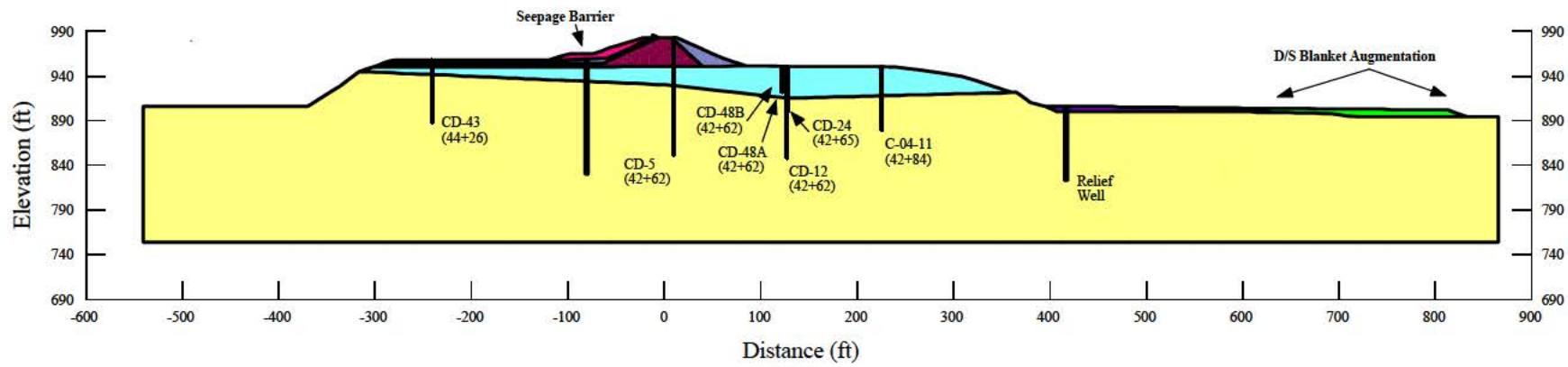
Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station
43+00

Model Expected Saturated Hydraulic Conductivity Values: Horizontal (Kx) and Vertical (Ky)

Material	Kx (ft/s) *(cm/s)*	Ky (ft/s) *(cm/s)*	Ky/Kx	Kx/Ky	Model Color
Core	8.2E-07 *2.5E-05*	1.6E-07 *5.0E-06*	2.0E-01	5.0E+00	Dark Red
Shell	6.2E-04 *1.9E-02*	6.2E-05 *1.9E-03*	1.0E-01	1.0E+01	Light Purple
Foundation gravel	3.3E-02 *1.0E+00*	1.7E-02 *5.2E-01*	5.2E-01	1.9E+00	Turquoise
Rock toe	1.6E-01 *4.9E+00*	1.6E-01 *4.9E+00*	1.0E+00	1.0E+00	Gray
Foundation silty sand	2.8E-03 *8.4E-02*	2.3E-04 *7.1E-03*	8.5E-02	1.2E+01	Light Yellow
Upstream blanket	4.7E-06 *1.4E-04*	9.4E-07 *2.9E-05*	2.0E-01	5.0E+00	Dark Purple
Downstream blanket	3.3E-04 *1.0E-02*	1.7E-04 *5.0E-03*	5.0E-01	2.0E+00	Purple
Relief well screen	6.6E-03 *2.0E-01*	1.3E+02 *3.9E+03*	1.9E+04	5.2E-05	Red
Relief well riser	3.2E-08 *9.9E-07*	1.3E+02 *3.9E+03*	3.9E+09	2.6E-10	Light Orange
Developed gravel and outwash	3.3E-03 *1.0E-01*	1.7E-03 *5.0E-02*	5.0E-01	2.0E+00	Coral
Parapet wall	Non-permeable				Black
Seepage barrier	3.2E-08 *9.9E-07*	3.2E-08 *9.9E-07*	1.0E+00	1.0E+00	Pink
Blanket augmentation	3.3E-04 *1.0E-02*	1.7E-04 *5.0E-03*	5.0E-01	2.0E+00	Green
Bedrock	Non-permeable				NA



Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
43+00	952	906

Model Predictions

Piezometric Levels

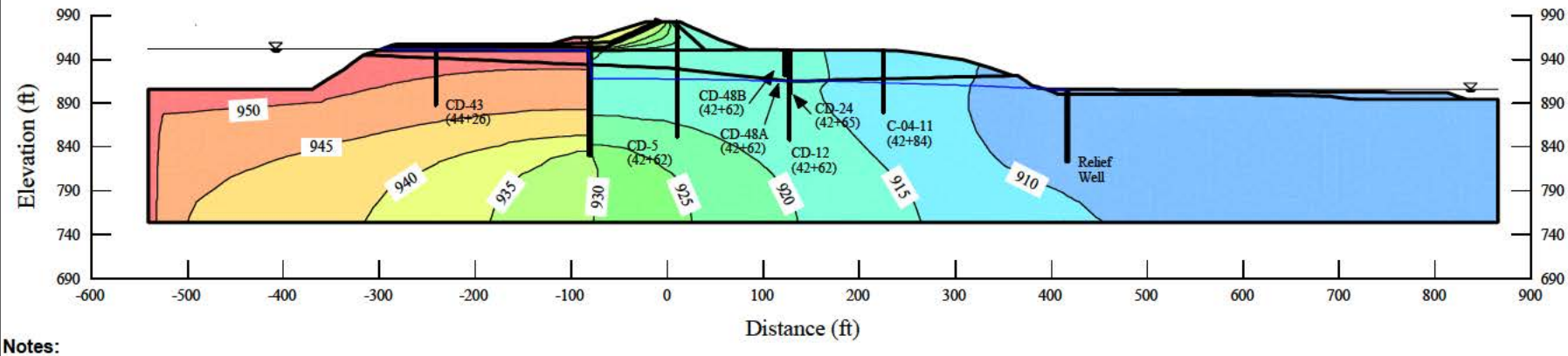
Piezometer	Predicted (ft)
CD-43	947.9
CD-5	921.6
CD-48A	Dry
CD-48B	Dry
CD-12	917.3
CD-24	915.6
C-04-11	913.1

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Toe/Above Toe	9.1E-04	0.4
D/S Blanket	6.8E-04	0.0
D/S of Blanket	0.0E+00	0.0

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/85)
1.4E-02	6.1	NA



Notes:

1. Bottom tip elevation of modeled seepage barrier remedy component is 830 ft (barrier depth from it's top is 135 ft)
2. Downstream seepage blanket augmentation ties in with existing seepage blanket and extends >=200 ft further downstream with 1% top slope
3. Recommended remedy provides $FS_{(piping)}$ (Toe) >= 2.5, and $FS_{(piping)}$ (D/S of Blanket) and $FS_{(effective\text{-}uplift)}$ (D/S Blanket) >=1.5, as well as high reliability (R) values, for all load cases
4. Recommended remedy includes maintenance program for relief wells to ensure adequate efficiency over time

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	906.0

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.14	0.13	0.01	906.0	900.0	6.31

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
4.47	71.01	18.16

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
5.14	20.88

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
43+00	962	908.5

Model Predictions

Piezometric Levels

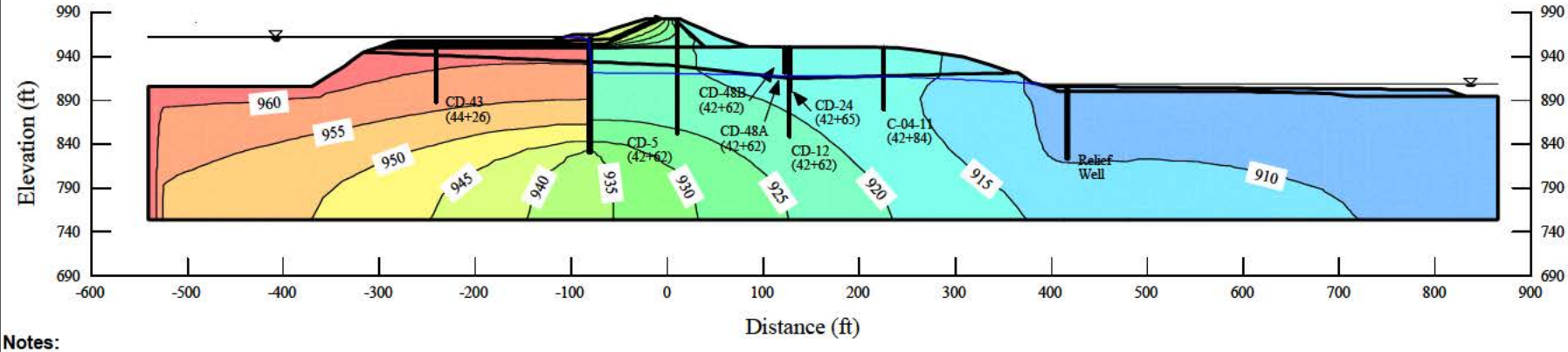
Piezometer	Predicted (ft)
CD-43	955.0
CD-5	926.1
CD-48A	Dry
CD-48B	Dry
CD-12	921.1
CD-24	918.7
C-04-11	916.4

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Toe/Above Toe	2.4E-03	1.1
D/S Blanket	7.7E-04	0.3
D/S of Blanket	0.0E+00	0.0

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/85)
1.5E-02	6.5	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	908.5

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.28	0.23	0.02	906.0	900.0	8.74

