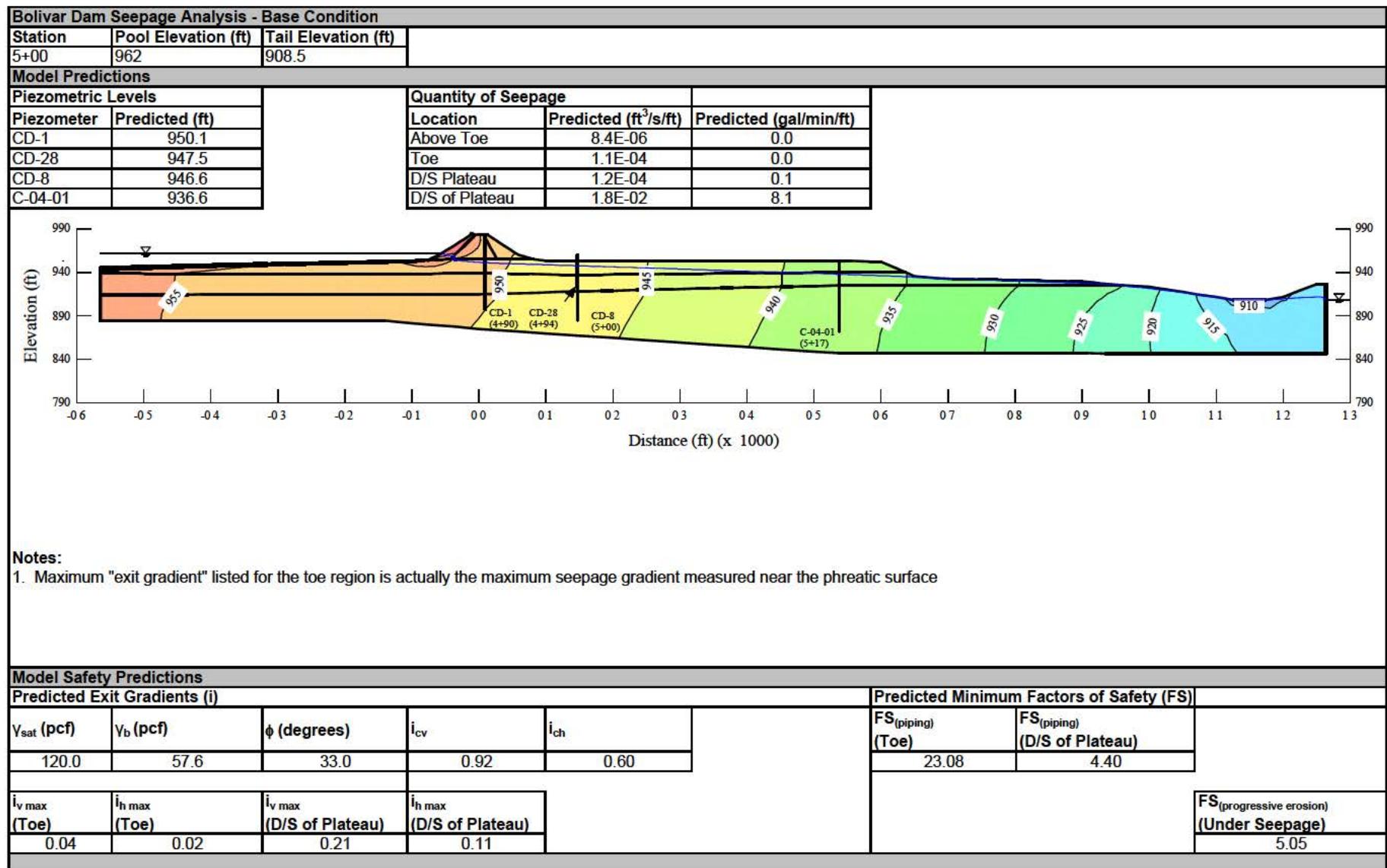
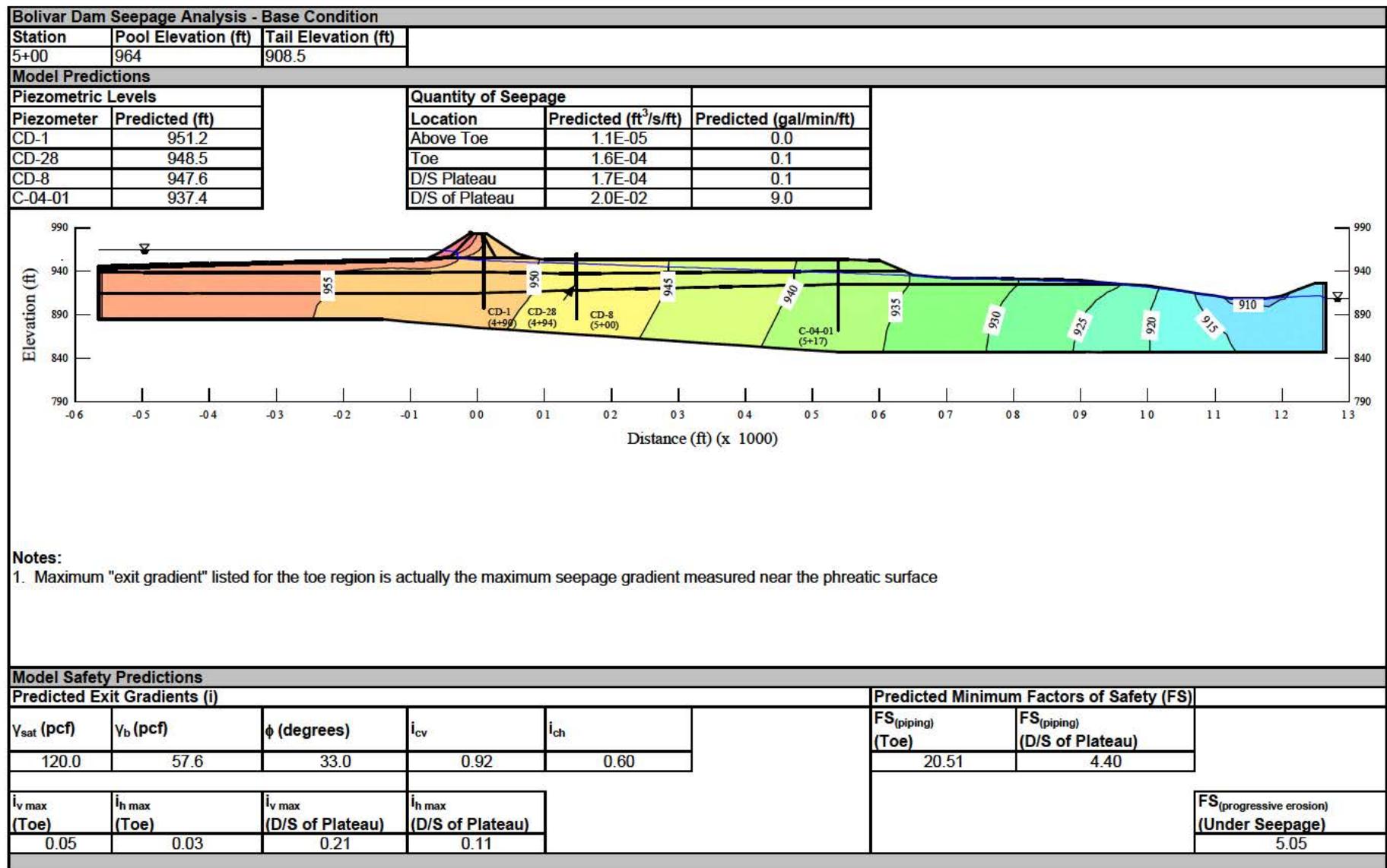


| Bolivar Dam Seepage Analysis - Base Condition | | | | | |
|--|-----------------------|--|----------------------------------|----------|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | |
| 5+00 | 936 | 894 | | | |
| Model Predictions | | | | | |
| Piezometric Levels | Predicted (ft) | Quantity of Seepage | | | |
| Piezometer | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | |
| CD-1 | Above Toe | 6.7E-09 | 0.0 | | |
| CD-28 | Toe | 4.8E-09 | 0.0 | | |
| CD-8 | D/S Plateau | 9.6E-09 | 0.0 | | |
| C-04-01 | D/S of Plateau | 1.1E-03 | 0.5 | | |
| | | | | | |
| <p>Notes:</p> <ol style="list-style-type: none"> Maximum "exit gradient" listed for the toe region is actually the maximum seepage gradient measured near the phreatic surface | | | | | |
| Model Safety Predictions | | | | | |
| Predicted Exit Gradients (i) | | | | | |
| γ_{sat} (pcf) | γ_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | Predicted Minimum Factors of Safety (FS) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | $FS_{(\text{piping})}$ (Toe) |
| | | | | | 59.95 |
| $i_{v \max}$ (Toe) | $i_{h \max}$ (Toe) | $i_{v \max}$ (D/S of Plateau) | $i_{h \max}$ (D/S of Plateau) | | $FS_{(\text{piping})}$ (D/S of Plateau) |
| 0.01 | 0.01 | 0.03 | 0.01 | | 36.92 |
| | | | | | $FS_{(\text{progressive erosion})}$ (Under Seepage) |
| | | | | | 42.46 |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|------------------------------|------------------------------|-----------------------------------|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 5+00 | 949 | 896 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted (ft ³ /s/ft) | Predicted (gal/min/ft) | | | |
| CD-1 | 931.2 | 931.6 | Above Toe | 5.4E-08 | 0.0 | | | |
| CD-28 | 930.2 | 931.6 | Toe | 3.7E-08 | 0.0 | | | |
| CD-8 | 929.9 | 931.6 | D/S Plateau | 6.1E-08 | 0.0 | | | |
| C-04-01 | 925.1 | NA | D/S of Plateau | 5.3E-03 | 2.4 | | | |
| Avg. Absolute Difference (ft) = | | 1.2 | | | | | | |
| | | | | | | | | |
| Notes: <ol style="list-style-type: none"> Observed piezometric data are maximum readings during January 1991 Piezometers were not yet installed or measurements were not made for observed piezometer readings indicated as NA Maximum "exit gradient" listed for the toe region is actually the maximum seepage gradient measured near the phreatic surface | | | | | | | | |
| Model Safety Predictions | | | | | | | | |
| Predicted Exit Gradients (i) | | | | | Predicted Minimum Factors of Safety (FS) | | | |
| γ_{sat} (pcf) | γ_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | $FS_{(piping)} (Toe)$ | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 46.15 | | | |
| $i_{v max}$ (Toe) | $i_{h max}$ (Toe) | $i_{v max}$ (D/S of Plateau) | $i_{h max}$ (D/S of Plateau) | | $FS_{(piping)} (D/S of Plateau)$ | | | |
| 0.02 | 0.01 | 0.11 | 0.11 | | 5.45 | | | |
| | | | | | $FS_{(progressive erosion)} (Under Seepage)$ | | | |
| | | | | | 6.27 | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | |
|---|---|----------------------------------|----------------------------------|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | |
| 5+00 | 952 | 906 | | | |
| Model Predictions | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) |
| CD-1 | 938.6 | 935.3 | Above Toe | 2.1E-07 | 0.0 |
| CD-28 | 936.9 | 935.8 | Toe | 1.4E-07 | 0.0 |
| CD-8 | 936.8 | 934.3 | D/S Plateau | 2.7E-07 | 0.0 |
| C-04-01 | 930.6 | 929.2 | D/S of Plateau | 9.1E-03 | 4.1 |
| Avg. Absolute Difference (ft) = | | 2.1 | | | |
| | | | | | |
| Notes: | | | | | |
| 1. | Observed piezometric data are maximum readings during January 2005 | | | | |
| 2. | Seepage was noted downstream of the downstream plateau during January 2005 but flow rate was not measured | | | | |
| 3. | Maximum "exit gradient" listed for the toe region is actually the maximum seepage gradient measured near the phreatic surface | | | | |
| Model Safety Predictions | | | | | |
| Predicted Exit Gradients (i) | | | | | Predicted Minimum Factors of Safety (FS) |
| γ_{sat} (pcf) | γ_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | $FS_{(\text{piping})}$ (Toe) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 39.96 |
| $i_{v \max}$ (Toe) | $i_{h \max}$ (Toe) | $i_{v \max}$ (D/S of Plateau) | $i_{h \max}$ (D/S of Plateau) | | $FS_{(\text{piping})}$ (D/S of Plateau) |
| 0.02 | 0.02 | 0.18 | 0.10 | | 5.13 |
| | | | | | $FS_{(\text{progressive erosion})}$ (Under Seepage) |
| | | | | | 5.90 |





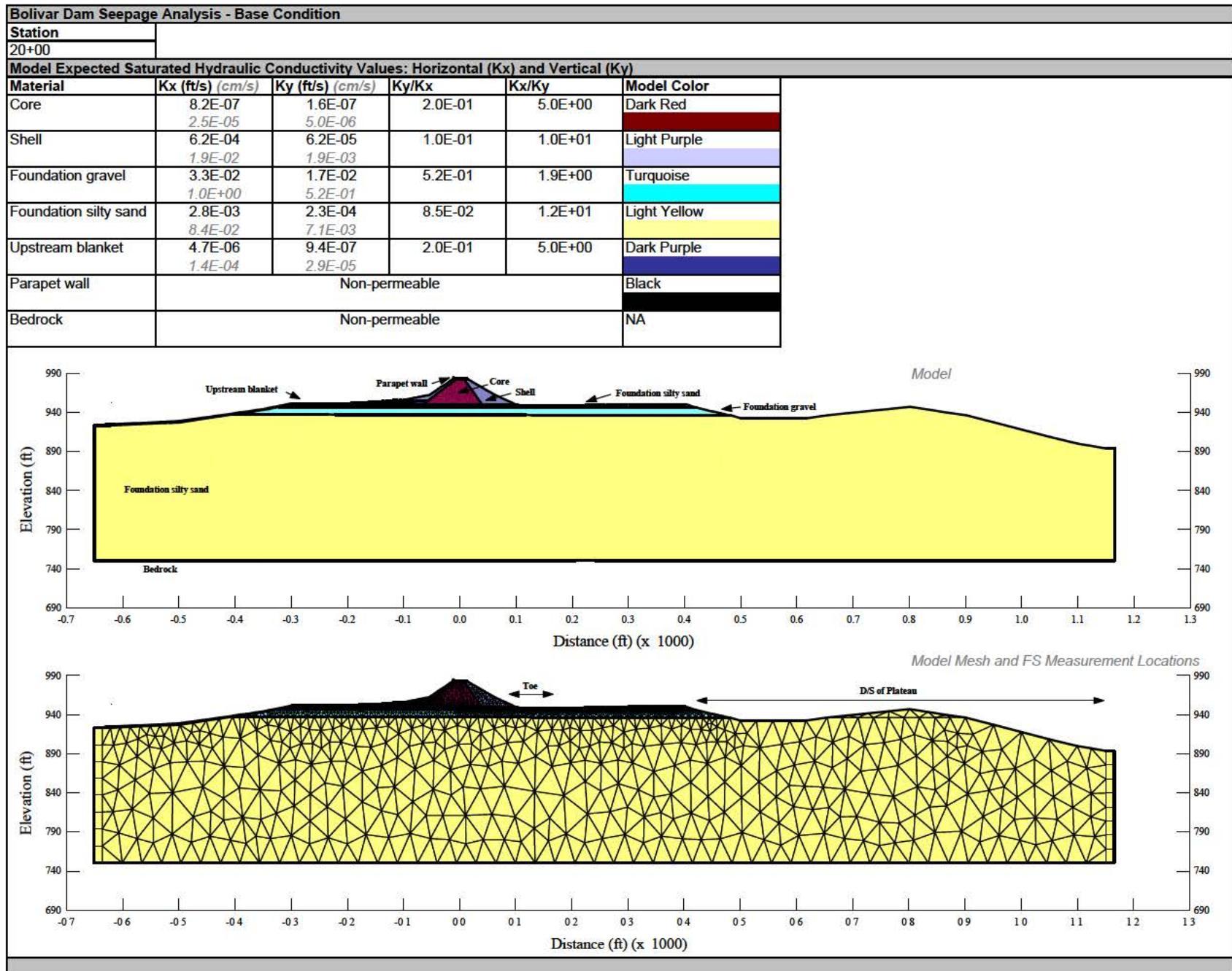
| Bolivar Dam Seepage Analysis - Base Condition | | | | | | |
|---|----------------------------|--|---------------------------------------|----------|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | |
| 5+00 | 982 | 930 | | | | |
| Model Predictions | | | | | | |
| Piezometric Levels | Predicted (ft) | Quantity of Seepage | | | | |
| Piezometer | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | |
| CD-1 | Above Toe | 1.2E-04 | 0.1 | | | |
| CD-28 | Toe | 2.1E-03 | 0.9 | | | |
| CD-8 | D/S Plateau | 4.8E-03 | 2.2 | | | |
| C-04-01 | D/S of Plateau | 2.9E-02 | 13.0 | | | |
| | | | | | | |
| Model Safety Predictions | | | | | | |
| Predicted Exit Gradients (i) | | | | | Predicted Minimum Factors of Safety (FS) | |
| γ_{sat} (pcf) | γ_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Plateau) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 4.40 | 9.99 |
| $i_v \text{ max}$ (Toe) | $i_h \text{ max}$ (Toe) | $i_v \text{ max}$ (D/S of Plateau) | $i_h \text{ max}$ (D/S of Plateau) | | $FS_{(\text{progressive erosion})}$ (Under Seepage) | 5.05 |
| 0.21 | 0.12 | 0.07 | 0.06 | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | |
|---|--|---------------------------|--|------|
| Station | | | | |
| 5+00 | | | | |
| Model Safety Predictions Summary | | | | |
| Pool Elevation (ft), Tail Elevation (ft) | | Minimum Factors of Safety | | |
| | | $FS_{(piping)}$ (Toe) | $FS_{(piping)}$ (D/S of Plateau) | |
| | | | $FS_{(progressive erosion)}$ (Under Seepage) | |
| 936, 894 | | 59.9 | 36.9 | 42.5 |
| 949, 896 | | 46.2 | 5.4 | 6.3 |
| 952, 906 | | 40.0 | 5.1 | 5.9 |
| 962, 908.5 | | 23.1 | 4.4 | 5.1 |
| 964, 908.5 | | 20.5 | 4.4 | 5.1 |
| 982, 930 | | 4.4 | 10.0 | 5.1 |

