at discharge

Trapezoidal Riprap Channel Inputs:

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Material: Riprap

Bottom Width (ft)}	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
8.00	6.0:1	6.0:1	16.7			

Riprap Channel Results:

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	16.37 cfs	
Depth:	0.33 ft	
Top Width:	11.93 ft	
Velocity:	5.01 fps	
X-Section Area:	3.26 sq ft	
Hydraulic Radius:	0.272	
Froude Number:	1.69	
Manning's n:	0.0510	
Dmin:	2.00 in	
D50:	3.00 in	
Dmax:	4.50 in	

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#2	1	1.880	0.203	0.000	0.000	86.000	TR55	6.75	0.612
	∑	**1.880**						**6.75**	**0.612**
#1	1	2.830	0.220	0.000	0.000	86.000	TR55	9.70	0.922
	∑	**2.830**						**9.70**	**0.922**
#3	1	0.000	0.000	0.000	0.000	86.000	TR55	0.00	0.000
	∑	**4.710**						**16.37**	**1.534**
#4	1	0.000	0.000	0.000	0.000	86.000	TR55	0.00	0.000
	∑	**4.710**						**16.37**	**1.534**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	1.00	5.40	540.00	1.000	0.150
		6. Grassed waterway	1.00	3.80	380.00	1.500	0.070
#1	**1**	**Time of Concentration:**					**0.220**
#2	1	5. Nearly bare and untilled, and alluvial valley fans	1.00	4.79	480.00	1.000	0.133
		6. Grassed waterway	1.00	3.80	380.00	1.500	0.070
#2	**1**	**Time of Concentration:**					**0.203**

DRAFT

Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Lateral Expansion (Cell 4)** **Ash Stacking**

Document Control Number	RDP-0114-A
Calculation Package	FPGKIFFESCDX00030020110001

Stantec

Exhibit 04
SEDCAD – Flume 11 Watershed

Purpose:

- Determine the peak flow associated with the 25 year-24 hour storm event. (12.1)
- Size the ditch to convey said flow without overtopping.
- Check ditch hydraulics for shear and armor appropriately.
- Meet Section 12 of the Design Basis Criteria Dredge Cell Closure, Kingston Fossil Plant

Methods:

- Use SECAD4 Build 2000.09.07 to model peak flows using TR-55 emulator. (12.3)
- Use precipitation event from NOAA-14. (12.4)
- Use SECAD to model velocities for determination of ditch lining protection. (12.4)

Results:

- Armor flume with TDOT A-3 Machined Riprap.
- Armor confluence with Ditch 5.
- Trapezoidal Ditch conveys sufficient flow.

*Numbers in parentheses references Sections of Design Basis Criteria

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: DEH	*Reviewed by: TC*
Revisions:	

DRAFT

KIF Lateral Expansion

Flume 11 Watershed

DRAFT

Darrell Herron

Stantec Consulting Services, Inc
1409 N. Forbes Road
Lexington, KY 40511

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 24 hr
Rainfall Depth:	5.470 inches

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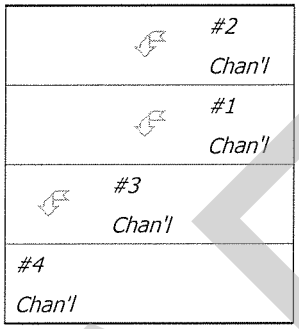
Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#1	==>	#3	0.000	0.000	East watershed
Channel	#2	==>	#3	0.000	0.000	West Watershed
Channel	#3	==>	#4	0.002	0.439	Head of flume
Channel	#4	==>	End	0.000	0.000	Flume Outlet



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#3	8. Large gullies, diversions, and low flowing streams	16.66	16.66	100.00	12.24	0.002
#3	**Muskingum K:**					**0.002**

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#2	2.200	2.200	7.90	0.72
#1	0.710	0.710	2.64	0.23
#3	0.000	2.910	10.40	0.95
#4	0.000	2.910	10.40	0.95

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Structure Detail:

Structure #2 (Vegetated Channel)

West Watershed

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.0:1	60.0:1	1.0	D, B				4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	7.90 cfs		7.90 cfs	
Depth:	0.59 ft		1.08 ft	
Top Width:	38.81 ft		71.28 ft	
Velocity:	0.69 fps		0.21 fps	
X-Section Area:	11.41 sq ft		38.49 sq ft	
Hydraulic Radius:	0.294		0.540	
Froude Number:	0.23		0.05	
Roughness Coefficient:	0.0948		0.4812	

Structure #1 (Vegetated Channel)

East watershed

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.0:1	6.0:1	1.0	D, B				4.0

Vegetated Channel Results:

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	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	2.64 cfs		2.64 cfs	
Depth:	0.71 ft		1.25 ft	
Top Width:	8.47 ft		14.94 ft	
Velocity:	0.88 fps		0.28 fps	
X-Section Area:	2.99 sq ft		9.30 sq ft	
Hydraulic Radius:	0.348		0.614	
Froude Number:	0.26		0.06	
Roughness Coefficient:	0.0836		0.3794	

Structure #3 (Riprap Channel)

Head of flume

Trapezoidal Riprap Channel Inputs:

Material: Riprap

Bottom Width (ft)}	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
8.00	6.0:1	6.0:1	16.7			

Riprap Channel Results:

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	10.40 cfs	
Depth:	0.24 ft	
Top Width:	10.90 ft	
Velocity:	4.55 fps	
X-Section Area:	2.28 sq ft	
Hydraulic Radius:	0.209	
Froude Number:	1.75	
Manning's n:	0.0470	
Dmin:	2.00 in	
D50:	3.00 in	
Dmax:	4.50 in	

Structure #4 (Riprap Channel)

Flume Outlet

Trapezoidal Riprap Channel Inputs:

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Material: Riprap

Bottom Width (ft)}	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
8.00	6.0:1	6.0:1	16.7			

Riprap Channel Results:

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	10.40 cfs	
Depth:	0.24 ft	
Top Width:	10.90 ft	
Velocity:	4.55 fps	
X-Section Area:	2.28 sq ft	
Hydraulic Radius:	0.209	
Froude Number:	1.75	
Manning's n:	0.0470	
Dmin:	2.00 in	
D50:	3.00 in	
Dmax:	4.50 in	

DRAFT

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#2	1	2.200	0.184	0.000	0.000	86.000	TR55	7.90	0.716
	Σ	**2.200**						**7.90**	**0.716**
#1	1	0.710	0.123	0.000	0.000	86.000	TR55	2.64	0.231
	Σ	**0.710**						**2.64**	**0.231**
#3	1	0.000	0.000	0.000	0.000	86.000	TR55	0.00	0.000
	Σ	**2.910**						**10.40**	**0.948**
#4	1	0.000	0.000	0.000	0.000	86.000	TR55	0.00	0.000
	Σ	**2.910**						**10.40**	**0.948**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	1.00	3.00	300.00	1.000	0.083
		6. Grassed waterway	1.00	2.18	218.00	1.500	0.040
#1	**1**	**Time of Concentration:**					**0.123**
#2	1	5. Nearly bare and untilled, and alluvial valley fans	1.00	5.00	500.00	1.000	0.138
		6. Grassed waterway	1.00	2.50	250.00	1.500	0.046
#2	**1**	**Time of Concentration:**					**0.184**

DRAFT

Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Lateral Expansion (Cell 4)** **Ash Stacking**

Document Control Number	RDP-0114-A
Calculation Package	FPGKIFFESCDX00030020110001

Stantec

Exhibit 05
SEDCAD – Flume 12 Watershed

Purpose:

- Determine the peak flow associated with the 25 year-24 hour storm event. (12.1)
- Size the ditch to convey said flow without overtopping.
- Check ditch hydraulics for shear and armor appropriately.
- Meet Section 12 of the Design Basis Criteria Dredge Cell Closure, Kingston Fossil Plant

Methods:

- Use SECAD4 Build 2000.09.07 to model peak flows using TR-55 emulator. (12.3)
- Use precipitation event from NOAA-14. (12.4)
- Use SECAD to model velocities for determination of ditch lining protection. (12.4)

Results:

- Armor flume with TDOT A-3 Machined Riprap.
- Armor confluence with Ditch 5.
- Trapezoidal Ditch conveys sufficient flow.

*Numbers in parentheses references Sections of Design Basis Criteria

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: DEH	*Reviewed by: TC*
Revisions:	

DRAFT

KIF Lateral Expansion

Flume 12 Watershed

DRAFT

Darrell Herron

Stantec Consulting Services, Inc
1409 N. Forbes Road
Lexington, KY 40511

General Information

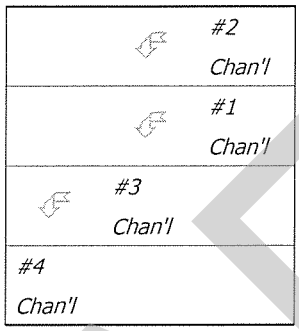
Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 24 hr
Rainfall Depth:	5.470 inches

DRAFT

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#1	==>	#3	0.000	0.000	East Watershed
Channel	#2	==>	#3	0.000	0.000	West Watershed
Channel	#3	==>	#4	0.000	0.000	Head fo Flume
Channel	#4	==>	End	0.000	0.000	Flume outlet



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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#2	4.090	4.090	13.95	1.33
#1	3.100	3.100	11.22	1.01
#3	0.001	7.191	25.10	2.34
#4	0.001	7.192	25.10	2.34

DRAFT

Structure Detail:

Structure #2 (Vegetated Channel)

West Watershed

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.0:1	6.0:1	1.0	D, B				4.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	13.95 cfs		13.95 cfs	
Depth:	1.15 ft		1.80 ft	
Top Width:	13.84 ft		21.60 ft	
Velocity:	1.75 fps		0.72 fps	
X-Section Area:	7.98 sq ft		19.44 sq ft	
Hydraulic Radius:	0.569		0.888	
Froude Number:	0.41		0.13	
Roughness Coefficient:	0.0584		0.1917	

Structure #1 (Vegetated Channel)

East Watershed

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.0:1	6.0:1	1.0	D, B				4.0

Vegetated Channel Results:

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	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	11.22 cfs		11.22 cfs	
Depth:	1.08 ft		1.72 ft	
Top Width:	12.97 ft		20.58 ft	
Velocity:	1.60 fps		0.64 fps	
X-Section Area:	7.01 sq ft		17.65 sq ft	
Hydraulic Radius:	0.533		0.846	
Froude Number:	0.38		0.12	
Roughness Coefficient:	0.0612		0.2095	

Structure #3 (Riprap Channel)

Head fo Flume

Trapezoidal Riprap Channel Inputs:

Material: Riprap

Bottom Width (ft)}	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
8.00	6.0:1	6.0:1	16.7			

Riprap Channel Results:

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	25.10 cfs	
Depth:	0.40 ft	
Top Width:	12.83 ft	
Velocity:	5.99 fps	
X-Section Area:	4.19 sq ft	
Hydraulic Radius:	0.325	
Froude Number:	1.85	
Manning's n:	0.0480	
Dmin:	2.00 in	
D50:	3.00 in	
Dmax:	4.50 in	

Structure #4 (Riprap Channel)

Flume outlet

Trapezoidal Riprap Channel Inputs:

DRAFT

Material: Riprap

Bottom Width (ft)}	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
8.00	6.0:1	6.0:1	16.7			

Riprap Channel Results:

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	25.10 cfs	
Depth:	0.40 ft	
Top Width:	12.83 ft	
Velocity:	5.99 fps	
X-Section Area:	4.19 sq ft	
Hydraulic Radius:	0.325	
Froude Number:	1.85	
Manning's n:	0.0480	
Dmin:	2.00 in	
D50:	3.00 in	
Dmax:	4.50 in	

DRAFT

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#2	1	4.090	0.223	0.000	0.000	86.000	TR55	13.95	1.332
	Σ	**4.090**						**13.95**	**1.332**
#1	1	3.100	0.176	0.000	0.000	86.000	TR55	11.22	1.010
	Σ	**3.100**						**11.22**	**1.010**
#3	1	0.001	0.000	0.000	0.000	86.000	TR55	0.00	0.000
	Σ	**7.191**						**25.10**	**2.342**
#4	1	0.001	0.000	0.000	0.000	86.000	TR55	0.00	0.000
	Σ	**7.192**						**25.10**	**2.342**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	1.00	4.69	470.00	1.000	0.130
		6. Grassed waterway	1.00	2.50	250.00	1.500	0.046
#1	**1**	**Time of Concentration:**					**0.176**
#2	1	5. Nearly bare and untilled, and alluvial valley fans	1.00	6.39	640.00	1.000	0.177
		6. Grassed waterway	1.00	2.50	250.00	1.500	0.046
#2	**1**	**Time of Concentration:**					**0.223**

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Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Lateral Expansion (Cell 4)** **Ash Stacking**

Document Control Number	RDP-0114-A
Calculation Package	FPGKIFFESCDX00030020110001

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Exhibit 06
Slope Stability Narrative

Purpose:

- Evaluate the stability of the ash stacking outslopes for static load conditions. (3.1)
- Develop threshold limits for geotechnical instrumentation monitoring during construction of the ash embankments. (3.2)(4.1.7)
- Meet Section 3 of the Design Basis Criteria Dredge Cell Closure, Kingston Fossil Plant

Methods:

- Conventional, two-dimensional, limit-equilibrium slope stability analyses. (3.1)
- Use SLOPE/W software, from GEO-SLOPE International, Ltd., of Calgary, Alberta, Canada (www.geo-slope.com) for drained, effective stress stability analyses. (3.2)
- Use UTEXAS 4 software, from ENSOFT, Inc., of Austin, Texas (www.ensoftinc.com) for undrained stability analysis using the 3-stage approach. (3.2)
- Use classic lateral earth pressures for deep-seated wedge block stability analyses. (3.2)

Results:

- Drained, effective stress stability analyses were performed on six representative cross sections; results for various excess pore water pressures generated by embankment loading are included.
- Undrained stability analyses were performed on two cross sections, indicating unstable condition if fully undrained condition is triggered.
- Results of wedge block analyses indicated that the deep-seated failure was not a controlling failure mode.
- Threshold limits for geotechnical instrumentation monitoring were established.

*Numbers in parentheses references Sections of Design Basis Criteria

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: YW	*Reviewed by:* KDL
Revisions:	

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Issued for Review 90%

Slope Stability Analyses

Lateral Expansion (Cell 4) Ash Stacking
Kingston Fossil Plant
Harriman, Roane County, Tennessee

1. Introduction

In association with ongoing ash recovery efforts at the Kingston Fossil Plant, Stantec Consulting Services Inc. (Stantec) is providing design and engineering services for the planned ash stacking across the Lateral Expansion area. The ash embankment will have maximum side slopes of 6 horizontal to 1 vertical (6H:1V) with cross slopes of 1 percent to a peak elevation of approximately 783 feet. Footprint and slope configurations are shown on the "*Lateral Expansion (Cell 4) Ash Stacking"* plans submitted to Tennessee Valley Authority (TVA).

Foundation materials across the subject Lateral Expansion footprint consist of saturated, loose, hydraulically placed fly ash underlain by soft to loose, alluvial deposits of lean clay and silty sand to sandy silt. Slope stability is a primary concern when constructing an embankment over weak foundation soils. The rate of fill placement will often need to be regulated such that excess pore water pressures due to embankment loadings can dissipate and fully undrained conditions do not develop. Field observations, including quantitative measurements obtained from geotechnical instrumentation, are considered an integral part of constructing embankments across similar foundation conditions successfully. In order to monitor vertical consolidation, lateral movements, and excess pore water pressures generated by embankment loading, settlement plates, slope inclinometers, and piezometers are proposed at selected locations. Data measured from these instruments will be monitored during embankment construction as part of the quality control program.

2. Test Embankment Program

A test embankment was successfully constructed across a portion of the Central Dredge Cell in accordance with approved program documents. The completed test embankment has tiers at about mean elevation 777, elevation 794 and elevation 801 feet. These tiers are sloped to drain at approximately one percent, so elevations vary. There are two outslope benches with minimum 30-foot widths. The side slope of each tier is about 3H:1V; thus the overall slope is roughly 5.2H:1V. The final crest elevation of the test embankment is about 802 feet. Extensive geotechnical instrumentation consisting of settlement plates, slope inclinometers and piezometers were installed and monitored as part of the quality control program. The intent was to evaluate the rate of embankment construction as well as to provide a forewarning of instability, thus allowing remedial measures to be implemented before critical situations arise. The collected data is also being used to support continued site design activities.

Final threshold limits developed for the test embankment program were presented in Stantec's letter "*Revised Instrumentation Monitoring Criteria*", dated January 6, 2010. These limits were developed based on the results of effective stress stability analyses conducted on representative test embankment cross sections during construction and engineering judgments.

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"Piezometers – Embankment filling may continue, with regular monitoring frequency, as long as the ratio of excess pore pressure to the applied embankment load is 10 percent or below. When the excess pore pressure ratio within ***native foundation soil layers*** *ranges from 10 to 15 percent, embankment filling may continue, but with an increase in instrumentation monitoring specified by the QC Manager. All fill placements shall stop immediately when the excess pore pressure ratio is above the 15 percent level within the* ***native foundation soil layers****. Embankment filling shall stop immediately when the excess pore pressure ratio is above the 10 percent level within* ***wet (foundation) ash layers****. All excess pore pressure measurements shall be evaluated from baseline data values.*

Slope Inclinometers and Settlement Plates – Embankment filling may continue with regular monitoring frequency, as long as the displacement ratio of lateral inclinometer movement to vertical settlement plate movement is 20 percent or below. When the displacement ratio ranges from 20 to 30 percent, embankment filling may continue, but with increase in instrumentation monitoring specified by the QC Manager. All fill placements shall stop immediately when the displacement ratio is above the 30 percent level.

Following a stoppage, embankment filling in affected areas may resume based on the discretion of the QC Manager and engineering considerations on embankment stability. It should be noted that embankment loading may be restricted and/or modified at the discretion of the QC Manager based on other potential unstable conditions not outlined herein."

The test embankment program is considered a valuable field demonstration program. It verified the methodologies of constructing an embankment over challenging foundation conditions located across portions of the Central Dredge Cell. It also demonstrated the importance of using geotechnical instrumentation data to avoid potential slope failures. The confidence and experience gained from the test embankment program will serve as the basis for future embankment design and construction activities across the site.

3. Stability Analyses

Two-dimensional, limit equilibrium stability analyses were performed on selected cross sections using Spencer's method, as implemented in computer programs SLOPE/W (from Geo-Slope International) and UTEXAS4 (from Shinoak Software). A total of six cross sections, designated as A through F and shown on the drawing provided in Exhibit 07, were selected for the analyses. These cross sections were judged to be representative relative to slope stability based on the proposed grading configurations. Groundwater levels were generally assumed based on the surface water elevations in the adjacent Ash Pond, Stilling Pond, and Watts Bar Lake.

Soil parameters used in the analyses, as summarized in Table 1, were previously determined. These parameters, along with the supporting field and laboratory data, are documented in a Stantec's report entitled "*Material Properties for Geotechnical Analysis – Dredge Cell Closure Plan*", dated May 27, 2010. Borings advanced around the Lateral Expansion area indicated similar materials as those encountered in the Dredge Cell. A thin layer of sensitive silt and clay at the base of the existing ash deposits was suggested by AECOM as one of the root causes of the Dredge Cell failure in December 2008. As detailed in the aforementioned material property report, this material was characterized to have slightly higher strengths (both drained and undrained) than the hydraulically placed ash. Its

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strengths were then conservatively assumed to be the same as those of the ash material and this thin layer was not defined separately in the stability models.

Table 1 – Material Parameters used in Stability Analyses

Material Name	Unit Weight		Static Drained Strength		Static Undrained Strength	
	γ_m, (pcf)	γ_{sat}, (pcf)	ϕ', (deg.)	c', (psf)	ϕ, (deg.)	c, (psf)
Hydraulically Placed Ash	100	107	25	0	10	0
Landfilled Ash Embankment	109	111	30	0	30	0
Lean Clay Foundation Soil	--	130	32	0	24	0
Sandy Silt to Silty Sand	--	128	30	0	12	1,000

3.1 Static Stability Criteria

The design criteria for this project require a factor of safety of 1.3 or greater for slope stability during construction and 1.5 for long-term conditions. These criteria are presented in the project document entitled "*Kingston Ash Recovery Project (KRP), Design Basis and Criteria*", prepared by Stantec and dated October 20, 2010.

3.2 Undrained Strength Analyses

First, undrained strength analyses were performed using the three-stage analysis approach implemented in the computer program UTEXAS4. The purpose of these analyses is to assess whether the planned construction should be closely monitored through a detailed geotechnical instrumentation program (i.e. calculated factors of safety below 1.3 for relatively instantaneous loading conditions). Because the ash embankment will be constructed over the existing loose, saturated hydraulically placed ash, and this foundation material exhibits a brittle stress-strain behavior with the peak undrained strength occurring at a relatively low strain, there are concerns that the embankment construction could trigger a static, undrained failure.

The three-stage analysis approach was discussed and agreed upon by TVA, AECOM, and Stantec to compute factors of safety for the static, undrained failure scenario. The three-stage computation consists of three complete sets of stability calculations. The first stage involves stability analysis of the slope using the conventional effective stress approach to calculate both effective normal stresses and shear stresses along the potential slip surface. These stresses represent the anisotropic consolidation stresses and are used to calculate the undrained shear strengths (to be used in the second stage calculation) for materials without free drainage. The second stage involves stability analysis of the slope using the computed undrained shear strengths. The third stage computation compares the drained and undrained shear strengths at each slice base along the potential slip surface, and selects the lower strength to compute the final factor of safety for the slope. This method was adopted by the U.S. Army Corps of Engineers for rapid drawdown analyses, and is described in EM 1110-2-1902 and Duncan and Wright (2005)[1]. The constructed ash

[1] Duncan, J. M., and Wright, S. G. (2005), *Soil Strength and Slope Stability,* John Wiley & Sons

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embankment was modeled as a distributed load and was not included in the first stage computation, thus, the estimated undrained shear strengths of the foundation soils did not consider the contributions due to consolidation under the embankment load. The distributed load was used in the second and third stage calculations to account for the weight of the embankment.

A linear interpolation scheme is used in the three-stage analysis to determine the undrained strength of anisotropically consolidated soils. The interpolation is based on two limiting strength envelopes, representing the fully drained strength and the undrained strength of an isotropically consolidated soil sample. Both of these envelopes represent a relationship between the shear strength and the effective normal consolidation stress on the failure plane. The envelopes correspond to effective principal stress ratios ($K_c=\sigma'_1/\sigma'_3$) at consolidation of K_f and 1, respectively, and are defined by an intercept and a slope. The envelope corresponding to $K_c=K_f$ is identical to the conventional effective stress shear strength envelope. Thus, its intercept ($d_{Kc=Kf}$) is the same as the effective stress cohesion value (c') and its slope ($\psi_{Kc=kf}$) is the same as the effective stress friction angle (ϕ'). The K_c=1 envelope can be derived from the total stress cohesion value (c) and the total stress friction angle (ϕ), as determined from conventional CU triaxial compression tests. When c and ϕ are obtained from a line drawn tangent to the total stress Mohr's circles, the relationships among the intercept ($d_{Kc=1}$) and slope ($\psi_{Kc=1}$) of the K_c=1 envelope, the total stress c and ϕ, and the effective stress ϕ' are (Duncan and Wright 2005):

$$d_{k_c=1} = c\left(\frac{\cos\phi\cos\phi'}{1-\sin\phi}\right)$$

$$\psi_{k_c=1} = \tan^{-1}\left(\frac{\sin\phi\cos\phi'}{1-\sin\phi}\right)$$

Values of $d_{Kc=1}$ and $\psi_{Kc=1}$ for different soils are presented on the enclosed UTEXAS4 output plot (Appendix A1).

Cross sections A and F were selected for the undrained analysis. The calculated factors of safety are 0.89 and 0.94, respectively. The UTEXAS output files for these sections are provided in Exhibit 08. These results were considered conservative because of the following assumptions in the analysis. First, the load of the entire ash embankment was applied instantaneously in the model, while in reality the embankment will be constructed over a period of time. Second, the ash embankment was modeled as a distributed load, thus slip resistance from the embankment was not taken into account in the analysis. Although the calculated factors of safety are somewhat conservative, the fact that they are far below the required criterion of 1.3 indicates the high risk of a static, undrained failure if no precautions are taken during construction. Hence, a geotechnical instrumentation and monitoring program needs to be implemented so that the measured data can be used to regulate construction activities and engineering judgment can be made to reduce the potential for static, undrained slope failures.

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3.3 Effective Stress Analyses

As discussed by Dr. Charles C. Ladd (1991)[2] in the twenty-second Karl Terzaghi lecture, slope stability evaluation of embankments across soft foundations is very complex and undrained strength analysis accounting for shear-induced pore water pressures appears to be more appropriate. However, because the main purpose of this document is to develop quantitative criteria for the planned piezometers, effective stress analyses were subsequently performed with varying excess pore water pressures generated by the weight of the embankment. As mentioned earlier, threshold limits for the test embankment were also based on effective stress analyses. Movements of embankment slopes and foundation soils will be closely monitored by the installed instruments and construction sequence will be adjusted accordingly such that shear-induced excess pore water pressures would not be significant. All effective stress analyses were performed using the computer program SLOPE/W.

The results of the effective stress analyses indicate the failure mode is generally circular for all six evaluated cross sections. This failure mode is considered reasonable, given the material strength characterizations summarized in Table 1. Because surficial failures (shallow sloughing of material parallel to the slope face) pose little risk to the overall embankment stability, only deep failures were considered in the analyses. The deep failures were specified by defining a minimum sliding depth of 10 feet. As shown on the SLOPE/W output plots (Exhibit 09), the bases of the critical slip surfaces are within the hydraulically placed ash material for all six analyzed cross sections.

The calculated factors of safety are summarized in Table 2. Since all the soils are characterized as purely frictional materials (c' = 0), deeper failure surfaces will result in higher factors of safety. For slip surfaces deeper than 10 feet, the factors of safety will be greater than those presented in Table 2.

In the effective stress analyses, excess pore water pressures generated by embankment loading were applied to the hydraulically placed ash and the alluvial foundation soil layers in addition to the static pore water pressure associated with the groundwater table. The excess pore water pressure ratio (r_u) was defined as

$$r_u = \frac{\Delta u}{\Delta \sigma_v}$$

Where:

Δu : *increase in pore water pressure at a location*

$\Delta \sigma_v$: *increase in vertical stress due to added embankment weight at the same location*

The ratio (r_u) was varied from 0 (no excess pore water pressure) to 100 percent (the entire embankment weight is transferred to excess pore water pressure). It should be noted that the r_u = 0 case is equivalent to the long-term, drained condition. The change of r_u was implemented by using the *B-bar* function in SLOPE/W.

[2] Charles C. Ladd, *Stability Evaluation During Staged Construction*, Journal of Geotechnical Engineering, Vol. 117, No. 4, April, 1991.

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Table 2 – Results of Effective Stress Stability Analyses

Excess P.W.P Ratio (%)	Calculated Factors of Safety					
	Cross Section A	Cross Section B	Cross Section C	Cross Section D	Cross Section E	Cross Section F
0	2.64	3.33	2.88	2.60	2.94	2.57
10	2.55	3.22	2.78	2.53	2.84	2.51
20	2.46	3.10	2.66	2.44	2.73	2.44
30	2.36	2.97	2.53	2.35	2.61	2.36
40	2.25	2.84	2.41	2.26	2.50	2.28
50	2.12	2.69	2.28	2.17	2.33	2.18
60	2.04	2.55	2.14	2.06	2.14	2.08
70	1.89	2.39	2.01	1.89	1.94	1.97
80	1.72	2.23	1.82	1.70	1.73	1.82
90	1.55	2.04	1.62	1.52	1.54	1.65
100	1.34	1.85	1.40	1.25	1.32	1.45

Note: The above effective stress analyses are intended to provide a consistent comparison against those previously conducted for the test embankment program. Results are not to be used to establish threshold limits during construction. Recommended limits are consistent with those used in the test embankment program and are outlined in Section 14.4 of the QC Plan.

3.4 Wedge Block Analyses

Supplemental wedge block analyses were carried out for cross sections D and F to evaluate the potential impact of the planned ash stacking on Dike C and the need for backfilling the existing channel to the east of the Lateral Expansion, respectively. The slip surfaces were assumed to be within the sensitive silt/clay layer at the interface of the hydraulically placed ash and the lean clay foundation soil. Fully undrained conditions were assumed to have been triggered in the sensitive silt/clay layer. Classic active and passive earth pressures were used in the calculations.

Details of the analyses are presented in the handwritten calculations (Exhibit 10). The calculated factors of safety are 2.6 and 3.5 for cross sections D and F, respectively. These results indicate that the planned ash stacking will not adversely impact the Dike C stability and there is no need for backfilling the channel to the east of the Lateral Expansion.

4. Conclusions and Recommendations

The following conclusions and recommendations are based on the results of the stability analyses presented herein in conjunction with our engineering judgments as well as the established threshold limits used in the test embankment program.

- The evaluated landfilled ash embankment geometries exceed the minimum required factor of safety of 1.5 under long-term, drained conditions (equivalent to r_u = 0). The calculated factors of safety with r_u = 0 range from 2.57 (cross section F) to 3.33 (cross section B).

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- The three-stage analyses performed on the cross sections A and F slopes result in undrained factors of safety (0.89 and 0.94) far below the minimum required short-term factor of safety of 1.3, indicating a potential for embankment failure if fully undrained conditions are triggered within the wet foundation layers. Thus, geotechnical instrumentation needs to be installed, and embankment construction needs to be monitored to reduce the potential for undrained slope failures. The completed test embankment program demonstrates that this is a proven method to proceed with the planned embankment construction in a safe manner.

- The results of the effective stress analyses indicate that all evaluated cross sections with the exception of cross section D would have short-term factors of safety greater than 1.3, even with r_u = 1. These results are considered unconservative because shearing will induce additional excess pore water pressure due to the contractive behavior of the hydraulically placed ash. Results of the three-stage undrained analyses on cross sections A and F indicate factors of safety of 0.89 and 0.94, which are much smaller than the effective stress factors of safety of 1.34 and 1.45 on the same cross sections at r_u = 1. The difference in undrained and effective stress factors of safety indicates the significance of shear-induced excess pore water pressure. Hence, movements of embankment slopes and foundation soils (settlement plates and slope inclinometers) must be closely monitored in conjunction with the piezometers. If the measured data indicate signs of incipient significant movements, engineering evaluations must be carried out and construction activities must be adjusted accordingly such that fully undrained conditions would not be triggered.

- The purpose of the effective stress analyses presented herein is to provide some guidelines on selecting threshold limits for piezometer monitoring. Because these analyses only include the excess pore water pressures generated by embankment loading, while other excess pore water pressures (such as shear-induced) are not considered, the results are unconservative. Hence, selection of piezometer threshold limits requires engineering judgments and the results presented in Table 2 should not be used directly. Considering the successful experience with the test embankment program, we recommend the same instrumentation monitoring criteria used for the test embankment (see Section 2 – Test Embankment Program) be adopted for the current ash stacking plan.

- The results of the wedge block analyses indicate that the deep block failure is not a controlling failure mode. The planned ash stacking in the Lateral Expansion area has no adverse impact on the Dike C stability. The existing channel to the east of the Lateral Expansion does not need to be backfilled from a slope stability perspective.

- The six analyzed cross sections are selected from the final ash stacking configurations. For monitoring purposes, we have prepared an instrumentation plan, submitted along with the "*Lateral Expansion (Cell 4) Ash Stacking"* plan. The proposed instruments are planned to achieve a full coverage of the entire stacking footprint.

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Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Lateral Expansion (Cell 4)** **Ash Stacking**

Document Control Number	RDP-0114-A
Calculation Package	FPGKIFFESCDX00030020110001

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Exhibit 07
Stability Analysis Section Locations

Purpose:

- Select representative cross sections for slope stability evaluations. (3.1)(3.2)
- Meet Section 3 of the Design Basis Criteria Dredge Cell Closure, Kingston Fossil Plant

Methods:

- Use engineering judgment to select cross sections representing the range of subsurface conditions and ground surface geometries. (3.1)(3.2)

Results:

- Six cross sections were selected for drained, effective stress stability analyses.
- Two cross sections were selected for undrained stability analyses.
- Two cross sections were selected for deep-seated wedge block stability analyses.

*Numbers in parentheses references Sections of Design Basis Criteria

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: YW	*Reviewed by: KDL*
Revisions:	

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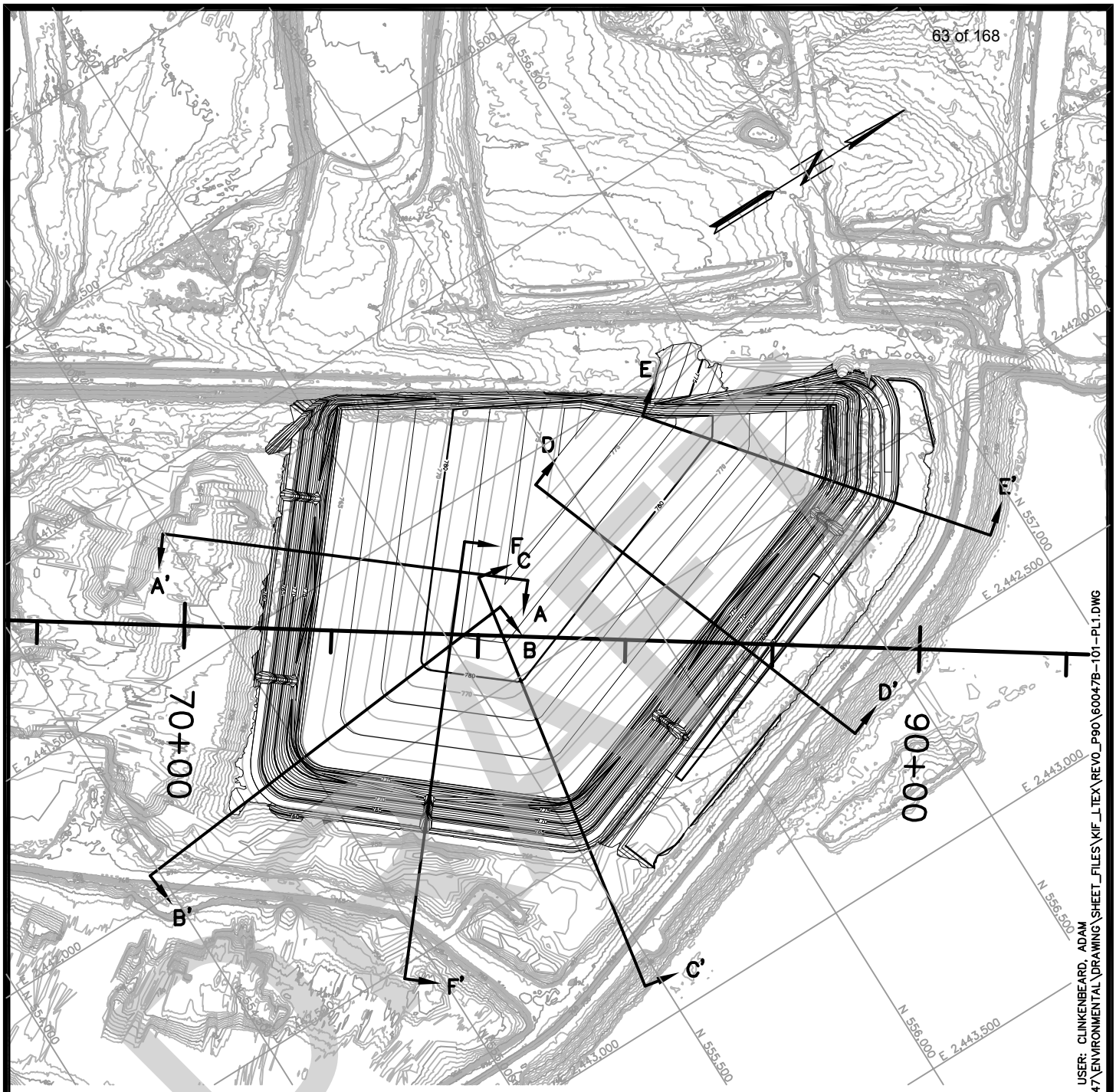

NOTE:
TOPOGRAPHIC MAPPING WAS GENERATED FROM A LIDAR SURVEY PERFORMED ON JANUARY 24, 2011 BY TUCK MAPPING SOLUTIONS, INC., MERGED WITH THE SUBGRADE PLAN AND SUPPLEMENTED WITH A HYDROGRAPHIC SURVEY PERFORMED ON FEBRUARY 7, 2011 BY THE TENNESSEE VALLEY AUTHORITY.

STABILITY ANALYSIS SECTION LOCATIONS
LATERAL EXPANSION (CELL 4)
ASH STACKING - RDP-0114-A

Stantec

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Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Lateral Expansion (Cell 4)** **Ash Stacking**

Document Control Number	RDP-0114-A
Calculation Package	FPGKIFFESCDX00030020110001

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Exhibit 08
Stability Analysis – Cross Sections A & F (FSul)

Purpose:

- Evaluate slope stability under undrained loading conditions to assess the need for geotechnical instrumentation monitoring during construction. (3.2)(4.1.7)
- Meet Section 3 of the Design Basis Criteria Dredge Cell Closure, Kingston Fossil Plant

Methods:

- Use the 3-stage approach implemented in UTEXAS 4 software. (3.2)(4.1.7)

Results:

- Factors of safety of less than 1.0 were calculated, indicating the need for construction monitoring.

*Numbers in parentheses references Sections of Design Basis Criteria

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: YW	*Reviewed by: KDL*
Revisions:	

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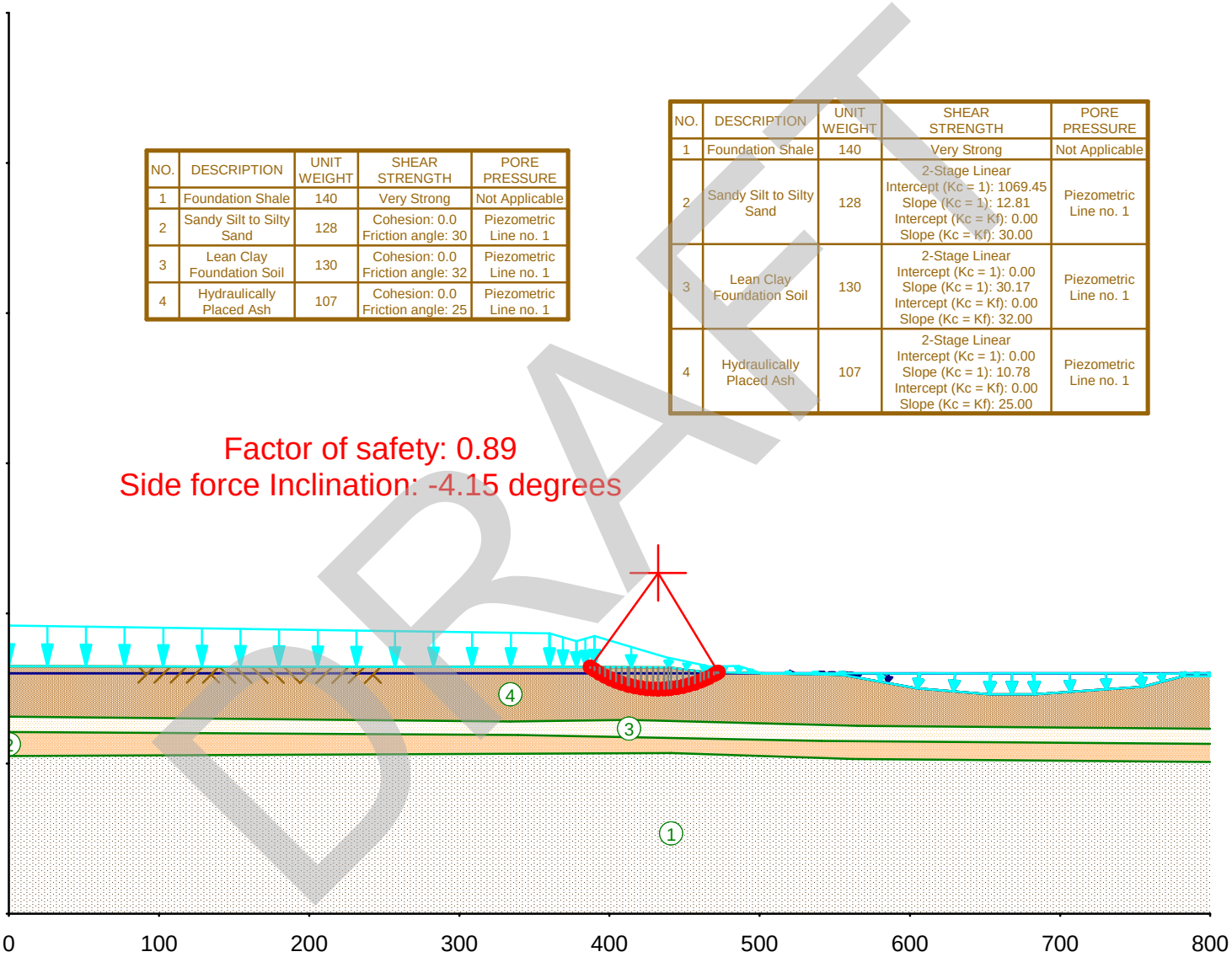
Lateral Expansion (Cell 4) Ash Stacking - Section A

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation Shale	140	Very Strong	Not Applicable
2	Sandy Silt to Silty Sand	128	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
3	Lean Clay Foundation Soil	130	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
4	Hydraulically Placed Ash	107	Cohesion: 0.0 Friction angle: 25	Piezometric Line no. 1

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation Shale	140	Very Strong	Not Applicable
2	Sandy Silt to Silty Sand	128	2-Stage Linear Intercept (Kc = 1): 1069.45 Slope (Kc = 1): 12.81 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Lean Clay Foundation Soil	130	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 30.17 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 32.00	Piezometric Line no. 1
4	Hydraulically Placed Ash	107	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 10.78 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 25.00	Piezometric Line no. 1

Factor of safety: 0.89
Side force Inclination: -4.15 degrees



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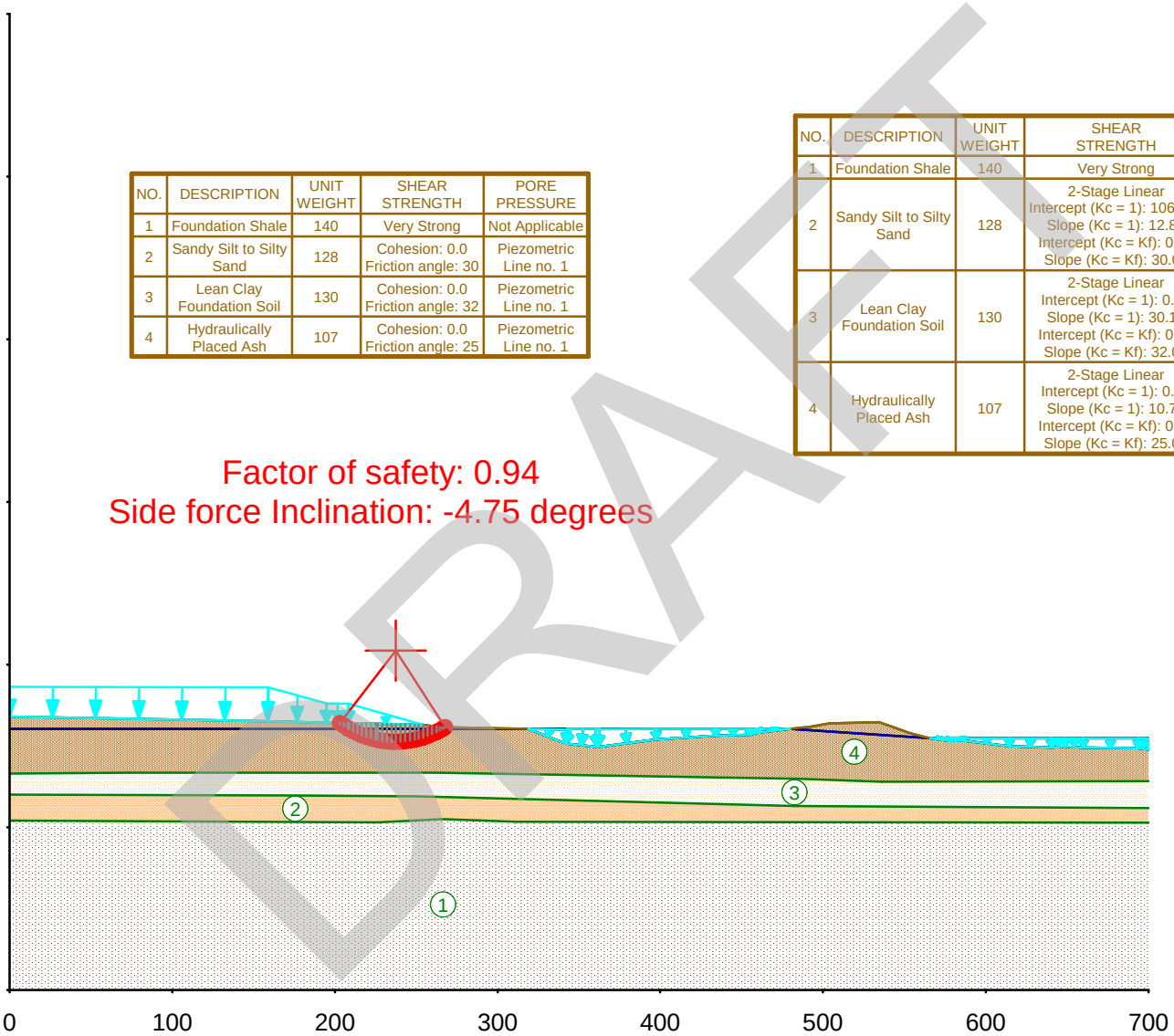
Lateral Expansion (Cell 4) Ash Stacking - Section F

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation Shale	140	Very Strong	Not Applicable
2	Sandy Silt to Silty Sand	128	Cohesion: 0.0 Friction angle: 30	Piezometric Line no. 1
3	Lean Clay Foundation Soil	130	Cohesion: 0.0 Friction angle: 32	Piezometric Line no. 1
4	Hydraulically Placed Ash	107	Cohesion: 0.0 Friction angle: 25	Piezometric Line no. 1

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Foundation Shale	140	Very Strong	Not Applicable
2	Sandy Silt to Silty Sand	128	2-Stage Linear Intercept (Kc = 1): 1069.45 Slope (Kc = 1): 12.81 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 30.00	Piezometric Line no. 1
3	Lean Clay Foundation Soil	130	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 30.17 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 32.00	Piezometric Line no. 1
4	Hydraulically Placed Ash	107	2-Stage Linear Intercept (Kc = 1): 0.00 Slope (Kc = 1): 10.78 Intercept (Kc = Kf): 0.00 Slope (Kc = Kf): 25.00	Piezometric Line no. 1

Factor of safety: 0.94
Side force Inclination: -4.75 degrees



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Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Lateral Expansion (Cell 4)** **Ash Stacking**

Document Control Number	RDP-0114-A
Calculation Package	FPGKIFFESCDX00030020110001

Exhibit 09
Stability Analysis – Cross Sections A,B,C,D,E & F

Purpose:

- Evaluate slope stability under drained loading conditions with various excess pore water pressures; provide some basis for establishing threshold limits for piezometer monitoring. (3.2)(4.1.7)
- Meet Section 3 of the Design Basis Criteria Dredge Cell Closure, Kingston Fossil Plant

Methods:

- Use SLOPE/W software for effective stress slope stability analyses. (3.2)

Results:

- Factors of safety versus excess pore water pressures were calculated.

