Lower Feather River Corridor Management Plan Flood Hydraulic Analysis of Future Conditions

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Table of Contents

List of Tables

List of Figures

1 Introduction

The California Department of Water Resources (DWR) has initiated development of a Lower Feather River Corridor Management Plan (LFR CMP) project from the Sutter Bypass to Marysville/Yuba City at the Yuba River confluence. The LFR CMP project will develop a vision and strategy for future management of flood protection facilities, conveyance channels, floodplains, and associated uplands; and will recommend policies for compatible land uses, such as habitat restoration and mitigation, agriculture, and river recreation.

2 Purpose

The purpose of this document is to summarize the flood hydraulic analysis of potential Future Conditions in the Lower Feather River. The potential Future Conditions anticipated for implementation will be analyzed in subsequent California Environmental Quality Act (CEQA) or National Environmental Policy Act (NEPA) environmental review process. This hydraulic study evaluates the effects of larger flood events. Simulations will focus on the 1-in-100 annual exceedance probability (AEP), 1-in-200 AEP, and the 1957 Sacramento River Flood Control Project (SRFCP) Design Flow events. Included in this document are:

- Background on the hydraulic model used for the analysis;
- Description of the hydrology in the study area;
- Description of the modeled Future Conditions;
- A selection of Baseline and Future cross sections;
- Water surface elevation profiles derived from the hydraulic analysis;
- Top-of-levee elevation profiles in relation to water surface elevation profiles;
- Velocity and velocity difference contours derived from the hydraulic analysis.

3 Methodology

To determine the potential Future Condition's effects on flood hydraulics, the water-surface elevations and flow velocities in the study area under the recommended Future Conditions scenario were calculated and compared with Baseline Conditions. The Baseline Conditions flood hydraulic analysis is documented in the "Lower Feather River Corridor Management Plan Hydraulic Analysis-Baseline Model Documentation" (MBK, 2012). Simulation runs were conducted for different flow and stage conditions. Similar to the Baseline Study, the Future Conditions are simulated with 1-in-100 AEP, 1-in-200 AEP, and 1957 Sacramento River Flood Control Project design flow and stage conditions. The computed water surface elevations and velocities for the Future Conditions are then compared and contrasted with the Baseline Study. Levee freeboards and the difference in velocities have been evaluated and assessed for all simulation runs.

4 Model Software

The hydraulic modeling software used for this analysis is RMA-2 Version 4.5 (Corps, 2008). RMA-2 is a two dimensional finite element hydrodynamic numeric model (2-D model). It computes water surface elevation and horizontal velocity components for subcritical, free surface two-dimensional flow fields. RMA-2 solves the depth integrated equations of fluid mass and momentum conservation in two horizontal directions.

The RMA-2 hydraulic model is assembled with Surface Water Modeling System (SMS) Version 10.1 and 11.0. SMS is a pre- and post-processor for surface water modeling and analysis. SMS provides a graphical user interface to develop the two dimensional model and to visualize and analyze results.

5 Hydraulic Model – Future Conditions

5.1 Mesh Development

Finite element models use a system of nodes to define boundaries for each element in the model. Nodes are typically assigned to topographic points of interests which include major transitions in topography or vegetation. The network of connected elements is called a mesh or finite element mesh. Each element is categorized according to their specific physical properties called material types. The properties in each material type describe the physical properties, for instance turbulence coefficients or roughness coefficients.

A finite element mesh of the Sutter Bypass, Feather, Bear, and Yuba Rivers was developed during the Baseline Study. The Future Conditions model uses the Baseline Study's finite element mesh as a starting point and the elements were modified to reflect the Future Condition changes to topography and vegetation roughness. The triangular and quadrilateral elements of the mesh were re-aligned to follow the contours of the proposed grading features. The element material type was also re-characterized to represent future vegetation or restored habitats.

The model's study area is referenced in river miles (RM) established by the Corps' Comprehensive Study. The model study area begins at RM 28.7 on the Feather River at Marysville and extends down the Feather River to RM 2.9 where the river runs parallel to the east flank of the Sutter Bypass. (Note however that the LFR CMP planning area only extends downstream (DS) to RM 7.5 at the Nelson Slough rock weir at the junction with Sutter Bypass.) The Bear River was simulated from RM 4.75 on Bear River to the confluence with the Feather River at RM 12.1. A short portion of the Yuba River was simulated from the confluence with the Feather River up to RM 1.2. Figure 1 illustrates, in plan-view, the finite element mesh and the modeling study area.

5.2 Future Conditions

The following narratives describe the LFR CMP project sites that were simulated under the recommended Future Conditions. Some features are intended to improve flood way conveyance capacity and reduce flood stage, or to minimize the burden of costly vegetation management in certain areas. Most features are conceptually designed for "low-flow" conveyance to promote the ecological functions and values of natural floodplain areas. Flows that occur more frequently than the 1-in-100 AEP are considered low-flows in this study. Low-flow simulations for the Future Conditions are being simulated by cbec Inc. and will include ecological flows (Frequently Activated Floodplain (FAF) flows) and 2-, 10-, 25-, and 100-year AEP hydrology and sediment transport.

5.2.1 State-Cut and Eliza Bend/Old Feather River (Feather River Left Floodplain)

The State-Cut begins at approximately Yuba RM 1 left bank and extends 2.5 miles southward down the floodplain, then converges with the Old Feather River channel east of Eliza Bend. The State-Cut and Eliza Bend/Old Feather River are primarily grading features. The State-Cut and Old Feather River channels are to be upgraded into a better defined open-channel from Yuba RM 1 to Feather River RM 21.5. In the Future Conditions, low flows diverted from the Yuba River into the State-Cut channel are conveyed into the Feather River Setback area. A crossing blocks low flows from the Old Feather River at approximately RM 22.3 and these flows are diverted into the Feather River Setback area. Eliza Bend/Old Feather River channel grading begins at approximately RM 24.8. Figure 2 illustrates the conceptual grading linework in plan-view and locations of representative grading cross-sections for the State-Cut and Eliza Bend/Old Feather River. Cross sections 5.2.1-XA through 5.2.1-XG (Figures 4.1 to 4.7) are grading section lines that compare the Baseline model's topography with the Future Conditions model topography.

Vegetation in the State-Cut and Eliza Bend/Old Feather River features assume channel or open water roughness (n=0.03). Figures 5 and 6 show the Future Conditions roughness (n-value) assignments.

5.2.2 Feather River Setback Area (Feather River Left Floodplain)

The Feather River Setback (FRS) Area begins east of approximately RM 24.1 and extends southward down the left (east) floodplain to approximately RM 17.1. The most prominent grading features in the setback area are two overbank swales connecting the south end of Old Feather River to Upper Messick Lake and three smaller drainage swales north and south of Lower Messick Lake. The two swales north of Upper Messick Lake generally convey low-flow water from a northerly to a southerly direction with one swale draining the toe drains of the Feather River setback levee and one swale conveying water from Old Feather River that originate from overbank diversions at State-Cut and Eliza Bend. The proposed swales are tied into Upper and Lower Messick Lakes and the Messick Lake wetland mitigation site. The three swales south of Upper Messick Lake connect the Messick Lake mitigation site with Lower Messick Lake and existing ponds and swales that drain back into

the main channel of Feather River. Topographic depressions and isolated ponds and swales in this area are susceptible to retaining surface water after the recession of high flows. The connection of these areas with graded swales would provide positive drainage from the setback area to the river at the downstream (south) end of the 1,600-acre setback area. The swale network conveys drainage back into the main channel at RM 18.7 and RM 17.5. Figure 2 illustrates the conceptual grading linework in plan-view and locations of representative grading cross-sections for the Feather River Setback Area. Cross sections 5.2.2-XA to 5.2.2-XH (Figures 4.8 to 4.15) are grading section lines that compare the Baseline model topography with the Future Condition model topography.

Proposed vegetation in the Feather River setback area consists of grasslands (n=0.03) along the degraded Feather River levee (RM 17.2 to RM 24.3) and a grassland corridor between the two swales north of Upper Messick Lake (RM 21.1 to RM 22.5), oak woodland vegetation (n=0.05), dense willow scrub (n=0.065), walnut orchards (n=0.075), dense riparian forest (n=0.08), and a densely planted wind-wave buffer (n=0.10) parallel to the Feather River setback levee (RM 19.7 to RM 23.8). Figures 5 and 6 show the Future conditions roughness assignments.

5.2.3 Abbott Lake Unit (Feather River Right Floodplain)

The Abbott Lake Unit begins along the right bank floodplain at approximately RM 20.7 and extends downstream to approximately RM 18.8. There are no proposed grading features in the Abbott Lake project area. The Abbott Lake project in this LFR CMP is in conjunction with the "Abbott Lake Restoration Project" designed by River Partners (River Partners, 2009). The "North Field" restoration site is located approximately between RM 20 to RM 20.7. The "South Field" restoration site is located approximately between RM 19.9 to RM 18.8. Vegetation in the North Field consists of a riparian shrubland (n=0.055). Vegetation in the South Field consists of grasslands (n=0.03), widely spaced hedgerows of low shrubland (n=0.055), and dense willow scrubs (n=0.065). Figures 5 and 6 show the Future Conditions roughness assignments.

5.2.4 Star Bend Unit (Feather River Left Floodplain)

The Star Bend Unit area begins along the left bank floodplain at approximately RM 18.3 and extends downstream to RM 17.8. The Star Bend project area is primarily a grading feature and the apex of the sharp left bend is proposed to be degraded to a lower elevation to improve flood conveyance and reduce scour velocity. Figures 2 and 3 illustrate the conceptual grading linework in plan-view and locations of representative grading cross-sections for the Star Bend degrade. Cross sections 5.2.4-XA and 5.2.4-XB (Figures 4.16 and 4.17) are grading section lines that compare the Baseline model topography with the Future Condition model topography.

No future planting is proposed on the Star Bend site. Vegetation on higher ground is assumed to revert to a grassland roughness (n=0.03).

5.2.5 O'Connor Lakes (Feather River Right Floodplain)

The O'Connor Lakes project area begins along the right bank floodplain at approximately RM 17.9 and extends downstream to RM 16.2. A bench and a better defined overbank channel south of the bench are proposed through O'Connor Lakes. Figures 2 and 3 illustrate the conceptual grading linework in plan-view and locations of representative grading cross-sections for the O'Connor Lakes project area. Cross sections 5.2.5-XA to 5.2.5-XC (Figures 4.18 to 4.20) are grading section lines that compare the Baseline model topography with the Future Condition model topography.

Vegetation in O'Connor Lakes consists of grasslands (n=0.03) at the mouth of the bench (RM 17.8 to RM 17.6), oak woodland (n=0.05) from RM 17.6 to RM 16.8, and grasslands/savannah (n=0.03) at the channel (RM 16.8 to RM 16.2). Figures 5 and 6 show the Future Condition roughness assignments.

5.2.6 Lake of the Woods Unit (Feather River Left and Right Floodplain)

The Lake of the Woods Unit begins along the left bank floodplain at approximately RM 16.4 and extends downstream to RM 12.1. A bench with an adjacent swale is proposed to be graded between approximately RM 16.4 and RM 15.5. Cross sections 5.2.6-XA and 5.2.6-XB (Figures 4.21 to 4.22) are grading section lines that compare the Baseline model topography with Future Condition model topography. The bench and swale is assumed to revert to a willow scrub habitat (n=0.055). Degrading of the remnant of an abandoned levee is proposed in the left floodplain between RM 14.5 and RM 14. No vegetation change is assumed at this degrade (grassland, n=0.03). Degrading of a levee access ramp on the right floodplain is proposed at RM 14. Vegetation is assumed to revert to a dense willow scrub (n=0.065) at the ramp degrade. Degrading of a high ground is proposed in the right floodplain between RM 13.9 and RM 13.3. No vegetation change is assumed at this degrade (grassland, n=0.03). A toe-drain is proposed to be graded at approximately RM 13.6. Cross sections 5.2.6-XC to 5.2.6-XE (Figures 4.23 to 4.25) are grading section lines that compare the Baseline model topography with the Future Condition model topography. Vegetation is assumed to revert to willow scrub (n=0.055). No grading is proposed at the confluence of Feather and Bear Rivers. A State maintained floodplain area is located approximately between RM 12.1 and RM 16.4 along the left bank upstream (US) of the confluence with the Bear River. Maintenance activities could cease between RM 12.1 and RM 13.1 where the levee was removed as part of the Bear River Setback project. Vegetation in this one mile long area is assumed to revert to a dense willow scrub (n=0.065). Figure 3 illustrates the conceptual grading linework in plan-view and locations of representative grading cross-sections for the Lake of the Woods projects. Figures 5 and 6 show the Future Conditions roughness assignments.

5.2.7 Nelson Slough Unit (Feather River Right Floodplain)

The Nelson Slough Unit begins along the right bank floodplain at approximately RM 10.5 to RM 7.5 where it abuts the east side of Sutter Bypass. Recommended Future Condition features consists of two graded benches and widening along the right bank of the river

channel to increase channel capacity and sediment capture potential. The graded benches are located on the right bank floodplain between RM 7.5 and RM 9.1. The right bank of the main channel is proposed to be widened between RM 7.5 and RM 8.0 to match average channel width immediately up and downstream (DS) of this constricted segment. Figure 3 illustrates the conceptual grading linework in plan-view and locations of representative grading cross-sections for Nelson Slough. Cross sections 5.2.7-XA to 5.2.7-XC (Figures 4.26 to 4.28) shows grading section lines that compare the Baseline model topography with the Future Condition model topography.

Vegetation in the Nelson Slough project area consists of grasslands (n=0.03), oak woodlands (n=0.05), and dense riparian forests (n=0.08). Figure 6 maps the Future Condition roughness assignments.

5.2.8 Sutter Bypass and Feather Confluence Levee Re-Alignments (Feather River Left and Right Floodplain)

The Sutter Bypass and Feather Confluence Levee Re-Alignments are located approximately between RM 7.3 and RM 7.7. The levee re-alignment along the left bank is proposed to be a relatively short setback levee to increase the radius of curvature at the tight bend of the levee and constricted channel. The training levee on the right bank is proposed to be realigned at the upstream end to further improve the constricted channel at the apex of the bend. Vegetation is assumed to revert to grassland (n=0.03). Figure 3 illustrates the conceptual grading linework in plan-view and locations of representative grading cross-sections for the levee re-alignments. Cross section 5.2.8-XA (Figure 4.29) shows grading section lines that compare the Baseline model topography with the Future Condition model topography.