Minimum Factors of Safety Against Erosion

| Pool Elevation (ft), Tail Elevation (ft) | $FS_{(piping)}$ (Toe) | $FS_{(piping)}$ (D/S of Plateau) | $FS_{(progressive erosion)}$ (Under Seepage) |
|--|-----------------------|----------------------------------|--|
| 936, 894 | 59.9 | 36.9 | 42.5 |
| 949, 896 | 46.2 | 5.4 | 6.3 |
| 952, 906 | 40.0 | 5.1 | 5.9 |
| 962, 908.5 | 23.1 | 4.4 | 5.1 |
| 964, 908.5 | 20.5 | 4.4 | 5.1 |
| 982, 930 | 4.4 | 10.0 | 5.1 |

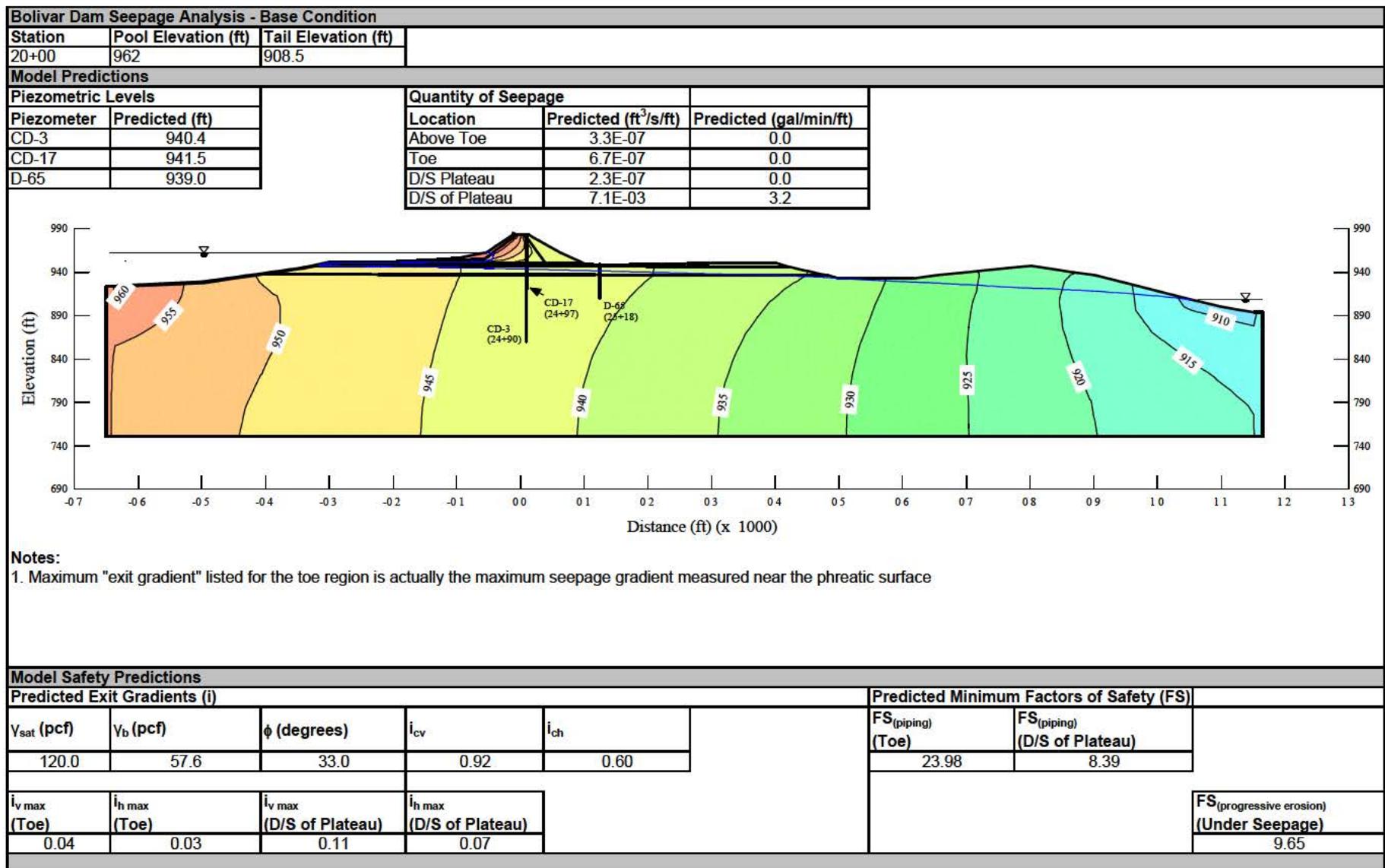
| Model Calibration Summary | | | |
|--|-----------------|--|--|
| Pool Elevation (ft), Tail Elevation (ft) | Field Data Date | Avg. Absolute Difference of Predicted and Observed Piezometric Levels (ft) | Additional |
| Pool = 949, Tail = 896 | Jan-1991 | 1.2 | |
| Pool = 952, Tail = 906 | Jan-2005 | 2.1 | |
| | Average | 1.6 | Seepage noted D/S of plateau on field data date is predicted by model; flow rates of observed seepage were not measured in field |

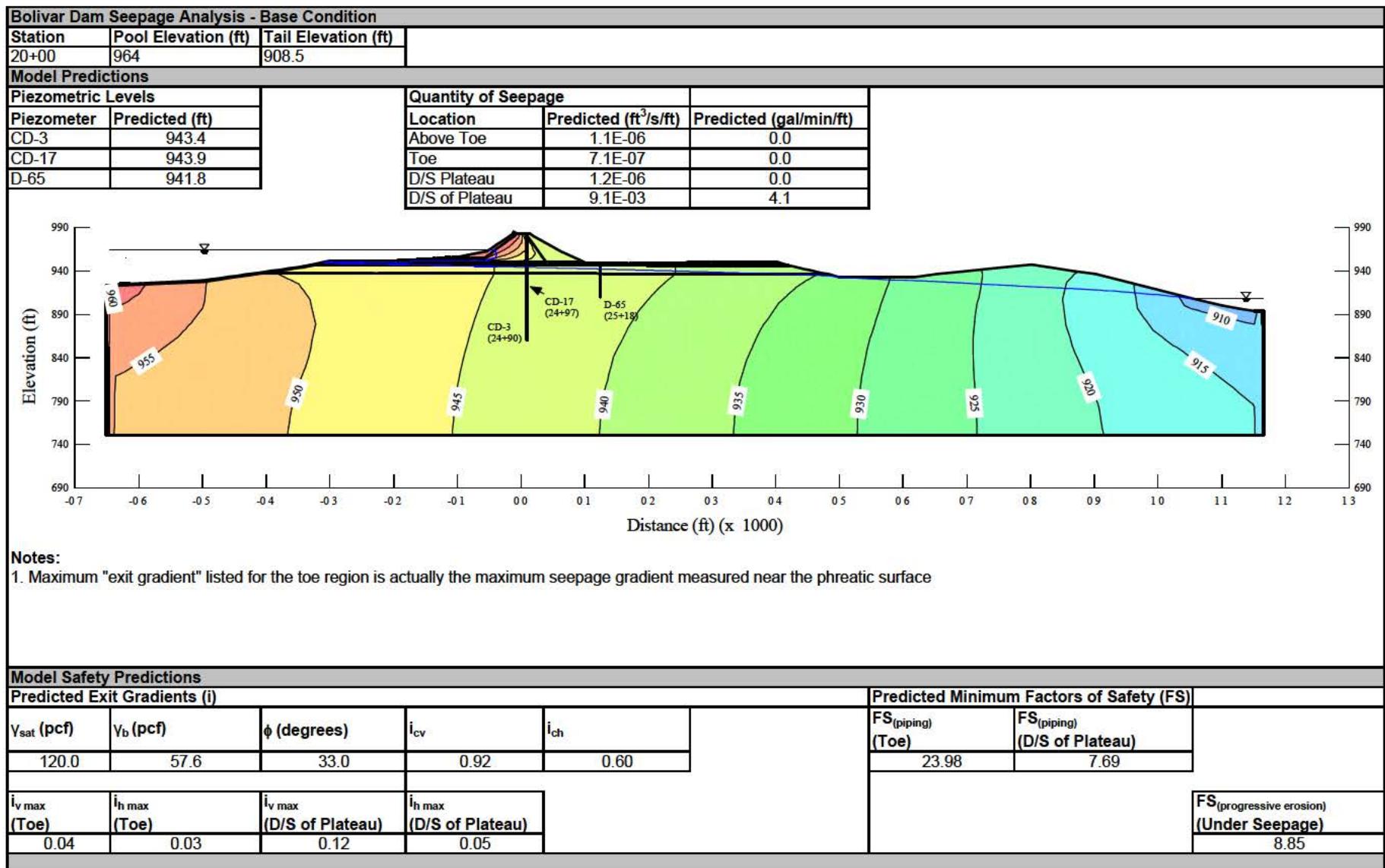


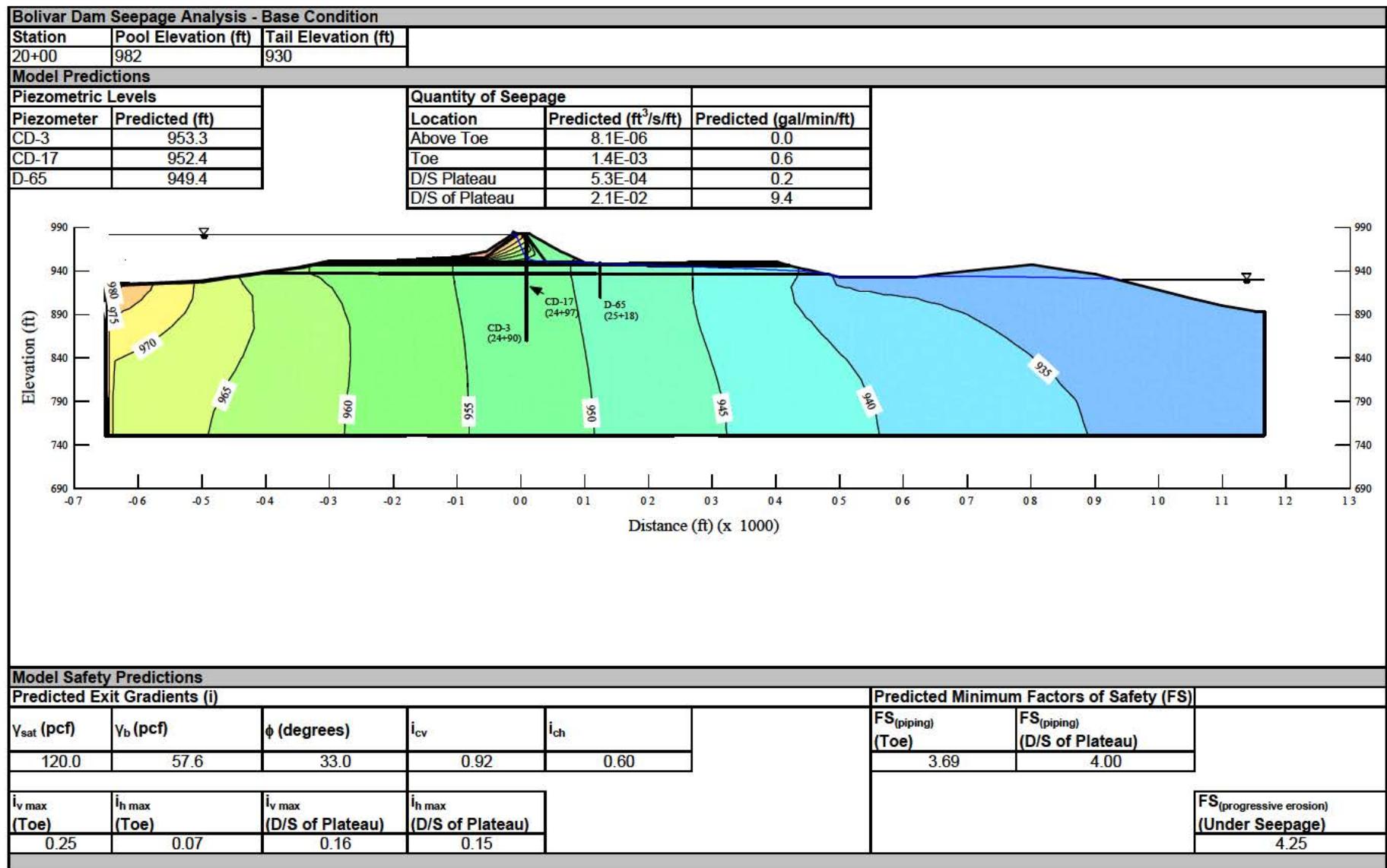
| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|---|-----------------------|----------------------------------|----------------------------------|--|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 20+00 | 936 | 894 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | | | | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | |
| CD-3 | 919.9 | 917.3 | Above Toe | 1.4E-08 | 0.0 | | | |
| CD-17 | 920.4 | 921.6 | Toe | 3.3E-08 | 0.0 | | | |
| D-65 | 917.8 | 914.4 | D/S Plateau | 1.2E-08 | 0.0 | | | |
| Avg. Absolute Difference (ft) = | | 2.4 | D/S of Plateau | 1.9E-03 | 0.9 | | | |
| | | | | | | | | |
| Notes: <ol style="list-style-type: none"> 1. Observed piezometric data are maximum readings during September 2004 2. Maximum "exit gradient" listed for the toe region is actually the maximum seepage gradient measured near the phreatic surface | | | | | | | | |
| Model Safety Predictions | | | | | | | | |
| Predicted Exit Gradients (i) | | | | | Predicted Minimum Factors of Safety (FS) | | | |
| γ_{sat} (pcf) | γ_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | $FS_{(\text{piping})}$ (Toe) | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 39.96 | | | |
| $i_{v \max}$ (Toe) | $i_{h \max}$ (Toe) | $i_{v \max}$ (D/S of Plateau) | $i_{h \max}$ (D/S of Plateau) | | $FS_{(\text{piping})}$ (D/S of Plateau) | | | |
| 0.01 | 0.02 | 0.06 | 0.05 | | 11.99 | | | |
| | | | | | $FS_{(\text{progressive erosion})}$ (Under Seepage) | | | |
| | | | | | 13.79 | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|------------------------------|------------------------------|-----------------------------------|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 20+00 | 949 | 896 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted (ft ³ /s/ft) | Predicted (gal/min/ft) | | | |
| CD-3 | 929.9 | 930.9 | Above Toe | 6.6E-08 | 0.0 | | | |
| CD-17 | 930.3 | 929.9 | Toe | 1.4E-07 | 0.0 | | | |
| D-65 | 926.9 | NA | D/S Plateau | 5.5E-08 | 0.0 | | | |
| Avg. Absolute Difference (ft) = | | 0.7 | D/S of Plateau | 4.2E-03 | 1.9 | | | |
| | | | | | | | | |
| <p>Notes:</p> <ol style="list-style-type: none"> 1. Observed piezometric data are maximum readings during January 1991 2. Piezometers were not yet installed or measurements were not made for observed piezometer readings indicated as NA 3. Maximum "exit gradient" listed for the toe region is actually the maximum seepage gradient measured near the phreatic surface | | | | | | | | |
| Model Safety Predictions | | | | | | | | |
| Predicted Exit Gradients (i) | | | | | Predicted Minimum Factors of Safety (FS) | | | |
| γ_{sat} (pcf) | γ_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | $FS_{(piping)} (Toe)$ | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 29.97 | | | |
| $i_{v max}$ (Toe) | $i_{h max}$ (Toe) | $i_{v max}$ (D/S of Plateau) | $i_{h max}$ (D/S of Plateau) | | $FS_{(piping)} (D/S of Plateau)$ | | | |
| 0.01 | 0.02 | 0.12 | 0.07 | | 7.69 | | | |
| | | | | | $FS_{(progressive erosion)} (Under Seepage)$ | | | |
| | | | | | 8.85 | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|---|-----------------------|----------------------------------|----------------------------------|--|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 20+00 | 952 | 906 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | |
| CD-3 | 934.9 | 933.6 | Above Toe | 1.5E-07 | 0.0 | | | |
| CD-17 | 935.7 | 932.5 | Toe | 3.2E-07 | 0.0 | | | |
| D-65 | 933.1 | 929.6 | D/S Plateau | 1.4E-07 | 0.0 | | | |
| Avg. Absolute Difference (ft) = | | 2.7 | D/S of Plateau | 5.1E-03 | 2.3 | | | |
| | | | | | | | | |
| Notes: | | | | | | | | |
| 1. Observed piezometric data are maximum readings during January 2005 2. Maximum "exit gradient" listed for the toe region is actually the maximum seepage gradient measured near the phreatic surface | | | | | | | | |
| Model Safety Predictions | | | | | | | | |
| Predicted Exit Gradients (i) | | | | | Predicted Minimum Factors of Safety (FS) | | | |
| γ_{sat} (pcf) | γ_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | $FS_{(\text{piping})}$ (Toe) | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 29.97 | | | |
| $i_{v \max}$ (Toe) | $i_{h \max}$ (Toe) | $i_{v \max}$ (D/S of Plateau) | $i_{h \max}$ (D/S of Plateau) | | $FS_{(\text{piping})}$ (D/S of Plateau) | | | |
| 0.02 | 0.02 | 0.10 | 0.05 | | 9.23 | | | |
| | | | | | $FS_{(\text{progressive erosion})}$ (Under Seepage) | | | |
| | | | | | 10.62 | | | |

