Attachment 2

Levee Designs
San Joaquin Reach 4B Levees
Appraisal Level Analysis and Design

I. General

The proposed levee system for reach 4B of the San Joaquin River (SJR) would channelize flood water flows to protect adjacent farmlands. The levee system would consist of left and right of channel levees ranging from approximately 12 miles per side to 19 miles per side based on the levee alignment. Other levee systems in the area include levees at the Chowchilla Bypass and Eastside Bypass, both maintained by the State of California and the Lower San Joaquin River Levee District.

A. Existing Levees

Original flood system levees exist on both sides of the SJR from the Sand Slough structure to the Mariposa Bypass. These levees are not system levees and no information regarding the construction or materials of these levees is available.

The levee alignment for these levees is typically very close to the original river channel. Slopes range from 1.5:1 (H:V) to 3:1 (H:V) (estimated from area topography). The levees typically range in height from approximately ground surface to 4 to 5 feet.

It is expected that if new levees will be built on the same alignment as the existing levees, the new levees will be built over the existing without degrading. If the new levees will be built on a different alignment, the material in the existing levees will likely be used as part of the fill for the new levees, dependent on the floodplain grading.

B. Regional Geology

The headwaters of the SJR originate in the high Sierra Nevada Mountains near Thousand Island Lake, California. The SJR and its tributaries drain the mountains between El Dorado and Kings Counties.

The SJR is located in two geologic provinces with the upper segment located in the Sierra Nevada Geologic Province and the lower segment moving northwest through the Central Valley Geologic Province (in which reach 4B is located). The lower SJR enters the Central Valley Geologic Province as the river exits the
SJRR Reach 4B Levee Design

Foothills near Friant Dam. The Central Valley Geologic Province is bounded on the east by the Sierra Nevada Mountain range and on the west by the Coastal Mountain range. The Central Valley Geologic Province is mostly comprised of alluvial, continental, and marine sediments that are up to thousands of feet thick.

C. Reach 4B Geology

Reach 4 of the SJR is dominated by sandy deposits with varying amounts of silt and clay. Borings for monitoring well installation throughout the area typically encounter laminated alluvial deposits with interlayered sandy clay, silty sand, and clayey sand. Thick layers of poorly graded sand are also common. The geology of the reach is likely related to the low gradient of the SJR in this reach allowing finer grained materials to deposit across the floodplain area.

D. Reach 4B Subdivisions

Subsurface data is relatively limited on the proposed levee alignments. Information typically consists of boring logs from Bureau of Reclamation monitoring well installations [1,2] and general subsurface profiles from older water well installations [3]. Based on the limited amount of data, reach 4B was subdivided into 8 sub-reaches as shown on Figure 1. The 8 sub-reaches were assumed to have similar geologic profiles to local monitoring well boring logs. Seepage and stability calculation results as well as levee section were then assumed to extend the length of the sub-reach.

II. Levee Design

A. Levee Design Criteria

Levee design criteria used for the reach 4B levees are based primarily on the U.S. Army Corps of Engineers Engineering Manual EM 1110-2-1913, “Design and Construction of Levees” [4]. Seepage estimates and mitigation measures included information from the U.S. Army Corps of Engineers Report DIVR 1110-1-400, Section 8, Change 2 “Groundwater and Seepage” [5]. Seepage design criteria were also changed from 1110-2-1913 values to meet updated criteria outlined in U.S. Army Corps of Engineers Engineering Technical Letter ETL 1110-2-569 “Design Guidance for Levee Underseepage” [6]. The design criteria outlined in the listed documents represents current design criteria.
1. **Levee Alignment**

Four levee alignment options were prepared by the Bureau of Reclamation sediment information group. Each alignment has a different setback from the river channel and was influenced by existing structures, canal alignments, property boundaries, and flood plain attributes. The four options are shown on Figure 2 and attributes of the options are listed below:

- **Option A:** Minimal setback levee constructed over existing levees.
  - Left Levee Length: 102,000 feet
  - Right Levee Length: 90,200 feet

- **Option B:** Levee setback proposed during earlier studies. Most of the levees would be setback from existing levee alignments except in the north end of the levees.
  - Left Levee Length: 77,800 feet
  - Right Levee Length: 76,400 feet

- **Option C:** Levee setback based on levee option B setbacks, however, incorporating further alignment alterations based on canal locations, bridge locations, and other physical obstacles to construction.
  - Left Levee Length: 72,800 feet
  - Right Levee Length: 66,300 feet

- **Option D:** Levee setback based on a wide floodplain and side channel model.
  - Left Levee Length: 70,200 feet
  - Right Levee Length: 65,100 feet

Levee design considerations and calculations were prepared for each levee setback option to compare costs for the various levee construction conditions.

2. **Levee Height**

Typically, levee height calculations take into account freeboard requirements over project flood water elevations, settlement of levee structures after construction, and increased levee sections for utility and road crossings. Ground surface elevations for the levee setback options were taken from LIDAR data of the area prepared for previous studies.

Water surface elevations were estimated with HEC-RAS modeling different river channel flows by the Bureau of Reclamation Sediment group. Water elevations also varied based on the levee setback option. The HEC-RAS models used 250 cross sections numbered starting at zero at the upstream end of Reach 4B and ending at 250 at the downstream end of Reach 4B. Water elevations were calculated for the following river channel flow values:
SJRR Reach 4B Levee Design

- 475 ft$^3$/s
- 1,200 ft$^3$/s
- 2,200 ft$^3$/s
- 4,500 ft$^3$/s

In order to minimize the number of levee options, the water elevation for the 4,500 ft$^3$/s flow was used for levee height design for all levee setback options. Levee height values should be adjusted if a lower project flow is ultimately used.

Levee freeboard was estimated to be 3 feet. Preliminary settlement calculations indicate typical settlement of the levee will be approximately 1 foot. The post settlement levee height will provide 2 feet of freeboard in addition to any overbuild due to ground surface elevation variations. This is estimated to be suitable freeboard due to the presence of other flood control measures (Friant Dam, Chowchilla Bypass, Eastside Bypass). The other flood control measures are expected to relatively limit uncontrolled flows into the river channel.

Levee height was then calculated to a height above ground surface at the 4,500 ft$^3$/s water elevation plus 3 feet of freeboard. This value was further rounded to the next higher round number of feet to provide a constant crest elevation. Large spikes in the calculated levee heights are assumed to be due to low ground elevation values such as canal and ditch crossings. The canal and ditch crossings were left out of the levee height calculations. Ground elevation values were not available for parts of levee setback D due to levee setback D being outside the boundaries of the available LIDAR data. Ground elevation and levee height values were estimated for these areas. Attachment A is a collection of charts that display the ground surface and water elevation for each levee setback option and side of the river channel followed by a chart of the calculated levee height including the 3 feet of freeboard. Distance along the river on the charts is represented by increasing HEC-RAS cross section ID’s.

3. Levee Slope and Crest

The levee slopes and crest width were estimated based on maintenance and inspection criteria. Levee design guidance indicates that levee slopes should be between 2:1 (H:V) and 5:1. Steeper slopes are allowed when construction materials exhibit higher cohesion values and seepage through the levee onto the downstream slope is unlikely. Shallower slopes are easier to maintain (mowing, other vegetation removal) and facilitate inspection. Levee slopes of 3:1 on the upstream and downstream slopes were chosen due to the construction materials available combined with the ease of maintenance.
Levee design guidance indicates that levee crest width should be 10 to 12 feet with occasional wider areas for turnaround. This width allows for a minimum single lane of traffic on the levee crest which is critical for levee inspection during high water events as well as allowing for travel of construction equipment during construction. Typically, the crest width of levees is increased if the crest road will be publically accessible or for increased seepage resistance. Crest widths for the project levees at the Eastside Bypass [7] vary from 12 feet to 24 feet. The crest width for the reach 4B proposed levees is 20 feet. This value is based on increased seepage resistance and ease of construction for gravel surfacing. The typical levee section with no seepage mitigation measures is shown on Figure 3.

4. **Levee Inspection Trench**

The levee inspection trench is a trench excavated beneath the center line of the levee (or offset as necessary) to provide an inspection of the geologic conditions present during construction. The individual levee lengths are up to 19 miles and even extensive subsurface exploration will not be able to fully define the subsurface profile for this length of construction. The inspection trench will be used to recognize localized areas that may be subject to increased seepage (coarse sandy zones) or subject to decreased seepage (typically clay filled meander channels). The proposed levee inspection trench for the reach 4B levees is 6 feet deep and 6 feet wide with 1:1 (H:V) side slopes.

5. **Levee Surfacing**

Levee crest surfacing for existing levees is typically either gravel surfacing or pavement. A non-surfaced levee crest typically becomes impassable due to mud during high water events. Non-surfaced levee crests are also susceptible to considerable rutting and depressions when subject to traffic, even during clear weather. Proposed levee surfacing for the reach 4B levees is 4 inches of compacted roadbase.

6. **Levee Bank Protection**

Levee setback options A and B both follow the existing river channel relatively closely. The alignment of the river and the levees in these areas indicates there is potential for erosion and scour of the levee slopes during high water events. This potential will be increased after construction of the levees until significant grassy vegetation can be established on the levee slopes. A high-performance turf reinforcement mat is proposed to protect the riverside slopes and facilitate vegetation growth after levee construction for vulnerable reaches of levee setback options A and B. Figures 4 and 5 show the proposed areas of slope protection for setback options A and B, respectively.
B. Levee Slope Stability

1. Levee Slope Stability Design Criteria

Levee slope stability was calculated using Slope/W software from Geo-Slope [8]. The current design criterion for evaluating levee slope stability is based on EM 1110-2-1913 [4]. According to design criteria, levee slope stability is calculated for the following loading scenarios:

- Case I: End of construction
- Case II: Sudden drawdown
- Case III: Steady state seepage from full flood state (fully developed phreatic surface)
- Case IV: Earthquake

Criteria for the Case IV loading (seismic) are currently under development. Additionally, the case of an earthquake occurring during a large flood event is considered to be a very remote event. Therefore; for this appraisal level design, seismic stability was not calculated.