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
2.61	61.54	23.08

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
3.00	26.54

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
43+00	964	908.5

Model Predictions

Piezometric Levels

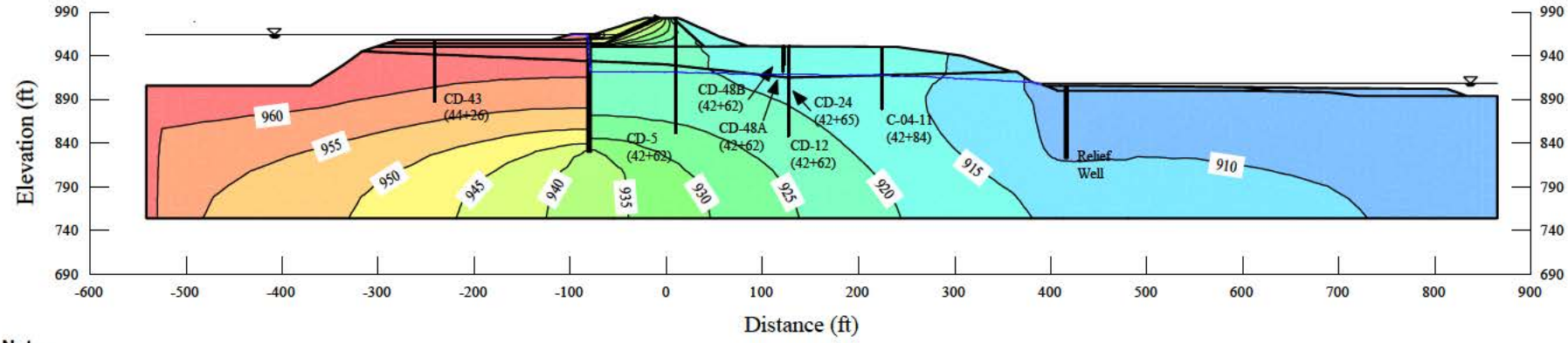
Piezometer	Predicted (ft)
CD-43	956.7
CD-5	926.7
CD-48A	Dry
CD-48B	Dry
CD-12	921.6
CD-24	918.9
C-04-11	916.7

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Toe/Above Toe	2.5E-03	1.1
D/S Blanket	8.0E-04	0.4
D/S of Blanket	0.0E+00	0.0

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/85)
1.5E-02	6.9	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	908.5

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.29	0.24	0.02	906.0	900.0	8.78

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
2.55	57.69	19.78

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
2.93	22.75

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
43+00	982	930

Model Predictions

Piezometric Levels

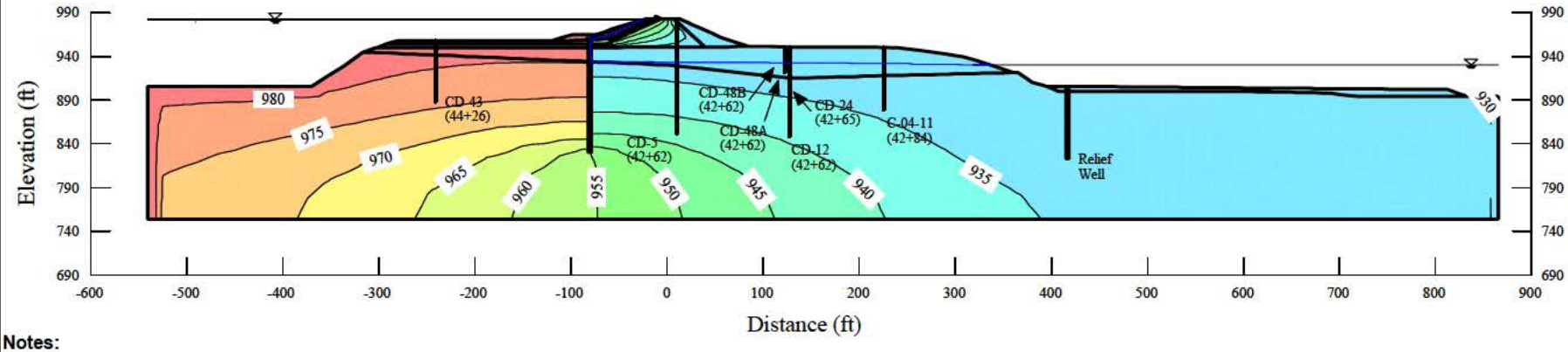
Piezometer	Predicted (ft)
CD-43	976.9
CD-5	943.7
CD-48A	932.6
CD-48B	932.5
CD-12	938.8
CD-24	933.9
C-04-11	934.2

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Toe/Above Toe	8.1E-03	3.7
D/S Blanket	6.3E-04	0.3
D/S of Blanket	0.0E+00	0.0

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/85)
9.9E-03	4.4	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	930.0

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.04	0.03	0.01	906.0	900.0	30.10

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
19.98	73.85	55.38

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
22.98	63.69

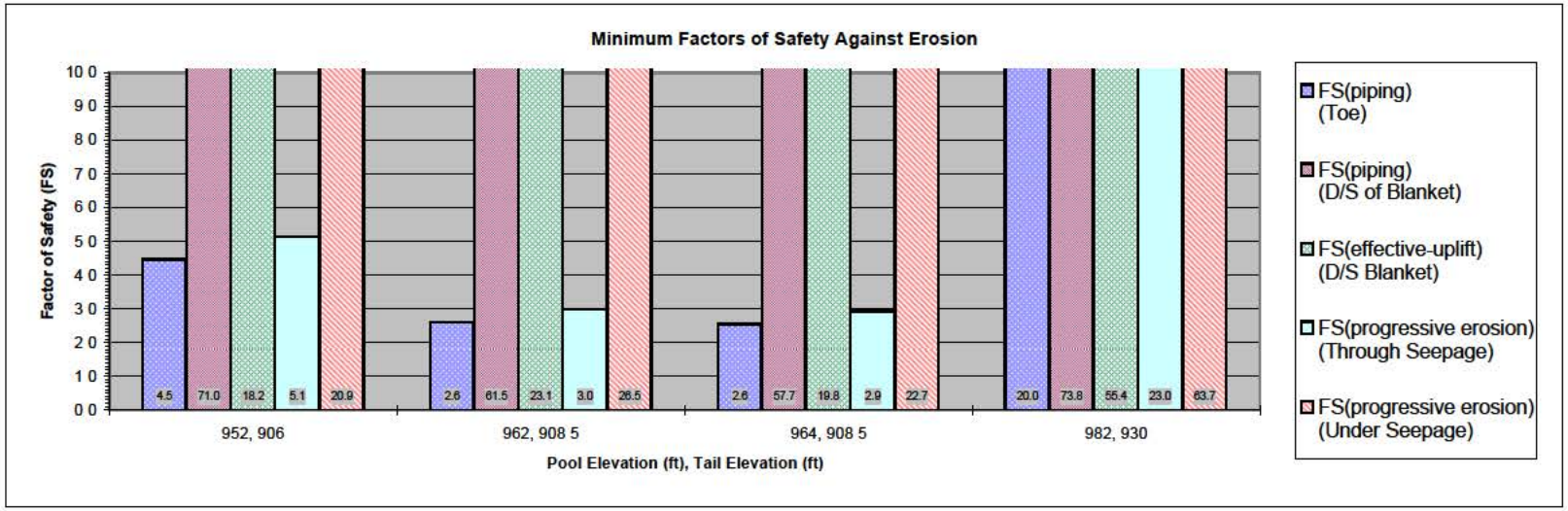
Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station

43+00

Model Safety Predictions Summary

Pool Elevation (ft), Tail Elevation (ft)	Minimum Factors of Safety: $FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)	$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
952, 906	4.5	71.0	18.2	5.1	20.9
962, 908.5	2.6	61.5	23.1	3.0	26.5
964, 908.5	2.6	57.7	19.8	2.9	22.7
982, 930	20.0	73.8	55.4	23.0	63.7



Notes:

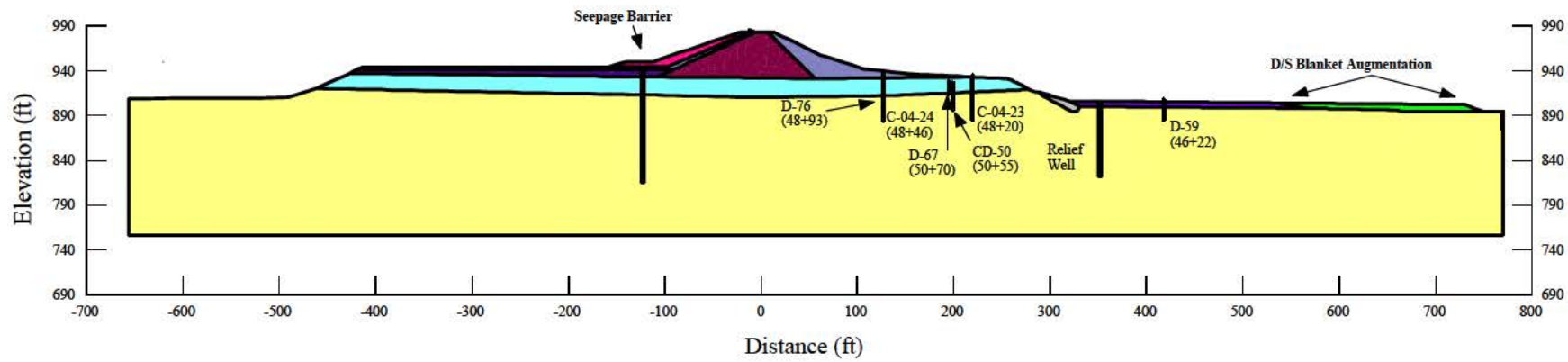
1. Refer to notes for this section listed on prior sheet

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station
49+00

Model Expected Saturated Hydraulic Conductivity Values: Horizontal (Kx) and Vertical (Ky)

