APPENDIX E

Kleinfelder Letter Report: Levee Seepage and Stability Analysis
April 8, 2010  
File: 94582

Mr. Tim Washburn, Esq.  
Sacramento Area Flood Control Agency  
1007 7th Street, 7th Floor  
Sacramento, California 95814

Subject: Vegetation Variance Geotechnical Evaluation  
Natomas Levee Improvement Program (NLIP)  
Sacramento and Sutter Counties, California

Dear Mr. Washburn:

At the request of SAFCA, Kleinfelder performed analyses of potential seepage and stability impacts associated with the presence of vegetation along the waterside slope/base of existing Natomas levees.

Kleinfelder conducted a series of analyses that evaluated:

- Steady-state seepage exit gradients and riverside sudden drawdown stability after a hypothetical complete loss (erosion) of a vegetative zone on the waterside face of the levee. The vegetative zone was assumed to be 15 feet wide at the base, measured at the riverside toe of the levee, with a backslope of 3H:1V (horizontal:vertical) or steeper, as required to maintain a 20-foot-wide levee crown width.

- Sudden drawdown slope stability to evaluate impact of local scour on slope stability. This analysis was based on scour analyses conducted by Northwest Hydraulic Consultants (nhc) for specific trees judged to be critical in terms of location and depth of scour.

- Sudden drawdown slope stability due to loss of the riverside face due to tree fall in the upper one-third of the waterside slope. The zone of erosion is defined as a 10-foot-thick wide zone measured perpendicular to the existing slope face at the riverside levee crown hinge point with a 2H:1V backslope. A widened levee section will be constructed on the landside slope to provide a minimum 20-foot crown width. Landside slopes will vary between 2H:1V and 3H:1V.

The 15-foot-wide vegetative zone is based on eight representative levee geometries (Index Sections) selected by AECOM, SAFCA’s environmental consultant. These sections were judged to be critical in terms of impacts of vegetation on the NLIP levees. Kleinfelder selected seven representative cross sections from previous and ongoing studies judged to have similar geometry to AECOM Index Sections.
The impact of scour of selected trees is based on studies by nhc. NhC was retained by SAFCA to conduct an evaluation of the riverside vegetation to identify trees that could have the greatest impact to levee stability if tree fall and erosion (scour) should occur. Ten sites were selected by nhc for scour analyses, and their analyses identified two locations where the depth of scour could potentially impact the levee template\(^1\): one on the Natomas Cross Canal (NCC) and the second on the upper portion of the Sacramento River East Levee (SREL). The location (levee slope or toe) and size (depth and width) of the resulting scour holes were provided to Kleinfelder. Seven cross sections were selected from previous or ongoing analyses to evaluate the sudden drawdown stability due to the presence of a scour hole (defined herein as the remnant scour section).

The impact of vegetation within the upper one-third of slope was conducted for two sections along the Sacramento and American Rivers. The levee geometry was also checked to confirm that nhc scour estimates for tree fall scour within the upper one-third of the levee did not impact the levee template.

**AECOM INDEX SECTIONS**

AECOM identified eight Index Sections with corresponding post-remediation levee geometries where a vegetation variance will be required to allow trees to remain. The locations of these sections, referenced by both levee acronym and levee mile (LM) are discussed below and shown in Table 1. Kleinfelder reviewed the most current levee models that have been completed for the basin and selected cross sections that best matched the Index Section geometries. The locations of these sections with respect to the Index Sections are summarized in Table 1.

For this analysis it was assumed that, for an extreme condition, a 15-foot-wide section, measured horizontally from the levee waterside toe, would erode leaving a levee remnant section. This section was modeled to have a waterside slope inclination of 3H:1V or steeper to maintain a 20-foot-wide crown. Steady state seepage analysis was then conducted to check that exit gradients at the toe of the remnant levee section did not exceed USACE design criteria of 0.5 for the design water surface elevation (WSE). For the NLIP project, a 200-year WSE has been selected for design of the project. The results of this analysis are described in more detail below.

**Location of Analysis**

Vegetation variance analysis was performed by Kleinfelder at seven representative locations selected by AECOM. Information regarding these Index Sections are summarized below and in Table 1.

\(^1\) Levee template taken as waterside slope no steeper than 2H:1V, landside slope no steeper than 3H:1V; and a levee crown width of 20 feet.
### Table 1 – AECOM Index Cross Sections and Kleinfelder Representative Cross Section Summary Table

<table>
<thead>
<tr>
<th>Index Cross Section Number</th>
<th>Levee Section</th>
<th>Section Levee Mile</th>
<th>Representative Length (miles)</th>
<th>Feature</th>
<th>Kleinfelder Representative Model Station</th>
<th>Kleinfelder Report Reference Number</th>
<th>Date Published</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-1</td>
<td>SREL 2</td>
<td>5.8</td>
<td>13.8</td>
<td>Raised adjacent levee alone, or with a seepage cutoff wall or seepage berm</td>
<td>320+00</td>
<td>1</td>
<td>January 15, 2010</td>
</tr>
<tr>
<td>I-2</td>
<td>SREL 4</td>
<td>15.2</td>
<td>3.4</td>
<td>Adjacent levee alone, or with a seepage cutoff wall or seepage berm</td>
<td>838+00</td>
<td>2</td>
<td>November 6, 2009</td>
</tr>
<tr>
<td>I-3</td>
<td>SREL 4</td>
<td>17.0</td>
<td>2</td>
<td>Adjacent levee alone, or with a seepage cutoff wall or seepage berm</td>
<td>904+50</td>
<td>2</td>
<td>November 6, 2009</td>
</tr>
<tr>
<td>I-4</td>
<td>ARNL</td>
<td>1.1</td>
<td>2.2</td>
<td>Over-built levee</td>
<td>47+98</td>
<td>3</td>
<td>November 2, 2009</td>
</tr>
<tr>
<td>I-5</td>
<td>NEMDC South</td>
<td>0.0</td>
<td>0.3</td>
<td>Over-built levee</td>
<td>Anp³</td>
<td>4</td>
<td>November 2, 2009</td>
</tr>
<tr>
<td>I-6</td>
<td>NEMDC South</td>
<td>0.3</td>
<td>4.6</td>
<td>Typical section</td>
<td>58+00</td>
<td>4</td>
<td>November 2, 2009</td>
</tr>
<tr>
<td>I-7</td>
<td>NCC</td>
<td>0.7</td>
<td>4.3</td>
<td>Standard levee</td>
<td>183+00</td>
<td>5</td>
<td>January 21, 2009</td>
</tr>
<tr>
<td>I-8</td>
<td>NCC</td>
<td>3.6</td>
<td>1</td>
<td>Expanded levee</td>
<td>21+00</td>
<td>5</td>
<td>January 21, 2009</td>
</tr>
</tbody>
</table>

**Note:**
1. Source: AECOM
2. A “Reference” page is attached to this report.
3. Anp = analysis not performed on this section because no remediation is planned for this section and the section had an 85-foot crown.
Index 1 - SREL from the NCC downstream to about Powerline Road: This levee segment is characterized by a new adjacent levee constructed landward of the existing hydraulic-fill sand levee. Remediation measures planned along this reach include seepage berms and soil-bentonite (SB) seepage cutoff walls.

Index 2 - SREL downstream of Powerline Road to about Reach 19: This levee segment is characterized by a widened levee section constructed landward of the existing levee. Remediation measures planned along this reach include seepage berms and SB seepage cutoff walls.

Index 3 - SREL from Reach 19 to confluence of the American River North Levee (ARNL): Because of existing development at/near the landside levee toe, this segment will have neither adjacent nor widened levee construction. However, this segment has a relatively wide crown due to the presence of both the multi-lane Garden Highway and adjacent improvements. Remediation measures planned along this segment include SB cutoff walls.

Index 4 - ARNL from the confluence with Sacramento River extending to about Northgate Boulevard: Because of existing development at/near the landside levee toe, this segment will have neither adjacent nor widened levee construction. However, this reach has a relatively wide crown due to the presence of Garden Highway. Remediation measures planned along this segment include SB cutoff walls.

Index 5 - Natomas East Main Drainage Canal (NEMDC) from Northgate Boulevard upstream to the Arden-Garden Connector bridge structure: This levee segment has a wide crown width due to the presence of the multiple-lane Garden Highway. No remediation measures are currently planned along this segment, and no analyses were performed due to the 85-foot-wide crown.

Index 6 - NEMDC from the Arden-Garden Connector bridge structure upstream to the County of Sacramento Pumping Plant: No additional levee width is proposed along this alignment. Proposed remediation measures include SB cutoff walls and relief wells.

Index 7 - NCC from about Station 54+00 to Pleasant Grove Creek Canal levee: This levee segment consists of a conventional levee with 3H:1V waterside and landside slopes with a 20-foot crown width. Completed levee remediation along this alignment includes a SB seepage cutoff wall.

Index 8 - NCC from the confluence with the Sacramento River to about Station 54+00: This levee segment consists of a conventional crown width embankment with a waterside slope generally flatter than about 3H:1V. Completed levee remediation along this alignment includes a soil-cement-bentonite (SCB) seepage cutoff wall.
Kleinfelder selected cross sections previously analyzed as part of Alternatives Analysis or Basis of Design Reports. The cross sections selected are near the selected levee mile or judged to be close to the typical levee section as developed by AECOM. Table 1 summarizes the station of the model used for each section and the Kleinfelder report it was taken from. Specific details concerning analysis methods and input parameters for strength and permeability are contained in the respective reports.