*Numbers in parentheses references Sections of Design Basis Criteria

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: YW	*Reviewed by: KDL*
Revisions:	

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Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

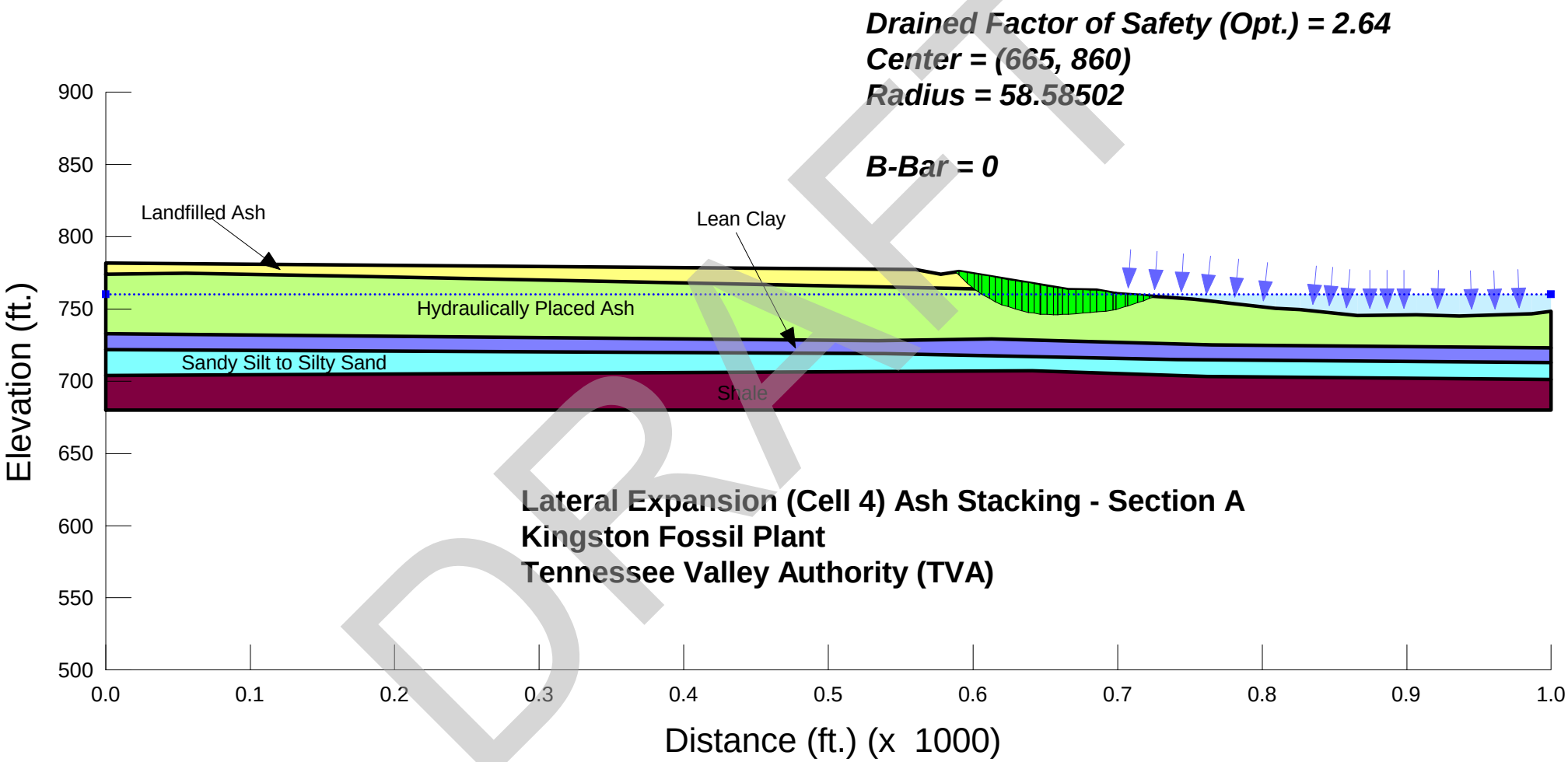

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Figure A - 1: Excess Pore Water Pressure Ratio = 0

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

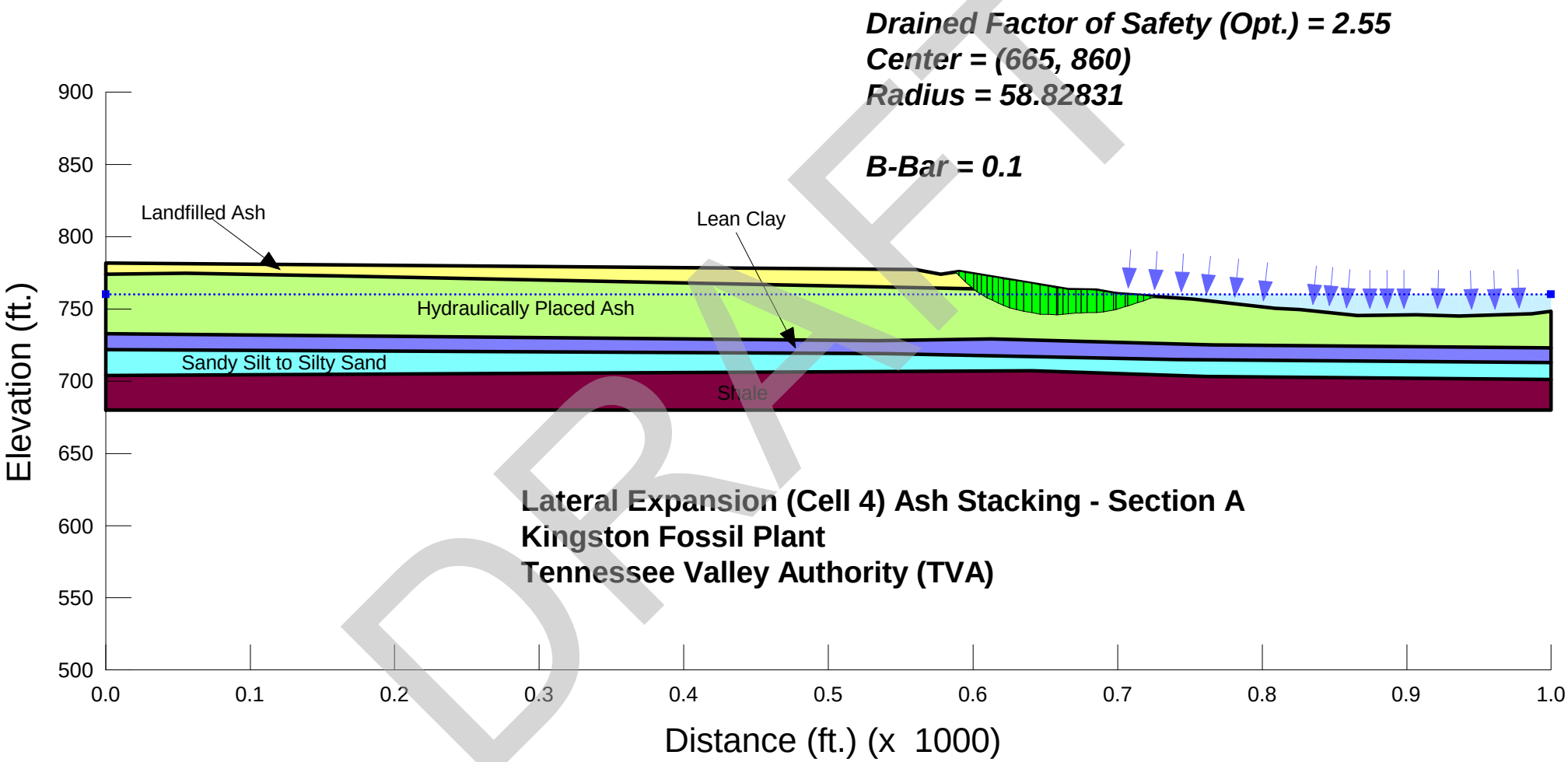

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Figure A - 2: Excess Pore Water Pressure Ratio = 10%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

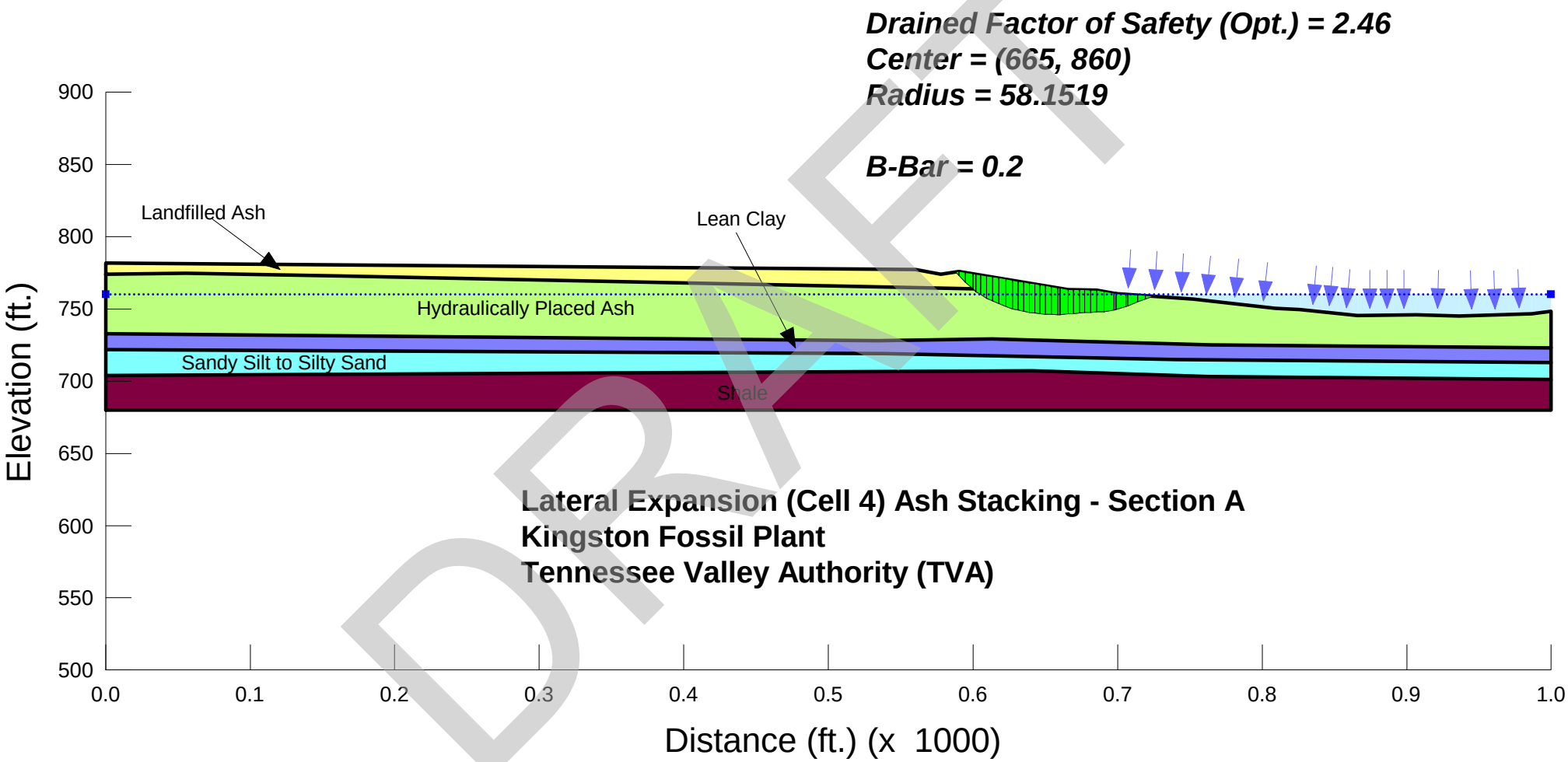

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Figure A - 3: Excess Pore Water Pressure Ratio = 20%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

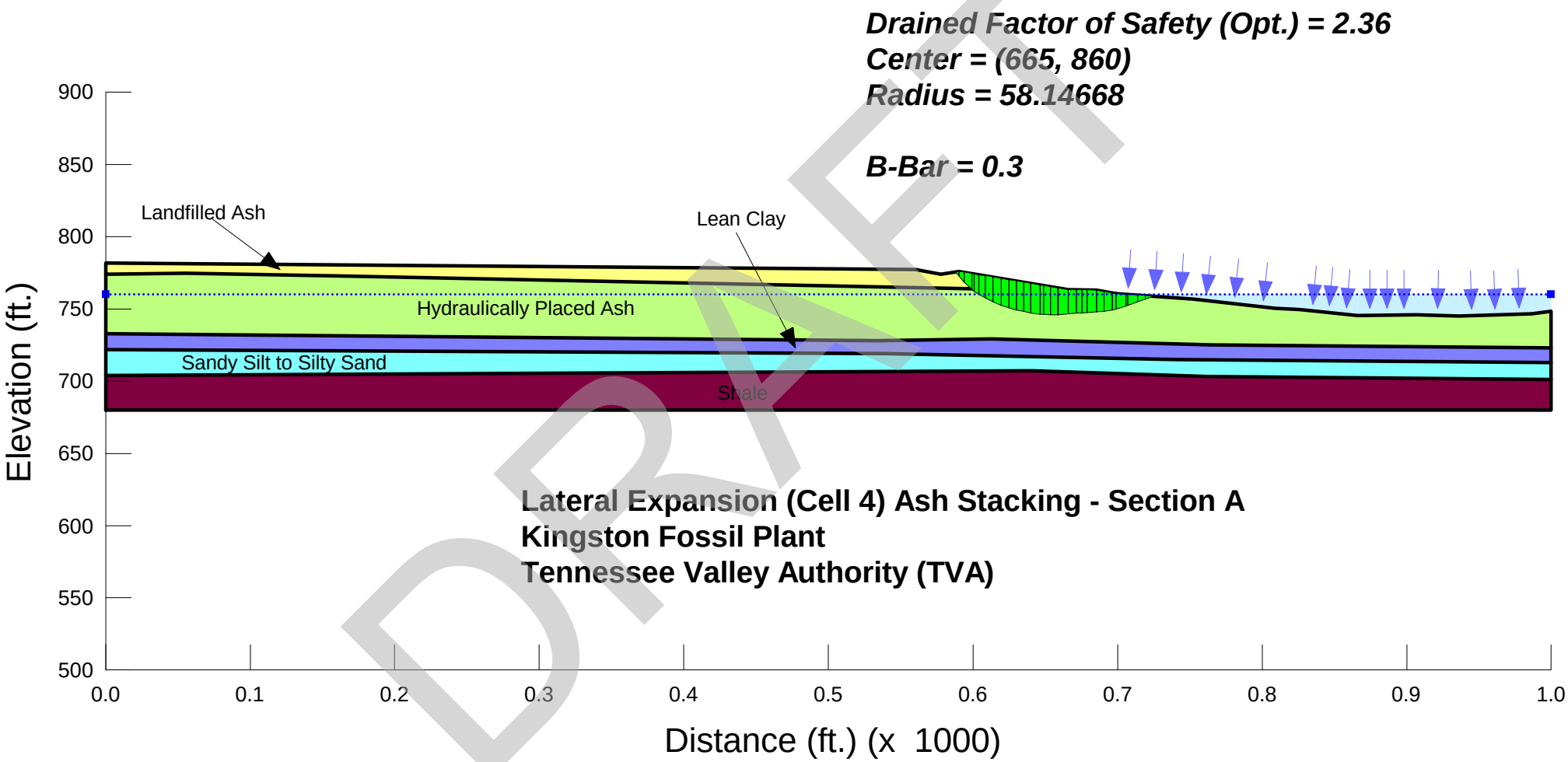

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Figure A - 4: Excess Pore Water Pressure Ratio = 30%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

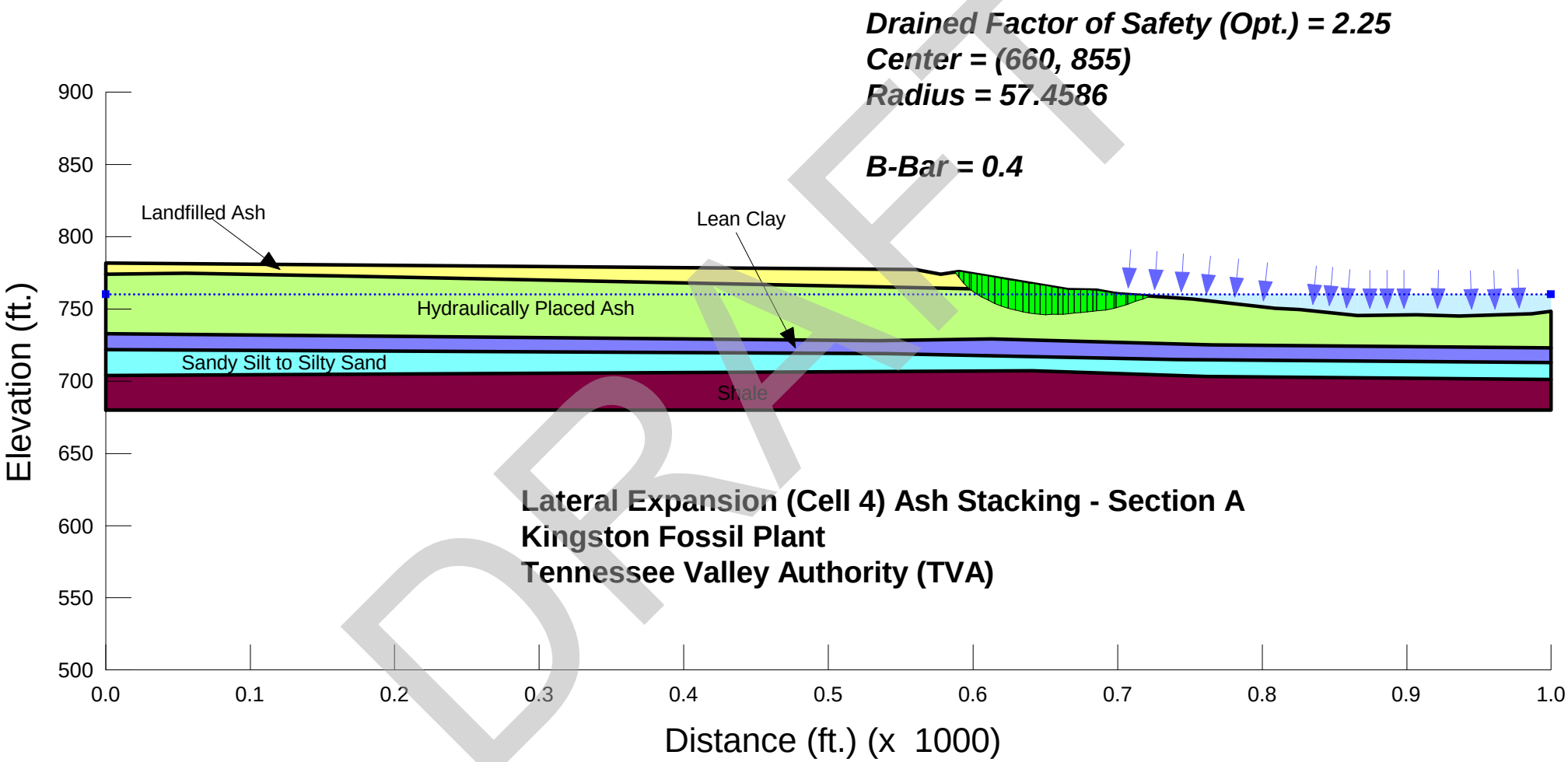

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Figure A - 5: Excess Pore Water Pressure Ratio = 40%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

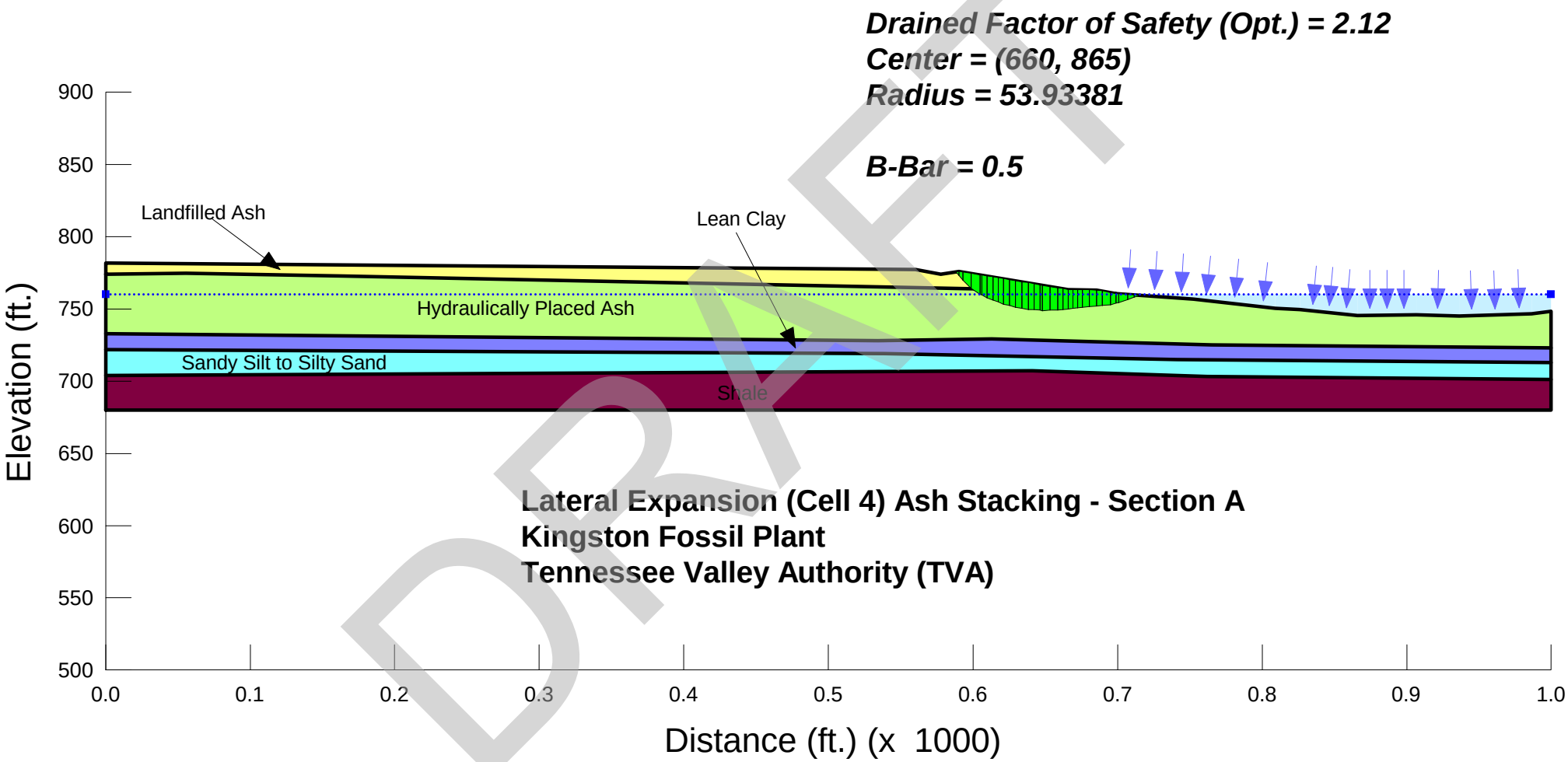

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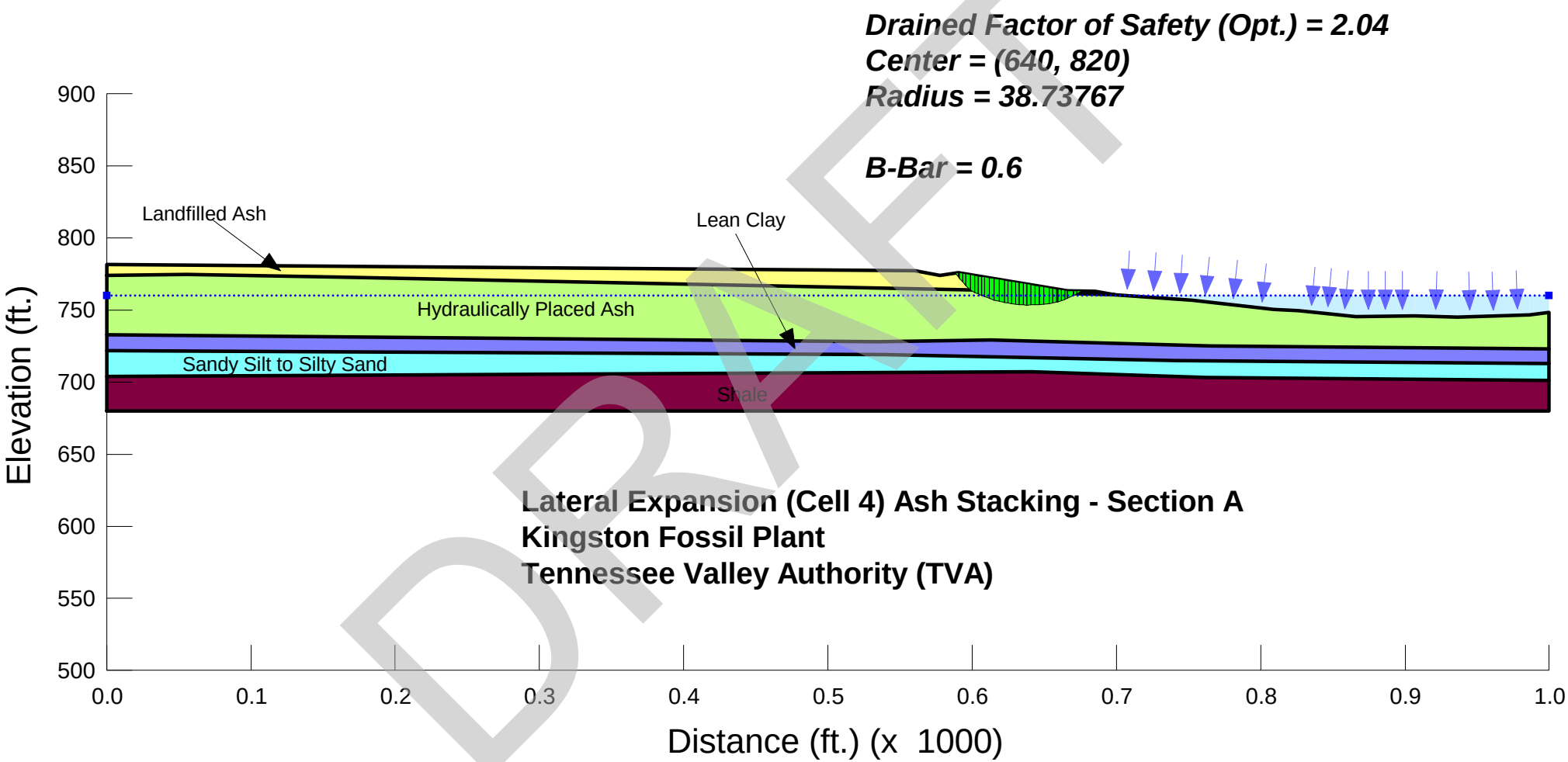
Figure A - 6: Excess Pore Water Pressure Ratio = 50%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/22/2011 at 3:36:44 PM

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Figure A - 7: Excess Pore Water Pressure Ratio = 60%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

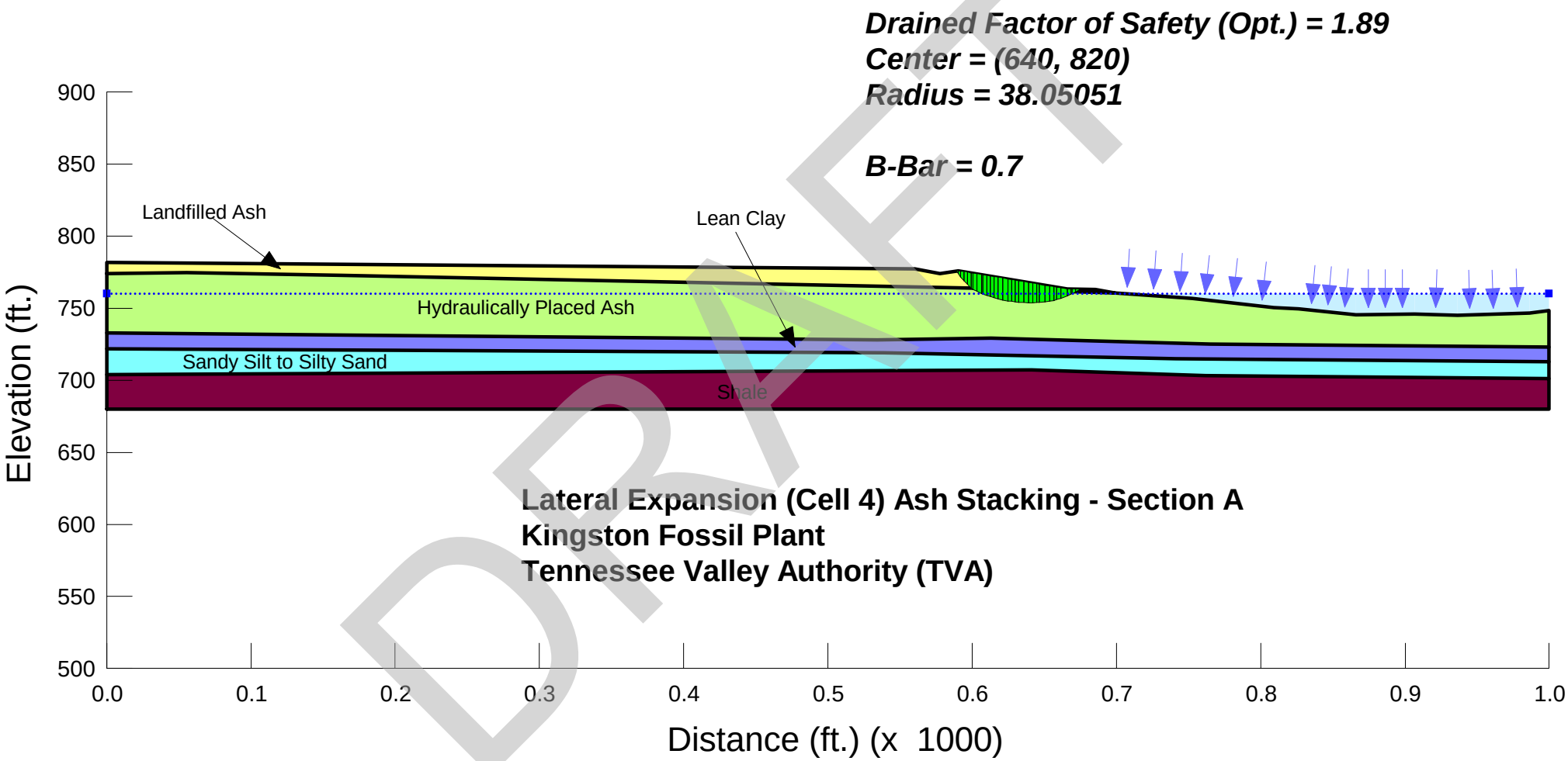

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Figure A - 8: Excess Pore Water Pressure Ratio = 70%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

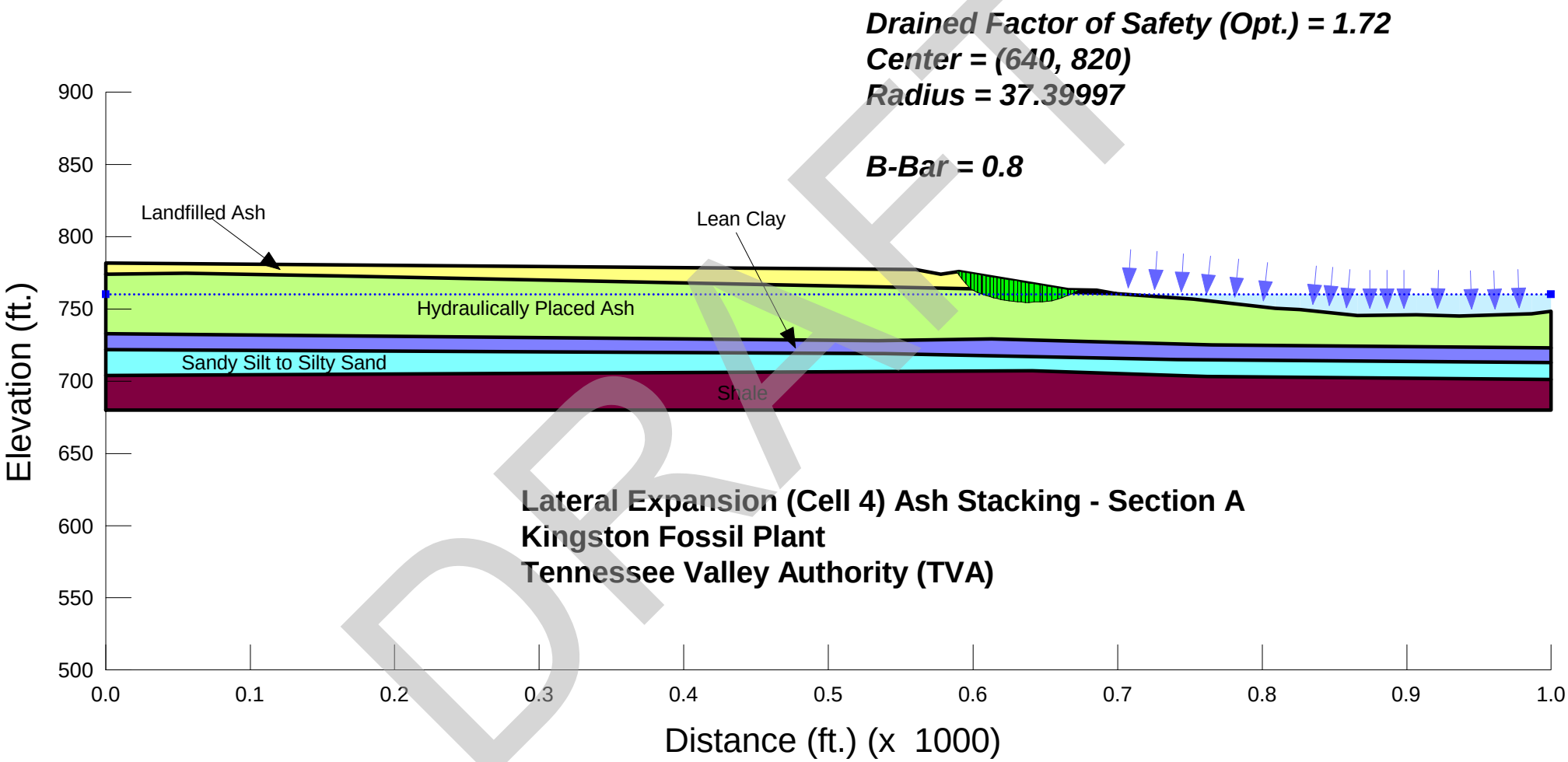

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Figure A - 9: Excess Pore Water Pressure Ratio = 80%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

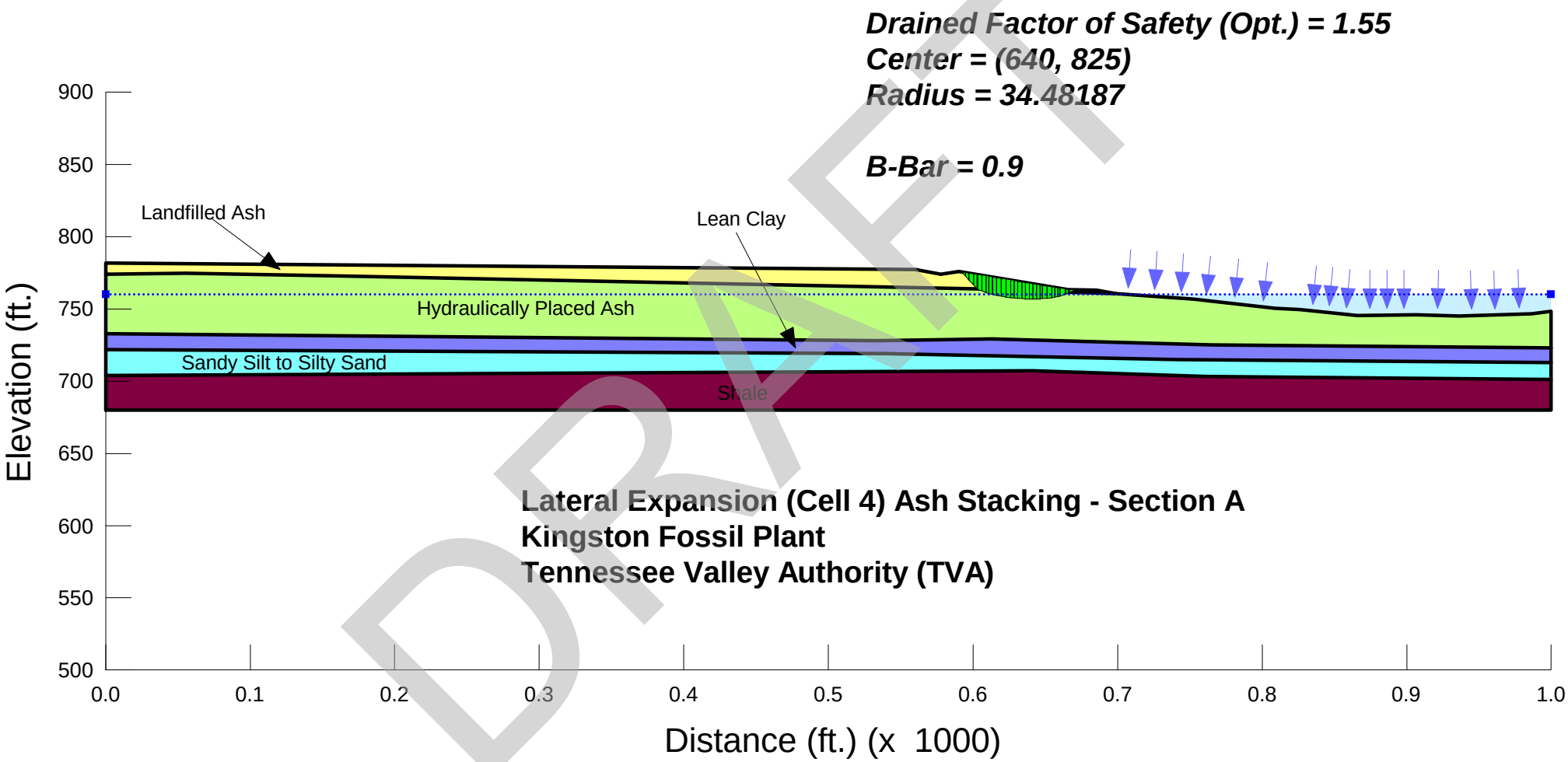

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Figure A - 10: Excess Pore Water Pressure Ratio = 90%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