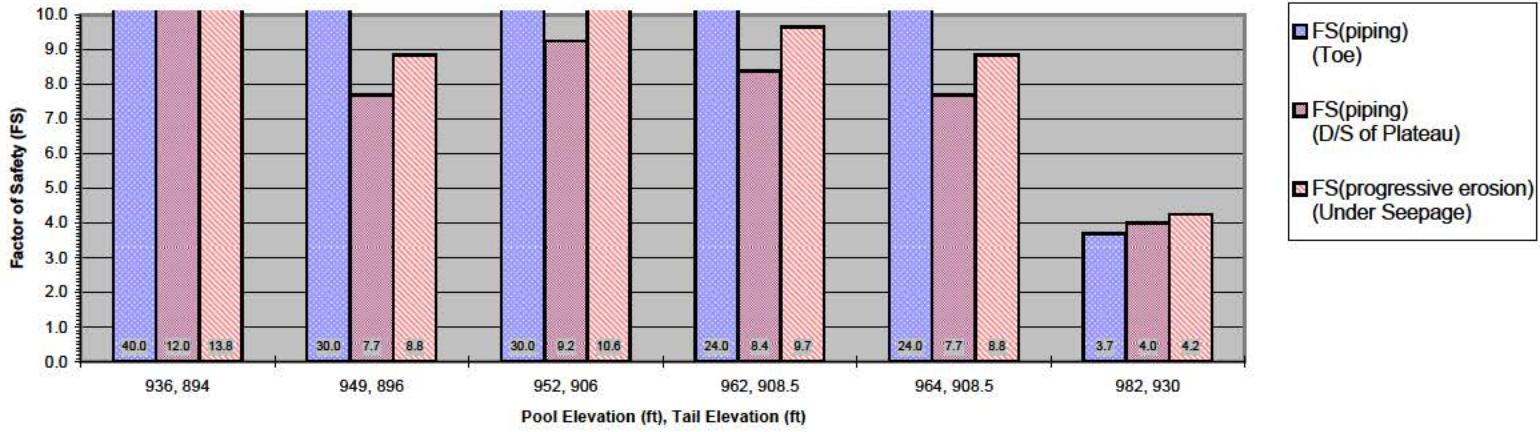




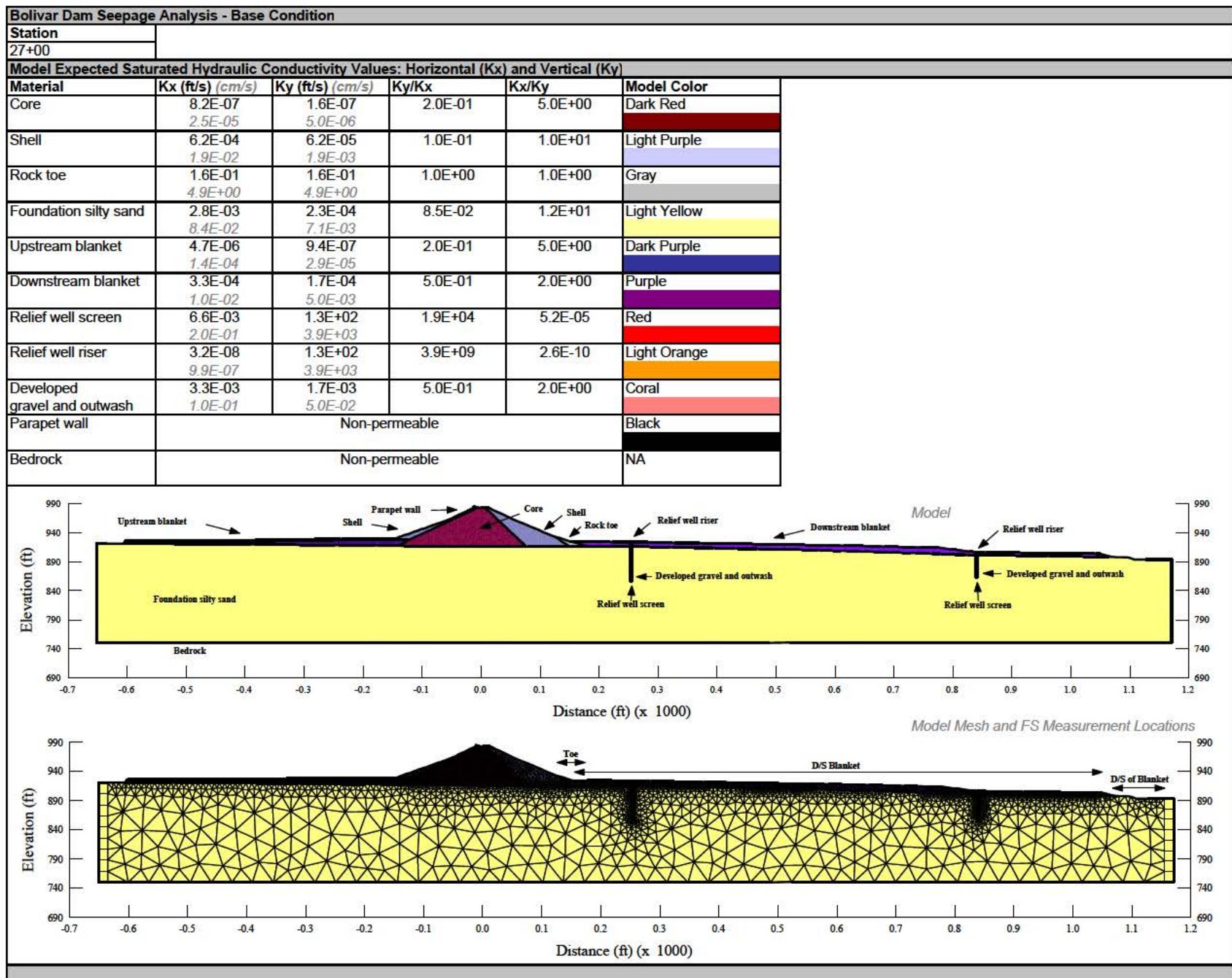


Bolivar Dam Seepage Analysis - Base Condition
Station
20+00
Model Safety Predictions Summary

| Pool Elevation (ft), Tail Elevation (ft) | Minimum Factors of Safety | | |
|---|---------------------------------|--|--|
| | FS _(piping) (Toe) | FS _(piping) (D/S of Plateau) | FS _(progressive erosion) (Under Seepage) |
| 936, 894 | 40.0 | 12.0 | 13.8 |
| 949, 896 | 30.0 | 7.7 | 8.8 |
| 952, 906 | 30.0 | 9.2 | 10.6 |
| 962, 908.5 | 24.0 | 8.4 | 9.7 |
| 964, 908.5 | 24.0 | 7.7 | 8.8 |
| 982, 930 | 3.7 | 4.0 | 4.2 |

Minimum Factors of Safety Against Erosion

Model Calibration Summary

| Pool Elevation (ft), Tail Elevation (ft) | Field Data Date | Avg. Absolute Difference of Predicted and Observed Piezometric Levels (ft) |
|---|--------------------|---|
| Pool = 936, Tail = 894 | Sept-2004 | 2.4 |
| Pool = 949, Tail = 896 | Jan-1991 | 0.7 |
| Pool = 952, Tail = 906 | Jan-2005 | 2.7 |
| | Average | 1.9 |



| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | |
|--|---------------------|------------------------------|----------------------------|--|---|---|---|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | |
| 27+00 | 936 | 894 | | | | | |
| Model Predictions | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | | | Relief Well Flow (left well) |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min) |
| CD-26 | 917.5 | 914.0 | Above Toe | 7.4E-06 | 0.0 | 2.1E-06 | 0.0 |
| D-62 | 902.6 | 900.8 | Toe | 7.1E-07 | 0.0 | Relief Well Flow (right well) | |
| D-63 | 916.1 | 913.6 | D/S Blanket | 3.1E-06 | 0.0 | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) |
| D-64 | 909.8 | 908.0 | D/S of Blanket | 6.9E-07 | 0.0 | 1.5E-06 | 0.0 |
| D-66 | 920.2 | 917.5 | | | | | Observed (gal/min/100) |
| Avg. Absolute Difference (ft) = | | 2.5 | | | | | |
| | | | | | | | |
| Notes: <ol style="list-style-type: none"> Observed piezometric data are maximum readings during September 2004 Observed relief well flow was measured during September 2004 in well W-5 (right well); well W-35 (left well) wasn't flowing; observed flow was divided by 100 due to well spacing of 100 ft Seepage was noted downstream of the blanket during September 2004 but the flow rate was not measured Maximum "exit gradient" listed for the toe region is actually the maximum seepage gradient measured near the phreatic surface | | | | | | | |
| Model Safety Predictions | | | | | | | |
| Predicted Exit Gradients (i_e) and Pressure Head (P) | | | | | | Predicted Minimum Factors of Safety (FS) | |
| V_{sat} (pcf) | V_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | Tail Elevation at P_{max} Location (ft) | FS _(piping) (Toe) | FS _(piping) (D/S of Blanket) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 917.1 | 19.98 | 4.86 |
| $i_{v max}$ (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) | |
| 0.04 | 0.03 | 0.19 | 924.5 | 916.0 | 1.20 | 5.59 | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | | | |
|--|--|-------------------------------|----------------------------|--|--|---|---|--|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | | | |
| 27+00 | 949 | 896 | | | | | | | | | | |
| Model Predictions | | | | | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | Relief Well Flow (left well) | | | | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min) | | | | | |
| CD-26 | 924.8 | 926.0 | Above Toe | 3.1E-05 | 0.0 | 1.3E-05 | 0.0 | | | | | |
| D-62 | 905.4 | NA | Toe | 5.4E-06 | 0.0 | Relief Well Flow (right well) | | | | | | |
| D-63 | 922.9 | NA | D/S Blanket | 1.3E-05 | 0.0 | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | | | |
| D-64 | 914.7 | NA | D/S of Blanket | 3.6E-03 | 1.6 | 1.5E-03 | 0.7 | | | | | |
| D-66 | 928.3 | NA | | | | | Observed (gal/min/100) | | | | | |
| W-35 (static) | 921.8 | 921.5 | | | | | | | | | | |
| Avg. Absolute Difference (ft) = | | 0.8 | | | | | | | | | | |
| | | | | | | | | | | | | |
| Notes: | | | | | | | | | | | | |
| 1. | Observed piezometric data are maximum readings during January 1991 | | | | | | | | | | | |
| 2. | Observed relief well flow listed was measured during January 1991 in well W-5 (right well); well W-35 (left well) wasn't flowing; observed flow was divided by 100 due to well spacing of 100 ft | | | | | | | | | | | |
| 3. | Seepage was noted downstream of the blanket during January 1991 but the flow rate was not measured | | | | | | | | | | | |
| 4. | Piezometers were not yet installed or measurements were not made for observed piezometer readings indicated as NA; well W-35 (left well) static level was considered as a piezometric level | | | | | | | | | | | |
| 5. | Maximum "exit gradient" listed for the toe region is actually the maximum seepage gradient measured near the phreatic surface | | | | | | | | | | | |
| Model Safety Predictions | | | | | | | | | | | | |
| Predicted Exit Gradients (i_e) 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) | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Blanket) | | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 924.3 | 19.98 | 4.69 | | | | | |
| $i_{v \max}$ (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) | $FS_{(\text{progressive erosion})}$ (Under Seepage) | | | | | | |
| 0.05 | 0.03 | 0.20 | 924.5 | 916.0 | 8.35 | 5.39 | | | | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | | | |
|--|---|-------------------------------|----------------------------|--|--|---|---|--|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | | | |
| 27+00 | 952 | 906 | | | | | | | | | | |
| Model Predictions | | | | | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | Relief Well Flow (left well) | | | | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min) | | | | | |
| CD-26 | 925.8 | 927.8 | Above Toe | 5.0E-05 | 0.0 | 2.0E-06 | 0.0 | | | | | |
| D-62 | 906.2 | 905.5 | Toe | 2.1E-04 | 0.1 | Relief Well Flow (right well) | | | | | | |
| D-63 | 924.0 | 921.4 | D/S Blanket | 2.1E-04 | 0.1 | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | | | |
| D-64 | 915.9 | 916.1 | D/S of Blanket | 4.8E-04 | 0.2 | 8.0E-03 | 3.6 | | | | | |
| D-66 | 929.7 | 931.2 | | | | | NA | | | | | |
| Avg. Absolute Difference (ft) = | | 1.4 | | | | | | | | | | |
| | | | | | | | | | | | | |
| Notes: | | | | | | | | | | | | |
| 1. | Observed piezometric data are maximum readings during January 2005 | | | | | | | | | | | |
| 2. | Relief wells flow was not measured on maximum piezometric readings date; therefore listed as NA | | | | | | | | | | | |
| 3. | Downstream blanket elevation, thickness, and pressure head values listed are those which provide minimum FS(uplift) value | | | | | | | | | | | |
| 4. | Seepage could not be observed downstream of the blanket during all of January 2005 due to tail water level | | | | | | | | | | | |
| Model Safety Predictions | | | | | | | | | | | | |
| Predicted Exit Gradients (i_e) and Pressure Head (P_e) | | | | | | 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) | | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 924.5 | 11.54 | 34.19 | | | | | |
| $i_{v \max}$ (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) | | | | | | |
| 0.08 | 0.05 | 0.03 | 924.5 | 916.0 | 8.77 | 13.27 | | | | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|-----------------------------------|---------------------------------|-----------------------------------|-----------------------------|---|--|--|---|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 27+00 | 962 | 908.5 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | | | | | | | |
| Piezometer | Predicted (ft) | | | | | | | |
| CD-26 | 926.9 | | | | | | | |
| D-62 | 908.7 | | | | | | | |
| D-63 | 924.6 | | | | | | | |
| D-64 | 917.6 | | | | | | | |
| D-66 | 932.3 | | | | | | | |
| Quantity of Seepage | | | | | | | | |
| Location | Predicted (ft ³ /s/ft) | Predicted (gal/min/ft) | Predicted (ft ³ /s/ft) | Predicted (gal/min/ft) | Observed (gal/min) | | | |
| Above Toe | 8.7E-05 | 0.0 | 2.9E-03 | 1.3 | NA | | | |
| Toe | 2.3E-04 | 0.1 | Relief Well Flow (right well) | | | | | |
| D/S Blanket | 3.2E-04 | 0.1 | Predicted (ft ³ /s/ft) | Predicted (gal/min/ft) | Observed (gal/min/100) | | | |
| D/S of Blanket | 4.5E-04 | 0.2 | 7.3E-03 | 3.3 | NA | | | |
| | | | | | | | | |
| Model Safety Predictions | | | | | | | | |
| Predicted Exit Gradients (i_e) and Pressure Head (P) | | | | | | | | |
| γ_{sat} (pcf) | γ_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | Tail Elevation at P_{max} Location (ft) | Predicted Minimum Factors of Safety (FS) | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 924.5 | FS _(piping) (Toe) | FS _(piping) (D/S of Blanket) | FS _(effective-uplift) (D/S Blanket) |
| 0.15 | 0.08 | 0.09 | 924.5 | 916.0 | 8.79 | 6.15 | 10.73 | 27.06 |
| $i_{v max}$ (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 | 0.08 | 0.09 | 924.5 | 916.0 | 8.79 | 7.08 | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | |
|--|---------------------|-----------------------------|--|---|---|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | |
| 27+00 | 964 | 908.5 | | | |
| Model Predictions | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | Relief Well Flow (left well) |
| Piezometer | Predicted (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) |
| CD-26 | 927.1 | Above Toe | 9.3E-05 | 0.0 | 3.4E-03 |
| D-62 | 908.7 | Toe | 2.5E-04 | 0.1 | Relief Well Flow (right well) |
| D-63 | 924.7 | D/S Blanket | 3.4E-04 | 0.2 | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) |
| D-64 | 917.7 | D/S of Blanket | 6.5E-04 | 0.3 | Predicted (gal/min/ft) |
| D-66 | 932.8 | | | | Observed (gal/min/100) |
| | | | | | |
| Model Safety Predictions | | | | | |
| Predicted Exit Gradients (i_e) 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 | 924.5 |
| $i_v \max$ (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) |
| 0.16 | 0.09 | 0.09 | 924.5 | 916.0 | 8.79 |
| Predicted Minimum Factors of Safety (FS) | | | | | |
| | | | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Blanket) | $FS_{(\text{effective-uplift})}$ (D/S Blanket) |
| | | | 5.77 | 10.73 | 27.06 |
| | | | | | $FS_{(\text{progressive erosion})}$ (Under Seepage) |
| | | | | | 6.63 |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | |
|--|---------------------|-------------------------------|------------------------------|-----------------------------|---|---|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | |
| 27+00 | 982 | 930 | | | | | | | | |
| Model Predictions | | | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | Relief Well Flow (left well) | | | | | | | |
| Piezometer | Predicted (ft) | | Location | Predicted (ft³/s/ft) | Predicted (gal/min/ft) | Predicted (ft³/s/ft) | | | | |
| CD-26 | 934.1 | Above Toe | Above Toe | 3.3E-04 | 0.1 | 1.2E-02 | | | | |
| D-62 | 930.1 | | Toe | 1.7E-03 | 0.8 | 5.3 | | | | |
| D-63 | 930.9 | D/S Blanket | D/S Blanket | 1.8E-03 | 0.8 | NA | | | | |
| D-64 | 930.7 | | D/S of Blanket | 9.8E-05 | 0.0 | 0.4 | | | | |
| D-66 | 942.0 | Relief Well Flow (right well) | | | | Observed (gal/min) | | | | |
| | | | | | | | | | | |
| Model Safety Predictions | | | | | | | | | | |
| Predicted Exit Gradients (i_e) 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) | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 930.0 | 3.30 | | | | |
| $i_{v max}$ (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 _(piping) (D/S of Blanket) | | | | |
| 0.28 | 0.14 | 0.03 | 924.5 | 916.0 | 14.36 | 21.79 | | | | |
| | | | | | | FS _(progressive erosion) (Under Seepage) | | | | |
| | | | | | | 3.79 | | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | |
|---|------------------------------|---|--|---|--|--|--|--|--|--|
| Station | | | | | | | | | | |
| 27+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-uplift) (D/S Blanket) | FS _(progressive erosion) (Under Seepage) | | | | | | |
| 936, 894 | 20.0 | 4.9 | 152.5 | 5.6 | | | | | | |
| 949, 896 | 20.0 | 4.7 | 81.0 | 5.4 | | | | | | |
| 952, 906 | 11.5 | 34.2 | 29.1 | 13.3 | | | | | | |
| 962, 908.5 | 6.2 | 10.7 | 27.1 | 7.1 | | | | | | |
| 964, 908.5 | 5.8 | 10.7 | 27.1 | 6.6 | | | | | | |
| 982, 930 | 3.3 | 36.9 | 21.8 | 3.8 | | | | | | |