The grading features and vegetation changes discussed in this section are physically represented in the Future Conditions 2-D model. Conceptual design of re-vegetation projects and other future land cover types were selected under the classifications of the AECOM vegetation mapping performed during the Baseline Study. The roughness values of these classifications were calibrated during the Baseline Study. In the Future Conditions model, similar vegetation or habitat groups were assigned the calibrated Manning's 'n' values. Table 1 summarizes the Future Condition vegetation or habitats and their corresponding roughness values assigned to the respective project areas. Figures 4.1 to 4.29 are representative cross-section samples of the changes in floodplain topography between the Baseline model and the Future Conditions model.

Table 1. Future Condition Roughness Values

Description	Manning's 'n' Roughness
Channel Widening @ RM 7.5-8.0, right bank	0.02
Grassland	0.03
Open Water/Floating Aquatic	0.03
Open Riparian Forest, Valley Oak Woodland	0.05
Upland Scrub, Open Willow Scrub, Elderberry Scrub, Blackberry Bramble	0.055
Dense Willow Scrub	0.065
Walnut Orchard	0.075
Dense Riparian Forest	0.08
Wind-Wave Buffer along Feather River Setback Levee	0.10

5.3 Boundary Conditions

Similar to the Baseline Study, the Future Conditions are simulated with two AEP hydrologies and the 1957 Corps' SRFCP Design Flow. The two AEP hydrologies are the 1-in-100 AEP and the 1-in-200 AEP. The AEP hydrologies and the SRFCP Design Flows were then further subdivided into two hypothetical flow centerings to emphasize the larger flows on the upper reaches of the Feather River (Upper Feather Centering) and the lower reaches of the Feather River (Lower Feather Centering). They are identified as follows:

- 1-in-100 AEP – Upper Feather Centering
- 1-in-100 AEP – Lower Feather Centering
- 1-in-200 AEP – Upper Feather Centering
- 1-in-200 AEP – Lower Feather Centering
- 1957 SRFCP Design Flow – Upper Feather Centering
- 1957 SRFCP Design Flow – Lower Feather Centering

The boundary conditions of the AEP hydrologies were obtained from a HEC-RAS model developed by Peterson Brustad Inc. (PBI model) for the Sutter-Butte Flood Control Agency as part of the "Feather River West Levee Rehabilitation Project." The PBI model is a current and improved version of the Corps' Sacramento River Comprehensive Study. The boundary condition selection procedures and assumptions are documented in the Baseline Documentation (MBK, 2012).

Sensitivity of the Baseline study's flow and stage boundary conditions were tested against the Future Condition features in the PBI 1-D model (PBI, 2011) discussed in the Baseline Documentation (MBK, 2012). Roughness values were modified in the 1-D model within the Feather River Setback Area. Peak stage and corresponding flows were extracted and analyzed. The resulting flow and stage at the boundary conditions of the 1-D Future Condition compares

closely with the Baseline Study. Therefore, it was found appropriate to use the flow and stage boundary conditions that were used in the Baseline Study.

The boundary conditions used in the 2-D model are the 1-in-100 AEP, 1-in-200 AEP, and 1957 SRFCP. Simulated flows and downstream river stages are tabulated in Table 2 through Table 7.

Table 2. 1-in-100 AEP Flood, Upper Feather Centering Boundary Conditions

Boundary Condition[1]	Stage (feet-NGVD)	Peak flow (cfs)
Feather River DS of Jack Slough[2] RM 28.75	N/A	130,100
Yuba River at Western Pacific Railroad (WPRR)[2] RM 1.23	N/A	154,600
Bear River US of Western Pacific Interceptor Canal(WPIC)[2] RM 4.75	N/A	37,000
Yankee Slough at Bear River[2] RM 0.54	N/A	0
WPIC at Bear River[2] RM 0.06	N/A	-6,100
Sutter Bypass US of Feather River[2] RM 68.13	N/A	94,000
Sutter Bypass US of Sacramento River[2] RM 61.83	41.5	N/A

[1]Naming convention is in reference to the cross-section location in the PBI Model and is named as 'River Reach Station'
[2]See Figure 1 for location of boundary condition

Table 3. 1-in-100 AEP Flood, Lower Feather Centering Boundary Conditions

Boundary Condition[1]	Stage (feet-NGVD)	Peak flow (cfs)
Feather River DS of Jack Slough[2] RM 28.75	N/A	162,900
Yuba River at WPRR[2] RM 1.23	N/A	91,500
Bear River US of WPIC[2] RM 4.75	N/A	28,100
Yankee Slough at Bear River[2] RM 0.54	N/A	0
WPIC at Bear River[2] RM 0.06	N/A	6,200
Sutter Bypass US of Feather River[2] RM 68.13	N/A	164,000
Sutter Bypass US of Sacramento River[2] RM 61.83	43	N/A

[1]Naming convention is in reference to the cross-section location in the PBI Model and is named as 'River Reach Station'
[2]See Figure 1 for location of boundary condition

Table 4. 1-in-200 AEP Flood, Upper Feather Centering Boundary Conditions

Boundary Condition[1]	Stage (feet-NGVD)	Peak flow (cfs)
Feather River DS of Jack Slough[2] RM 28.75	N/A	160,100
Yuba River at WPRR[2] RM 1.23	N/A	199,800
Bear River US of WPIC[2] RM 4.75	N/A	46,500
Yankee Slough at Bear River[2] RM 0.54	N/A	0
WPIC at Bear River[2] RM 0.06	N/A	-8,400
Sutter Bypass US of Feather River[2] RM 68.13	N/A	141,000
Sutter Bypass US of Sacramento River[2] RM 61.83	43.8	N/A

[1]Naming convention is in reference to the cross-section location in the PBI Model and is named as 'River Reach Station'
[2]See Figure 1 for location of boundary condition

Table 5. 1-in-200 AEP Flood, Lower Feather Centering Boundary Conditions

Boundary Condition[1]	Stage (feet-NGVD)	Peak flow (cfs)
Feather River DS of Jack Slough[2] RM 28.75	N/A	190,000
Yuba River at WPRR[2] RM 1.23	N/A	109,300
Bear River US of WPIC[2] RM 4.75	N/A	39,500
Yankee Slough at Bear River[2] RM 0.54	N/A	600
WPIC at Bear River[2] RM 0.06	N/A	3,400
Sutter Bypass US of Feather River[2] RM 68.13	N/A	217,600
Sutter Bypass US of Sacramento River[2] RM 61.83	45	N/A

[1]Naming convention is in reference to the cross-section location in the PBI Model and is named as 'River Reach Station'
[2]See Figure 1 for location of boundary condition

The flow boundary conditions for the SRFCP Design Flows were developed using a flow balance approach at each centering. The upper Feather River centering's flow boundary conditions are determined by balancing the system's flows with respect to the Yuba River. The lower Feather River centering's flow boundary conditions are determined by balancing the system's flows with respect to the Bear River. Throughout the study area, mass balance is achieved by making sure all inflows accumulate to the Feather River SRFCP Design Flow at upstream and downstream of confluences. The most downstream stage boundary condition is determined by extracting the design water-surface elevation from the 1957 project design flood plane. The 1957 project design flood plane required a conversion factor of -3 feet. This was necessary to convert the US Corps Engineers Datum (USED) to NGVD 1929. The boundary conditions used in the 2-D model for the 1957 SRFCP Design Flows are tabulated in Tables 6 and 7.

Table 6. 1957 SRFCP Design Flow, Upper Feather Centering Boundary Conditions

Boundary Condition[1]	Stage (feet-NGVD)	Peak flow (cfs)
Feather River DS of Jack Slough[2] RM 28.75	N/A	210,000
Yuba River at WPRR[2] RM 1.23	N/A	90,000
Bear River US of WPIC[2] RM 4.75	N/A	20,000
Yankee Slough at Bear River[2] RM 0.54	N/A	0
WPIC at Bear River[2] RM 0.06	N/A	0
Sutter Bypass US of Feather River[2] RM 68.13	N/A	60,000
Sutter Bypass US of Sacramento River[2] RM 61.83	40.5	N/A

[1]Naming convention is in reference to the cross-section location in the PBI Model and is named as 'River Reach Station'
[2]See Figure 1 for location of boundary condition

Table 7. 1957 SRFCP Design Flow, Lower Feather Centering Boundary Conditions

Boundary Condition[1]	Stage (feet-NGVD)	Peak flow (cfs)
Feather River DS of Jack Slough[2] RM 28.75	N/A	210,000
Yuba River at WPRR[2] RM 1.23	N/A	70,000
Bear River US of WPIC[2] RM 4.75	N/A	40,000
Yankee Slough at Bear River[2] RM 0.54	N/A	0
WPIC at Bear River[2] RM 0.06	N/A	0
Sutter Bypass US of Feather River[2] RM 68.13	N/A	60,000
Sutter Bypass US of Sacramento River[2] RM 61.83	40.5	N/A

[1]Naming convention is in reference to the cross-section location in the PBI Model and is named as 'River Reach Station'
[2]See Figure 1 for location of boundary condition

6 Results and Discussion

6.1 Effects on Water Surface Elevation

The effects on water surface elevation associated with the Future Conditions are analyzed and compared to Baseline Conditions. The water-surface elevation profiles provide indicators of locations along the levees where freeboard requirements are met or exceeded, or where there is less than the minimum 3 feet of desired freeboard above design flood stage. Therefore, water-surface elevation profiles adjacent to the left- and right- levee were sampled from the 2-D model. Figures 7 through 9 maps the alignments and levee stationing utilized to sample the 2-D model. The water surface elevation profiles were plotted with their corresponding top-of-levee elevations. Each plot displays water surface elevation profiles at Baseline Conditions and Future Conditions during the 1-in-100 AEP, 1-in-200 AEP, and the 1957 SRFCP Design Flow to illustrate the relative difference between the Baseline Study and the Future Conditions.

Figure 10 through Figure 39 plot water-surface elevation profiles along the right- and left- banks of the model study area. The profile plots are referenced in NAVD 88. Across all simulated events, the changes in water-surface elevation between the Baseline Conditions and the Future Conditions occur at or near the same locations. Using the same sampling line, the Future Condition's water surface elevations were subtracted from the Baseline Condition's water surface elevations. The differences were calculated and averaged for each profile. Table 8 to Table 10 summarizes the average water surface elevation difference for the Upper Feather and Lower Feather Centering 1-in-200 AEP, 1-in-100 AEP, and 1957 Design Flow (Q) simulation runs. In general, the average differences across all simulated events follow a similar trend of reduction in Future Condition water surface elevations. Therefore, modeling results demonstrate that the Future Conditions have a desirable effect on water surface elevations and levee freeboard throughout the entire study area.

Table 8. Water Surface Differences, 1-in-200 AEP Simulation Run (Average Difference, Future minus Baseline)

Water-Surface Elevation Profile	Upper Centering (Δ ft)	Lower Centering (Δ ft)
Feather River-Right Bank (RM 7.8 to 28.7)	-0.7	-0.6
Feather River - Left Bank (RM 2.9 to 12.2)	-0.3	-0.2
Feather River - Left Bank (RM 13.2 to 27.2)	-0.8	-0.7
Bear River - Right Bank (RM 0.3 to 4.75)	-0.3	-0.2
Yuba River - Left Bank (RM 0.3 to 1.2)	-1.2	-1.2

Table 9. Water Surface Differences, 1-in-100 AEP Simulation Run (Average Difference, Future minus Baseline)

Water-Surface Elevation Profile	Upper Centering (Δ ft)	Lower Centering (Δ ft)
Feather River-Right Bank (RM 7.8 to 28.7)	-0.7	-0.6
Feather River - Left Bank (RM 2.9 to 12.2)	-0.3	-0.2
Feather River - Left Bank (RM 13.2 to 27.2)	-0.8	-0.8
Bear River - Right Bank (RM 0.3 to 4.75)	-0.2	-0.2
Yuba River - Left Bank (RM 0.3 to 1.2)	-1.2	-1.2

Table 10. Water Surface Differences, 1957 Design Q Simulation Run (Average Difference, Future minus Baseline)

Water-Surface Elevation Profile	Upper Centering (Δ ft)	Lower Centering (Δ ft)
Feather River-Right Bank (RM 7.8 to 28.7)	-0.7	-0.7
Feather River - Left Bank (RM 2.9 to 12.2)	-0.3	-0.3
Feather River - Left Bank (RM 13.2 to 27.2)	-0.8	-0.8
Bear River - Right Bank (RM 0.3 to 4.75)	-0.3	-0.2
Yuba River - Left Bank (RM 0.3 to 1.2)	-1.2	-1.2

During the 1-in-100 AEP, the Feather River levees (RM 2.9 to 28.7) have freeboard ranging from 5 feet to 8 feet and the Bear River levees (RM 0.3 to 4.75) have freeboard ranging from 5 feet to 7 feet. During the 1-in-200 AEP, the Feather River levees (RM 2.0 to 28.7) have freeboards ranging from 3 feet to 6 feet, with less than 3 feet of freeboard occurring between approximately RM 16.0 and RM 16.8 north of Wilkie Avenue on the right (west) levee of the Feather River. During the 1-in-200 AEP, the Bear River levees (RM 0.3 to 4.75) have freeboard ranging from 3 feet to 6.

6.2 Effects on Velocity

Figure 40 to Figure 60 maps depict the contoured velocity magnitudes throughout the modeling study area during the 1-in-100 AEP, 1-in-200 AEP, and the 1957 SRFCP Design Flow runs.

Contoured velocity figures in this report were selected to display only the flow centering runs having the dominant effect in the project reach.

The effects on flow velocities are best understood by analyzing their relative changes from the Baseline Condition. Therefore, velocity differences between the Baseline Study and the Future Condition Study were calculated at all model nodes. For each model node, the calculated velocity from the Baseline Study was subtracted from the calculated velocity of the Future Conditions, expressed as (Nodal $\text{Velocity}_{\text{Future}}$-Nodal $\text{Velocity}_{\text{Baseline}}$). The resulting data points were contoured and mapped to visualize the spatial distribution of velocity differences. Figures 61 through 81 illustrates the contoured velocity difference maps for the 1-in-100 AEP, 1-in-200 AEP, and the 1957 SRFCP Design Flow run simulations. Similar to the contoured velocity figures, the contoured velocity difference maps depicted for this analysis were selected to display only the flow centering having the dominant net effect in the project reach. Since a majority of the study area resulted in "minimal or no difference," the figures were screened to not display fill-hatching on velocity difference between -1 fps to +1 fps (feet per second). In other words, locations within the study area showing only the aerial photographic imagery are those areas with "minimal or no difference in velocities." Furthermore, velocity differences less than -1 fps indicate simulated velocity reduction in the Future Condition; likewise, velocity differences greater than +1 fps indicates a simulated increase in velocity of the Future Condition.