ANALYSES

Kleinfelder analyzed the potential effects of vegetation presence along the waterside slope/toe by evaluating the levee with removal of a portion of the waterside slope, referenced herein as the remnant levee configuration. All analyses were conducted using the 200-year WSE. In areas where there was existing/proposed excessive crown width, a 15-foot-wide section of levee (measured horizontally) was removed. The resulting waterside slope analyzed ranged from about 1.7H:1V to 3.5H:1V. In most cases, this resulted in a remaining crown width greater than 20 feet. This condition is expressed in Kleinfelder Model Stations SREL 320+00, SREL 838+00, and ARNL 47+98 (AECOM I-1, I-2, and I-4), attached.

For Kleinfelder Model Stations SREL 904+50, NEMDC 58+00, NCC 21+00, and NCC 183+00 (AECOM I-3, I-6 through I-8), a 15-foot-wide portion of the levee (measured at the base width) was removed. If the crown width was at least 20 feet, the levee slope was projected from the resulting theoretical levee toe to the top of a 20-foot-wide crown. If the existing crown width was 20 feet or less, the levee slope was projected from the bottom of the slope (with a 15-foot-wide portion removed) to the levee crown.

As stated above, no analyses were performed at AECOM Section I-5.

MATERIAL VARIABILITY

Kleinfelder reviewed existing analyses for other levee cross sections modeled by Kleinfelder for the NLIP project. By inspection, these cross sections were comprised of and had geometric configurations represented by the Index Sections. Kleinfelder believes these cross sections will perform similarly in terms of steady-state seepage and sudden drawdown stability as the sections modeled, as described in the following section.

INDEX SECTION RESULTS

Regarding waterside sudden drawdown conditions, Kleinfelder performed analyses on the waterside slopes with and without the erosion of the levee waterside embankment. The results are shown in Table 2. For Sections I-2, I-3, I-6 through I-8, a decrease in Factor of Safety (FOS) between 0.16 and 0.58 is shown. Despite the decrease in FOS in some of the sections, the remnant levee configuration exceeds USACE criteria for the sudden drawdown loading condition (FOS >1.1).
Underseepage was also evaluated in each cross section with the remnant levee configuration. The seepage gradients at the landside levee toe are less than USACE maximum criteria in all cases. Results of all the analyses are presented in Table 2 and on Plates 1 through 21.

**Table 2 –Vegetation Variance Seepage and Stability Results Summary**

<table>
<thead>
<tr>
<th>Index Cross Section Number</th>
<th>Levee Section</th>
<th>Station Number</th>
<th>Seepage Gradient at Landside Levee Toe (200-Year WSE) Remnant Levee Configuration</th>
<th>Sudden Drawdown Factor of Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Existing Configuration</td>
</tr>
<tr>
<td>I-1</td>
<td>SREL 2</td>
<td>320+00</td>
<td>&lt;0.10</td>
<td>1.67</td>
</tr>
<tr>
<td>I-2</td>
<td>SREL 4</td>
<td>838+00</td>
<td>0.20</td>
<td>1.64</td>
</tr>
<tr>
<td>I-3</td>
<td>SREL 4</td>
<td>904+50</td>
<td>0.10</td>
<td>3.08</td>
</tr>
<tr>
<td>I-4</td>
<td>ARNL</td>
<td>47+50</td>
<td>&lt;0.10</td>
<td>1.25</td>
</tr>
<tr>
<td>I-5</td>
<td>NEMDC</td>
<td>N/A</td>
<td>anp¹</td>
<td>anp¹</td>
</tr>
<tr>
<td>I-6</td>
<td>NEMDC</td>
<td>58+00</td>
<td>0.29</td>
<td>1.86</td>
</tr>
<tr>
<td>I-7</td>
<td>NCC</td>
<td>183+00</td>
<td>&lt;0.10</td>
<td>1.60</td>
</tr>
<tr>
<td>I-8</td>
<td>NCC</td>
<td>21+00</td>
<td>0.46</td>
<td>1.65</td>
</tr>
</tbody>
</table>

Note: 1. anp = analysis not performed on this section because no remediation is planned for this section and the section had an 85-foot crown.

**nhc SCOUR REMNANT SECTIONS**

**SECTION SELECTION**

As documented in nhc’s March 2010 report, site selection for scour analysis was based on the following:

- Identify at least one site in each NLIP levee segment and for each of the different proposed improvements along the SREL where there is greatest potential for erosion to penetrate the levee;
- Where the existing waterside levee slope was close to the existing minimum levee template and where large trees were observed on the section; and
- Where local river velocities were judged to be highest along the bank or levee slope.

A total of ten sites were selected by nhc for analysis, summarized in Table 3.
### Table 3 – Summary of nhc Selected Cross Sections

<table>
<thead>
<tr>
<th>nhc Cross Section ID (LM)</th>
<th>Levee Section</th>
<th>Section River Mile (Station)</th>
<th>nhc Vegetation Description</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sac 1 (0.3)</td>
<td>SREL</td>
<td>78.5 (17+00)</td>
<td>Large trees on the lower bank and waterside slope</td>
<td>Raised adjacent levee, alone or with a seepage cutoff wall or seepage berm</td>
</tr>
<tr>
<td>Sac 2 (5.3)</td>
<td>SREL</td>
<td>74.8 (280+00)</td>
<td>A large tree on the berm</td>
<td>Raised adjacent levee, alone or with a seepage cutoff wall or seepage berm</td>
</tr>
<tr>
<td>Sac 3 (12.0)</td>
<td>SREL</td>
<td>61.3 (917+44)</td>
<td>A large tree on the berm</td>
<td>Adjacent levee alone or with a seepage cutoff wall or seepage berm</td>
</tr>
<tr>
<td>Sac 4 (13.3)</td>
<td>SREL</td>
<td>66.5 (631+63.5)</td>
<td>A very large tree about 20 feet from the levee toe at a location of greatest river velocities</td>
<td>Raised adjacent levee, alone or with a seepage cutoff wall or seepage berm</td>
</tr>
<tr>
<td>Sac 5 (14.9)</td>
<td>SREL</td>
<td>63.9 (788+10)</td>
<td>A large tree located on the riverside berm about 15 feet from the toe</td>
<td>Adjacent levee, alone or with a seepage cutoff wall or seepage berm</td>
</tr>
<tr>
<td>Sac 6 (17.4)</td>
<td>SREL</td>
<td>65.5 (710+72)</td>
<td>A large tree located on the levee slope</td>
<td>Raised adjacent levee, alone or with a seepage cutoff wall or seepage berm</td>
</tr>
<tr>
<td>NEMDC (1.3)</td>
<td>NEMDC</td>
<td>-- (67+71)</td>
<td>Large tree at toe of levee opposite Arcade Creek</td>
<td>Seepage cutoff wall</td>
</tr>
<tr>
<td>NCC1 (3.7)</td>
<td>NCC</td>
<td>-- (35+00)</td>
<td>Large tree on either the levee slope or near the toe</td>
<td>Raised levee with seepage cutoff wall</td>
</tr>
<tr>
<td>ARNL 1 (0.7)</td>
<td>ARNL</td>
<td>35+50</td>
<td>Large tree in upper one-third of slope</td>
<td>Wide levee with seepage cutoff wall</td>
</tr>
<tr>
<td>ARNL 2 (1.7)</td>
<td>ARNL</td>
<td>-- (92+68)</td>
<td>Large tree on either the levee slope or berm near the toe</td>
<td>Wide levee with seepage cutoff wall</td>
</tr>
</tbody>
</table>

Note: *1 Source: nhc

### LOCATION OF ANALYSIS

The vegetation variance scour analysis was performed at seven of the ten locations summarized in a report published by nhc on April 1, 2010. Kleinfelder selected cross sections previously analyzed as part of Alternatives Analysis or Basis of Design Reports. The cross sections selected are near the selected levee station, as developed by nhc.

Table 4 summarizes the station of the model used for each nhc section and the Kleinfelder report from which it was taken. Specific details concerning analysis methods and input parameters for strength and permeability are contained in the respective reports. The results of nhc scour analyses are summarized in Table 5. Analyses were not conducted for nhc locations Sac 4, Sac 6, and ARNL 1, since the depth of scour is less than 3 feet and does not penetrate the levee template. Based on the model results for the other sections, this small amount of scour is judged to have little impact on the global stability of the levee and was not modeled.
Table 4 – nhc Scour Analysis Cross Section and Kleinfelder Model Station Summary Table

