Oxbow South Development

Hydraulic Analysis, Slope Protection, and FEMA Submittal Recommendations

February 2019 Draft Report (IN PROGRESS)

Prepared for:
Oxbow Holdings, LLC
933 Water, LLC

Prepared by:
River Focus Water Resource Consultants
Oxbow South Development

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Prepared by
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1 INTRODUCTION

1.1 Study Location

The proposed Oxbow South development is located within the Napa River Oxbow and is bordered by First Street, Vernon Street, Water Street, and the Napa River. A project location map is provided in Figure 1-1.

![Figure 1-1. Oxbow South - Project Location Map](image)

1.2 Study Purpose

This hydraulic study is intended to answer the following questions related to the proposed Oxbow South development:

1. What impact would the proposed project fill have on computed flood elevations in the Oxbow compared to existing conditions (Post-Bypass Conditions)?

2. What impact would the proposed project fill have on computed flood elevations in the Oxbow after the Lincoln Avenue area floodwalls have been constructed and the Napa River flow is higher in the project reach (Future Interim Conditions)?

3. Which type of FEMA map revision submittal—LOMR based on Fill (LOMR-F) or LOMR—is the best option for the proposed project?
(4) What is the required elevation of the proposed fill based on Ultimate Conditions with all Napa River floodwalls constructed (i.e., the highest flood elevation conditions)?

(5) What protection is required for the proposed fill slope, given the computed flow velocities and shear stresses along the slope (based on Ultimate Conditions)?

### 1.3 Hydraulic Modeling

River Focus performed one-dimensional (1-D) and two-dimensional (2-D) hydraulic modeling to help answer the study questions.

#### 1-D Hydraulic Modeling

The current effective FEMA 1-D hydraulic model was used in addressing Question #1 (project impacts based on existing conditions) and Question #3 (selecting the appropriate FEMA map revision approach).

The ultimate conditions 1-D hydraulic model that was developed for the Napa River-Napa Creek Flood Protection Project was used for addressing Question #4 (required fill elevations for the project) and Question #5 (fill slope protection).

Both 1-D hydraulic models were run using HEC-RAS (River Analysis System), Version 4.1, which is consistent with the effective FEMA modeling, as well as the modeling for the Flood Protection Project.

#### 2-D Hydraulic Modeling

Because the project site is located within an Oxbow area and not a straight river reach, more complex, two-dimensional flow patterns are experienced. To supplement the 1-D hydraulic modeling, a 2-D hydraulic model was developed using HEC-RAS Version 5.0.6 to address the effects of these more complex flow patterns.

The results of the 2-D model were used to determine if there were any areas along the project reach where the fill elevation should be higher, or more protection was needed along the fill slope (Question #5). The 2-D model was also used to confirm what potential impacts the proposed fill would have on other properties within the Oxbow area, including Question #2 (project impacts based on future interim conditions).

#### Vertical Datum

All hydraulic models for this study are in the NAVD88 vertical datum. To convert from NGVD29 to NAVD88, a conversion factor of +2.55 feet was used (consistent with the FEMA Flood Insurance Study).
2 FLOODWALLS AND PROJECT FILL

2.1 Line of Protection

The proposed Oxbow South development is located within the floodplain fringe, i.e., the portion of the floodplain outside of the FEMA regulatory floodway area. The FEMA Flood Insurance Study map within the Oxbow area is shown in Figure 2-1.

Compacted fill is proposed for the Oxbow South project site instead of the originally proposed U.S. Army of Corps Engineers floodwall. The fill would provide a similar function as the Corps floodwall; however, elevating the entire project site with fill is preferred from a floodplain management perspective because there is less residual risk with fill than with a floodwall.