Material	Kx (ft/s) *(cm/s)*	Ky (ft/s) *(cm/s)*	Ky/Kx	Kx/Ky	Model Color
Core	8.2E-07 *2.5E-05*	1.6E-07 *5.0E-06*	2.0E-01	5.0E+00	Dark Red
Shell	6.2E-04 *1.9E-02*	6.2E-05 *1.9E-03*	1.0E-01	1.0E+01	Light Purple
Foundation gravel	3.3E-02 *1.0E+00*	1.7E-02 *5.2E-01*	5.2E-01	1.9E+00	Turquoise
Rock toe	1.6E-01 *4.9E+00*	1.6E-01 *4.9E+00*	1.0E+00	1.0E+00	Gray
Foundation silty sand	2.8E-03 *8.4E-02*	2.3E-04 *7.1E-03*	8.5E-02	1.2E+01	Light Yellow
Upstream blanket	4.7E-06 *1.4E-04*	9.4E-07 *2.9E-05*	2.0E-01	5.0E+00	Dark Purple
Downstream blanket	3.3E-04 *1.0E-02*	1.7E-04 *5.0E-03*	5.0E-01	2.0E+00	Purple
Relief well screen	6.6E-03 *2.0E-01*	1.3E+02 *3.9E+03*	1.9E+04	5.2E-05	Red
Relief well riser	3.2E-08 *9.9E-07*	1.3E+02 *3.9E+03*	3.9E+09	2.6E-10	Light Orange
Developed gravel and outwash	3.3E-03 *1.0E-01*	1.7E-03 *5.0E-02*	5.0E-01	2.0E+00	Coral
Parapet wall	Non-permeable				Black
Bedrock	Non-permeable				NA



Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
49+00	936	894

Model Predictions

Piezometric Levels

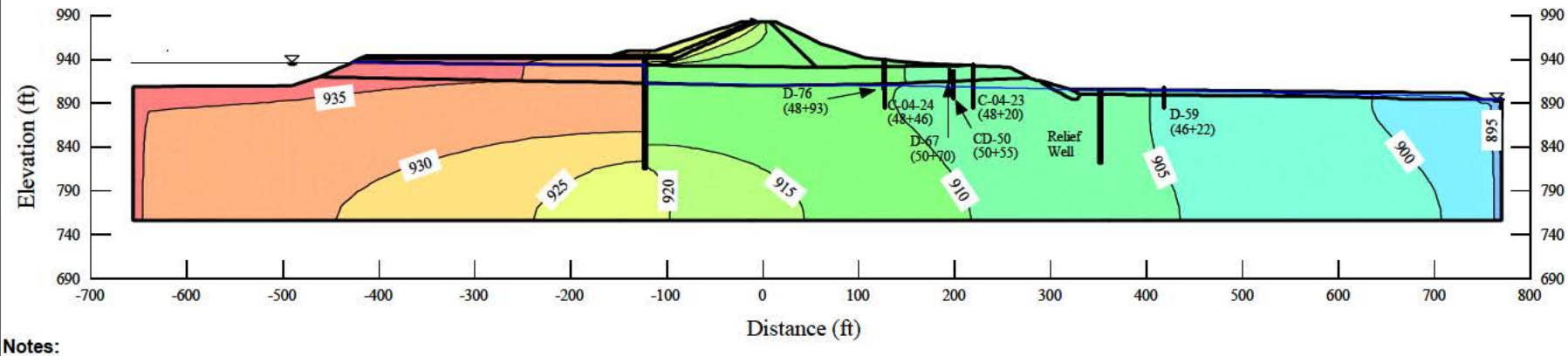
Piezometer	Predicted (ft)
C-04-23	908.4
C-04-24	910.2
CD-50	908.8
D-59	904.7
D-67	Dry
D-76	910.2

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	1.5E-06	0.0
Toe	1.7E-03	0.8
D/S Blanket	1.2E-05	0.0
D/S of Blanket	4.2E-04	0.2

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
3.7E-04	0.2	NA



Notes:

1. Bottom tip elevation of modeled seepage barrier remedy component is 815 ft (barrier depth from it's top is 135 ft)
2. Downstream seepage blanket augmentation ties in with existing seepage blanket and extends >=200 ft further downstream with 1% top slope
3. Recommended remedy provides $FS_{(piping)}$ (Toe) >= 2.5, and $FS_{(piping)}$ (D/S of Blanket) and $FS_{(effective\text{-}uplift)}$ (D/S Blanket) >=1.5, as well as high reliability (R) values, for all load cases
4. Recommended remedy includes maintenance program for relief wells to ensure adequate efficiency over time

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	906.0

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	Pmax (D/S Blanket Base)
0.05	0.05	0.18	906.0	900.0	6.07

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
13.32	5.19	79.12

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
15.32	5.96

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
49+00	949	896

Model Predictions

Piezometric Levels

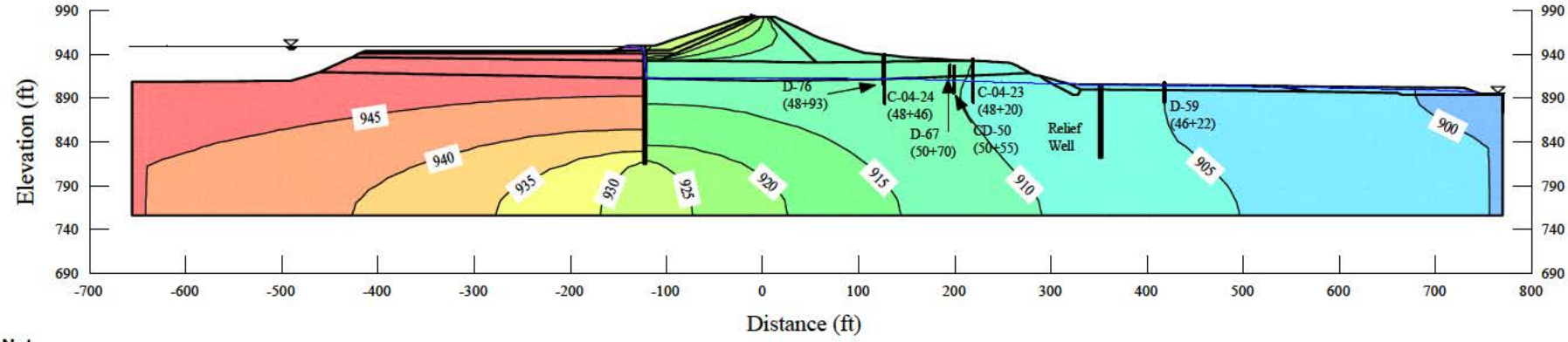
Piezometer	Predicted (ft)
C-04-23	909.5
C-04-24	912.1
CD-50	910.2
D-59	905.0
D-67	Dry
D-76	912.2

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	2.6E-06	0.0
Toe	2.7E-03	1.2
D/S Blanket	1.7E-05	0.0
D/S of Blanket	3.6E-04	0.2

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
4.5E-03	2.0	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	906.0

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.11	0.12	0.15	906.0	900.0	6.07

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
5.00	6.15	79.12

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
5.74	7.08

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
49+00	952	906

Model Predictions

Piezometric Levels

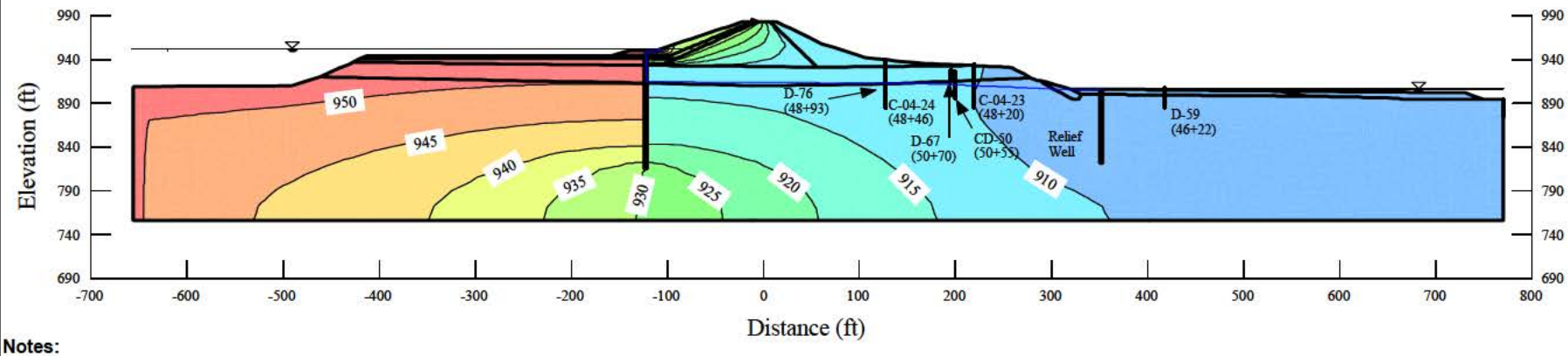
Piezometer	Predicted (ft)
C-04-23	910.6
C-04-24	912.7
CD-50	910.6
D-59	906.1
D-67	911.3
D-76	912.6

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	3.1E-06	0.0
Toe	3.2E-03	1.4
D/S Blanket	5.2E-04	0.0
D/S of Blanket	1.8E-05	0.0

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
1.0E-02	4.7	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	906.0

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.13	0.15	0.01	906.0	900.0	6.01

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
4.00	83.92	553.85

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
4.60	96.50

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
49+00	962	908.5

Model Predictions

Piezometric Levels

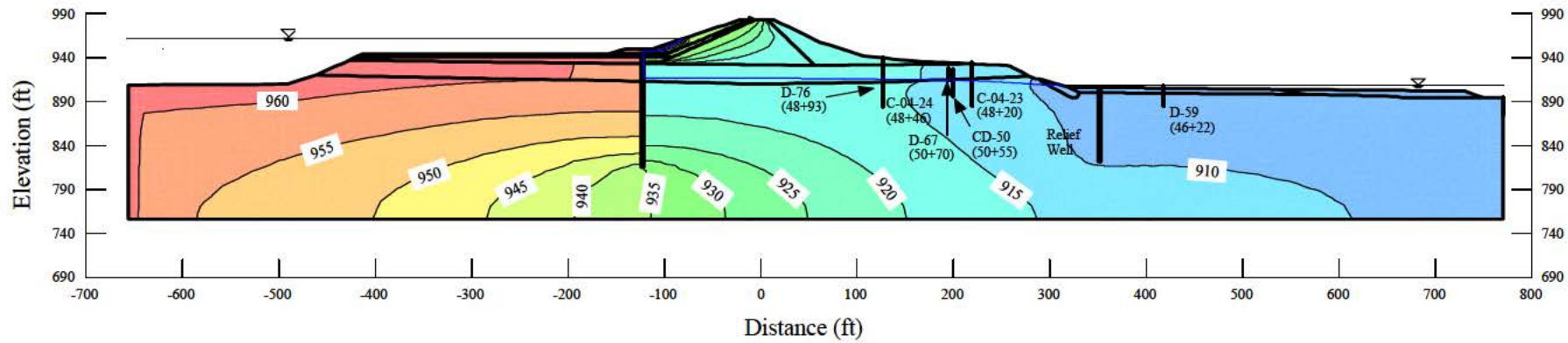
Piezometer	Predicted (ft)
C-04-23	912.8
C-04-24	915.8
CD-50	913.6
D-59	908.6
D-67	914.6
D-76	915.4