In general, changes in velocity between the Baseline Condition and the Future Conditions range from a net reduction of -4 fps to a net increase of up to 8 fps across all simulated flow events. The State-Cut and the Feather River Setback area (RM 18.7 to RM 27.0) Future Conditions simulated effects compared to Baseline Conditions resulted in an increase in velocities across all simulation runs. However, the velocity increase does not exceed 2 fps. In the main channel of the Feather River (RM 20.2 to RM 22.2), the simulated Future Conditions shows a decrease in average channel velocities. These effects are considered a balance of resistance through a wide portion of the floodplain. The Future Conditions provide less resistance through the setback area, thereby increasing floodway capacity across the floodplain and relieving flows in the main channel.

The Star Bend project's (RM 17.9 to RM 18.2) simulated effects compared to Baseline Conditions results in an increase in velocities through the degraded bend. The Star Bend Future Condition degrade is a widening of the main channel with a decrease in roughness. The Abbott Lake and O'Connor Lakes projects' simulated effects compared to Baseline Conditions are minimal. The Abbott Lake project area simulated a decrease in velocities along an area where dense willow scrubs are proposed (RM 19.2 to RM 19.7). The O'Connor Lakes project area simulated almost no change in velocities under Future Conditions.

The Lake of the Woods (RM 12.1 to RM 16.1) project's simulated effects compared to Baseline conditions resulted in an increase in velocities through the graded bench areas in the floodplain. An area of considerable velocity increase is at the degraded access ramp at approximately the right bank of RM 14. However, the velocity increase does not exceed 3 fps across all simulated events. The absolute velocity through the degraded access ramp is in the range of 0 fps to 3 fps. The elimination of vegetation removal along a mile long corridor on the left bank floodplain of the State maintained area (RM 12.1 to RM 13.1) results in a decrease in overbank velocities.

This effect is considered reasonable since the Future Conditions model assumed an increase in roughness after maintenance ceased.

The Nelson Slough (RM 7.5 to RM 10.5) project's simulated effects compared to Baseline Condition results in an overall decrease in velocities through the main channel and across large portions of the floodplain. Flow velocity in the main channel is reduced due to the widening of the channel, levee realignments, and excavated benches. Overbank flow velocity is reduced on the lower bench area due to an increase in roughness (changed from grassland to riparian vegetation), and in the north floodplain area where roughness is changed from grassland to oak woodland. The training levee re-alignment in the Sutter Bypass (RM 7.4 to RM 7.6 on right bank of Feather River) results in an increase in velocity at the upstream end of the training levee due to an overall increase in floodway capacity which converges at that location. The levee setback area on the left bank at the sharp bend of the levee (RM 7.4 to RM 7.7) is outside of the floodway and precluded in the Baseline Study's finite element mesh; therefore velocity differences in the area are the same as absolute velocities for Future Conditions (i.e., there's no flow under Baseline so the change in flow equals absolute flow in Future).

Overall, under Future Conditions, areas of increased velocity generally occur on broad floodplains and in overbank swales and low-flow bypass channels distanced away from levees and river banks, or in areas of low absolute velocity. Areas of decreased velocity generally occur within the main river channel and nearer to eroding river banks and levees, or in floodplain areas with substantial increases in future vegetation roughness.

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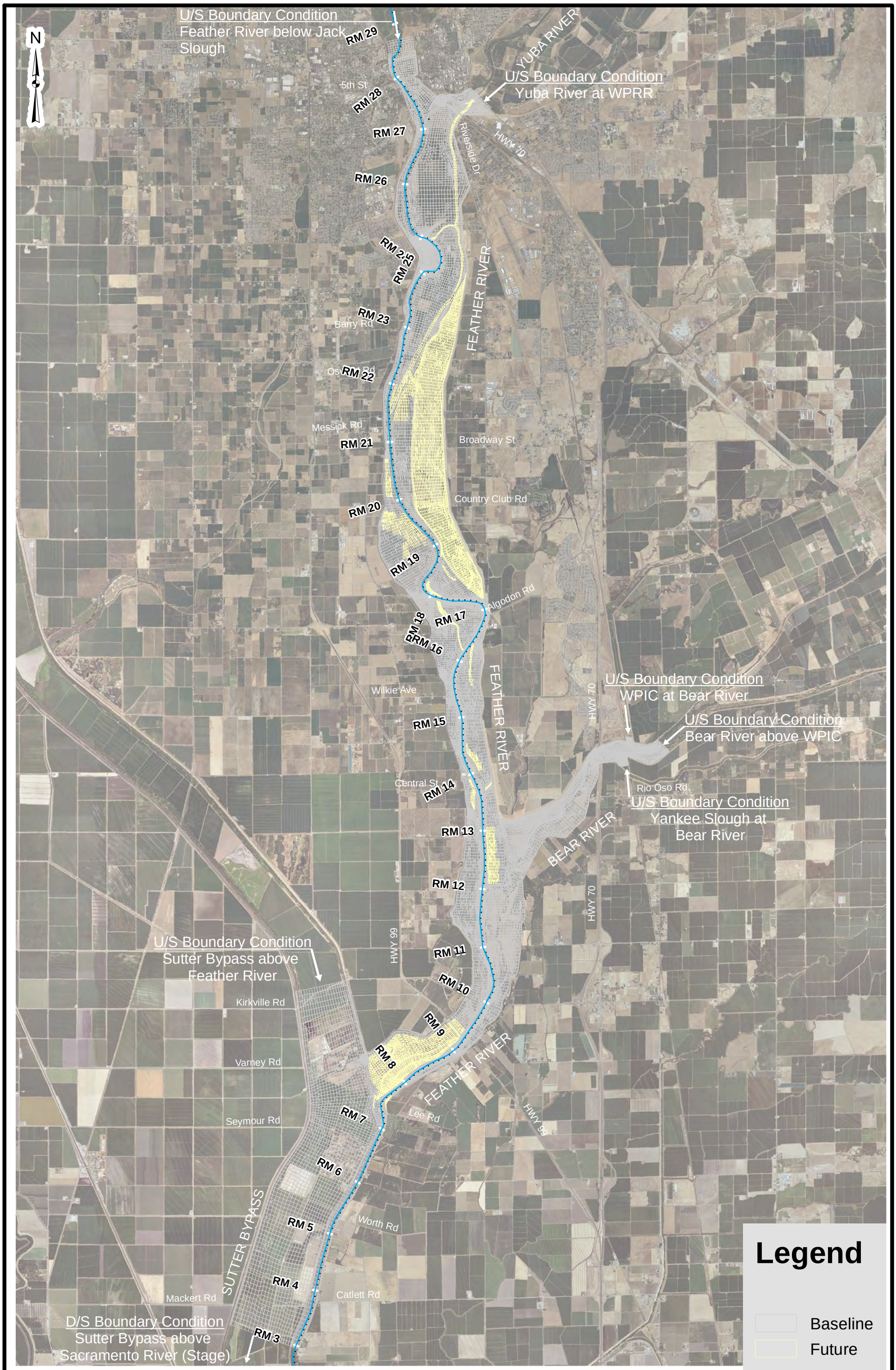
Figures



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RMA2 Model - Future Condition
Finite Element Mesh

0 8,000
Scale in Feet

Figure 1

N

RM 29
HWY 20
5th St
RM 28
YUBA RIVER
5.2.1-XA
RM 27
5.2.1-XB
HWY 70
Alicia Ave
RM 26
5.2.1-XC
5.2.1-XD
RM 25
RM 24
5.2.1-XE
5.2.1-XF
RM 23
Barry Rd
5.2.1-XG
Ella Ave
Oswald Rd
RM 22
5.2.2-XA
5.2.2-XB
Messick Rd
RM 21
5.2.2-XC
Broadway St
5.2.2-XD
RM 20
5.2.2-XE
Country Club Rd
5.2.2-XF
FEATHER RIVER
RM 19
5.2.2-XG
5.2.4-XA
5.2.4-XB
5.2.2-XH
5.2.5-XA
5.2.5-XB
RM 18
RM 17
Algodon Rd
5.2.5-XC
RM 16
5.2.6-XA
Match Line
(See Figure 3)

Legend

Proposed Grading
Grading Section

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RMA2 Model - Future Condition
Conceptual Grading Design

0 4,000
Scale in Feet

Figure 2

N

RM 19

5.2.2-XG

5.2.4-XA

5.2.4-XB

5.2.2-XH

5.2.5-XA

5.2.5-XB

RM 18

RM 17

Algodon Rd

Match Line

(See Figure 2)

5.2.5-XC

RM 16

5.2.6-XA

5.2.6-XB

Wilkie Ave

HWY 70

FEATHER RIVER

RM 15

5.2.6-XC

5.2.6-XD

Central St

RM 14

5.2.6-XE

Rio Oso Rd

RM 13

BEAR RIVER

RM 12

HWY 70

HWY 99

Cornelius Ave

RM 11

RM 10

RM 9

FEATHER RIVER

RM 8

5.2.7-XA

5.2.7-XB

5.2.7-XC

5.2.8-XA

Lee Rd

HWY 99

RM 7

RM 6

Legend

Proposed Grading

Grading Section

MBK ENGINEERS 1771 Tribute Road, Suite A Sacramento, California 95815-4401 (916) 456-4400	**RMA2 Model - Future Condition** **Conceptual Grading Design**	0 4,000 Scale in Feet	**Figure 3**