![Figure 2-1. FEMA Regulatory Floodway within the Napa River Oxbow Area](image)

2.2 Fill Elevation

**Effective Conditions vs. Ultimate Conditions**

On January 22, 2019, the FEMA floodplain maps representing Post-Bypass Conditions became effective. While the new FEMA maps show the latest flood elevations for the Napa River along the project site, the design fill elevations should be based on Ultimate Conditions along the river, i.e., where all remaining Flood Protection Project floodwalls have been completed.
Ultimate Conditions include a floodwall from the Lake Park Levee to the Bypass, completion of the floodwall along the north side of the Bypass (i.e., filling the gaps in the floodwall near Soscol Avenue and the railroad), floodwall segments along the Oxbow, a floodwall from the Hatt Building to Imola Avenue, and a floodwall from Sixth Street to Tulocay Creek.

**FEMA vs. Corps of Engineers Hydraulic Models**

The Napa River hydraulic models used by FEMA and the U.S. Army Corps of Engineers have some significant differences, with the main one being the assumed downstream boundary condition. The Corps of Engineers’ downstream boundary conditions is based on a more detailed analysis of tidal conditions. For determining the required fill elevations for the Oxbow South site, the Ultimate Conditions model from the Corps of Engineers was used.

**Sea Level Rise**

The Corps of Engineers (2011) studied the potential impact of sea level rise on the Napa River Flood Protection Project and concluded that during a major flood event, the impact of sea level rise “will result in negligible impact on levee heights.”

**Freeboard**

Consistent with City of Napa regulations, the fill elevation should be set at least 1 foot above the Base (100-year) Flood Elevation.

**Proposed Fill Elevations**

The required minimum elevation (NAVD88) of the proposed fill ranges from approximately 20.4 ft upstream of the railroad bridge to 21.3 ft just downstream of First Street, based on the computed 100-year flood elevations plus 1 foot of freeboard (see Table 2-1). Fill elevations are rounded up to the nearest 0.1 ft. Maximum water surface elevations and proposed fill elevations for the Oxbow South Development are shown in Figure 2-2 and Figure 2-3. HEC-RAS model cross sections from the Corps of Engineers model are shown in Figure 2-4.
Figure 2-2. Ultimate Conditions 100-year Water Surface Elevation (NAVD88)
Figure 2-3. Ultimate Conditions 100-year Fill Elevations (NAVD88)
**Table 2-1.** Computed 1-D Water Surface Elevations and Fill Elevations (NAVD88)

<table>
<thead>
<tr>
<th>River Station (ft)</th>
<th>Computed 100-yr WSEL (ft)</th>
<th>Min. Fill Elevation (100-yr + 1 ft Freeboard) (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First St Bridge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79849</td>
<td>20.27</td>
<td>21.3</td>
</tr>
<tr>
<td>79722</td>
<td>20.25</td>
<td>21.3</td>
</tr>
<tr>
<td>79588</td>
<td>20.05</td>
<td>21.1</td>
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<tr>
<td>79468</td>
<td>20.05</td>
<td>21.1</td>
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<tr>
<td>79276</td>
<td>19.96</td>
<td>21.0</td>
</tr>
<tr>
<td>79102</td>
<td>20.09</td>
<td>21.1</td>
</tr>
<tr>
<td>78976</td>
<td>20.11</td>
<td>21.2</td>
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<td>78813</td>
<td>19.86</td>
<td>20.9</td>
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<tr>
<td>78692</td>
<td>19.60</td>
<td>20.6</td>
</tr>
<tr>
<td>78560</td>
<td>19.66</td>
<td>20.7</td>
</tr>
<tr>
<td>78464</td>
<td>19.55</td>
<td>20.6</td>
</tr>
<tr>
<td>78390</td>
<td>19.53</td>
<td>20.6</td>
</tr>
<tr>
<td>78310</td>
<td>19.43</td>
<td>20.5</td>
</tr>
<tr>
<td>78292</td>
<td>19.39</td>
<td>20.4</td>
</tr>
<tr>
<td>78286</td>
<td>19.38</td>
<td>20.4</td>
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<td>78221</td>
<td>19.28</td>
<td>20.3</td>
</tr>
<tr>
<td>78161</td>
<td>19.31</td>
<td>20.4</td>
</tr>
<tr>
<td>78114</td>
<td>19.34</td>
<td>20.4</td>
</tr>
<tr>
<td>78070</td>
<td>19.36</td>
<td>20.4</td>
</tr>
<tr>
<td>Railroad Bridge</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 2-4. Corps of Engineers HEC-RAS Model Cross Sections (1-D Ultimate Conditions). River Station Numbers corresponding to Table 2-1 shown.
3 POTENTIAL PROJECT IMPACTS