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	2.4E-05	0.0
Toe	4.3E-03	1.9
D/S Blanket	5.9E-04	0.3
D/S of Blanket	2.0E-05	0.0

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
1.2E-02	5.2	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	908.5

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.10	0.14	0.01	906.0	900.0	8.51

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
4.28	71.01	553.85

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
4.92	81.66

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
49+00	964	908.5

Model Predictions

Piezometric Levels

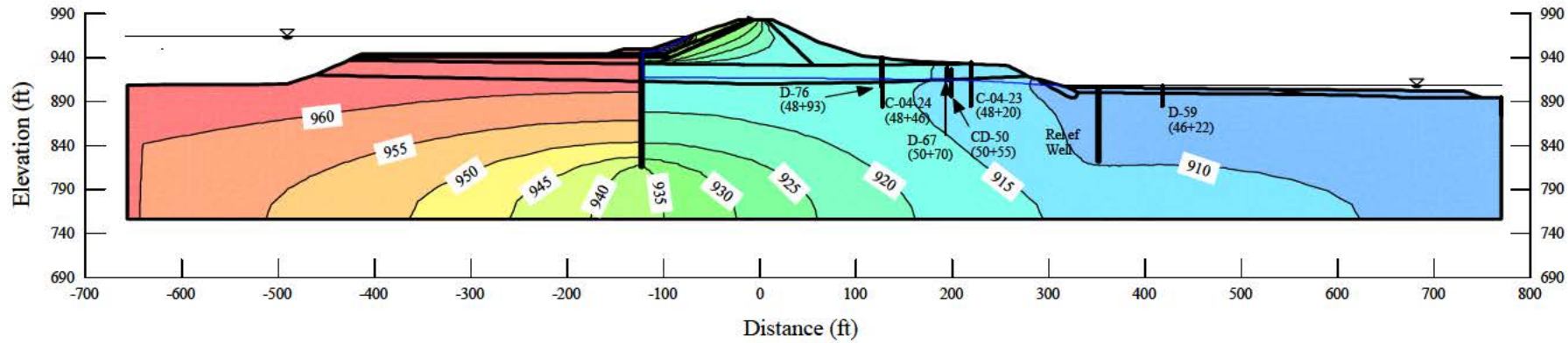
Piezometer	Predicted (ft)
C-04-23	913.0
C-04-24	916.1
CD-50	913.8
D-59	908.6
D-67	914.8
D-76	915.8

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	2.7E-05	0.0
Toe	4.5E-03	2.0
D/S Blanket	6.1E-04	0.3
D/S of Blanket	2.1E-05	0.0

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
1.2E-02	5.4	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	908.5

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.12	0.15	0.01	906.0	900.0	8.51

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
4.00	71.01	553.85

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
4.60	81.66

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
49+00	982	930

Model Predictions

Piezometric Levels

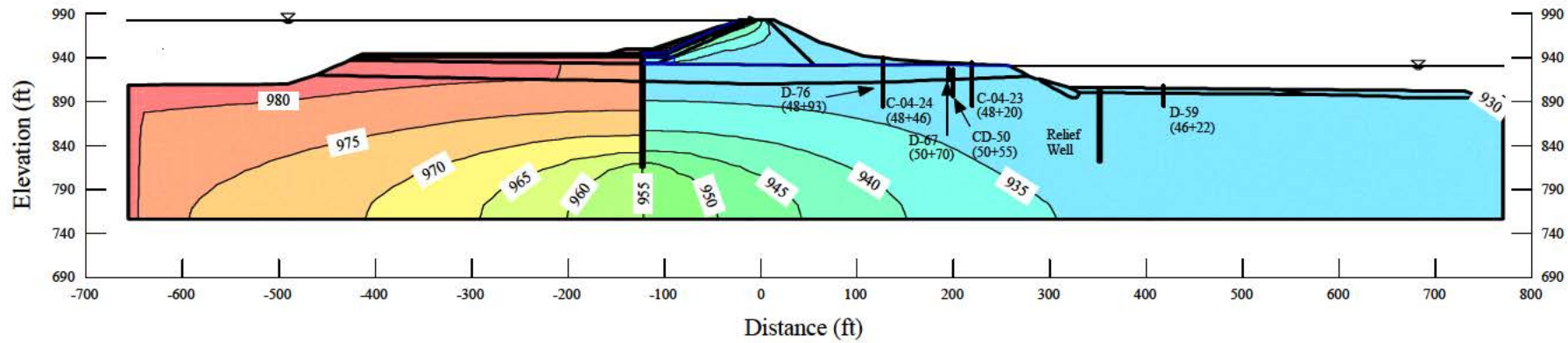
Piezometer	Predicted (ft)
C-04-23	931.8
C-04-24	933.6
CD-50	931.5
D-59	930.1
D-67	930.9
D-76	932.0

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	7.0E-03	3.1
Toe	1.2E-03	0.5
D/S Blanket	4.9E-04	0.2
D/S of Blanket	1.7E-05	0.0

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
8.4E-03	3.8	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	930.0

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.04	0.03	0.01	906.0	900.0	30.10

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
21.41	92.31	55.38

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
24.62	63.69

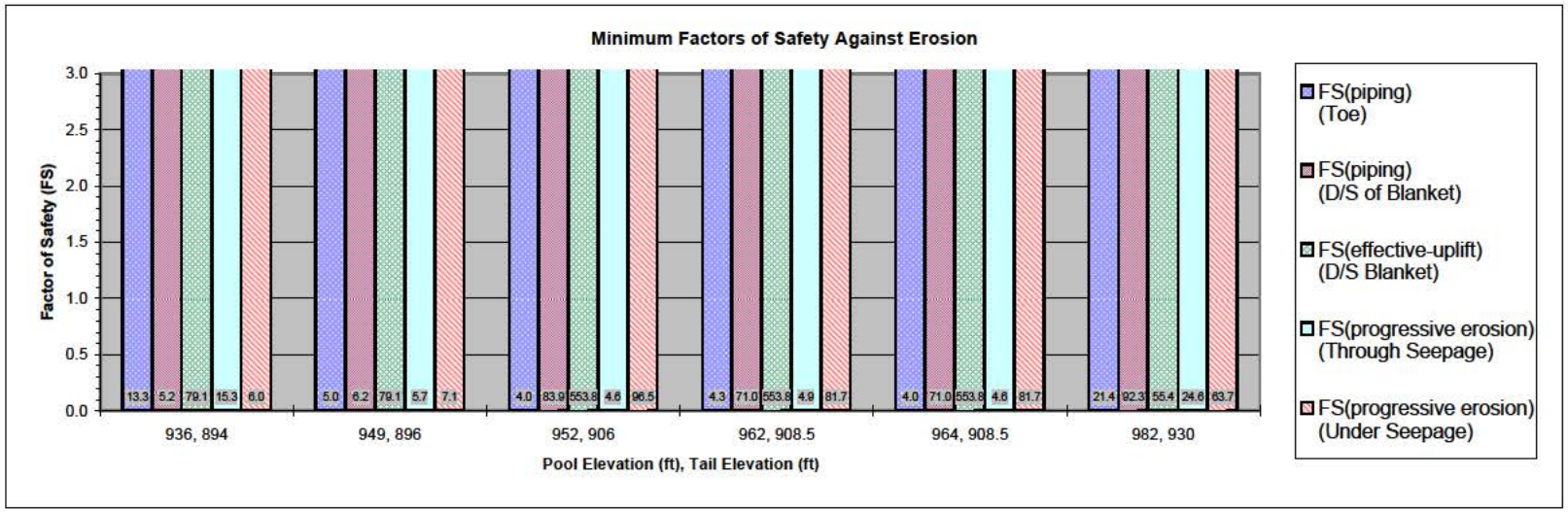
Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station

49+00

Model Safety Predictions Summary

Pool Elevation (ft), Tail Elevation (ft)	Minimum Factors of Safety: $FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)	$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
936, 894	13.3	5.2	79.1	15.3	6.0
949, 896	5.0	6.2	79.1	5.7	7.1
952, 906	4.0	83.9	553.8	4.6	96.5
962, 908.5	4.3	71.0	553.8	4.9	81.7
964, 908.5	4.0	71.0	553.8	4.6	81.7
982, 930	21.4	92.3	55.4	24.6	63.7



Notes:

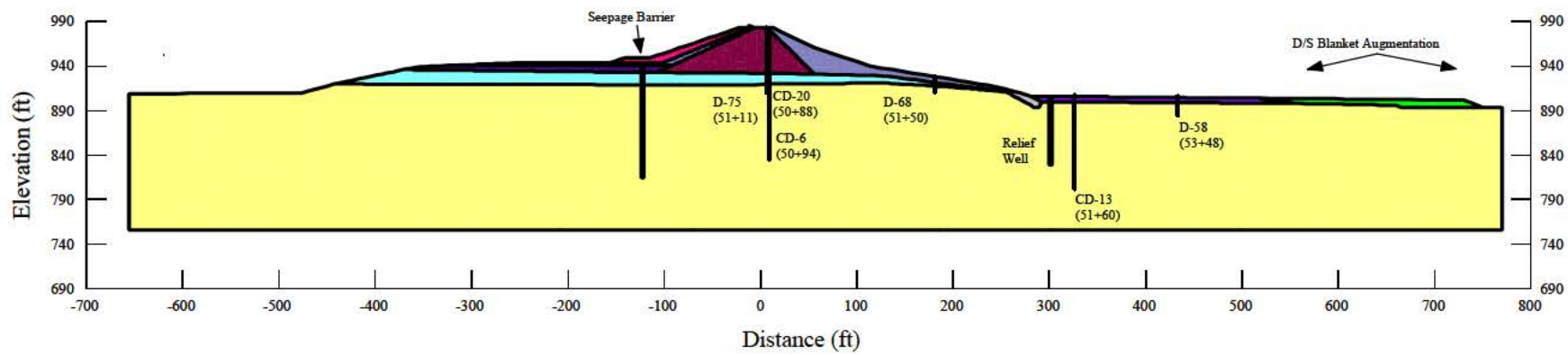
1. Refer to notes for this section listed on prior sheet