Figure 4.1: State Cut
Section 5.2.1-XA

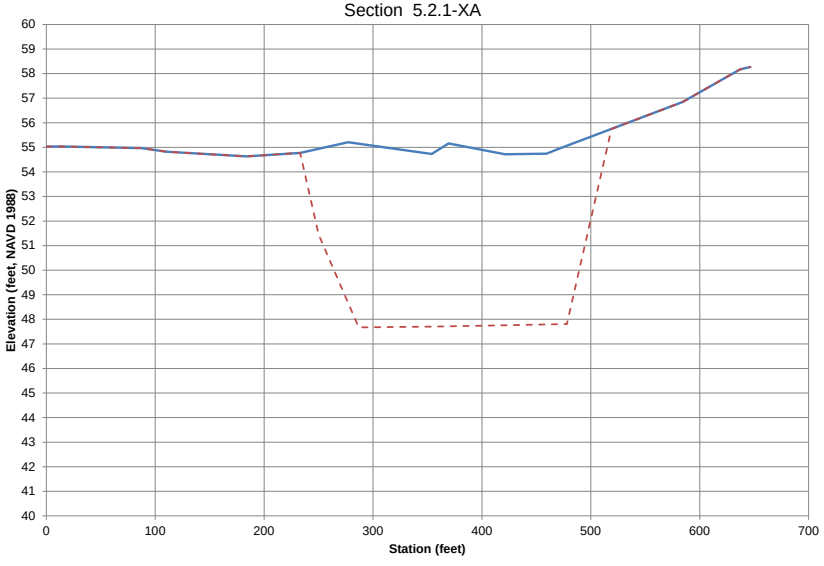


Figure 4.2: State Cut
Section 5.2.1-XB

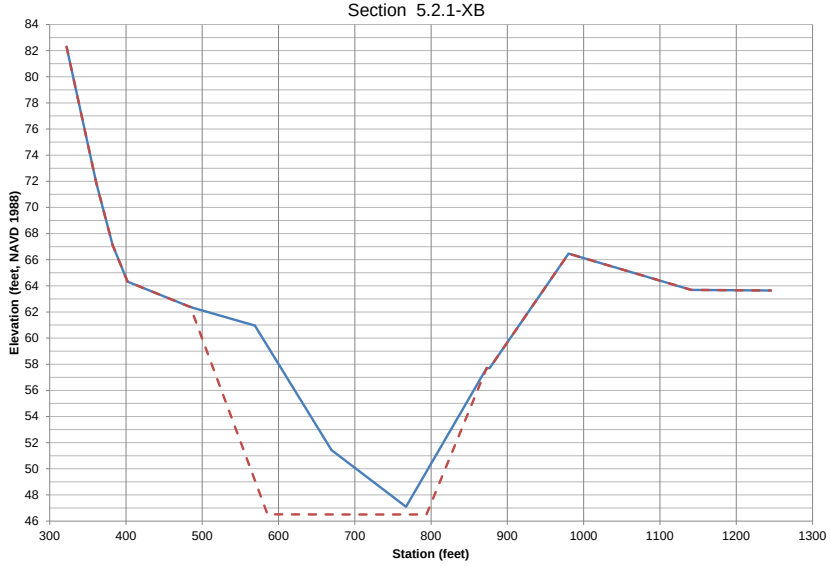


Figure 4.3: State Cut
Section 5.2.1-XC

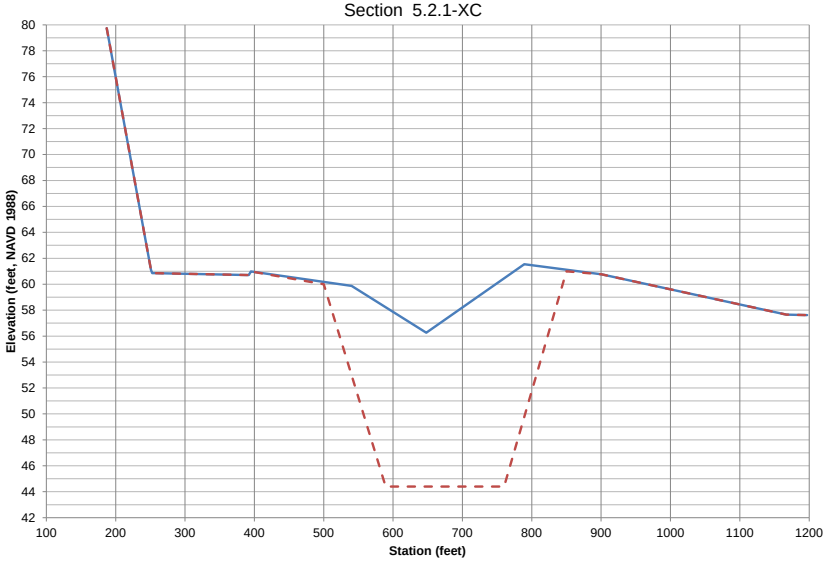


Figure 4.4: Eliza Bend
Section 5.2.1-XD

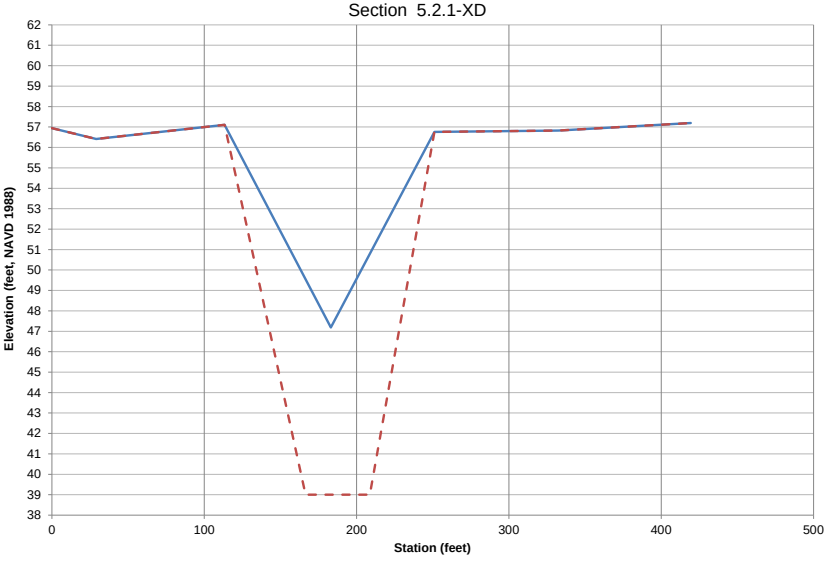


Figure 4.5: Old Feather River
Section 5.2.1-XE

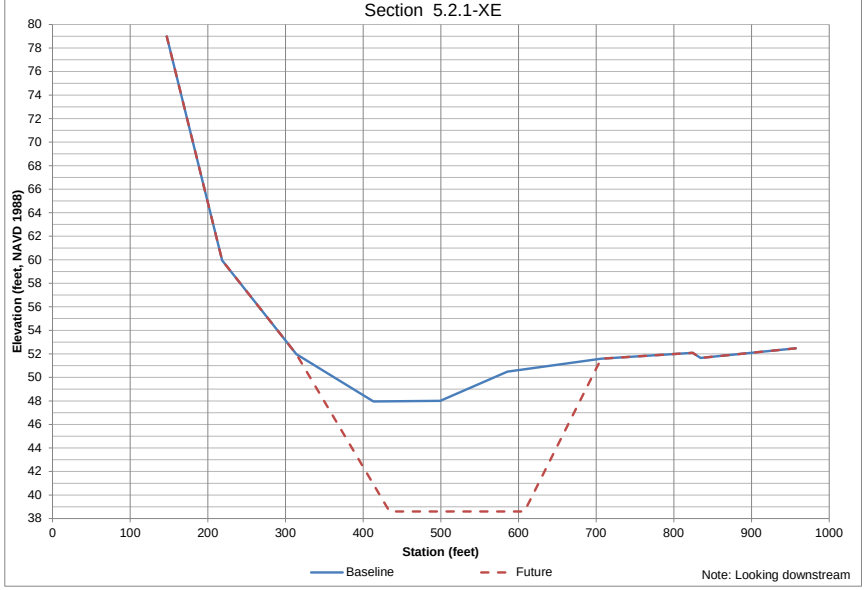


Figure 4.6: Old Feather River
Section 5.2.1-XF

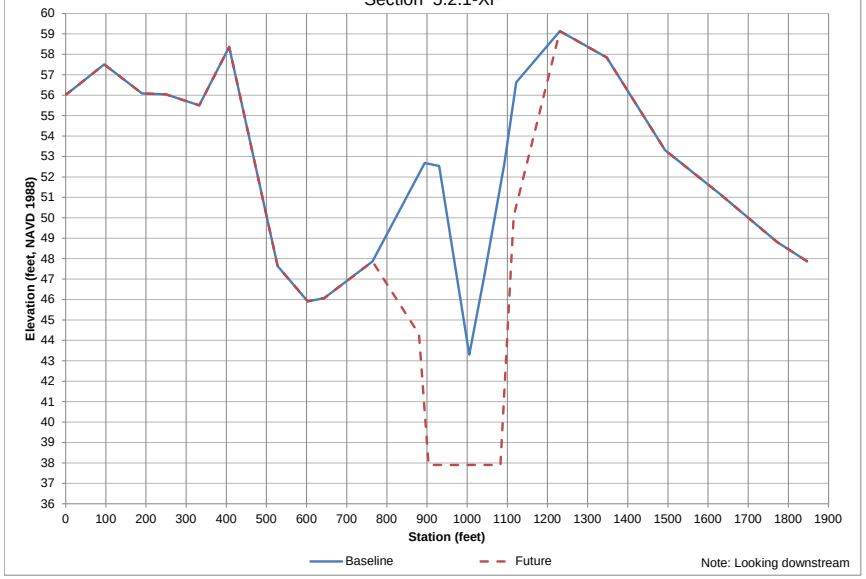


Figure 4.7: Old Feather River
Section 5.2.1-XG

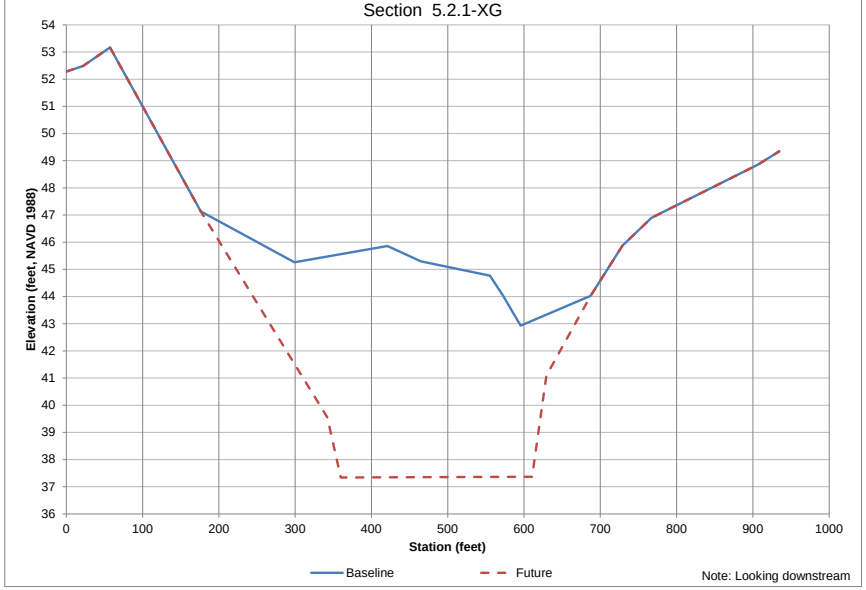


Figure 4.8: FRS Swales
Section 5.2.2-XA

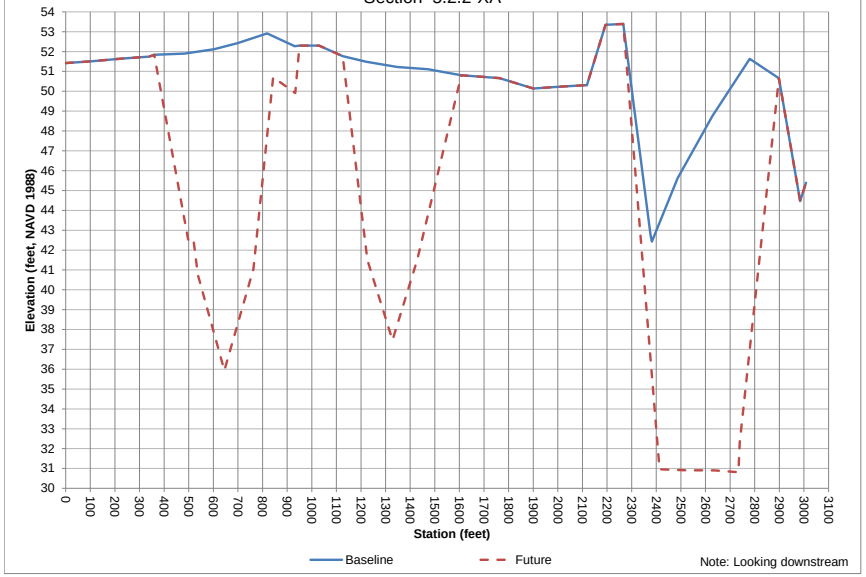


Figure 4.9: FRS Swales
Section 5.2.2-XB

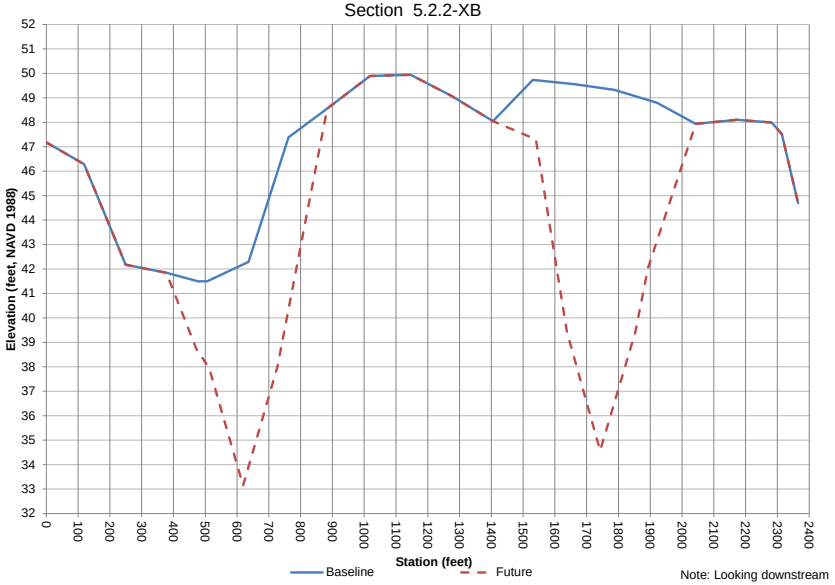


Figure 4.10: FRS Swales
Section 5.2.2-XC

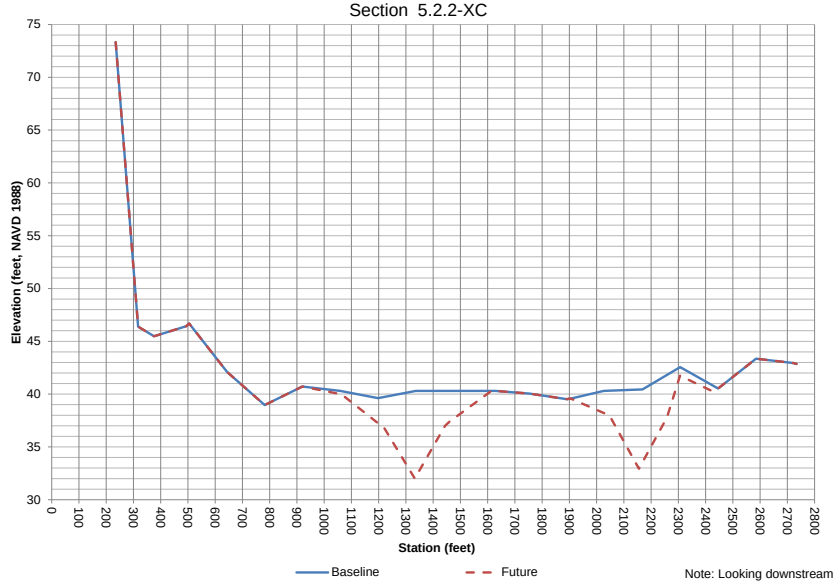


Figure 4.11: FRS Swales
Section 5.2.2-XD

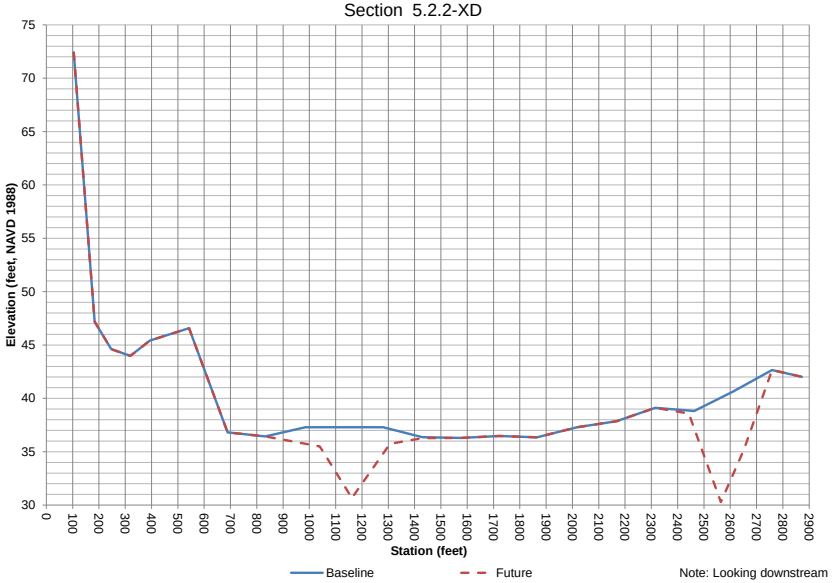


Figure 4.12: FRS Swales
Section 5.2.2-XE

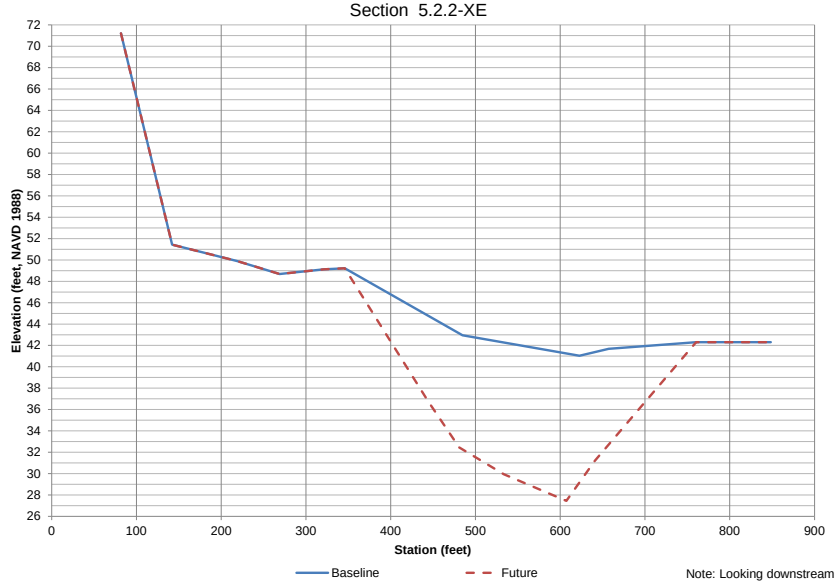
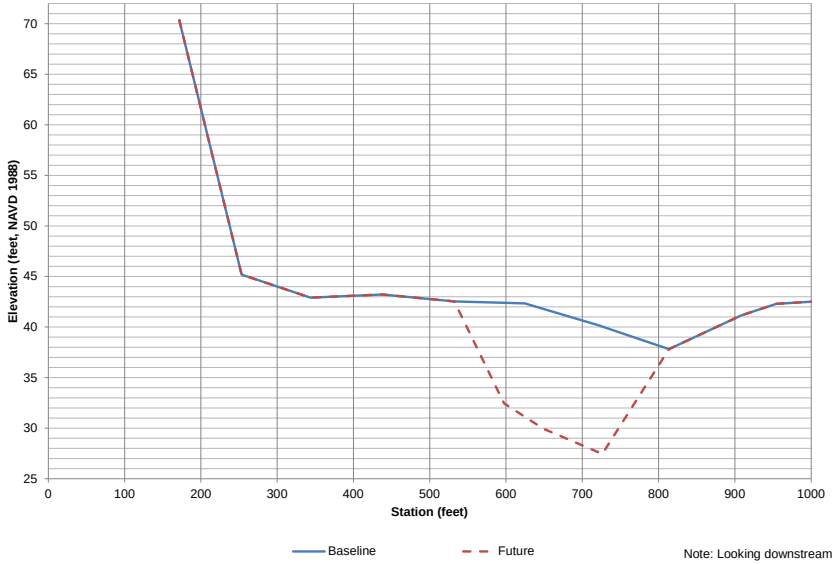
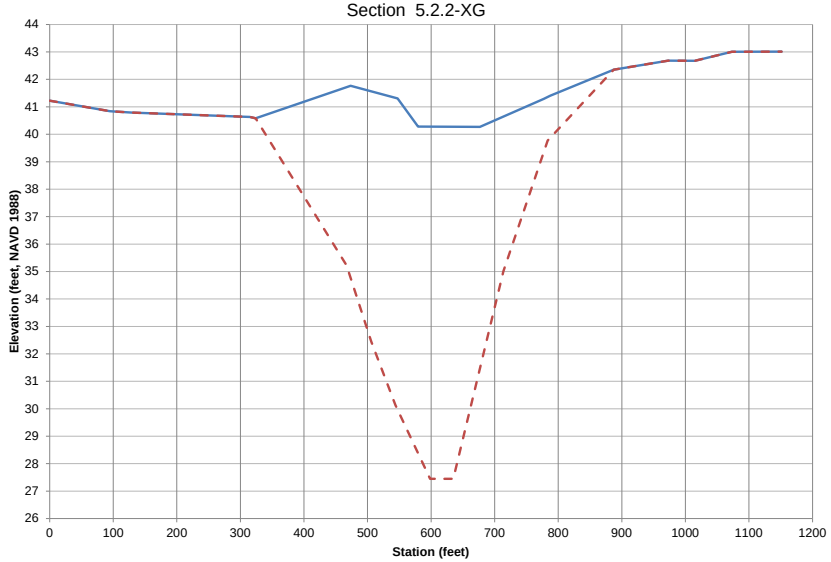