3.1 Post-Bypass Conditions

The post-bypass conditions were modeled using the FEMA effective model. The proposed fill showed no adverse water surface elevation impacts within the project reach or offsite.

The 100-year maximum water surface elevation results of the post-bypass conditions (existing site and proposed project fill) are shown in Figure 3-1 and Figure 3-2 respectively.

3.2 Future Conditions

The future interim conditions (including the Lincoln area floodwalls) were also modeled by modifying the 2-D model by including the proposed floodwalls. The proposed fill showed no adverse water surface elevation impacts within the project reach or offsite even with the increased flows due to the Lincoln area floodwalls.

The 100-year maximum water surface elevation results of the future interim conditions (existing site and proposed project fill) are shown in Figure 3-3 and Figure 3-4 respectively.

3.3 Ultimate Conditions

The ultimate conditions (including the Lincoln area floodwalls as well as all of the future proposed flood protection project floodwalls) were modeled using the U.S. Army Corps of Engineers model. The proposed fill showed no adverse water surface elevation impacts within the project reach or offsite even with the increased flows due to the Ultimate Conditions floodwalls.

The 100-year maximum water surface elevation results of the ultimate conditions are shown in Figure 3-5 respectively.
Figure 3-1. Post-Bypass Conditions with Existing Site – 100-yr Maximum Depth and Flow Tracers
Figure 3-2. Post-Bypass Conditions with Project Fill – 100-yr Maximum Depth and Flow Tracers
Figure 3-3. Future Interim Conditions with Existing Site - 100-yr Maximum Depth and Flow Tracers
Figure 3-4. Future Interim Conditions with Project Fill - 100-yr Maximum Depth and Flow Tracers
Figure 3-5. Ultimate Conditions with Project Fill – 100-yr Maximum Depth and Flow Tracers
4 FEMA MAP REVISION

4.1 Recommended FEMA Submittals

CLOMR-F Submittal
A FEMA Conditional Letter of Map Revision based on Fill (CLOMR-F) will be processed for the Oxbow South development prior to grading approval. The CLOMR-F will allow FEMA to review the proposed fill and will provide FEMA confirmation that if the fill is placed as proposed, the raised portion of the site will be removed from the FEMA Zone AE floodplain.

LOMR-F Submittal
A FEMA Letter of Map Revision based on Fill (LOMR-F) will be processed for the Oxbow South development following construction. The LOMR-F will remove the portion of the project site raised by fill from FEMA Zone AE floodplain. While other Oxbow area properties would be not be removed from the Zone AE floodplain.

4.2 Future LOMR Submittal
Other Oxbow area properties (see Figure 4-1) will be protected by a combination of the Bypass floodwall, high ground along the Napa River, compacted fill for the Oxbow South project site, and a proposed floodwall at the downstream end of the Oxbow South development. A future LOMR application would be required to remove the remaining Oxbow area properties from Zone AE floodplain.

While a LOMR submittal could be prepared for the Oxbow South development instead of a LOMR-F submittal, it is not recommended because the LOMR would likely require certification of the Bypass south floodwall. Certification of this wall should be conducted as part of a large, future certification process of Flood Protection Project floodwalls and levees after all floodwall segments within the Oxbow have been constructed.
Figure 4-1. Residential and Commercial Structures affected by a Future LOMR.
5 FILL SLOPE PROTECTION

5.1 Flow Depth, Velocity, and Shear Stress

Flow Depth
The results of the 2-D model show an average 100-year flow depth along the proposed fill slope is 1.5 feet, with a maximum depth of 2.0 feet (Figure 5-3).