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station
51+00

Model Expected Saturated Hydraulic Conductivity Values: Horizontal (Kx) and Vertical (Ky)

Material	Kx (ft/s) *(cm/s)*	Ky (ft/s) *(cm/s)*	Ky/Kx	Kx/Ky	Model Color
Core	8.2E-07 *2.5E-05*	1.6E-07 *5.0E-06*	2.0E-01	5.0E+00	Dark Red
Shell	6.2E-04 *1.9E-02*	6.2E-05 *1.9E-03*	1.0E-01	1.0E+01	Light Purple
Foundation gravel	3.3E-02 *1.0E+00*	1.7E-02 *5.2E-01*	5.2E-01	1.9E+00	Turquoise
Rock toe	1.6E-01 *4.9E+00*	1.6E-01 *4.9E+00*	1.0E+00	1.0E+00	Gray
Foundation silty sand	2.8E-03 *8.4E-02*	2.3E-04 *7.1E-03*	8.5E-02	1.2E+01	Light Yellow
Upstream blanket	4.7E-06 *1.4E-04*	9.4E-07 *2.9E-05*	2.0E-01	5.0E+00	Dark Purple
Downstream blanket	3.3E-04 *1.0E-02*	1.7E-04 *5.0E-03*	5.0E-01	2.0E+00	Purple
Relief well screen	6.6E-03 *2.0E-01*	1.3E+02 *3.9E+03*	1.9E+04	5.2E-05	Red
Relief well riser	3.2E-08 *9.9E-07*	1.3E+02 *3.9E+03*	3.9E+09	2.6E-10	Light Orange
Developed gravel and outwash	3.3E-03 *1.0E-01*	1.7E-03 *5.0E-02*	5.0E-01	2.0E+00	Coral
Parapet wall	Non-permeable				Black
Seepage barrier	3.2E-08 *9.9E-07*	3.2E-08 *9.9E-07*	1.0E+00	1.0E+00	Pink
Blanket augmentation	3.3E-04 *1.0E-02*	1.7E-04 *5.0E-03*	5.0E-01	2.0E+00	Green
Bedrock	Non-permeable				NA



Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
51+00	936	894

Model Predictions

Piezometric Levels

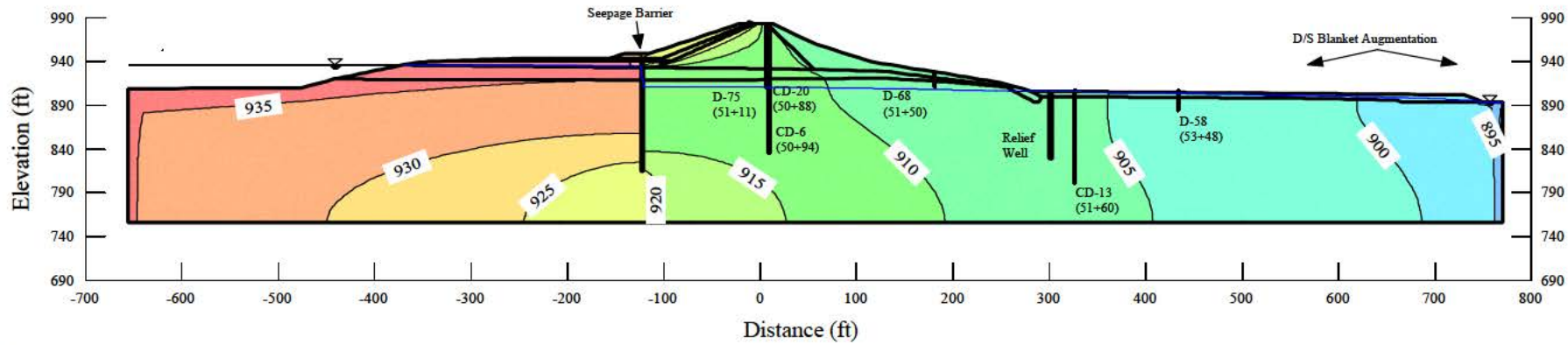
Piezometer	Predicted (ft)
CD-6	913.3
CD-13	906.3
CD-20	Dry
D-58	903.6
D-68	Dry
D-75	910.8

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	1.4E-05	0.0
Toe	9.5E-04	0.4
D/S Blanket	1.1E-05	0.0
D/S of Blanket	2.7E-04	0.1

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
1.4E-03	0.6	NA



Notes:

1. Bottom tip elevation of modeled seepage barrier remedy component is 815 ft (barrier depth from it's top is 135 ft)
2. Downstream seepage blanket augmentation ties in with existing seepage blanket and extends >=200 ft further downstream with 1% top slope
3. Recommended remedy provides $FS_{(piping)}$ (Toe) >= 2.5, and $FS_{(piping)}$ (D/S of Blanket) and $FS_{(effective\text{-}uplift)}$ (D/S Blanket) >=1.5, as well as high reliability (R) values, for all load cases
4. Recommended remedy includes maintenance program for relief wells to ensure adequate efficiency over time

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	906.0

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.05	0.05	0.20	906.0	900.0	6.07

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
13.32	4.62	79.12

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
15.32	5.31

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
51+00	949	896

Model Predictions

Piezometric Levels

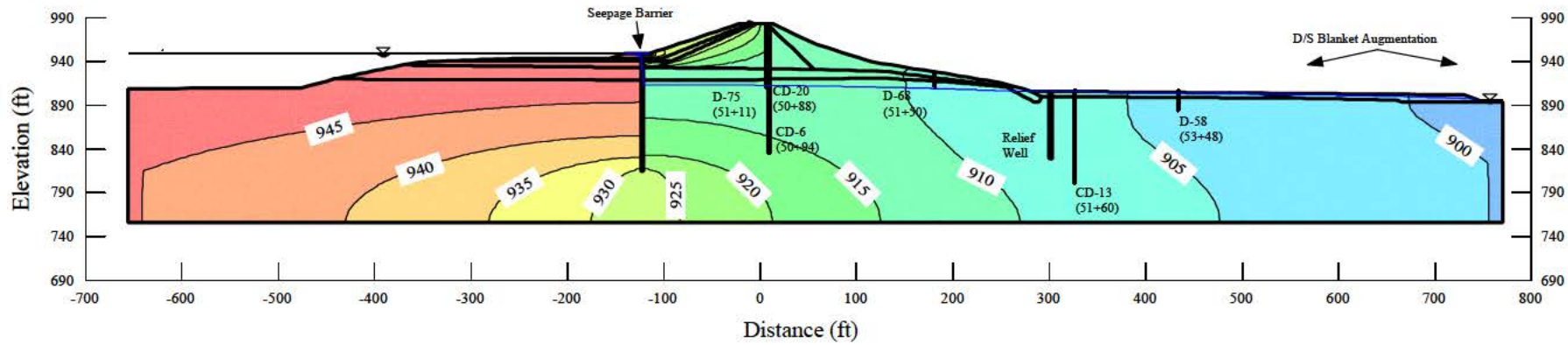
Piezometer	Predicted (ft)
CD-6	916.7
CD-13	907.6
CD-20	Dry
D-58	904.3
D-68	Dry
D-75	912.5

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	2.4E-05	0.0
Toe	1.5E-03	0.7
D/S Blanket	2.0E-05	0.0
D/S of Blanket	2.4E-04	0.1

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
5.5E-03	2.5	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	906.0

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.07	0.07	0.18	906.0	900.0	6.07

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
8.56	5.27	79.12

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
9.85	6.07

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
51+00	964	908.5

Model Predictions

Piezometric Levels

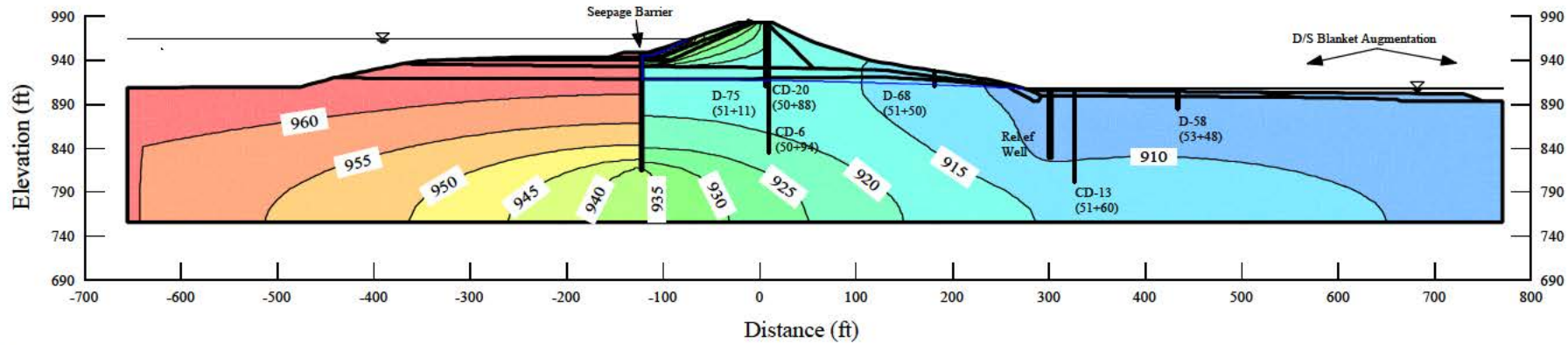
Piezometer	Predicted (ft)
CD-6	922.7
CD-13	912.5
CD-20	Dry
D-58	908.8
D-68	912.3
D-75	917.4