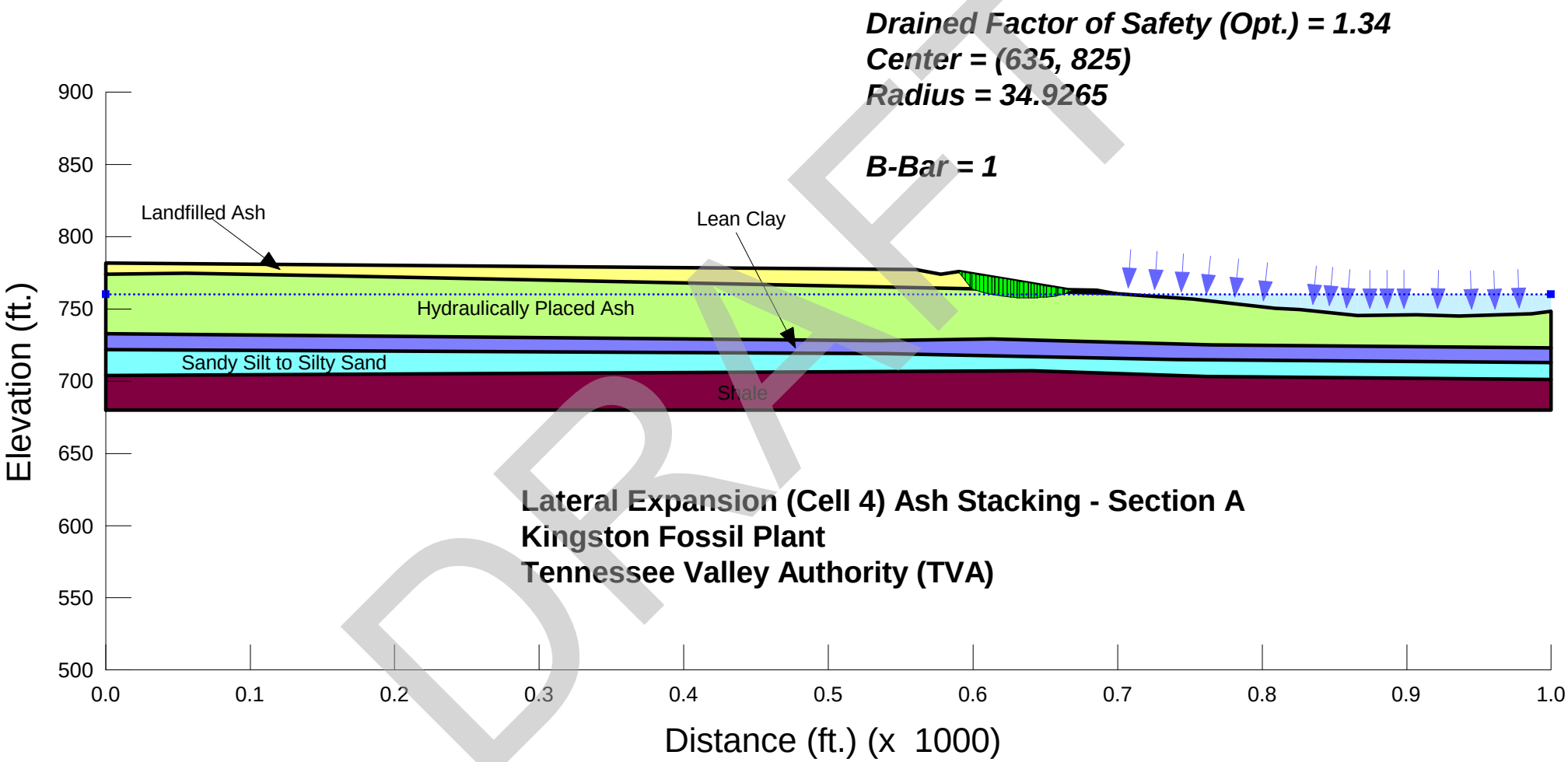

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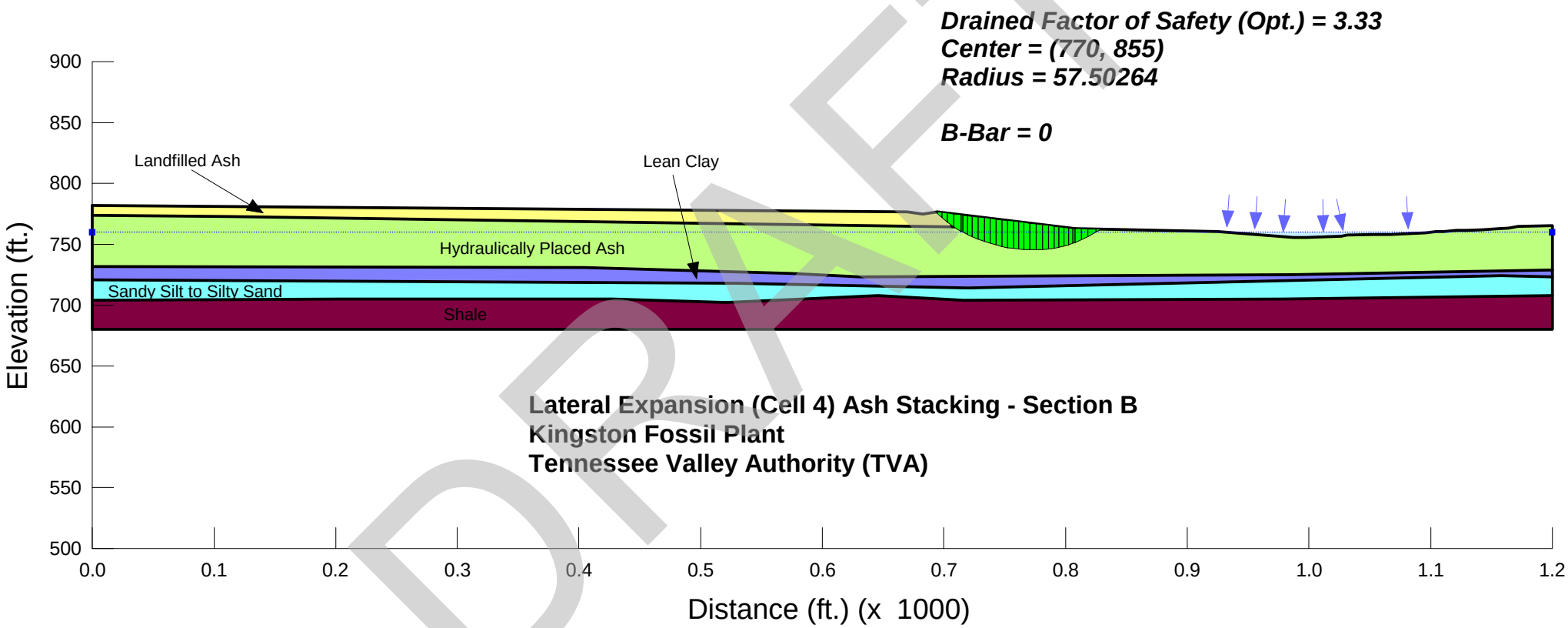
Figure A - 11: Excess Pore Water Pressure Ratio = 100%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/22/2011 at 4:12:36 PM

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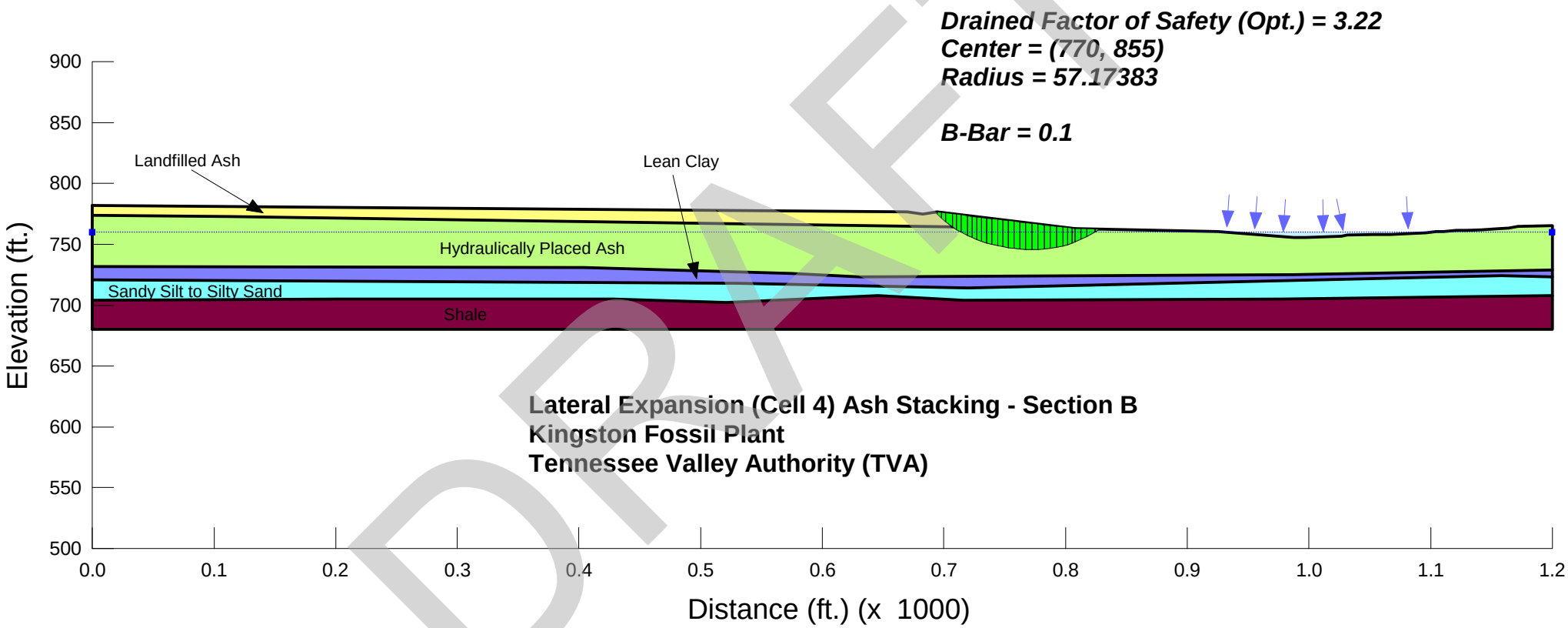
Figure B - 1: Excess Pore Water Pressure Ratio = 0

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



File Name: Section_B_Drained_PWP-10.gsz
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Figure B - 2: Excess Pore Water Pressure Ratio = 10%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

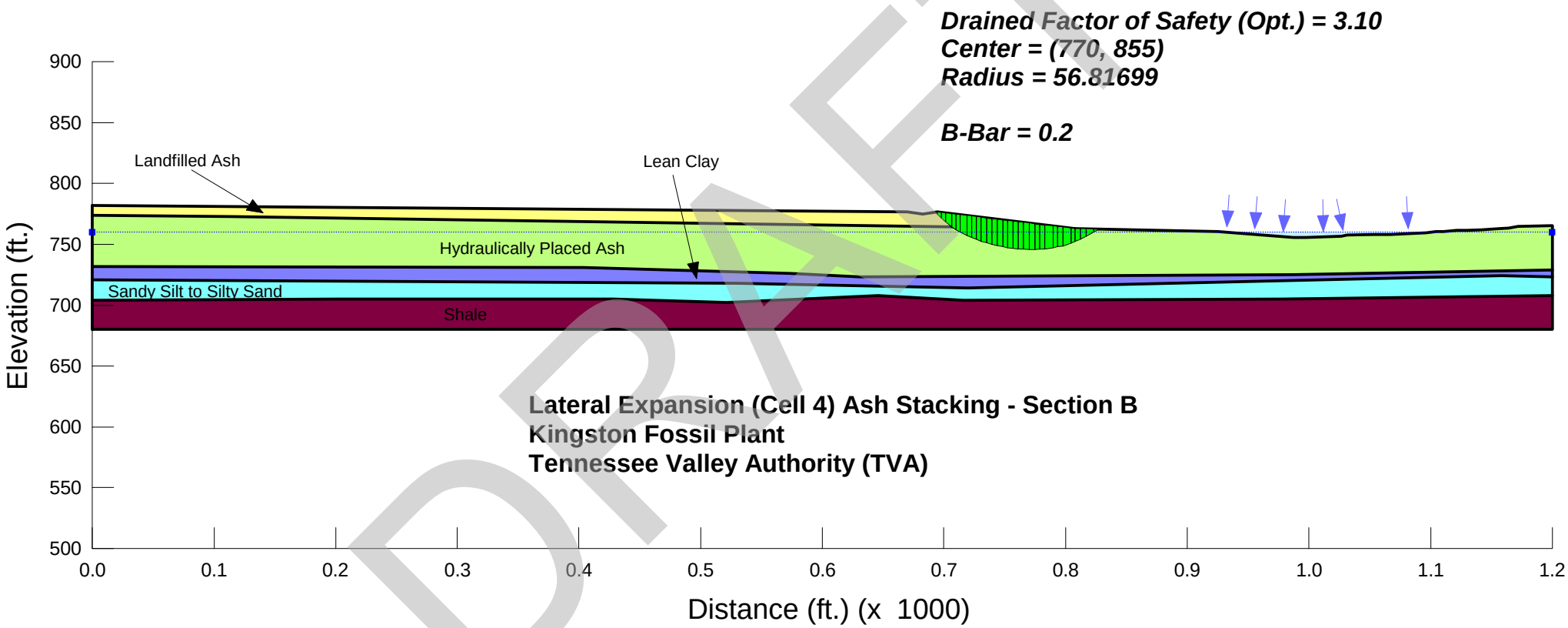

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Figure B - 3: Excess Pore Water Pressure Ratio = 20%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

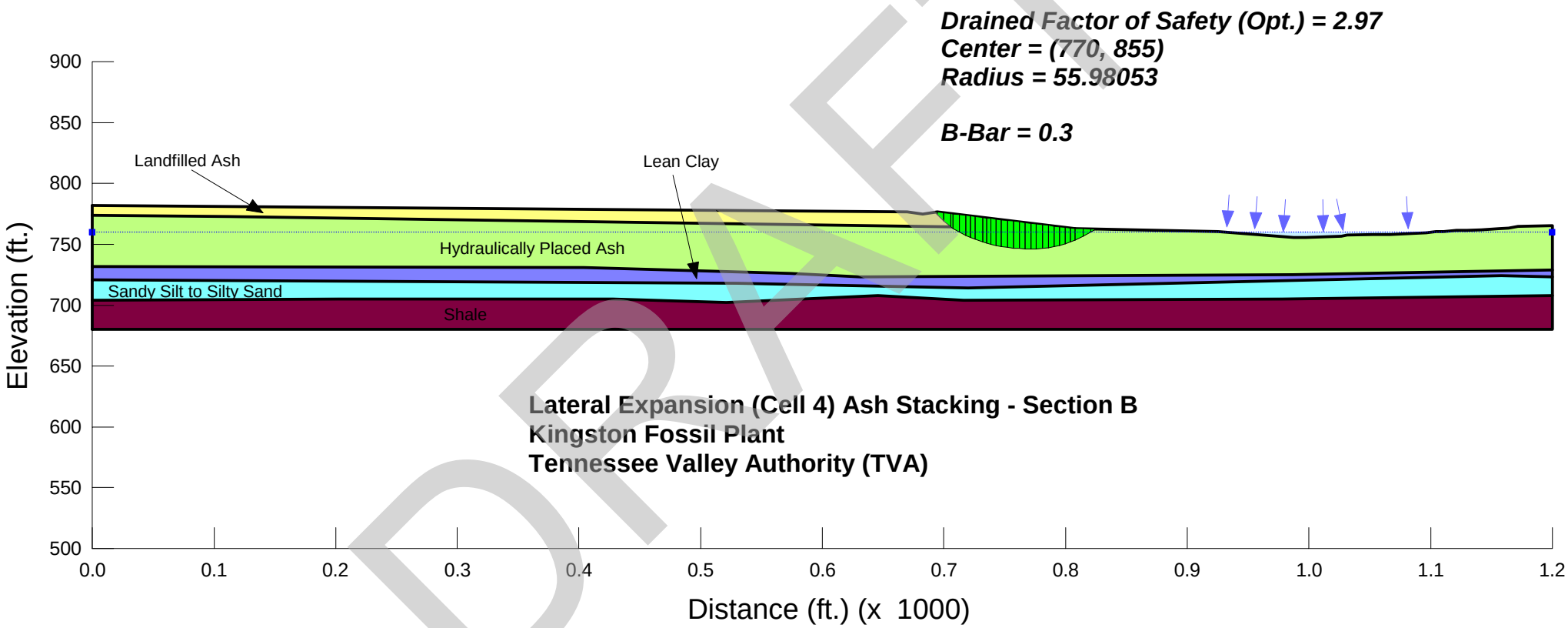

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Figure B - 4: Excess Pore Water Pressure Ratio = 30%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

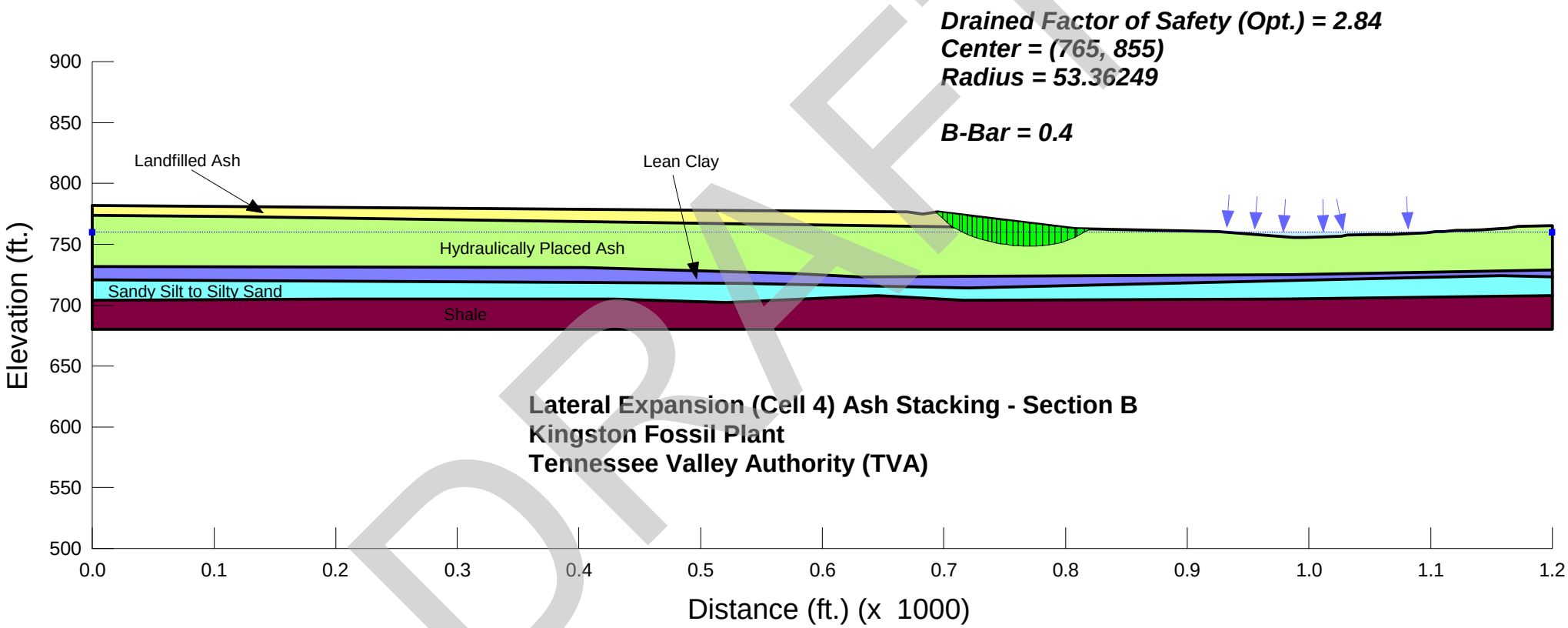

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Figure B - 5: Excess Pore Water Pressure Ratio = 40%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

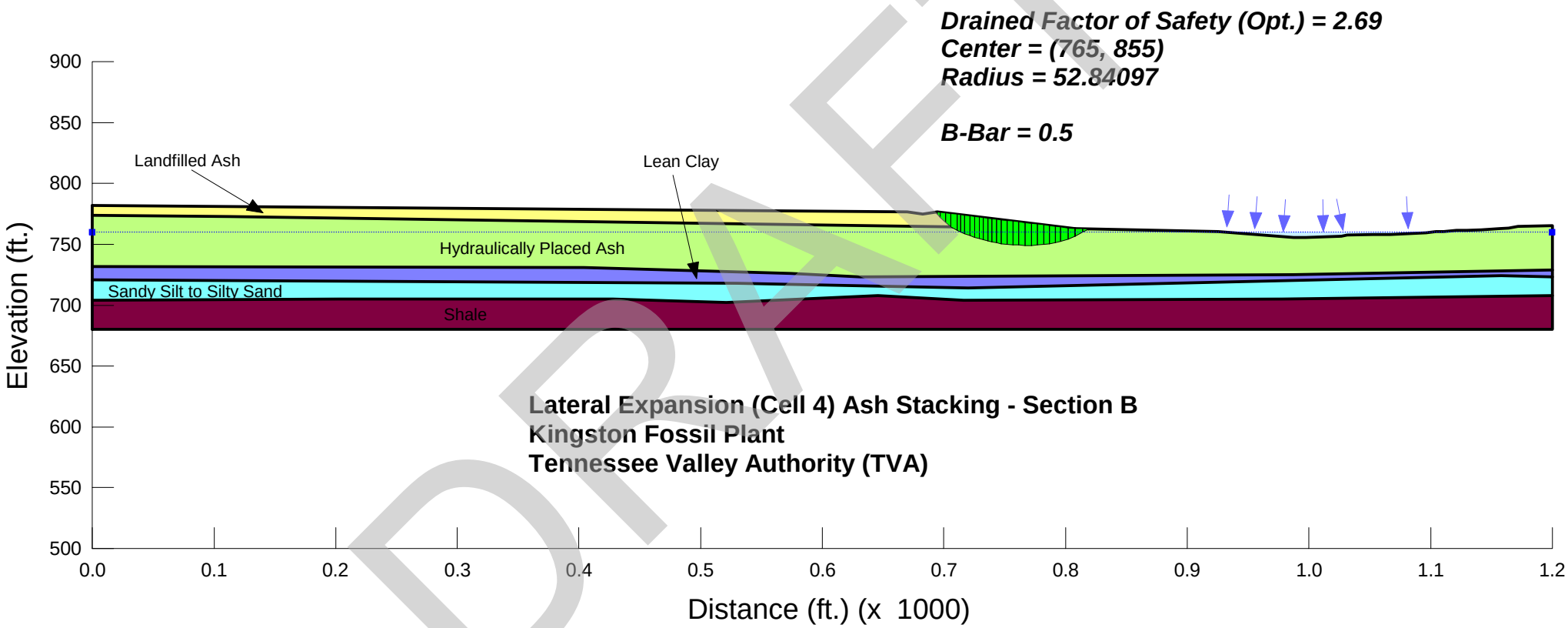

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Figure B - 6: Excess Pore Water Pressure Ratio = 50%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

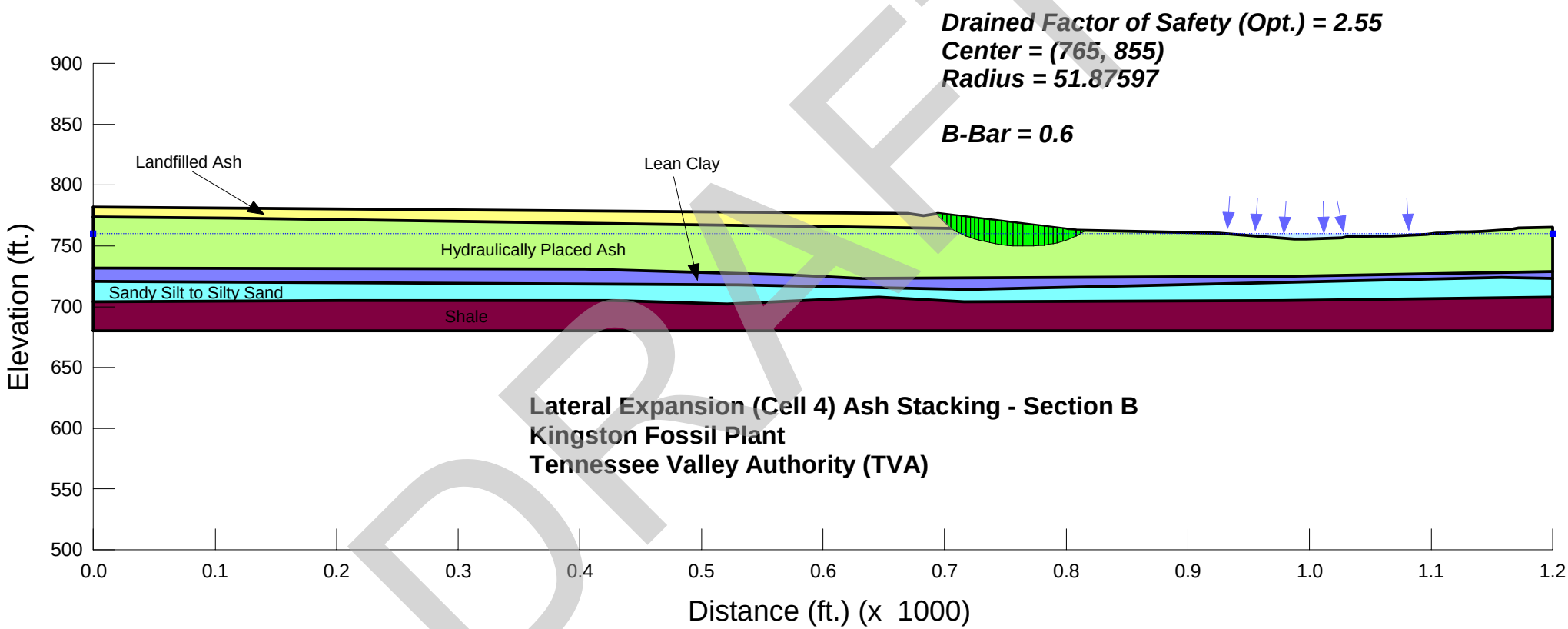

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Figure B - 7: Excess Pore Water Pressure Ratio = 60%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

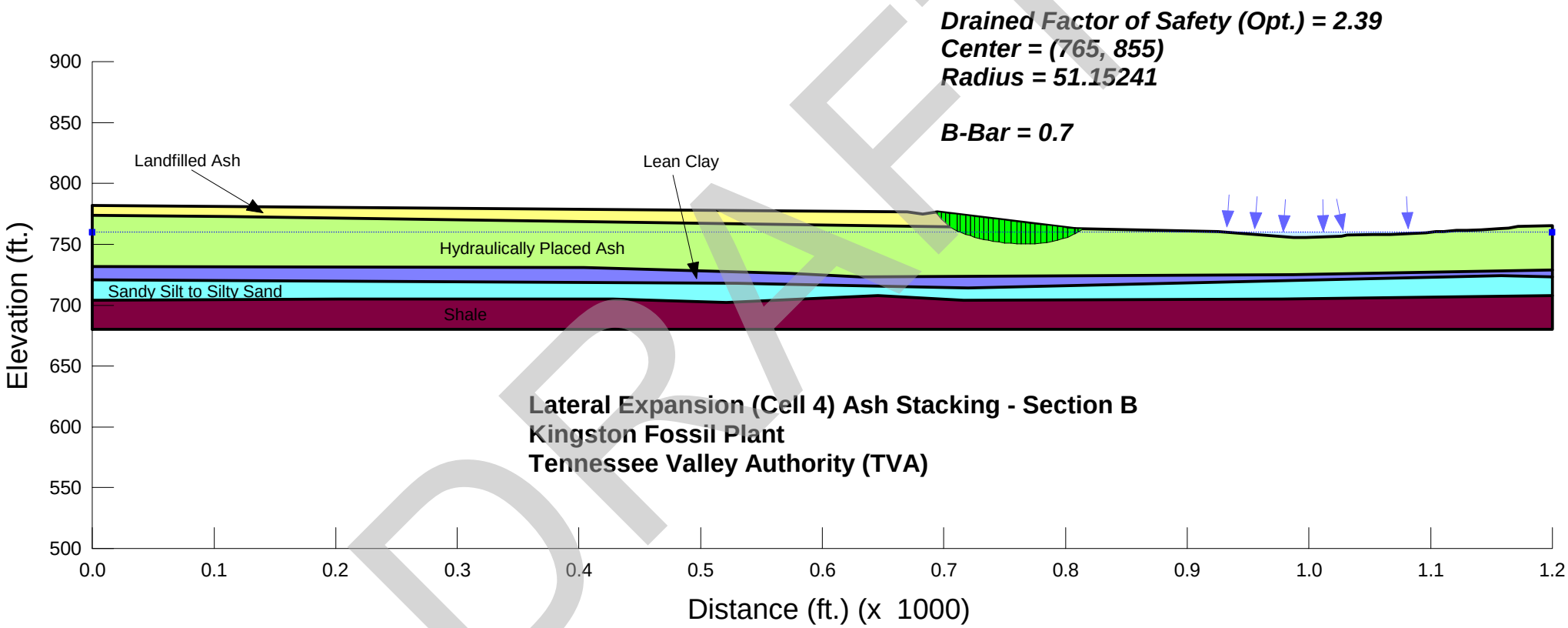

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Figure B - 8: Excess Pore Water Pressure Ratio = 70%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

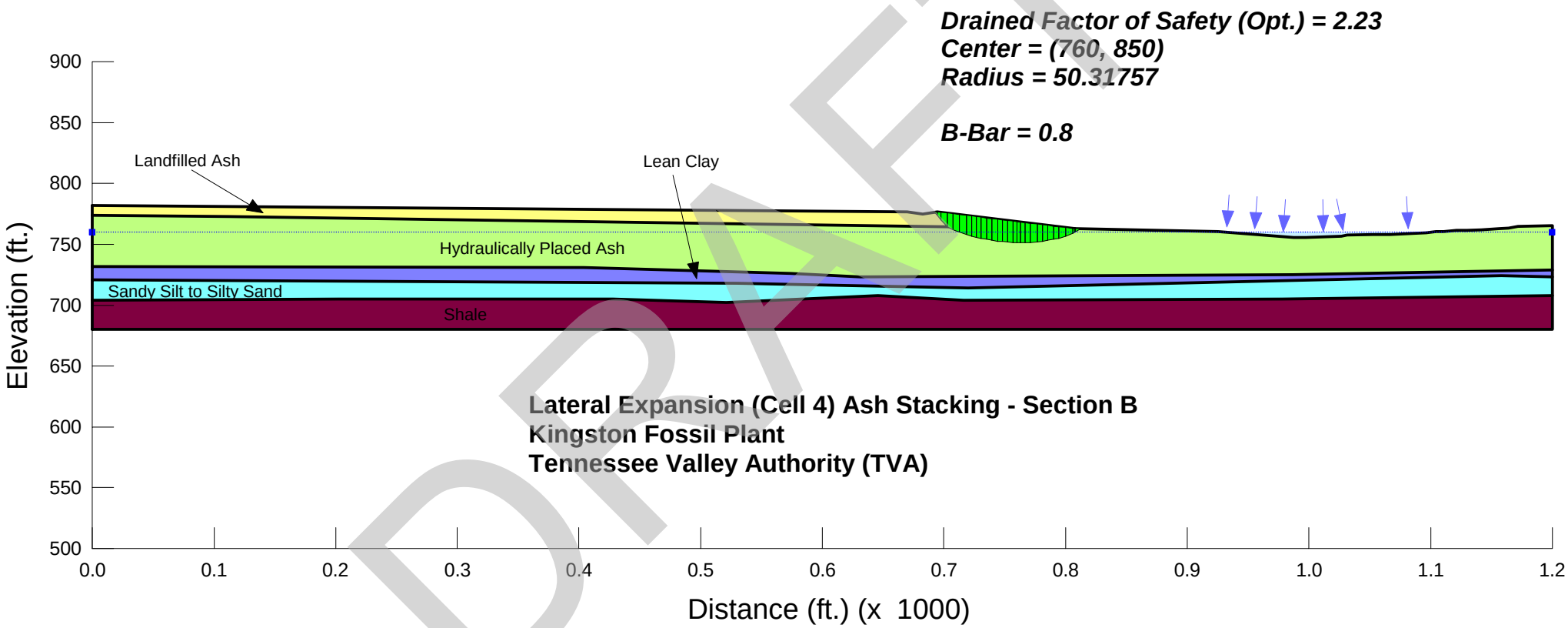

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Figure B - 9: Excess Pore Water Pressure Ratio = 80%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

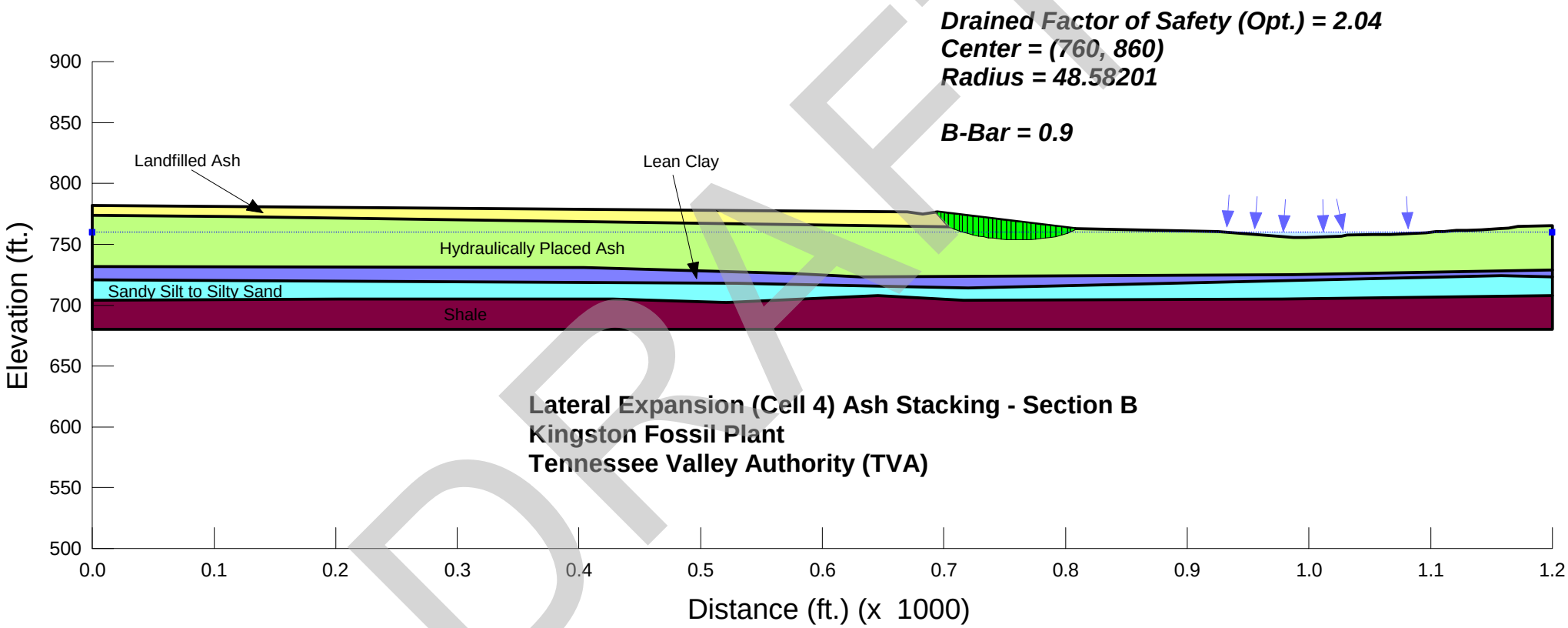

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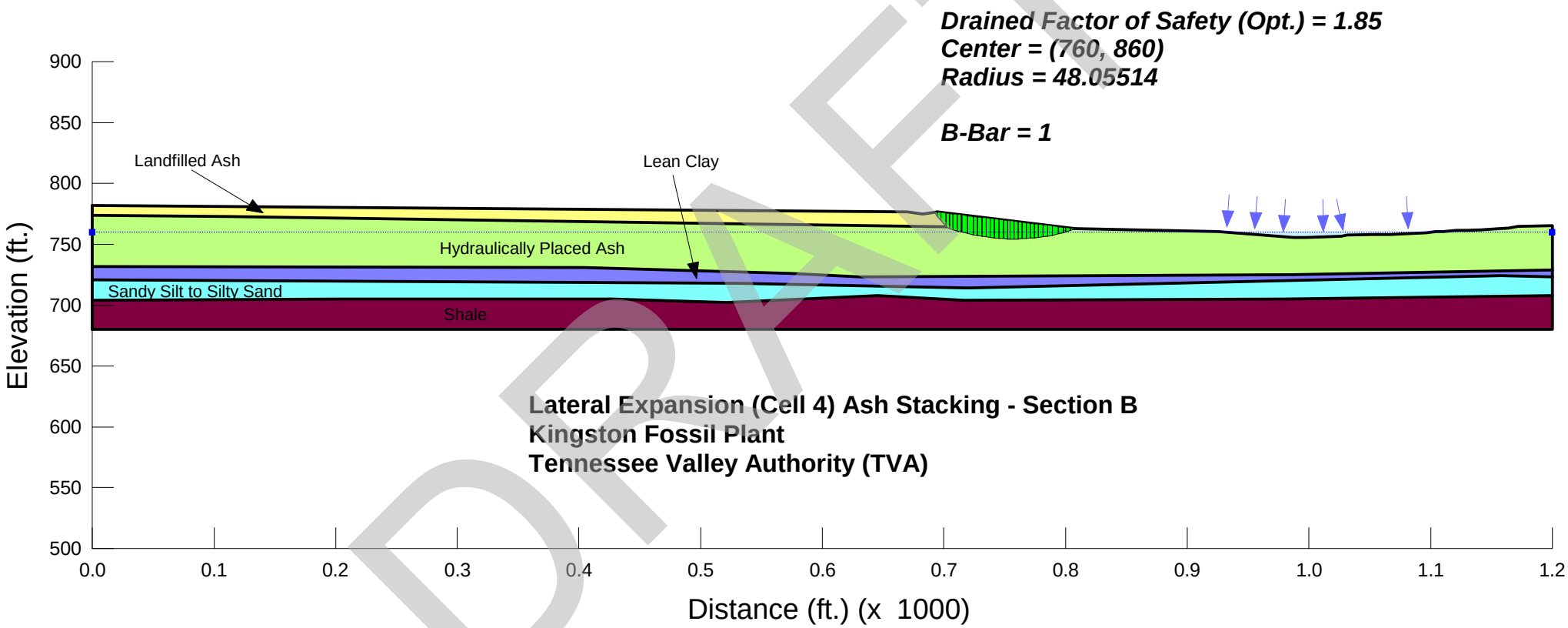
Figure B - 10: Excess Pore Water Pressure Ratio = 90%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



File Name: Section_B_Drained_PWP-100.gsz
Last Solved on 3/22/2011 at 5:12:04 PM

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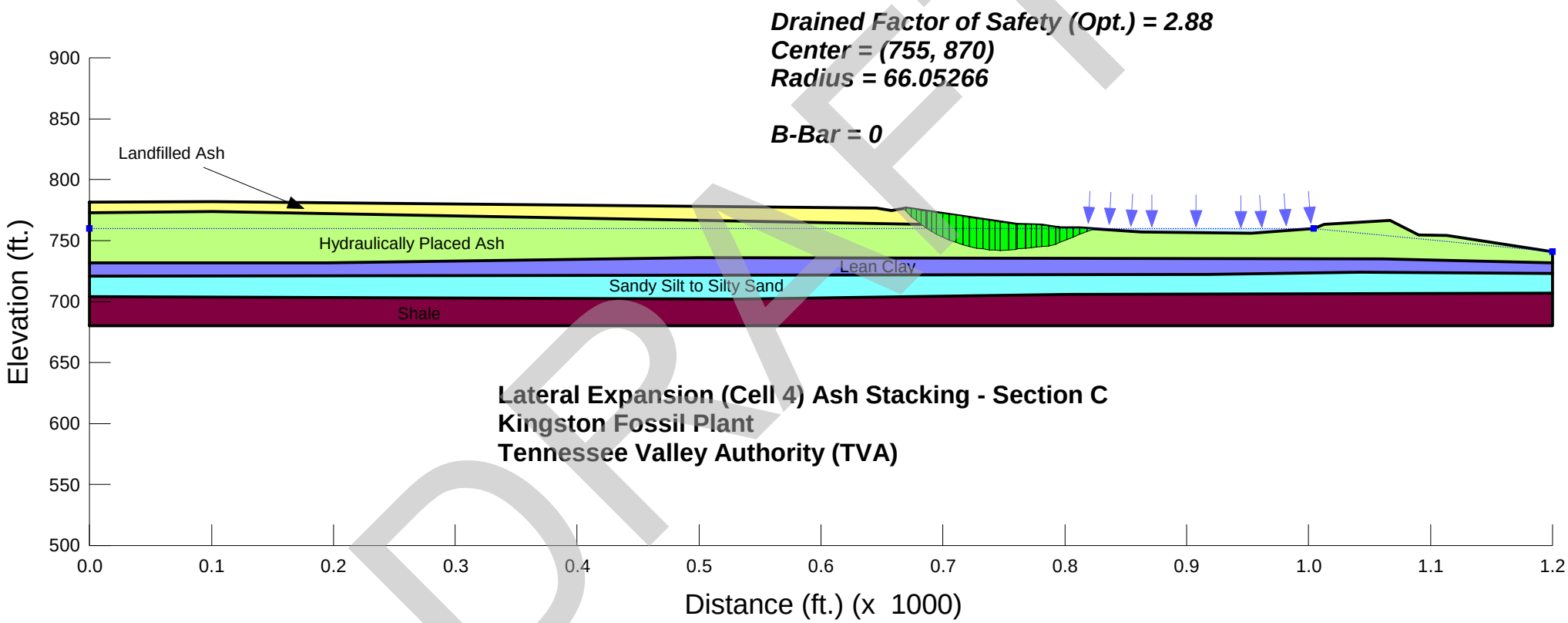
Figure B - 11: Excess Pore Water Pressure Ratio = 100%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/23/2011 at 10:08:48 AM