<table>
<thead>
<tr>
<th>nhc Cross Section ID (LM)</th>
<th>Section Station¹</th>
<th>Levee Section</th>
<th>Kleinfelder Representative Model Station</th>
<th>Kleinfelder Report Reference Number²</th>
<th>Date Published</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sac 1 (0.3)</td>
<td>17+00</td>
<td>SREL 1</td>
<td>27+00</td>
<td>7</td>
<td>January 30, 2009</td>
</tr>
<tr>
<td>Sac 2 (5.3)</td>
<td>280+00</td>
<td>SREL 2</td>
<td>287+00</td>
<td>1</td>
<td>January 15, 2010</td>
</tr>
<tr>
<td>Sac 3 (12.0)</td>
<td>631+63.5</td>
<td>SREL 3</td>
<td>640+00</td>
<td>6</td>
<td>September 23, 2009</td>
</tr>
<tr>
<td>Sac 4 (13.3)</td>
<td>710+72</td>
<td>SREL 3</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Sac 5 (14.9)</td>
<td>788+10</td>
<td>SREL 4</td>
<td>789+00</td>
<td>2</td>
<td>November 6, 2009</td>
</tr>
<tr>
<td>Sac 6 (17.4)</td>
<td>917+44</td>
<td>SREL 4</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>NEMDC (1.3)</td>
<td>67+71</td>
<td>NEMDC South</td>
<td>58+00</td>
<td>4</td>
<td>November 2, 2009</td>
</tr>
<tr>
<td>NCC1 (3.7)</td>
<td>35+00</td>
<td>NCC</td>
<td>21+00</td>
<td>5</td>
<td>January 30, 2009</td>
</tr>
<tr>
<td>ARNL 1 (0.7)</td>
<td>35+60</td>
<td>ARNL</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>ARNL 2 (1.7)</td>
<td>92+68</td>
<td>ARNL</td>
<td>96+65</td>
<td>3</td>
<td>November 2, 2009</td>
</tr>
</tbody>
</table>

Notes: ¹ Source: nhc ² A "Reference" page is attached to this report
-- not analyzed

Table 5 – Summary of nhc Scour Analysis Results

<table>
<thead>
<tr>
<th>Site (LM)</th>
<th>200-year WSE (NAVD88 ft)</th>
<th>Elevation of Tree (NAVD88 ft)</th>
<th>Maximum Scour Depth for Event (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sac 1 (0.3)</td>
<td>43.1</td>
<td>31</td>
<td>11.8</td>
</tr>
<tr>
<td>Sac 2 (5.3)</td>
<td>41.3</td>
<td>35</td>
<td>11.6+</td>
</tr>
<tr>
<td>Sac 3 (12.0)</td>
<td>36.4</td>
<td>27</td>
<td>11.7</td>
</tr>
<tr>
<td>Sac 4 (13.3)</td>
<td>35.7</td>
<td>33.7</td>
<td>2.4</td>
</tr>
<tr>
<td>Sac 5 (14.9)</td>
<td>34.4</td>
<td>27</td>
<td>11.7</td>
</tr>
<tr>
<td>Sac 6 (17.4)</td>
<td>34.9</td>
<td>31</td>
<td>0.1</td>
</tr>
<tr>
<td>NEMDC (1.3)</td>
<td>36.1</td>
<td>30</td>
<td>7.3</td>
</tr>
<tr>
<td>NCC1 (3.7)</td>
<td>42.3</td>
<td>31</td>
<td>9.6</td>
</tr>
<tr>
<td>ARNL 1 (0.7)</td>
<td>35.4</td>
<td>34.4</td>
<td>3.9</td>
</tr>
<tr>
<td>ARNL 2 (1.7)</td>
<td>35.8</td>
<td>25</td>
<td>11.7</td>
</tr>
</tbody>
</table>

ANALYSES

Kleinfelder analyzed the potential effects of scour holes caused by tree falls on the waterside slope/toe by evaluating sudden drawdown stability with the scour remnant levee configuration. The geometry of this portion was based off of the nhc drawings provided to Kleinfelder on March 11, 2010, and are included in the April 8, 2010, nhc report. All analyses were conducted using the 200-year WSE. Nhc also defined a scour envelope for the eight AECOM Index Sections. Based on the area defined by the scour envelope, a supplemental analysis was performed on the NEMDC index cross (1-5). The scour envelope in the NEMDC index section is defined by a 1.7H: 1V slope
starting at the waterside crown hinge point and extending to the toe of the waterside slope. In the NEMDC model, all material not contained within the 1.7H:1V waterside slope was removed and a sudden drawdown analysis was performed. Supplemental analysis was not performed on the other six AECOM Index Sections since the scour envelope defined by nhc for these sections did not extend into the remnant levee geometry.

RESULTS

Regarding waterside sudden drawdown conditions, Kleinfelder performed analyses on the waterside slopes with the removal of the scour hole on the waterside slope and with the scour envelope removed for the NEMDC Index Section. The results are shown in Table 6. All scour remnant sections were found to have a sudden drawdown FOS greater than 1.1, the USACE minimum criteria.

Results of these analyses are presented in Table 6 and on Plates 22 through 29.

<table>
<thead>
<tr>
<th>nhc Cross Section ID</th>
<th>Analysis Type</th>
<th>Levee Section</th>
<th>Kleinfelder Representative Station (Model)</th>
<th>Sudden Drawdown FOS With Scour Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sac 1</td>
<td>Scour Hole</td>
<td>SREL 2</td>
<td>27+00</td>
<td>1.34</td>
</tr>
<tr>
<td>Sac 2</td>
<td>Scour Hole</td>
<td>SREL 2</td>
<td>287+00</td>
<td>1.27</td>
</tr>
<tr>
<td>Sac 3</td>
<td>Scour Hole</td>
<td>SREL 3</td>
<td>640+00</td>
<td>2.23</td>
</tr>
<tr>
<td>Sac 5</td>
<td>Scour Hole</td>
<td>SREL 4</td>
<td>789+00</td>
<td>1.58</td>
</tr>
<tr>
<td>NEMDC</td>
<td>Scour Hole</td>
<td>NEMDC</td>
<td>58+00</td>
<td>1.29</td>
</tr>
<tr>
<td>NEMDC</td>
<td>Scour Envelope</td>
<td>NEMDC</td>
<td>58+00</td>
<td>1.18</td>
</tr>
<tr>
<td>NCC1</td>
<td>Scour Hole</td>
<td>NCC</td>
<td>21+00</td>
<td>1.19</td>
</tr>
<tr>
<td>ARNL 2</td>
<td>Scour Hole</td>
<td>ARNL</td>
<td>96+65</td>
<td>1.15</td>
</tr>
</tbody>
</table>

TREE FALL WITHIN THE UPPER ONE-THIRD OF SLOPE

From discussions with SAFCA and the USACE, tree fall within the upper one-third of the levee is a concern. It is Kleinfelder’s current understanding that, to allow existing trees to remain in the upper one-third of the levee, there has to be a stable remnant levee section. For this case, the remnant levee is defined as a levee section with a waterside slope no steeper than 2H:1V, a 3H:1V landside slope (or stable existing slope if steeper than 3H:1V), and a 20-foot crown width. The location of the remnant levee 2H:1V waterside slope is determined by offsetting the existing waterside slope by projecting a 10-foot line perpendicular to the existing waterside slope. Kleinfelder conducted sudden drawdown slope stability analyses for two cross sections where trees on the upper one-third of the levee are of particular concern, SREL Station 838+00 and ARNL Station 47+98, presented on Plates 30 and 31. The analysis for SREL 838+00 (Plate 30) requires widening the adjacent levee slope to achieve a total crown width of...
approximately 44 feet with a resulting remnant crown width of 20 feet. The analysis for ARNL 47+98 (Plate 31) does not require an adjacent levee to provide the levee remnant section. Both of these analyses show that the remnant levee section have a calculated FOS of greater than USACE minimum of 1.1.

CONCLUSIONS AND RECOMMENDATIONS

Kleinfelder evaluated both the effects of steady state seepage and sudden drawdown stability for the remnant levee configurations. Since all levee segments include through seepage remediation, Kleinfelder has concluded that the loss of a 15-foot-wide zone of the levee waterside slopes or the inclusion of scour holes as calculated by nhc would not impact the effectiveness of proposed remedial measures.

Although the remnant levee conditions resulted in a decrease in waterside stability, the FOS for representative cross sections exceeds USACE criteria.

As shown in Table 2, representative cross sections I-1 and I-4 had increased FOS, indicating that waterside stability is improved when a section of the waterside is removed. The reason for improved stability is likely due to the failure surface moving landward into the existing levee granular fill material combined with flattening of the waterside slope to 3H:1V. It is important to note that the removal of this material should not be seen as a means of improving overall levee performance.

As shown in Table 6, the NEMDC section had the lowest FOS of all the scour analyses but meets USACE design criteria.

For trees located within the upper one-third of the existing waterside slope, the width of the widened levee section within the SREL will need to be increased to provide the minimum 20-foot crown width and a 2H:1V waterside remnant levee slope. The sudden drawdown stability of the remnant levee for SREL and ARNL models exceed the minimum USACE FOS criteria of 1.1.

LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder’s profession practicing in the same locality, under similar conditions, and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. Kleinfelder makes no other representation, guarantee or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.
This report may be used only by the Client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than two (2) years from the date of the report.

The work performed was based on project information provided by Client. If Client does not retain Kleinfelder to review any plans and specifications, including any revisions or modifications to the plans and specifications, Kleinfelder assumes no responsibility for the suitability of our recommendations. In addition, if there are any changes in the field to the plans and specifications, Client must obtain written approval from Kleinfelder's engineer that such changes do not affect our recommendations. Failure to do so will vitiate Kleinfelder's recommendations.

Recommendations contained in this report are based on Kleinfelder's field observations, subsurface explorations completed by Kleinfelder and others, laboratory tests, and Kleinfelder's present knowledge of the existing levee conditions. It is possible that soil conditions could vary between or beyond the points explored.

We appreciate the opportunity of providing our services for this project. If you have questions regarding this report or if we may be of further assistance, please contact the undersigned.

Respectfully,

KLEINFELDER WEST, INC.