Minimum factors of safety for the loading cases used are summarized in Table 1.

Table 1. – Minimum factor of safety values for levee slope stability

<table>
<thead>
<tr>
<th>Type of Structure</th>
<th>Applicable Stability Conditions and Required Factor of Safety Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>End of Construction</td>
</tr>
<tr>
<td>New Levee</td>
<td>1.3</td>
</tr>
<tr>
<td>Existing Levee</td>
<td>N/A</td>
</tr>
<tr>
<td>Other Embankments and Dikes</td>
<td>1.3</td>
</tr>
</tbody>
</table>

* F.S. of 1.0 applies to pool levels prior to drawdown for conditions where these water levels are unlikely to persist for long periods preceding drawdown. F.S. of 1.2 applies to pool levels likely to persist for long periods prior to drawdown.

2. Levee Slope Stability Sections

Slope stability sections for the left levee of each levee setback option were used. The right levee section does not change from the left levee and slope stability was
not calculated for right levee sections. Levee slope stability was also calculated for different sub-reaches to evaluate the effect of differing geologic profiles. The levee slope stability sections used include:

- Levee Setback Option A
  - Sub-reach 2
  - Sub-reach 8
- Levee Setback Option B
  - Sub-reach 6
  - Sub-reach 7
- Levee Setback Option C
  - Sub-reach 1
- Levee Setback Option D
  - Sub-reach 3

3. **Levee Slope Stability Material Properties**

Levee slope stability material properties were estimated based on laboratory test results from samples taken during monitoring well installations in reach 4B. The estimate was supplemented by shear strength test results on samples from the San Luis Drain project [9], which is located approximately 18 to 20 miles south of reach 4B. The material properties estimated include soil unit weight, effective stress friction angle and cohesion and undrained friction angle (zero) and cohesion. The material properties were used in the analyses as directed by levee design guidance:

- **Case I: End of Construction**
  - Use undrained strengths for impervious embankment materials
- **Case II: Sudden Drawdown**
  - Use the lowest strength (drained or undrained) at the base of each slice. Typically chosen by calculating the shear resistance at the base of each slice for drained and undrained strengths and then using the lowest strength based on the lowest shear resistance
- **Case III: Steady State Seepage**
  - Use drained (effective) strengths for all materials. Residual strengths should be used if previous deformation has occurred.

The material properties used for the reach 4B slope stability modeling are listed in Table 2.
Table 2. – Reach 4B slope stability material properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Unit Weight $\gamma$ (pcf)</th>
<th>Phi Angle (degrees)</th>
<th>Cohesion (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levee Fill (drained)</td>
<td>115</td>
<td>28</td>
<td>100</td>
</tr>
<tr>
<td>Levee Fill (undrained)</td>
<td>118</td>
<td>0</td>
<td>300</td>
</tr>
<tr>
<td>Sandy Silt or Silty Sand (drained)</td>
<td>118</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>Sandy Silt or Silty Sand (undrained)</td>
<td>118</td>
<td>16</td>
<td>100</td>
</tr>
<tr>
<td>Lean Clay (drained)</td>
<td>112</td>
<td>28</td>
<td>300</td>
</tr>
<tr>
<td>Lean Clay (undrained)</td>
<td>112</td>
<td>0</td>
<td>300</td>
</tr>
<tr>
<td>Poorly Graded Sand (drained and undrained)</td>
<td>128</td>
<td>35</td>
<td>0</td>
</tr>
</tbody>
</table>

4. Levee Slope Stability Results

The results of the slope stability modeling are listed in Table 3. Annotated cross sections from the stability modeling are included in Attachment B. The factor of safety was calculated using Spencer’s method and circular failure surfaces for each cross-section. All factors of safety calculated meet or exceed the required factor of safety value from the design guidance.
## Table 3. – Reach 4B slope stability results

<table>
<thead>
<tr>
<th>Cross Section ID</th>
<th>Case I: End of Construction</th>
<th>Case II: Sudden Drawdown</th>
<th>Case III: Steady State Seepage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FS (U/S)*</td>
<td>FS (D/S)*</td>
<td>FS (Req)*</td>
</tr>
<tr>
<td>Levee Option A, Sub-Reach 2</td>
<td>2.9</td>
<td>2.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Levee Option A, Sub-Reach 8</td>
<td>2.8</td>
<td>2.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Levee Option B, Sub-Reach 6</td>
<td>3.5</td>
<td>3.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Levee Option B, Sub-Reach 7</td>
<td>2.8</td>
<td>2.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Levee Option C, Sub-Reach 1</td>
<td>3.7</td>
<td>3.7</td>
<td>1.3</td>
</tr>
<tr>
<td>Levee Option D, Sub-Reach 3</td>
<td>2.8</td>
<td>2.8</td>
<td>1.3</td>
</tr>
</tbody>
</table>

* U/S is failure surface on the upstream (riverside) slope of the levee  
  D/S is failure surface on the downstream (landside) slope of the levee  
  Req is the required factor of safety value from the design guidance

### C. Levee Seepage

Levee seepage and seepage mitigation measures have been studied since approximately 1940. Uncontrolled seepage beneath levees can result in the formation of sand boils, degradation of the levee crest and eventual failure. Certain foundation conditions including thick deposits of sandy materials can make seepage conditions worse. Existing levees in the Central Valley and the Sacramento-San Joaquin Delta have a history with multiple levee breaches caused by a multitude of issues, a primary one being seepage. Therefore, seepage investigation and mitigation is expected to be a primary concern for the design and construction of the reach 4B levees.
SJRR Reach 4B Levee Design

1. **Levee Seepage Design Criteria**

Seepage control measures for levee underseepage and through seepage include:

- Cutoff trenches
- Riverside impervious blankets
- Landside seepage berms
- Pervious toe trenches
- Pressure relief wells

Design calculations for seepage include estimating the exit gradient at the toe of the levee and determining the factor of safety versus uplift based on the exit gradient and unit weight of the in-situ soils. Recommended design limits for the estimated parameters include:

- For a computed upward gradient at the levee toe less than 0.5, no seepage mitigation is required unless severe seepage is expected or other considerations require seepage mitigation construction (for instance, continuing a seepage berm across small gaps to facilitate uniform construction).
- For a computed upward gradient at the levee toe of 0.5 to 0.8, seepage mitigation measures should be designed to reduce the exit gradient to 0.5 at the toe of the levee. If a seepage berm is used in this case, it should meet design requirements for a minimum seepage berm unless design calculations indicate otherwise.
- For a computed upward gradient at the levee toe greater than 0.8, seepage mitigation measures should be designed to reduce the exit gradient to 0.5 at the toe of the levee. If a seepage berm is used for this case, the factor of safety versus uplift at the toe of the seepage berm should be verified after seepage berm design.

For the proposed reach 4B levees, seepage calculations were performed according to the guidelines defined in Appendix B of EM 1110-2-1913 [4]. The calculations included distance to the river (point of effective seepage entrance), distance to the effective seepage exit, and the exit gradient at the toe of the levee as shown on Figure B-1 (from EM 1110-2-1913 [4]).
2. **Levee Seepage Material Properties**

The primary material properties used for the seepage calculations include:

- Estimated hydraulic conductivity of the blanket (low permeability) material
- Estimated hydraulic conductivity of the pervious stratum
- Thickness of the blanket layer (transformed as described in Appendix B)

The hydraulic conductivity of the blanket material and the pervious material was estimated based on permeability tests on material at the San Luis drain site [9] and material descriptions from the monitoring well installations at reach 4B. Typically, the ratio between the blanket conductivity and the pervious layer conductivity was kept to a round number to facilitate the calculations. Typical estimated values for hydraulic conductivity by material are:

- High plasticity clay: 0.0028
- Lean clay or sandy clay: 0.028 to 0.0567 feet/day
- Lean clay interlayered with silty sand: 0.28 feet/day
- Poorly graded sand: 14 to 28 feet/day

Blanket material thicknesses were estimated based on the nearest boring log information. Materials estimated to be significantly lower permeability than the poorly graded sand pervious materials included high and low plasticity clays, silty clays and sands and clayey sands. Typically, silty sands at the top of the poorly graded sands layer were also included in the blanket thickness.
3. **Levee Seepage Results**

Levee seepage calculations are included in Attachment C. Exit gradient values for the calculations are listed in Table 4.

Table 4. – Reach 4B calculated levee exit gradient values

<table>
<thead>
<tr>
<th>Levee Setback Option</th>
<th>Exit Gradient at the Levee Toe by Sub-Reach</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Option A, Left</td>
<td>0.29</td>
</tr>
<tr>
<td>Option A, Right</td>
<td>0.29</td>
</tr>
<tr>
<td>Option B, Left</td>
<td>0.09</td>
</tr>
<tr>
<td>Option B, Right</td>
<td>0.38</td>
</tr>
<tr>
<td>Option C, Left</td>
<td>0.05</td>
</tr>
<tr>
<td>Option C, Right</td>
<td>0.28</td>
</tr>
<tr>
<td>Option D, Left</td>
<td>0.16</td>
</tr>
<tr>
<td>Option D, Right</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Exit gradients exceeded 0.5 for every setback option for at least one sub-reach. Lower exit gradients were observed in several sub-reaches for setback options C and D due to the increased distance to the effective seepage entry point.