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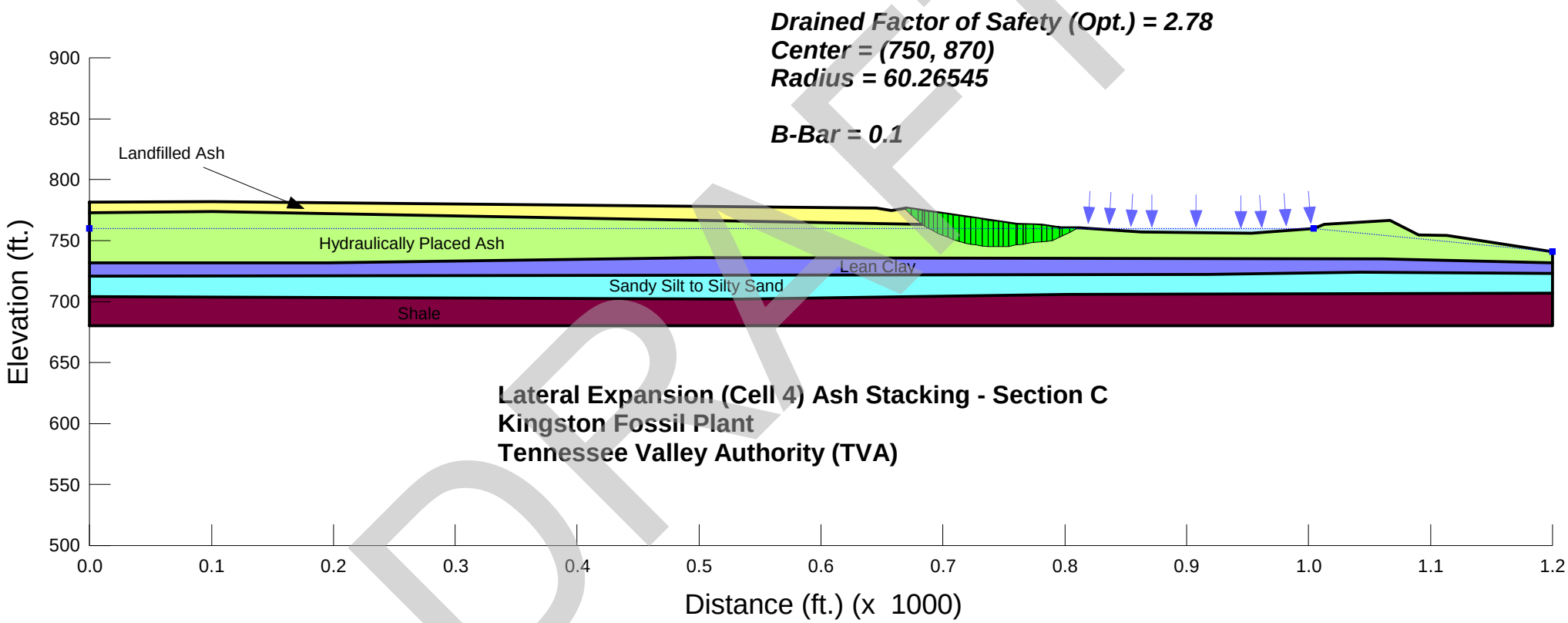
Figure C - 1: Excess Pore Water Pressure Ratio = 0

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/23/2011 at 10:12:32 AM

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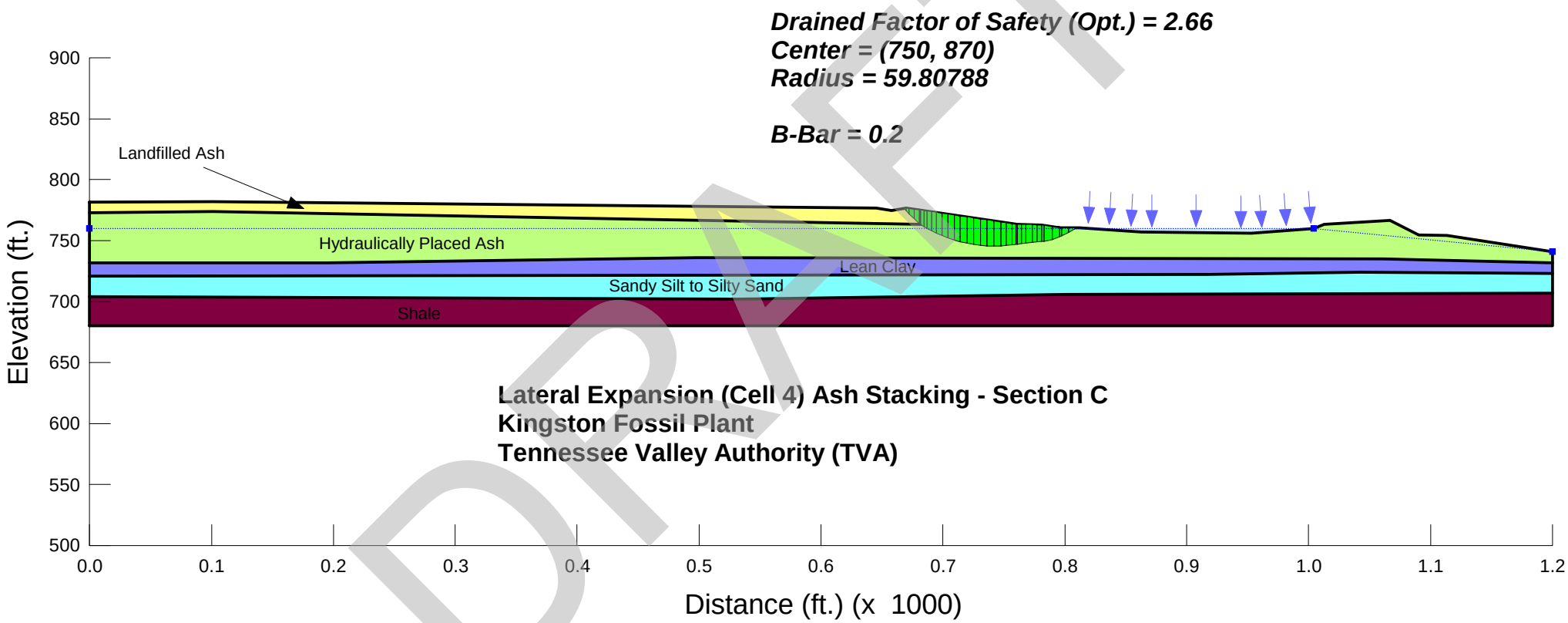
Figure C - 2: Excess Pore Water Pressure Ratio = 10%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/23/2011 at 10:16:20 AM

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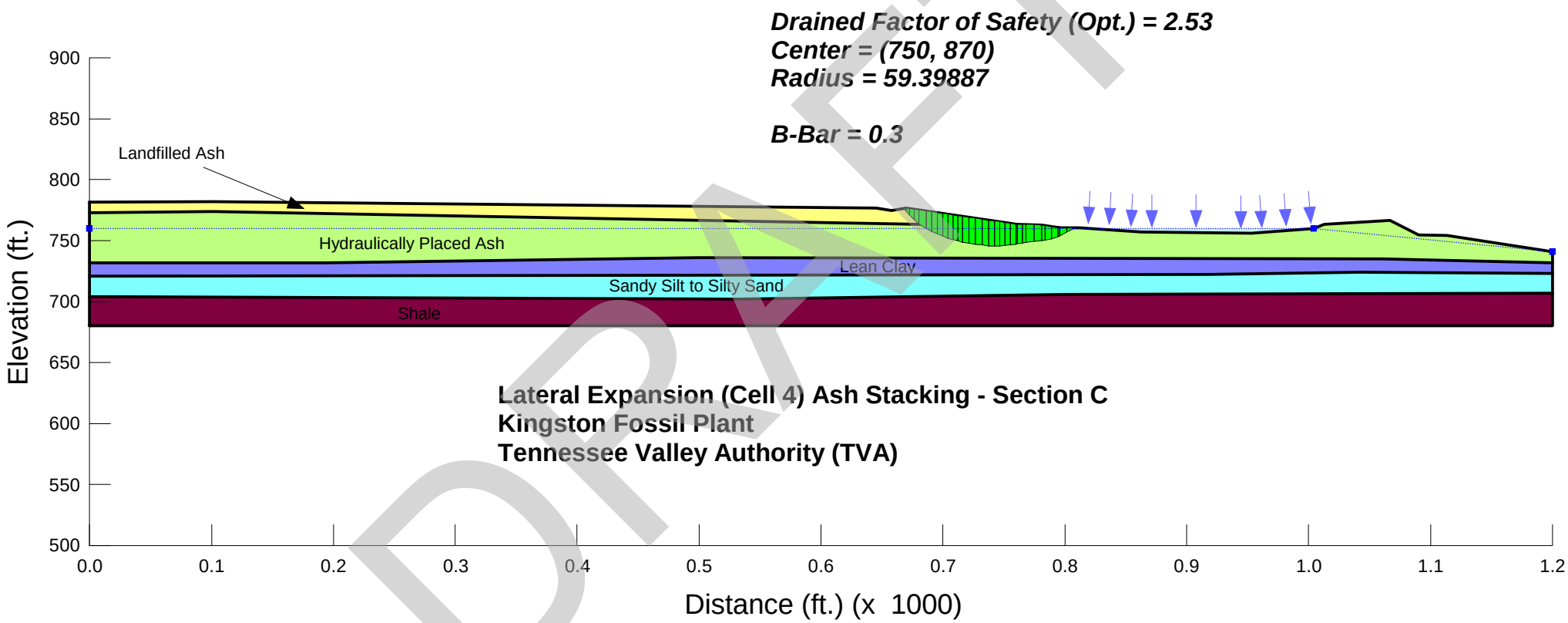
Figure C - 3: Excess Pore Water Pressure Ratio = 20%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/23/2011 at 10:19:46 AM

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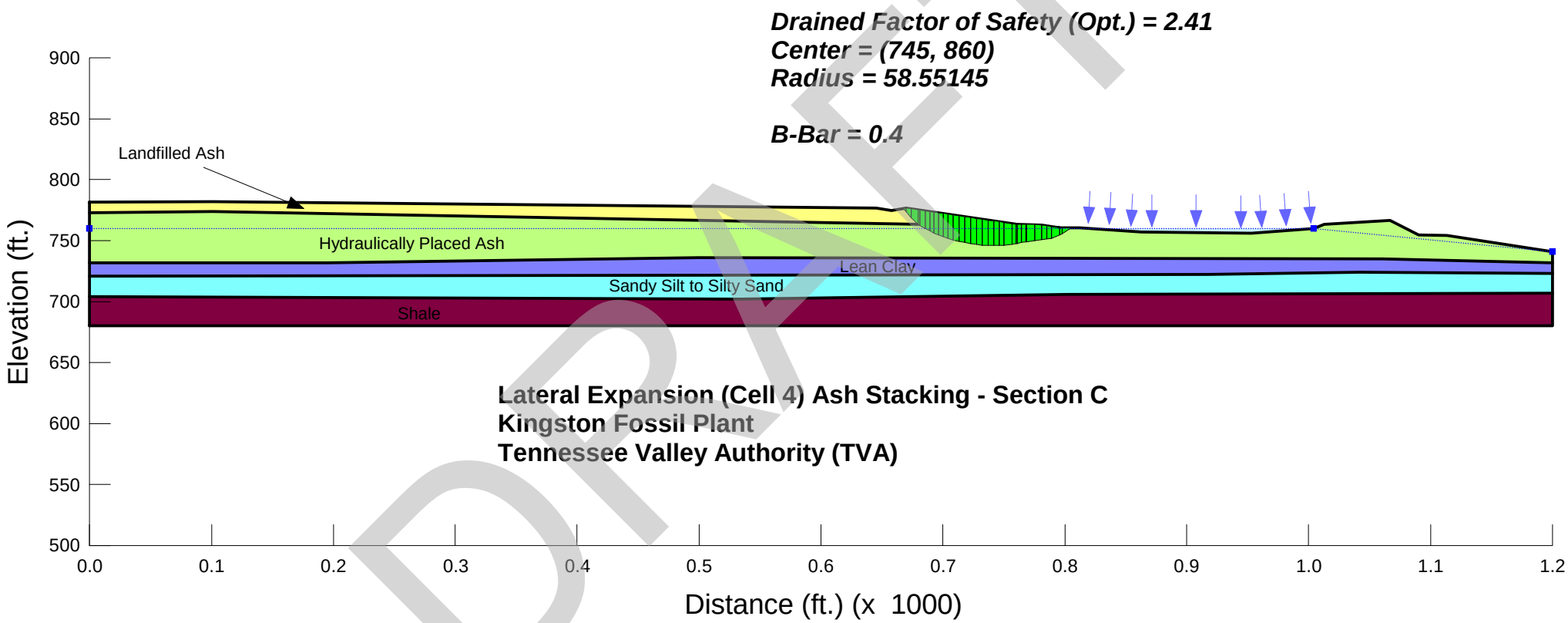
Figure C - 4: Excess Pore Water Pressure Ratio = 30%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/23/2011 at 10:23:24 AM

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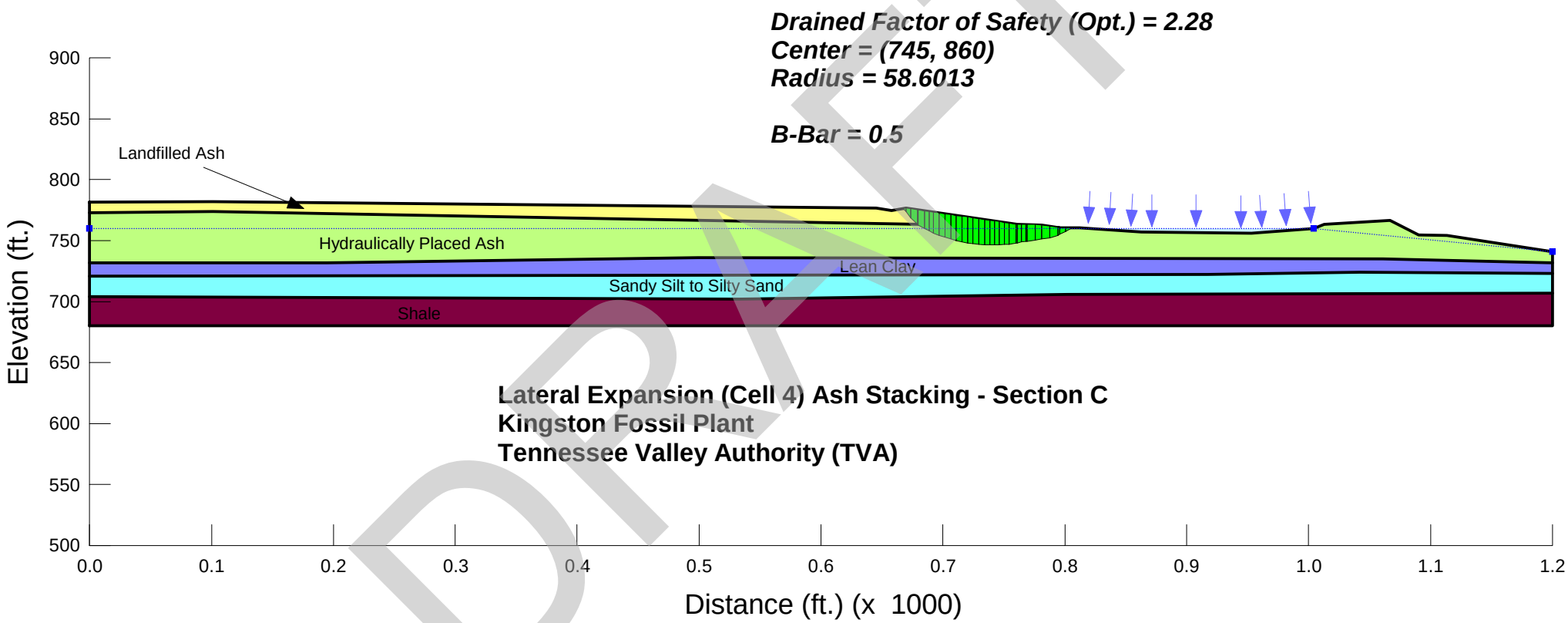
Figure C - 5: Excess Pore Water Pressure Ratio = 40%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/23/2011 at 10:27:24 AM

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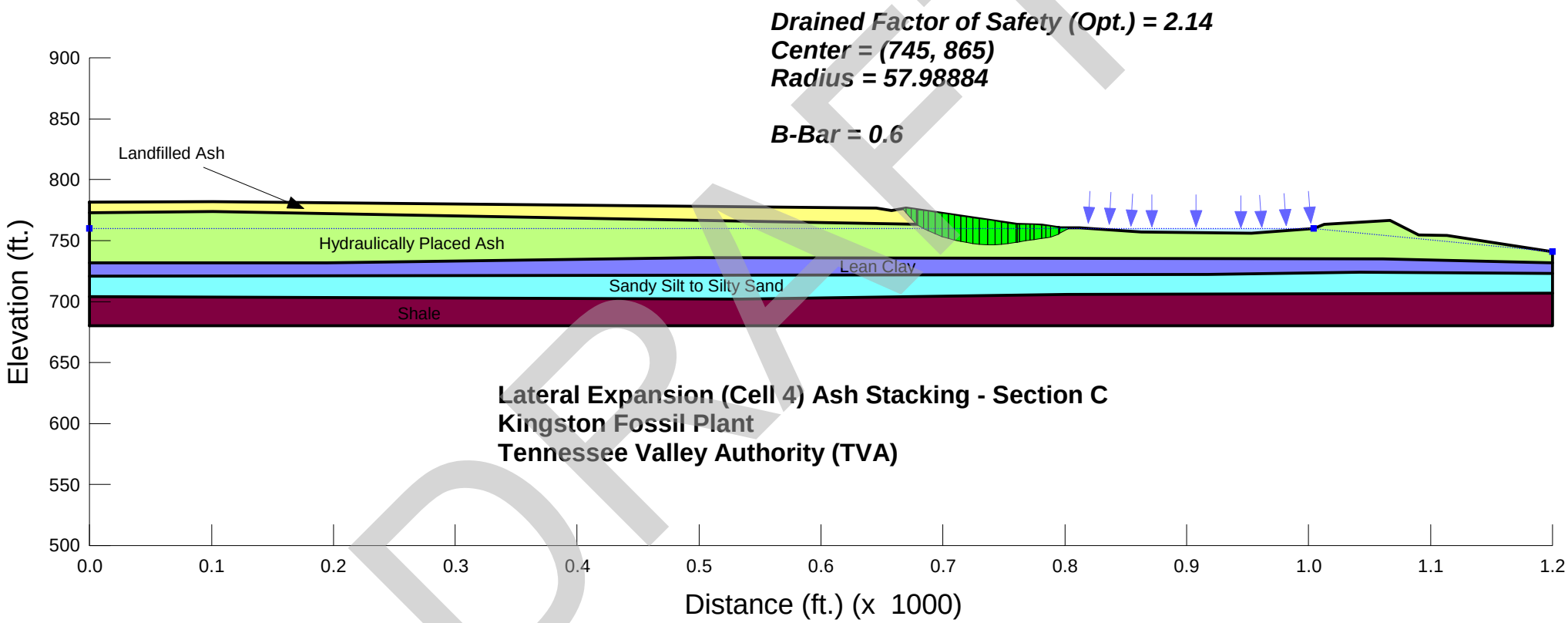
Figure C - 6: Excess Pore Water Pressure Ratio = 50%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/23/2011 at 10:31:18 AM

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Figure C - 7: Excess Pore Water Pressure Ratio = 60%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A

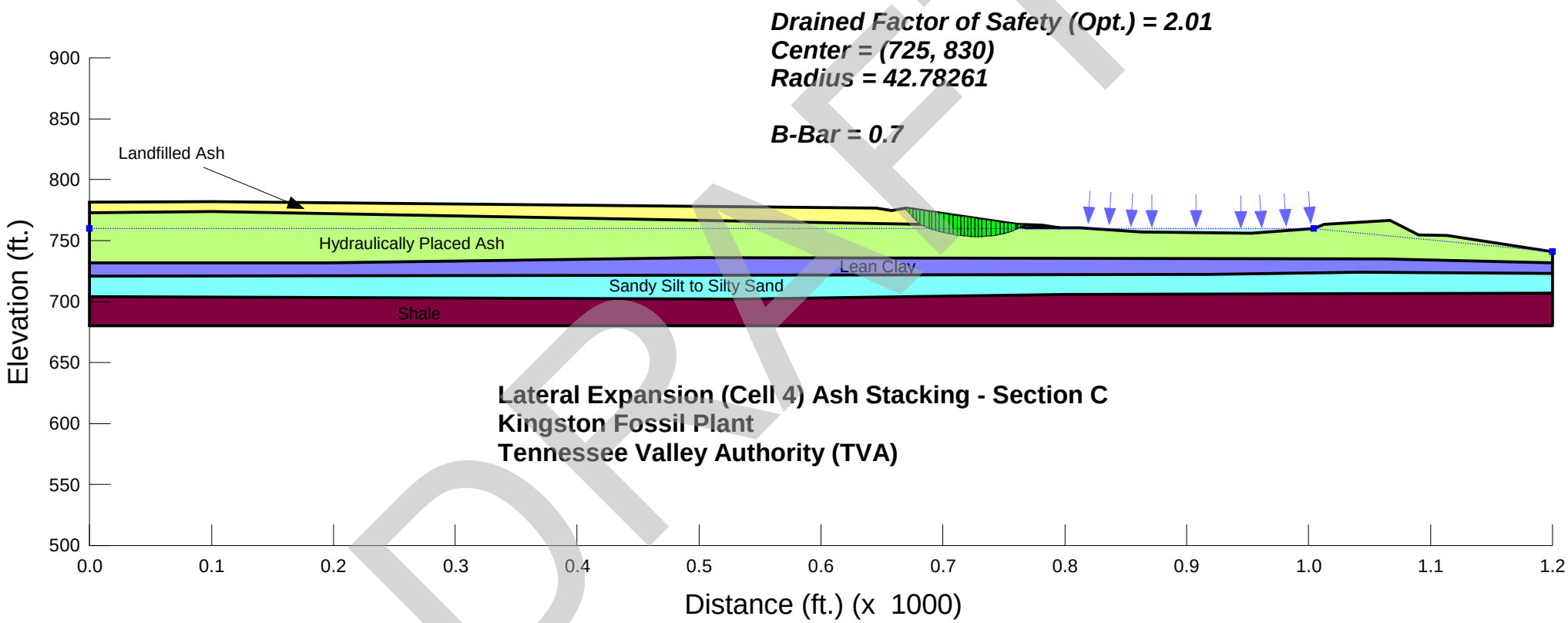

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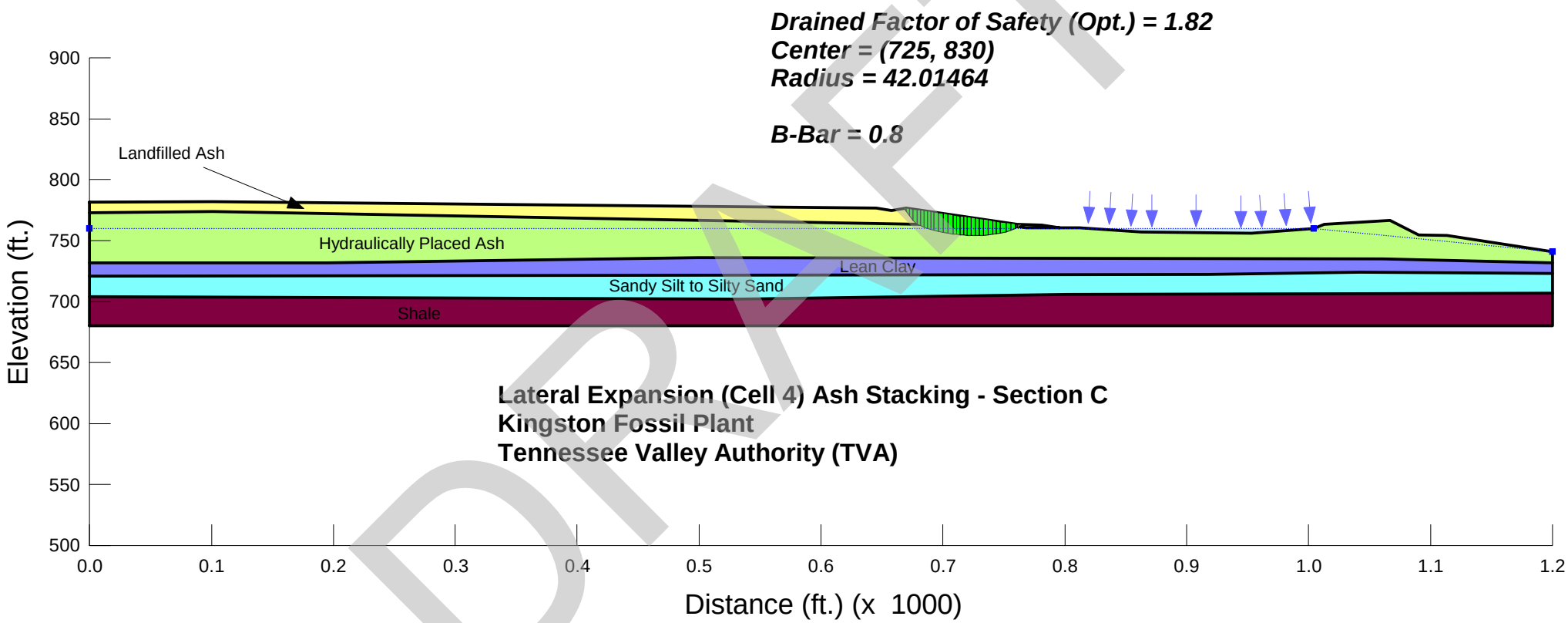
Figure C - 8: Excess Pore Water Pressure Ratio = 70%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/23/2011 at 10:39:40 AM

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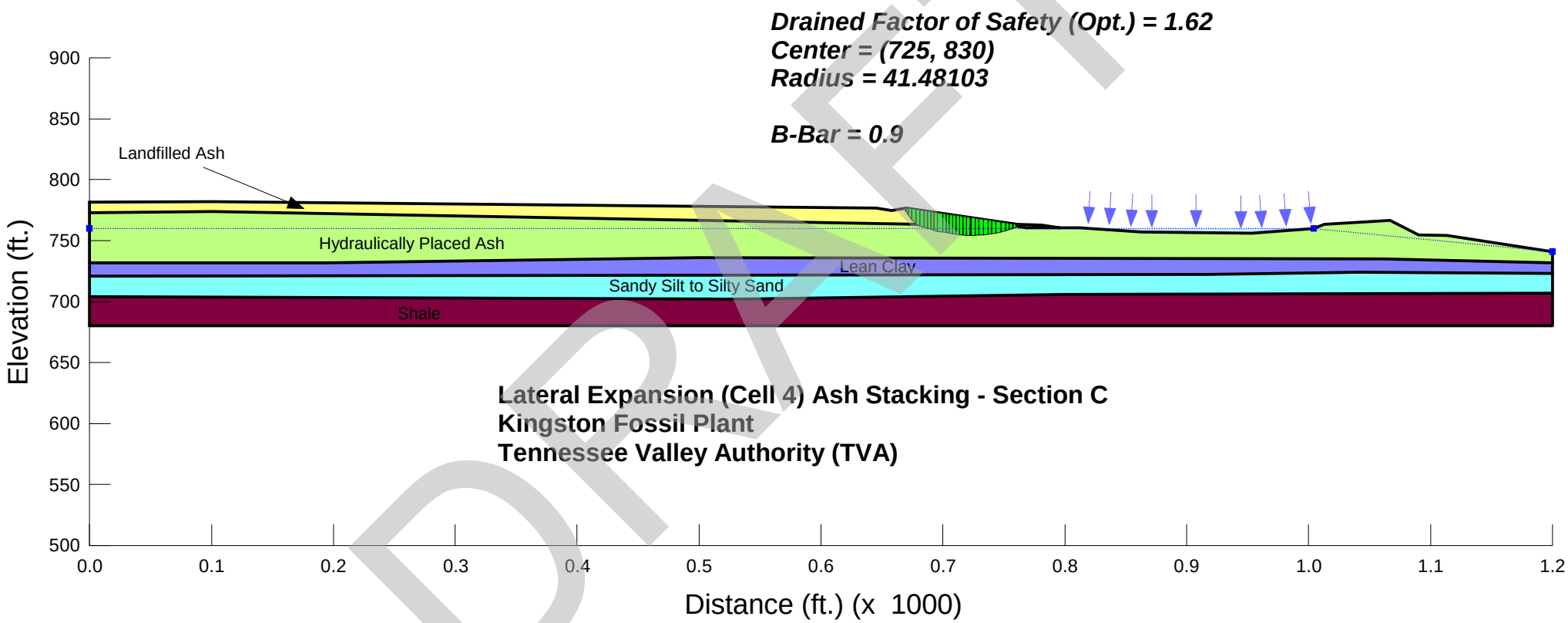
Figure C - 9: Excess Pore Water Pressure Ratio = 80%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/23/2011 at 10:43:34 AM

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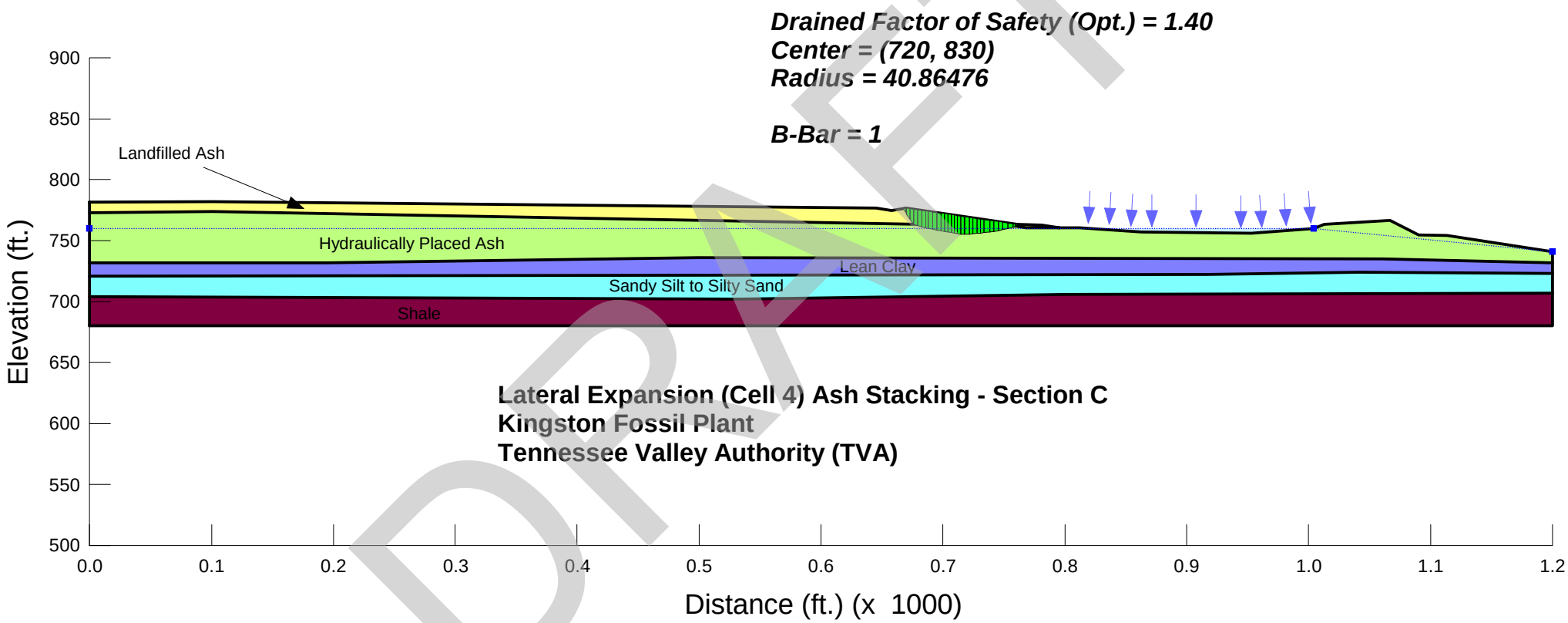
Figure C - 10: Excess Pore Water Pressure Ratio = 90%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



File Name: Section_C_Drained_PWP-100.gsz
Last Solved on 3/23/2011 at 10:47:30 AM

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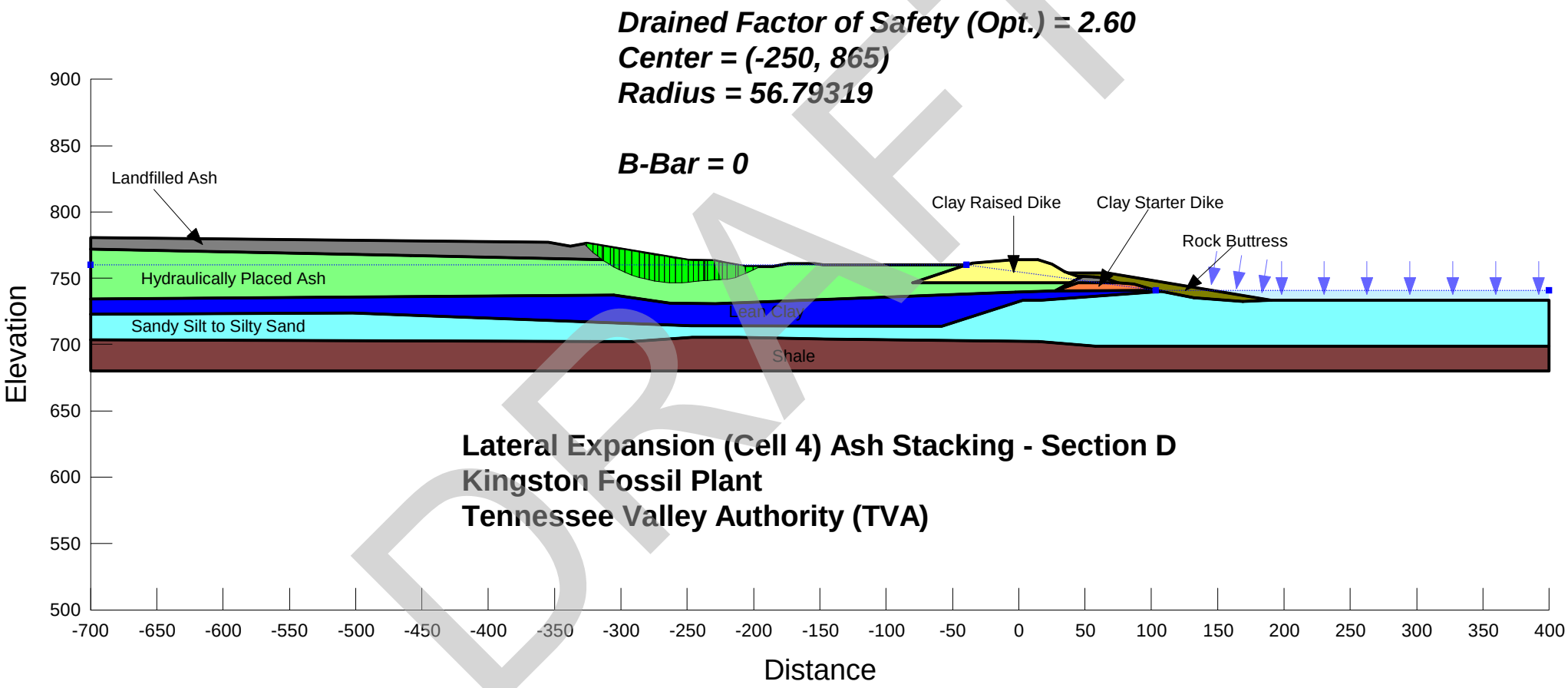
Figure C - 11: Excess Pore Water Pressure Ratio = 100%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	1
Clay Starter Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Clay Raised Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Rock	Mohr-Coulomb	128; 115	c'=0; phi'=38	1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



Lateral Expansion (Cell 4) Ash Stacking - Section D
Kingston Fossil Plant
Tennessee Valley Authority (TVA)

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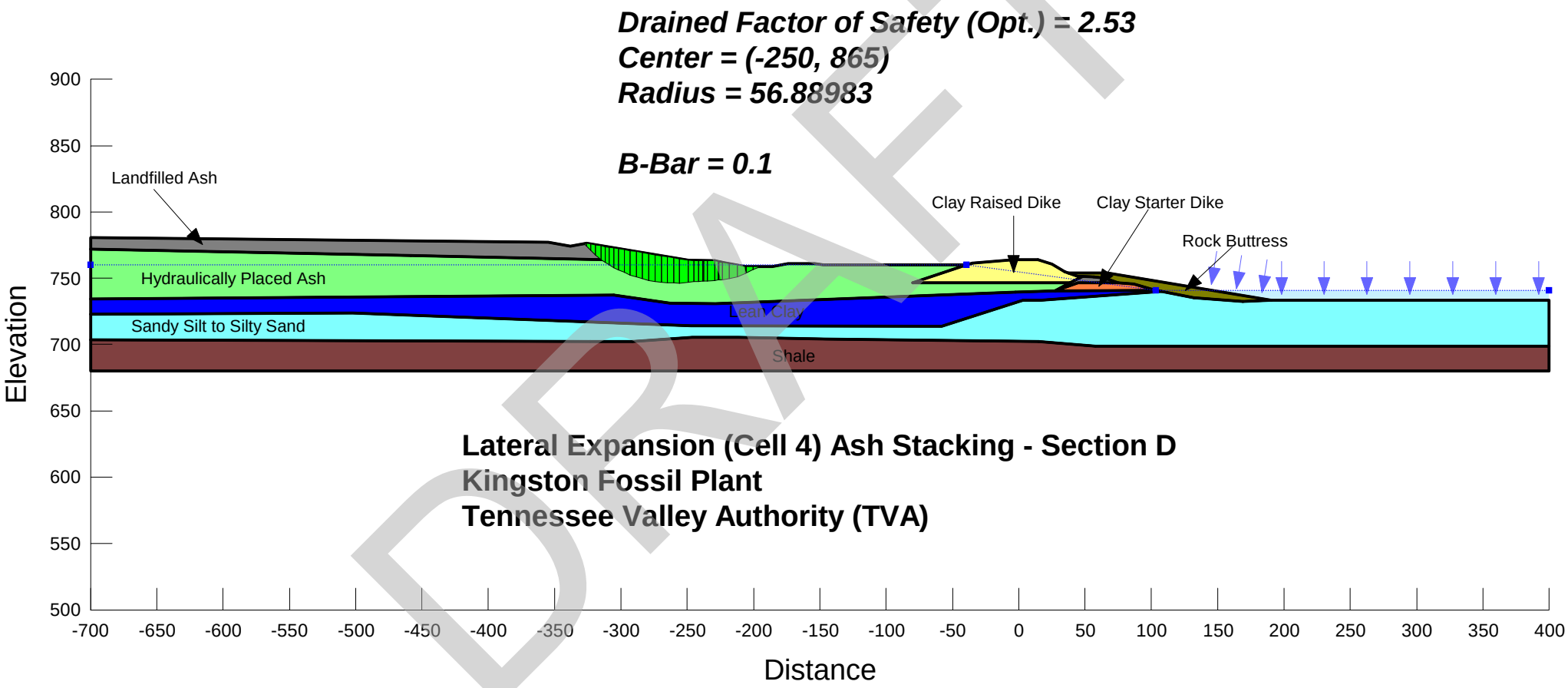
File Name: Section_D_Drained_PWP-0.gsz
Last Solved on 3/25/2011 at 9:23:22 AM

Figure D - 1: Excess Pore Water Pressure Ratio = 0

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	1
Clay Starter Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Clay Raised Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Rock	Mohr-Coulomb	128; 115	c'=0; phi'=38	1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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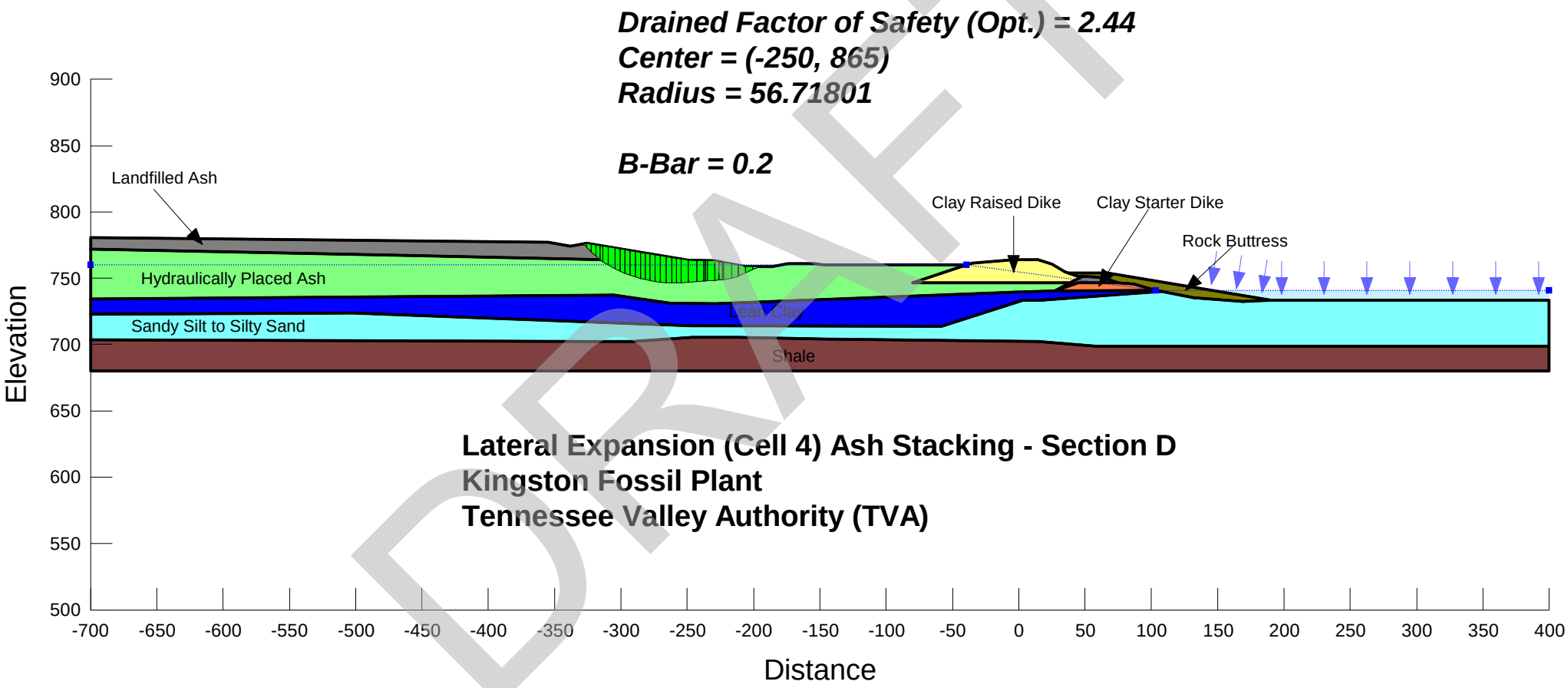
File Name: Section_D_Drained_PWP-10.gsz
Last Solved on 3/25/2011 at 9:28:19 AM