Maximum Water Surface elevation contours are shown for both the 1-D model (Figure 5-5) and 2-D model (Figure 5-4) below.

Velocity
The 2-D model computed 100-year overbank velocity adjacent to the proposed fill slope (Figure 5-2) ranges from 0.1 to 1.3 feet per second (ft/sec).

Computed Shear Stress
Based on the 1-D model results, the average 100-year shear stress along the fill slope is 0.03 lb/ft², with a maximum shear stress of 0.04 lb/ft².

Average shear stress results are similar for the 2-D model; however, there are two locations where the 100-year shear stress is higher: (1) along the proposed retaining wall, the maximum shear stress is approximately 0.2 lb/ft²; and (2) at the southernmost point of the project site, the maximum shear stress is approximately 0.3 to 1 lb/ft² along the slope (Figure 5-1).

5.2 Required Protection

Permissible Shear Stress
Table 5-1 below shows the permissible shear stress for unprotected soils is on the order of 0.05 lb/ft², while it is 0.7 to 0.95 lb/ft² for short native and bunch grass, 1.2 to 1.7 lb/ft² for long native grasses, and 1 to 3 lb/ft² for a turf grass cover (Fischenich, 2001).

Recommended Erosion Protection
With an expected 100-year shear stress of 1 lb/ft² or less, hard armor protection of any kind would not be required. Instead, a well-vegetated fill slope would be sufficient for providing adequate protection from the low shear-stress overbank flows.

At the southernmost point of the project site (see Figure 5-6), we would recommend the installation of a permanent turf reinforcement mat (TRM) to provide an additional level of protection beyond the vegetated fill slope.

Napa River Bank/Toe Protection
The proposed fill slope is setback approximately 50 feet from the top of the Napa River bank. It is our understanding that, if required, any improvements to the Napa River streambank and toe protection will be performed by the Napa County Flood Control & Water Conservation District.
Figure 5-1. Maximum 100-year Shear Stress (HEC-RAS 2-D Model Results)
Figure 5-2. 100-year Maximum Flow Velocity (HEC-RAS 2-D Model Results)
Figure 5-3. 100-year Maximum Flood Depth (HEC-RAS 2-D Model Results)
Figure 5-4. 100-year Maximum Water Surface Elevation (HEC-RAS 2-D Model Results)

Notes:
- 0.1’ W SEL contours shown
- Vertical datum: NAVD88
Figure 5-5. 100-year Maximum Water Surface Elevation (HEC-RAS 1-D Model Results)

Notes:
- 0.1' W SEL contours shown
- Vertical datum: NAVD88
Table 5-1. Permissible Shear Stress and Velocity (Fischenich, 2001)