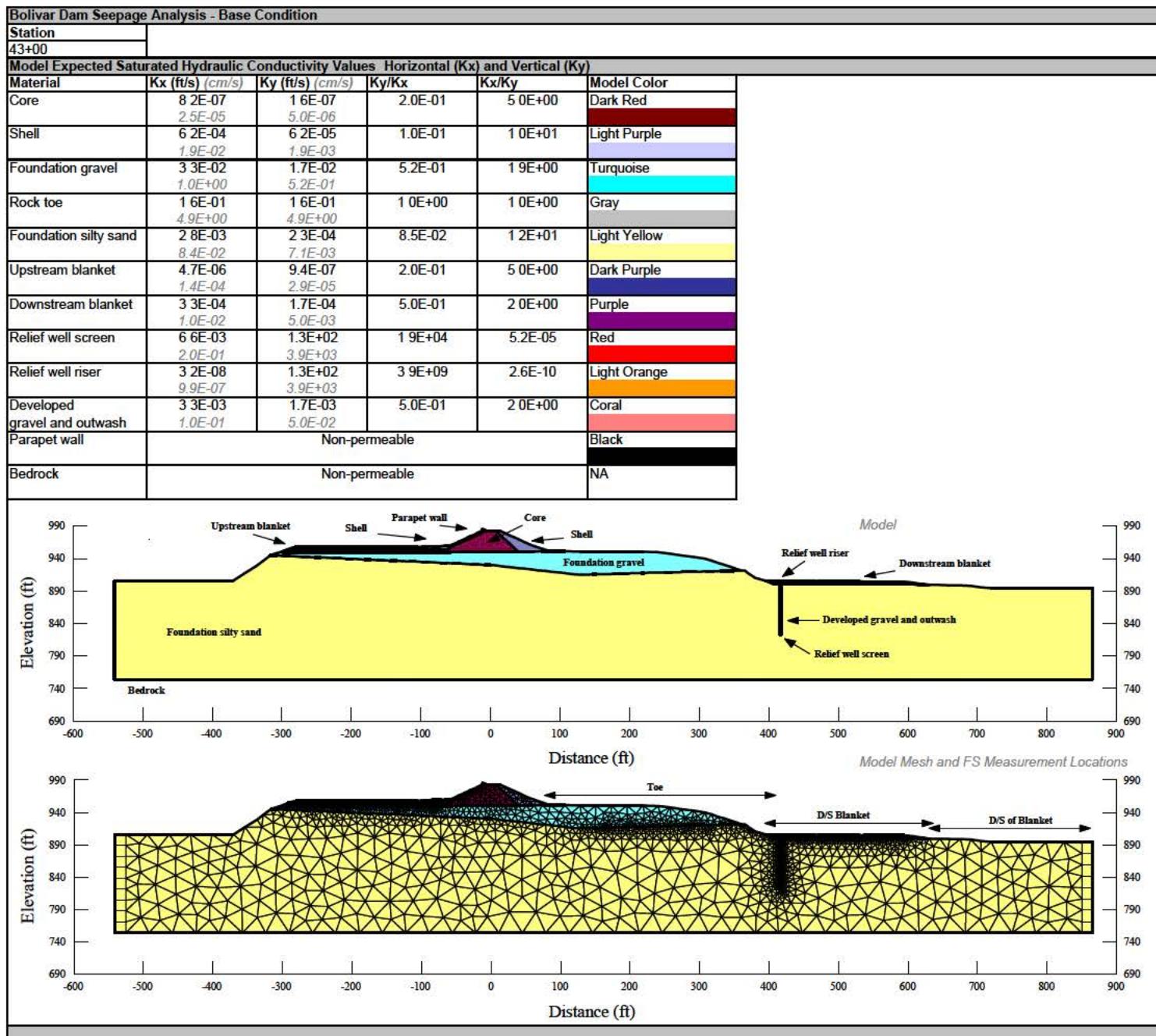
Minimum Factors of Safety Against Erosion

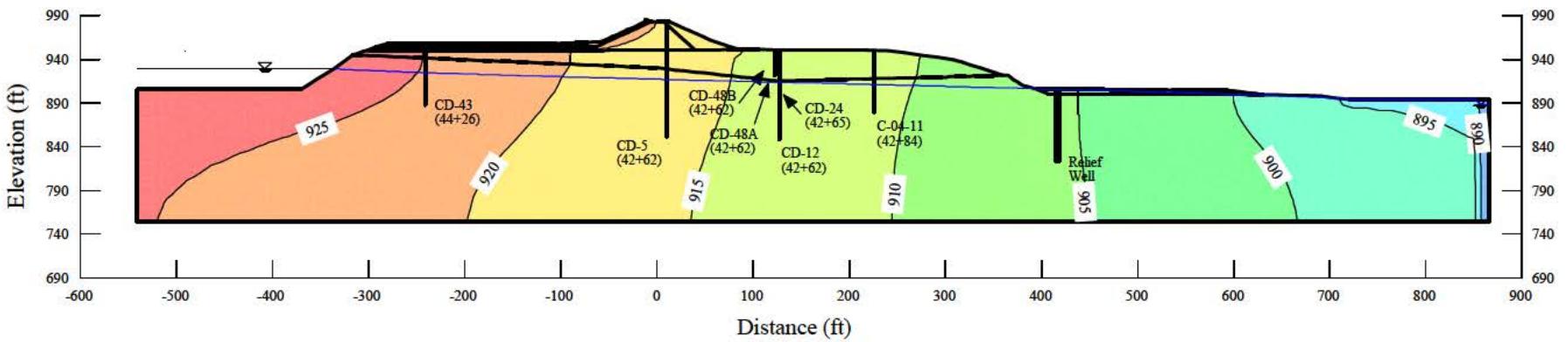
| Pool Elevation (ft), Tail Elevation (ft) | FS _(piping) (Toe) | FS _(piping) (D/S of Blanket) | FS _(effective-uplift) (D/S Blanket) | FS _(progressive erosion) (Under Seepage) |
|--|------------------------------|---|--|---|
| 936, 894 | 20.0 | 4.9 | 152.5 | 5.6 |
| 949, 896 | 20.0 | 4.7 | 81.0 | 5.4 |
| 952, 906 | 11.5 | 34.2 | 29.1 | 13.3 |
| 962, 908.5 | 6.2 | 10.7 | 27.1 | 7.1 |
| 964, 908.5 | 5.8 | 10.7 | 27.1 | 6.6 |
| 982, 930 | 3.3 | 36.9 | 21.8 | 3.8 |

| Model Calibration Summary | | | | | |
|--|-----------------|--|--|--|--|
| Pool Elevation (ft), Tail Elevation (ft) | Field Data Date | Avg. Absolute Difference of Predicted and Observed Piezometric Levels (ft) | Avg. Absolute Difference of Predicted and Observed Relief Well Flow (gal/min/ft) | Additional | |
| Pool = 936, Tail = 894 | Sept-2004 | 2.5 | 0.01 | Seepage noted D/S of blanket on field data dates are predicted by model; flow rates of observed seepage were not measured in field | |
| Pool = 949, Tail = 896 | Jan-1991 | 0.8 | 0.19 | | |
| Pool = 952, Tail = 906 | Jan-2005 | 1.4 | NA | | |
| | Average | 1.5 | 0.10 | | |

Notes:

1. Relief wells flow was not measured on maximum piezometric readings date; therefore listed as NA



| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|--|------------------------------|--|-----------------------------|--|---|---|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 43+00 | 929 | 888 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | | | | | | | |
| Piezometer | Predicted (ft) | | | | Relief Well Flow | | | |
| CD-43 | 923.8 | | | | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | 9.1E-06 | | |
| CD-5 | 915.9 | | | | Predicted (gal/min/ft) | 0.0 | | |
| CD-48A | Dry | | | | Observed (gal/min/85) | NA | | |
| CD-48B | Dry | | | | | | | |
| CD-12 | 912.9 | | | | | | | |
| CD-24 | 913.5 | | | | | | | |
| C-04-11 | 910.7 | | | | | | | |
| Quantity of Seepage | | | | | | | | |
| Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Relief Well Flow | | | | | |
| Toe/Above Toe | 4.9E-05 | 0.0 | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Observed (gal/min/85) | | | |
| D/S Blanket | 1.3E-05 | 0.0 | | | | | | |
| D/S of Blanket | 3.9E-03 | 1.8 | | | | | | |
|  | | | | | | | | |
| Model Safety Predictions | | | | | | | | |
| Predicted Exit Gradients (i) and Pressure Head (P) | | | | | | | | |
| V_{sat} (pcf) | V_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | Tail Elevation at P_{max} Location (ft) | Predicted Minimum Factors of Safety (FS) | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 905.9 | FS _(piping) (Toe) | FS _(piping) (D/S of Blanket) | FS _(effective-uplift) (D/S Blanket) |
| 0.06 | 0.06 | 0.09 | 906.0 | 900.0 | 5.96 | 10.90 | 9.93 | 51.71 |
| $i_{v max}$ (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) | Predicted Minimum Factors of Safety (FS) | | |
| | | | | | | FS _(progressive erosion) (Through Seepage) | FS _(progressive erosion) (Under Seepage) | |
| | | | | | | 12.53 | 11.41 | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | | | |
|---|---------------------|------------------------------|----------------------------|--|---|---|---|--|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | | | |
| 43+00 | 936 | 894 | | | | | | | | | | |
| Model Predictions | | | | | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | Relief Well Flow | | | | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | | | |
| CD-43 | 928.8 | NA | Toe/Above Toe | 9.6E-04 | 0.4 | 3.4E-03 | 1.5 | | | | | |
| CD-5 | 919.6 | 917.7 | D/S Blanket | 9.3E-06 | 0.0 | | NA | | | | | |
| CD-48A | Dry | Dry | D/S of Blanket | 5.3E-03 | 2.4 | | | | | | | |
| CD-48B | Dry | Dry | | | | | | | | | | |
| CD-12 | 915.8 | 914.7 | | | | | | | | | | |
| CD-24 | 916.4 | 914.7 | | | | | | | | | | |
| C-04-11 | 912.9 | NA | | | | | | | | | | |
| Avg. Absolute Difference (ft) = | | 1.2 | | | | | | | | | | |
| | | | | | | | | | | | | |
| Notes: <ul style="list-style-type: none"> 1. Observed piezometric data are maximum readings during September 2004 2. Piezometers were not yet installed or measurements were not made for observed piezometer readings indicated as NA | | | | | | | | | | | | |
| Model Safety Predictions | | | | | | | | | | | | |
| Predicted Exit Gradients (i) and Pressure Head (P) | | | | | | Predicted Minimum Factors of Safety (FS) | | | | | | |
| V_{sat} (pcf) | V_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | Tail Elevation at P_{max} Location (ft) | FS _(piping) (Toe) | FS _(piping) (D/S of Blanket) | | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 5.99 | 7.50 | | | | | |
| $i_{v max}$ (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) | FS _(progressive erosion) (Through Seepage) | FS _(progressive erosion) (Under Seepage) | | | | | |
| 0.14 | 0.10 | 0.12 | 906.0 | 900.0 | 6.31 | 6.89 | 8.63 | | | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | |
|--|---------------------|-------------------------------|----------------------------|--|---|---|---|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | |
| 43+00 | 949 | 896 | | | | | | | | |
| Model Predictions | | | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | | Relief Well Flow | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | | | | |
| CD-43 | 941.7 | 941.7 | Toe/Above Toe | 5.0E-03 | 2.2 | 1.5E-02 | | | | |
| CD-5 | 928.1 | 926.7 | D/S Blanket | 4.7E-06 | 0.0 | | | | | |
| CD-48A | 926.3 | 922.6 | D/S of Blanket | 5.0E-03 | 2.2 | | | | | |
| CD-48B | Dry | Dry | | | | | | | | |
| CD-12 | 922.5 | 922.0 | | | | | | | | |
| CD-24 | 925.2 | 922.2 | | | | | | | | |
| C-04-11 | NA | NA | | | | | | | | |
| Avg. Absolute Difference (ft) = | | 1.4 | | | | | | | | |
| | | | | | | | | | | |
| Notes: <ol style="list-style-type: none"> Observed piezometric data are maximum readings during January 1991 Piezometers were not yet installed or measurements were not made for observed piezometer readings indicated as NA Observed relief well flow listed was measured during January 1991 in well W-20; the observed flow was divided by 85 due to well spacing of 85 ft Seepage was noted at the toe and downstream of the blanket during January 1991 but flow rate was not measured | | | | | | | | | | |
| Model Safety Predictions | | | | | | | | | | |
| Predicted Exit Gradients (i) and Pressure Head (P) | | | | | Predicted Minimum Factors of Safety (FS) | | | | | |
| V_{sat} (pcf) | V_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | Tail Elevation at P_{max} Location (ft) | $FS_{(piping)}$ (Toe) | $FS_{(piping)}$ (D/S of Blanket) | $FS_{(\text{effective-uplift})}$ (D/S Blanket) | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 1.44 | 7.10 | 7.29 | | |
| $i_{v \max}$ (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) | $FS_{(\text{progressive erosion})}$ (Through Seepage) | $FS_{(\text{progressive erosion})}$ (Under Seepage) | | | |
| 0.64 | 0.28 | 0.13 | 906.0 | 900.0 | 6.76 | 1.66 | 8.17 | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | | | |
|--|---------------------|------------------------------|----------------------------|--|---|---|---|--|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | | | |
| 43+00 | 952 | 906 | | | | | | | | | | |
| Model Predictions | | | | | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | Relief Well Flow | | | | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | | | |
| CD-43 | 943.5 | 943.0 | Toe/Above Toe | 7.6E-03 | 3.4 | 2.5E-02 | 11.0 | | | | | |
| CD-5 | 930.4 | 929.3 | D/S Blanket | 3.2E-04 | 0.0 | | NA | | | | | |
| CD-48A | 929.1 | 925.9 | D/S of Blanket | 6.9E-04 | 0.3 | | | | | | | |
| CD-48B | Dry | Dry | | | | | | | | | | |
| CD-12 | 925.0 | 925.3 | | | | | | | | | | |
| CD-24 | 927.5 | 925.4 | | | | | | | | | | |
| C-04-11 | 921.8 | 921.8 | | | | | | | | | | |
| Avg. Absolute Difference (ft) = | | 1.0 | | | | | | | | | | |
| | | | | | | | | | | | | |
| Notes: <ol style="list-style-type: none"> Observed piezometric data are maximum readings during January 2005 Relief well flow was not measured on maximum piezometric reading date due to high tail water elevation; therefore listed as NA Seepage was noted in terrace area above toe during January 2005 but flow rate was not measured; seepage couldn't be observed downstream of blanket due to tail water level | | | | | | | | | | | | |
| Model Safety Predictions | | | | | | | | | | | | |
| Predicted Exit Gradients (i) and Pressure Head (P) | | | | | | Predicted Minimum Factors of Safety (FS) | | | | | | |
| V_{sat} (pcf) | V_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | Tail Elevation at P_{max} Location (ft) | FS _(piping) (Toe) | FS _(piping) (D/S of Blanket) | | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 1.21 | 57.69 | | | | | |
| $i_{v max}$ (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) (Through Seepage) | FS _(progressive erosion) (Under Seepage) | | | | | |
| 0.76 | 0.36 | 0.02 | 906.0 | 900.0 | 6.86 | 1.40 | 7.41 | | | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | |
|--|---------------------|-------------------------------|----------------------------|--|--|---|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | |
| 43+00 | 962 | 908.5 | | | | |
| Model Predictions | | | | | | |
| Piezometric Levels | | Quantity of Seepage | Relief Well Flow | | | |
| Piezometer | Predicted (ft) | | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) |
| CD-43 | 952.3 | | Toe/Above Toe | 2.0E-02 | 9.0 | 2.6E-02 |
| CD-5 | 936.1 | | D/S Blanket | 3.6E-04 | 0.2 | 11.7 |
| CD-48A | 934.6 | | D/S of Blanket | 7.9E-04 | 0.4 | NA |
| CD-48B | 934.5 | | | | | |
| CD-12 | 930.6 | | | | | |
| CD-24 | 932.7 | | | | | |
| C-04-11 | 926.8 | | | | | |
| | | | | | | |
| 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) | $FS_{(\text{piping})}$ (Toe) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 908.5 | 1.32 |
| $i_{v \max}$ (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) | $FS_{(\text{progressive erosion})}$ (Through Seepage) |
| 0.70 | 0.44 | 0.02 | 906.0 | 900.0 | 9.27 | 1.52 |
| | | | | | | $FS_{(\text{progressive erosion})}$ (Under Seepage) |
| | | | | | | 8.27 |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|-------------------------------|----------------------------|--|--|---|---|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 43+00 | 964 | 908.5 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | Relief Well Flow | | | | | |
| Piezometer | Predicted (ft) | | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | | |
| CD-43 | 953.8 | | Toe/Above Toe | 2.2E-02 | 9.9 | 2.7E-02 | | |
| CD-5 | 937.1 | | D/S Blanket | 3.7E-04 | 0.2 | | | |
| CD-48A | 935.4 | | D/S of Blanket | 8.2E-04 | 0.4 | | | |
| CD-48B | 935.3 | | | | | | | |
| CD-12 | 931.7 | | | | | | | |
| CD-24 | 933.4 | | | | | | | |
| C-04-11 | 925.9 | | | | | | | |
| | | | | | | | | |
| 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) | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Blanket) | $FS_{(\text{effective-uplift})}$ (D/S Blanket) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 908.5 | 1.30 | 48.58 | 7.10 |
| $i_{v \max}$ (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) | $FS_{(\text{progressive erosion})}$ (Through Seepage) | $FS_{(\text{progressive erosion})}$ (Under Seepage) | |
| 0.71 | 0.44 | 0.02 | 906.0 | 900.0 | 9.28 | 1.50 | 8.17 | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | |
|--|---------------------|-------------------------------|----------------------------|--|---|---|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | |
| 43+00 | 982 | 930 | | | | | | | | |
| Model Predictions | | | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | Relief Well Flow | | | | | | | |
| Piezometer | Predicted (ft) | | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | | | | |
| CD-43 | 969.9 | | Toe/Above Toe | 4.4E-02 | 19.7 | 1.6E-02 | | | | |
| CD-5 | 951.6 | | D/S Blanket | 2.8E-04 | 0.1 | 7.3 | | | | |
| CD-48A | 944.4 | | D/S of Blanket | 6.1E-04 | 0.3 | NA | | | | |
| CD-48B | 944.3 | | | | | | | | | |
| CD-12 | 945.7 | | | | | | | | | |
| CD-24 | 944.7 | | | | | | | | | |
| C-04-11 | 939.6 | | | | | | | | | |
| | | | | | | | | | | |
| Model Safety Predictions | | | | | | | | | | |
| Predicted Exit Gradients (i) and Pressure Head (P) | | | | | | Predicted Minimum Factors of Safety (FS) | | | | |
| V_{sat} (pcf) | V_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | Tail Elevation at P_{max} Location (ft) | FS _{(piping) (Toe)} | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 930.0 | 2.61 | | | | |
| $i_{v \max}$ (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 _{(piping) (D/S of Blanket)} | | | | |
| 0.16 | 0.23 | 0.01 | 906.0 | 900.0 | 30.25 | 63.66 | | | | |
| | | | | | | FS _{(progressive erosion) (Through Seepage)} | | | | |
| | | | | | | 3.00 | | | | |
| | | | | | | FS _{(progressive erosion) (Under Seepage)} | | | | |
| | | | | | | 25.48 | | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | |
|---|------------------------------|---|--|---|---|--|--|--|--|--|
| Station | | | | | | | | | | |
| 43+00 | | | | | | | | | | |
| Model Safety Predictions Summary | | | | | | | | | | |
| | | | | | | | | | | |
| Pool Elevation (ft), Tail Elevation (ft) | FS _{(piping) (Toe)} | FS _{(piping) (D/S of Blanket)} | FS _{(effective-uplift) (D/S Blanket)} | FS _{(progressive erosion) (Through Seepage)} | FS _{(progressive erosion) (Under Seepage)} | | | | | |
| 929, 888 | 10.9 | 9.9 | 51.7 | 12.5 | 11.4 | | | | | |
| 936, 894 | 6.0 | 7.5 | 17.9 | 6.9 | 8.6 | | | | | |
| 949, 896 | 1.4 | 7.1 | 7.3 | 1.7 | 8.2 | | | | | |
| 952, 906 | 1.2 | 57.7 | 6.4 | 1.4 | 7.4 | | | | | |
| 962, 908.5 | 1.3 | 48.6 | 7.2 | 1.5 | 8.3 | | | | | |
| 964, 908.5 | 1.3 | 48.6 | 7.1 | 1.5 | 8.2 | | | | | |
| 982, 930 | 2.6 | 63.7 | 22.2 | 3.0 | 25.5 | | | | | |

Minimum Factors of Safety Against Erosion

Factor of Safety (FS)

Pool Elevation (ft), Tail Elevation (ft)

- FS(piping) (Toe)
- FS(piping) (D/S of Blanket)
- FS(effective-uplift) (D/S Blanket)
- FS(progressive erosion) (Through Seepage)
- FS(progressive erosion) (Under Seepage)

| Model Calibration Summary | | | | | |
|--|-----------------|--|--|---|--|
| Pool Elevation (ft), Tail Elevation (ft) | Field Data Date | Avg. Absolute Difference of Predicted and Observed Piezometric Levels (ft) | Avg. Absolute Difference of Predicted and Observed Relief Well Flow (gal/min/ft) | Additional | |
| Pool = 936, Tail = 894 | Sept-2004 | 1.2 | NA | Seepage noted in terrace area, at toe, and D/S of blanket on field data dates are predicted by model; flow rates of observed seepage were not measured in field | |
| Pool = 949, Tail = 896 | Jan-1991 | 1.4 | 0.2 | | |
| Pool = 952, Tail = 906 | Jan-2005 | 1.0 | NA | | |
| Average | | 1.2 | 0.2 | | |

Notes:

1. Relief well flow was not measured on maximum piezometric readings date; therefore listed as NA

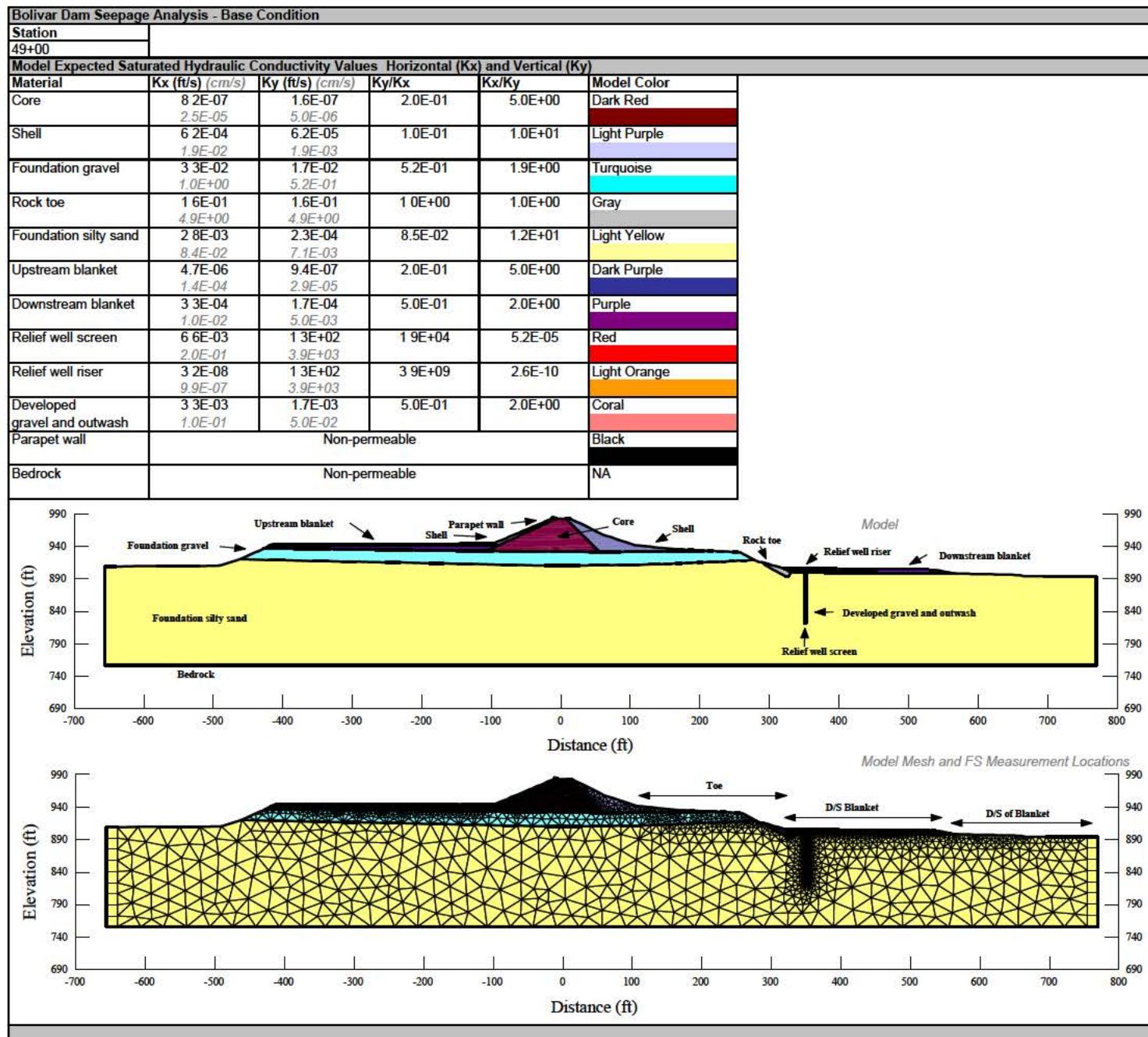


Plate F34

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | |
|--|---------------------|-------------------------------|--|-----------------------------|--|---|---|---|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | |
| 49+00 | 929 | 888 | | | | | | | |
| Model Predictions | | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | Relief Well Flow | | | | |
| Piezometer | Predicted (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | | | | |
| C-04-23 | 911.6 | Above Toe | 7.5E-05 | 0.0 | 4.9E-04 | | | | |
| C-04-24 | 914.9 | Toe | 5.1E-03 | 2.3 | | | | | |
| CD-50 | 912.8 | D/S Blanket | 2.4E-05 | 0.0 | | | | | |
| D-59 | 904.0 | D/S of Blanket | 3.7E-03 | 1.7 | | | | | |
| D-67 | 915.2 | | | | | | | | |
| D-76 | 916.3 | | | | | | | | |
| | | | | | | | | | |
| 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) | Predicted Minimum Factors of Safety (FS) | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Blanket) | $FS_{(\text{effective-uplift})}$ (D/S Blanket) | |
| 0.12 | 0.18 | 0.17 | 906.0 | 900.0 | 6.10 | | | | |
| $i_{v \max}$ (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) | $FS_{(\text{progressive erosion})}$ (Through Seepage) | | $FS_{(\text{progressive erosion})}$ (Under Seepage) | |
| | | | | | | 3.83 | | 6.24 | |