D. **Seepage Mitigation Calculations**

Exit gradients at the toe of the levee exceeded 0.5 for several sub-reaches in the different levee setback options. Design guidance indicates that seepage mitigation measures should be used when the exit gradient exceeds 0.5. Additionally, boring information for sub-reach 7 indicates that the presence of a thin, very low permeability blanket layer overlying a very thick, very permeable layer. This situation was considered very susceptible to seepage damage and seepage mitigation was deemed necessary for this sub-reach regardless of calculation results.

Of the various seepage mitigation techniques, seepage berms and cut-off walls are likely to be the most cost effective measures. These seepage mitigation measures were designed and cost estimated where needed for the levee options.
1. **Seepage Berm Design**

The seepage berms were designed to meet criteria from Appendix C of EM 1110-2-1913 [4]. The seepage berm design also meets minimum criteria from ETL 1110-2-569 [6]. The seepage berm design for the proposed reach 4B levees assumes that the seepage berm will be semi-pervious based on the sandy materials available for construction.

The seepage berm design was based on reducing exit gradients at the toe of the levee to 0.5. Generally for reach 4B, the calculated berm design resulted in very narrow seepage berms from approximately 1 to 16 feet wide. In these cases, design guidance indicates that a minimum seepage berm should be used with the following characteristics:

- Width equal to four times the height of the levee
- A minimum thickness at the levee toe of 5 feet
- A minimum thickness at the berm crown of 2 feet
- All seepage berms should incorporate overbuild to account for consolidation and settlement of the seepage berm

The design guidance from EM 1110-2-1913 suggests that overbuild should be 25% to account for consolidation and settlement. This value may be changed based on settlement calculations for the design material, however; for this appraisal level design, 25% was utilized due to a lack of specific material information.

Based on the design criteria, seepage berms designed for the proposed reach 4B levees range from 25 to 35 feet wide, are 6.25 feet thick at the levee toe, generally 5.5 feet thick at the crown and are sloped 40:1 (H:V) to drain. The typical levee section with a minimum seepage berm is shown on Figure 6. The exception to this design is left levee setback option A in sub-reach 8. Calculations indicated a smaller berm, however, seepage modeling indicated the need for a wider berm. For this reach, a 300 foot wide berm was chosen based on the geologic conditions.

2. **Slurry Wall Design**

The alternate option for seepage mitigation is a soil-bentonite slurry cut-off wall. The slurry wall cut-off design required several general assumptions including:

- The slurry wall is 3 feet wide
- The slurry wall is nearly impervious
- The slurry wall increases the seepage path twice the depth of the slurry wall
The slurry wall depth was adjusted to reduce the exit gradient at the toe of the levee to 0.5. The exception to this occurred when boring logs indicated a low permeability layer available at a depth shallower than required to reach an exit gradient of 0.5. For these cases, the slurry wall was assumed to key 3 feet into the low permeability layer. The slurry wall design also assumed a minimum depth of 15 feet into the levee foundation would be required for cut-off if the design depth indicated shallower cut-off depths. The typical levee section with a minimum slurry wall cut-off is shown on Figure 7.

The slurry wall assumed design depths range from 15 to 78 feet. The 78 foot depth is a theoretical depth that would not be achievable through conventional construction methods. This area would require further subsurface characterization to evaluate the cut-off depth. The cut-off wall is included for cost estimating purposes.
References


Figures
Figure 1:
Monitoring Well Locations and Levee Design Reach Boundaries

Explanation
- Monitoring Well Locations
- Reach Boundaries
- Setback Option A
- Setback Option B
- Setback Option C
- Setback Option D

For Information Only
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San Joaquin River Restoration
Levee Typical Section

Figure 3: Levee Typical Section

- Lean Clay
- Poorly Graded Sand
- Silty Sand or Sandy Silt

Distance

Elevation

San Joaquin River

Inspection Trench
Figure 4:
Setback Option A Bank Protection

Explanation
- Option A Bank Protection

Legend:
- Draft
  - For Information Only
  - Do Not Distribute
Figure 5:
Setback Option B Bank Protection

Explanation

Option B Bank Protection

Draft
For Information Only
Do Not Distribute
Figure 6: Levee Typical Section with Landside Seepage Berm

San Joaquin River Restoration
Levee Typical Section
Landside Seepage Berm

- Lean Clay
- Poorly Graded Sand
- Silty Sand or Sandy Silt
San Joaquin River Restoration
Levee Typical Section
Slurry Cut-off Wall

Figure 7: Levee Typical Section with Slurry Cut-off Wall
Attachment A

Water Elevation

And

Levee Height
Note: Levee height assumes 3 feet of freeboard.
Note: Levee height assumes 3 feet of freeboard.
Left Levee Setback Option B

Elevation, feet

HEC-RAS Cross Section ID

- Water Surface Elevation, 475 cfs
- Water Surface Elevation, 1200 cfs
- Water Surface Elevation, 2200 cfs
- Water Surface Elevation, 4500 cfs
- Ground Surface Elevation
Note: Levee height assumes 3 feet of freeboard
Right Levee Setback Option B

Elevation, feet

HEC-RAS Cross Section ID

- Water Surface Elevation, 475 cfs
- Water Surface Elevation, 1200 cfs
- Water Surface Elevation, 2200 cfs
- Water Surface Elevation, 4500 cfs
- Ground Surface Elevation
Right Levee Height, Option B

Note: Levee height assumes 3 feet of freeboard.
Note: Levee height assumes 3 feet of freeboard.
Right Levee Setback Option C

- Water Surface Elevation, 475 cfs
- Water Surface Elevation, 1200 cfs
- Water Surface Elevation, 2200 cfs
- Water Surface Elevation, 4500 cfs
- Ground Surface Elevation

HEC-RAS Cross Section ID
Right Levee Height, Option C

3 miles

Note: Levee height assumes 3 feet of freeboard.
Left Levee Setback Option D

- Water Surface Elevation, 475 cfs
- Water Surface Elevation, 1200 cfs
- Water Surface Elevation, 2200 cfs
- Water Surface Elevation, 4500 cfs
- Ground Surface Elevation

HEC-RAS Cross Section ID
Note: Levee height assumes 3 feet of freeboard.
Right Levee Setback Option D

Elevation, feet

0 50 100 150 200 250 300

HEC-RAS Cross Section ID

Water Surface Elevation, 475 cfs
Water Surface Elevation, 1200 cfs
Water Surface Elevation, 2200 cfs
Water Surface Elevation, 4500 cfs
Ground Surface Elevation
Right Levee Height, Option D

Note: Levee height assumes 3 feet of freeboard.
Attachment B

Levee Slope Stability Sections
Flux across levee: 0.6230037 ft³/days

San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2

Steady Seepage at Flood Elevation

head at base of blanket: 102.18964 ft
i at toe of levee = 0.354
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2
Seepage Berm

Flux across levee: 0.56949562 ft³/days

Steady Seepage at Flood Elevation

Total Head: 102.16709 ft

i at toe of berm = 0.352
San Joaquin River Restoration
Levee Option A
Levee Reach Number 2

End of Construction Stability
Factor of Safety: 2.903

<table>
<thead>
<tr>
<th>Name</th>
<th>Unit Weight</th>
<th>Cohesion</th>
<th>Phi</th>
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</thead>
<tbody>
<tr>
<td>Levee Fill Undrained</td>
<td>118 pcf</td>
<td>300 psf</td>
<td>28°</td>
</tr>
<tr>
<td>Lean Clay</td>
<td>112 pcf</td>
<td>300 psf</td>
<td>28°</td>
</tr>
<tr>
<td>Sandy Silt or Silty Sand</td>
<td>118 pcf</td>
<td>0 psf</td>
<td>32°</td>
</tr>
<tr>
<td>Poorly Graded Sand</td>
<td>128 pcf</td>
<td>0 psf</td>
<td>35°</td>
</tr>
</tbody>
</table>
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2
Downstream Slope Stability
Factor of Safety: 2.533
Steady Seepage at Flood Elevation

Distance
-700 -650 -600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400 450 500 550

Elevation
-100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600

2.533
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2
Upstream Slope Stability
Factor of Safety: 3.565
Steady Seepage at Flood Elevation

Distance

Elevation

-100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700

-700 -650 -600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700

3.565
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2
Rapid Drawdown Stability
Factor of Safety: 2.060

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °
Drawdown Total Cohesion: 100 psf
Drawdown Total Phi: 16 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35 °
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2
Rapid Drawdown Stability
Factor of Safety: 1.880

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °
Drawdown Total Cohesion: 100 psf
Drawdown Total Phi: 16 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35 °
Flux across levee: 3.4342037 ft³/days

San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8

Steady Seepage at Flood Elevation
head at base of blanket: 93.170257 ft
i at toe of levee = 1.22
Flux across levee: 3.4342037 ft³/days

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1
K-Direction: 0°

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6
K-Direction: 0°

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1
K-Direction: 0°

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
K-Direction: 0°
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8

Steady Seepage at Flood Elevation

head at base of blanket: 92.947186 ft
i at toe of berm = 1.133
Flux across levee: 3.0299383 ft³/days

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1
K-Direction: 0 °

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6
K-Direction: 0 °

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1
K-Direction: 0 °

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
K-Direction: 0 °
Flux across levee: 1.6726802 ft³/days

San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8

Steady Seepage at Flood Elevation
head at base of blanket: 91.431553 ft
i at toe of levee = 0.55
Flux across levee: 1.6726802 ft³/days

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1
K-Direction: 0°

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6
K-Direction: 0°

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1
K-Direction: 0°

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.75
K-Direction: 0°
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8
End of Construction Stability
Factor of Safety: 2.789
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8
End of Construction Stability
Factor of Safety: 2.780

Silty Sand or Sandy Silt
End of Construction Stability
Silty Sand or Sandy Silt
Poorly Graded Sand