Figure D - 2: Excess Pore Water Pressure Ratio = 10%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	1
Clay Starter Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Clay Raised Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Rock	Mohr-Coulomb	128; 115	c'=0; phi'=38	1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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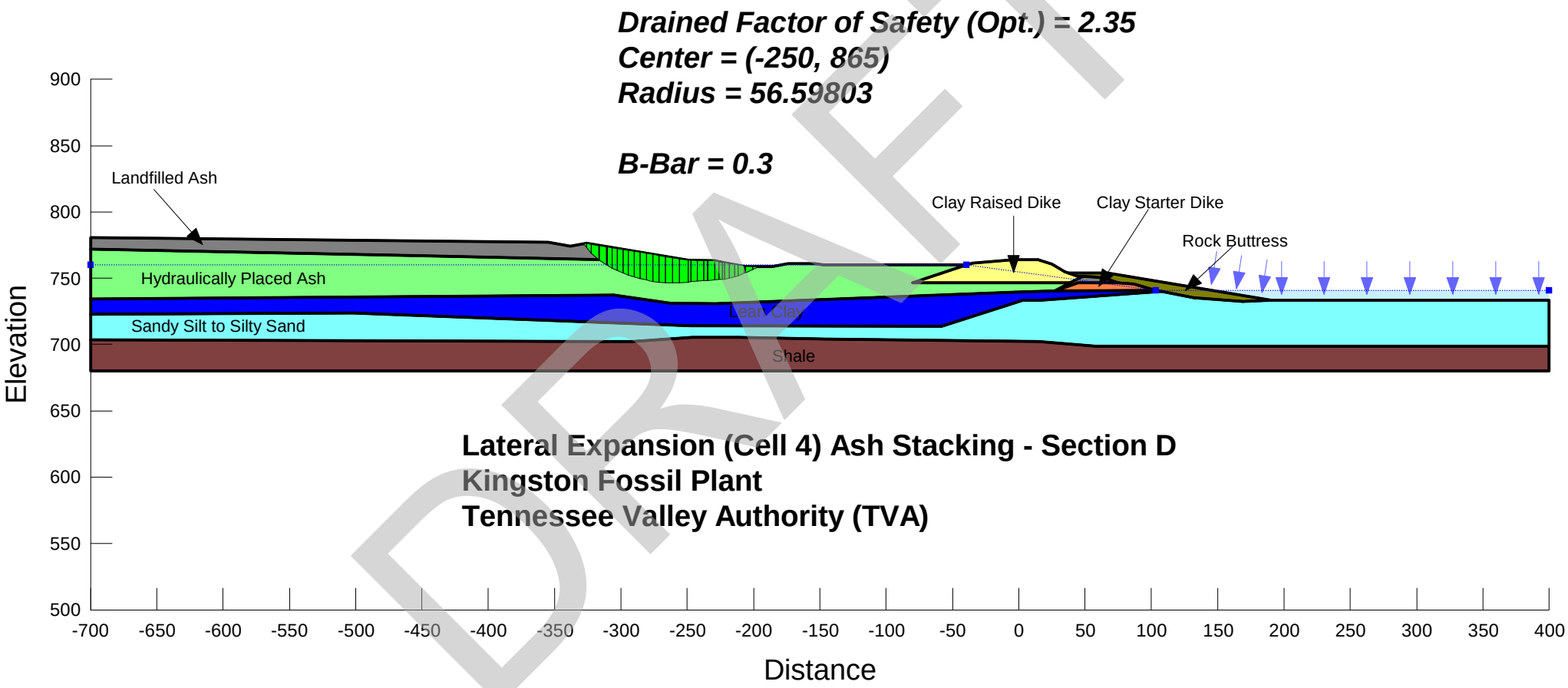
File Name: Section_D_Drained_PWP-20.gsz
Last Solved on 3/25/2011 at 9:33:04 AM

Figure D - 3: Excess Pore Water Pressure Ratio = 20%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	1
Clay Starter Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Clay Raised Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Rock	Mohr-Coulomb	128; 115	c'=0; phi'=38	1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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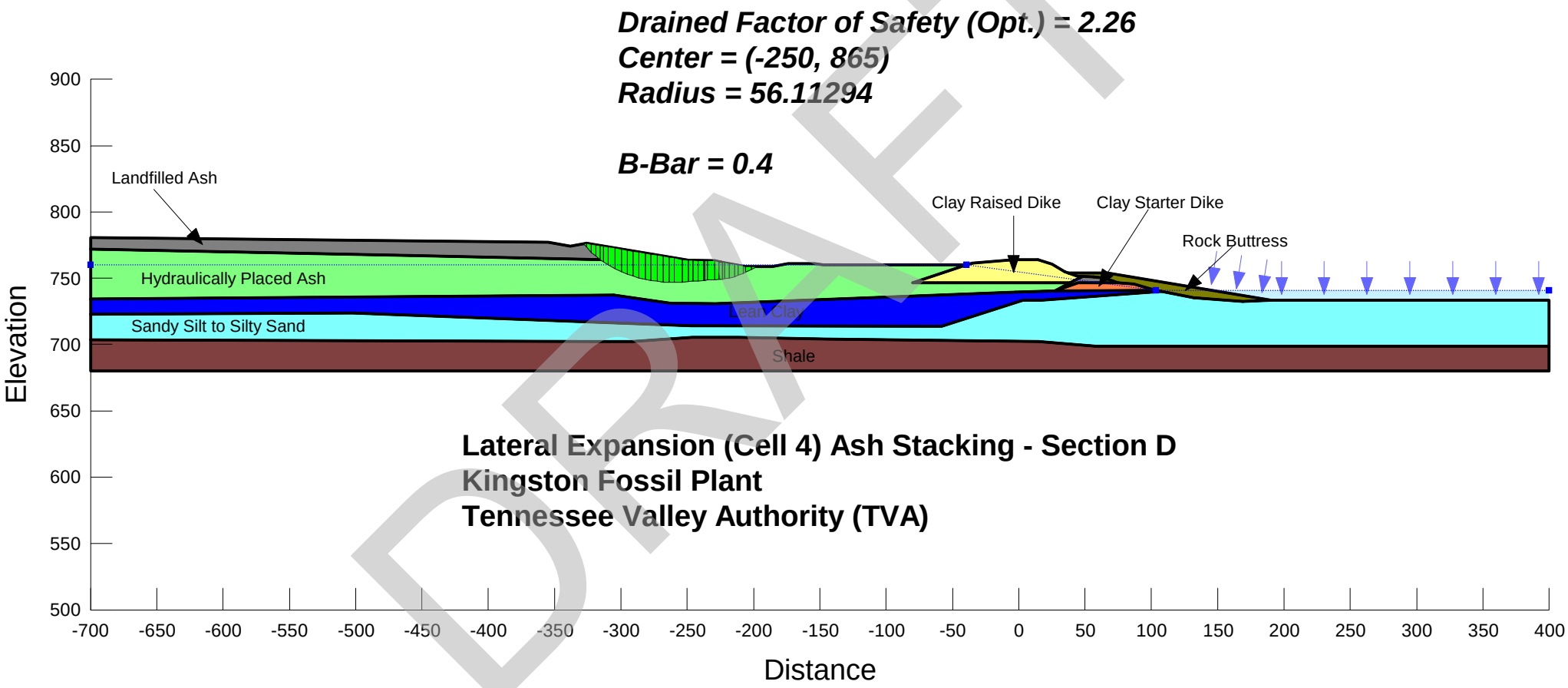
File Name: Section_D_Drained_PWP-30.gsz
Last Solved on 3/25/2011 at 9:37:17 AM

Figure D - 4: Excess Pore Water Pressure Ratio = 30%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	1
Clay Starter Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Clay Raised Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Rock	Mohr-Coulomb	128; 115	c'=0; phi'=38	1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



Lateral Expansion (Cell 4) Ash Stacking - Section D
Kingston Fossil Plant
Tennessee Valley Authority (TVA)

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File Name: Section_D_Drained_PWP-40.gsz
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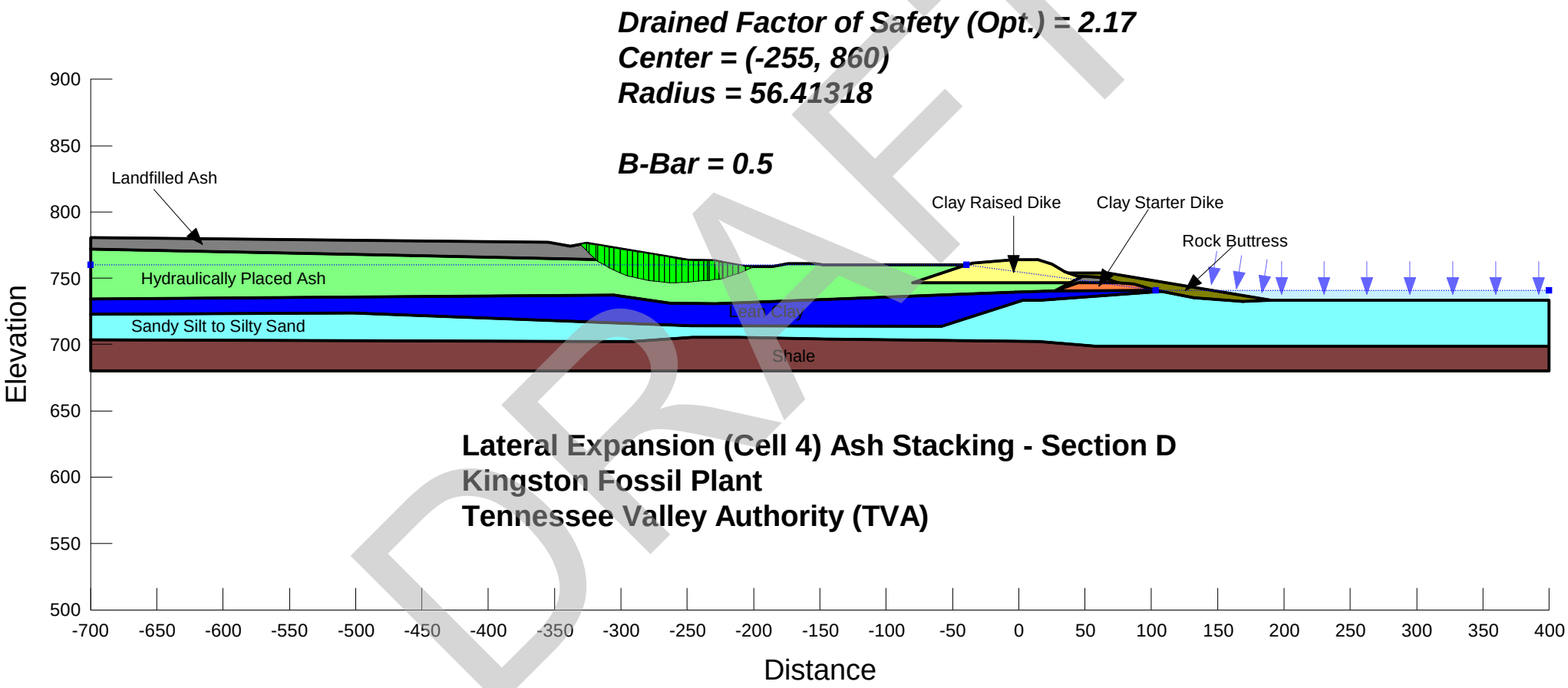
Figure D - 5: Excess Pore Water Pressure Ratio = 40%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	1
Clay Starter Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Clay Raised Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Rock	Mohr-Coulomb	128; 115	c'=0; phi'=38	1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



Lateral Expansion (Cell 4) Ash Stacking - Section D
Kingston Fossil Plant
Tennessee Valley Authority (TVA)

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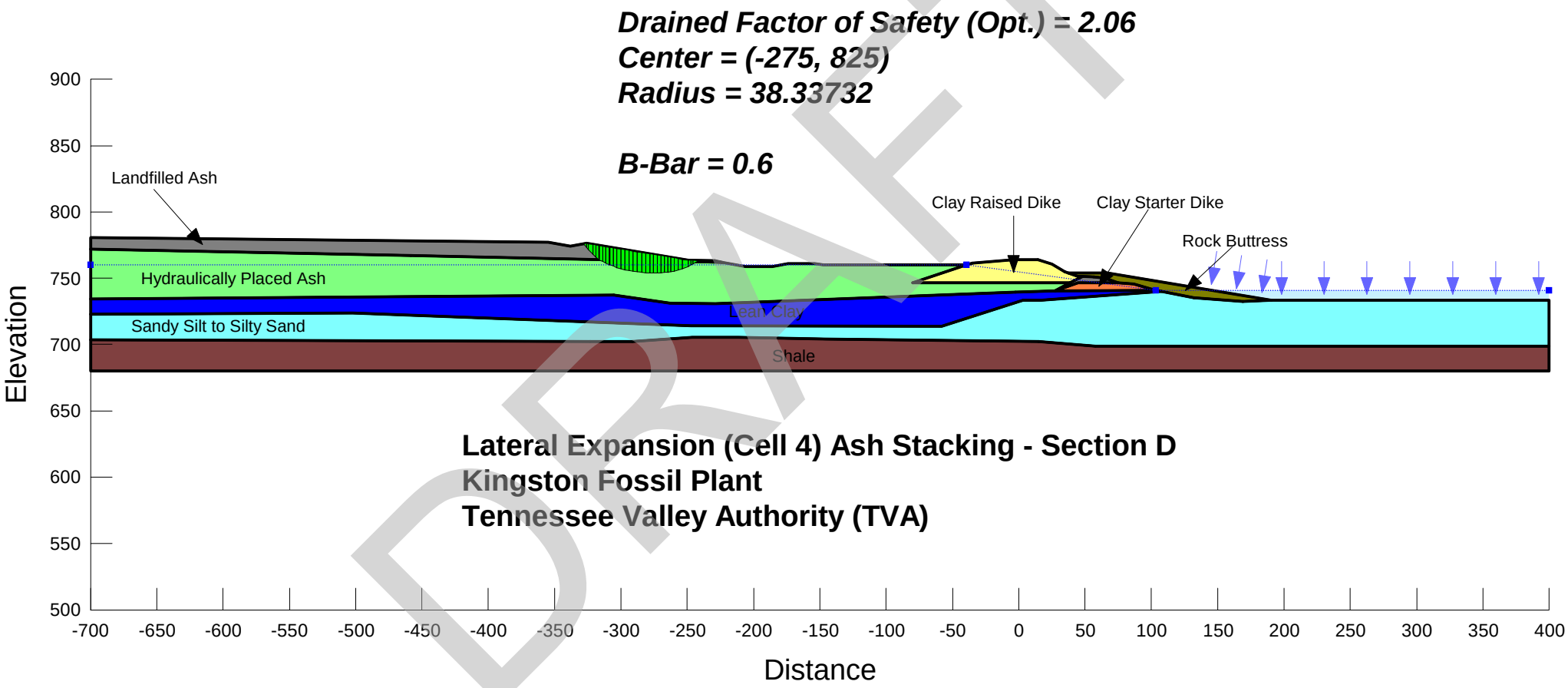
File Name: Section_D_Drained_PWP-50.gsz
Last Solved on 3/25/2011 at 9:46:25 AM

Figure D - 6: Excess Pore Water Pressure Ratio = 50%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	1
Clay Starter Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Clay Raised Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Rock	Mohr-Coulomb	128; 115	c'=0; phi'=38	1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/25/2011 at 9:51:49 AM

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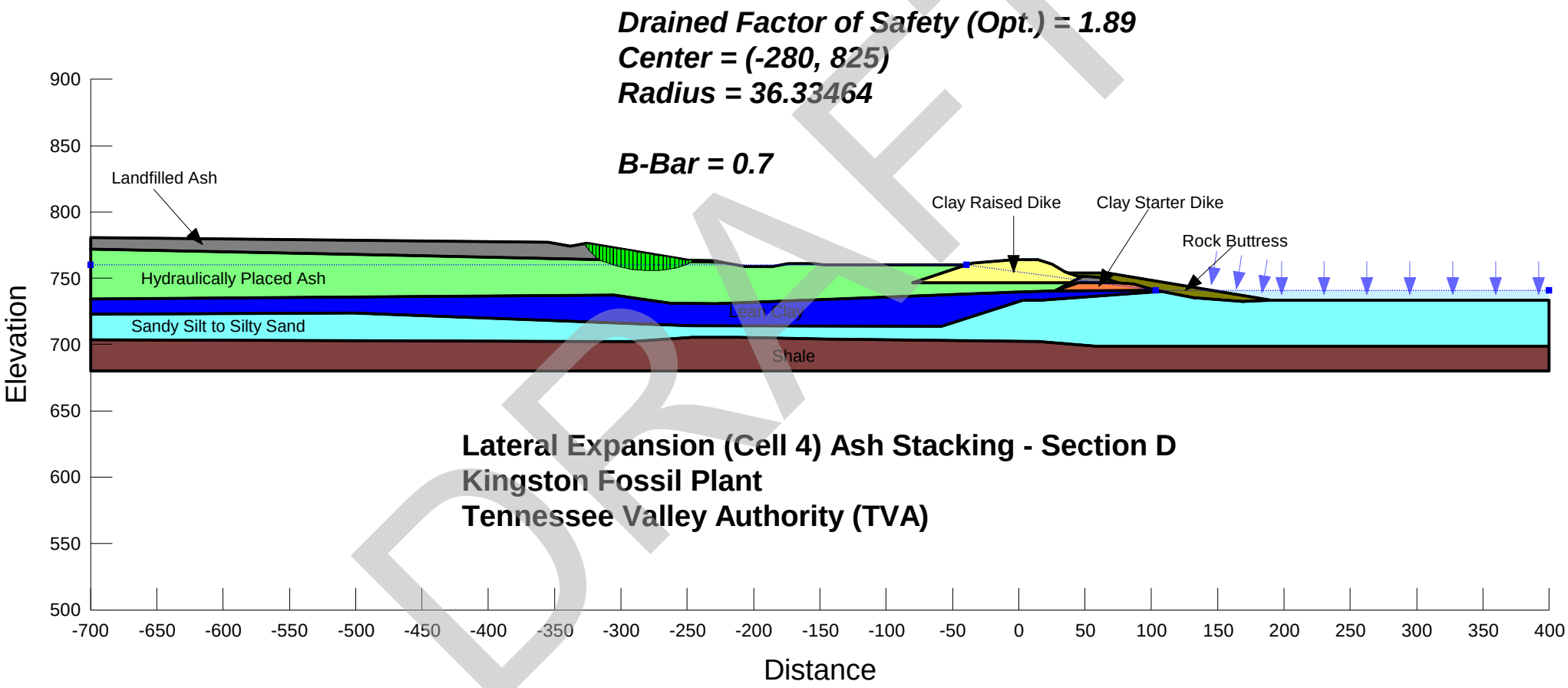
Figure D - 7: Excess Pore Water Pressure Ratio = 60%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	1
Clay Starter Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Clay Raised Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Rock	Mohr-Coulomb	128; 115	c'=0; phi'=38	1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/25/2011 at 9:56:54 AM

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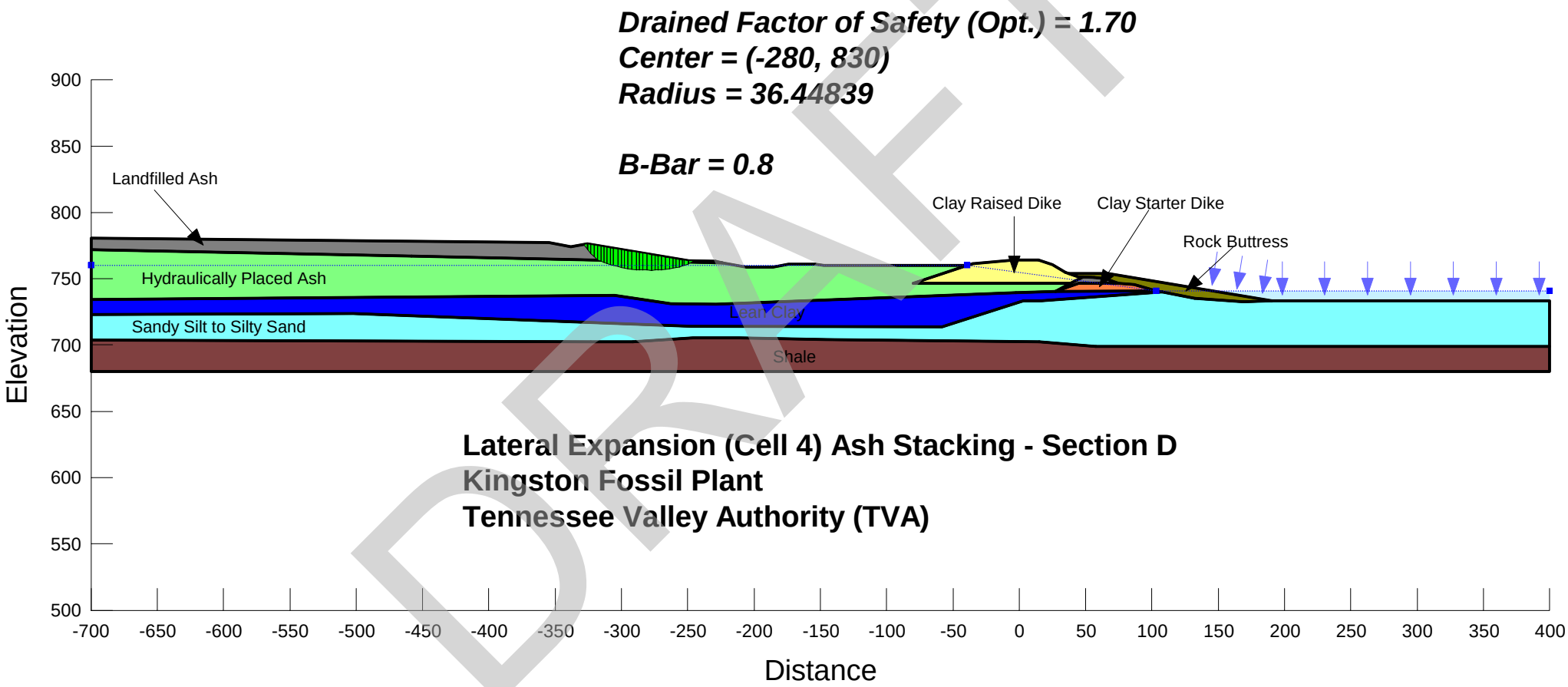
Figure D - 8: Excess Pore Water Pressure Ratio = 70%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	1
Clay Starter Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Clay Raised Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Rock	Mohr-Coulomb	128; 115	c'=0; phi'=38	1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



File Name: Section_D_Drained_PWP-80.gsz
Last Solved on 3/25/2011 at 10:32:02 AM

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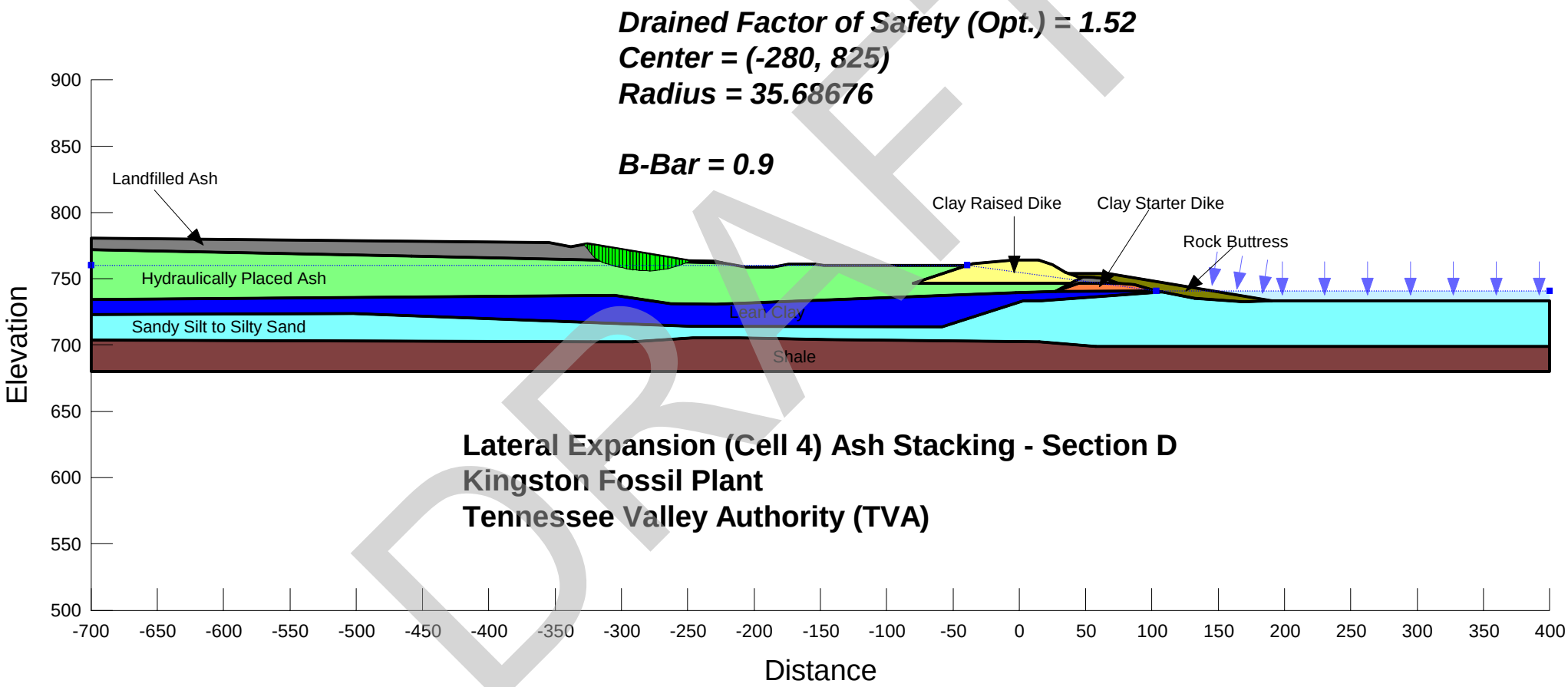
Figure D - 9: Excess Pore Water Pressure Ratio = 80%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	1
Clay Starter Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Clay Raised Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Rock	Mohr-Coulomb	128; 115	c'=0; phi'=38	1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



File Name: Section_D_Drained_PWP-90.gsz
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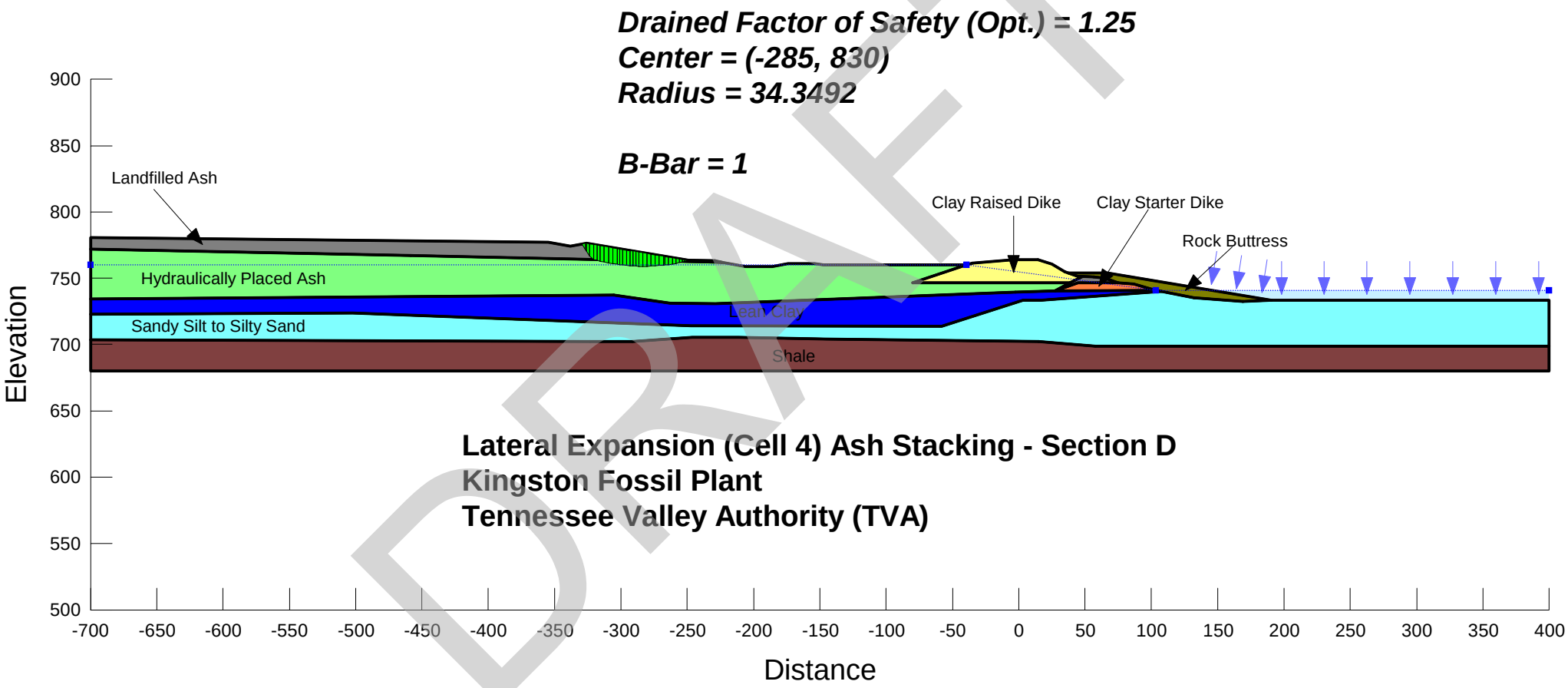
Figure D - 10: Excess Pore Water Pressure Ratio = 90%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	1
Clay Starter Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Clay Raised Dike	Mohr-Coulomb	128; 125	c'=0; phi'=30	1
Rock	Mohr-Coulomb	128; 115	c'=0; phi'=38	1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



File Name: Section_D_Drained_PWP-100.gsz
Last Solved on 3/25/2011 at 10:42:08 AM

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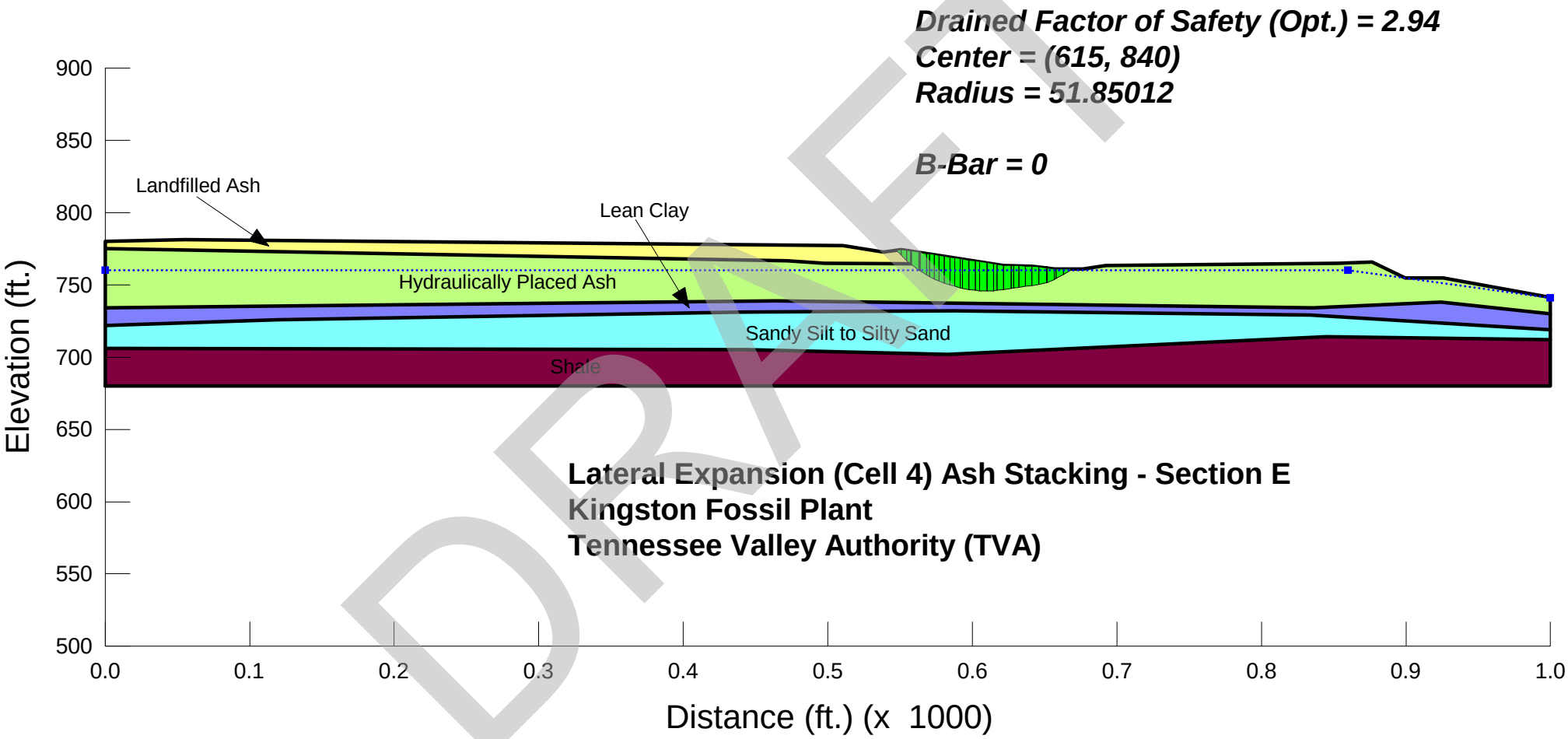
Figure D - 11: Excess Pore Water Pressure Ratio = 100%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



File Name: Section_E_Drained_PWP-0.gsz
Last Solved on 3/23/2011 at 2:26:14 PM

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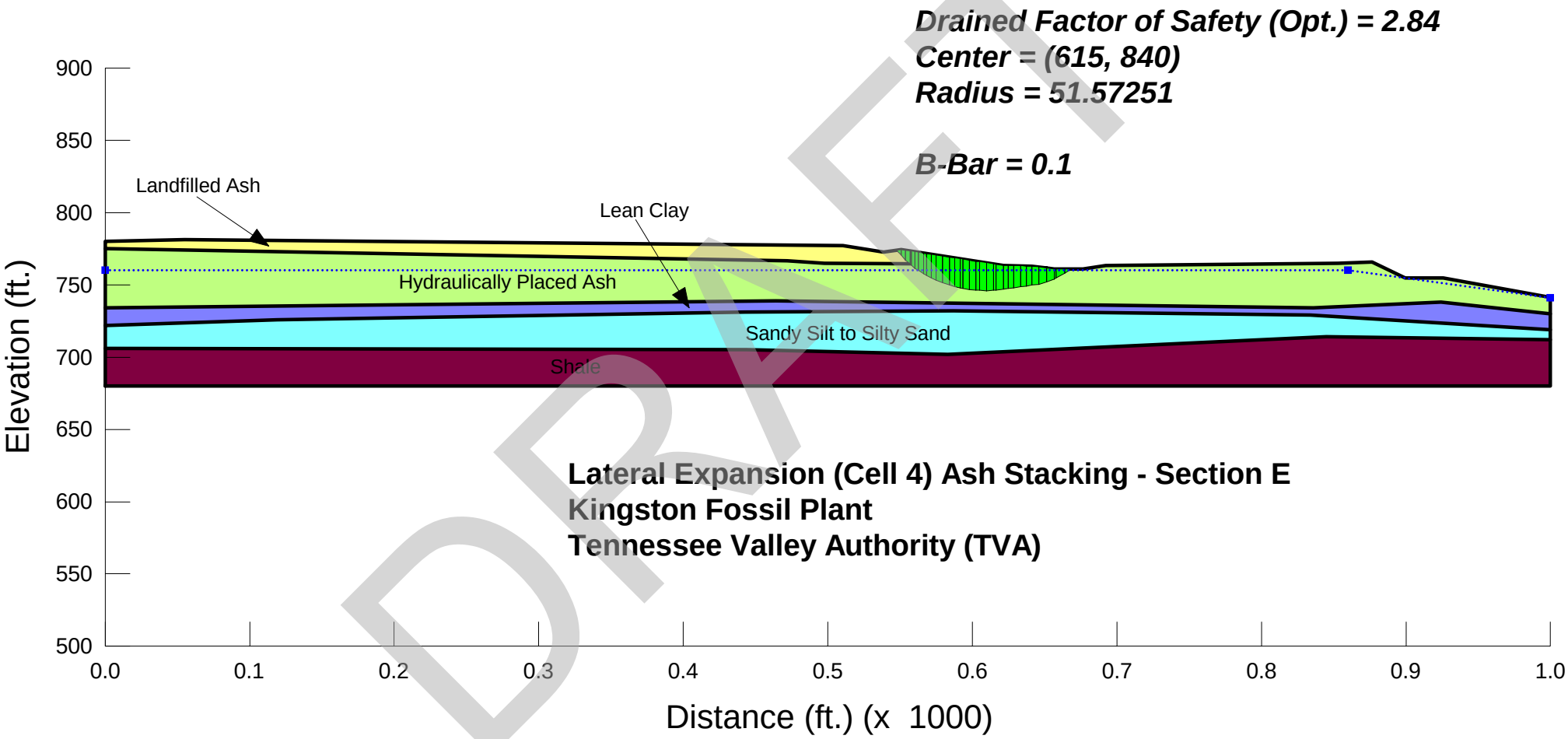
Figure E - 1: Excess Pore Water Pressure Ratio = 0

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



File Name: Section_E_Drained_PWP-10.gsz
Last Solved on 3/23/2011 at 2:31:52 PM

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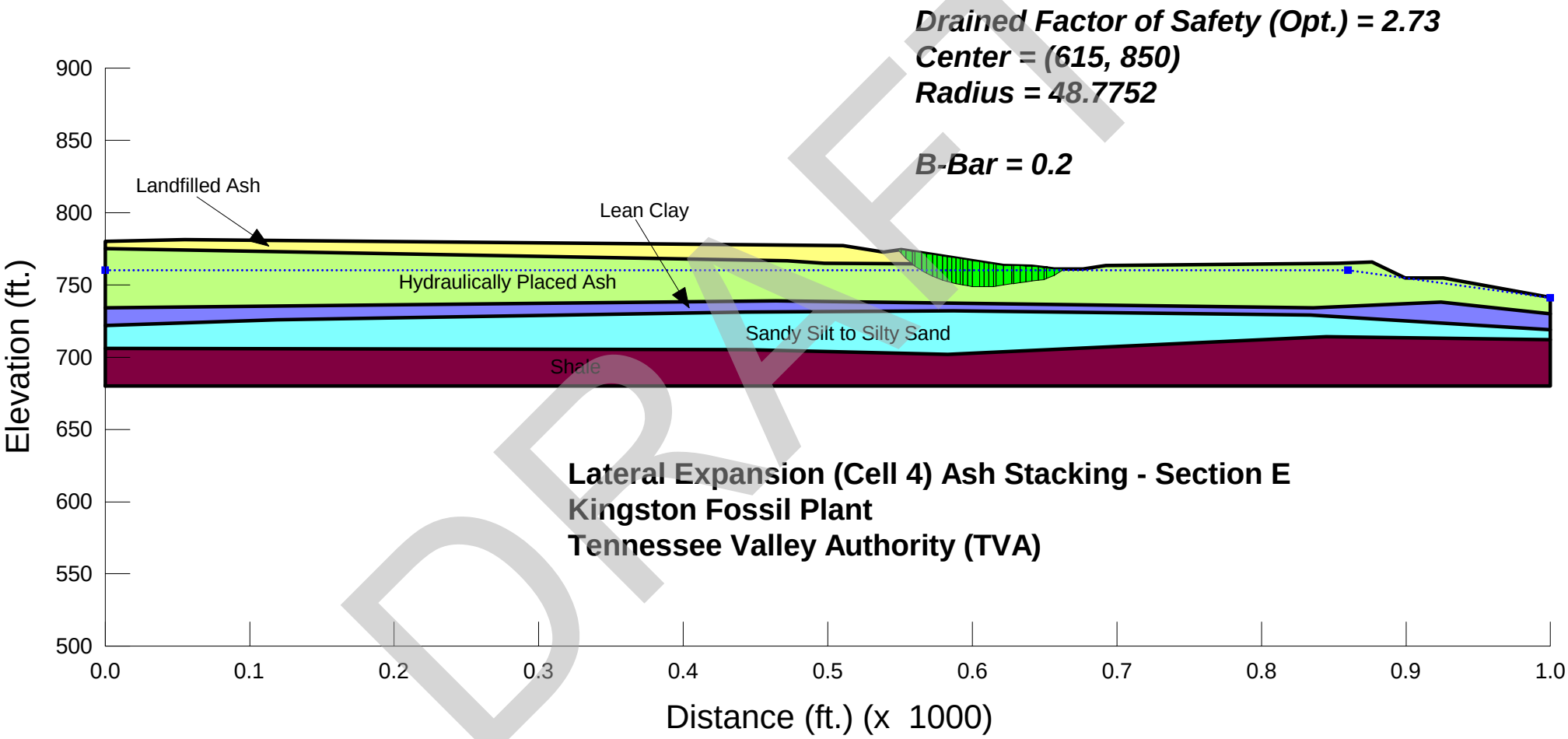
Figure E - 2: Excess Pore Water Pressure Ratio = 10%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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Last Solved on 3/23/2011 at 2:36:20 PM