Elizabeth Roesler, EIT
Geotechnical Professional

Lynn M. O'Leary, PE, PMP
Project Manager

Mark Stanley, PE, GE
Senior Principal Engineer

Attachments:

References
Plates 1-31
REFERENCES


Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 3.5H:1V slope starting 15 feet from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, soil stratigraphy, permeability, and cutoff wall elevation are based off of the seepage model for the 200-year WSE, at Station 320+00 presented in Kleinfelder’s "Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 2 (Reaches 5 Through 9), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 15, 2010.

Average Gradient at Adjacent Levee Toe: < 0.10

Top of Adjacent Levee Elevation: 45.5 ft
Adjacent Levee Toe Elevation: 28 ft
Cutoff Wall Tip Elevation: -73 ft
200-Year WSE: 41.9 ft
Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H=WSE

INDEX CROSS SECTION #1 - SREL
ADJACENT LEVEE WIDTH: 20 FT
EXISTING LEVEE WIDTH: 15 FT
200-YEAR WSE
TOTAL HEAD CONTOURS
REMNANT LEVEE CONFIGURATION

SREL STATION 320+00
SEEPAGE ANALYSIS

PROJECT NO. VVR DSGN
DATE: 3.12.10
DRAWN BY: L. Roesler
CHECKED BY: R. Costa
FILE NAME: SREL_320+00_200YR_AJ31_COW-73_2-17-10_VVR.gsz
Last Saved Date: 2/17/2010
Analysis Type: Steady-State
Analysis View: 2D

Horizontal Hydraulic Conductivity (Ks) and Anisotropy Ratio (K-Ratio)

Material #1: Levee Fill - PG Sand; Sand with Silt 0-7% fines, Ks=14 ft/day (5.0x10E-3 cm/s); K-Ratio: 1
Material #2: Silt; Silt, Non-Plastic Fines P1=4 Ks=0.14 ft/day (5.0x10E-5 cm/s); K-Ratio: 0.25
Material #3: Interbedded Silty Sand, Silt, and Clay; Silty Sand 30-49% fines, Ks=0.28 ft/day (1.0x10E-4 cm/s); K-Ratio: 0.1
Material #4: PG Sand; Sand with Silt 0-7% fines, Ks=14 ft/day (5.0x10E-3 cm/s); K-Ratio: 1
Material #5: PG Gravel; Gravel with Silt 0-12% fines, Ks=28 ft/day (1.0x10E-2 cm/s); K-Ratio: 1
Material #6: Clay; Pleistocene Clay Ks=0.00028 ft/day (1.0x10E-7 cm/s); K-Ratio: 0.25
Material #7: Adjacent Levee; Clay: Levee Embankment Fill Ks=0.00028 ft/day (1.0x10E-7 cm/s); K-Ratio: 0.25
Material #8: Cutoff Wall; SB Cutoff Wall Ks=0.00028 ft/day (1.0x10E-7 cm/s); K-Ratio: 1

Top of Adjacent Levee Elevation: 45.5 ft
Adjacent Levee Toe Elevation: 28 ft
Cutoff Wall Tip Elevation: -73 ft
200-Year WSE: 41.9 ft
Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H=WSE
Results
Average Gradient at Adjacent Levee Toe: < 0.10

Vegetation Variance Geotechnical Evaluation
Natomas Levee Improvement Program
Sacramento and Sutter Counties, California
Notes:
1) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 320+00 presented in Kleinfelder’s “Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 2 (Reaches 5 Through 9), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated January 15, 2010.

Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Levee Fill - PG Sand; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 33°; Total Cohesion: 0 psf; Total Phi: 33°
Material #2: Silt; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 26°; Total Cohesion: 100 psf; Total Phi: 20°
Material #3: Interbedded Silty Sand, Silt, and Clay; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #4: PG Sand; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 33°; Total Cohesion: 0 psf; Total Phi: 33°
Material #5: PG Gravel; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Clay; Unit Weight: 112pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #7: Adjacent Levee; Unit Weight: 123pcf; Eff Cohesion: 200 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #8: Cutoff Wall; Unit Weight: 110pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Top of Adjacent Levee Elevation: 45.5 ft
Adjacent Levee Toe Elevation: 28 ft
Cutoff Wall Tip Elevation: -75 ft
Sudden Drawdown: WSE from 41.9 ft to 26.9 ft

Results
Factor of Safety: 1.67
Notes:
1) A section from the waterside slope was removed for this investigation. The section followed a 3.5H:1V slope starting 15 feet from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 320+00 presented in Kleinfelder’s "Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 2 (Reaches 5 Through 9), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 15, 2010.
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File Name: SREL_838+00_200YR_31AJ15_2-17-10-VVR2.gsz
Last Saved Date: 4/2/2010
Analysis Type: SEEP/W
Analysis View: 2D

Horizontal Hydraulic Conductivity (Ks) and Anisotropy Ratio (K-Ratio)

Material #1: PG Sand (Levee Fill); Sand w/ 3-7% ML or 0-2% CL, Ks=14 ft/day (5x10E-3 cm/s); K-Ratio: 0.25
Material #2: Silt; Silt Ks=0.56 ft/day (2x10E-4 cm/s); K-Ratio: 0.25
Material #3: Silty Sand; Sand w/ 28-49% ML, Ks= 1.12 ft/day (4x10E-4 cm/s); K-Ratio: 0.25
Material #4: PG Sand; Sand w/ 3-7% ML or 0-2% CL, Ks=14 ft/day (5x10E-3 cm/s); K-Ratio: 0.25
Material #5: Existing Cutoff Wall; Cutoff Wall Ks=0.0028 ft/day (1x10E-6 cm/s); K-Ratio: 1
Material #6: Adjacent Levee; Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 1.7H:1V slope starting 15 feet from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, soil stratigraphy, permeability and cutoff wall elevation are based off of the seepage model for the 200- year WSE, at Station 838+00 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 6, 2009.

Top of Levee Elevation: 40 ft
Widened Adjacent Levee: 15 ft
Landside Toe Elevation: 24 ft
Existing Cutoff Wall Tip Elevation: 11 ft

200-Year WSE: 36.3 ft
Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H = WSE

Results
Average Gradient at Landside Toe: 0.20
The information included on this graphic representation has been compiled from a variety of sources and is subject to change without notice. Kleinfelder makes no representations or warranties, express or implied, as to accuracy, completeness, timeliness, or rights to the use of such information. This document is not intended for use as a land survey product nor is it designed or intended as a construction design document. The use or misuse of the information contained on this graphic representation is at the sole risk of the party using or misusing the information.

Notes:
1) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 838+00 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 6, 2009.

Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill); Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Silt; Unit Weight: 110pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #3: Silty Sand; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #4: PG Sand; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°
Material #5: Existing Cutoff Wall; Unit Weight: 100pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #6: Adjacent Levee; Unit Weight: 123pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Levee Elevation: 40 ft
Widened Adjacent Levee: 15 ft
Landside Toe Elevation: 24 ft
Existing Cutoff Wall Tip Elevation: 11 ft
Sudden Drawdown WSE from 36.3 ft to 21.3 ft

Results
Factor of Safety: 1.64
Notes:
1. A section from the waterside slope was removed for this investigation. The section removed followed a 1.7H:1V slope starting 15 feet from the waterside toe to the crest of the levee.
2. A levee width of 20 feet or more was retained.
3. WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 838+00 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 6, 2009.

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Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Silt; Unit Weight: 110 pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #3: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #4: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°
Material #5: Existing Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #6: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

---

Factor of Safety Spectrum

Material #1: 1.35
Material #2: 1.8
Material #3: 1.3
Material #4: 1.3
Material #5: 1.3
Material #6: 1.3

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Top of Levee Elevation: 40 ft
Widened Adjacent Levee: 15 ft
Landside Toe Elevation: 24 ft
Existing Cutoff Wall Tip Elevation: 11 ft
Sudden Drawdown WSE from 36.3 ft to 21.3 ft

Results
Factor of Safety: 1.35
File Name: SREL_904+50_200YR_CW-37_2-17-10_VVR.gsz
Last Saved Date: 2/25/2010
Analysis Type: Steady-State
Analysis View: 2D

Horizontal Hydraulic Conductivity (Ks) and Anisotropy Ratio (K-Ratio)

Material #1: PG Sand (Levee Fill); Sand w/ 0-2% CL or 3-7% ML, Ks=14 ft/day (5x10E-3 cm/s); K-Ratio: 0.25
Material #2: Clay; Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25
Material #3: Silty Sand; Sand w/ 3-12% CL or 8-27% ML, Ks=2.8 ft/day (1x10E-3 cm/s); K-Ratio: 0.25
Material #4: Existing Cutoff Wall; Cutoff Wall Ks=0.0028 ft/day (1x10E-6 cm/s); K-Ratio: 1
Material #5: PG Sand; Sand w/ 0-2% CL or 3-7% ML, Ks=14 ft/day (5x10E-3 cm/s); K-Ratio: 0.25
Material #6: Proposed Cutoff Wall; Cutoff Wall Ks=0.0028 ft/day (1x10E-6 cm/s); K-Ratio: 1

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 4H:1V slope starting 15 feet (horizontally) from the waterside toe projected to the crest of the levee.
2) A levee width of 20 feet was retained.
3) WSE, stratigraphy, permeability, and cutoff wall elevations are based off of the seepage model for the 200-year WSE, at Station 904+50 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California." dated November 6, 2009.