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	6.7E-05	0.0
Toe	3.2E-03	1.4
D/S Blanket	1.0E-03	0.4
D/S of Blanket	2.3E-05	0.0

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
1.3E-02	5.7	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	908.5

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.13	0.12	0.02	906.0	900.0	8.51

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
5.21	48.58	553.85

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
5.99	55.87

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
51+00	982	930

Model Predictions

Piezometric Levels

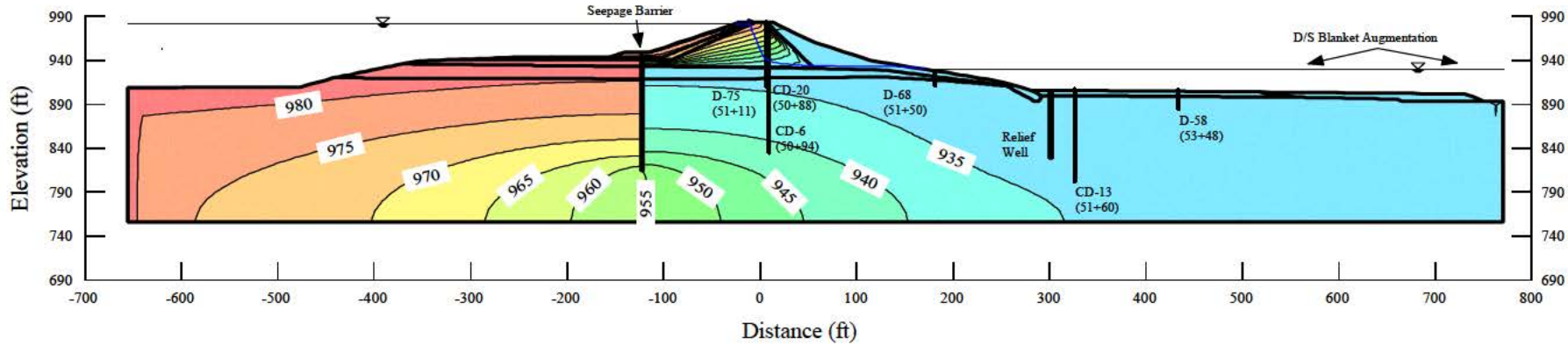
Piezometer	Predicted (ft)
CD-6	941.6
CD-13	933.5
CD-20	934.1
D-58	930.2
D-68	932.4
D-75	934.8

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	2.5E-03	1.1
Toe	2.7E-03	1.2
D/S Blanket	8.7E-04	0.4
D/S of Blanket	2.0E-05	0.0

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
1.0E-02	4.6	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	930.0

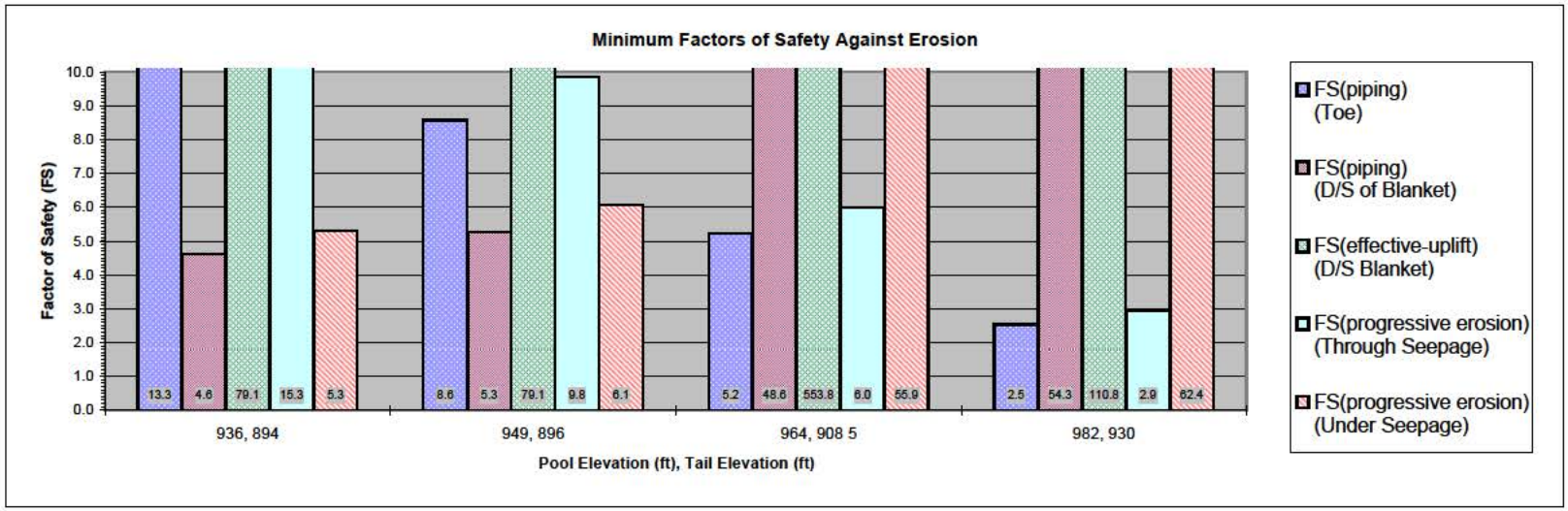
$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.36	0.11	0.02	906.0	900.0	30.05

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
2.54	54.30	110.77

$FS_{(progressive\ erosion)}$ (Through Seepage)	$FS_{(progressive\ erosion)}$ (Under Seepage)
2.92	62.44

Bolivar Dam Seepage Analysis - Rehab Condition - Seepage Barrier and Downstream Blanket Augmentation					
Station					
51+00					
Model Safety Predictions Summary					
	Minimum Factors of Safety				
Pool Elevation (ft), Tail Elevation (ft)	**$FS_{(piping)}$ (Toe)**	**$FS_{(piping)}$ (D/S of Blanket)**	**$FS_{(effective\text{-}uplift)}$ (D/S Blanket)**	**$FS_{(progressive\ erosion)}$ (Through Seepage)**	**$FS_{(progressive\ erosion)}$ (Under Seepage)**
936, 894	13.3	4.6	79.1	15.3	5.3
949, 896	8.6	5.3	79.1	9.8	6.1
964, 908.5	5.2	48.6	553.8	6.0	55.9
982, 930	2.5	54.3	110.8	2.9	62.4



Notes:

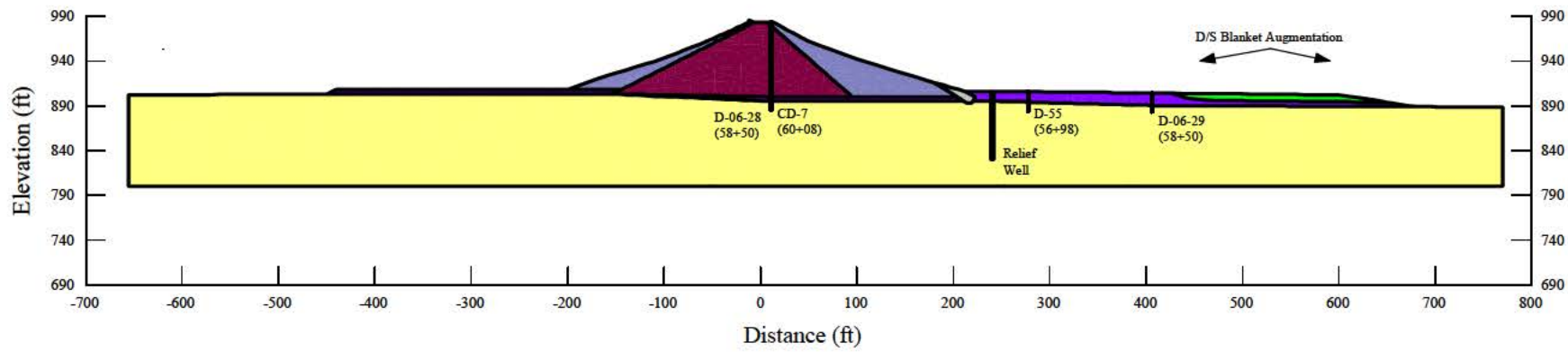
1. Refer to notes for this section listed on prior sheet

Bolivar Dam Seepage Analysis - Rehab Condition - Downstream Blanket Augmentation

Station
57+00

Model Expected Saturated Hydraulic Conductivity Values: Horizontal (Kx) and Vertical (Ky)

Material	Kx (ft/s) *(cm/s)*	Ky (ft/s) *(cm/s)*	Ky/Kx	Kx/Ky	Model Color
Core	8.2E-07 *2.5E-05*	1.6E-07 *5.0E-06*	2.0E-01	5.0E+00	Dark Red
Shell	6.2E-04 *1.9E-02*	6.2E-05 *1.9E-03*	1.0E-01	1.0E+01	Light Purple
Rock toe	1.6E-01 *4.9E+00*	1.6E-01 *4.9E+00*	1.0E+00	1.0E+00	Gray
Foundation silty sand	2.8E-03 *8.4E-02*	2.3E-04 *7.1E-03*	8.5E-02	1.2E+01	Light Yellow
Upstream blanket	4.7E-06 *1.4E-04*	9.4E-07 *2.9E-05*	2.0E-01	5.0E+00	Dark Purple
Downstream blanket	3.3E-04 *1.0E-02*	1.7E-04 *5.0E-03*	5.0E-01	2.0E+00	Purple
Relief well screen	6.6E-03 *2.0E-01*	1.3E+02 *3.9E+03*	1.9E+04	5.2E-05	Red
Relief well riser	3.2E-08 *9.9E-07*	1.3E+02 *3.9E+03*	3.9E+09	2.6E-10	Light Orange
Developed gravel and outwash	3.3E-03 *1.0E-01*	1.7E-03 *5.0E-02*	5.0E-01	2.0E+00	Coral
Parapet wall	Non-permeable				Black
Blanket augmentation	3.3E-04 *1.0E-02*	1.7E-04 *5.0E-03*	5.0E-01	2.0E+00	Green
Bedrock	Non-permeable				NA