Name: Levee Fill Undrained
Model: Undrained (\(\Phi_e=0\))
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
\(\Phi_e: 32^\circ\)

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
\(\Phi_e: 35^\circ\)
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8
Downstream Slope Stability
Factor of Safety: 1.922

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8
Factor of Safety: 2.616

Upstream Slope Stability
Steady Seepage
Factor of Safety: 2.616

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28°

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32°

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28°

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35°
San Joaquin River Restoration
Levee Option A
Reach Number 8
Rapid Drawdown Stability
Factor of Safety: 2.693

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Sandy Silt or Silty Sand
Unit Weight: 119 pcf
Cohesion: 0 psf
Phi: 32 °
Drawdown Total Cohesion: 100 psf
Drawdown Total Phi: 16 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35 °
Flux across levee: 0.80438761 ft³/days

San Joaquin River Restoration
Levee Option B
Reach Number 6

Steady Seepage at Flood Elevation

head at base of blanket: 97.233765 ft

i at toe of levee = 0.771

Silty Sand or Sandy Silt
4:1 Vertical Exaggeration

Poorly Graded Sand
Lean Clay

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5

Distance
-600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700
Elevation
69 74 79 84 89 94 99 104 109 114 119 124 129 134 139 144

Flux across levee: 0.80438761 ft³/days
Steady Seepage at Flood Elevation

Flux across levee: 0.75197405 ft³/days

Head at base of blanket: 97.227698 ft

i at toe of berm = 0.767

Silty Sand or Sandy Silt
Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Lean Clay
Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Silty Sand or Sandy Silt
Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5

Distance

Elevation
Flux across levee: 0.79581994 ft³/days

San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 6

Steady Seepage at Flood Elevation
Head at base of blanket: 97.225086 ft
i at toe of levee = 0.765
Flux across levee: 0.79581994 ft³/days

Silty Sand or Sandy Silt

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
San Joaquin River Restoration
Levee Option B
Reach Number 6
End of Construction Stability
Factor of Safety: 3.539

Name: Levee Fill Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °

4:1 Vertical Exaggeration
### San Joaquin River Restoration

**Levee Option B**

**Reach Number 6**

**Downstream Slope Stability**

**Factor of Safety:** 2.738

#### Material Properties

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Unit Weight</th>
<th>Cohesion</th>
<th>Phi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levee Fill</td>
<td>115 pcf</td>
<td>0 psf</td>
<td>28°</td>
</tr>
<tr>
<td>Lean Clay</td>
<td>112 pcf</td>
<td>300 psf</td>
<td>28°</td>
</tr>
<tr>
<td>Silty Sand or Sandy Silt</td>
<td>118 pcf</td>
<td>0 psf</td>
<td>32°</td>
</tr>
<tr>
<td>Poorly Graded Sand</td>
<td>128 pcf</td>
<td>0 psf</td>
<td>35°</td>
</tr>
</tbody>
</table>

#### Distance and Elevation

<table>
<thead>
<tr>
<th>Distance (feet)</th>
<th>Elevation (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-600</td>
<td>69</td>
</tr>
<tr>
<td>-550</td>
<td>74</td>
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<tr>
<td>-500</td>
<td>79</td>
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<td>84</td>
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<td>-400</td>
<td>89</td>
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<td>-350</td>
<td>94</td>
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<td>-300</td>
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<td>109</td>
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<td>-100</td>
<td>119</td>
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<tr>
<td>100</td>
<td>139</td>
</tr>
<tr>
<td>150</td>
<td>144</td>
</tr>
</tbody>
</table>

#### 4:1 Vertical Exaggeration

Elevation: 69, 74, 79, 84, 89, 94, 99, 104, 109, 114, 119, 124, 129, 134, 139, 144
San Joaquin River Restoration
Levee Option B
Reach Number 6

Factor of Safety: 3.246

Upstream Slope Stability

Silty Sand or Sandy Silt

4:1 Vertical Exaggeration

Poorly Graded Sand

Lean Clay

Silty Sand or Sandy Silt

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
<table>
<thead>
<tr>
<th>Material Type</th>
<th>Unit Weight</th>
<th>Cohesion</th>
<th>Phi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levee Fill</td>
<td>115 pcf</td>
<td>100 psi</td>
<td>28°</td>
</tr>
<tr>
<td>Sandy Silt or Silty Sand</td>
<td>118 pcf</td>
<td>0 psi</td>
<td>32°</td>
</tr>
<tr>
<td>Lean Clay</td>
<td>112 pcf</td>
<td>300 psi</td>
<td>28°</td>
</tr>
<tr>
<td>Poorly Graded Sand</td>
<td>128 pcf</td>
<td>0 psi</td>
<td>35°</td>
</tr>
</tbody>
</table>

San Joaquin River Restoration
Levee Option B
Reach Number 6
Rapid Drawdown Stability
Factor of Safety: 2.655

Distance
-600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700

Elevation
69 74 79 84 89 94 99 104 109 114 119 124 129 134 139 144
San Joaquin River Restoration
Levee Option B
Reach Number 6

Rapid Drawdown Stability
Factor of Safety: 2.538
4:1 Vertical Exaggeration

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °

Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Drawdown Total Cohesion: 100 psf
Drawdown Total Phi: 16 °

Name: Poorly Graded Sand
Unit Weight: 128 psf
Cohesion: 0 psf
Phi: 35 °

Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35 °
Flux across levee: 0.74097207 ft³/days

San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7

Steady Seepage at Flood Elevation
head at base of blanket: 95.388988 ft
i at toe of levee = 0.459
Flux across levee: 0.74097207 ft³/days

4:1 Vertical Exaggeration

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
Flux across levee: 0.69160922 ft³/days

San Joaquin River Restoration
Levee Option B
Reach Number 7

Left Levee
Steady Seepage at Flood Elevation
head at base of blanket: 95.362707 ft
i at toe of levee = 0.454
Silty Sand or Sandy Silt
4:1 Vertical Exaggeration

K-Function: LeveeFill
K-Ratio: 1

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5

Distance
Elevation

67 72 77 82 87 92 97 102 107 112 117 122 127 132 137 142
-600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400
Flux across levee: 0.73595452 ft³/days

San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7

Steady Seepage at Flood Elevation
head at base of blanket: 95.386671 ft
i at toe of levee = 0.459
Flux across levee: 0.73595452 ft³/days

Silty Sand or Sandy Silt
4:1 Vertical Exaggeration

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7
End of Construction Stability
Factor of Safety: 2.798

Name: Levee Fill Undrained
Model: Undrained (Φ=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Φ: 32°

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Φ: 28°

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Φ: 35°

4:1 Vertical Exaggeration
San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7
End of Construction Stability
Factor of Safety: 2.787

4:1 Vertical Exaggeration

Name: Levee Fill Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
San Joaquin River Restoration
Levee Option B
Reach Number 7

Downstream Slope Stability
Factor of Safety: 2.307

4:1 Vertical Exaggeration

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 26 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7
Upstream Slope Stability
Factor of Safety: 2.486

4.1 Vertical Exaggeration

Distance
-600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400

Elevation
67 72 77 82 87 92 97 102 107 112 117 122 127 132 137 142

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °
San Joaquin River Restoration
Levee Option B
Left Levee Reach Number 7
Rapid Drawdown Stability
Factor of Safety: 2.368

Silty Sand or Sandy Silt
- Unit Weight: 118 pcf
- Cohesion: 0 psf
- Phi: 32 °
- Drawdown Total Cohesion: 100 psf
- Drawdown Total Phi: 16 °

Lean Clay
- Unit Weight: 112 pcf
- Cohesion: 300 psf
- Phi: 28 °
- Drawdown Total Cohesion: 300 psf
- Drawdown Total Phi: 0 °

Poorly Graded Sand
- Unit Weight: 128 pcf
- Cohesion: 0 psf
- Phi: 35 °
- Drawdown Total Cohesion: 0 psf
- Drawdown Total Phi: 35 °

Levee Fill
- Unit Weight: 115 pcf
- Cohesion: 100 psf
- Phi: 28 °
- Drawdown Total Cohesion: 300 psf
- Drawdown Total Phi: 0 °

Rapid Drawdown Stability Factor of Safety: 2.368
San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7
Rapid Drawdown Stability
Factor of Safety: 2.307

4:1 Vertical Exaggeration

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °
Drawdown Total Cohesion: 100 psf
Drawdown Total Phi: 16 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35 °

Distance
Elevation
Flux across levee: 0.30109417 ft³/days

San Joaquin River Restoration
Levee Option C
Left Levee
Reach Number 1

Steady Seepage at Flood Elevation
head at base of blanket: 105.32979 ft
i at bottom of ditch = 0.721

Silty Sand or Sandy Silt
6:1 Vertical Exaggeration
Flux across levee: 0.30109417 ft³/days

Lean Clay
Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Poorly Graded Sand
Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
San Joaquin River Restoration
Levee Option C
Left Levee
Reach Number 1

Downstream Slope Stability
Factor of Safety: 3.263

6:1 Vertical Exaggeration

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
San Joaquin River Restoration
Levee Option C
Left Levee
Reach Number 1
Upstream Slope Stability
Factor of Safety: 3.215

Upstream Slope Stability
Silty Sand or Sandy Silt

6:1 Vertical Exaggeration
Lean Clay
Poorly Graded Sand
Silty Sand or Sandy Silt

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °

Distance (x 1000)
-0.50 -0.45 -0.40 -0.35 -0.30 -0.25 -0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00

Elevation
76 81 86 91 96 101 106 111 116 121 126 131 136 141 146 151

3.215
San Joaquin River Restoration

Levee Option C
Left Levee
Reach Number 1

Rapid Drawdown Stability
Factor of Safety: 2.655

Silty Sand or Sandy Silt

- Unit Weight: 118 pcf
- Cohesion: 0 psf
- Phi: 32 °
- Drawdown Total Cohesion: 100 psf
- Drawdown Total Phi: 16 °