<table>
<thead>
<tr>
<th>Boundary Category</th>
<th>Boundary Type</th>
<th>Permissible Shear Stress (lb/sq ft)</th>
<th>Permissible Velocity (ft/sec)</th>
<th>Citation(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soils</td>
<td>Fine colloidal sand</td>
<td>0.02 - 0.03</td>
<td>1.5</td>
<td>A</td>
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<tr>
<td></td>
<td>Sandy loam (noncolloidal)</td>
<td>0.03 - 0.04</td>
<td>1.75</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Alluvial silt (noncolloidal)</td>
<td>0.045 - 0.05</td>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Silty loam (noncolloidal)</td>
<td>0.045 - 0.05</td>
<td>1.75 - 2.25</td>
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</tr>
<tr>
<td></td>
<td>Firm loam</td>
<td>0.075</td>
<td>2.5</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Fine gravels</td>
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</tr>
<tr>
<td></td>
<td>Stiff clay</td>
<td>0.26</td>
<td>3 - 4.5</td>
<td>A, F</td>
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<tr>
<td></td>
<td>Alluvial silt (colloidal)</td>
<td>0.26</td>
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<td>Graded loam to cobbles</td>
<td>0.38</td>
<td>3.75</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Graded silts to cobbles</td>
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<td>4</td>
<td>A</td>
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<td>Shales and hardpan</td>
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<td>6</td>
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<tr>
<td>Gravel/Cobble</td>
<td>1-in.</td>
<td>0.33</td>
<td>2.5 - 5</td>
<td>A</td>
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<tr>
<td></td>
<td>2-in.</td>
<td>0.67</td>
<td>3 - 6</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>6-in.</td>
<td>2.0</td>
<td>4 - 7.5</td>
<td>A</td>
</tr>
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<td></td>
<td>12-in.</td>
<td>4.0</td>
<td>5.5 - 12</td>
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<tr>
<td>Vegetation</td>
<td>Class A turf</td>
<td>3.7</td>
<td>6 - 8</td>
<td>E, N</td>
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<td>Class B turf</td>
<td>2.1</td>
<td>4 - 7</td>
<td>E, N</td>
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<td>Class C turf</td>
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<tr>
<td></td>
<td>Long native grasses</td>
<td>1.2 - 1.7</td>
<td>4 - 6</td>
<td>G, H, L, N</td>
</tr>
<tr>
<td></td>
<td>Short native and bunch grass</td>
<td>0.7 - 0.95</td>
<td>3 - 4</td>
<td>G, H, L, N</td>
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<td>Reed plantings</td>
<td>0.1-0.6</td>
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<tr>
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<td>Hardwood tree plantings</td>
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<tr>
<td>Temporary Degradable RECPs</td>
<td>Jute net</td>
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<td>1 - 2.5</td>
<td>E, H, M</td>
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<tr>
<td></td>
<td>Straw with net</td>
<td>1.5 - 1.65</td>
<td>1 - 3</td>
<td>E, H, M</td>
</tr>
<tr>
<td></td>
<td>Coconut fiber with net</td>
<td>2.25</td>
<td>3 - 4</td>
<td>E, M</td>
</tr>
<tr>
<td></td>
<td>fiberglass roving</td>
<td>2.00</td>
<td>2.5 - 7</td>
<td>E, H, M</td>
</tr>
<tr>
<td></td>
<td>Unvegetated</td>
<td>3.00</td>
<td>5 - 7</td>
<td>E, G, M</td>
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<tr>
<td></td>
<td>Partially established</td>
<td>4.0 - 6.0</td>
<td>7.5 - 15</td>
<td>E, G, M</td>
</tr>
<tr>
<td></td>
<td>Fully vegetated</td>
<td>8.00</td>
<td>8 - 21</td>
<td>F, L, M</td>
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<td>Non-Degradable RECPs</td>
<td>6 - in. $d_{50}$</td>
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<td>5 - 10</td>
<td>H</td>
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<td></td>
<td>9 - in. $d_{50}$</td>
<td>3.8</td>
<td>7 - 11</td>
<td>H</td>
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<td>12 - in. $d_{50}$</td>
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<td>H</td>
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<td>24 - in. $d_{50}$</td>
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<td>14 - 18</td>
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<td>Riprap</td>
<td>Wattles</td>
<td>0.2 - 1.0</td>
<td>3</td>
<td>C, I, J, N</td>
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<tr>
<td></td>
<td>Reed fascine</td>
<td>0.6-1.25</td>
<td>5</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Coir roll</td>
<td>3 - 5</td>
<td>8</td>
<td>E, M, N</td>
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<tr>
<td></td>
<td>Vegetated coir mat</td>
<td>4 - 8</td>
<td>9.5</td>
<td>E, M, N</td>
</tr>
<tr>
<td></td>
<td>Live brush mattress (initial)</td>
<td>0.4 - 4.1</td>
<td>4</td>
<td>B, E, I</td>
</tr>
<tr>
<td></td>
<td>Live brush mattress (grown)</td>
<td>3.90-8.2</td>
<td>12</td>
<td>B, C, E, I, N</td>
</tr>
<tr>
<td></td>
<td>Brush layering (initial/grown)</td>
<td>0.4 - 6.25</td>
<td>12</td>
<td>E, I, N</td>
</tr>
<tr>
<td></td>
<td>Live fascine</td>
<td>1.25-3.10</td>
<td>6 - 8</td>
<td>C, E, I, J</td>
</tr>
<tr>
<td></td>
<td>Live willow stakes</td>
<td>2.10-3.10</td>
<td>3 - 10</td>
<td>E, N, O</td>
</tr>
<tr>
<td>Soil Bioengineering</td>
<td>Gabions</td>
<td>10</td>
<td>14 - 19</td>
<td>D</td>
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<tr>
<td>Hard Surfacing</td>
<td>Concrete</td>
<td>12.5</td>
<td>&gt; 18</td>
<td>H</td>
</tr>
</tbody>
</table>