Top of Existing Levee Elevation: 40.5 ft
Landslide Toe Elevation: 23 ft
Existing Cutoff Wall Tip Elevation: 11 ft
Proposed Cutoff Wall Tip Elevation: -37 ft

200-Year WSE: 36.4 ft
Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H=WSE

Results
Average Gradient at Adjacent Levee Toe: 0.10
Material #1: PG Sand (Levee Fill); Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°

Material #2: Clay; Unit Weight: 112pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°

Material #3: Silty Sand; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°

Material #4: Existing Cutoff Wall; Unit Weight: 100pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Material #5: PG Sand; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°

Material #6: Proposed Cutoff Wall; Unit Weight: 100pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Notes:
1) WSE, stratigraphy, strength parameters, and cutoff wall elevations are based off of the sudden drawdown model for the 200-year WSE, at Station 904+50 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 6, 2009.
INDEX CROSS SECTION #3 - SREL
EXISTING LEVEE WIDTH: 20 FT
WSE: 36.4 FT TO 21.4 FT
SUDDEN DRAWDOWN
REMNANT LEVEE CONFIGURATION

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 4H:1V slope starting 15 feet (horizontally) from the waterside toe projected to the crest of the levee.
2) A levee width of 20 feet was retained.
3) WSE, stratigraphy, strength parameters, and cutoff wall elevations are based off of the sudden drawdown model for the 200-year WSE, at Station 904+50 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 6, 2009.

File Name: SREL_904+50_200YR_RD_CW-37_2-16-10_VVR.gsz
Last Saved Date: 2/25/2010
Analysis Type: Spencer
Analysis View: 2D

Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Clay; Unit Weight: 112 pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #3: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #4: Existing Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #5: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°
Material #6: Proposed Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Top of Levee Elevation: 40.5 ft
Landside Toe Elevation: 23 ft
Existing Cutoff Wall Tip Elevation: 11 ft
Proposed Cutoff Wall Tip Elevation: -37 ft

Sudden Drawdown WSE from 36.4 ft to 21.4 ft

Results
Factor of Safety: 2.50

Material #, Description, Unit Weight, Eff Cohes, Eff Phi, Total Cohes, Total Phi
Material #1, PG Sand, 115 pcf, 0 psf, 28°, 0 psf, 28°
Material #2, Clay, 112 pcf, 150 psf, 25°, 400 psf, 15°
Material #3, Silty Sand, 115 pcf, 0 psf, 27°, 0 psf, 27°
Material #4, Existing CW, 100 pcf, 20 psf, 0°, 20 psf, 0°
Material #5, PG Sand, 115 pcf, 0 psf, 29°, 0 psf, 29°
Material #6, Proposed CW, 100 pcf, 20 psf, 0°, 20 psf, 0°
Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 3H:1V slope starting 15 feet from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, stratigraphy, permeability, and cutoff wall elevation are based off of the seepage model for the 200-year WSE, at Station 47+98 presented in Kleinfelder’s “Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 2, 2009.

Result:
Average Gradient at Landside Toe < 0.10
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Silt (ML); Unit Weight: 115 pcf; Eff Cohesion: 50 psf; Eff Phi: 30 degrees; Total Cohesion: 100 psf; Total Phi: 20 degrees
Material #2: Clay (CL); Unit Weight: 115 pcf; Eff Cohesion: 100 psf; Eff Phi: 28 degrees; Total Cohesion: 200 psf; Total Phi: 15 degrees
Material #3: Silty Sand (SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32 degrees; Total Cohesion: 0 psf; Total Phi: 32 degrees
Material #4: Poorly Graded Sand (SP); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32 degrees; Total Cohesion: 0 psf; Total Phi: 32 degrees
Material #5: Proposed Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0 degrees; Total Cohesion: 20 psf; Total Phi: 0 degrees

Notes:
1) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 47+98 presented in Kleinfelder’s “Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 2, 2009.

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

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Top of Existing Levee Elevation: 40 ft
Landslide Toe Elevation: 20 ft
Proposed Cutoff Wall Tip Elevation: 0 ft
Sudden Drawdown WSE from 37.2 ft to 24.2 ft
Results
Factor of Safety: 1.25
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Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 3H:1V slope starting 15 feet from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 47+98 presented in Kleinfelder’s “Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 2, 2009.

Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Silt (ML); Unit Weight: 115pcf; Eff Cohesion: 50 psf; Eff Phi: 30 degrees; Total Cohesion: 100 psf; Total Phi: 20 degrees
Material #2: Clay (CL); Unit Weight: 115pcf; Eff Cohesion: 100 psf; Eff Phi: 28 degrees; Total Cohesion: 200 psf; Total Phi: 15 degrees
Material #3: Silty Sand (SM); Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 32 degrees; Total Cohesion: 0 psf; Total Phi: 32 degrees
Material #4: Poorly Graded Sand (SP); Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 32 degrees; Total Cohesion: 0 psf; Total Phi: 32 degrees
Material #5: Proposed Cutoff Wall; Unit Weight: 110pcf; Eff Cohesion: 20 psf; Eff Phi: 0 degrees; Total Cohesion: 20 psf; Total Phi: 0 degrees

Factor of Safety Spectrum
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Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 2.5H:1V slope starting 15 feet (horizontally) from the waterside toe projected to the crest of the levee.
2) The entire levee width of 18 feet was retained.
3) WSE, stratigraphy, permeability, and cutoff wall elevation are based off of the seepage model for the 200-year WSE, at Station 58+00 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Natomas East Main Drainage Canal—South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 2, 2009.

Horizontal Hydraulic Conductivity (Ks) and Anisotropy Ratio (K-Ratio)
- Material #1 Clay Kx=0.028 ft/day (1x10E-5 cm/s) K-Ratio: 0.25
- Material #2 Sand w/ 13-27% CL or 28-49% ML, Kx=1.12 ft/day (4x10E-4 cm/s) K-Ratio: 0.25
- Material #3 Clay Kx=0.028 ft/day (1x10E-5 cm/s) K-Ratio: 0.25
- Material #4 Sand w/ 0-2% CL or 3-7% ML, Kx=14 ft/day (5x10E-3 cm/s) K-Ratio: 0.25
- Material #5 Silt Kx=0.028 ft/day (1x10E-5 cm/s) K-Ratio: 0.25
- Material #6 Sand Kx=0.28 ft/day (1x10E-4 cm/s) K-Ratio: 0.25
- Material #7 Silt Kx=0.028 ft/day (1x10E-5 cm/s) K-Ratio: 0.25
- Material #8 Slurry Wall Kx=0.0028 ft/day (1x10E-6 cm/s) K-Ratio: 1

Top of Levee Elevation: 43.4 ft
Landside Toe Elevation: 21 ft
Cutoff Wall Tip Elevation: -9 ft
200-Year WSE: 38.6 ft

Landslide Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H=WSE

Results
Average Gradient at Landside Toe: 0.29
1.86

Material #1: Clay (CL); Unit Weight: 120 pcf; Eff Cohesion: 150 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #2: Silty Clayey Sand (SC-SM); Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #3: Clay (CL) (2); Unit Weight: 110 pcf; Eff Cohesion: 150 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 24°
Material #4: Sand (SP-SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #5: Sand (SP); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Slurry Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Silt (ML) (2) Unit Weight: 110 pcf, Eff Cohesion: 50 psf, Eff Phi: 32°, Total Cohesion: 200 psf, Total Phi: 24°
Material #8: Slurry Wall Unit Weight: 100 pcf, Eff Cohesion:50 psf, Eff Phi:0°, Total Cohesion: 50 psf, Total Phi: 0°

Notes:
1) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 58+00 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Natomas East Main Drainage Canal—South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 2, 2009.
Material #1: Clay (CL); Unit Weight: 120 pcf; Eff Cohesion: 150 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #2: Silty Clayey Sand (SC-SM); Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #3: Clay (CL) (2); Unit Weight: 110 pcf; Eff Cohesion: 150 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 24°
Material #4: Sand (SP-SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 24°
Material #5: Sand (SP); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 24°
Material #6: Slurry Wall: Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Silt (ML) (2) Unit Weight: 110 pcf, Eff Cohesion: 50 psf, Eff Phi: 32 °, Total Cohesion: 200 psf, Total Phi: 24 °
Material #8: Slurry Wall Unit Weight: 100 pcf, Eff Cohesion:50 psf, Eff Phi:0 °, Total Cohesion: 50 psf, Total Phi: 0 °

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 2.5H:1V slope starting 15 feet (horizontally) from the waterside toe projected to the crest of the levee.
2) The entire levee width of 18 feet was retained.
3) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 58+00 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Natomas East Main Drainage Canal—South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 2, 2009.

Results
Factor of Safety : 1.42
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Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 2H:1V slope starting 15 feet (horizontally) from the waterside toe projected to the crest of the levee.
2) The entire levee width of 20 feet was retained.
3) WSE, stratigraphy, permeability, and cutoff wall elevation are based off of the seepage model for the 200-year WSE, at Station 183+00 presented in Kleinfelder’s “Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated January 30, 2009.