Bolivar Dam Seepage Analysis - Rehab Condition - Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
57+00	929	888

Model Predictions

Piezometric Levels

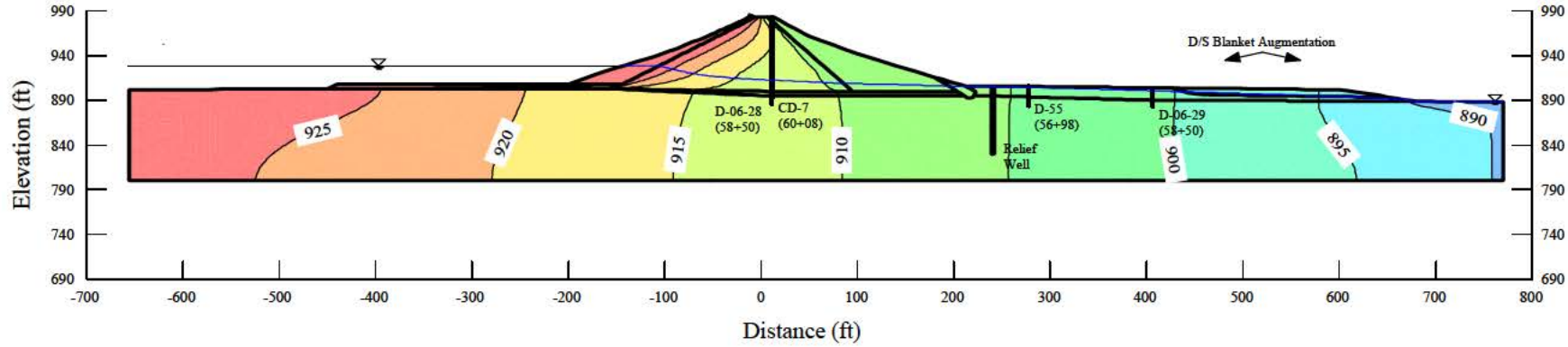
Piezometer	Predicted (ft)
CD-7	912.2
D-55	904.5
D-06-28	912.3
D-06-29	900.7

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	8.8E-05	0.0
Toe	5.4E-04	0.2
D/S Blanket	7.3E-04	0.3
D/S of Blanket	3.3E-03	1.5

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
2.4E-06	0.0	NA



Notes:

1. Downstream seepage blanket augmentation ties in with existing seepage blanket and extends >=200 ft further downstream with 1% top slope
2. Recommended remedy provides FS(piping) (Toe) >= 2.5, and FS(piping) (D/S of Blanket) and FS(effective-uplift) (D/S Blanket) >=1.5, as well as high reliability (R) values, for all load cases
3. Recommended remedy includes maintenance program for relief wells to ensure adequate efficiency over time

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	906.0

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.04	0.04	0.17	906.0	895.0	11.01

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
14.99	5.43	1015.38

$FS_{(progressive\ erosion)}$ (Under Seepage)
6.24

Bolivar Dam Seepage Analysis - Rehab Condition - Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
57+00	936	894

Model Predictions

Piezometric Levels

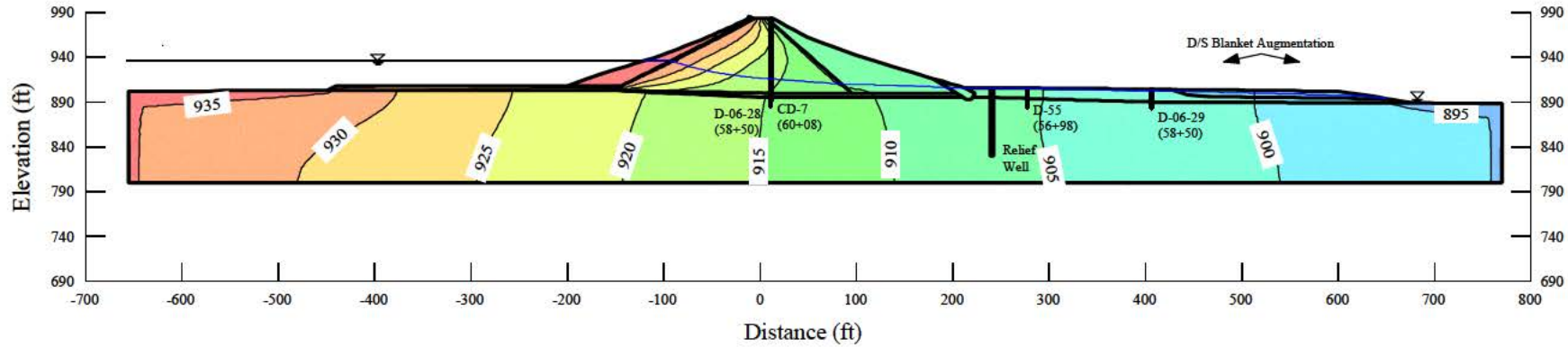
Piezometer	Predicted (ft)
CD-7	914.5
D-55	905.3
D-06-28	914.6
D-06-29	902.6

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	1.4E-04	0.1
Toe	1.7E-03	0.8
D/S Blanket	1.5E-03	0.7
D/S of Blanket	1.9E-03	0.9

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
2.8E-03	1.3	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	906.0

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)
0.08	0.07	0.23	906.0	895.0	11.02

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
8.56	4.01	507.69

$FS_{(progressive\ erosion)}$ (Under Seepage)
4.62

Bolivar Dam Seepage Analysis - Rehab Condition - Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
57+00	949	896

Model Predictions

Piezometric Levels

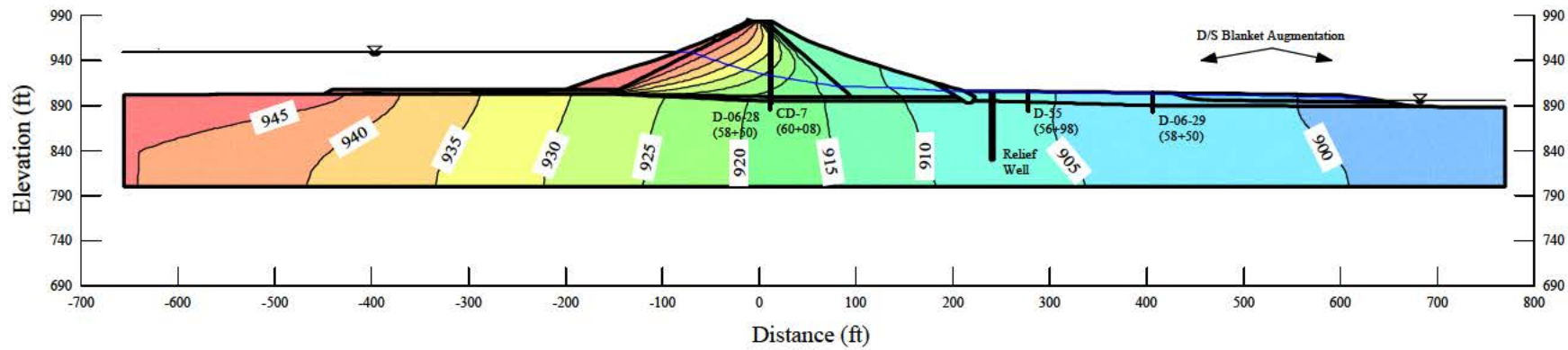
Piezometer	Predicted (ft)
CD-7	918.2
D-55	905.4
D-06-28	918.5
D-06-29	903.2

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	2.2E-04	0.1
Toe	2.5E-03	1.1
D/S Blanket	1.5E-03	0.7
D/S of Blanket	1.5E-03	0.7

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)	Observed (gal/min/100)
7.1E-03	3.2	NA



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	906.0

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	Pmax (D/S Blanket Base)
0.12	0.09	0.17	906.0	895.0	11.03

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
6.66	5.43	338.46

$FS_{(progressive\ erosion)}$ (Under Seepage)
6.24

Bolivar Dam Seepage Analysis - Rehab Condition - Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
57+00	952	908.5

Model Predictions

Piezometric Levels

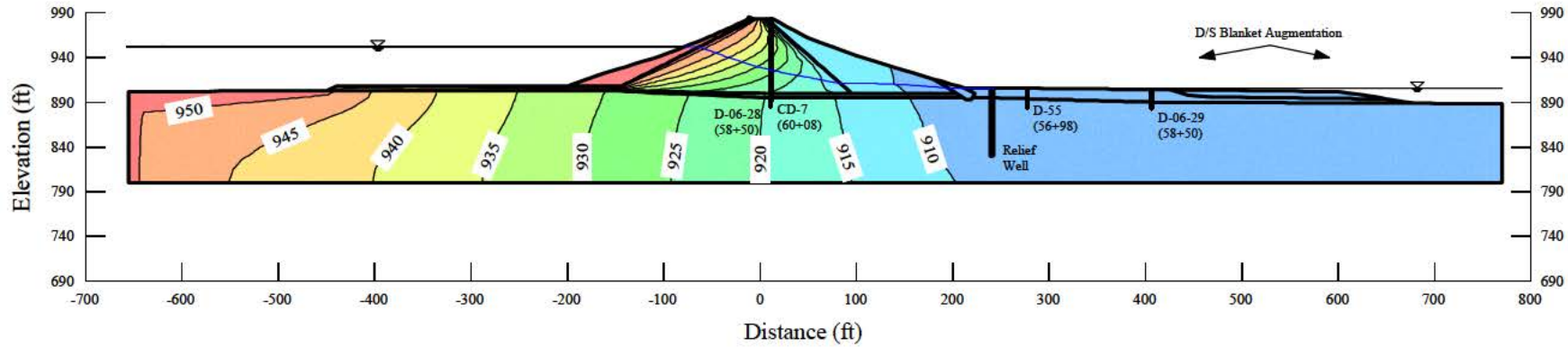
Piezometer	Predicted (ft)
CD-7	919.2
D-55	906.0
D-06-28	919.5
D-06-29	906.1