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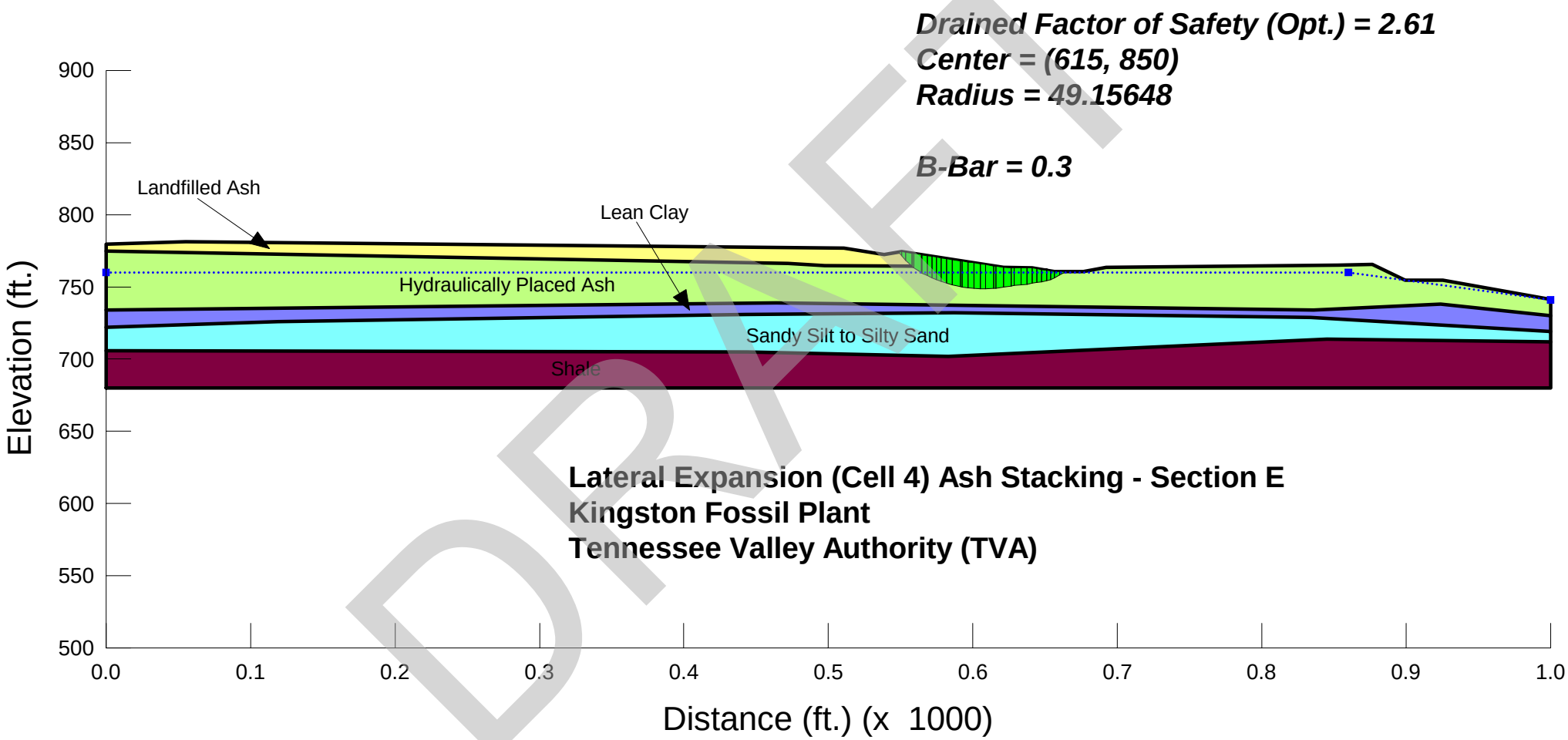
Figure E - 3: Excess Pore Water Pressure Ratio = 20%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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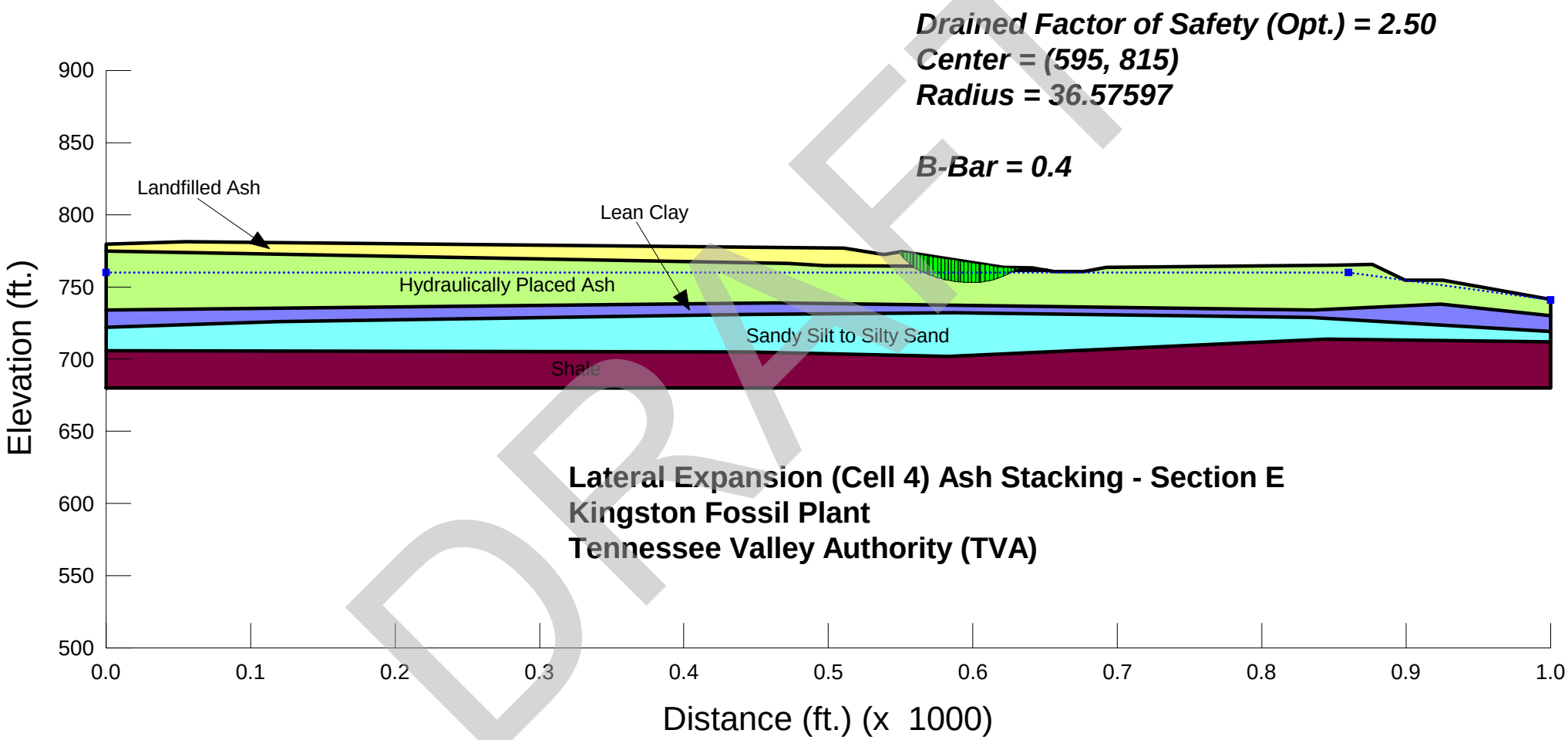
File Name: Section_E_Drained_PWP-30.gsz
Last Solved on 3/23/2011 at 2:40:30 PM

Figure E - 4: Excess Pore Water Pressure Ratio = 30%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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File Name: Section_E_Drained_PWP-40.gsz
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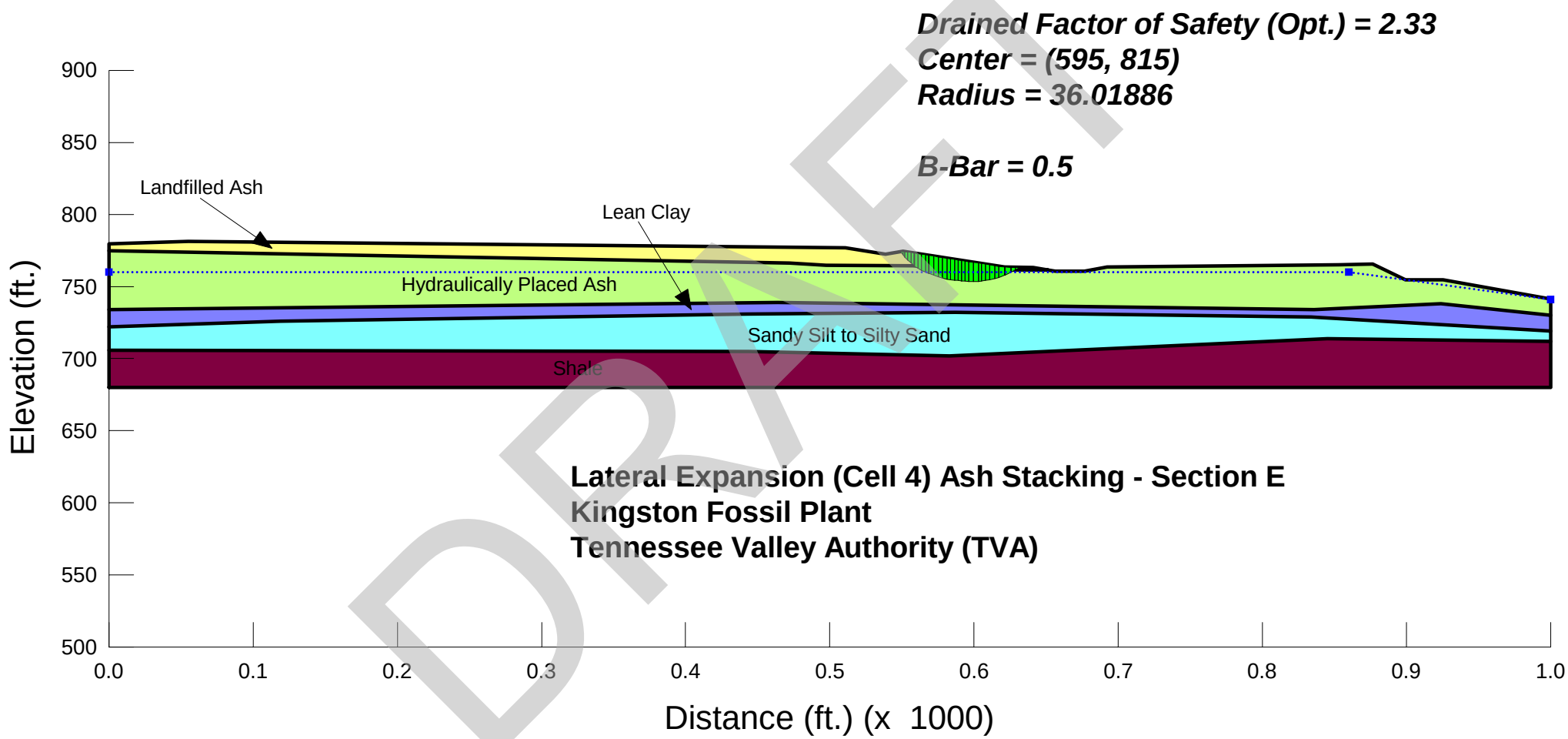
Figure E - 5: Excess Pore Water Pressure Ratio = 40%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



File Name: Section_E_Drained_PWP-50.gsz
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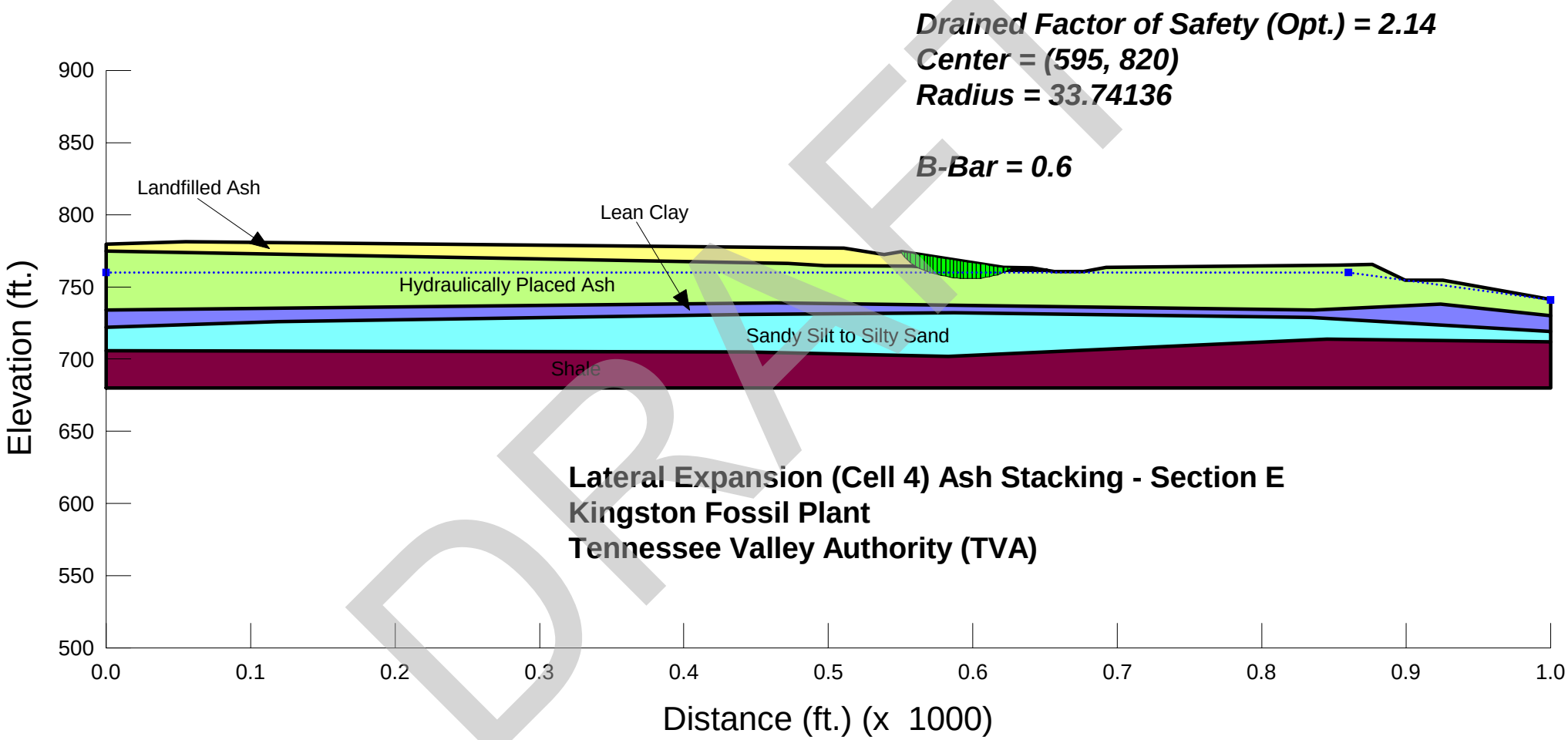
Figure E - 6: Excess Pore Water Pressure Ratio = 50%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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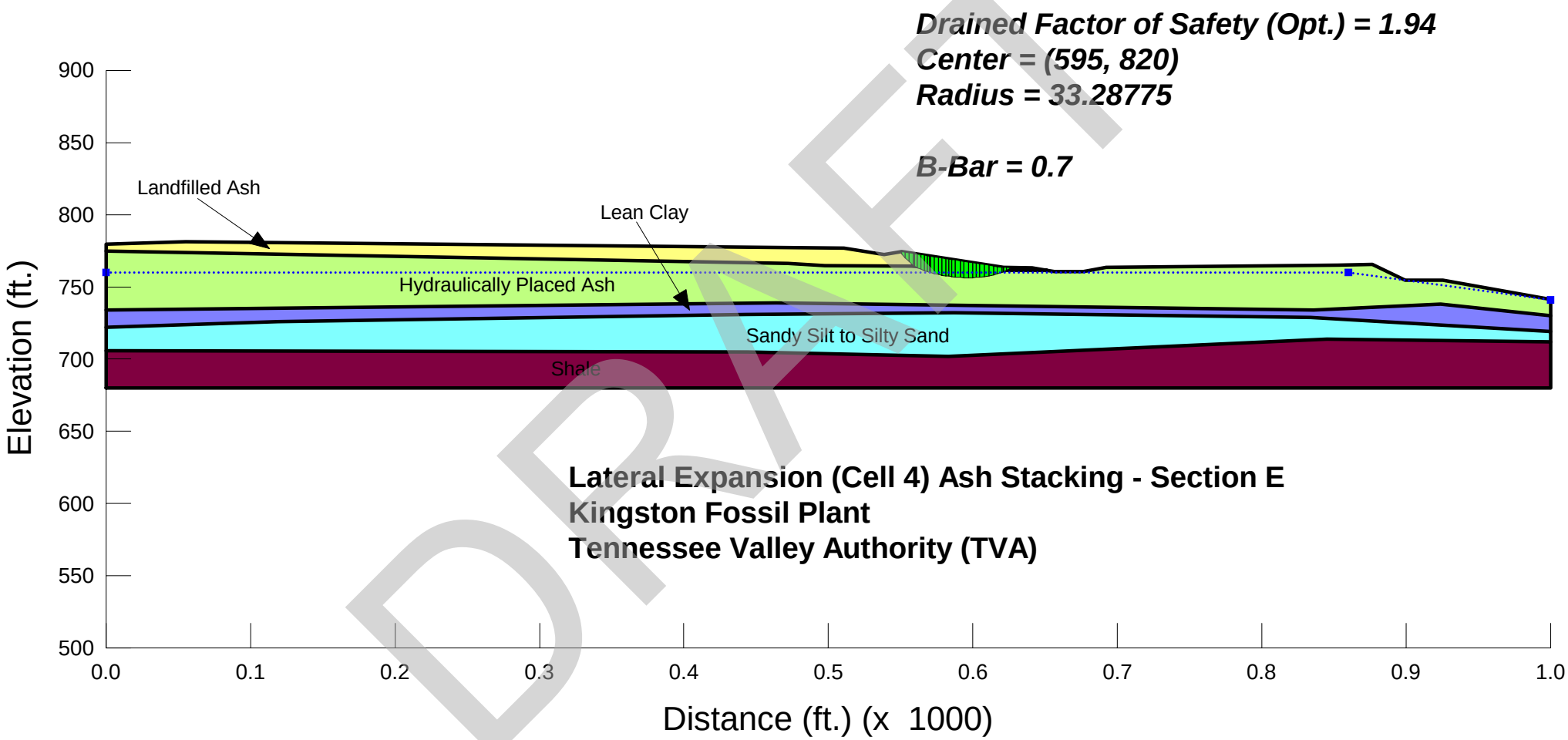
File Name: Section_E_Drained_PWP-60.gsz
Last Solved on 3/23/2011 at 2:53:28 PM

Figure E - 7: Excess Pore Water Pressure Ratio = 60%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



File Name: Section_E_Drained_PWP-70.gsz
Last Solved on 3/23/2011 at 2:57:58 PM

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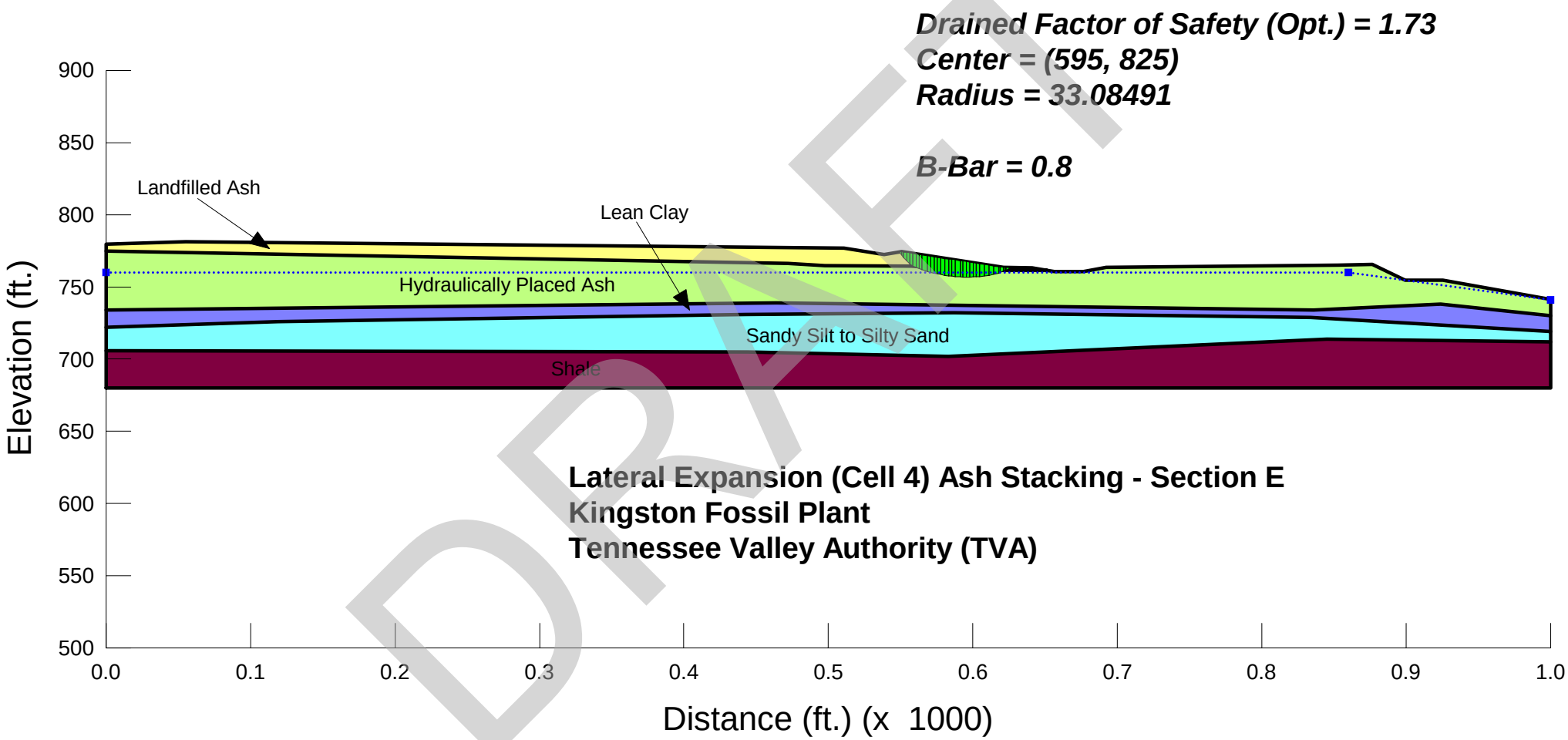
Figure E - 8: Excess Pore Water Pressure Ratio = 70%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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File Name: Section_E_Drained_PWP-80.gsz
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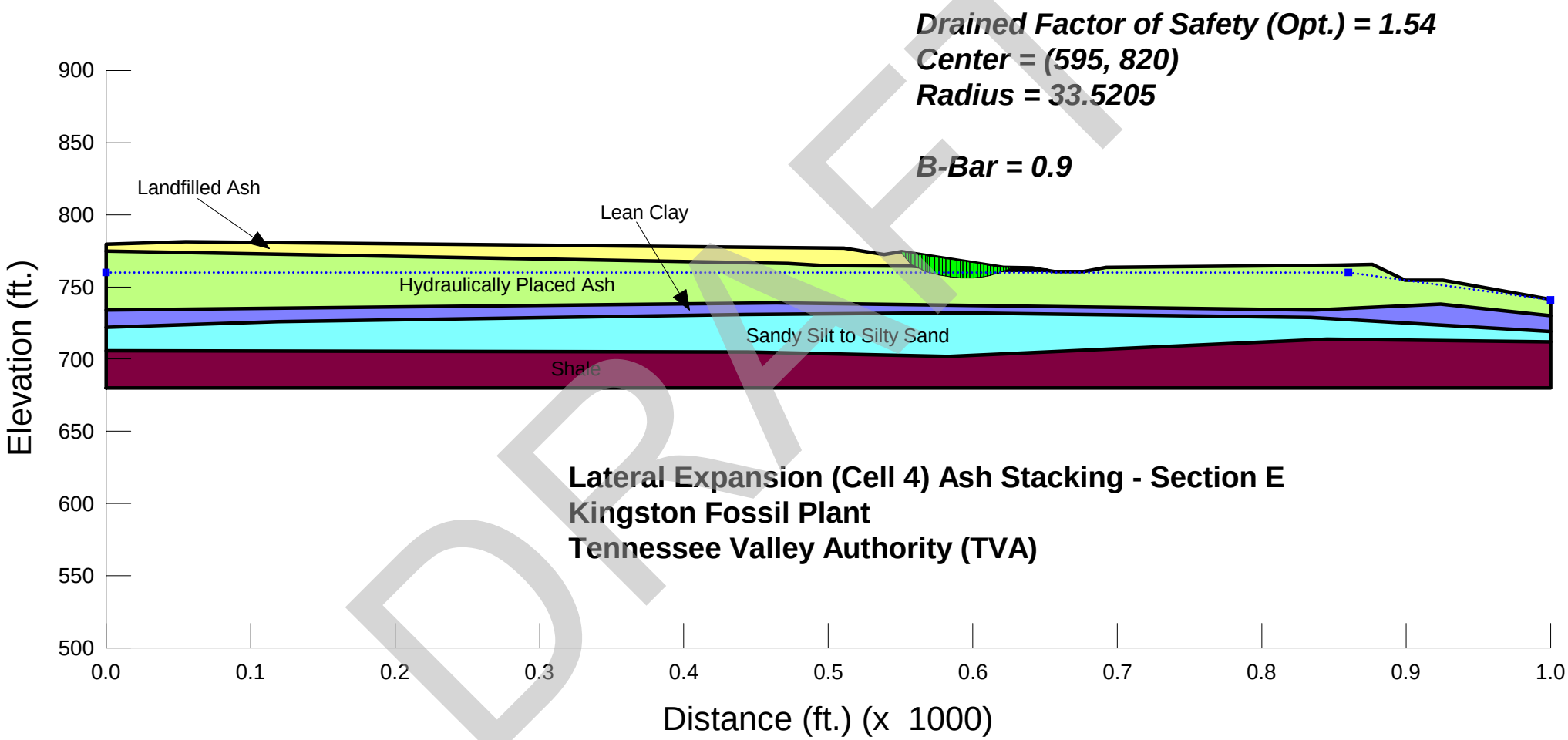
Figure E - 9: Excess Pore Water Pressure Ratio = 80%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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File Name: Section_E_Drained_PWP-90.gsz
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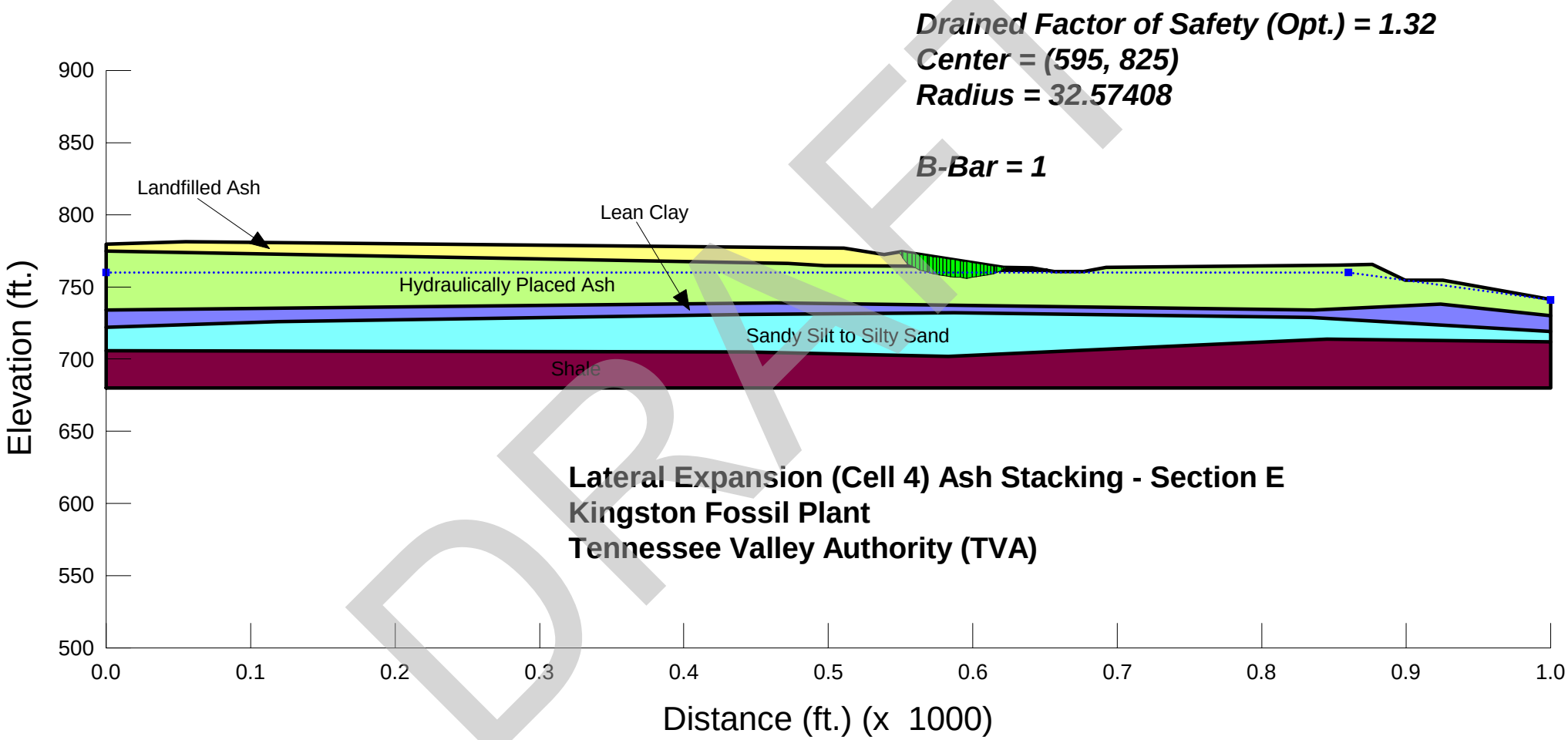
Figure E - 10: Excess Pore Water Pressure Ratio = 90%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	Bedrock (Impenetrable)	N/A	N/A	N/A



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File Name: Section_E_Drained_PWP-100.gsz
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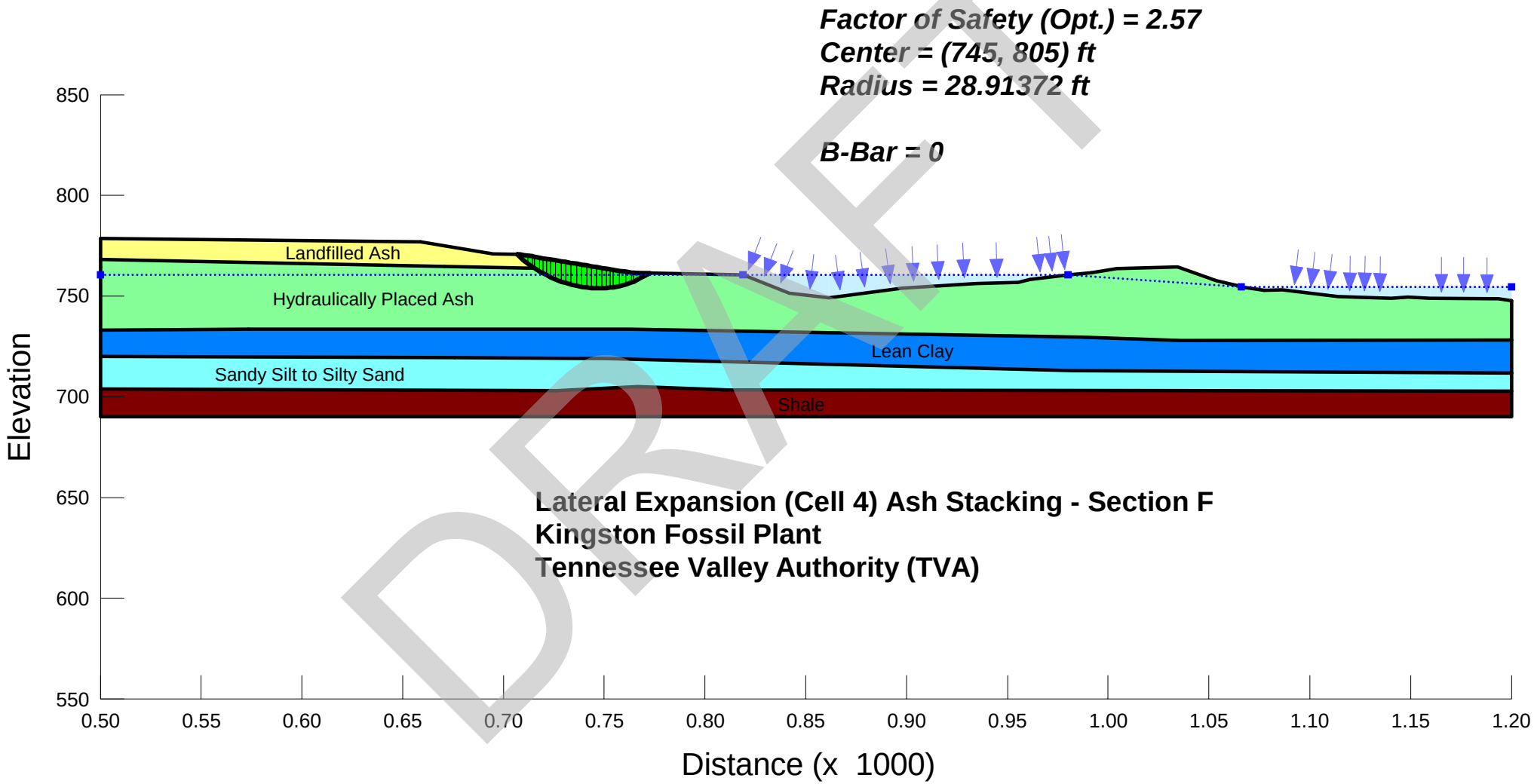
Figure E - 11: Excess Pore Water Pressure Ratio = 100%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	N/A	N/A	N/A	N/A



File Name: Section_F_Drained_PWP-0.gsz
Last Solved on 3/24/2011 at 9:15:34 AM

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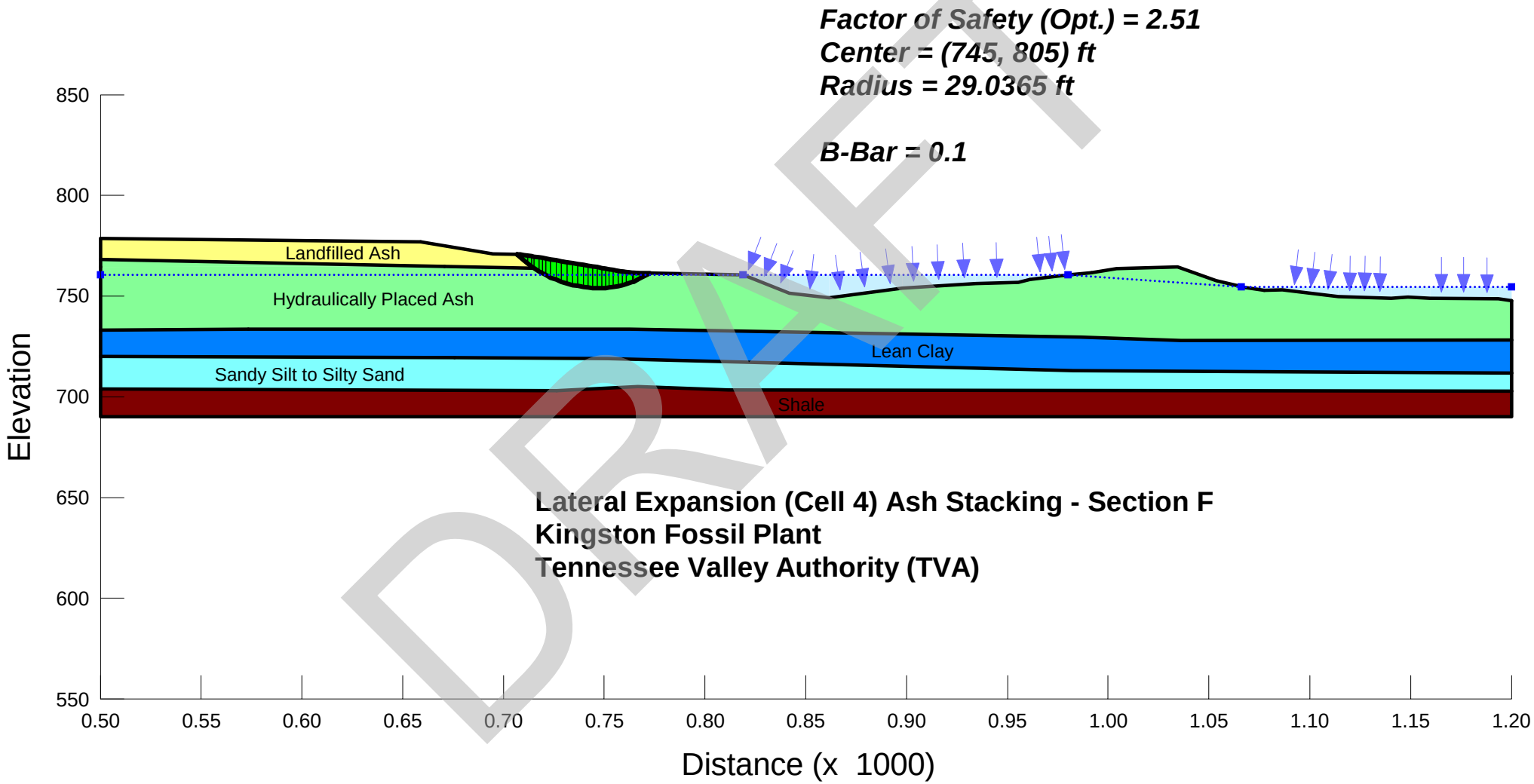
Figure F - 1: Excess Pore Water Pressure Ratio = 0

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	N/A	N/A	N/A	N/A



File Name: Section_F_Drained_PWP-10.gsz
Last Solved on 3/24/2011 at 9:10:47 AM

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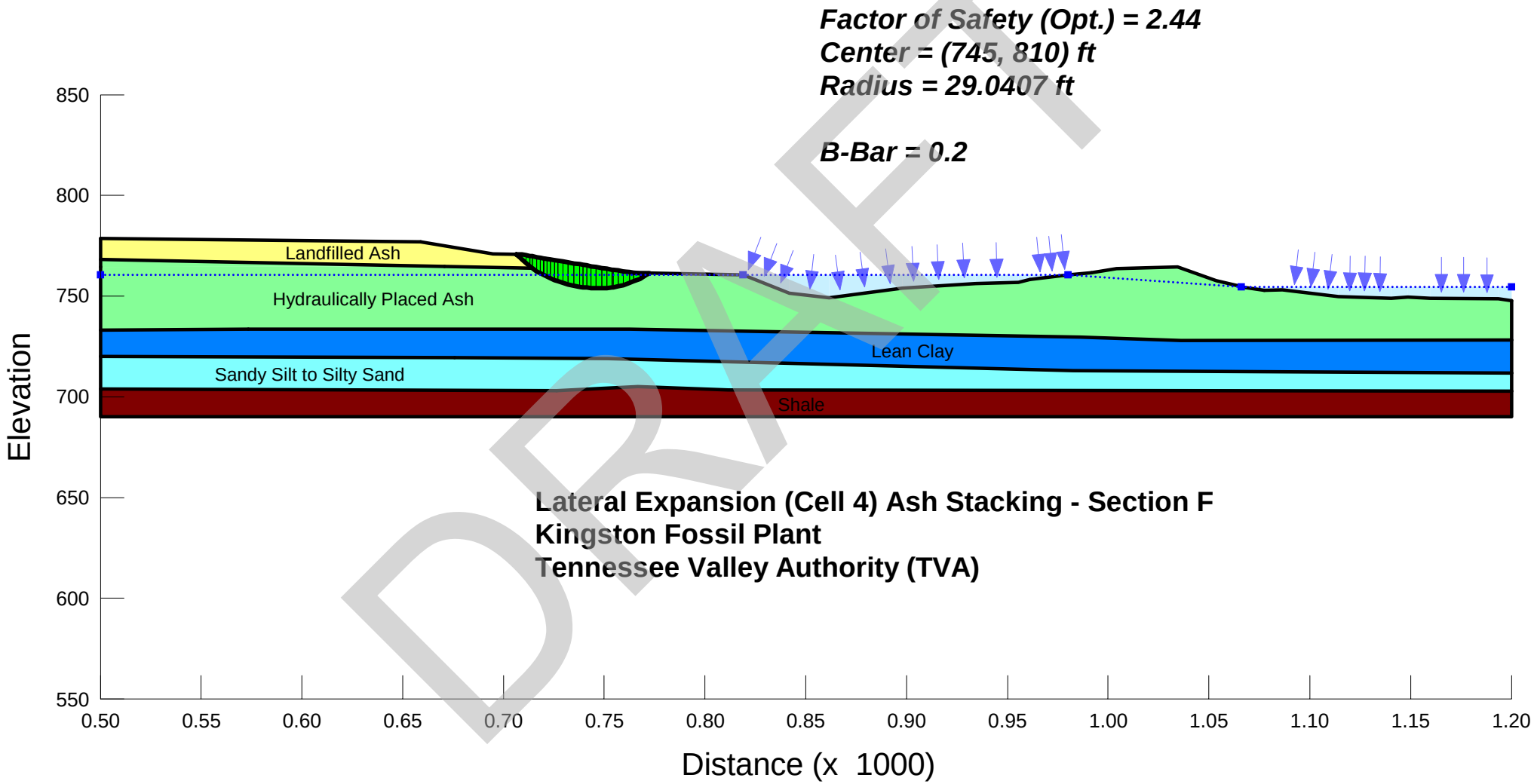
Figure F - 2: Excess Pore Water Pressure Ratio = 10%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	N/A	N/A	N/A	N/A



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Last Solved on 3/24/2011 at 9:02:27 AM