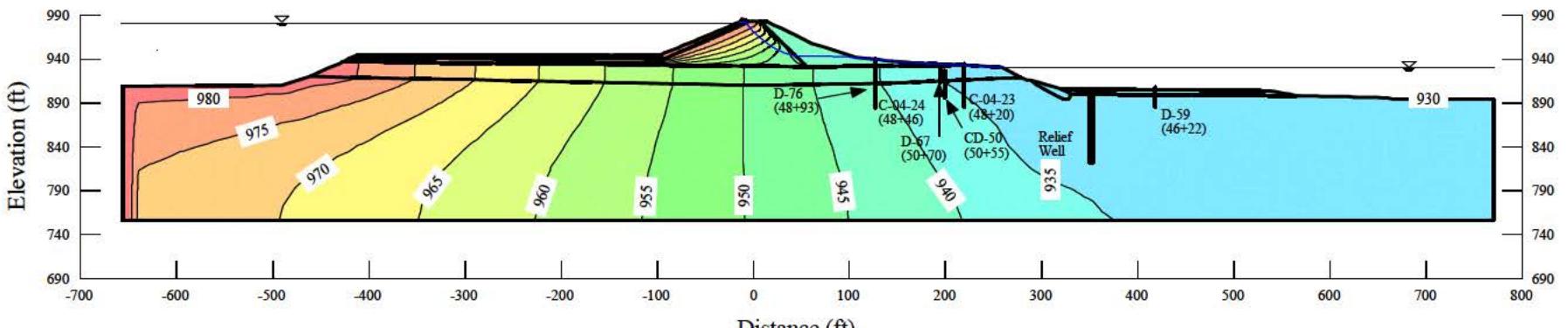
| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | | | | | |
|--|--|-----------------------------|----------------------------|--|--|---|---|--|--|--|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | | | | | |
| 49+00 | 936 | 894 | | | | | | | | | | | | |
| Model Predictions | | | | | | | | | | | | | | |
| Piezometric Levels | | | Quantity of Seepage | | | Relief Well Flow | | | | | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Observed (gal/min/100) | | | | | | |
| C-04-23 | 914.1 | NA | Above Toe | 1.1E-03 | 0.5 | 5.8E-03 | 2.6 | 3.3 | | | | | | |
| C-04-24 | 918.5 | NA | Toe | 9.7E-03 | 4.4 | | | | | | | | | |
| CD-50 | 915.8 | 915.7 | D/S Blanket | 3.2E-05 | 0.0 | | | | | | | | | |
| D-59 | 904.1 | 904.4 | D/S of Blanket | 4.6E-03 | 2.1 | | | | | | | | | |
| D-67 | 918.1 | 915.6 | | | | | | | | | | | | |
| D-76 | 920.4 | 920.0 | | | | | | | | | | | | |
| Avg. Absolute Difference (ft) = 0.8 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Notes: | | | | | | | | | | | | | | |
| 1. | Observed piezometric data are maximum readings during September 2004 | | | | | | | | | | | | | |
| 2. | Observed relief well flow listed was measured during September 2004 in well W-24; the observed flow was divided by 100 due to well spacing of 100 ft | | | | | | | | | | | | | |
| 3. | Piezometers were not yet installed or measurements were not made for observed piezometer readings indicated as NA | | | | | | | | | | | | | |
| 4. | Seepage was noted in terrace area above the rock toe and at the rock toe during September 2004 but flow rate was not measured | | | | | | | | | | | | | |
| 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-uplift) (D/S Blanket) | | | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 1.87 | 4.40 | 50.35 | | | | | | |
| $i_v \max$ (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) | FS _(progressive erosion) (Through Seepage) | FS _(progressive erosion) (Under Seepage) | 5.05 | | | | | | |
| 0.24 | 0.32 | 0.21 | 906.0 | 900.0 | 6.11 | | | | | | | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|--|------------------------------|----------------------------|--|---|--|---|---|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 49+00 | 949 | 896 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | | Quantity of Seepage | | | Relief Well Flow | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Observed (gal/min/100) |
| C-04-23 | 916.9 | NA | Above Toe | 8.3E-03 | 3.7 | 1.1E-02 | 5.0 | 4.88 |
| C-04-24 | 923.1 | NA | Toe | 1.4E-02 | 6.2 | | | |
| CD-50 | 919.4 | 920.6 | D/S Blanket | 3.5E-05 | 0.0 | | | |
| D-59 | 904.5 | NA | D/S of Blanket | 5.3E-03 | 2.4 | | | |
| D-67 | 923.7 | NA | | | | | | |
| D-76 | 925.6 | NA | | | | | | |
| Avg. Absolute Difference (ft) = 1.2 | | | | | | | | |
| | | | | | | | | |
| Notes: | | | | | | | | |
| 1. | Observed piezometric data are maximum readings during January 1991 | | | | | | | |
| 2. | Piezometers were not yet installed or measurements were not made for observed piezometer readings indicated as NA | | | | | | | |
| 3. | Observed relief well flow listed was measured during January 1991 in well W-24; the observed flow was divided by 100 due to well spacing of 100 ft | | | | | | | |
| 4. | Seepage was noted at the rock toe and downstream of the blanket during January 1991 but flow rate was not measured | | | | | | | |
| Model Safety Predictions | | | | | | | | |
| Predicted Exit Gradients (i) and Pressure Head (P) | | | | | | Predicted Minimum Factors of Safety (FS) | | |
| V_{sat} (pcf) | V_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-uplift) (D/S Blanket) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 0.94 | 5.77 | 46.15 |
| $i_{v max}$ (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) (Through Seepage) | FS _(progressive erosion) (Under Seepage) |
| 0.82 | 0.64 | 0.16 | 906.0 | 900.0 | 6.12 | | 1.08 | 6.63 |

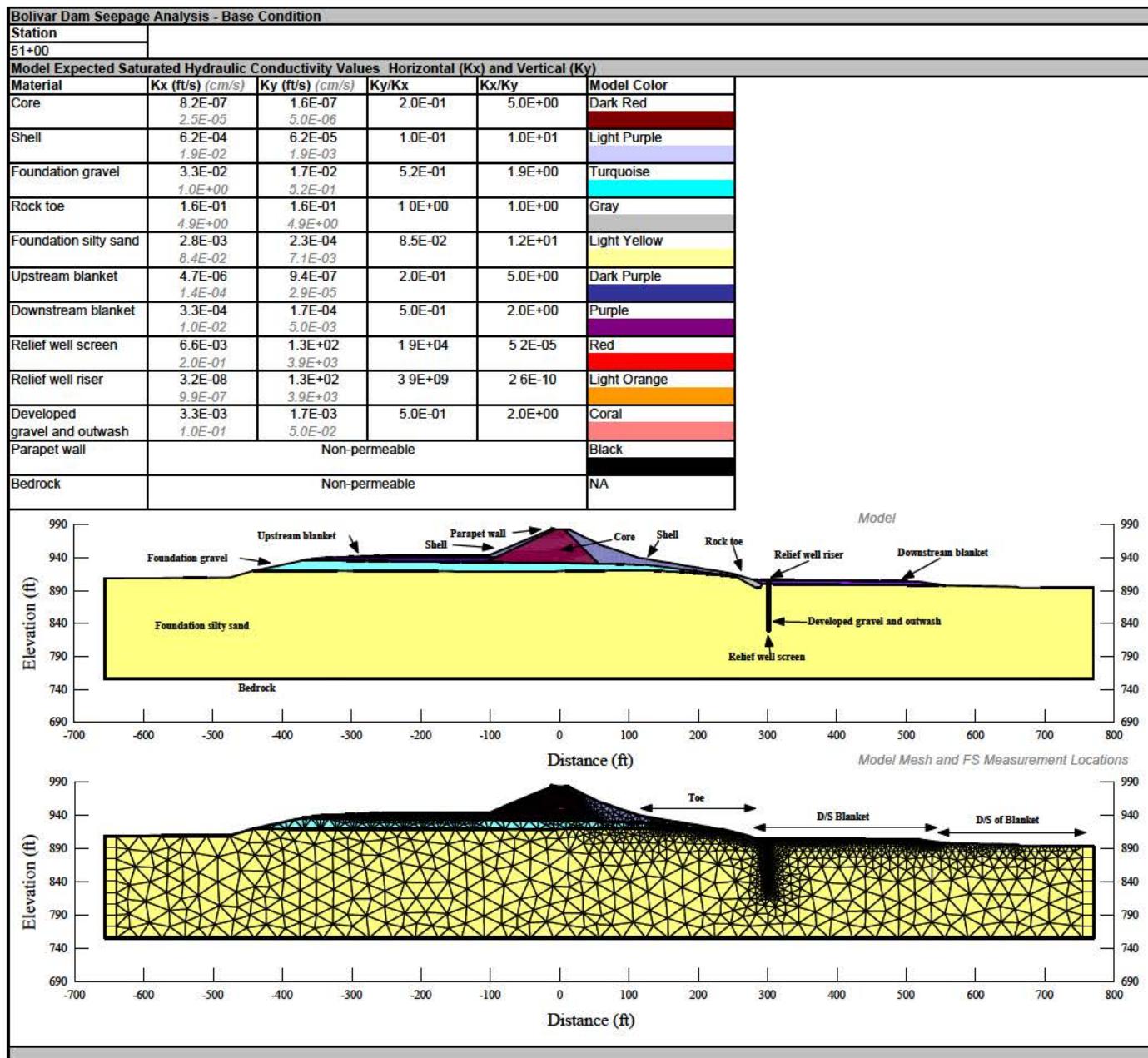
| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|-------------------------------|----------------------------|--|--|---|---|---|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 49+00 | 952 | 906 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | | Quantity of Seepage | | | Relief Well Flow | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Observed (gal/min/100) |
| C-04-23 | 918.3 | 921.5 | Above Toe | 1.1E-02 | 4.8 | 2.0E-02 | 8.8 | NA |
| C-04-24 | 924.0 | 924.2 | Toe | 1.5E-02 | 6.6 | | | |
| CD-50 | 921.2 | 923.6 | D/S Blanket | 2.8E-04 | 0.0 | | | |
| D-59 | 906.1 | 906.2 | D/S of Blanket | 6.3E-04 | 0.3 | | | |
| D-67 | 924.4 | 924 | | | | | | |
| D-76 | 926.6 | 927.9 | | | | | | |
| Avg. Absolute Difference (ft) = 1.3 | | | | | | | | |
| | | | | | | | | |
| Notes: <ol style="list-style-type: none"> Observed piezometric data are maximum readings during January 2005 Relief well flow was not measured on maximum piezometric reading date due to high tail water elevation; therefore listed as NA Seepage was noted in terrace area and at the rock toe during January 2005 but flow rate was not measured; seepage couldn't be observed downstream of blanket due to tail water level | | | | | | | | |
| 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-uplift) (D/S Blanket) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 0.92 | 54.30 | 55.38 |
| $i_{v \max}$ (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) (Through Seepage) | | FS _(progressive erosion) (Under Seepage) |
| 0.81 | 0.65 | 0.02 | 906.0 | 900.0 | 6.10 | 1.06 | | 62.44 |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | |
|--|---------------------|---------------------|--|------------------------|--|--|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | |
| 49+00 | 962 | 908.5 | | | | | | | | |
| Model Predictions | | | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | Relief Well Flow | | | | | |
| Piezometer | Predicted (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | | | | | |
| C-04-23 | 920.0 | Above Toe | 2.1E-02 | 9.4 | 2.1E-02 | | | | | |
| C-04-24 | 927.5 | Toe | 2.1E-02 | 9.4 | | | | | | |
| CD-50 | 922.6 | D/S Blanket | 3.1E-04 | 0.1 | | | | | | |
| D-59 | 908.6 | D/S of Blanket | 6.9E-04 | 0.3 | | | | | | |
| D-67 | 926.7 | | | | | | | | | |
| D-76 | 929.8 | | | | | | | | | |
| | | | | | | | | | | |
| Model Safety Predictions | | | | | | | | | | |
| Predicted Exit Gradients (i) and Pressure Head (P) | | | | | | | | | | |
| V_{sat} (pcf) | V_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | Tail Elevation at P_{max} Location (ft) | Predicted Minimum Factors of Safety (FS) | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 908.5 | $FS_{(piping)} (Toe)$ | $FS_{(piping)} (D/S of Blanket)$ | $FS_{(\text{effective-uplift})} (D/S Blanket)$ | | |
| 0.63 | 0.60 | 0.02 | 906.0 | 900.0 | 8.53 | | | | | |
| | | | | | | $FS_{(\text{progressive erosion})} (\text{Through Seepage})$ | | | | |
| | | | | | | | | | | |
| | | | | | | 1.15 | $FS_{(\text{progressive erosion})} (\text{Under Seepage})$ | | | |
| | | | | | | | 58.97 | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|---------------------|------------------|--|--|--|---|---|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 49+00 | 964 | 908.5 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | Relief Well Flow | | | | | |
| Piezometer | Predicted (ft) | | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | |
| C-04-23 | 920.7 | | Above Toe | 2.3E-02 | 10.3 | | | |
| C-04-24 | 928.0 | | Toe | 2.1E-02 | 9.4 | | | |
| CD-50 | 923.0 | | D/S Blanket | 3.2E-04 | 0.1 | | | |
| D-59 | 908.6 | | D/S of Blanket | 7.2E-04 | 0.3 | | | |
| D-67 | 927.1 | | | | | | | |
| D-76 | 930.3 | | | | | | | |
| | | | | | | | | |
| 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) | Predicted Minimum Factors of Safety (FS) | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 908.5 | FS _(piping) (Toe) | FS _(piping) (D/S of Blanket) | FS _(effective-uplift) (D/S Blanket) |
| 0.63 | 0.60 | 0.02 | 906.0 | 900.0 | 8.53 | | FS _(progressive erosion) (Through Seepage) | FS _(progressive erosion) (Under Seepage) |
| | | | | | | | 1.15 | 58.97 |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | |
|--|---------------------|---------------------|--|--|--|---|---|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | |
| 49+00 | 982 | 930 | | | | | | | | |
| Model Predictions | | | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | Relief Well Flow | | | | | | | |
| Piezometer | Predicted (ft) | | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | | | |
| C-04-23 | 936.0 | | Above Toe | 5.1E-02 | 22.9 | | | | | |
| C-04-24 | 941.1 | | Toe | 4.0E-03 | 1.8 | | | | | |
| CD-50 | 937.2 | | D/S Blanket | 2.5E-04 | 0.1 | | | | | |
| D-59 | 930.1 | | D/S of Blanket | 5.6E-04 | 0.3 | | | | | |
| D-67 | 935.3 | | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | | | | | | | |
| D-76 | 941.2 | | Predicted (gal/min/ft) | | | | | | | |
| Observed (gal/min/100) | | | | | | | | | | |
| NA | | | | | | | | | | |
|  | | | | | | | | | | |
| 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) | Predicted Minimum Factors of Safety (FS) | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 930.0 | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Blanket) | $FS_{(\text{effective-uplift})}$ (D/S Blanket) | | |
| 0.70 | 0.11 | 0.02 | 906.0 | 900.0 | 30.10 | | | | | |
| | | | | | | $FS_{(\text{progressive erosion})}$ (Through Seepage) | | | | |
| | | | | | | | | | | |
| | | | | | | 1.52 | $FS_{(\text{progressive erosion})}$ (Under Seepage) | | | |
| | | | | | | 63.69 | | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | |
|---|-----------------|--|--|--|---|--|--|
| Station | | | | | | | |
| 49+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-uplift) (D/S Blanket) | FS _(progressive erosion) (Through Seepage) | | |
| 929, 888 | | 3.3 | 5.4 | 55.4 | 3.8 | | |
| 936, 894 | | 1.9 | 4.4 | 50.3 | 2.2 | | |
| 949, 896 | | 0.9 | 5.8 | 46.2 | 1.1 | | |
| 952, 906 | | 0.9 | 54.3 | 55.4 | 1.1 | | |
| 962, 908.5 | | 1.0 | 51.3 | 184.6 | 1.1 | | |
| 964, 908.5 | | 1.0 | 51.3 | 184.6 | 1.1 | | |
| 982, 930 | | 1.3 | 61.5 | 55.4 | 1.5 | | |
| | | | | | | | |
| Minimum Factors of Safety Against Erosion | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Model Calibration Summary | | | | | | | |
| Pool Elevation (ft), Tail Elevation (ft) | Field Data Date | Avg. Absolute Difference of Predicted and Observed Piezometric Levels (ft) | Avg. Absolute Difference of Predicted and Observed Relief Well Flow (gal/min/ft) | Additional | | | |
| Pool = 936, Tail = 894 | Sept-2004 | 0.8 | 0.7 | Seepage noted in terrace area, at rock toe, and D/S of blanket on field data dates are predicted by model; flow rates of observed seepage were not measured in field | | | |
| Pool = 949, Tail = 896 | Jan-1991 | 1.2 | 0.1 | | | | |
| Pool = 952, Tail = 906 | Jan-2005 | 1.3 | NA | | | | |
| | Average | 1.1 | 0.4 | | | | |
| Notes: | | | | | | | |
| 1. Relief well flow was not measured on maximum piezometric readings date; therefore listed as NA | | | | | | | |