Figure 4.13: FRS Swales
Section 5.2.2-XF



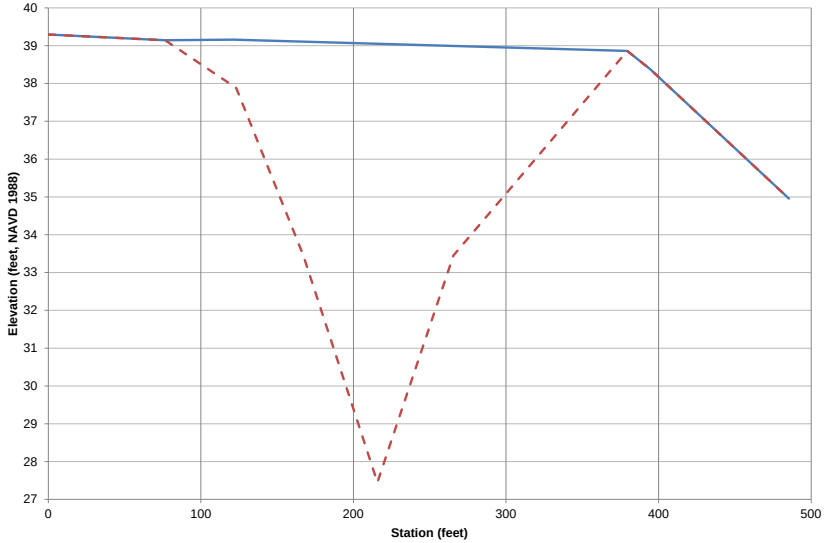
Note: Looking downstream

Figure 4.14: FRS Swales
Section 5.2.2-XG



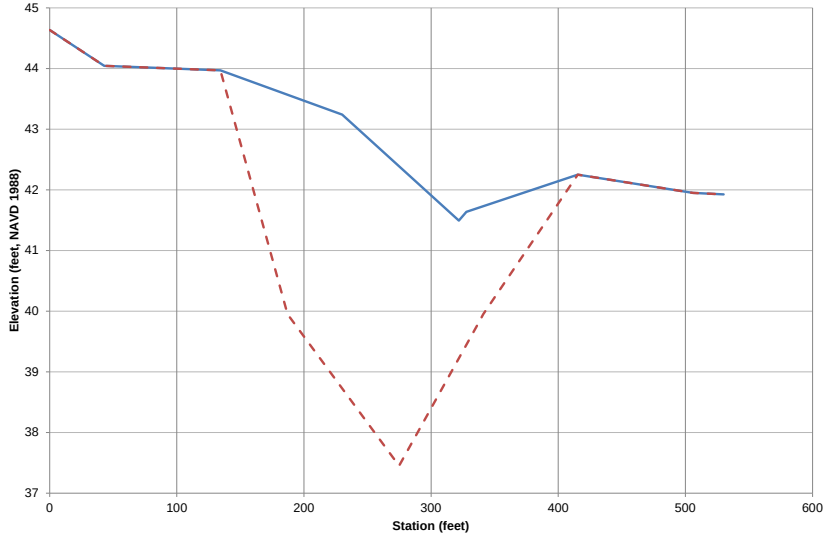
Note: Looking downstream

Figure 4.15: FRS Swales
Section 5.2.2-XH



Note: Looking downstream

Figure 4.16: Star Bend
Section 5.2.4-XA



Note: Looking downstream

Figure 4.17: Star Bend

Section 5.2.4-XB

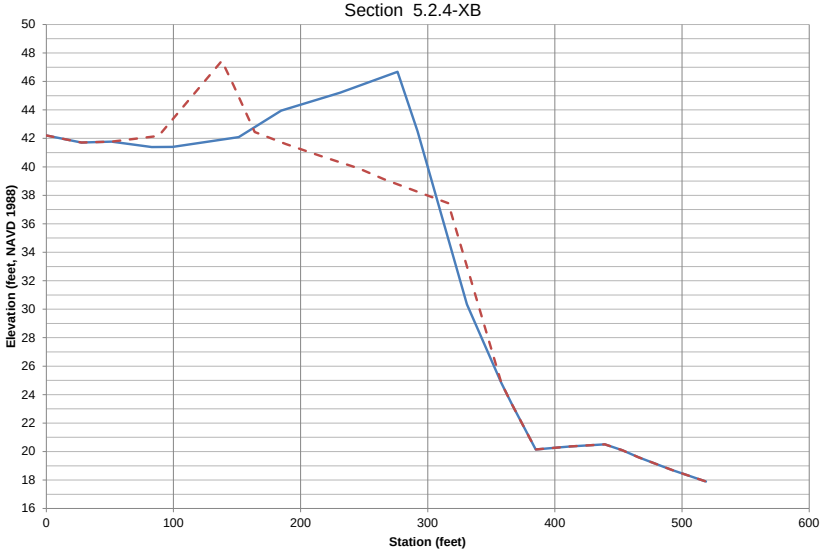


Figure 4.18: O'Connor Lakes

Section 5.2.5-XA

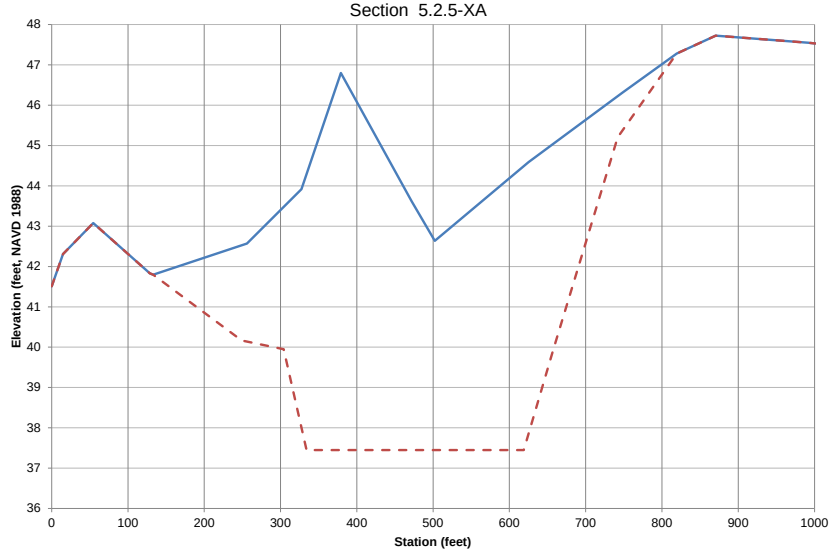


Figure 4.19: O'Connor Lakes

Section 5.2.5-XB

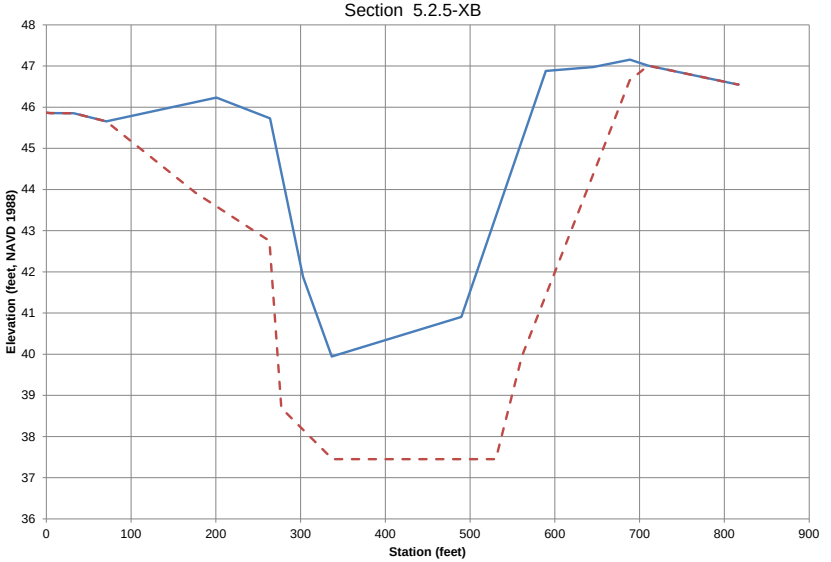


Figure 4.20: O'Connor Lakes

Section 5.2.5-XC

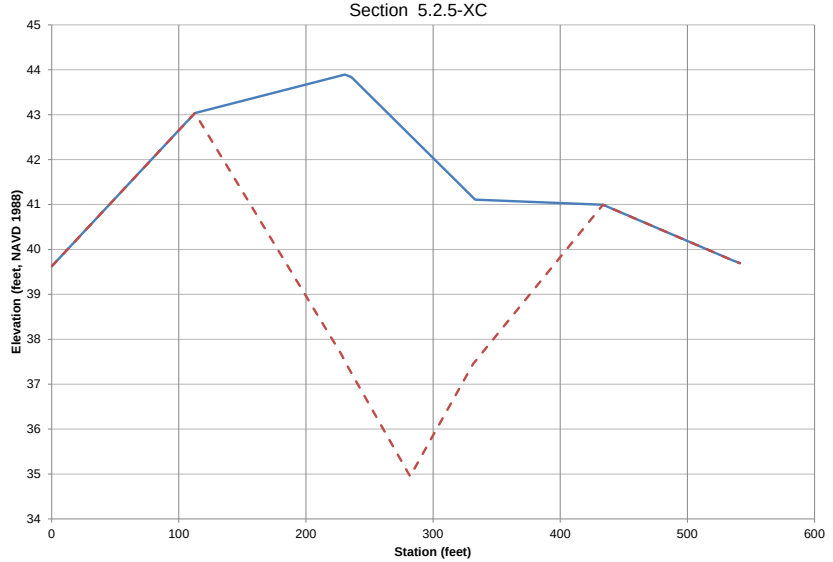


Figure 4.21: Lake of the Woods
Section 5.2.6-XA

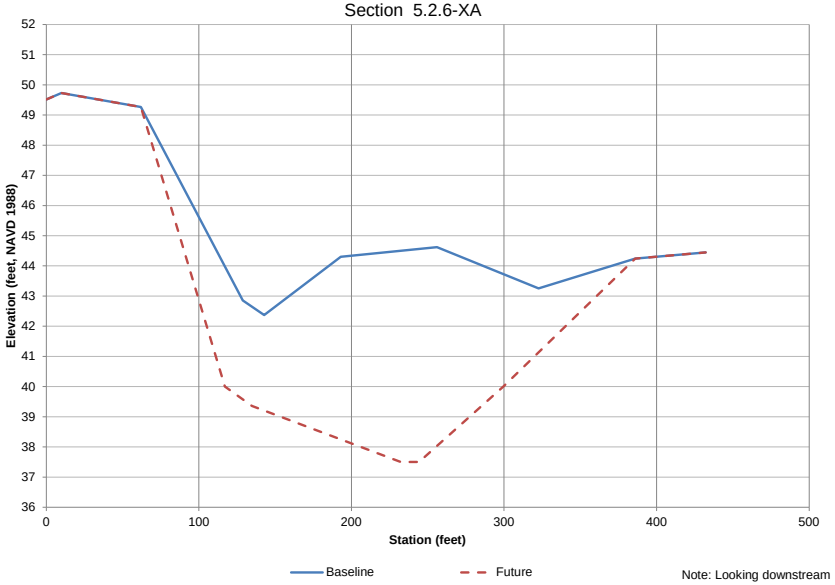


Figure 4.22: Lake of the Woods
Section 5.2.6-XB

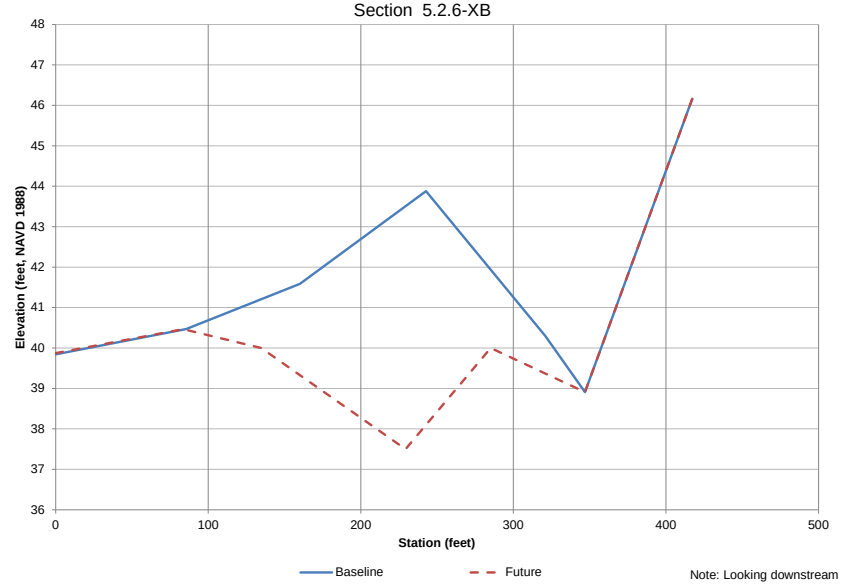


Figure 4.23: Lake of the Woods
Section 5.2.6-XC

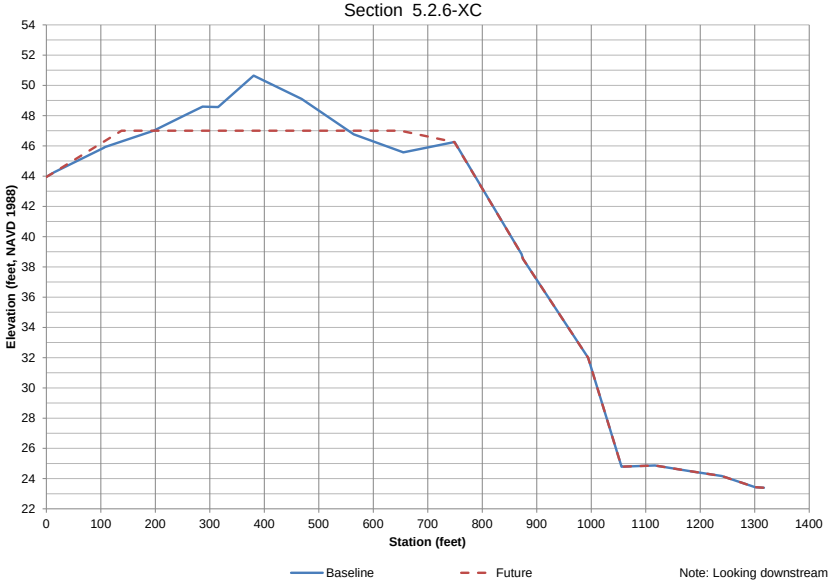


Figure 4.24: Lake of the Woods