Lean Clay

- Unit Weight: 112 pcf
- Cohesion: 300 psf
- Phi: 28 °
- Drawdown Total Cohesion: 300 psf
- Drawdown Total Phi: 0 °

Sandy Silt or Silty Sand

- Unit Weight: 115 pcf
- Cohesion: 100 psf
- Phi: 28 °
- Drawdown Total Cohesion: 300 psf
- Drawdown Total Phi: 0 °

Poorly Graded Sand

- Unit Weight: 128 pcf
- Cohesion: 0 psf
- Phi: 35 °
- Drawdown Total Cohesion: 0 psf
- Drawdown Total Phi: 35 °
Flux across levee: 1.1064288 ft³/days

San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3
Steady Seepage at Flood Elevation

head at base of blanket: 98.145779 ft
i at toe of levee = 0.438
Flux across levee: 1.1064288 ft³/days

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5

Distance (x 1000)

-0.5 -0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5

Elevation

75 80 85 90 95 100 105 110 115 120 125

8.1 Vertical Exaggeration
San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3
End of Construction Stability
Factor of Safety: 2.797

Name: Levee Fill Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3
End of Construction Stability
Factor of Safety: 2.785

8:1 Vertical Exaggeration

Name: Levee Fill Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32°

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28°

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35°
San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3

Downstream Slope Stability
Factor of Safety: 2.232
8:1 Vertical Exaggeration

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Φn: 28 °

Name: Sandy Silt or Silty Sand
Unit Weight: 116 pcf
Cohesion: 0 psf
Φn: 32 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Φn: 28 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Φn: 35 °
San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3

Factor of Safety: 2.695

Upstream Slope Stability
Silty Sand or Sandy Silt
8:1 Vertical Exaggeration
Lean Clay
Poorly Graded Sand
Lean Clay
Silty Sand or Sandy Silt

Distance (x 1000)

Elevation

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Distance (x 1000)
San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3
Rapid Drawdown Stability
Factor of Safety: 2.318
8.1 Vertical Exaggeration

Silty Sand or Sandy Silt
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °
Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °
Drawdown Total Cohesion: 100 psf
Drawdown Total Phi: 16 °

Lean Clay

Poorly Graded Sand
Unit Weight: 112 pcf
Cohesion: 0 psf
Phi: 35 °
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35 °

Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °
Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35 °
San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3

Rapid Drawdown Stability
Factor of Safety: 2.077

8:1 Vertical Exaggeration

Unit Weight: 115 pcf
Cohesion: 100 psf
phi: 28°
Drawdown Total Cohesion: 300 psf
Drawdown Total phi: 0°

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
phi: 32°
Drawdown Total Cohesion: 100 psf
Drawdown Total phi: 16°

Unit Weight: 112 pcf
Cohesion: 0 psf
phi: 35°
Drawdown Total Cohesion: 0 psf
Drawdown Total phi: 35°
Attachment C

Levee Seepage Calculations

And

Seepage Berm and Slurry Wall Design
| Project Segment | H Riverside Borrow Pit | X1 ft | X2 ft | S ft | El Flow Line | Seepage Exit Case | El LS Ground | El Tailwater | Z1 ft | Soil Type | Xo (ft/day) | Kf (ft/day) | D ft | Kf/Kf* | C=(Kf/Kf*ZD)^0.5 | X3 ft | L ft | Z ft | n ft | h0/Zt | \( h0/Zt \) | 1 | 2 | 3 | 4 |
|----------------|-----------------------|-------|-------|------|-------------|------------------|--------------|--------------|-------|-----------|------------|-------------|------|--------|---------------------|-------|-----|-----|-----|------|---------|----|----|----|----|-----|--------|
| 1             | 227+38                | 242+49| 95    | 2    | 9.99884    | 10              | 56           | 15.99789    | 105   | 2         | 102        | 102         | 3    | 9.92/L | 0.002835                               | 2.85  | 17.5| 600 | 0.00251976 | 996.8627 | 9     | 2.57/22976 | 0.26984 |
| 3             | 224+49                | 240+83| 95    | 1.8   | 125.95572 | 16              | 56           | 71.95572    | 103.9 | 2         | 99         | 99          | 4.9  | 5.8/L/ML | 0.02835                               | 14.17 | 110 | 499.8286 | 0.01730849 | 564.7012 | 8    | 4.3453923 | 0.54324 |
| 3             | 540+83                | 550+65| 95    | 0     | 28.60243  | 30              | 68           | 36.60243    | 100.1 | 1         | 96         | 96          | 4.1  | 4.96/L/LM | 0.2835                               | 28.35 | 15.2| 100 | 0.012824729 | 77.93435 | 4.9  | 1.831256 | 0.373724 |
| 4             | 550+65                | 564+96| 92    | 0     | 49.97314  | 50              | 50           | 105.9731    | 99    | 2         | 96         | 96          | 3    | 15.3/L | 0.002835                               | 2.85  | 100 | 6000 | 0.000310219 | 1244.99 | 19.6 | 2.7646732 | 0.141055 |
| 4             | 664+98                | 768+50| 88    | 0     | 39.84051  | 80              | 56           | 115.8405    | 100   | 2         | 97         | 97          | 3    | 9/L/C  | 0.0567                               | 28.35 | 100 | 500  | 0.01490712 | 670.8204 | 11.4 | 2.5582323 | 0.224485 |
| 5             | 664+98                | 768+50| 88    | 0     | 39.84051  | 80              | 56           | 115.8405    | 100   | 2         | 97         | 97          | 3    | 9/L/C  | 0.0567                               | 28.35 | 100 | 500  | 0.01490712 | 670.8204 | 11.4 | 2.5582323 | 0.224485 |
| 6             | 768+50                | 990+47| 89    | 0     | 36.18928  | 100             | 62           | 118.1893    | 99.1   | 1         | 96         | 96          | 3.1  | 1.7/L/SM | 0.2835                               | 28.35 | 21.3| 100 | 0.016540792 | 60.4568 | 1.7  | 1.094089 | 0.617311 |
| 6             | 990+47                | 983+69| 86    | 0     | 138.2671  | 140             | 62           | 220.2671    | 96    | 2         | 93         | 93          | 3    | 5.2/L/CL | 0.02835                               | 28.35 | 100 | 6000 | 0.00138675 | 721.1102 | 5.2  | 2.347911 | 0.451525 |
| 8             | 983+69                | 928+39| 83    | 0     | 39.976238 | 10              | 62           | 71.97628    | 93.8   | 7         | 90         | 90          | 3.8  | 1.4/L/CL | 0.2835                               | 28.35 | 100 | 100  | 0.08451549  | 118.3216 | 2.6  | 2.526728 | 0.908742 |

**Levee Station**

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**Conditions**: Landside

**Levee**: Left

**Option**: A
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Based on geostudios model.
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**Right Levee Option A**

- **Estimated Slurry Cutoff Depth**
- **No cutoff required**
- **Marginal Reach, use minimum cutoff wall**
- **Modified**
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<th>Soil Type</th>
<th>X± ft</th>
<th>Y± ft</th>
<th>El</th>
<th>Seepage Exit Case</th>
<th>El</th>
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<th>m ft</th>
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Design Values indicate using minimum berm
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**Left Levee Option B**

Levee station Estimated Slurry Cutoff Depth

- No cutoff required
- No cutoff required
- No cutoff required
- No cutoff required
- No cutoff required
- No cutoff required
- No cutoff required
- No cutoff required
- No cutoff required
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Marginal reach, use minimum cutoff wall.
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Levee Station: Semi Pervious Berm Design Values or Minimum Berm Design Values; Final Recommended Berm Dimensions.

Marginal Reach, Minimum Berm Not Recommended.
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- **Landside Conditions:**
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### Notes
- Project: Semi Porous Berm Design Values or Minimum Berm Design Values
- Final Recommended Berm Dimensions
- Design indicates using minimum berm
- Marginal Reach, Minimum Berm Needed
- No Berm Needed
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**Project:** Right Levee Option D

**Levee Station: Riverside Conditions**

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- Marginal Reach, use minimum cutoff wall
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Reach 2
Reach 3
Reach 4
Reach 5
Reach 6
Reach 7
Reach 8

Monitoring Well Locations
Reach Boundaries
Setback Option A
Setback Option B
Setback Option C
Setback Option D

For Information Only
Do Not Distribute

Figure 1:
Monitoring Well Locations And Levee Design Reach Boundaries
Figure 2: Levee Option Map

**Explanation**

- **Setback Option A**
- **Setback Option B**
- **Setback Option C**
- **Setback Option D**

Legend:

- **N**

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Do Not Distribute
San Joaquin River Restoration
Levee Typical Section

Figure 3: Levee Typical Section

- Distance: -100 -75 -50 -25 0 25 50 75 100
- Elevation: 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140

- Lean Clay
- Poorly Graded Sand
- Silty Sand or Sandy Silt
- San Joaquin River

Inspection Trench
20 feet
3:1
Figure 4:
Setback Option A Bank Protection

Explanation

- Option A Bank Protection

Scale: 0 5,000 10,000 Feet

Draft
For Information Only
Do Not Distribute
Figure 5:
Setback Option B Bank Protection

Explanation
- Option B Bank Protection

Draft
For Information Only
Do Not Distribute
San Joaquin River Restoration
Levee Typical Section
Landside Seepage Berm

Figure 6: Levee Typical Section with Landside Seepage Berm
San Joaquin River Restoration
Levee Typical Section
Slurry Cut-off Wall