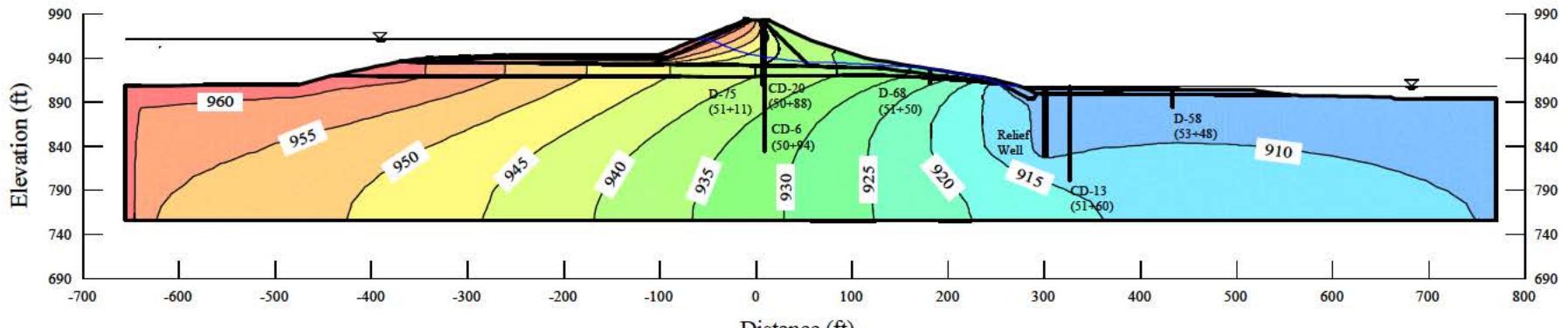


| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|-------------------------------|--|-----------------------------|--|---|---|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 51+00 | 929 | 888 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | | | | | | |
| Piezometer | Predicted (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Observed (gal/min/100) | |
| CD-6 | 915.4 | Above Toe | 4.3E-05 | 0.0 | 1.7E-03 | 0.8 | NA | |
| CD-13 | 905.8 | Toe | 2.3E-03 | 1.0 | | | | |
| CD-20 | Dry | D/S Blanket | 3.4E-04 | 0.2 | | | | |
| D-58 | 902.4 | D/S of Blanket | 2.9E-03 | 1.3 | | | | |
| D-68 | 910.8 | | | | | | | |
| D-75 | 918.6 | | | | | | | |
| | | | | | | | | |
| 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) | Predicted Minimum Factors of Safety (FS) | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | FS _(piping) (Toe) | FS _(piping) (D/S of Blanket) | FS _(effective-uplift) (D/S Blanket) |
| 0.08 | 0.11 | 0.14 | 906.0 | 900.0 | 6.08 | | | |
| $i_{v \max}$ (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) (Through Seepage) | FS _(progressive erosion) (Under Seepage) | |
| | | | | | | 6.27 | 7.86 | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|------------------------------|----------------------------|--|---|---|---|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 51+00 | 936 | 894 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | | Quantity of Seepage | | | Relief Well Flow | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Observed (gal/min/100) |
| CD-6 | 918.3 | 915.1 | Above Toe | 1.7E-04 | 0.1 | 7.3E-03 | 3.3 | 3.8 |
| CD-13 | 906.6 | 903.5 | Toe | 5.8E-03 | 2.6 | | | |
| CD-20 | Dry | Dry | D/S Blanket | 4.2E-04 | 0.2 | | | |
| D-58 | 902.6 | 902.3 | D/S of Blanket | 4.6E-03 | 2.1 | | | |
| D-68 | 915.5 | 915.6 | | | | | | |
| D-75 | 923.8 | 922.6 | | | | | | |
| Avg. Absolute Difference (ft) = 1.6 | | | | | | | | |
| | | | | | | | | |
| Notes: <ol style="list-style-type: none"> Observed piezometric data are maximum readings during September 2004 Observed relief well flow listed was measured during September 2004 in well W-26; the observed flow was divided by 100 due to well spacing of 100 ft Seepage was noted at the rock toe during September 2004 but flow rate was not measured | | | | | | | | |
| Model Safety Predictions | | | | | | | | |
| Predicted Exit Gradients (i) and Pressure Head (P) | | | | | | Predicted Minimum Factors of Safety (FS) | | |
| V_{sat} (pcf) | V_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-uplift) (D/S Blanket) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 1.71 | 5.43 | 61.54 |
| $i_{v max}$ (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) (Through Seepage) | FS _(progressive erosion) (Under Seepage) | |
| 0.27 | 0.35 | 0.17 | 906.0 | 900.0 | 6.09 | 1.97 | 6.24 | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|--|------------------------------|----------------------------|--|---|--|---|---|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 51+00 | 949 | 896 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | | Quantity of Seepage | | | Relief Well Flow | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Observed (gal/min/100) |
| CD-6 | 924.4 | 923 | Above Toe | 6.0E-04 | 0.3 | 1.4E-02 | 6.1 | 5.7 |
| CD-13 | 908.5 | ≥907.3 | Toe | 1.3E-02 | 5.7 | | | |
| CD-20 | Dry | Dry | D/S Blanket | 5.2E-04 | 0.2 | | | |
| D-58 | 903.1 | NA | D/S of Blanket | 4.7E-03 | 2.1 | | | |
| D-68 | 921.1 | NA | | | | | | |
| D-75 | 930.1 | NA | | | | | | |
| Avg. Absolute Difference (ft) = 1.4 | | | | | | | | |
| | | | | | | | | |
| Notes: | | | | | | | | |
| 1. | Observed piezometric data are maximum readings during January 1991 | | | | | | | |
| 2. | For the observed CD-13 piezometric level the ≥ symbol is used because water was indicated at riser top | | | | | | | |
| 3. | Piezometers were not yet installed or measurements were not made for observed piezometer readings indicated as NA | | | | | | | |
| 4. | Observed relief well flow listed was measured during January 1991 in well W-26; the observed flow was divided by 100 due to well spacing of 100 ft | | | | | | | |
| 5. | Seepage was noted at the rock toe and downstream of the blanket during January 1991 but flow rate was not measured | | | | | | | |
| Model Safety Predictions | | | | | | | | |
| Predicted Exit Gradients (i) and Pressure Head (P) | | | | | | Predicted Minimum Factors of Safety (FS) | | |
| V_{sat} (pcf) | V_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-uplift) (D/S Blanket) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 0.64 | 6.15 | 46.15 |
| $i_{v max}$ (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) (Through Seepage) | FS _(progressive erosion) (Under Seepage) |
| 0.58 | 0.94 | 0.15 | 906.0 | 900.0 | 6.12 | | 0.73 | 7.08 |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | | | | | |
|---|---------------------|------------------------------|----------------------------|--|---|---|---|--|--|--|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | | | | | |
| 51+00 | 952 | 906 | | | | | | | | | | | | |
| Model Predictions | | | | | | | | | | | | | | |
| Piezometric Levels | | | Quantity of Seepage | | | Relief Well Flow | | | | | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Observed (gal/min/100) | | | | | | |
| CD-6 | 926.2 | 924.2 | Above Toe | 6.8E-04 | 0.3 | 2.2E-02 | 10.1 | NA | | | | | | |
| CD-13 | 909.8 | ≥909.8 | Toe | 1.4E-02 | 6.2 | | | | | | | | | |
| CD-20 | 933.3 | 934.1 | D/S Blanket | 4.1E-04 | 0.2 | | | | | | | | | |
| D-58 | 906.2 | 906.4 | D/S of Blanket | 5.7E-04 | 0.3 | | | | | | | | | |
| D-68 | 922.2 | 924.5 | | | | | | | | | | | | |
| D-75 | 931.8 | 933.6 | | | | | | | | | | | | |
| Avg. Absolute Difference (ft) = 1.4 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Notes: <ol style="list-style-type: none"> Observed piezometric data are maximum readings during January 2005 For the observed CD-13 piezometric level the ≥ symbol is used because water was frozen in a 3 foot extension added to the riser top which is at 906.8 ft Relief well flow was not measured on maximum piezometric readings date due to high tail water elevation; therefore listed as NA Seepage was noted at the rock toe during January 2005 but flow rate was not measured; seepage couldn't be observed downstream of the blanket due to tail water level | | | | | | | | | | | | | | |
| Model Safety Predictions | | | | | | | | | | | | | | |
| Predicted Exit Gradients (i_e) 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-uplift) (D/S Blanket) | | | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 0.61 | 51.28 | 55.38 | | | | | | |
| $i_{v max}$ (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) (Through Seepage) | FS _(progressive erosion) (Under Seepage) | | | | | | | |
| 0.72 | 0.99 | 0.02 | 906.0 | 900.0 | 6.10 | 0.70 | 58.97 | | | | | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|--|------------------|--|--|---|---|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 51+00 | 962 | 908.5 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | Relief Well Flow | | | | | |
| Piezometer | Predicted (ft) | | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | |
| CD-6 | 931.7 | | Above Toe | 2.2E-03 | 1.0 | | | |
| CD-13 | 913.7 | | Toe | 2.0E-02 | 9.0 | | | |
| CD-20 | 939.9 | | D/S Blanket | 7.1E-04 | 0.3 | | | |
| D-58 | 908.8 | | D/S of Blanket | 8.9E-04 | 0.4 | | | |
| D-68 | 925.2 | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | | | 10.8 | | | |
| D-75 | 938.2 | Predicted (gal/min/ft) | | | NA | | | |
| Observed (gal/min/100) | | | | | | | | |
|  | | | | | | | | |
| 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) | Predicted Minimum Factors of Safety (FS) | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 908.5 | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Blanket) | $FS_{(\text{effective-uplift})}$ (D/S Blanket) |
| 1.14 | 1.04 | 0.03 | 906.0 | 900.0 | 8.53 | | | |
| $i_{v \max}$ (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) | | | | | | $FS_{(\text{progressive erosion})}$ (Through Seepage) | $FS_{(\text{progressive erosion})}$ (Under Seepage) | |
| 1.14 | 1.04 | 0.03 | 906.0 | 900.0 | 8.53 | 0.66 | 36.60 | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | |
|--|---------------------|--|------------------|--|---|--|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | |
| 51+00 | 964 | 908.5 | | | | | | | | |
| Model Predictions | | | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | Relief Well Flow | | | | | | | |
| Piezometer | Predicted (ft) | | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | | | |
| CD-6 | 932.6 | | Above Toe | 2.6E-03 | 1.2 | | | | | |
| CD-13 | 913.9 | | Toe | 2.1E-02 | 9.4 | | | | | |
| CD-20 | 940.1 | | D/S Blanket | 7.3E-04 | 0.3 | | | | | |
| D-58 | 908.8 | | D/S of Blanket | 9.3E-04 | 0.4 | | | | | |
| D-68 | 926.1 | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | | | Observed (gal/min/100) | | | | | |
| D-75 | 939.3 | 2.5E-02 | | | NA | | | | | |
| | | | | | | | | | | |
| Model Safety Predictions | | | | | | | | | | |
| Predicted Exit Gradients (i) and Pressure Head (P) | | | | | | | | | | |
| V_{sat} (pcf) | V_b (pcf) | ϕ (degrees) | i_{cv} | i_{ch} | Tail Elevation at P_{max} Location (ft) | Predicted Minimum Factors of Safety (FS) | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 908.5 | $FS_{(piping)} (Toe)$ | $FS_{(piping)} (D/S of Blanket)$ | $FS_{(\text{effective-uplift})} (D/S Blanket)$ | | |
| 1.17 | 1.06 | 0.03 | 906.0 | 900.0 | 8.53 | | | | | |
| | | | | | | $FS_{(\text{progressive erosion})} (\text{Through Seepage})$ | | | | |
| | | | | | | | | | | |
| | | | | | | 0.65 | $FS_{(\text{progressive erosion})} (\text{Under Seepage})$ | | | |
| | | | | | | 34.24 | | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|----------------------------|----------------------------|--|--|---|---|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 51+00 | 982 | 930 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | Relief Well Flow | | | | | |
| Piezometer | Predicted (ft) | | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | |
| CD-6 | 951.1 | | Above Toe | 1.9E-02 | 8.3 | | | |
| CD-13 | 935.8 | | Toe | 1.2E-02 | 5.6 | | | |
| CD-20 | 956.3 | | D/S Blanket | 6.4E-04 | 0.3 | | | |
| D-58 | 930.3 | | D/S of Blanket | 8.2E-04 | 0.4 | | | |
| D-68 | 941.8 | | | | NA | | | |
| D-75 | 955.6 | | | | | | | |
| | | | | | | | | |
| 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) | Predicted Minimum Factors of Safety (FS) | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 930.0 | FS _(piping) (Toe) | FS _(piping) (D/S of Blanket) | FS _(effective-uplift) (D/S Blanket) |
| 1.92 | 0.60 | 0.03 | 906.0 | 900.0 | 30.10 | | | |
| 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) (Through Seepage) | FS _(progressive erosion) (Under Seepage) | |
| 1.92 | 0.60 | 0.03 | 906.0 | 900.0 | 30.10 | 0.55 | 37.91 | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | |
|---|------------------------------|---|--|---|---|
| Station | | | | | |
| 51+00 | | | | | |
| Model Safety Predictions Summary | | | | | |
| Pool Elevation (ft), Tail Elevation (ft) | FS _{(piping) (Toe)} | FS _{(piping) (D/S of Blanket)} | FS _{(effective-uplift) (D/S Blanket)} | FS _{(progressive erosion) (Through Seepage)} | FS _{(progressive erosion) (Under Seepage)} |
| 929, 888 | 5.4 | 6.8 | 69.2 | 6.3 | 7.9 |
| 936, 894 | 1.7 | 5.4 | 61.5 | 2.0 | 6.2 |
| 949, 896 | 0.6 | 6.2 | 46.2 | 0.7 | 7.1 |
| 952, 906 | 0.6 | 51.3 | 55.4 | 0.7 | 59.0 |
| 962, 908.5 | 0.6 | 31.8 | 184.6 | 0.7 | 36.6 |
| 964, 908.5 | 0.6 | 29.8 | 184.6 | 0.7 | 34.2 |
| 982, 930 | 0.5 | 33.0 | 55.4 | 0.6 | 37.9 |

Minimum Factors of Safety Against Erosion

Factor of Safety (FS)