Results:
- Average Gradient at Landside Toe: <0.10

Horizontal Hydraulic Conductivity (Ks) and Anisotropy Ratio (K-Ratio)

Material #1: Clay (Existing Levee); Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25
Material #2: Clay (Blanket); Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25
Material #3: Sand with Silt; Sand w/ 3.7% ML or 0.2% CL Ks=14 ft/day (5x10E-3 cm/s); K-Ratio: 0.25
Material #4: Clay; Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25
Material #5: Silty Sand; Sand w/ 8.27% ML or 3.12% CL Ks=2.8 ft/day (1x10E-3 cm/s); K-Ratio: 0.25
Material #6: Cutoff Wall, Slurry Wall Ks=0.0039 ft/day (1x10E-6 cm/s); K-Ratio: 0.25
Material #7: Clay (Levee Raise); Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25

Top of Raised Levee Elevation: 49 ft
Landside Levee Toe Elevation: 29 ft
Cutoff Wall Bottom Elevation: -38 ft
200-Year WSE: 45.3 ft
Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H=Flood Elevation

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INDEX CROSS SECTION #7 - NCC EXISTING RAISED LEVEE WIDTH: 20 FT 200-YEAR WSE TOTAL HEAD CONTOURS REMNANT LEVEE CONFIGURATION

PLATE

VEGETATION VARIANCE GEOENGINEERING EVALUATION NATOMAS LEVEE IMPROVEMENT PROGRAM SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

FILE NAME: NCC_183+00_200YR_SP_COW75_3-31-10_VVR.gsz
Last Saved Date: 4/1/2010
Analysis Type: Steady-State
Analysis View: 2D

Horizontal Distance (feet)

Elevation, NAVD88 (feet)
Notes:
1) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 183+00 presented in Kleinfelder’s “Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter, California,” dated January 30, 2009.

Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (Existing Levee); Unit Weight: 115pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #2: Clay (Blanket); Unit Weight: 115pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Sand with Silt; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 30°; Total Cohesion: 0 psf; Total Phi: 30°
Material #4: Clay; Unit Weight: 115pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #5: Silty Sand; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 31°; Total Cohesion: 0 psf; Total Phi: 31°
Material #6: Cutoff Wall; Unit Weight: 100pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Clay (Levee Raise); Unit Weight: 125pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Raised Levee Elevation: 49 ft
Landside Levee Toe Elevation: 29 ft
Cutoff Wall Tip Elevation: -38 ft
Sudden Drawdown WSE from 45.3 ft to 35.3 ft

Results
Factor of Safety: 1.60
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**Notes:**

1. A section from the waterside slope was removed for this investigation. The section removed followed a 2H:1V slope starting 15 feet (horizontally) from the waterside toe projected to the crest of the levee.
2. The entire levee width of 20 feet was retained.
3. WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 183+00 presented in Kleinfelder’s “Draft Final Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated January 30, 2009.

**Results**

Factor of Safety: 1.35

### Material Properties

<table>
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<th>Material #</th>
<th>Description</th>
<th>Unit Weight</th>
<th>Eff Cohesion</th>
<th>Eff Phi</th>
<th>Total Cohesion</th>
<th>Total Phi</th>
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</thead>
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<td>115 pcf</td>
<td>150 psf</td>
<td>24°</td>
<td>200 psf</td>
<td>15°</td>
</tr>
<tr>
<td>#2</td>
<td>Clay (Blanket)</td>
<td>115 pcf</td>
<td>150 psf</td>
<td>27°</td>
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<td>15°</td>
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<td>Sand with Silt</td>
<td>115 pcf</td>
<td>0 psf</td>
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<td>0 psf</td>
<td>30°</td>
</tr>
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<td>#4</td>
<td>Clay</td>
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<td>150 psf</td>
<td>24°</td>
<td>200 psf</td>
<td>15°</td>
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<td>31°</td>
<td>0 psf</td>
<td>31°</td>
</tr>
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<td>#6</td>
<td>Cutoff Wall</td>
<td>100 pcf</td>
<td>50 psf</td>
<td>0°</td>
<td>200 psf</td>
<td>15°</td>
</tr>
<tr>
<td>#7</td>
<td>Clay (Levee Raise)</td>
<td>125 pcf</td>
<td>150 psf</td>
<td>24°</td>
<td>200 psf</td>
<td>15°</td>
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</tbody>
</table>

### Topography

- **Top of Raised Levee Elevation:** 49 ft
- **Landslide Levee Toe Elevation:** 29 ft
- **Cutoff Wall Tip Elevation:** -38 ft
- **Sudden Drawdown WSE from 45.3 ft to 35.3 ft**

**File Name:** NCC_183+00_200YR_RD_COW75_3-8-10.gsz
**Last Saved Date:** 4/1/2010
**Analysis Type:** Spencer
**Analysis View:** 2D
Top of Raised Levee Elevation: 48.3 ft
Landside Levee Toe Elevation: 23 ft
Cutoff Wall Tip Elevation: -36 ft

200-Year WSE: 45.3 ft
Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H=Flood Elevation

Results
Average Gradient at Landside Levee Toe: 0.46

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 3H:1V slope starting 15 feet (horizontally) from the waterside toe to the crest of the levee.
2) The entire levee width of 20 feet was retained.
3) WSE, stratigraphy, permeability, and cutoff wall elevation are based off of the seepage model for the 200-year WSE, at Station 21+00 presented in Kleinfelder’s "Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.
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Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (Existing Levee); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #2: Clay (Blanket); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Silt; Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 15°
Material #4: Sand; Unit Weight: 125 pcf; Eff Cohesion: 0 psf; Eff Phi: 31°; Total Cohesion: 0 psf; Total Phi: 31°
Material #5: Clay; Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #6: Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Clay (Levee Raise); Unit Weight: 125 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #8: Clay (Field); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Results
Factor of Safety: 1.56

Notes:
1) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 21+00 presented in Kleinfelder’s "Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.
Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 3H:1V slope starting 15 feet (horizontally) from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 21+00 presented in Kleinfelder’s “Draft Final Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated January 30, 2009.

Results
Factor of Safety: 1.56
Material Number, Description, Unit Weight, Drained Cohesion, Drained Friction Angle, Undrained Cohesion, Undrained Friction Angle

Material # 1: Poorly Graded Sand - Unit Weight: 115pcf, Drained C: 0 psf, Drained Phi: 28 °, Undrained C: 0 psf, Undrained Phi: 28 °
Material # 2: Silty Sand (2) - Unit Weight: 115pcf, Drained C: 0 psf, Drained Phi: 31 °, Undrained C: 0 psf, Undrained Phi: 31 °
Material # 3: Adjacent Levee Clay (CL) - Unit Weight: 123pcf, Drained C: 200 psf, Drained Phi: 24 °, Undrained C: 200 psf, Undrained Phi: 15 °
Material # 4: Clay - Unit Weight: 110pcf, Drained C: 100 psf, Drained Phi: 25 °, Undrained C: 200 psf, Undrained Phi: 15 °
Material # 5: Cutoff Wall - Unit Weight: 120pcf, Drained C: 20 psf, Drained Phi: 0 °, Undrained C: 20 psf, Undrained Phi: 0 °
Material # 6: Poorly Graded Sand (SP) - Unit Weight: 115pcf, Drained C: 0 psf, Drained Phi: 31 °, Undrained C: 0 psf, Undrained Phi: 31 °

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 3b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 30, 2010.
2) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the stability model for the 200-year WSE, at Station 27+00 presented in Kleinfelder’s "Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 1 (Reaches 1 Through 4A), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.
Notes:

1. A section from the waterside slope was removed for this investigation. The section removed was based on Figure 4b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 30, 2010.

2. WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 287+00 presented in Kleinfelder’s “Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 2 (Reaches 5 Through 9), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated January 15, 2010.
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Material #1: PG Sand (Levee Fill); Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°

Material #2: Silt; Unit Weight: 110pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°

Material #3: Clay Blanket; Unit Weight: 112pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°

Material #4: Clay; Unit Weight: 112pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°

Material #5: Silty Sand; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°

Material #6: PG Sand; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°

Material #7: Existing Cutoff Wall; Unit Weight: 110pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Material #8: Adjacent Levee; Unit Weight: 123pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Material #9: SB Cutoff Wall; Unit Weight: 110pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 5b in the NHC report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 12, 2010.

2) WSE, stratigraphy, strength parameters, and cutoff wall elevations are based off of the sudden drawdown model for the 200-year WSE, at Station 640+00 presented in Kleinfelder’s "Draft Basis of Design Report, Sacramento River East Levee, SREL 3 (Reaches 10 Through 15), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated September 23, 2009.
Notes:

1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 7b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 30, 2010.

2) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 789+00 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 6, 2009.

File Name: SREL_789+00_200YR_15AJ31_SDD-tree hole 3 12 10.gsz
Last Saved Date: 3/12/2010
Revision Number: 229
Analysis Type: Spencer
Analysis View: 2D

Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Clay; Unit Weight: 112 pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #3: Silt; Unit Weight: 110 pcf; Eff Cohesion: 0 psf; Eff Phi: 26°; Total Cohesion: 100 psf; Total Phi: 20°
Material #4: Clayey Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #5: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°
Material #6: Existing Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #7: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Levee Elevation: 41.5 ft
Widened Adjacent Levee: 15 ft
Adjacent Levee Toe: 22 ft

Sudden Drawdown: WSE from 36.2 ft to 21.2 ft
Results
Factor of Safety: 1.58

Factor of Safety Spectrum

2H:1V

MAXIMUM SCOUR DEPTH: 11.7 ft
WSE: 38.2 FT to 21.2 FT

SUDDEN DRAWDOWN SCOUR REMNANT LEVEE CONFIGURATION

PROJECT NO. DATE: DRAWN BY: CHECKED BY: FILE NAME:

P

SREL STATION 789+00 STABILITY ANALYSIS

FILE NAME:
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Silt (Levee Fill, ML); Unit Weight: 115pcf; Eff Cohesion: 50 psf; Eff Phi: 30°; Total Cohesion: 100 psf; Total Phi: 20°
Material #2: Clay (CL); Unit Weight: 115pcf; Eff Cohesion: 100 psf; Eff Phi: 28°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Silty Sand (SM); Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #4: Clay (CL) (2); Unit Weight: 115pcf; Eff Cohesion: 100 psf; Eff Phi: 28°; Total Cohesion: 200 psf; Total Phi: 15°
Material #5: Silty Sand (SM) (2); Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Clay (CL) (3); Unit Weight: 115pcf; Eff Cohesion: 100 psf; Eff Phi: 28°; Total Cohesion: 200 psf; Total Phi: 15°
Material #7: Cutoff Wall; Unit Weight: 110pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 10b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 30, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 96+65 presented in Kleinfelder’s “Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 2, 2009.
Material #1: Clay (CL); Unit Weight: 120 pcf; Eff Cohesion: 150 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #2: Silty Clayey Sand (SC-SM); Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #3: Clay (CL) (2); Unit Weight: 110 pcf; Eff Cohesion: 150 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 24°
Material #4: Sand (SP-SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #5: Sand (SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Slurry Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Silt (ML) (2); Unit Weight: 110 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #8: Slurry Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf, Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 11b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 12, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 58+00 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Natomas East Main Drainage Canal—South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 2, 2009.