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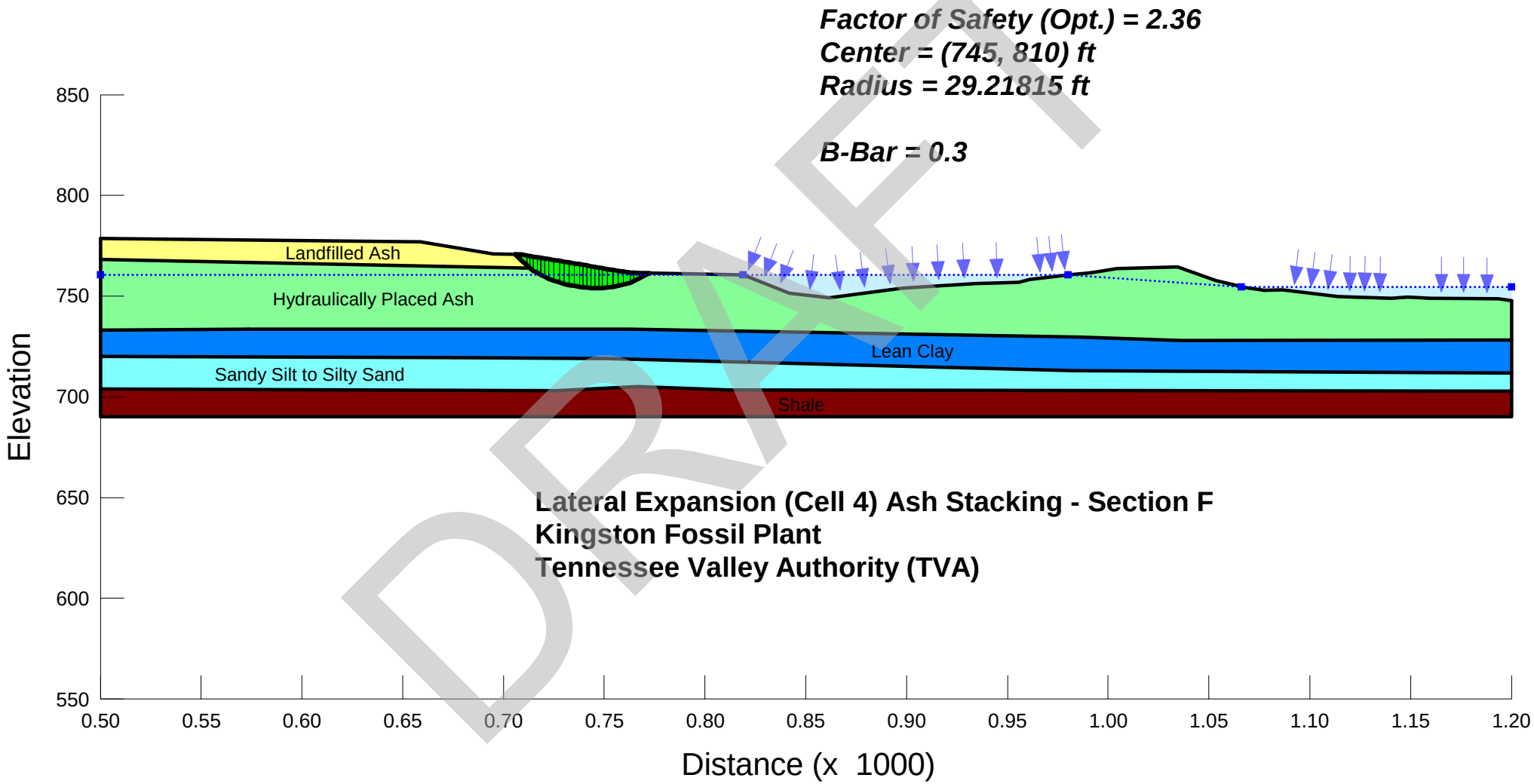
Figure F - 3: Excess Pore Water Pressure Ratio = 20%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	N/A	N/A	N/A	N/A



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Last Solved on 3/24/2011 at 8:58:36 AM

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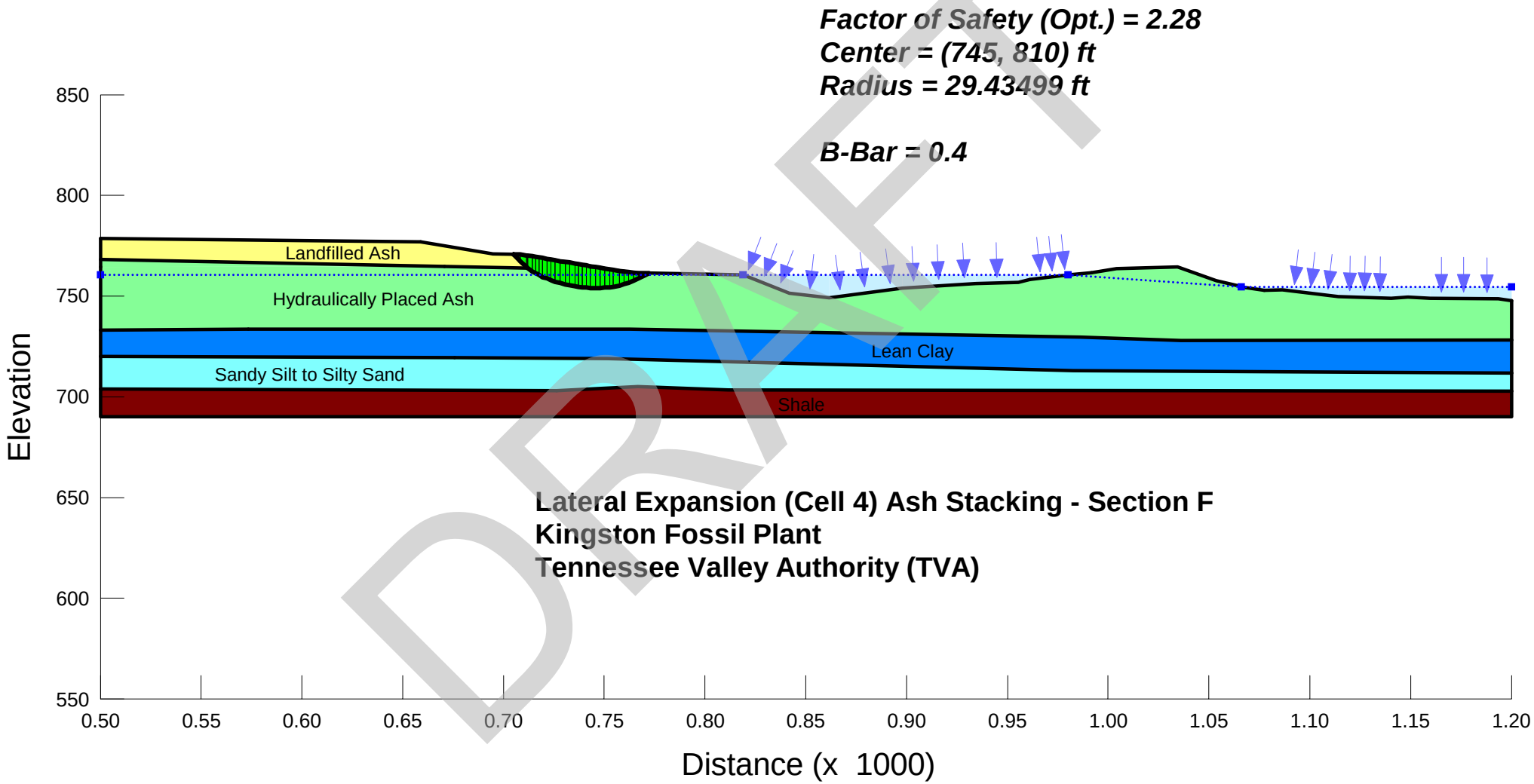
Figure F - 4: Excess Pore Water Pressure Ratio = 30%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	N/A	N/A	N/A	N/A



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Last Solved on 3/24/2011 at 8:54:41 AM

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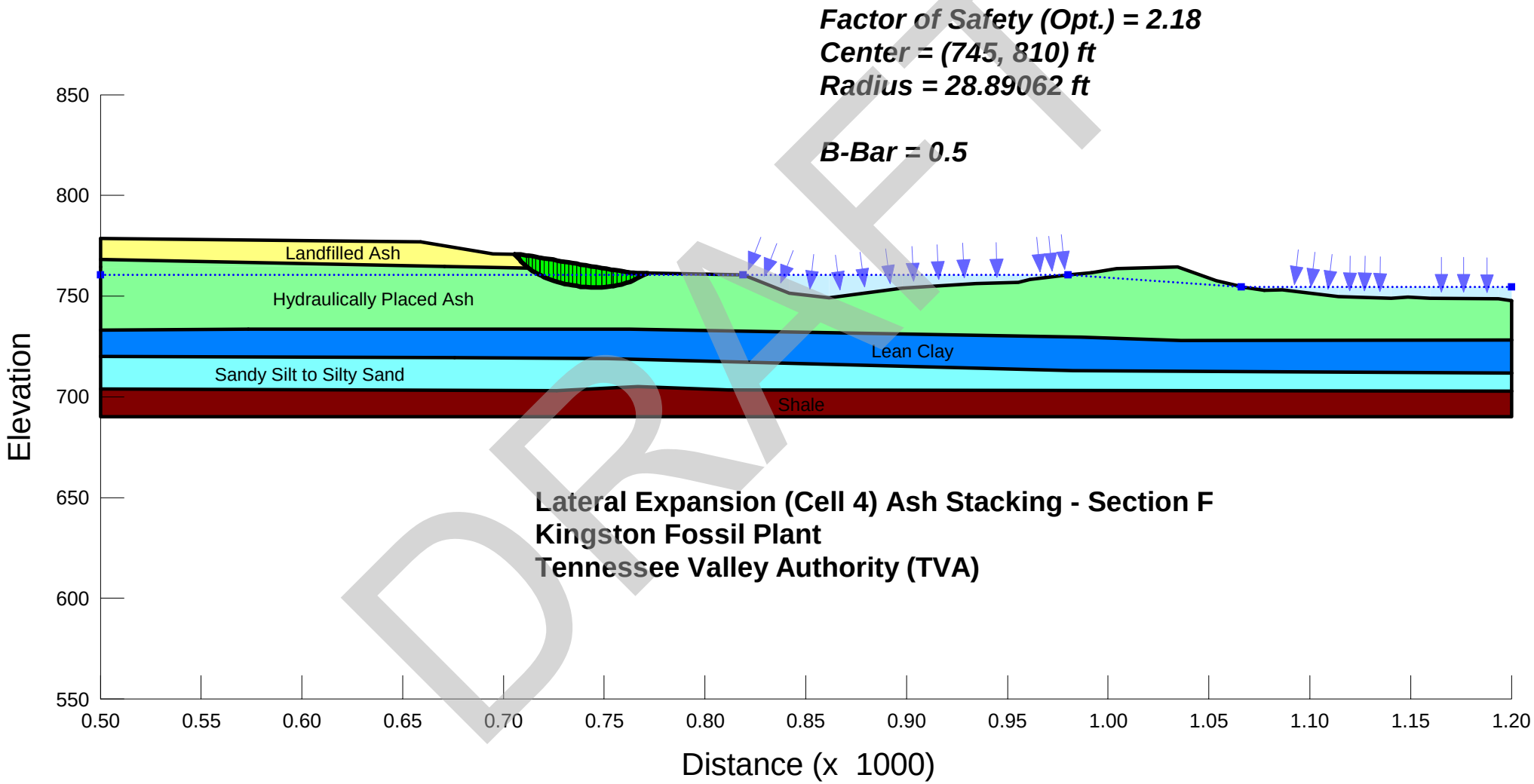
Figure F - 5: Excess Pore Water Pressure Ratio = 40%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	N/A	N/A	N/A	N/A



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Last Solved on 3/23/2011 at 5:02:51 PM

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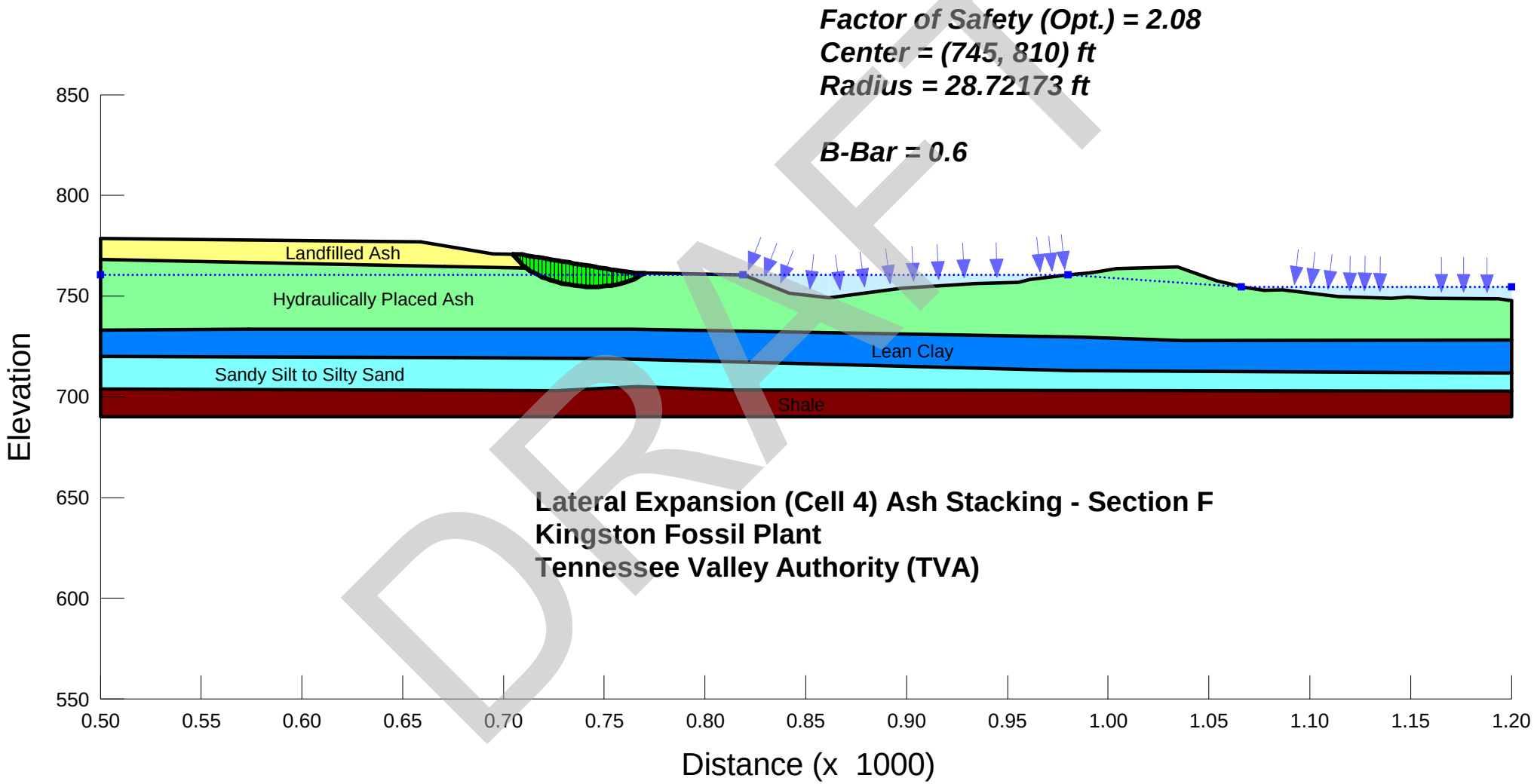
Figure F - 6: Excess Pore Water Pressure Ratio = 50%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	N/A	N/A	N/A	N/A



File Name: Section_F_Drained_PWP-60.gsz
Last Solved on 3/23/2011 at 4:58:37 PM

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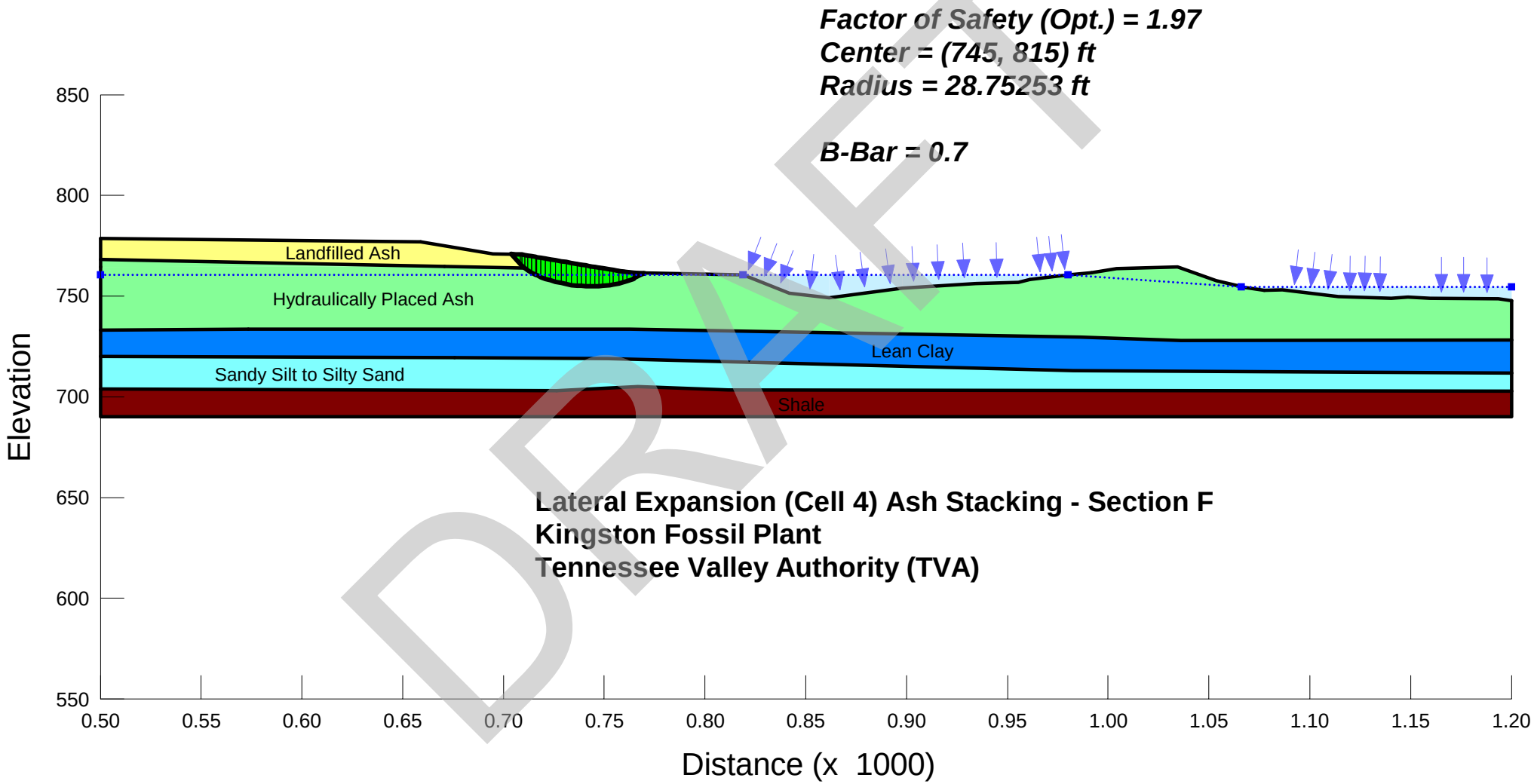
Figure F - 7: Excess Pore Water Pressure Ratio = 60%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	N/A	N/A	N/A	N/A



File Name: Section_F_Drained_PWP-70.gsz
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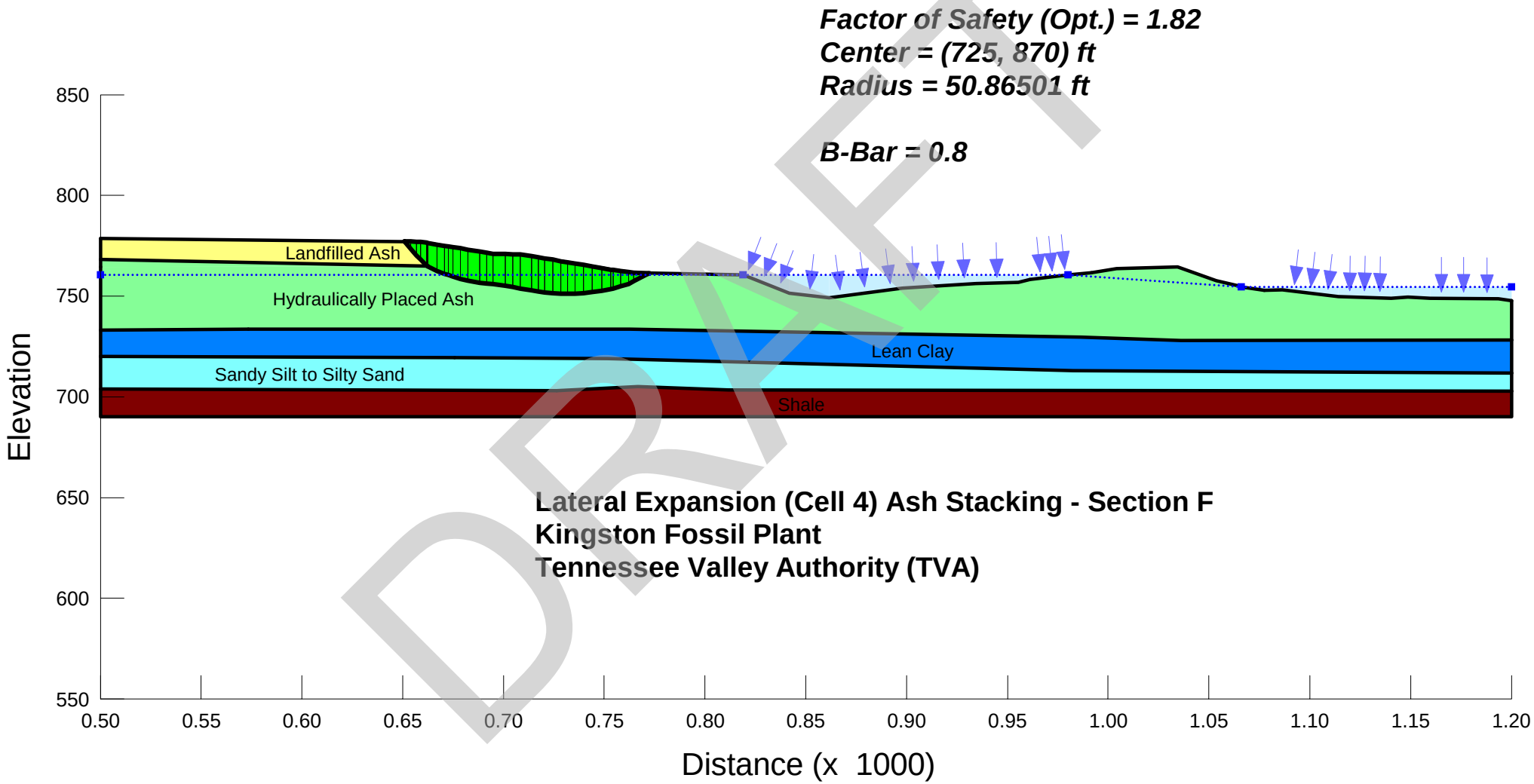
Figure F - 8: Excess Pore Water Pressure Ratio = 70%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	N/A	N/A	N/A	N/A



File Name: Section_F_Drained_PWP-80.gsz
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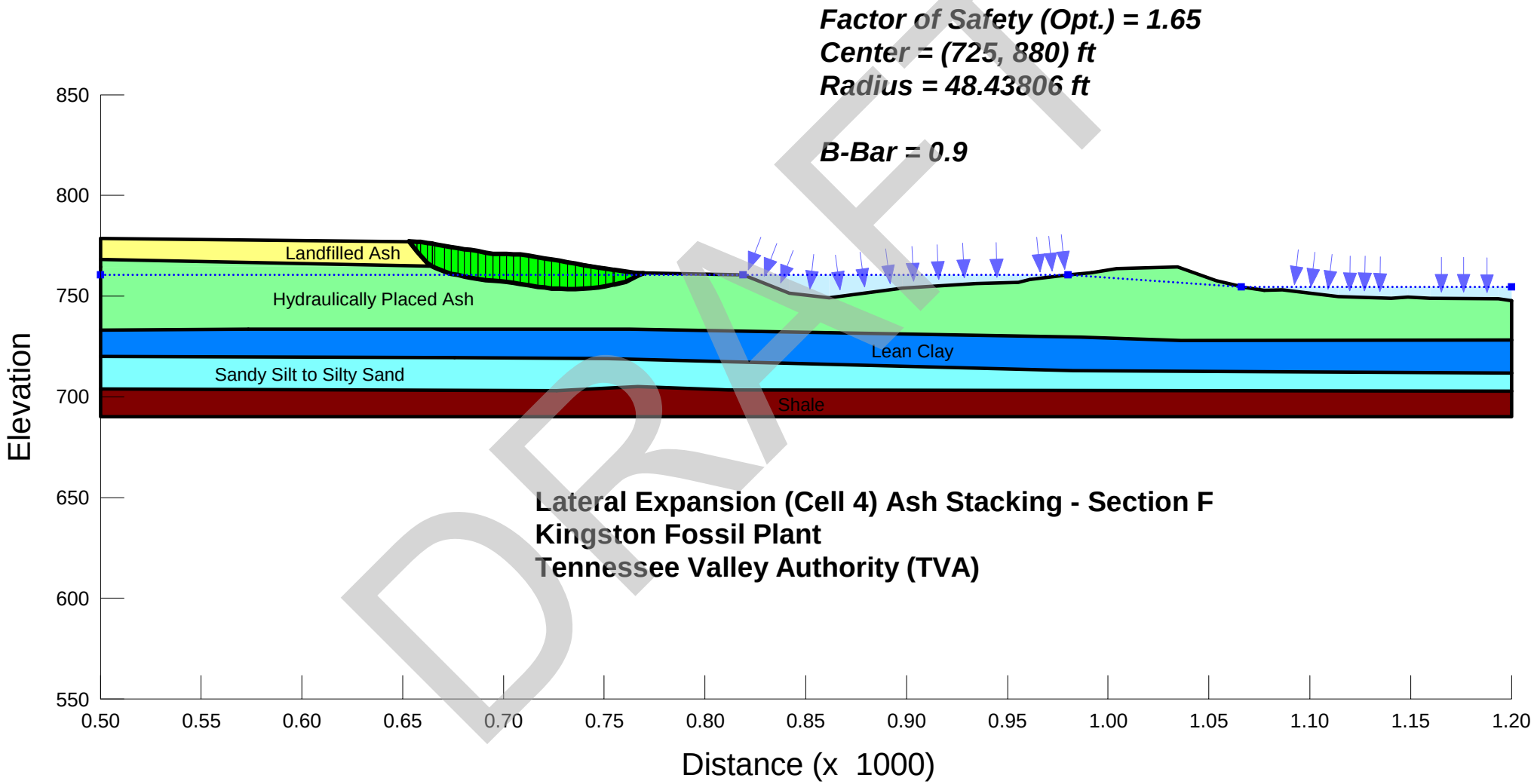
Figure F - 9: Excess Pore Water Pressure Ratio = 80%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	N/A	N/A	N/A	N/A



File Name: Section_F_Drained_PWP-90.gsz
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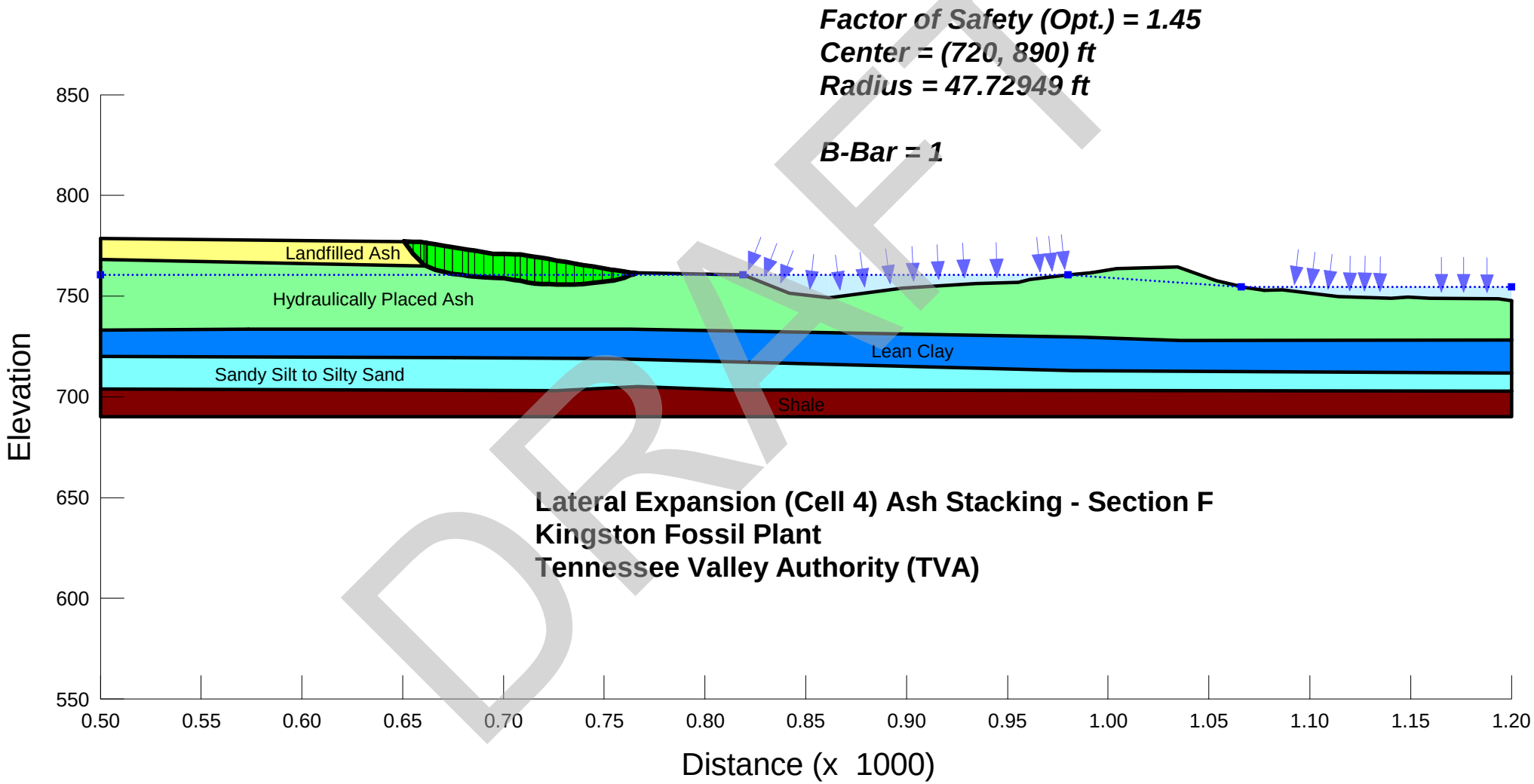
Figure F - 10: Excess Pore Water Pressure Ratio = 90%

Material Name	Model	Unit Weight (Below/Above W.T.)	Strength Parameters	Pore Water Pressure
Landfilled Ash	Mohr-Coulomb	111; 109	c'=0; phi'=30	Piez. Line 1
Hydraulically Placed Ash	Mohr-Coulomb	107; 100	c'=0; phi'=25	Piez. Line 1
Lean Clay	Mohr-Coulomb	130; N/A	c'=0; phi'=32	Piez. Line 1
Sandy Silt to Silty Sand	Mohr-Coulomb	128; N/A	c'=0; phi'=30	Piez. Line 1
Shale	N/A	N/A	N/A	N/A



File Name: Section_F_Drained_PWP-100.gsz
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Figure F - 11: Excess Pore Water Pressure Ratio = 100%

Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Lateral Expansion (Cell 4)** **Ash Stacking**
Document Control Number RDP-0114-A *Calculation Package* FPGKIFFESCDX00030020110001	

Exhibit 10
Stability Analysis – Cross Sections D & F

Purpose:

- Evaluate deep-seated wedge block stabilities to assess the impact of the ash stacking on Dike C and to assess the need for backfilling the existing channel to the east of the ash stacking. (3.2)
- Meet Section 3 of the Design Basis Criteria Dredge Cell Closure, Kingston Fossil Plant

Methods:

- Use classic lateral earth pressures to analyze the wedge block stability, assuming a thin sensitive silt/clay layer at the interface of the hydraulically placed ash and the lean clay foundation soil within which undrained conditions have been triggered. (3.1)(3.2)(4.1.7)

Results:

- Factors of safety for the wedge blocks were calculated, indicating the deep-seated failure was not a controlling failure mode.
- The ash stacking has no adverse impact on the Dike C stability.
- The channel to the east of the ash stacking does not need to be backfilled.

*Numbers in parentheses references Sections of Design Basis Criteria

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: YW	*Reviewed by: KDL/DBR*
Revisions:	

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Lateral Expansion Ash stacking
Section D (perpendicular to Dike C)
Wedge Block Analysis 1 of 6

* Geometry and material profiles are shown on page 2

* Conservatively assuming a thin sensitive silt/clay layer at the bottom of the hydraulically-placed ash, which has been triggered to the undrained condition.

* Material properties:

	Effective stress		Total stress	
	ϕ' (deg.)	c' (psf)	ϕ (deg.)	c (psf)
Landfilled Ash	25 (1)	0	10 (1)	0
Hydraulically-placed Ash	25	0	10	0
Sensitive Silt/Clay	25	0	10	0
Rock Buttress	38	0	—	—

(1) For simplicity in calculation, the landfilled ash is conservatively assumed to have same strengths as the hydraulically-placed ash

(2) The analysis is not very sensitive to unit weights, for simplifying the calculation, all materials are assumed to have a same unit weight of $\gamma = 115$ pcf.

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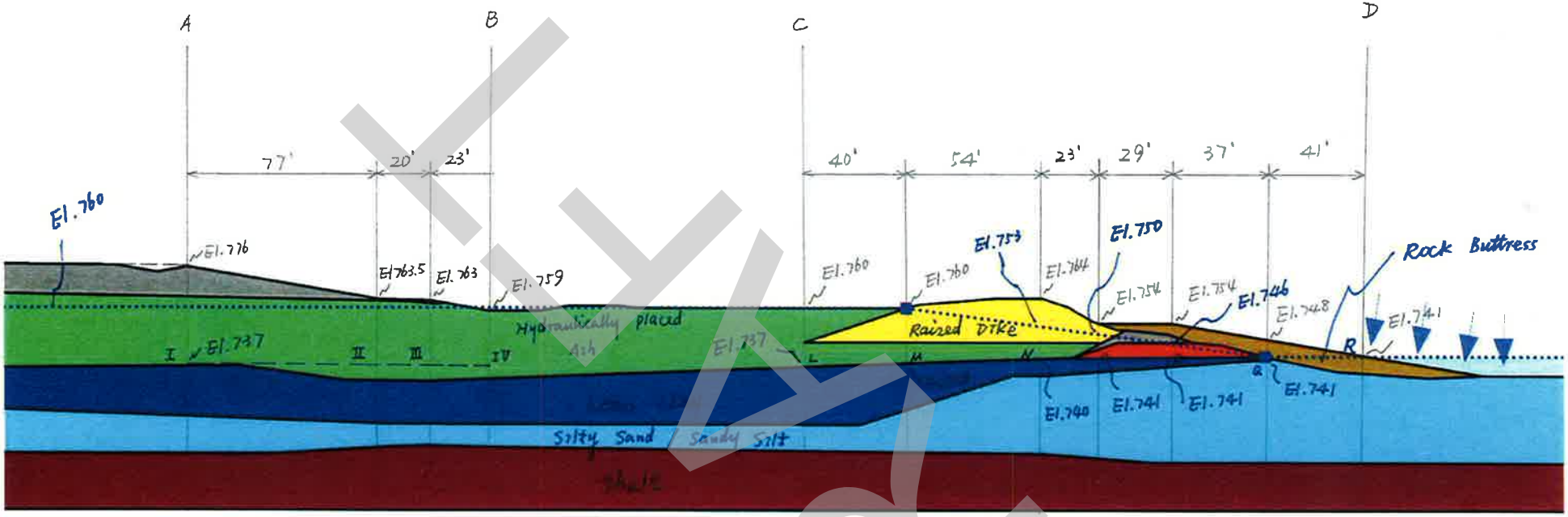
Lateral Expansion Ash Stacking
section D
wedge Block Analysis

2 of 6



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Lateral Expansion Ash Stacking
Section D
Wedge Block Analysis

- Consider Block between A and B
  (conservatively assuming bottom of block at El. 737)

* Calculate Active Pressure

(1) Above Groundwater (El. 776 ~ El. 760)

$$P_{A1} = \frac{1}{2} K_a \gamma H_1^2 = \frac{1}{2} * \tan^2(45^\circ - 25^\circ/2) * 115 * (776-760)^2$$

$$= \frac{1}{2} * 0.41 * 115 * 16^2 = 6{,}035 \quad lb/ft$$

(2) Below Groundwater (El. 760 ~ El. 737)

$$P_{A2} = K_a \gamma H_1 \cdot H_2 + \frac{1}{2} K_a (\gamma - \gamma_w) H_2^2$$

$$= 0.41 * 115 * 16 * (760-737) + \frac{1}{2} * 0.41 * (115 - 62.4) * (760-737)^2$$

$$= 17{,}351 + 5{,}704 = 23{,}055 \quad lb/ft$$

(3) Hydrostatic pressures are balanced out at A and B

(4) Total Active Load:

$$P_A = P_{A1} + P_{A2} = 6{,}035 + 23{,}055 = 29{,}090 \quad lb/ft$$

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Section D
Wedge Block Analysis 4 of 6

* Calculate Passive Pressure (El. 759 ~ El. 737)

$$P_p = \frac{1}{2} K_p (\gamma - \gamma_w) H_3^2$$

$$= \frac{1}{2} * \tan^2 (45^\circ + 25^\circ/2) * (115 - 62.4) * (759 - 737)^2$$

$$= \frac{1}{2} * 2.46 * 52.6 * 22^2 = 31,314 \quad lb/ft$$

* Since $P_p > P_A$, no concern for this block to fail.

– Consider Block between C an D

* Calculate Active Pressure

(1) Earth pressure (El. 760 ~ El. 737)

$$P_{A1} = \frac{1}{2} K_a (\gamma - \gamma_w) H_1^2 = \frac{1}{2} * 0.41 * (115 - 62.4) * (760 - 737)^2$$

$$= 5,704 \quad lb/ft$$

(2) Hydrostatic pressure (El. 760 ~ El. 737)

$$P_{A2} = \frac{1}{2} \gamma_w H_1^2 = \frac{1}{2} * 62.4 * 23^2 = 16,505 \quad lb/ft$$

(3) Total Active Load

$$P_A = P_{A1} + P_{A2} = 5,704 + 16,505 = 22,209 \quad lb/ft$$

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Lateral Expansion Ash Stacking
Section D
Wedge Block Analysis

* Calculate Resistance along Block Bottom:

(1) Calculate Effective Vertical stress at Points L, M, N, O, P, Q, and R

$\sigma_L' = (115-62.4)*(760-737) = 1,210$ psf

$\sigma_M' = (115-62.4)*(760-738) = 1,157$ psf

$\sigma_N' = 115*(764-753) + (115-62.4)*(753-740) = 1,949$ psf

$\sigma_O' = 115*(754-750) + (115-62.4)*(750-741) = 933$ psf

$\sigma_P' = 115*(754-746) + (115-62.4)*(746-741) = 1,183$ psf

$\sigma_Q' = 115*(748-741) = 805$ psf

$\sigma_R' = 0$

(2) Calculate weighted Average Effective vertical stress along $\overline{LQ}$ and $\overline{QR}$.

$$\bar{\sigma}_{LQ}' = \left\{\tfrac{1}{2}(\sigma_L'+\sigma_M')*40 + \tfrac{1}{2}(\sigma_M'+\sigma_N')*54 + \tfrac{1}{2}(\sigma_N'+\sigma_O')*23 + \tfrac{1}{2}(\sigma_O'+\sigma_P')*29 + \tfrac{1}{2}(\sigma_P'+\sigma_Q')*37\right\} / (40+54+23+29+37)$$

$= 1,267$ psf

$$\bar{\sigma}_{QR}' = \tfrac{1}{2}(\sigma_Q'+\sigma_R') = 403 \text{ psf}$$

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Lateral Expansion Ash stacking
Section D
Wedge Block Analysis

(3). Total Resistance:

$$P_B = \bar{\sigma}'_{LQ} * \tan\psi * \overline{LQ} + \bar{Q}'_{QR} * \tan 38^\circ * \overline{QR}$$

For the sensitive silt/clay w/ $\phi' = 25^\circ$ and $\phi = 10^\circ$,

$$\tan\psi = \frac{\sin\phi \cos\phi'}{1 - \sin\phi} = 0.19$$

$$\therefore P_B = (140 + 54 + 23 + 29 + 37) * 1,267 * 0.19 + 403 * \tan 38^\circ * 41$$

$$= 56,963 \text{ lb/ft}$$

* Calculate F.S for Block between C and D
(Approximately assuming the driving force and the resisting force in the same direction)

$$F.S = \frac{56,963}{22,209} = 2.56$$

$\therefore$ slope is stable

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Lateral Expansion Ash Stacking
Section F
Wedge Block Analysis

* The cross section is located on the east side of the lateral expansion, perpendicular to the divider dike between the ash pond and the stilling pond. This cross section represents the most critical slope along the east side of the lateral expansion ash stacking.

cross section geometry and the material profile are shown on page 2.

* Assumptions:

It is assumed that fully undrained condition has been triggered within a thin sensitive silt/clay layer located at the bottom of the wedge block (at the interface of hydraulically-placed ash and lean clay). Movements in the slope are small enough such that the hydraulically-placed ash remains in drained condition, but the movements are assumed to be sufficient to develop full active and passive pressures.