Section 5.2.6-XD

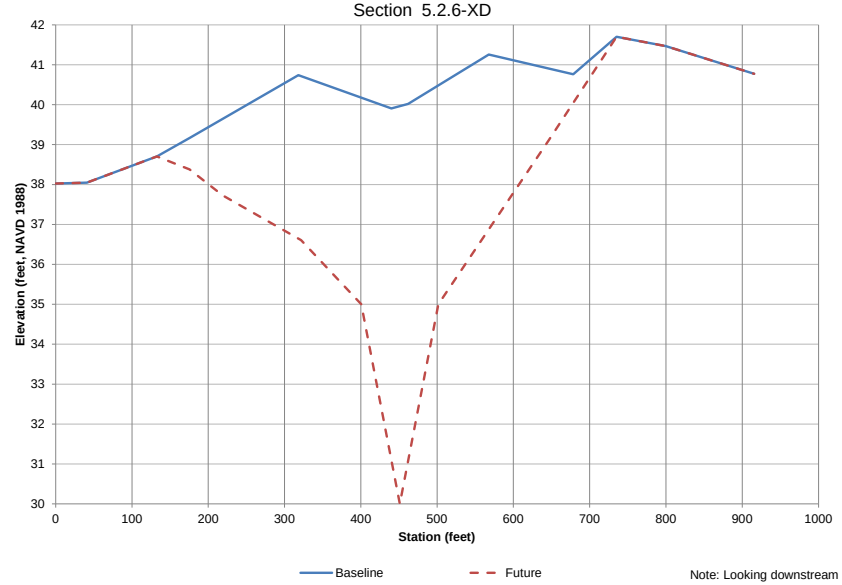


Figure 4.25: Lake of the Woods

Section 5.2.6-XE

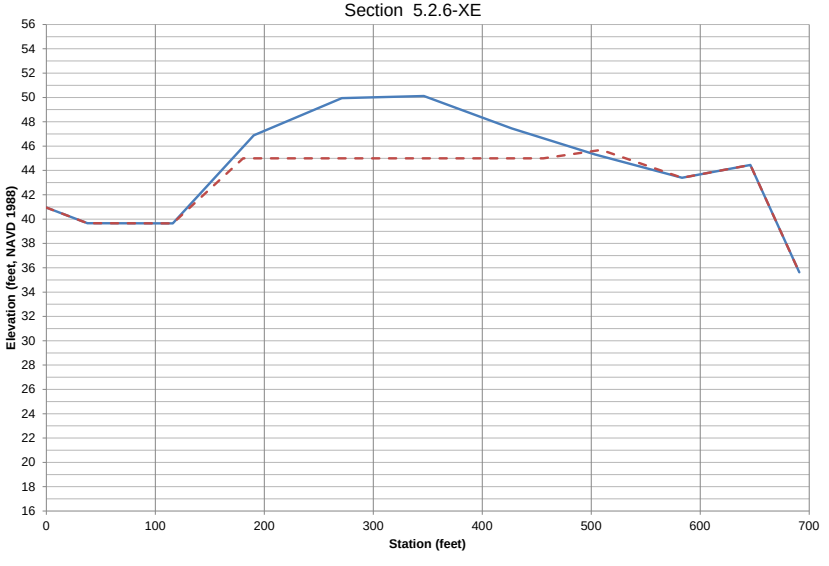


Figure 4.26: Nelson Slough

Section 5.2.7-XA

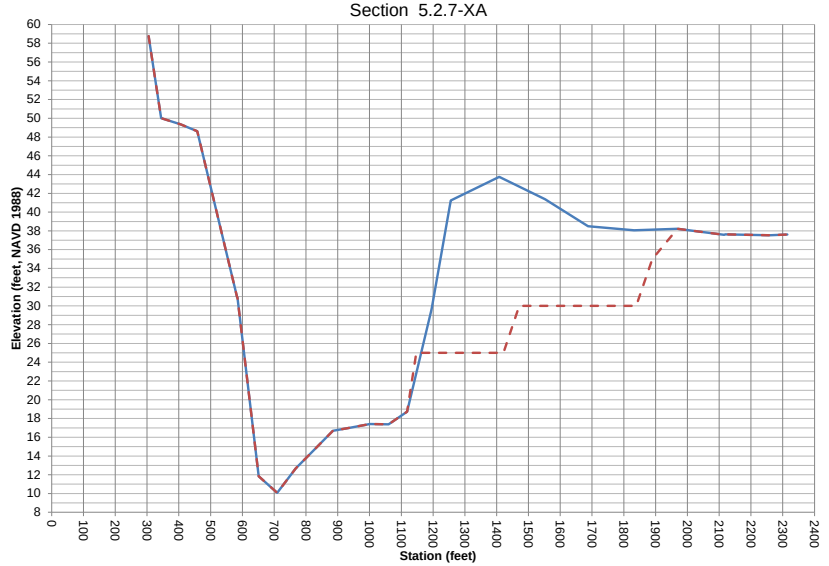


Figure 4.27: Nelson Slough

Section 5.2.7-XB

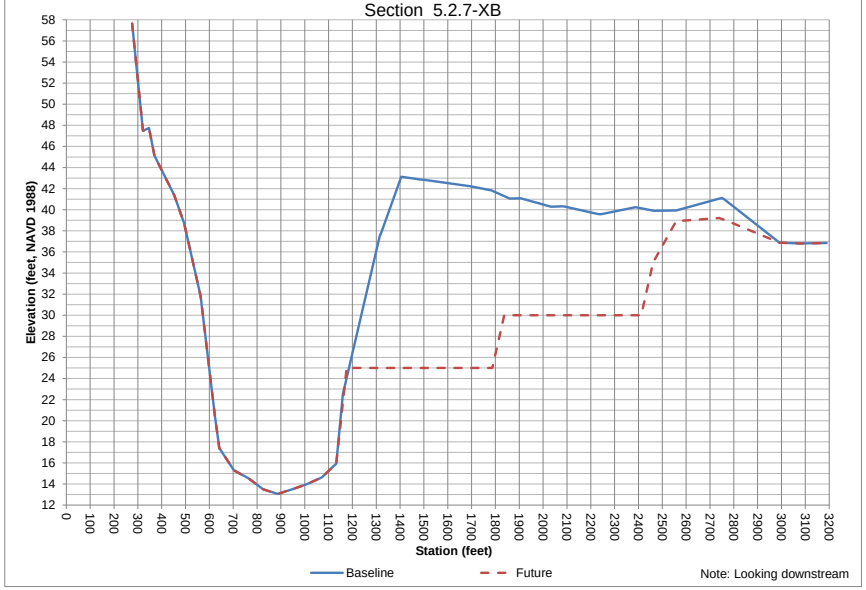


Figure 4.28: Nelson Slough

Section 5.2.7-XC

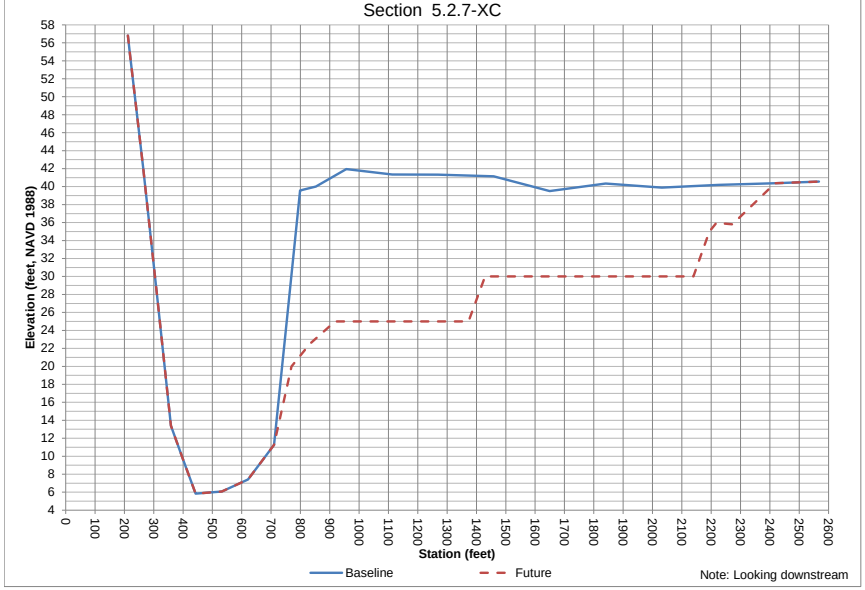
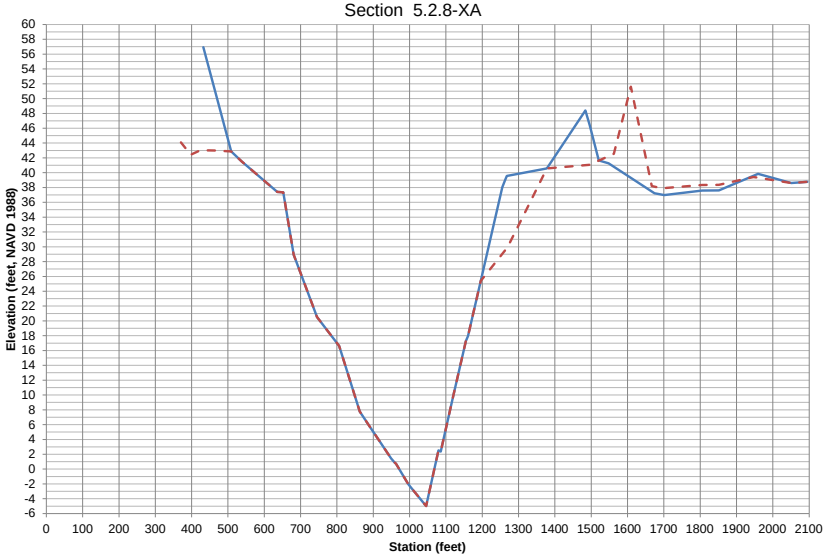


Figure 4.29: Levee Realignments

Section 5.2.8-XA



Note: Looking downstream

N

RM 29
RM 28
RM 27
RM 26
RM 25
RM 24
RM 23
RM 22
RM 21
RM 20
RM 19
RM 18
RM 17
RM 16

HWY 20
5th St
YUBA RIVER
Riverside Dr
HWY 70
Alicia Ave
Barry Rd
Ella Ave
Oswald Rd
Messick Rd
Broadway St
Country Club Rd
FEATHER RIVER
Algodon Rd

0.03
0.08
0.075
0.1
0.05
0.055
0.065

Match Line
(See Figure 6)

Note: Roughness Values are Hatched and Filled for Future Conditions Only. See Baseline Documentation for All Other Roughness Values in the Study Area.