Results
Factor of Safety: 1.29

Top of Levee Elevation: 43.4 ft
Landslide Toe Elevation: 21 ft
Cutoff Wall Tip Elevation: -9 ft
Sudden Drawdown WSE from 38.6 ft to 16.8 ft

Maximum Scour Depth: 8 FT
WSE: 38.6 ft to 26.8 FT
Sudder Drawdown
Scour Remnant Levee Configuration
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Notes:
1) A section from the waterside slope was removed for this investigation. The based on scour data provided in the nhc report titled, “NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies,” dated March 30, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 58+00 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Natomas East Main Drainage Canal—South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 2, 2009.

Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (CL); Unit Weight: 120 pcf; Eff Cohesion: 150 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #2: Silty Clayey Sand (SC-SM); Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #3: Clay (CL); Unit Weight: 110 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #4: Sand (SP-SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #5: Sand (SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Slurry Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Silt (ML); Unit Weight: 110 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #8: Slurry Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°

Top of Levee Elevation: 43.4 ft
Landside Toe Elevation: 21 ft
Cutoff Wall Tip Elevation: -9 ft
Sudden Drawdown WSE from 38.6 ft to 16.8 ft

Results
Factor of Safety: 1.18

Material:
- Top of Levee Elevation: 43.4 ft
- Landside Toe Elevation: 21 ft
- Cutoff Wall Tip Elevation: -9 ft
- Sudden Drawdown WSE from 38.6 ft to 16.8 ft

Factors of Safety:
- Factor of Safety Spectrum: 1.6 to 1.1

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

GEOLOGY
- Maximum Scour Depth: 8 ft (in lower 1/2 of levee)
- Sudden Drawdown WSE from 38.6 ft to 16.8 ft

Analysis Type: Spencer
Analysis View: 2D

Material Properties:
- Material #1: Clay (CL) - Unit Weight: 120 pcf, Eff Cohesion: 150 psf, Eff Phi: 32°, Total Cohesion: 200 psf, Total Phi: 24°
- Material #2: Silty Clayey Sand (SC-SM) - Unit Weight: 120 pcf, Eff Cohesion: 50 psf, Eff Phi: 32°, Total Cohesion: 200 psf, Total Phi: 24°
- Material #3: Clay (CL) - Unit Weight: 110 pcf, Eff Cohesion: 50 psf, Eff Phi: 32°, Total Cohesion: 200 psf, Total Phi: 24°
- Material #4: Sand (SP-SM) - Unit Weight: 115 pcf, Eff Cohesion: 0 psf, Eff Phi: 32°, Total Cohesion: 0 psf, Total Phi: 32°
- Material #5: Sand (SM) - Unit Weight: 115 pcf, Eff Cohesion: 0 psf, Eff Phi: 32°, Total Cohesion: 0 psf, Total Phi: 32°
- Material #6: Slurry Wall - Unit Weight: 100 pcf, Eff Cohesion: 50 psf, Eff Phi: 0°, Total Cohesion: 50 psf, Total Phi: 0°
- Material #7: Silt (ML) - Unit Weight: 110 pcf, Eff Cohesion: 50 psf, Eff Phi: 32°, Total Cohesion: 200 psf, Total Phi: 24°
- Material #8: Slurry Wall - Unit Weight: 100 pcf, Eff Cohesion: 50 psf, Eff Phi: 0°, Total Cohesion: 50 psf, Total Phi: 0°
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (Existing Levee); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #2: Clay (Blanket); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Silt; Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 15°
Material #4: Sand; Unit Weight: 125 pcf; Eff Cohesion: 0 psf; Eff Phi: 31°; Total Cohesion: 0 psf; Total Phi: 31°
Material #5: Clay; Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #6: Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Clay (Levee Raise); Unit Weight: 125 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #8: Clay (Field); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Raised Levee Elevation: 48.3 ft
Landside Levee Toe Elevation: 23 ft
Cutoff Wall Tip Elevation: -36 ft
Sudden Drawdown WSE from 45.3 ft to 35.3 ft

Results
Factor of Safety: 1.19

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 12b in the nhc report titled, “NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies,” dated March 30, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 21+00 presented in Kleinfelder’s “Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated January 30, 2009.

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Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill); Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Silt; Unit Weight: 110pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #3: Silty Sand; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #4: PG Sand; Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°
Material #5: Existing Cutoff Wall; Unit Weight: 100pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #6: Adjacent Levee; Unit Weight: 123pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 2H:1V slope 10 feet perpendicular to the slope of the levee.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 838+00 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 6, 2009.
INDEX CROSS SECTION #4 - ARNL
EXISTING LEVEE WIDTH: 27 FT
WSE: 37.2 FT to 24.2 FT
SUDDEN DRAWDOWN
REMNANT LEVEE CONFIGURATION
VEGETATION IN UPPER 1/3 OF LEVEE

Material Number, Description, Unit Weight, Cohesion, Friction Angle

Material #1: Silt (ML); Unit Weight: 115pcf; Eff Cohesion: 50 psf; Eff Phi: 30 degrees; Total Cohesion: 100 psf; Total Phi: 20 degrees
Material #2: Clay (CL); Unit Weight: 115pcf; Eff Cohesion: 100 psf; Eff Phi: 28 degrees; Total Cohesion: 200 psf; Total Phi: 15 degrees
Material #3: Silty Sand (SM); Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 32 degrees; Total Cohesion: 0 psf; Total Phi: 32 degrees
Material #4: Poorly Graded Sand (SP); Unit Weight: 115pcf; Eff Cohesion: 0 psf; Eff Phi: 32 degrees; Total Cohesion: 0 psf; Total Phi: 32 degrees
Material #5: New Cutoff Wall; Unit Weight: 110pcf; Eff Cohesion: 20 psf; Eff Phi: 0 degrees; Total Cohesion: 20 psf; Total Phi: 0 degrees

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 2H:1V slope 10 feet perpendicular to the slope of the levee.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 47+96 presented in Kleinfelder’s “Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California.” dated November 2, 2009.
Kleinfelder Letter Report: Supplemental Evaluation
April 23, 2010
File: 94582

Mr. Tim Washburn, Esq.
Sacramento Area Flood Control Agency
1007 7th Street, 7th Floor
Sacramento, California 95814

Subject: Vegetation Variance Supplemental Geotechnical Evaluation
Natomas Levee Improvement Program (NLIP)
Sacramento and Sutter Counties, California

Dear Mr. Washburn:

At the request of SAFCA, Kleinfelder performed supplemental analyses of potential waterside stability impacts based on the most recent analyses performed by Northwest Hydraulic Consultants (nhc). The information provided in this letter is intended to supplement the analyses in Kleinfelder’s report "Vegetation Variance Geotechnical Evaluation," dated April 8, 2010.

BACKGROUND

In the scour analyses presented in nhc’s “Report for: NLIP Vegetation Variance Request Tree Fall Levee Erosion Studies,” dated March 30, 2010, a 15-foot by 3-foot root plate was used to model erosion/scour for tree falls at ten sites. The resulting scour holes were calculated by nhc and used to establish the geometry of the scour remnant levee configuration. SAFCA requested that nhc further its study to include analyses with a 20 foot by 4 foot root plate. Due to the increased size of the root plate, the scour analyses resulted in deeper and wider scour holes at the ten nhc study sites, changing the geometry of the scour remnant levee configuration at each location. The results of the nhc scour analyses are summarized in Table 1.

SAFCA requested that Kleinfelder perform supplemental sudden draw down analyses including the revised nhc scour remnant sections presented in nhc's “Report for: NLIP Vegetation Variance Request Tree Fall Levee Erosion Studies,” dated April 22, 2010.

Please refer to the section titled “nhc Scour Remnants Sections” in Kleinfelder’s aforementioned report for details regarding site selection, location, and results of the previous analyses.
ANALYSES

Kleinfelder analyzed the potential effects of deeper scour holes on sudden draw down stability caused by tree falls with a 20-foot by 4-foot root plate on the waterside slope/toe. The geometry of the larger scour holes was submitted in the nhc drawings provided to Kleinfelder on April 16, 2010, and are included in the April 22, 2010, nhc report. All analyses were conducted using the 200-year water surface elevation (WSE). Based on the model results for the other sections, the small amount of scour in nhc locations Sac 4, Sac 6, and ARNL 1 is judged to have little impact on the global stability of the levee and was not modeled.