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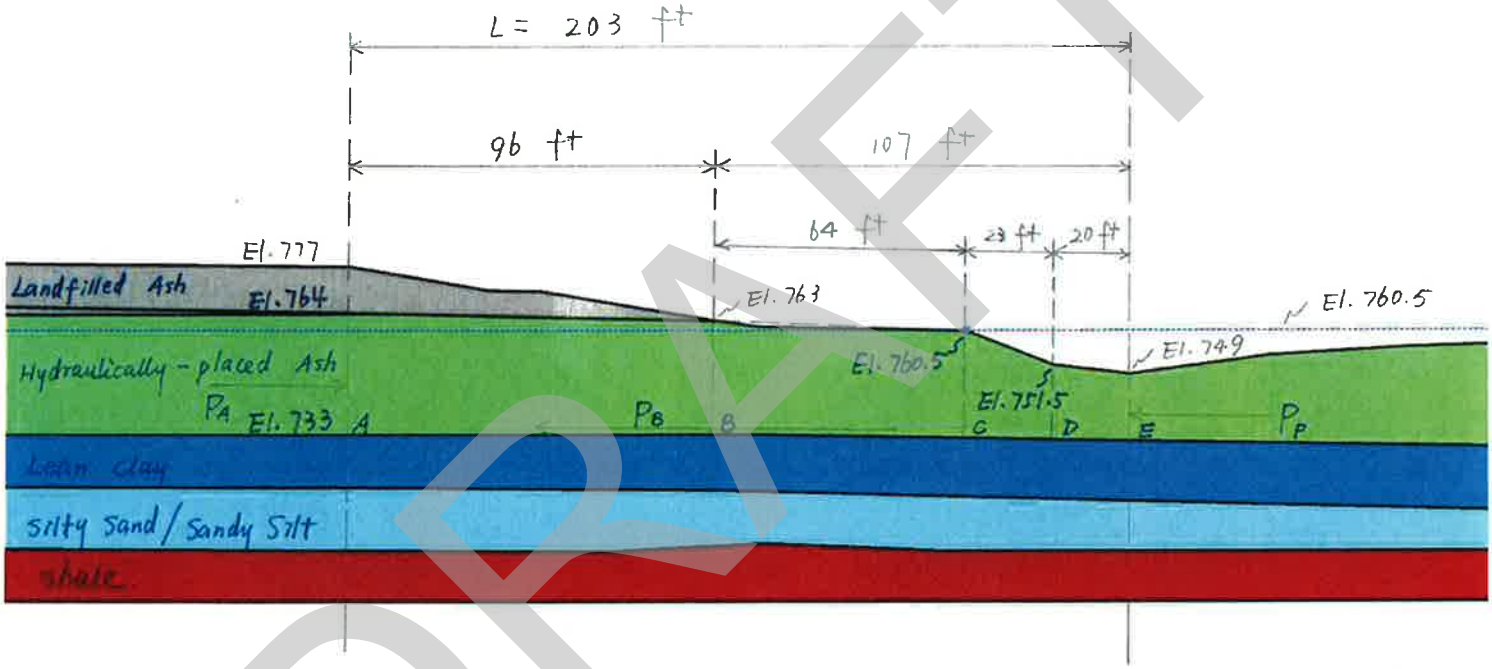
Lateral Expansion Ash stacking
Section F
wedge Block Analysis

* Geometry:



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Lateral Expansion Ash stacking
Section F
Wedge Block Analysis

* Material properties

	γ_{sat} (pcf)	γ_{moist} (pcf)	Effective stress ϕ' (deg.)	Effective stress c' (psf)	Total stress ϕ (deg.)	Total stress c (psf)
Landfilled Ash	111	109	30	0	30	0
Hydraulically-placed Ash	107	100	25	0	10	0
Sensitive silt/clay	107	100	25	0	10	0

* Calculate Active Pressure, P_A

(1) Active Earth Pressure from Landfilled Ash (El. 777 ~ El. 764)

$\phi' = 30^\circ \Rightarrow K_{a_1} = \tan^2(45^\circ - 30^\circ/2) = 1/3$

$\gamma_{moist} = 109$ pcf, $H_1 = 777 - 764 = 13$ ft

$\therefore p_{a_1} = \gamma_{moist} \cdot H_1 \cdot K_{a_1} = 109 * 13 * 1/3 = 472.3$ psf

$\therefore P_{A_1} = \frac{1}{2} p_{a_1} \cdot H_1 = \frac{1}{2} * 472.3 * 13 = 3{,}070$ lb / ft

(2) Active Earth Pressure from Hydraulically-Place Ash (El. 764 ~ El. 733)

Groundwater level (El. 760.5) is near the top of the Hydraulically-placed Ash, assuming the entire layer is saturated.

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Lateral Expansion Ash stacking
Section F
Wedge Block Analysis

$\phi' = 25^\circ \Rightarrow K_{a2} = \tan^2(45^\circ - 25^\circ/2) = 0.41$

$p_{a1}' = \gamma_{moist-Landfilled\ Ash} * H_1 * K_{a2}$

$= 109 * 13 * 0.41 = 581$ psf

$\gamma_{sat} = 107$ pcf , $H_2 = 764 - 760.5 = 3.5$ ft

$p_{a2} = \gamma_{sat} \cdot H_2 \cdot K_{a2} = 107 * 3.5 * 0.41 = 153.5$ psf

$\gamma' = \gamma_{sat} - \gamma_w = 107 - 62.4 = 44.6$ pcf

$H_3 = 760.5 - 733 = 27.5$ ft

$p_{a3} = \gamma' \cdot H_3 \cdot K_{a2} = 44.6 * 27.5 * 0.41 = 503$ psf

$\therefore P_{A2} = \frac{1}{2}(p_{a1}' + (p_{a1}' + p_{a2})) * H_2 + \frac{1}{2}((p_{a1}' + p_{a2}) + (p_{a1}' + p_{a2} + p_{a3})) * H_3$

$= \frac{1}{2}(581 + (581 + 153.5)) * 3.5 + \frac{1}{2}((581 + 153.5) + (581 + 153.5 + 503)) * 27.5$

$= 29,417$ lb/ft

(3). Active Zone Hydrostatic Pressure (El. 760.5 ~ El. 733)

$P_{A3} = \frac{1}{2}\gamma_w \cdot H_3^2 = \frac{1}{2} * 62.4 * 27.5^2 = 23,595$ lb/ft

$\therefore P_A = P_{A1} + P_{A2} + P_{A3} = 3,070 + 29,417 + 23,595$

$= 56,082$ lb/ft

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Lateral Expansion Ash Stacking
Section F
Wedge Block Analysis

* Calculate passive Pressure, P_p

(1) Passive Earth Pressure from Hydraulically-Placed Ash (El. 749 ~ El. 733)

$\phi' = 25^\circ \Rightarrow K_p = \tan^2(45^\circ + 25^\circ/2) = 2.46$

$\gamma' = 44.6$ pcf , $H_4 = 749 - 733 = 16$ ft

$\therefore p_{p_1} = \gamma' * H_4 * K_p = 44.6 * 16 * 2.46 = 1,755.5$ psf

$\therefore P_{p_1} = \frac{1}{2} p_{p_1} * H_4 = \frac{1}{2} * 1,755.5 * 16 = 14,044$ lb/ft

(2) Passive Zone Hydrostatic Pressure, (El. 760.5 ~ El. 733)

$H_5 = 760.5 - 733 = 27.5$ ft

$P_{p_2} = \frac{1}{2} \gamma_w * H_5^2$

$= \frac{1}{2} * 62.4 * 27.5^2 = 23,595$ lb/ft

$\therefore P_p = P_{p_1} + P_{p_2} = 14,044 + 23,595 = 37,639$ lb/ft

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Lateral Expansion Ash stacking
Section F
Wedge Block Analysis

* Calculate Resistance along Wedge Bottom, P_B

(1). Effective vertical stress at Point "A"

$$\sigma_A' = 109 * (777-764) + 107 * (764-760.5) + (107-62.4) * (760.5-733)$$

$$= 3,018 \text{ psf}$$

(2). Effective vertical stress at Point "B"

$$\sigma_B' = 107 * (763-760.5) + (107-62.4) * (760.5-733)$$

$$= 1,494 \text{ psf}$$

(3). Effective vertical stress at Point "C"

$$\sigma_C' = (107-62.4) * (760.5-733) = 1,226.5 \text{ psf}$$

(4). Effective vertical stress at Point "D"

$$\sigma_D' = (107-62.4) * (751.5-733) = 825.1 \text{ psf}$$

(5). Effective vertical stress at Point "E"

$$\sigma_E' = (107-62.4) * (749-733) = 713.6 \text{ psf}$$

(6) Average effective vertical stress.

$$\sigma_{AB}' = \frac{1}{2}(\sigma_A' + \sigma_B') = \frac{1}{2}(3,018 + 1,494) = 2,256 \text{ psf}$$

$$\sigma_{BC}' = \frac{1}{2}(1,494 + 1,226.5) = 1,360.3 \text{ psf}$$

$$\sigma_{CD}' = \frac{1}{2}(1,226.5 + 825.1) = 1,025.8 \text{ psf}, \quad \sigma_{DE}' = \frac{1}{2}(825.1 + 713.6) = 769.4 \text{ psf}$$

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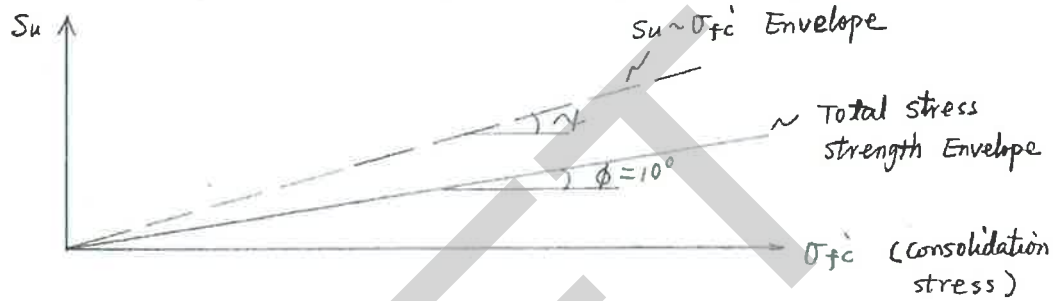
Lateral Expansion Ash stacking
Section F
Wedge Block Analysis

(7) Undrained shear strength of Hydraulically-Placed Ash



$$\tan\psi = \frac{\sin\phi \cos\phi'}{1-\sin\phi} = \frac{\sin 10^\circ \cos 25^\circ}{1-\sin 10^\circ} = 0.19$$

$$\therefore P_B = (\sigma'_{AB} * \overline{AB} + \sigma'_{BC} * \overline{BC} + \sigma'_{CD} * \overline{CD} + \sigma'_{DE} * \overline{DE}) * \tan\psi$$

$$= (2{,}256 * 96 + 1{,}360.3 * 64 + 1{,}025.8 * 23 + 769.4 * 20) * 0.19$$

$$= 65{,}097 \text{ lb / ft}$$

* Calculate Factor of safety F.S.

$$F.S = \frac{P_B}{P_A - P_P} = \frac{65{,}097}{56{,}082 - 37{,}639} = 3.5$$

$\therefore$ slope is stable

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ISSUED FOR REVIEW

Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Lateral Expansion (Cell 4)** **Ash Stacking**

Document Control Number	RDP-0114-A
Calculation Package	FPGKIFFESCDX00030020110001

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Exhibit 11
Ditch Design Supporting Calculations

Purpose:

- Check geotextile gradation against that of ash to meet filter criteria for riprap placed in ditch. (13.2)
- Check geotextile for permeability and clogging. (13.2)
- Determine if commercially available fabrics meet design criteria.
- Determine gradation of fly ash for use in calculations.
- Determine precipitation amount for various design storms for the site. (12.4)
- Use determined 25 year-24 hour event of input to hydrologic model. (12.1)
- Meet sections 12 and 13 of the Design Basis Criteria Dredge Cell Closure, Kingston Fossil Plant

Methods:

- Design analysis based on methods presented in the technical literature (Christopher and Holtz 1984, Giroud 1982, Koerner et al 1994, USEPA 1987). (13.2)
- Used gradation for site fly ash.
- ASTM 421 for sample preparation.
- ASTM D 422 for gradation and hydrometer methods.
- Used NOAA website calculator that is based on NOAA Atlas 14. (12.4)
- Used site locator on website. (12.4)
- Used SEDCAD Model TR-55 emulator. (12.4)

Results:

- Six commercially available geotextiles met design criteria.
- 16 ounce non-woven fabric met design criteria and constructability issues.
- Gradation established.
- Material classified as sandy silt under Unified Soil Classification System.
- 25 Year-24 hour storm event of 5.47 inches determined
- Ditch segment designs based on SEDCAD results.

* Numbers in parentheses reference Sections of Design Basis Criteria

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: DEH	*Reviewed by: TC*
Revisions:	

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Geotextile Design Analysis - Ditch
Kingston Fly Ash
175669014

Methodology – Design Analysis based on methods presented in the technical literature (Christopher and Holtz 1984, Giroud 1982, Koerner et al 1994, USEPA 1987).

Geotextile Class 1

Non-woven fabric

Lab ID 30:

Soil Retention

Percent passing 0.075mm sieve = 59.1%

Soils with more than 50% particles ≤ 0.075mm; O_{95} ≤ 210mm (US Sieve No. 70)

Permeability

$K_{geotextile} > 10\ K_{soil}$

$K_{geotextile} > 10\ (1x10^{-4}\ cm/s)$

$K_{geotextile} > 1x10^{-3}\ cm/s$

Anti-clogging

Porosity, $n_g > 30\%$
-Use largest opening size to meet retention criteria

Clogging

Porosity, n_g

$n_g = 1 - [\mu_g / (p_g t_g)]$

where,

μ_g = geotextile mass per unit area
p_g = polymer density
t_g = geotextile thickness

Geotex 1701

$n_g = 1 – [542\ g/m^2 / (0.905\ g/m^2 * 4{,}200\ m)]$
$= 1 – [542 / (0.9 * 4200)]$

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= 1 – (542 / 3801)
= 1 – 0.14
= 0.86

Skaps GE-116

n_g = 1 –[542 g/m^2 / (0.905 g/m^2 * 4,450 m)]
= 1 – (542 / 4027.25)
= 1 – 0.13
= 0.87

Tencate Mirafi S1600

n_g = 1 –[542 g/m^2 / (0.905 g/m^2 * 4,400 m)]
= 1 – (542 / 3982)
= 1 – 0.14
= 0.86

Suggested Fabrics

Fabric	Mass (oz/yd^2)	AOS (O_{95})	Permittivity	Permeability	Clogging
Propex Geosynthetics Geotex 1701	16.0	0.15 (100)	0.7	0.27	0.86
Agru America Agrutex 1161	16.0	0.15 (100)	0.5	N/A	N/A
Dalco Nonwovens Daltex 1161	16.0	0.15 (100)	0.5	N/A	N/A
GSE Lining Technology NW16	16.0	0.15 (100)	0.7	N/A	N/A
SKAPS Industries GE116	16.0	0.15 (100)	0.57	0.25	0.87
TenCate Geosynthetics Mirafi S1600	16.0	0.15 (100)	0.7	0.31	0.86

Designed by: JTB Checked by: DEH

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POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Tennessee 35.840 N 84.49 W 898 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 2, Version 3
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2004

Extracted: Tue Sep 14 2010

Confidence Limits | Seasonality | Related Info | GIS data | Maps | Docs | Return to State Map

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.34	0.55	0.69	0.94	1.17	1.38	1.50	1.86	2.31	2.81	3.44	3.94	4.80	5.49	7.59	9.32	11.72	14.06
2	0.40	0.65	0.81	1.12	1.41	1.65	1.79	2.21	2.73	3.36	4.11	4.71	5.72	6.51	8.96	10.95	13.71	16.44
5	0.47	0.76	0.96	1.36	1.75	2.04	2.20	2.67	3.30	4.10	5.00	5.70	6.86	7.75	10.41	12.53	15.54	18.58
10	0.54	0.87	1.09	1.59	2.07	2.42	2.59	3.12	3.82	4.68	5.71	6.45	7.71	8.68	11.46	13.65	16.86	20.09
25	0.63	1.00	1.27	1.88	2.50	2.92	3.12	3.72	4.53	5.47	6.67	7.44	8.82	9.90	12.76	15.03	18.45	21.91
50	0.70	1.12	1.41	2.13	2.88	3.37	3.59	4.25	5.13	6.10	7.43	8.20	9.65	10.83	13.71	16.00	19.58	23.18
100	0.78	1.23	1.56	2.39	3.29	3.85	4.08	4.81	5.75	6.74	8.20	8.96	10.46	11.74	14.59	16.89	20.60	24.32
200	0.85	1.35	1.71	2.65	3.72	4.37	4.61	5.40	6.40	7.40	8.98	9.70	11.25	12.64	15.41	17.70	21.52	25.33
500	0.96	1.52	1.91	3.04	4.36	5.11	5.37	6.24	7.30	8.28	10.05	10.68	12.26	13.79	16.40	18.66	22.60	26.51
1000	1.05	1.65	2.08	3.36	4.91	5.75	6.04	6.97	8.07	8.96	10.87	11.41	13.01	14.64	17.10	19.32	23.32	27.30

* These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

* Upper bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.38	0.60	0.75	1.03	1.29	1.51	1.64	2.02	2.49	2.99	3.67	4.20	5.11	5.82	7.98	9.75	12.23	14.66
2	0.44	0.71	0.89	1.23	1.54	1.80	1.95	2.39	2.95	3.58	4.39	5.01	6.09	6.91	9.43	11.46	14.32	17.16
5	0.52	0.83	1.05	1.49	1.91	2.23	2.39	2.89	3.56	4.36	5.34	6.07	7.30	8.21	10.96	13.10	16.23	19.38
10	0.59	0.95	1.20	1.74	2.26	2.63	2.81	3.36	4.12	4.97	6.09	6.86	8.20	9.20	12.06	14.28	17.60	20.97
25	0.69	1.09	1.38	2.05	2.73	3.18	3.38	4.01	4.87	5.81	7.11	7.91	9.37	10.49	13.43	15.72	19.27	22.87
50	0.76	1.22	1.54	2.32	3.14	3.67	3.88	4.58	5.52	6.47	7.91	8.72	10.25	11.48	14.43	16.74	20.45	24.20
100	0.84	1.34	1.70	2.60	3.58	4.17	4.41	5.18	6.18	7.15	8.74	9.53	11.12	12.45	15.35	17.67	21.52	25.41
200	0.93	1.47	1.86	2.90	4.06	4.74	4.99	5.82	6.90	7.85	9.57	10.34	11.96	13.40	16.23	18.53	22.49	26.49
500	1.04	1.65	2.08	3.31	4.75	5.55	5.83	6.74	7.89	8.78	10.72	11.38	13.05	14.64	17.30	19.55	23.65	27.75
1000	1.15	1.81	2.27	3.68	5.37	6.28	6.59	7.56	8.75	9.51	11.61	12.17	13.86	15.57	18.05	20.25	24.43	28.60

* The **upper** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.
** These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

* Lower bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.32	0.50	0.63	0.86	1.08	1.27	1.39	1.73	2.15	2.66	3.22	3.71	4.53	5.19	7.21	8.91	11.23	13.48
2	0.37	0.59	0.74	1.03	1.29	1.52	1.65	2.05	2.54	3.18	3.85	4.43	5.40	6.17	8.52	10.48	13.14	15.77
5	0.43	0.70	0.88	1.25	1.60	1.88	2.02	2.48	3.06	3.87	4.68	5.35	6.47	7.33	9.89	11.98	14.89	17.81
10	0.49	0.79	1.00	1.45	1.89	2.21	2.38	2.88	3.54	4.41	5.34	6.05	7.26	8.21	10.88	13.05	16.15	19.26
25	0.57	0.91	1.15	1.70	2.27	2.66	2.84	3.42	4.17	5.15	6.22	6.96	8.29	9.34	12.11	14.35	17.66	20.98

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50	0.63	1.01	1.27	1.92	2.60	3.05	3.24	3.88	4.70	5.72	6.91	7.67	9.05	10.19	12.98	15.26	18.72	22.18
100	0.69	1.10	1.39	2.13	2.94	3.44	3.65	4.35	5.23	6.30	7.61	8.35	9.79	11.02	13.80	16.09	19.67	23.25
200	0.76	1.20	1.51	2.35	3.29	3.86	4.09	4.84	5.79	6.89	8.30	9.02	10.50	11.83	14.55	16.84	20.52	24.19
500	0.83	1.32	1.66	2.65	3.79	4.45	4.69	5.51	6.52	7.67	9.23	9.87	11.40	12.84	15.45	17.73	21.51	25.28
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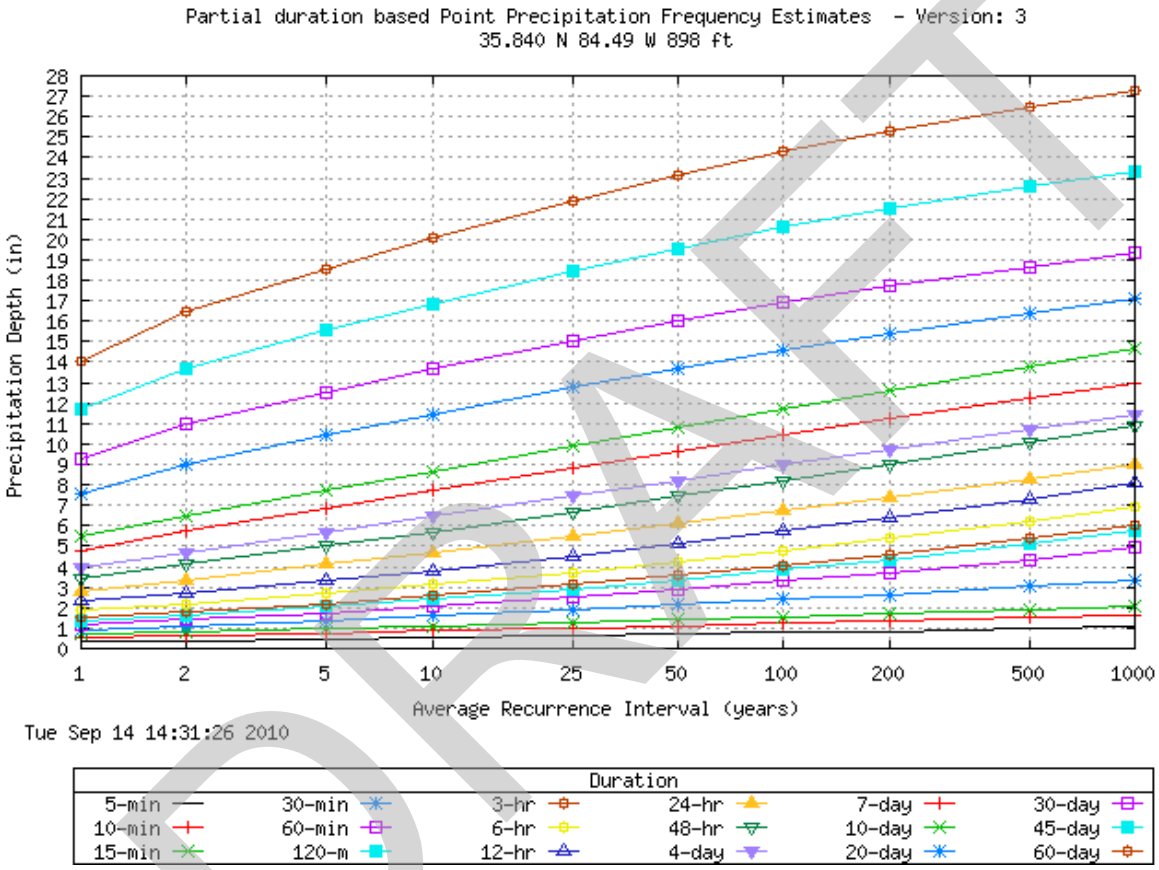
** These precipitation frequency estimates are based on a partial duration maxima series. **ARI** is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

Text version of tables



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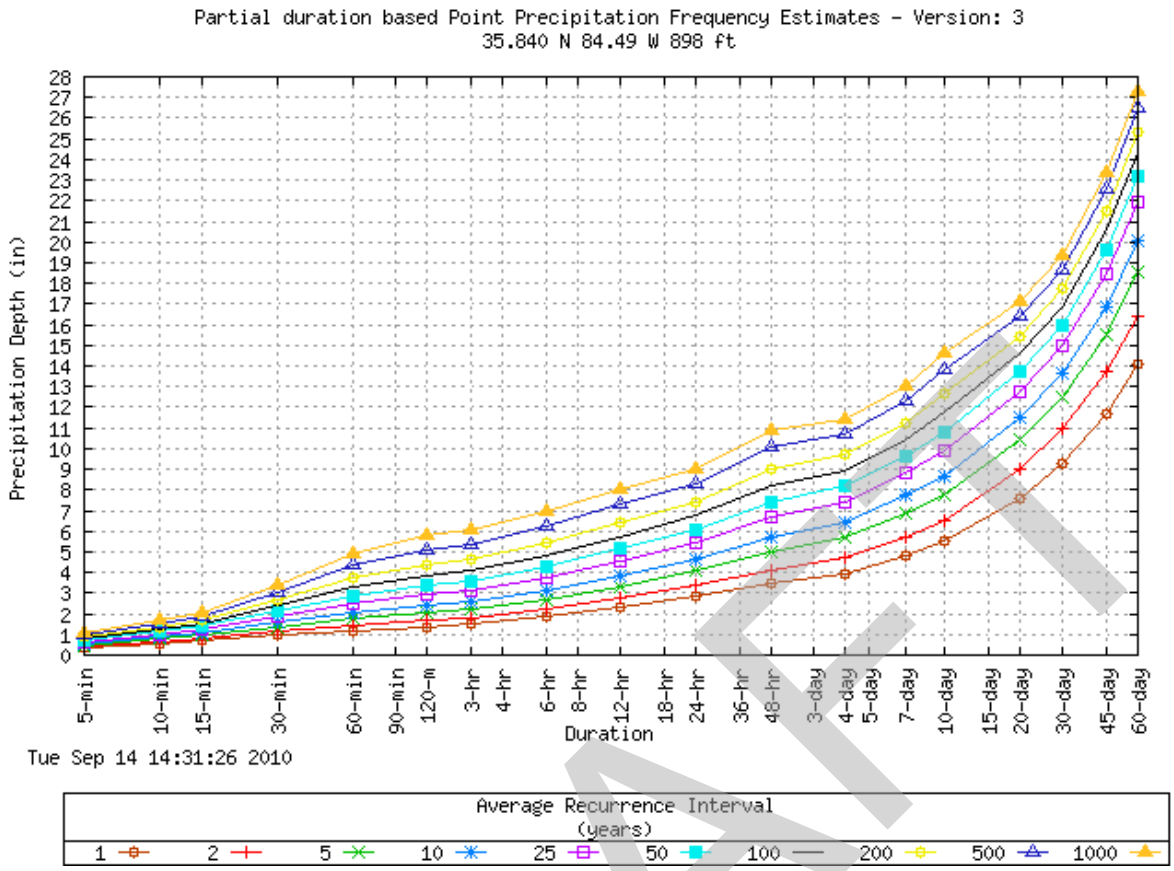

Related Information

Maps & Aerials

Click here to see topographic maps and aerial photographs available for this location from Microsoft Research Maps

Watershed/Streamflow Information

Click here to see watershed and streamflow information available for this location from the U.S. Environmental Protection Agency's site

Climate Data Sources

National Climatic Data Center (NCDC) database

Locate NCDC climate stations within:

+/-30 minutes or +/-1 degree of this location. Digital ASCII data can be obtained directly from **NCDC**.

Note: Precipitation frequency results are based on analysis of precipitation data from a variety of sources, but largely NCDC. The following links provide general information about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study, please refer to the matching documentation available at the PF Document page

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National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrologic Development
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

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Summary of Soil Tests

Project Name	TVA Kingston Plant Dike Failure	Project Number	171468117
Source	Kingston Fly Ash	Lab ID	30
County	N/A	Date Received	3-5-09
Sample Type	Bag	Date Reported	3-18-09

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 24.5

Particle Size Analysis

Preparation Method: ASTM D 421

Gradation Method: ASTM D 422

Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	100.0
3/4"	19	99.2
3/8"	9.5	96.5
No. 4	4.75	93.7
No. 10	2	88.3
No. 40	0.425	81.8
No. 200	0.075	59.1
	0.02	29.6
	0.005	7.6
	0.002	3.0
estimated	0.001	1.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	6.3	11.7
Coarse Sand	5.4	6.5
Medium Sand	6.5	---
Fine Sand	22.7	22.7
Silt	51.5	56.1
Clay	7.6	3.0

Atterberg Limits

Test Method: ASTM D 4318 Method A

Prepared: Dry

Liquid Limit: ---

Plastic Limit: Non Plastic

Plasticity Index: ---

Activity Index: N/A

NOTE: Assumed

Moisture-Density Relationship

Test Method: ASTM D 698 Method B

Maximum Dry Density (lb/ft^3): 82.8

Maximum Dry Density (kg/m^3): 1326

Optimum Moisture Content (%): 24.9

Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854

Prepared: Dry

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.31

Classification

Unified Group Symbol: ML

Group Name: Sandy silt

AASHTO Classification: A-4 (0)

Comments: Atterberg Limit Test not performed.

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ISSUED FOR REVIEW

Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Lateral Expansion (Cell 4)** **Ash Stacking**
Document Control Number RDP-0114-A *Calculation Package* FPGKIFFESCDX00030020110001	
Stantec	**Exhibit 12** **Design Basis Criteria**

Purpose:

- Establish the design goals, criteria, procedures, and design references for the Dredge Cell Closure.
- Provide guidance for design factors including stability, site geometry, surface and ground water, design elements, and site management during construction.

Methods:

- Review of applicable design standards and site requirements, as established by TVA.
- Drafts and revisions of the document were reviewed by TVA for concurrence.

Results:

- Criteria documented in attached report.

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: Stantec	*Reviewed by: TVA and Others*
Revisions:10/20/2010	

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Kingston Ash Recovery Project (KRP)
Design Basis and Criteria
Dredge Cell Closure
Kingston Fossil Plant
Harriman, Roane County, Tennessee

1. Purpose

The purpose of the Design Basis and Criteria is to establish the design goals, criteria procedures and design references for Dredge Cell Closure. This document provides guidance for design factors including stability, site geometry, surface and groundwater, design elements and site management during construction. This is a living document that may be amended or revised as the project proceeds

2. Scope

The objective of the closure project is to design a stable ash storage facility meeting stakeholder criteria within approved boundaries. Please see the attached drawing from EPA showing Cells 1, 2 and 3 of the Dredge Cell and providing an overview of the site.

2.1. Design Basis

- Construct dry (unsaturated) ash embankment within approved boundaries;
- Construct a stable embankment that will contain retrieved ash under static and seismic loading conditions;
- Construct a facility that accommodates predicted stormwater flows;
- Control infiltration of precipitation through the final cover ;
- Meet applicable regulatory closure requirements relative to stability and final cover; and
- Meet requirements of the approved Action Memorandum including ARARs.

2.2. Design Goals

- Design with the understanding that additional areas such as the ash pond and lateral expansion will be integrated;

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Insert Drawing

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- Address the documented contributing factors to the Dredge Cell failure as identified by AECOM. For design we should consider:
  - Control height of ash and loading on wet ash and in areas of slimes;
  - Construct containment dike on good foundation conditions or mitigate the poor foundation conditions;
  - Design to mitigate against creep failure; and
  - Control rate of construction on sluiced ash and analyze undrained conditions.
- Constructability – Safe use of construction equipment and processes to complete the project in accordance with project goals;
- Conduct phased embankment construction concurrent to perimeter improvements;
- Use industry best practices for design;
  - TVA Coal Combustion Products Management Program - Master Programmatic Document;
  - Tennessee Department of Environment & Conservation (TDEC) Regulations;
  - U.S. Army Corps of Engineers Manuals;
  - Established engineering methods; and
  - Independent peer review;
- Foster stakeholder buy-in;
- Monitor construction and post closure condition; and
- Consider existing NPDES permit requirements.

2.3. Proposed Improvements

The proposed improvements involve closure of the Dredge Cell in accordance with applicable TDEC regulations. The proposed improvements for this site address slope stability for static and dynamic loading conditions, defined geometric considerations, surface water control, and erosion/sediment control. Specific design items include:

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- Compacted dry ash embankment (unsaturated);
- Capillary break;
- Stabilized perimeter (included foundation improvements and berm);
- Surface water drainage facilities;
- Site revegetation, final cover, and erosion controls;
- Performance monitoring instrumentation shall be installed and monitored during and after closure; and
- Perimeter riprap and slope protection next to Watts Bar Reservoir to prevent scour and erosion during flooding and reservoir drawdown.

3. Static and Dynamic Slope Stability

3.1. Slope Stability

Stability analyses of the closure design shall be performed using established methods of engineering analysis.

3.2. Stability During Construction

The following factors of safety against slope stability shall be maintained during construction:

- Drained Stability (FS_d) $FS_d \geq 1.5$
- Undrained Stability (FS_u) $FS_u \geq 1.3$
- Undrained Stability After Next Lift (FS_{ul}) $FS_{ul} \geq 1.5$

The criteria for FS_{ul} applies only to potential failures through saturated fly ash. The stability of the embankment during construction shall be verified through monitoring, instrumentation, and engineering evaluation. Strengths to be used for analysis are shown in Table 1.

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Design Basis and Criteria
Dredge Cell Closure
Kingston Fossil Plant
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Table 1 – Material Parameters used in Stability Analyses

Material Name	Unit Weight		Static Drained Strength		Static Undrained Strength	
	γ_m, (pcf)	γ_{sat}, (pcf)	ϕ', (deg.)	c', (psf)	ϕ, (deg.)	c, (psf)
Hydraulically Placed Ash Above Groundwater	100	--	25	0	25	0
Hydraulically Placed Ash Below Groundwater	--	107	25	0	10	0
Landfilled Ash Embankment	109	111	30	0	30	0
Lean Clay Foundation Soil	--	130	32	0	24	0
Sandy Silt to Silty Sand	--	128	30	0	12	1,000

3.3. Stability Following Construction

The following factors of safety against static slope stability shall be maintained in the long-term, following project completion:

- Drained Stability (FS_d) $FS_d \geq 1.5$
- Veneer Sliding (FS_v) $FS_v \geq 1.0$

3.4. Liquefaction Analysis

3.4.1. For soils susceptible to classical liquefaction

$FS_{liq} \leq 1.1$	Assume layer liquefies under design event
$1.1 < FS_{liq} \leq 1.4$	Assume partial liquefaction and strength loss in layer
$FS_{liq} > 1.4$	Assume no liquefaction

3.4.2. For soils susceptible to cyclic softening

$FS_{CS} \leq 1.4$	Assume cyclic softening occurs as a result of design event
$FS_{CS} > 1.4$	Assume no cyclic softening occurs

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Kingston Fossil Plant
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3.5. Seismic Stability

3.5.1. Design Earthquake Event

- 10% Probability of Exceedance in 250 years (recurrence interval – 2,373 years) per Section 1.4.2.2.1 of the TVA Coal Combustion Products Management Program Master Programmatic Document;
- The facility will be designed to meet the criteria for stability after the occurrence of only one design earthquake event;
- The post-earthquake factor of safety for slope and foundation stability shall be greater than unity (1.0); and
- Following the design seismic event, ash from the closed facility shall not displace beyond the permitted boundary of the facility. Deformations that do not exceed this limit will be considered acceptable.

4. Geometry and Elevations

4.1. General Design Criteria

4.1.1. On the northern and eastern perimeters of the site, in areas bounded by Watts Bar Lake, the closed facility shall not extend beyond the limits of the previous Dredge Cell and ash pond;

4.1.2. The closed facility shall not encroach within 100 feet of the edge of the existing pavement along Swan Pond Road, on the western perimeter of the site;

4.1.3. The closed Dredge Cell, including the final cover, shall not exceed an elevation of 790 feet (plus or minus five feet);

4.1.4. Ash within the closed Dredge Cell shall be contained within a berm constructed of structural fill materials that meet the stability objectives. The berm shall have a crest that is no lower than an elevation of 765 feet around the perimeter;

4.1.5. An access road having a minimum width of 16 feet shall be established around the full perimeter of the closed facility. Surface grade on the access road shall not exceed five percent at any location;

4.1.6. Criteria for excavation in the northwest corner of the Dredge Cell will be defined by TVA Management; and

4.1.7. Maintain and monitor performance monitoring instrumentation to validate design assumptions.

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5. Water Elevations

5.1. Assumptions for Design

- Watts Bar Lake - Summer Pool Elevation: 741 feet;
- Watts Bar Lake - Winter Pool Elevation: 737 feet;
- Watts Bar Lake – 100 Year Flood Elevation: 746.8;
- Watts Bar Lake – 500 Year Flood Elevation: 748.0;
- Ash Pond in Operation During Construction - Pool Elevation: 761 feet;
- Stilling Pond in Operation During Construction – Pool Elevation: 755 feet; and
- Stilling pond, if decommissioned in the future, then pool elevation = Watts Bar Lake elevation.

6. Groundwater Seepage

6.1. Predictions of the long-term ground water levels within the closed facility shall be included in the design analyses. The predictions shall only consider the potential infiltration with the capped condition. The long term phreatic surface outside the Dredge Cell limits should be modeled as the existing groundline.

6.2. The facility will be an unlined facility. Regulations (TDEC Division of Solid Waste Management Chapter 1200-01-07, Rule 1200-01-07.04) that require less percolation through the cover than through the liner do not apply.

6.3. Groundwater from the facility shall not be collected and/or discharged at specified design points (no point discharges). Design of the top elevation of the Deep Soil Mixing (DSM) shall be based on the "Best Estimate" of the long term groundwater elevation based on modeling results.

6.4. The impact of elevated groundwater levels within the closed ash facility shall be evaluated. The capillary break will be constructed above the "Best Estimate" long-term groundwater elevation discussed in 6.1. and 6.3. The maximum acceptable groundwater elevation shall be below the capillary break and elevations at or above the DSM shall be evaluated.

6.5. Long-term monitoring of groundwater levels will be included with the closure plan, to allow the assessment of water levels in comparison to the maximum acceptable limits.

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7. Stabilized Perimeter

7.1. General Design Criteria

7.1.1. Ash will be placed in a facility that is fully enclosed (in plan) with a stabilized perimeter. The foundation soils will be stabilized, treated, or otherwise improved so the perimeter will support the lateral pressure of the facility and achieve the required performance for static and dynamic stability. The stabilized perimeter will be designed to contain material during a seismic event.

7.1.2. The stabilization process may reduce the hydraulic conductivity of various foundation layers, but the stabilized perimeter will not be designed for groundwater retention.

8. Compaction of Ash Fill

8.1. General Design Criteria

8.1.1. Recovered ash to be placed inside the Dredge Cell will be compacted in conformance with engineering controls. The material will be placed within specified ranges of water content in an unsaturated condition.

8.1.2. In some areas of the ash pond, ash may be sluiced to fill submerged areas. After a ground surface above water is established, additional fill in these areas will be compacted.

9. Capillary Break

9.1. General Design Criteria

- The design will include an internal layer of coarse material that will serve as a capillary break; and
- The purpose of the capillary break is to mitigate the upward migration of water by capillarity to elevations where stability criteria would not be achieved.

10. Final Cover

10.1. General Performance

Per TDEC Division of Solid Waste Management Chapter 1200-01-07 (Rule 1200-01-07.04):

- Provide long-term control of infiltration for the closed facility;
- Function with minimum maintenance;
- Promote positive surface drainage; and

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- Accommodate settling and subsidence so that the cap's integrity is maintained.

10.2. Cap Requirements

A total of 36 inches of soil are required of which a minimum of 12 inches shall be for the support of vegetative cover. This cap shall include a compacted soil layer of at least 24 inches which has a permeability no greater than 1 x 10^{-7} cm/sec.

Per Section 1.3.4.2 of the TVA Coal Combustion Products Management Program Master Programmatic Document, and in TDEC regulations, an alternate cap system may be considered, if clay materials are unavailable or difficult to obtain.

The alternate system should consist of the following layers: vegetative cover soil of 24 inches; drainage layer and a geomembrane liner (FML).

The slope of all cap system layers should not exceed 3 Horizontal to 1 Vertical (3H:1V).

Final slopes will be based on stability analyses. The cap system and final cover should not be constructed until after perimeter containment for that segment has been constructed.

10.3. Erosion Protection

Run-on from adjacent areas should be controlled and diverted around the subject area.

- Run-off from the landfilled area should be collected in a manner that controls erosive forces. This can be accomplished by:
  - Controlling erosion of cover material (e.g., no steep slopes);
  - Controlling drainage of precipitation falling on the disposal facility or disposal facility parcel (e.g., prevent pooling); and
  - Providing a surface drainage system which is consistent with the surrounding area and in no way significantly adversely affects proper drainage from these adjacent lands. Establish a protective vegetative cover of acceptable grasses over disturbed areas of the site.

In general, requirements of TDEC Division of Solid Waste Rule 1200-01-07.04 shall be met or exceeded for design and the site wide Stormwater Management Plan (SWMP) will be followed.

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11. Anchor Trench (if applicable)

11.1. General Design Criteria:

Per Section 1.4.5 of the TVA Coal Combustion Products Management Program Master Programmatic Document:

- Anchorage shall be designed for a worst-case temporary scenario occurring during construction;
- Anchor trench design should be in general accordance with the methodology given in Qian, Koerner, and Gray (2002); and
- A minimal anchor trench or combination runout section and anchor trench should be specified in the facility design.

12. Stormwater Management

12.1. Requirements

Per TDEC Division of Solid Waste Management Chapter 1200-01-07 (Rule 1200-01-07.04), the following are required:

- A run-on control system for all flow up to and including peak discharge from a 24-hour, 25-year storm;
- A run-off management system to collect and control at least the peak flow volume resulting from a 24-hour, 25-year storm;
- Holding facilities (e.g., sediment basins) designed to detain at least the water volume resulting from a 24 hour, 25 year storm and to divert through emergency spillways at least the peak flow resulting from a 24-hour, 100-year storm;
- Collection and holding facilities must be emptied after storms to maintain design capacity of the system; and
- Other erosion control measures (e.g., temporary mulching or seeding, silt barriers) as necessary to control erosion of the site.

12.2. Cap System Erosion Control

Per Section 1.6.1 of the TVA Coal Combustion Products Management Program Master Programmatic Document, the Revised Universal Soil Loss Equation (RUSLE) shall be used to predict maximum soil loss from the final cap system.

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Kingston Ash Recovery Project (KRP)
Design Basis and Criteria
Dredge Cell Closure
Kingston Fossil Plant
Harriman, Roane County, Tennessee

12.3. Erosion Control During Construction

12.3.1. Per Section 1.6.1 of the TVA Coal Combustion Products Management Program Master Programmatic Document, sediment and erosion control BMPs shall be provided during all construction activities, and to manage sediment from the facility area and stockpiles during operations. For the Kingston site, a site specific Stormwater Management Plan (SWMP) has been prepared and will be referenced in design documents.

12.3.2. Surface water calculations shall be prepared using the Soil Conservation Service (SCS) method (previously by the USDA Soil Conservation Service, now by the Natural Resources Conservation Service (NRCS)).

12.3.3. All surface water drainage structures, including channels, culverts, and benches on the facility cap system shall be designed to carry expected flows based on the 24-hour, 25-year storm event for the particular region.

12.3.4. The following additional design elements shall be considered during the design of the surface water system:

- Velocity of the surface water flow. The dimensions and slope of the surface water drainage structure energy dissipation devices; and
- The use of non-mechanical gravity-flow surface water conveyance structures is most desirable and recommended.

12.4. Assumptions

- Rainfall data used for design purposes will be obtained from National Oceanic and Atmospheric Administration (NOAA)-14 and Natural Resources Conservation Service (NRCS) publications;
- SEDCAD (Sediment, Erosion, Discharge by Computer Aided Design) will be utilized to design and evaluate the surface water, erosion and sediment control systems;
- Technical Release 55 (TR-55) methods will be utilized to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for the watershed;
- Runoff from the Dredge Cell prior to closure shall be routed to permitted NPDES discharge points; and
- Runoff from the closed cover of the facility may be discharged directly offsite at multiple locations.

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13. Filter or Separation Criteria (if applicable)

13.1. Granular Filter Criteria

Granular filter design must meet the criteria as established in the USACE Manual EM 1110-2-2300, Appendix B dated July 30, 2004.

13.2. Geotextile Design by Specification

The Geotextile must satisfy the American Association of State Highway and Transportation Officials (AASHTO) requirements established in the AASHTO M288 specifications.

13.3. Filter Cover and Protection

Adequate cover materials shall be placed over filter before allowing transit of heavy equipment. Manufacturer's recommendations for geotextile protection shall be followed.

Geotextile shall be protected from ultraviolet degradation as per the manufacturer's recommendations.

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