Legend

Manning's 'n'

- 0.02
- 0.03
- 0.05
- 0.055
- 0.065
- 0.075
- 0.08
- 0.1

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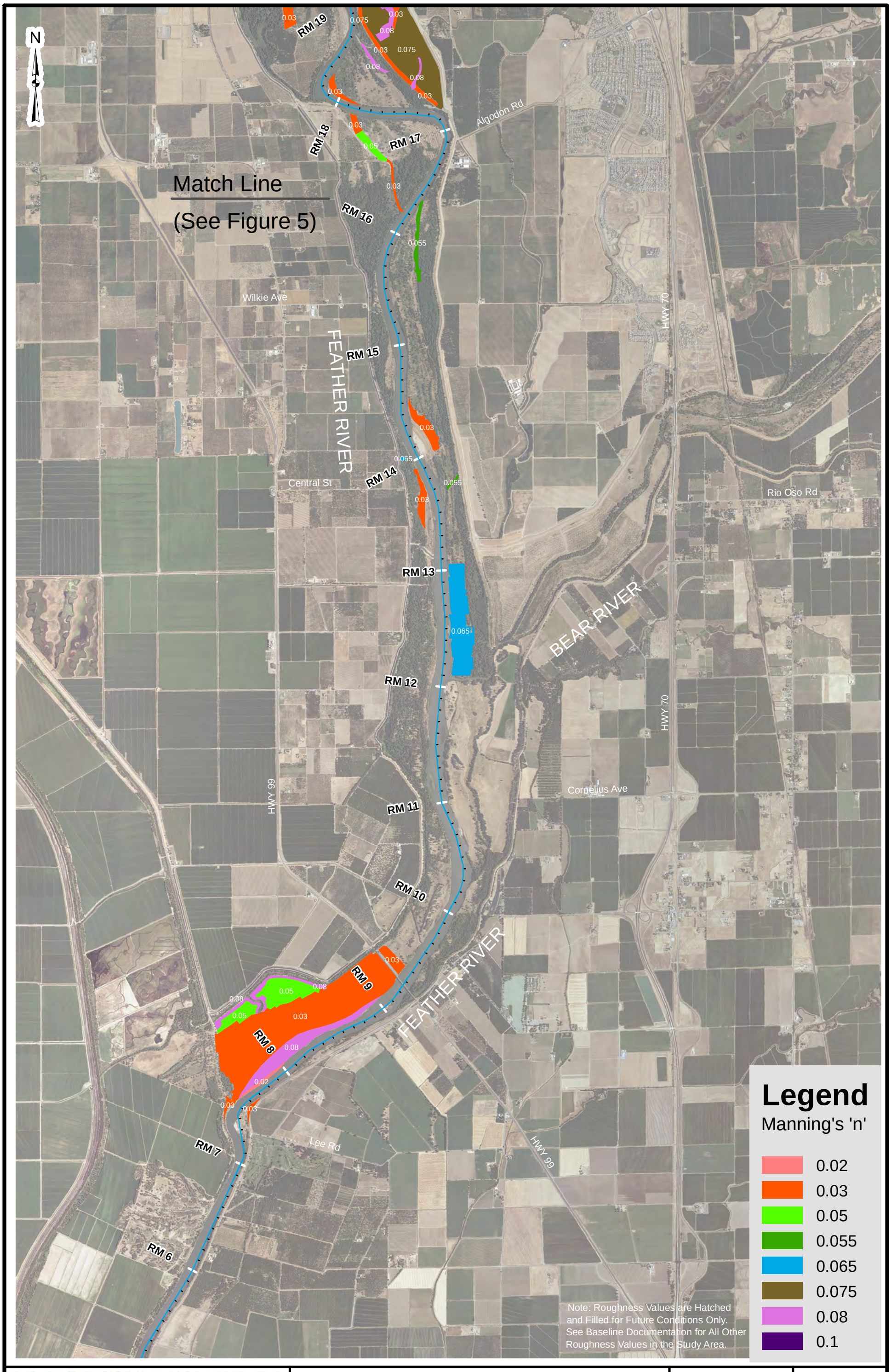
RMA2 Model - Future Condition
Roughness Values

0 4,000
Scale in Feet

Figure 5



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RMA2 Model - Future Condition
Roughness Values

0 4,000
Scale in Feet

Figure 6

N

RM 29

HWY 20

5th St

RM 28

RM 27

RM 26

RM 25

RM 24

RM 23

Barry Rd

RM 22

Oswald Rd

RM 21

Messick Rd

RM 20

RM 19

RM 18

RM 17

RM 16

Country Club Rd

Ella Ave

Broadway St

Algodon Rd

Riverside Dr

Alicia Ave

YUBA RIVER

FEATHER RIVER

Feather River
Left Bank
(RM 27.4 to 28.7)

Yuba River
Left Bank
(RM 0.3 to 1.2)

Feather River
Right Bank
(RM 7.8 to 28.7)

Feather River
Left Bank
(RM 13.2 to 27.2)

Match Line
(See Figure 8)

Legend

WS Profile Alignment

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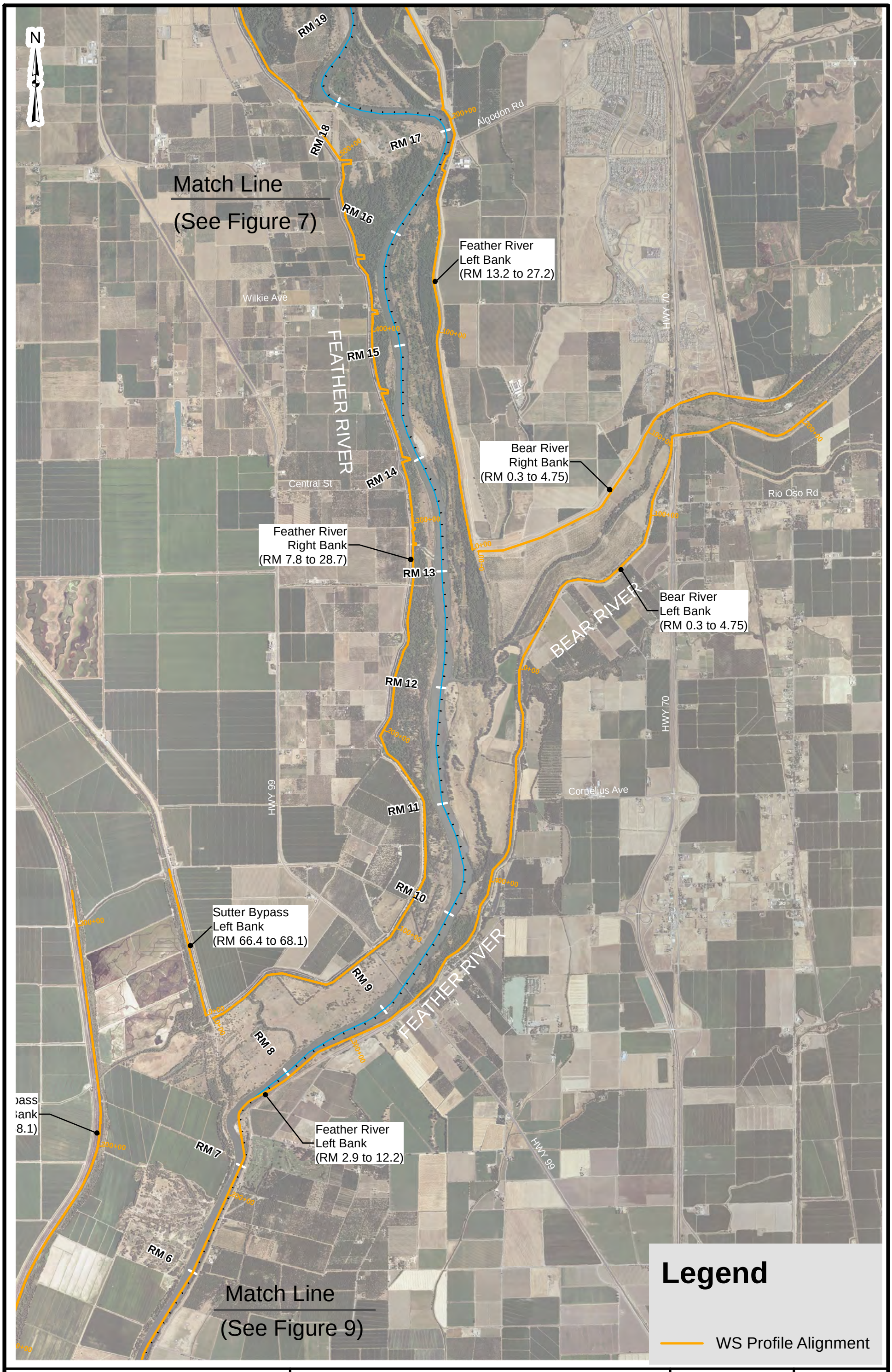
RMA2 Model - Future Condition
Water Surface Profile Alignments

0 4,000
Scale in Feet

Figure 7



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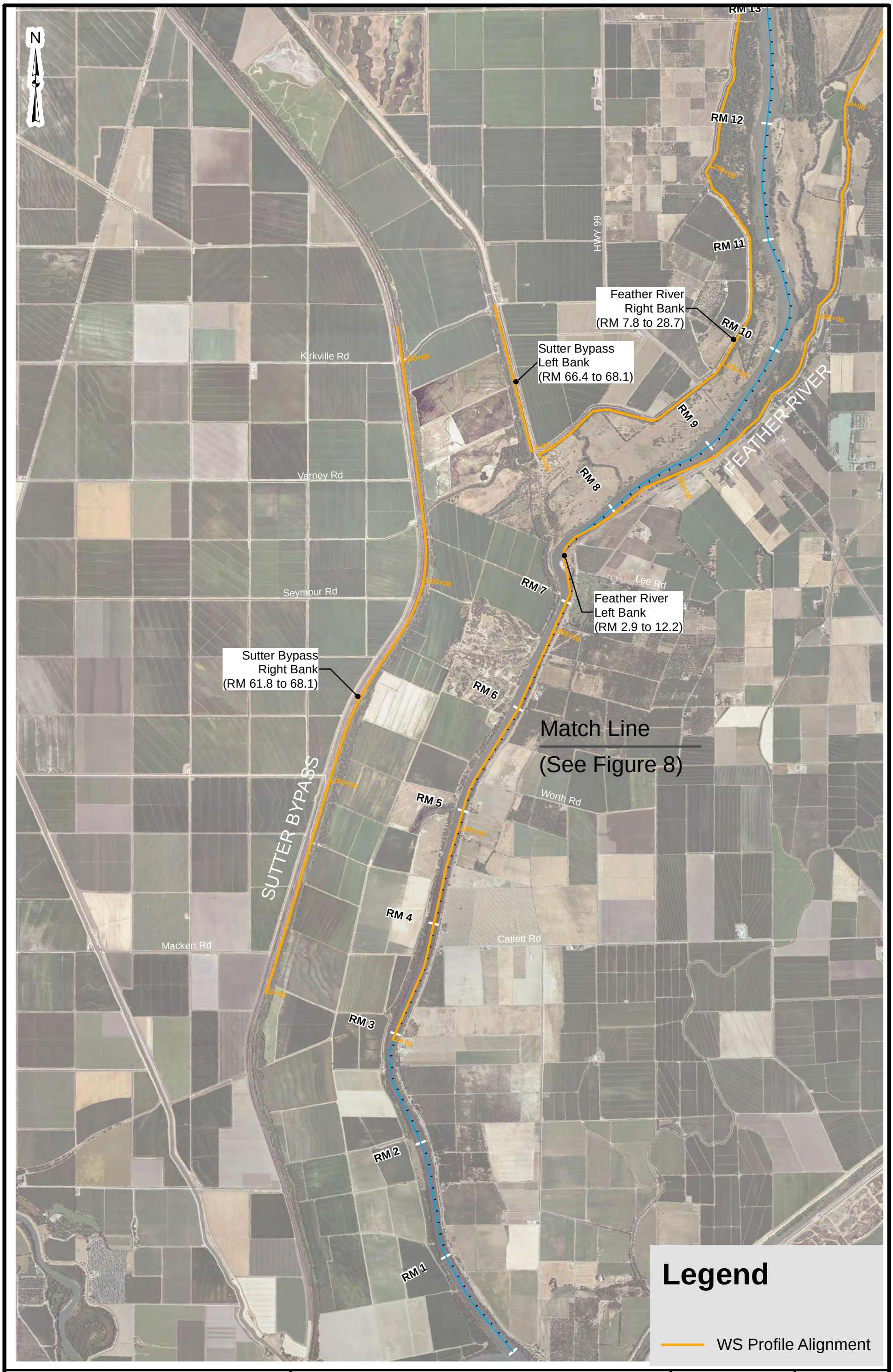
RMA2 Model - Future Condition
Water Surface Profile Alignments