Table 1 – Summary of nhc Scour Analysis Results for 20-foot by 4-foot Root Plate

<table>
<thead>
<tr>
<th>Site (LM)</th>
<th>200-year WSE (NAVD88 ft)</th>
<th>Elevation of Tree (NAVD88 ft)</th>
<th>Maximum Scour Depth for Scour Configuration (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sac 1 (0.3)</td>
<td>43.1</td>
<td>31</td>
<td>17.9</td>
</tr>
<tr>
<td>Sac 2 (5.3)</td>
<td>41.3</td>
<td>35</td>
<td>16.5</td>
</tr>
<tr>
<td>Sac 3 (12.0)</td>
<td>36.4</td>
<td>27</td>
<td>16.5</td>
</tr>
<tr>
<td>Sac 4 (13.3)</td>
<td>35.7</td>
<td>33.7</td>
<td>2.8</td>
</tr>
<tr>
<td>Sac 5 (14.9)</td>
<td>34.4</td>
<td>27</td>
<td>16.6</td>
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<tr>
<td>Sac 6 (17.4)</td>
<td>34.9</td>
<td>31</td>
<td>0.14</td>
</tr>
<tr>
<td>NEMDC (1.3)</td>
<td>36.1</td>
<td>30</td>
<td>9.8</td>
</tr>
<tr>
<td>NCC1 (3.7)</td>
<td>42.3</td>
<td>31</td>
<td>13.3</td>
</tr>
<tr>
<td>ARNL 1 (0.7)</td>
<td>35.4</td>
<td>34.4</td>
<td>6.7</td>
</tr>
<tr>
<td>ARNL 2 (1.7)</td>
<td>35.8</td>
<td>25</td>
<td>17.4</td>
</tr>
</tbody>
</table>

RESULTS

The results of our supplemental analyses are presented in Table 2 and are shown graphically on Plates 1 through 7. All scour remnant sections were found to have a sudden drawdown FOS greater than 1.1, the USACE minimum criteria.
Table 2 – Scour Analysis Stability Results Summary for 20-foot by 4-foot Root Plate

<table>
<thead>
<tr>
<th>nhec Cross Section ID</th>
<th>Analysis Type</th>
<th>Levee Section</th>
<th>Kleinfelder Representative Station (Model)</th>
<th>Sudden Drawdown FOS With Scour Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sac 1</td>
<td>Scour Hole</td>
<td>SREL 2</td>
<td>27+00</td>
<td>1.11</td>
</tr>
<tr>
<td>Sac 2</td>
<td>Scour Hole</td>
<td>SREL 2</td>
<td>287+00</td>
<td>1.11</td>
</tr>
<tr>
<td>Sac 3</td>
<td>Scour Hole</td>
<td>SREL 3</td>
<td>640+00</td>
<td>1.35</td>
</tr>
<tr>
<td>Sac 5</td>
<td>Scour Hole</td>
<td>SREL 4</td>
<td>789+00</td>
<td>1.33</td>
</tr>
<tr>
<td>ARNL 2</td>
<td>Scour Hole</td>
<td>ARNL</td>
<td>96+65</td>
<td>1.50</td>
</tr>
<tr>
<td>NEMDC</td>
<td>Scour Hole</td>
<td>NEMDC</td>
<td>58+00</td>
<td>1.17</td>
</tr>
<tr>
<td>NCC1</td>
<td>Scour Hole</td>
<td>NCC</td>
<td>21+00</td>
<td>1.11</td>
</tr>
</tbody>
</table>

We appreciate the opportunity to provide our services for this project. If you have questions regarding this report or if we may be of further assistance, please contact the undersigned.

Respectfully,

KLEINFELDER WEST, INC.

Elizabeth Roesler, EIT
Geotechnical Professional

Lynn M. O'Leary, PE, PMP
Project Manager

Attachments:

Plates 1-7
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Material Number, Description, Unit Weight, Drained Cohesion, Drained Friction Angle, Undrained Cohesion, Undrained Friction Angle

Material # 1: Poorly Graded Sand - Unit Weight: 115pcf, Drained C: 0 psf, Drained Phi: 28 °, Undrained C: 0 psf, Undrained Phi: 28 °
Material # 2: Silty Sand (2) - Unit Weight: 115pcf, Drained C: 0 psf, Drained Phi: 31 °, Undrained C: 0 psf, Undrained Phi: 31 °
Material # 3: Adjacent Levee Clay (CL) - Unit Weight: 123pcf, Drained C: 200 psf, Drained Phi: 24 °, Undrained C: 200 psf, Undrained Phi: 15 °
Material # 4: Clay - Unit Weight: 110pcf, Drained C: 100 psf, Drained Phi: 25 °, Undrained C: 200 psf, Undrained Phi: 15 °
Material # 5: Cutoff Wall - Unit Weight: 120pcf, Drained C: 20 psf, Drained Phi: 0 °, Undrained C: 20 psf, Undrained Phi: 0 °
Material # 6: Poorly Graded Sand (SP) - Unit Weight: 115pcf, Drained C: 0 psf, Drained Phi: 31 °, Undrained C: 0 psf, Undrained Phi: 31 °

Top of Adjacent Levee Elevation: 48.4 ft
Landslide Elevation at Adjacent Levee Toe: 29.5 ft
Cutoff Wall Tip Elev: 14 ft
Sudden Drawdown WSE from 45.4 ft to 30.4 ft
Results
Factor of Safety: 1.11

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 3b in the nhd report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated April 22, 2010.
2) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the stability model for the 200-year WSE, at Station 27+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 1 (Reaches 1 Through 4A), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.

Analysis View: 2D

File Name: SREL_Sta 27+00_SDD_AJ3to1_200yearCOW_VVR_NHC3.gsz
Last Saved Date: 4/21/2010
Analysis Type: Spencer
Analysis View: 2D

VEGETATION VARIANCE SUPPLEMENTAL GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUFTER COUNTIES, CALIFORNIA

PROJECT NO. VVR DSGN
DATE: 4.22.10
DRAWN BY: L. Roesler
CHECKED BY: M. Stanley
FILE NAME: SREL St 27+00 SDD AJ3to1 200year COW VVR NHC3.gsz
Last Saved Date: 4/21/2010
Analysis Type: Spencer
Analysis View: 2D

Factor of Safety Spectrum:

1.6 1.1

WSE = 45.4 ft.
WSE = 30.4 ft.

Elevation, NAVD88 (feet):
-100 -80 -60 -40 -20 0 20 40 60 80

Horizontal Distance (feet):
400 450 500 550 600 650 700 750 800

MAXIMUM SCOUR DEPTH: 17.9 FT
WSE: 45.4 FT to 30.4 FT
SUDDEN DRAWDOWN SCOUR REMNANT LEVEE CONFIGURATION

SREL STATION 27+00
STABILITY ANALYSIS
Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 4b in the nrc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated April 22, 2010.
2) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 287+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 2 (Reaches 5 Through 9), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 15, 2010.

Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Levee Fill - PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 33°; Total Cohesion: 0 psf; Total Phi: 33°
Material #2: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #3: Silt; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 26°; Total Cohesion: 100 psf; Total Phi: 20°
Material #4: Interbedded Silty Sand, Silt and Clay; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #5: Deep Silt; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 26°; Total Cohesion: 100 psf; Total Phi: 20°
Material #6: Clay; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #7: Deep Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #8: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 33°; Total Cohesion: 0 psf; Total Phi: 33°
Material #9: Deep Clay; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #10: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #11: Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Factor of Safety Spectrum

- 1.6
- 1.1

Factor of Safety Spectrum: 1.11
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill): Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Silt; Unit Weight: 110 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 100 psf; Total Phi: 20°
Material #3: Clay Blanket; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #4: Clay; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #5: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #6: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #7: Existing Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #8: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #9: SB Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 5b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated April 22, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevations are based off of the sudden drawdown model for the 200-year WSE, at Station 640+00 presented in Kleinfelder’s “Draft Basis of Design Report, Sacramento River East Levee, SREL 3 (Reaches 10 Through 15), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated September 23, 2009.

Results
Factor of Safety: 1.35
Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 7b in the nhc report titled, “NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies,” dated April 22, 2010.
2) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 789+00 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 6, 2009.

Horizontal Distance (feet)

Factor of Safety Spectrum

MAXIMUM SCOUR DEPTH: 16.6 FT
WSE: 36.2 FT to 21.2 FT
SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION
Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 10b in the NHC report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated April 22, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 96+65 presented in Kleinfelder’s “Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated November 2, 2009.
Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 11b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated April 22, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 58+00 presented in Kleinfelder’s “Draft Alternatives Analysis Report, Natomas East Main Drainage Canal—South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 2, 2009.

Results
Factor of Safety: 1.17
Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 12b in the nhc report titled, “NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies,” dated April 22, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 21+00 presented in Kleinfelder’s “Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California,” dated January 30, 2009.

Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (Existing Levee); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #2: Clay (Blanket); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Silt; Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 15°
Material #4: Sand; Unit Weight: 125 pcf; Eff Cohesion: 0 psf; Eff Phi: 31°; Total Cohesion: 0 psf; Total Phi: 31°
Material #5: Clay; Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #6: Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Clay (Levee Raise); Unit Weight: 125 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #8: Clay (Field); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°