*Ranges of values generally reflect multiple sources of data or different testing conditions.

M. TXDOT (1999)
N. Data from Author (2001)
O. USACE (1997).
Figure 5-6. Turf Reinforcement Mat - Recommended Extents
6 CONCLUSIONS

The main findings from the Oxbow South hydraulic analysis are summarized below in response to the questions posed in Study Purpose 1.2:

(1) What impact would the proposed project fill have on computed flood elevations in the Oxbow compared to existing conditions?

   Based on using the effective FEMA hydraulic model, the proposed project fill has a negligible impact on the computed 100-year Napa River flood elevations. This is because under existing conditions, only a small percentage of the Napa River discharge travels on the Oxbow South side of the river.

(2) What impact would the proposed project fill have on computed flood elevations in the Oxbow after the Lincoln Avenue area floodwalls have been constructed and the Napa River flow is higher in the project reach?

   Based on the 2-D model, no increase in flood elevations was found in the project reach due to the proposed project fill with respect to the Future Interim Conditions.

(3) Which type of FEMA map revision submittal—LOMR based on Fill (LOMR-F) or LOMR—is the best option for the proposed project?

   A LOMR based on Fill submittal appears to be the best option for the Oxbow South project. A full LOMR submittal would require a long floodwall certification process, which is better suited for after all planned Oxbow area floodwalls have been completed.

(4) What is the required elevation of the proposed fill based on ultimate conditions with all Napa River floodwalls constructed (i.e., the highest flood elevation conditions)?

   Based on using the Corps of Engineers Ultimate Conditions model, the required minimum elevation of the proposed fill ranges from 20.4 ft (NAVD88) upstream of the railroad bridge to 21.4 ft just downstream of First Street, based on the computed 100-year flood elevations and 1 foot of freeboard. If a higher level of protection (i.e., 500-year flood elevation) is desired, the proposed fill (without freeboard) would be 21.8 ft to 22.8 ft.

(5) What protection is required for the proposed fill slope, given the computed flow velocities and shear stresses along the slope (based on ultimate conditions)?

   The computed overbank flow velocities and shear stresses are very low; therefore, no additional protection other than natural vegetation is required except for at the southernmost point of the project site where installation of a permanent turf reinforcement mat (TRM) to provide an additional level of protection beyond the vegetated fill slope is recommended.
7 REFERENCES


8 ACKNOWLEDGMENTS

This study was performed by River Focus, Inc., for Oxbow Holdings, LLC, and 933 Water, LLC, led by Wayne O’Connell and Preston O’Connell. The River Focus study team includes A. Jake Gusman, PE (Project Manager), Darren Bertrand, CFM (Senior Hydraulic Modeler), and Mikell Warms, EIT (Hydraulic Engineer).