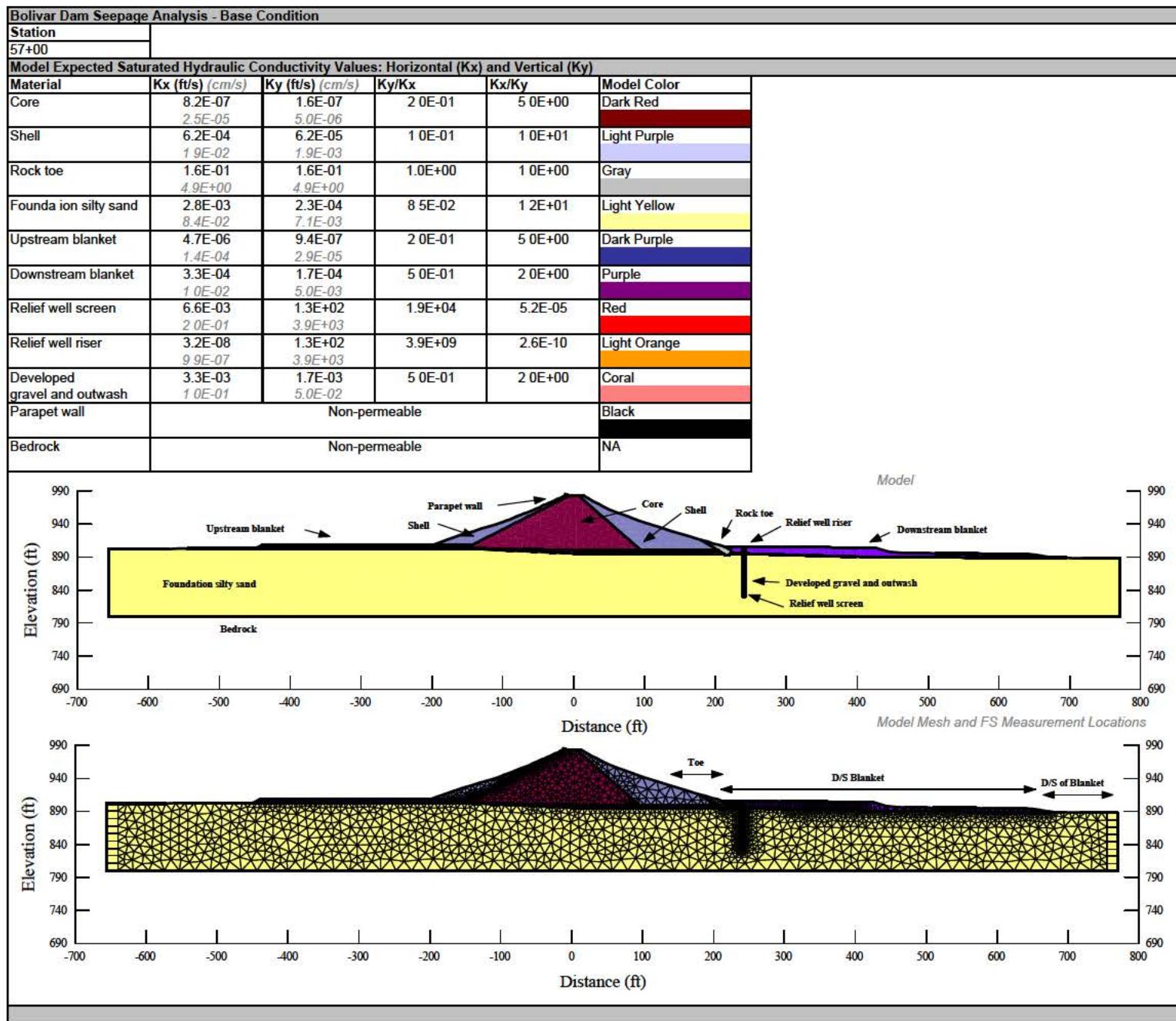
Pool Elevation (ft), Tail Elevation (ft)

- FS(piping) (Toe)
- FS(piping) (D/S of Blanket)
- FS(effective-uplift) (D/S Blanket)
- FS(progressive erosion) (Through Seepage)
- FS(progressive erosion) (Under Seepage)

| Model Calibration Summary | | | | | |
|--|-----------------|--|--|---|--|
| Pool Elevation (ft), Tail Elevation (ft) | Field Data Date | Avg. Absolute Difference of Predicted and Observed Piezometric Levels (ft) | Avg. Absolute Difference of Predicted and Observed Relief Well Flow (gal/min/ft) | Additional | |
| Pool = 936, Tail = 894 | Sept-2004 | 1.6 | 0.5 | Seepage noted at rock toe, and D/S of blanket on field data dates are predicted by model; flow rates of observed seepage were not measured in field | |
| Pool = 949, Tail = 896 | Jan-1991 | 1.4 | 0.4 | | |
| Pool = 952, Tail = 906 | Jan-2005 | 1.4 | NA | | |
| | Average | 1.5 | 0.5 | | |

Notes:

- Relief well flow was not measured on maximum piezometric readings date; therefore listed as NA



| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|-----------------------------|----------------------------|--|--|---|---|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 57+00 | 929 | 888 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | Relief Well Flow | | | | | |
| Piezometer | Predicted (ft) | | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | | |
| CD-7 | 911.9 | | Above Toe | 8.0E-05 | 0.0 | 2.1E-05 | 0.0 | |
| D-55 | 904.0 | | Toe | 1.4E-04 | 0.1 | | | |
| D-06-28 | 912.1 | | D/S Blanket | 1.1E-04 | 0.0 | | | |
| D-06-29 | 899.7 | | D/S of Blanket | 4.7E-03 | 2.1 | | | |
| | | | | | | | | |
| 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) | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Blanket) | $FS_{(\text{effective-uplift})}$ (D/S Blanket) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 14.99 | 5.43 | 1015.38 |
| $i_{v \max}$ (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) | $FS_{(\text{progressive erosion})}$ (Under Seepage) | | |
| 0.04 | 0.04 | 0.17 | 906.0 | 895.0 | 11.01 | 6.24 | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | | | | | |
|--|---|-------------------------------|----------------------------|--|--|---|---|--|--|--|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | | | | | |
| 57+00 | 936 | 894 | | | | | | | | | | | | |
| Model Predictions | | | | | | | | | | | | | | |
| Piezometric Levels | | | Quantity of Seepage | | | Relief Well Flow | | | | | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Observed (gal/min/100) | | | | | | |
| CD-7 | 914.5 | 913.2 | Above Toe | 1.7E-04 | 0.1 | 9.0E-04 | 0.4 | 1.0 | | | | | | |
| D-55 | 904.9 | 902.0 | Toe | 1.7E-03 | 0.8 | | | | | | | | | |
| D-06-28 | 914.6 | NA | D/S Blanket | 2.6E-04 | 0.1 | | | | | | | | | |
| D-06-29 | 900.7 | NA | D/S of Blanket | 5.6E-03 | 2.5 | | | | | | | | | |
| Avg. Absolute Difference (ft) = | | | | | | | | | | | | | | |
| 2.1 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Notes: | | | | | | | | | | | | | | |
| 1. | Observed piezometric data are maximum readings during September 2004 | | | | | | | | | | | | | |
| 2. | Observed relief well flow was measured during September 2004 in well W-30; observed flow was divided by 100 due to well spacing of 100 ft | | | | | | | | | | | | | |
| 3. | Seepage was noted downstream of the blanket during September 2004 but the flow rate was not measured | | | | | | | | | | | | | |
| 4. | Piezometers D-06-28 and D-06-29 were installed during fall 2006 and therefore had not yet provided data which could be used for calibration | | | | | | | | | | | | | |
| 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) | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Blanket) | $FS_{(\text{effective-uplift})}$ (D/S Blanket) | | | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 8.56 | 4.40 | 507.69 | | | | | | |
| $i_{v \max}$ (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) | $FS_{(\text{progressive erosion})}$ (Under Seepage) | | | | | | | | |
| 0.08 | 0.07 | 0.21 | 906.0 | 895.0 | 11.02 | 5.05 | | | | | | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|--|-------------------------------|----------------------------|--|--|---|---|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 57+00 | 949 | 896 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | | Quantity of Seepage | | | Relief Well Flow | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | Observed (gal/min/100) |
| CD-7 | 918.2 | 919.3 | Above Toe | 2.2E-04 | 0.1 | 4.9E-03 | 2.2 | 1.9 |
| D-55 | 905.0 | NA | Toe | 2.5E-03 | 1.1 | | | |
| D-06-28 | 918.5 | NA | D/S Blanket | 3.2E-04 | 0.1 | | | |
| D-06-29 | 901.1 | NA | D/S of Blanket | 5.3E-03 | 2.4 | | | |
| Avg. Absolute Difference (ft) = | | | 1.1 | | | | | |
| | | | | | | | | |
| Notes: | | | | | | | | |
| 1. | Observed piezometric data are maximum readings during January 1991 | | | | | | | |
| 2. | Observed relief well flow was measured during January 1991 in well W-30; observed flow was divided by 100 due to well spacing of 100 ft | | | | | | | |
| 3. | Seepage was noted downstream of the blanket during January 1991 but the flow rate was not measured | | | | | | | |
| 4. | Piezometer D-55 was installed in 1992, and piezometers D-06-28 and D-06-29 were installed during fall 2006; therefore they had not yet provided data which could be used for calibration | | | | | | | |
| 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) | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Blanket) | $FS_{(\text{effective-uplift})}$ (D/S Blanket) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 6.66 | 3.55 | 203.08 |
| $i_{v \max}$ (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) | $FS_{(\text{progressive erosion})}$ (Under Seepage) | | |
| 0.12 | 0.09 | 0.26 | 906.0 | 895.0 | 11.05 | | | 4.08 |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | | | | | | | |
|--|---|------------------------------|----------------------------|-----------------------------|---|--|----------------------------------|---|--|--|--|--|--|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | | | | | | | |
| 57+00 | 952 | 906 | | | | | | | | | | | | |
| Model Predictions | | | | | | | | | | | | | | |
| Piezometric Levels | | | Quantity of Seepage | | | Relief Well Flow | | | | | | | | |
| Piezometer | Predicted (ft) | Observed (ft) | Location | Predicted (ft³/s/ft) | Predicted (gal/min/ft) | Predicted (ft³/s/ft) | Predicted (gal/min/ft) | Observed (gal/min/100) | | | | | | |
| CD-7 | 919.2 | 921.9 | Above Toe | 2.4E-04 | 0.1 | 1.2E-02 | 5.4 | NA | | | | | | |
| D-55 | 906.0 | ≥906 | Toe | 2.7E-03 | 1.2 | | | | | | | | | |
| D-06-28 | 919.5 | NA | D/S Blanket | 1.2E-04 | 0.1 | | | | | | | | | |
| D-06-29 | 906.1 | NA | D/S of Blanket | 2.6E-04 | 0.1 | | | | | | | | | |
| Avg. Absolute Difference (ft) = | | 1.3 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Notes: | | | | | | | | | | | | | | |
| 1. | Observed piezometric data are maximum readings during January 2005; for D-55 the ≥ symbol is used as this reading was obtained prior to tail water level preventing further measurement | | | | | | | | | | | | | |
| 2. | Relief well flow was not measured on maximum piezometric readings date due to high tail water elevation; therefore listed as NA | | | | | | | | | | | | | |
| 3. | Seepage couldn't be observed downstream of blanket due to high tail water level | | | | | | | | | | | | | |
| 4. | Piezometers D-06-28 and D-06-29 were installed during fall 2006 and therefore had not yet provided data which could be used for calibration | | | | | | | | | | | | | |
| 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) | $FS_{(effective-uplift)}$ (D/S Blanket) | | | | | | |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 906.0 | 5.45 | 92.31 | 101.54 | | | | | | |
| $i_{v max}$ (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) | | | | | | | | |
| 0.12 | 0.11 | 0.01 | 906.0 | 895.0 | 11.10 | 6.27 | | | | | | | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|-------------------------------|----------------------------|--|--|---|---|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 57+00 | 962 | 908.5 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | Relief Well Flow | | | | | |
| Piezometer | Predicted (ft) | | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | |
| CD-7 | 922.8 | | Above Toe | 4.3E-04 | 0.2 | | | |
| D-55 | 908.5 | | Toe | 3.5E-03 | 1.6 | | | |
| D-06-28 | 924.2 | | D/S Blanket | 1.4E-04 | 0.1 | | | |
| D-06-29 | 908.6 | | D/S of Blanket | 2.9E-04 | 0.1 | | | |
| | | | | | | | | |
| 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) | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Blanket) | $FS_{(\text{effective-uplift})}$ (D/S Blanket) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 908.5 | 5.99 | 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) | $FS_{(\text{progressive erosion})}$ (Under Seepage) | | |
| 0.14 | 0.10 | 0.01 | 906.0 | 895.0 | 13.54 | 6.89 | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|-------------------------------|----------------------------|--|--|---|---|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 57+00 | 964 | 908.5 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | Quantity of Seepage | Relief Well Flow | | | | | |
| Piezometer | Predicted (ft) | | Location | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | | |
| CD-7 | 924.7 | | Above Toe | 4.6E-04 | 0.2 | | | |
| D-55 | 908.5 | | Toe | 3.6E-03 | 1.6 | | | |
| D-06-28 | 924.8 | | D/S Blanket | 1.5E-04 | 0.1 | | | |
| D-06-29 | 908.6 | | D/S of Blanket | 3.1E-04 | 0.1 | | | |
| | | | | | | | | |
| 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) | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Blanket) | $FS_{(\text{effective-uplift})}$ (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) | $FS_{(\text{progressive erosion})}$ (Under Seepage) | | |
| 0.15 | 0.11 | 0.01 | 906.0 | 895.0 | 13.54 | 6.27 | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | | | | |
|--|---------------------|-------------------------------|----------------------------|-----------------------------|--|---|---|--|
| Station | Pool Elevation (ft) | Tail Elevation (ft) | | | | | | |
| 57+00 | 982 | 930 | | | | | | |
| Model Predictions | | | | | | | | |
| Piezometric Levels | | | | | | | | |
| Piezometer | Predicted (ft) | | | | | | | |
| CD-7 | 945.1 | | | | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | | |
| D-55 | 930.0 | | | | 1.0E-03 | 0.5 | | |
| D-06-28 | 945.1 | | | | 2.2E-03 | 1.0 | | |
| D-06-29 | 930.1 | | | | 1.4E-04 | 0.1 | | |
| | | | | | | Predicted ($\text{ft}^3/\text{s}/\text{ft}$) | Predicted (gal/min/ft) | |
| | | | | | | 1.4E-02 | 6.1 | |
| Quantity of Seepage | | | | | | | | |
| Relief Well Flow | | | | | | | | |
| | | | | | | | | |
| 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) | $FS_{(\text{piping})}$ (Toe) | $FS_{(\text{piping})}$ (D/S of Blanket) | $FS_{(\text{effective-uplift})}$ (D/S Blanket) |
| 120.0 | 57.6 | 33.0 | 0.92 | 0.60 | 930.0 | 6.59 | 92.31 | 101.54 |
| $i_{v \max}$ (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 | 0.09 | 0.01 | 906.0 | 895.0 | 35.10 | $FS_{(\text{progressive erosion})}$ (Under Seepage) | | |
| | | | | | | 7.58 | | |

| Bolivar Dam Seepage Analysis - Base Condition | | | | | |
|---|---------------------------|----------------------------------|--|--|--|
| Station | | | | | |
| 57+00 | | | | | |
| Model Safety Predictions Summary | | | | | |
| Pool Elevation (ft), Tail Elevation (ft) | Minimum Factors of Safety | | | | |
| 929, 888 | $FS_{(piping)} (Toe)$ | $FS_{(piping)} (D/S of Blanket)$ | $FS_{(\text{effective-uplift})} (D/S Blanket)$ | $FS_{(\text{progressive erosion})} (\text{Under Seepage})$ | |
| 929, 888 | 15.0 | 5.4 | 1015.4 | 6.2 | |
| 936, 894 | 8.6 | 4.4 | 507.7 | 5.1 | |
| 949, 896 | 6.7 | 3.6 | 203.1 | 4.1 | |
| 952, 906 | 5.4 | 92.3 | 101.5 | 6.3 | |
| 962, 908.5 | 6.0 | 92.3 | 253.8 | 6.9 | |
| 964, 908.5 | 5.4 | 92.3 | 253.8 | 6.3 | |
| 982, 930 | 6.6 | 92.3 | 101.5 | 7.6 | |

Minimum Factors of Safety Against Erosion

| Pool Elevation (ft), Tail Elevation (ft) | $FS_{(piping)} (Toe)$ | $FS_{(piping)} (D/S of Blanket)$ | $FS_{(\text{effective-uplift})} (D/S Blanket)$ | $FS_{(\text{progressive erosion})} (\text{Under Seepage})$ |
|--|-----------------------|----------------------------------|--|--|
| 929, 888 | 15.0 | 5.4 | 1015.4 | 6.2 |
| 936, 894 | 8.6 | 4.4 | 507.7 | 5.1 |
| 949, 896 | 6.7 | 3.6 | 203.1 | 4.1 |
| 952, 906 | 5.4 | 92.3 | 101.5 | 6.3 |
| 962, 908.5 | 6.0 | 92.3 | 253.8 | 6.9 |
| 964, 908.5 | 5.4 | 92.3 | 253.8 | 6.3 |
| 982, 930 | 6.6 | 92.3 | 101.5 | 7.6 |

| Model Calibration Summary | | | | | |
|--|-----------------|--|--|--|--|
| Pool Elevation (ft), Tail Elevation (ft) | Field Data Date | Avg. Absolute Difference of Predicted and Observed Piezometric Levels (ft) | Avg. Absolute Difference of Predicted and Observed Relief Well Flow (gal/min/ft) | Additional | |
| Pool = 936, Tail = 894 | Sept-2004 | 2.1 | 0.60 | Seepage noted D/S of blanket on field data dates are predicted by model; flow rates of observed seepage were not measured in field | |
| Pool = 949, Tail = 896 | Jan-1991 | 1.1 | 0.29 | | |
| Pool = 952, Tail = 906 | Jan-2005 | 1.3 | NA | | |
| | Average | 1.5 | 0.44 | | |

Notes:

- Relief wells flow was not measured on maximum piezometric readings date; therefore listed as NA