Figure 7: Levee Typical Section with Slurry Cut-off Wall

Soil-Bentonite Slurry Wall

Distance

Elevation

Lean Clay

Poorly Graded Sand

Silty Sand or Sandy Silt

San Joaquin River
Attachment A

Water Elevation

And

Levee Height
Left Levee Height, Option A

Note: Levee height assumes 3 feet of freeboard.
Right Levee Height, Option A

Note: Levee height assumes 3 feet of freeboard.
Left Levee Setback Option B

- Water Surface Elevation, 475 cfs
- Water Surface Elevation, 1200 cfs
- Water Surface Elevation, 2200 cfs
- Water Surface Elevation, 4500 cfs
- Ground Surface Elevation

Elevation, feet

HEC-RAS Cross Section ID
Note: Levee height assumes 3 feet of freeboard.
Right Levee Setback Option B

Water Surface Elevation, 475 cfs
Water Surface Elevation, 1200 cfs
Water Surface Elevation, 2200 cfs
Water Surface Elevation, 4500 cfs
Ground Surface Elevation
Right Levee Height, Option B

Note: Levee height assumes 3 feet of freeboard.
Left Levee Setback Option C

Elevation, feet

HEC-RAS Cross Section ID

Water Surface Elevation, 475 cfs
Water Surface Elevation, 1200 cfs
Water Surface Elevation, 2200 cfs
Water Surface Elevation, 4500 cfs
Ground Surface Elevation
Left Levee Height, Option C

Levee Height, feet

2.25 miles

Note: Levee height assumes 3 feet of freeboard.
Right Levee Setback Option C

- Water Surface Elevation, 475 cfs
- Water Surface Elevation, 1200 cfs
- Water Surface Elevation, 2200 cfs
- Water Surface Elevation, 4500 cfs
- Ground Surface Elevation
Note: Levee height assumes 3 feet of freeboard.
Left Levee Setback Option D

Elevation, feet

HEC-RAS Cross Section ID

Water Surface Elevation, 475 cfs
Water Surface Elevation, 1200 cfs
Water Surface Elevation, 2200 cfs
Water Surface Elevation, 4500 cfs
Ground Surface Elevation
Left Levee Height, Option D

Note: Levee height assumes 3 feet of freeboard.
Right Levee Setback Option D

Water Surface Elevation, 475 cfs
Water Surface Elevation, 1200 cfs
Water Surface Elevation, 2200 cfs
Water Surface Elevation, 4500 cfs
Ground Surface Elevation
Note: Levee height assumes 3 feet of freeboard.
Attachment B

Levee Slope Stability Sections
Flux across levee: 0.6230037 ft³/days

San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2

Steady Seepage at Flood Elevation

head at base of blanket = 102.18964 ft
i at toe of levee = 0.354

Distance
-700 -650 -600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 200 250 300 350 400 450 500 550
Elevation
-100
-80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200

Flux across levee: 0.6230037 ft³/days
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2
Seepage Berm

Flux across levee: 0.56949562 ft³/days
Steady Seepage at Flood Elevation
Total Head: 102.16709 ft
i at toe of berm = 0.352

Distance
-700 -650 -600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400 450 500 550
Elevation
-100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200

San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2
Seepage Berm

Steady Seepage at Flood Elevation
Total Head: 102.16709 ft
i at toe of berm = 0.352

Flux across levee: 0.56949562 ft³/days
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2
End of Construction Stability
Factor of Safety: 2.903

Name: Levee Fill Undrained
Model: Undrained (\(\phi=0\))
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
\(\phi=28^\circ\)

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
\(\phi=32^\circ\)

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
\(\phi=35^\circ\)
San Joaquin River Restoration
Levee Option A
Levee 2
Reach Number 2
End of Construction Stability
Factor of Safety: 2.883

Name: Levee Fill Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28°

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32°

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35°
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2
Downstream Slope Stability
Factor of Safety: 2.533
Steady Seepage at Flood Elevation
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2
Upstream Slope Stability
Factor of Safety: 3.565
Steady Seepage at Flood Elevation
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 2
Silty Sand or Sandy Silt
Poorly Graded Sand
Lean Clay

Rapid Drawdown Stability
Factor of Safety: 1.880

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28°
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0°

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28°
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0°

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32°
Drawdown Total Cohesion: 100 psf
Drawdown Total Phi: 16°

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35°
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35°
Flux across levee: 3.4342037 ft³/days

San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8

Steady Seepage at Flood Elevation
head at base of blanket: 93.170257 ft
i at toe of levee = 1.22
Flux across levee: 3.4342037 ft³/days

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: Levee Fill
K-Ratio: 1
K-Direction: 0 °

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6
K-Direction: 0 °

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: Lean Clay
K-Ratio: 0.1
K-Direction: 0 °

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
K-Direction: 0 °
Flux across levee: 3.0299383 ft³/days

San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8

Steady Seepage at Flood Elevation
head at base of blanket: 92.947186 ft
i at toe of berm = 1.133
Flux across levee: 3.029383 ft³/days

Silty Sand or Sandy Silt
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6
K-Direction: 0 °

Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1
K-Direction: 0 °

Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
K-Direction: 0 °

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1
K-Direction: 0 °

Distance
Elevation
Flux across levee: 1.6726802 ft³/days

San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8

Steady Seepage at Flood Elevation
head at base of blanket: 91.431553 ft
i at toe of levee = 0.55
Flux across levee: 1.6726802 ft³/days

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1
K-Direction: 0 °

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6
K-Direction: 0 °

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1
K-Direction: 0 °

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.75
K-Direction: 0 °
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8
End of Construction Stability
Factor of Safety: 2.789

Name: Levee Fill Undrained
Model: Undrained (Φ=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Φ: 32 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Φ: 28 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Φ: 35 °

Distance
-700 -650 -600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400 450 500 550

Elevation
-100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200

Name: Levee Fill Undrained
Model: Undrained (Φ=0)
Unit Weight: 118 pcf
Cohesion: 300 psf
Φ: 32 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Φ: 32 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Φ: 28 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Φ: 35 °
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8
End of Construction Stability
Factor of Safety: 2.780

Name: Levee Fill Undrained
Model: Undrained (\(\phi=0\))
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
\(\phi: 32^\circ\)

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
\(\phi: 28^\circ\)

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
\(\phi: 35^\circ\)
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8
Downstream Slope Stability
Factor of Safety: 1.922

Name: Levee Fill
Unit Weight: 115pcf
Cohesion: 100psf
Phi: 28°

Name: Sandy Silt or Silty Sand
Unit Weight: 118psf
Cohesion: 0psf
Phi: 32°

Name: Lean Clay
Unit Weight: 112pcf
Cohesion: 300psf
Phi: 28°

Name: Poorly Graded Sand
Unit Weight: 128psf
Cohesion: 0psf
Phi: 35°
San Joaquin River Restoration
Levee Option A
Left Levee
Reach Number 8
Factor of Safety: 2.616

Upstream Slope Stability

Sandy Silt or Silty Sand
- Unit Weight: 118 pcf
- Cohesion: 0 psf
- Phi: 32°

Lean Clay
- Unit Weight: 112 pcf
- Cohesion: 300 psf
- Phi: 28°

Poorly Graded Sand
- Unit Weight: 128 pcf
- Cohesion: 0 psf
- Phi: 35°
**San Joaquin River Restoration**

**Levee Option B**

**Reach Number 6**

**Steady Seepage at Flood Elevation**

- **Head at base of blanket:** 97.23765 ft
- **i at toe of levee:** 0.771
- **Flux across levee:** 0.80438761 ft³/days

**Material Properties**

- **Lean Clay**
  - Model: Saturated / Unsaturated
  - K-Function: LeanClay
  - K-Ratio: 0.1

- **Poorly Graded Sand**
  - Model: Saturated / Unsaturated
  - K-Function: Poorly Graded Sand
  - K-Ratio: 0.5

- **Silty Sand or Sandy Silt**
  - Model: Saturated / Unsaturated
  - K-Function: Silty Sand
  - K-Ratio: 0.6

- **Levee Fill**
  - Model: Saturated / Unsaturated
  - K-Function: LeveeFill
  - K-Ratio: 1
San Joaquin River Restoration
Levee Option B
Reach Number 6
Steady Seepage at Flood Elevation

- Flux across levee: 0.75197405 ft³/days
- Head at base of blanket: 97.227698 ft
- i at toe of berm = 0.767
- Flux across levee: 0.75197405 ft³/days

Silty Sand or Sandy Silt
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Lean Clay
Model: Saturated / Unsaturated
K-Function: Lean Clay
K-Ratio: 0.1

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Sandy Silt or Silty Sand
K-Ratio: 0.5

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
Flux across levee: 0.79581994 ft³/days

San Joaquin River Restoration
Levee Option B
Reach Number 6

Steady Seepage at Flood Elevation
head at base of blanket: 97.225086 ft
i at toe of levee = 0.765
Flux across levee: 0.79581994 ft³/days

4:1 Vertical Exaggeration

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.3
San Joaquin River Restoration
Levee Option B
Reach Number 6
End of Construction Stability
Factor of Safety: 3.539

4:1 Vertical Exaggeration

Distance

Elevation

69 74 79 84 89 94 99 104 109 114 119 124 129 134 139 144

-600 -550 -500 -400 -300 -200 -100 0 100 200 300 400 500 600 700

Name: Levee Fill Undrained
Model: Undrained (Ph=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Ph: 28°

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Ph: 32°

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Ph: 35°
San Joaquin River Restoration
Levee Option B
Reach Number 6
End of Construction Stability
Factor of Safety: 3.474
4:1 Vertical Exaggeration

Silty Sand or Sandy Silt
End of Construction Stability
Factor of Safety: 3.474

Poorly Graded Sand

Name: Levee Fill Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28°

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35°
San Joaquin River Restoration
Levee Option B
Reach Number 6