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	2.4E-04	0.1
Toe	2.7E-03	1.2
D/S Blanket	3.2E-04	0.1
D/S of Blanket	5.7E-05	0.0

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
1.2E-02	5.4



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	906.0

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	Pmax (D/S Blanket Base)
0.11	0.09	0.01	906.0	895.0	11.04

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)	$FS_{(progressive\ erosion)}$ (Under Seepage)
6.66	92.31	253.85	7.66

Bolivar Dam Seepage Analysis - Rehab Condition - Downstream Blanket Augmentation

Station	Pool Elevation (ft)	Tail Elevation (ft)
57+00	962	908.5

Model Predictions

Piezometric Levels

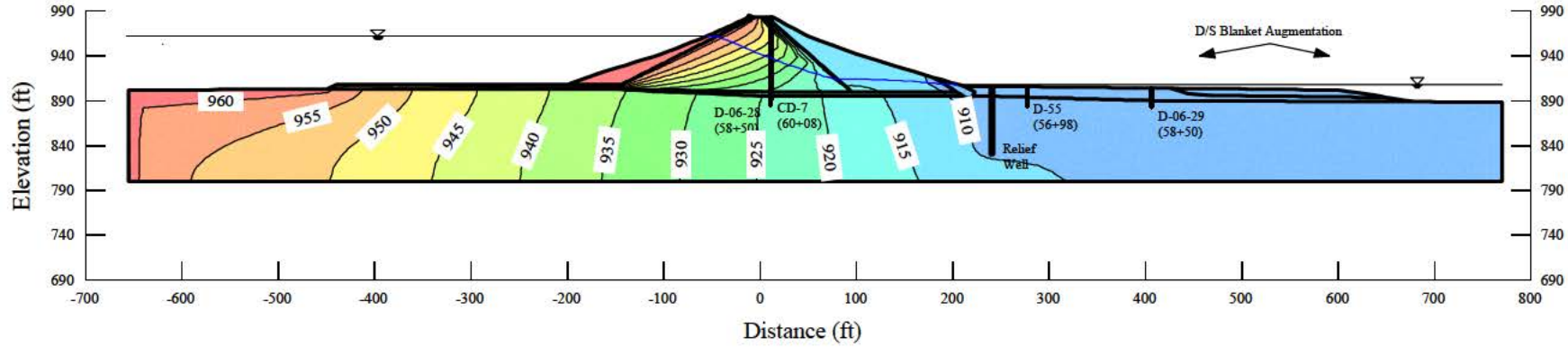
Piezometer	Predicted (ft)
CD-7	924.7
D-55	908.5
D-06-28	924.8
D-06-29	908.7

Quantity of Seepage

Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	4.4E-04	0.2
Toe	3.5E-03	1.6
D/S Blanket	3.7E-04	0.2
D/S of Blanket	6.6E-05	0.0

Relief Well Flow

Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
1.4E-02	6.3



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)

γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)
120.0	57.6	33.0	0.92	0.60	908.5

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	Pmax (D/S Blanket Base)
0.14	0.10	0.01	906.0	895.0	13.54

Predicted Minimum Factors of Safety (FS)

$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
5.99	92.31	253.85

$FS_{(progressive\ erosion)}$ (Under Seepage)
6.89

Bolivar Dam Seepage Analysis - Rehab Condition - Downstream Blanket Augmentation

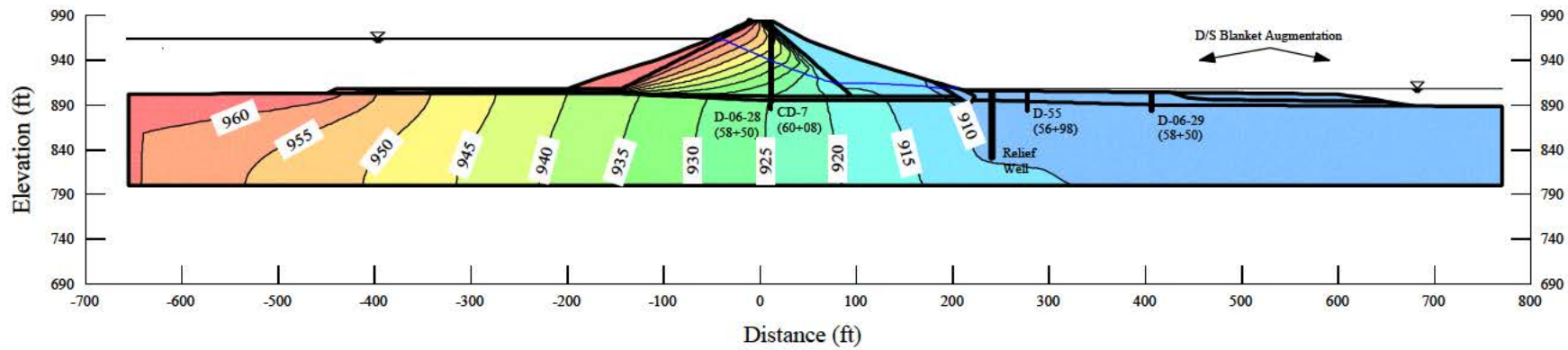
Station	Pool Elevation (ft)	Tail Elevation (ft)
57+00	964	908.5

Model Predictions

Piezometric Levels	
Piezometer	Predicted (ft)
CD-7	924.7
D-55	908.5
D-06-28	924.8
D-06-29	908.7

Quantity of Seepage		
Location	Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
Above Toe	4.6E-04	0.2
Toe	3.6E-03	1.6
D/S Blanket	3.8E-04	0.2
D/S of Blanket	6.8E-05	0.0

Relief Well Flow	
Predicted ($ft^3/s/ft$)	Predicted (gal/min/ft)
1.5E-02	6.5



Notes:

1. Refer to notes for this section listed on prior sheet

Model Safety Predictions

Predicted Exit Gradients (i) and Pressure Head (P)						Predicted Minimum Factors of Safety (FS)		
γ_{sat} (pcf)	γ_b (pcf)	ϕ (degrees)	i_{cv}	i_{ch}	Tail Elevation at P_{max} Location (ft)	$FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)
120.0	57.6	33.0	0.92	0.60	908.5	5.45	92.31	253.85

$i_{v\,max}$ (Toe)	$i_{h\,max}$ (Toe)	$i_{v\,max}$ (D/S of Blanket)	D/S Blanket Top Elev. (ft)	D/S Blanket Bot. Elev. (ft)	P_{max} (D/S Blanket Base)	$FS_{(progressive\ erosion)}$ (Under Seepage)
0.15	0.11	0.01	906.0	895.0	13.54	6.27

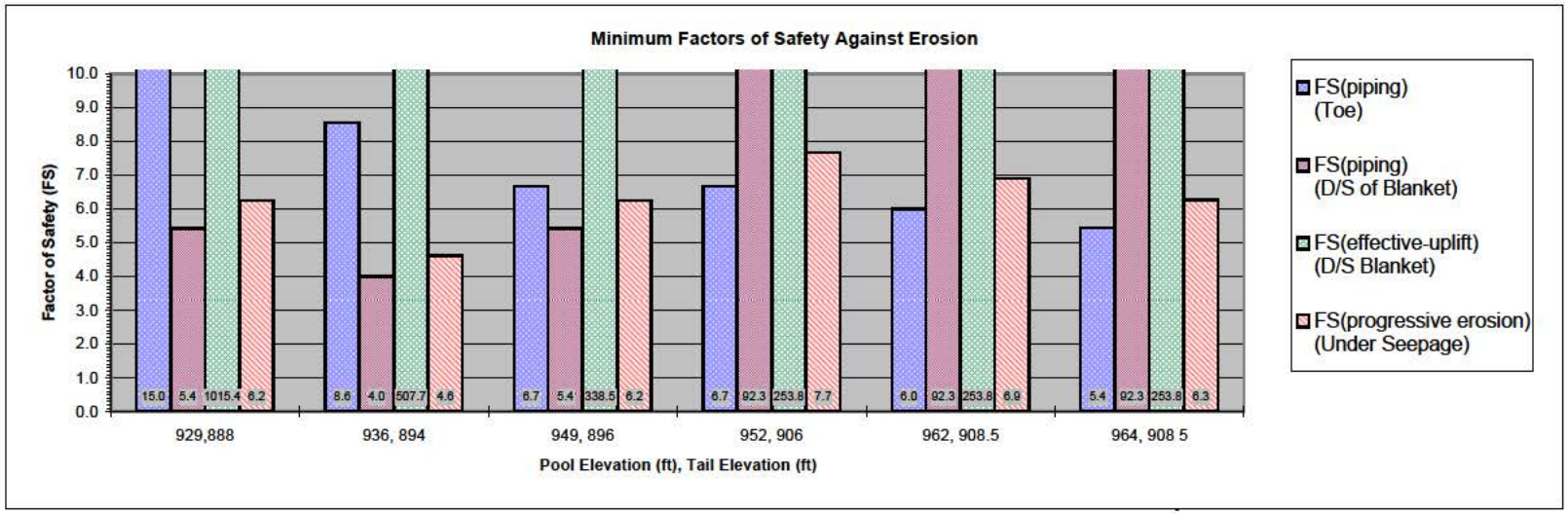
Bolivar Dam Seepage Analysis - Rehab Condition - Downstream Blanket Augmentation

Station

57+00

Model Safety Predictions Summary

Pool Elevation (ft), Tail Elevation (ft)	Minimum Factors of Safety $FS_{(piping)}$ (Toe)	$FS_{(piping)}$ (D/S of Blanket)	$FS_{(effective\text{-}uplift)}$ (D/S Blanket)	$FS_{(progressive\ erosion)}$ (Under Seepage)
929,888	15.0	5.4	1015.4	6.2
936, 894	8.6	4.0	507.7	4.6
949, 896	6.7	5.4	338.5	6.2
952, 906	6.7	92.3	253.8	7.7
962, 908.5	6.0	92.3	253.8	6.9
964, 908.5	5.4	92.3	253.8	6.3



Notes:

1. Refer to notes for this section listed on prior sheet