Downstream Slope Stability
Factor of Safety: 2.738

Distance
-600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700

Elevation
69 74 79 84 89 94 99 104 109 114 119 124 129 134 139 144

Silty Sand or Sandy Silt
Name: Levee Fill
Unit Weight: 115pcf
Cohesion: 100psf
Phi: 28°

Lean Clay
Name: Lean Clay
Unit Weight: 112pcf
Cohesion: 300psf
Phi: 28°

Sandy Silt or Silty Sand
Name: Sandy Silt or Silty Sand
Unit Weight: 118pcf
Cohesion: 0psf
Phi: 32°

Poorly Graded Sand
Name: Poorly Graded Sand
Unit Weight: 128pcf
Cohesion: 0psf
Phi: 35°
San Joaquin River Restoration
Levee Option B
Reach Number 6

Factor of Safety: 3.246

Upstream Slope Stability

4:1 Vertical Exaggeration

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °

Distance

-600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700

Elevation

69 74 79 84 89 94 99 104 109 114 119 124 129 134 139 144

4:1 Vertical Exaggeration

Distance
San Joaquin River Restoration
Levee Option B
Reach Number 6

Rapid Drawdown Stability

Factor of Safety: 2.655

4:1 Vertical Exaggeration

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °

Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Drawdown Total Cohesion: 100 psf
Drawdown Total Phi: 16 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °

Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35 °
### San Joaquin River Restoration

**Levee Option B**

**Reach Number 6**

**Rapid Drawdown Stability**

**Factor of Safety**: 2.538

#### 4:1 Vertical Exaggeration

**Name**: Levee Fill
- **Unit Weight**: 115 pcf
- **Cohesion**: 100 psf
- **Phi**: 28°

**Rapid Drawdown Stability**
- **Total Cohesion**: 300 psf
- **Total Phi**: 0°

**Name**: Lean Clay
- **Unit Weight**: 112 pcf
- **Cohesion**: 300 psf
- **Phi**: 28°

**Rapid Drawdown Stability**
- **Total Cohesion**: 300 psf
- **Total Phi**: 0°

**Name**: Sandy Silt or Silty Sand
- **Unit Weight**: 118 pcf
- **Cohesion**: 0 psf
- **Phi**: 32°

**Rapid Drawdown Stability**
- **Total Cohesion**: 100 psf
- **Total Phi**: 16°

**Name**: Poorly Graded Sand
- **Unit Weight**: 128 pcf
- **Cohesion**: 0 psf
- **Phi**: 35°

**Rapid Drawdown Stability**
- **Total Cohesion**: 0 psf
- **Total Phi**: 35°
Flux across levee: 0.74097207 ft³/days

San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7

Steady Seepage at Flood Elevation
head at base of blanket: 95.388988 ft
i at toe of levee = 0.459
Flux across levee: 0.74097207 ft³/days

4:1 Vertical Exaggeration

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
Flux across levee: 0.69160922 ft³/days

San Joaquin River Restoration
Levee Option B
Reach Number 7

Steady Seepage at Flood Elevation
head at base of blanket: 95.362707 ft
i at toe of levee = 0.454
Flux across levee: 0.69160922 ft³/days

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
San Joaquin River Restoration
Levee Option B
Reach Number 7

Steady Seepage at Flood Elevation
head at base of blanket: 95.386671 ft
i at toe of levee = 0.459
Flux across levee: 0.73595452 ft³/days

Distance

Elevation

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5

4:1 Vertical Exaggeration

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7
End of Construction Stability
Factor of Safety: 2.798

Name: Levee Fill Undrained
Model: Undrained (Φ=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Φ: 32°

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Φ: 28°

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Φ: 35°

4:1 Vertical Exaggeration
San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7
End of Construction Stability
Factor of Safety: 2.787

4:1 Vertical Exaggeration

Name: Levee Fill Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °

Distance
-600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400

Elevation
67 72 77 82 87 92 97 102 107 112 117 122 127 132 137 142

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Levee Fill Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 300 psf
San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7
Downstream Slope Stability
Factor of Safety: 2.307

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28°

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32°

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28°

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35°
San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7
Upstream Slope Stability
Factor of Safety: 2.486

4:1 Vertical Exaggeration

- San Joaquin River Restoration
- Levee Option B
- Left Levee
- Reach Number 7
- Upstream Slope Stability
- Factor of Safety: 2.486

Distance
-600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400

Elevation
- 67
- 72
- 77
- 82
- 87
- 92
- 97
- 102
- 107
- 112
- 117
- 122
- 127
- 132
- 137

- Lean Clay
- Unit Weight: 112 pcf
- Cohesion: 0 psf
- Phi: 28 °

- Poorly Graded Sand
- Unit Weight: 128 pcf
- Cohesion: 0 psf
- Phi: 35 °

- Sandy Silt or Silty Sand
- Unit Weight: 118 pcf
- Cohesion: 0 psf
- Phi: 32 °

- Levee Fill
- Unit Weight: 115 pcf
- Cohesion: 100 psf
- Phi: 28 °
San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7
Rapid Drawdown Stability
Factor of Safety: 2.368

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °
Drawdown Total Cohesion: 100 psf
Drawdown Total Phi: 16 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35 °
San Joaquin River Restoration
Levee Option B
Left Levee
Reach Number 7
Rapid Drawdown Stability
Factor of Safety: 2.307

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °
Drawdown Total Cohesion: 100 psf
Drawdown Total Phi: 16 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °
Drawdown Total Cohesion: 300 psf
Drawdown Total Phi: 0 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35 °

Silty Sand or Sandy Silt
Distance
-600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400
Elevation
67 72 77 82 87 92 97 102 107 112 117 122 127 132 137 142
Distance
-600 -550 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 400
Elevation
67 72 77 82 87 92 97 102 107 112 117 122 127 132 137 142
Flux across levee: 0.30109417 ft³/days

San Joaquin River Restoration
Levee Option C
Left Levee
Reach Number 1

Steady Seepage at Flood Elevation
Head at base of blanket: 105.32979 ft
i at bottom of ditch = 0.721

6:1 Vertical Exaggeration
Flux across levee: 0.30109417 ft³/days

Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
San Joaquin River Restoration  
Levee Option C  
Left Levee  
Reach Number 1  
End of Construction Stability  
Factor of Safety: 3.679  

6:1 Vertical Exaggeration  

Name: Levee Fill Undrained  
Model: Undrained (\(\phi=0\))  
Unit Weight: 118 pcf  
Cohesion: 300 psf  

Name: Lean Clay  
Unit Weight: 112 pcf  
Cohesion: 300 psf  
\(\phi: 28^\circ\)  

Name: Sandy Silt or Silty Sand  
Unit Weight: 118 pcf  
Cohesion: 0 psf  
\(\phi: 32^\circ\)  

Name: Poorly Graded Sand  
Unit Weight: 128 pcf  
Cohesion: 0 psf  
\(\phi: 35^\circ\)
San Joaquin River Restoration
Levee Option C
Left Levee
Reach Number 1
End of Construction Stability
Factor of Safety: 3.747

6:1 Vertical Exaggeration

San Joaquin River Restoration
Levee Option C
Left Levee
Reach Number 1
End of Construction Stability
Factor of Safety: 3.747

6:1 Vertical Exaggeration

- Model: Undrained (\(\Phi=0\))
  - Unit Weight: 118 pcf
  - Cohesion: 300 psf

- Lean Clay
  - Unit Weight: 112 pcf
  - Cohesion: 300 psf
  - \(\Phi=28^\circ\)

- Sandy Silt or Silty Sand
  - Unit Weight: 118 pcf
  - Cohesion: 0 psf
  - \(\Phi=32^\circ\)

- Poorly Graded Sand
  - Unit Weight: 128 pcf
  - Cohesion: 0 psf
  - \(\Phi=35^\circ\)
San Joaquin River Restoration
Levee Option C
Left Levee
Reach Number 1

Downstream Slope Stability
Factor of Safety: 3.263

6:1 Vertical Exaggeration

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
San Joaquin River Restoration
Levee Option C
Left Levee
Reach Number 1

Factor of Safety: 3.215

Upstream Slope Stability

- Silty Sand or Sandy Silt
  - Unit Weight: 118 pcf
  - Cohesion: 0 psf
  - Phi: 32°

- Poorly Graded Sand
  - Unit Weight: 128 pcf
  - Cohesion: 0 psf
  - Phi: 35°

- Lean Clay
  - Unit Weight: 112 pcf
  - Cohesion: 300 psf
  - Phi: 28°

- Levee Fill
  - Unit Weight: 115 pcf
  - Cohesion: 100 psf
  - Phi: 28°
San Joaquin River Restoration
Levee Option C
Levee Reach 1
Rapid Drawdown Stability
Factor of Safety: 2.655

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<th>Unit Weight</th>
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<th>Drawdown Total Cohesion</th>
<th>Drawdown Total Phi</th>
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<td>300 psf</td>
<td>0 °</td>
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<td>Lean Clay</td>
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<td>300 psf</td>
<td>28 °</td>
<td>300 psf</td>
<td>0 °</td>
</tr>
<tr>
<td>Sandy Silt or Silty Silt</td>
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<td>0 psf</td>
<td>32 °</td>
<td>100 psf</td>
<td>16 °</td>
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<tr>
<td>Poorly Graded Sand</td>
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<td>0 psf</td>
<td>35 °</td>
<td>0 psf</td>
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Flux across levee: 1.1064288 ft³/days

San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3

Steady Seepage at Flood Elevation

head at base of blanket: 98.145779 ft
i at toe of levee = 0.438
Flux across levee: 1.1064288 ft³/days

Silty Sand or Sandy Silt
Name: Levee Fill
Model: Saturated / Unsaturated
K-Function: LeveeFill
K-Ratio: 1

Lean Clay
Name: Sandy Silt or Silty Sand
Model: Saturated / Unsaturated
K-Function: Silty Sand
K-Ratio: 0.6

Poorly Graded Sand
Name: Lean Clay
Model: Saturated / Unsaturated
K-Function: LeanClay
K-Ratio: 0.1

Name: Poorly Graded Sand
Model: Saturated / Unsaturated
K-Function: Poorly Graded Sand
K-Ratio: 0.5
San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3
End of Construction Stability
Factor of Safety: 2.797

8:1 Vertical Exaggeration

Distance (x 1000)

Elevation

-0.5 -0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5

0 75 80 85 90 95 100 105 110 115 120 125

Levee Fill Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Levee Fill Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 300 psf

Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28°

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28°

Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32°

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32°

Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35°

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35°
San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3

End of Construction Stability
Factor of Safety: 2.785

8.1 Vertical Exaggeration

Name: Levee Fill Undrained
Model: Undrained (Phivd)
Unit Weight: 118 pcf
Cohesion: 300 psf

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28°

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35°
San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3

Downstream Slope Stability
Factor of Safety: 2.232
8:1 Vertical Exaggeration

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
\( \phi' \): 28 °

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
\( \phi' \): 32 °

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
\( \phi' \): 28 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
\( \phi' \): 35 °
San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3

Distance (x 1000)
-0.5 -0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5

Elevation
75 80 85 90 95 100 105 110 115 120 125

Upstream Slope Stability
Factor of Safety: 2.695

8:1 Vertical Exaggeration

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28°

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35°

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32°

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28°

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32°

Distance (x 1000)
-0.5 -0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5

Elevation
75 80 85 90 95 100 105 110 115 120 125

Upstream Slope Stability
Factor of Safety: 2.695

8:1 Vertical Exaggeration

Name: Lean Clay
Unit Weight: 112 pcf
Cohesion: 300 psf
Phi: 28°

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35°

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32°

Name: Levee Fill
Unit Weight: 115 pcf
Cohesion: 100 psf
Phi: 28°

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32°
San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3

Rapid Drawdown Stability
Factor of Safety: 2.318
8:1 Vertical Exaggeration

Name: Sandy Silt or Silty Sand
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 32 °
Drawdown Total Cohesion: 100 psf
Drawdown Total Phi: 16 °

Name: Poorly Graded Sand
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 35 °
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35 °
San Joaquin River Restoration
Levee Option D
Left Levee
Reach Number 3

Rapid Drawdown Stability
Factor of Safety: 2.077

8.1 Vertical Exaggeration

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<td>28 °</td>
<td>300 psf</td>
<td>0 °</td>
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<tr>
<td>Poorly Graded Sand</td>
<td>128 pcf</td>
<td>0 psf</td>
<td>35 °</td>
<td>0 psf</td>
<td>35 °</td>
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<tr>
<td>Lean Clay</td>
<td>112 pcf</td>
<td>0 psf</td>
<td>28 °</td>
<td>300 psf</td>
<td>0 °</td>
</tr>
<tr>
<td>Sandy Silt or Silty Silt</td>
<td>118 pcf</td>
<td>0 psf</td>
<td>32 °</td>
<td>100 psf</td>
<td>16 °</td>
</tr>
</tbody>
</table>
Attachment C

Levee Seepage Calculations

And

Seepage Berm and Slurry Wall Design
<p>| Project Segment | From | To | El Riverine Borrow Pit (ft) | Soil Type | Kf (ft/day) | ZBL (ft) | Soil Type | Kf/KBL | C=(Kf/KBL)0.5 | X1 (ft) | L1 (ft) | L2 (ft) | Zs (ft) | L3 (ft) | Zt (ft) | X2 (ft) | L4 (ft) | Zt (ft) | h0 (ft) | i0 (ft) | X3 (ft) | L5 (ft) | Zt (ft) | h0 (ft) | i0 (ft) | X4 (ft) | L6 (ft) | Zt (ft) | h0 (ft) | i0 (ft) | X5 (ft) | L7 (ft) | Zt (ft) | h0 (ft) | i0 (ft) | X6 (ft) | L8 (ft) | Zt (ft) | h0 (ft) | i0 (ft) | X7 (ft) | L9 (ft) | Zt (ft) | h0 (ft) | i0 (ft) | X8 (ft) | L10 (ft) | Zt (ft) | h0 (ft) | i0 (ft) | X9 (ft) | L11 (ft) | Zt (ft) | h0 (ft) | i0 (ft) |
|-----------------|------|----|-----------------------------|-----------|------------|----------|-----------|---------|----------------|--------|--------|--------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| MW 10-93       | 5242+49 | 5242+49 | 95 | 2 | EL | 9.99784 | 10 | 56 | 15.99788 | 105 | 2 | 102 | 102 | 3 | 9 | Kf/L/CH | 0.002835 | 2.835 | 17.5 | 1000 | 0.00251978 | 396.8627 | 9 | 2.572239 | 0.285404 |
| MW 10-94       | 5242+49 | 5300+83 | 95 | 1.8 | EL | 35.99572 | 16 | 56 | 71.99572 | 103.9 | 2 | 99 | 99 | 4.9 | 5.8 | Kf/ML | 0.02835 | 14.17 | 110 | 499.8236 | 0.01770849 | 564.7012 | 8 | 4.545024 | 0.54524 |
| MW 10-113      | 5350+65 | 5350+65 | 93 | 0 | EL | 28.60243 | 30 | 68 | 36.60243 | 100.1 | 7 | 96 | 96 | 4.1 | 4 | Kf/CL/SM | 0.2835 | 28.35 | 15.2 | 100 | 0.01262472 | 77.97435 | 4.9 | 1.831256 | 0.373726 |
| MW 10-111      | 5641+96 | 5868+50 | 88 | 0 | Kf/CH | 49.97314 | 50 | 50 | 105.9731 | 99 | 2 | 96 | 96 | 3 | 15.5 | Kf/CH | 0.002835 | 2.835 | 100 | 1000 | 0.000801219 | 1244.99 | 10.6 | 2.764672 | 0.141055 |
| MW 10-105      | 5641+96 | 5868+50 | 88 | 0 | Kf/CL | 39.84051 | 60 | 56 | 115.8405 | 100 | 2 | 97 | 97 | 3 | 9 | Kf/CL | 0.0567 | 28.35 | 100 | 500 | 0.01490712 | 670.8204 | 11.4 | 2.558232 | 0.224408 |
| MW 10-106      | 5930+50 | 5901+47 | 89 | 0 | Kf/SM | 36.18928 | 100 | 62 | 118.1893 | 99.1 | 7 | 96 | 96 | 3.1 | 1.7 | Kf/SM | 0.2835 | 28.35 | 21.3 | 100 | 0.01654079 | 60.4968 | 1.7 | 1.049089 | 0.617311 |
| MW 10-106      | 5930+50 | 5901+47 | 89 | 0 | Kf/SM | 36.18928 | 100 | 62 | 118.1893 | 99.1 | 7 | 96 | 96 | 3.1 | 1.7 | Kf/SM | 0.2835 | 28.35 | 21.3 | 100 | 0.01654079 | 60.4968 | 1.7 | 1.049089 | 0.617311 |
| MW 11-140      | 5983+69 | 5983+69 | 86 | 0 | Kf/CL | 138.2671 | 140 | 62 | 200.2671 | 96 | 2 | 93 | 93 | 3 | 5.2 | Kf/CL | 0.2835 | 28.35 | 100 | 1000 | 0.01383675 | 721.1103 | 5.2 | 2.347931 | 0.451525 |
| MW 10-110      | 6238+39 | 6238+39 | 83 | 0 | Kf/CL | 9.976238 | 10 | 62 | 71.97626 | 93.8 | 7 | 98 | 90 | 3.8 | 1.4 | Kf/CL | 0.2835 | 28.35 | 100 | 1000 | 0.008451544 | 118.3216 | 2.6 | 2.362728 | 0.908742 |</p>
<table>
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<th>trec at toe</th>
<th>X</th>
<th>Xrec</th>
<th>X/Xrec</th>
<th>Rec Final Berm Width</th>
<th>Rec Final Thickness at Toe</th>
<th>Rec Final Thickness at Crown</th>
<th>Rec Berm Slope</th>
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**Notes:**
- **MW:** Marginal Reach, Minimum Berm Recommended
- **trec at toe:** Berm thickness at toe
- **X:** Berm width at toe
- **Xrec:** Berm width at crown
- **X/Xrec:** Berm width ratio
- **Rec:** Recommended Berm Dimensions
- **MW 10-93:** Low excessive gradient values indicate using a minimum Berm
- **MW 10-98:** Minimum Berm
- **MW 10-105:** Minimum Berm
- **MW 10-10:** Minimum Berm
- **MW 11-14:** Minimum Berm
- Design indicates using minimum Berm
- Based on geostudies model
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<th>Start Station</th>
<th>End Station</th>
<th>R &lt;sub&gt;ave&lt;/sub&gt;</th>
<th>% Cutoff</th>
<th>% Penetration</th>
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Design indicates using minimum berm.
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### Levee Station

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<th>L1 ft</th>
<th>S ft</th>
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**Project: Left Levee Option C**

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**Note:** All calculations and values are based on specific design criteria and may vary depending on local regulations and site-specific conditions.
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**Project:** Left Levee Option C

**Levee Station:** Estimated Slurry Cutoff Depth

**d/D:**

- 1: 5217+38 to 5242+49
- 2: 5242+49 to 5430+83
- 3: 5430+83 to 5560+65
- 4: 5550+65 to 5641+96
- 5: 5641+96 to 5788+100
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- 7: 5901+47 to 5983+69
- 8: 5983+69 to 6238+39
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