0 4,000
Scale in Feet

Figure 8



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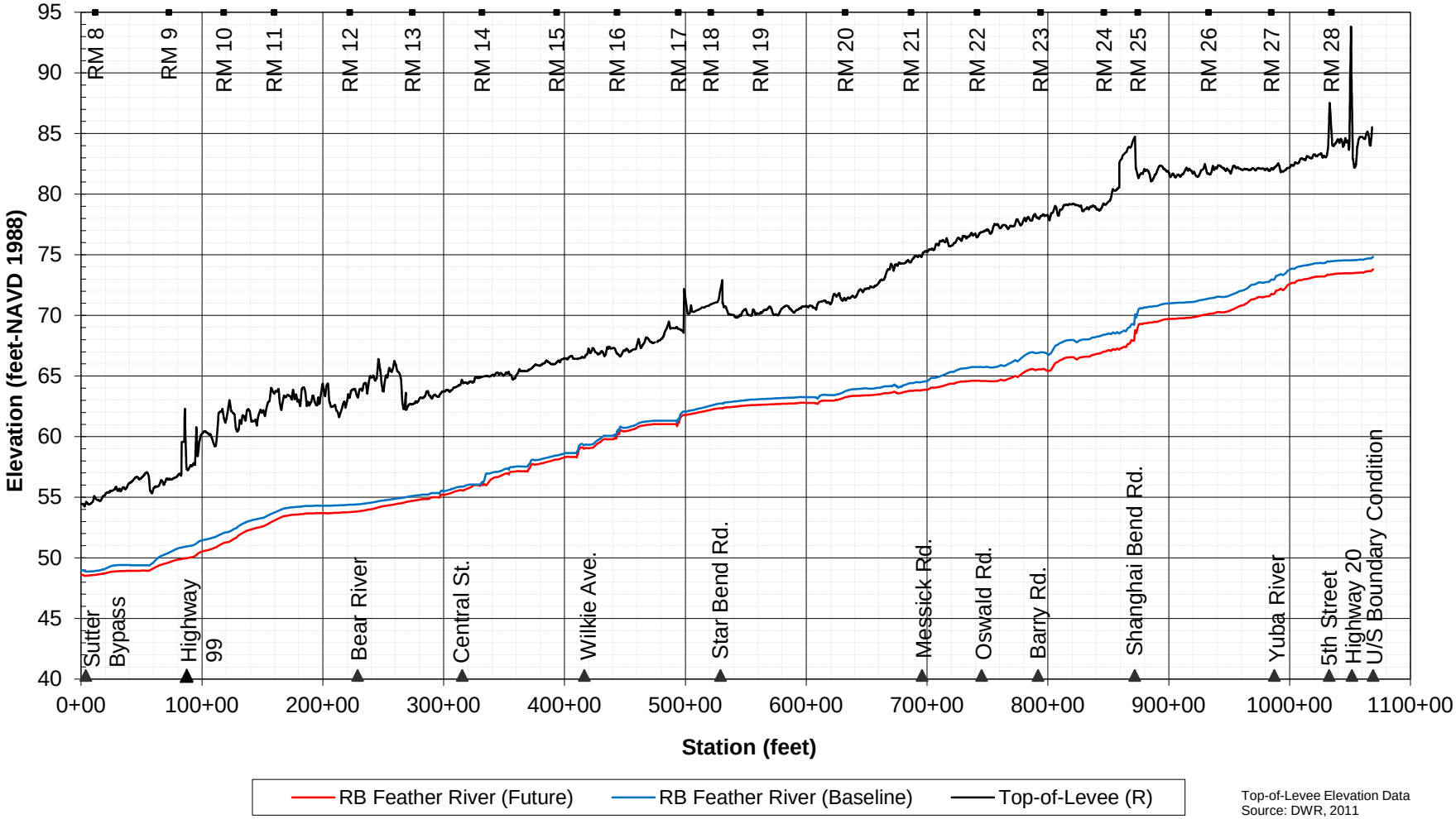
RMA2 Model - Future Condition
Water Surface Profile Alignments

0 4,000
Scale in Feet

Figure 9

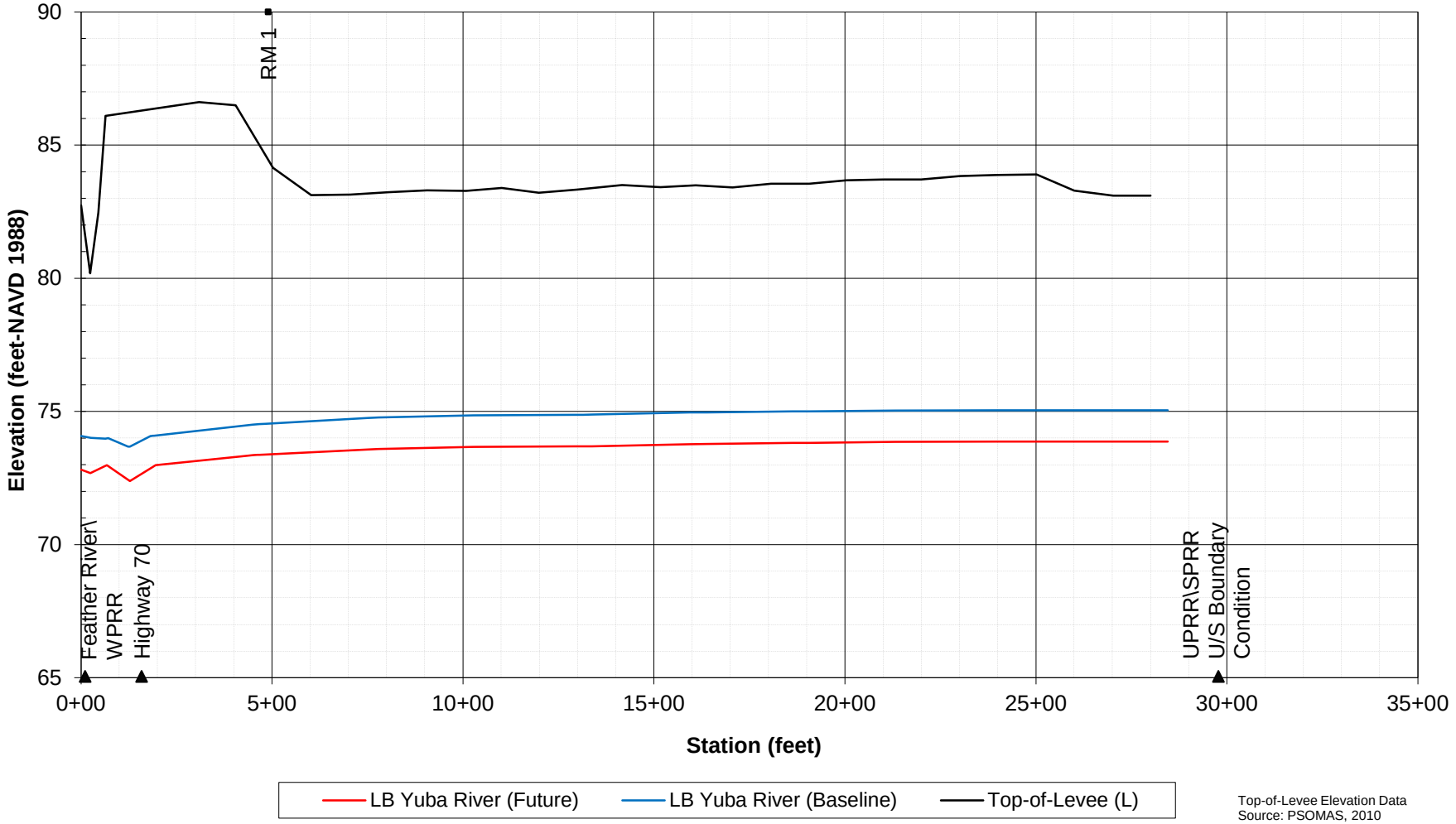
Figure 10
Feather River - Right Bank (RM 7.8 to 28.7)
Maximum Water Surface Profile (2-D Model)-1-in-100 AEP
Upper Feather Centering



Top-of-Levee Elevation Data
Source: DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\100yr_Upper_Max_WS_Profile_NAVD

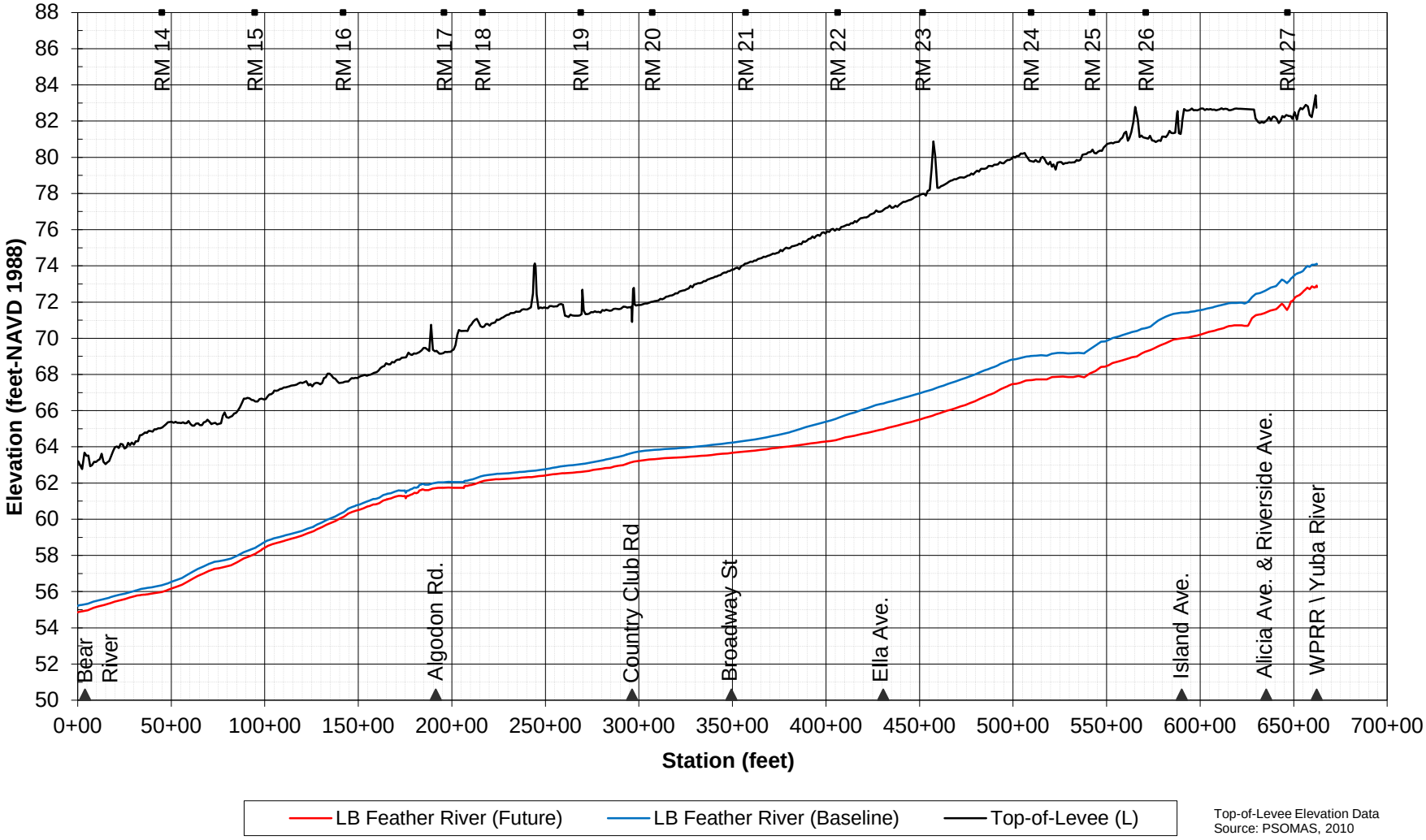
Figure 11
Yuba River - Left Bank (RM 0.3 to 1.2)
Maximum Water Surface Profile (2-D Model)-1-in-100 AEP
Upper Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\100yr_Upper_Max_WS_Profile_NAVD

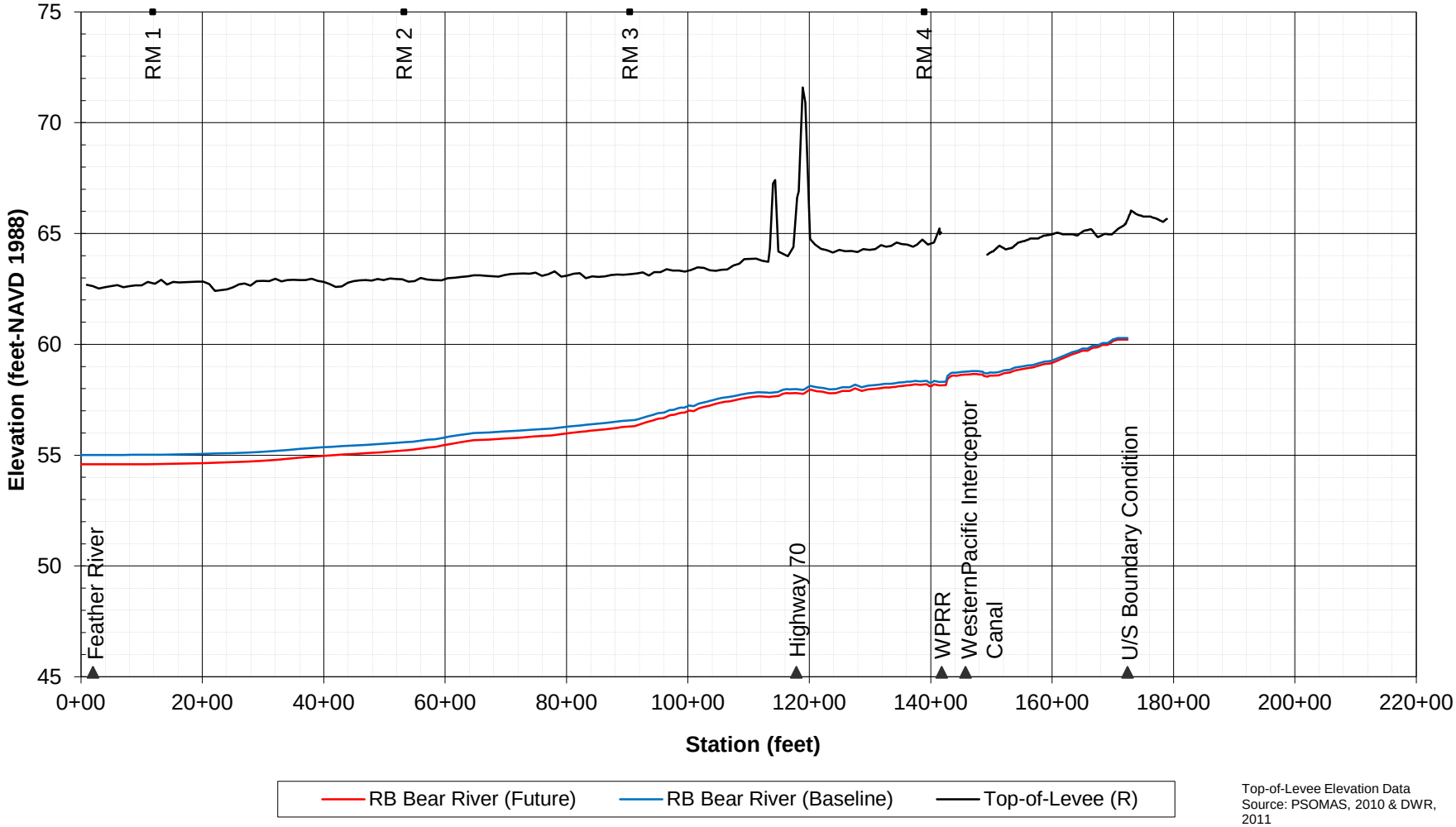
Figure 12
Feather River - Left Bank (RM 13.2 to 27.2)
Maximum Water Surface Profile (2-D Model)-1-in-100 AEP
Upper Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\100yr_Upper_Max_WS_Profile_NAVD

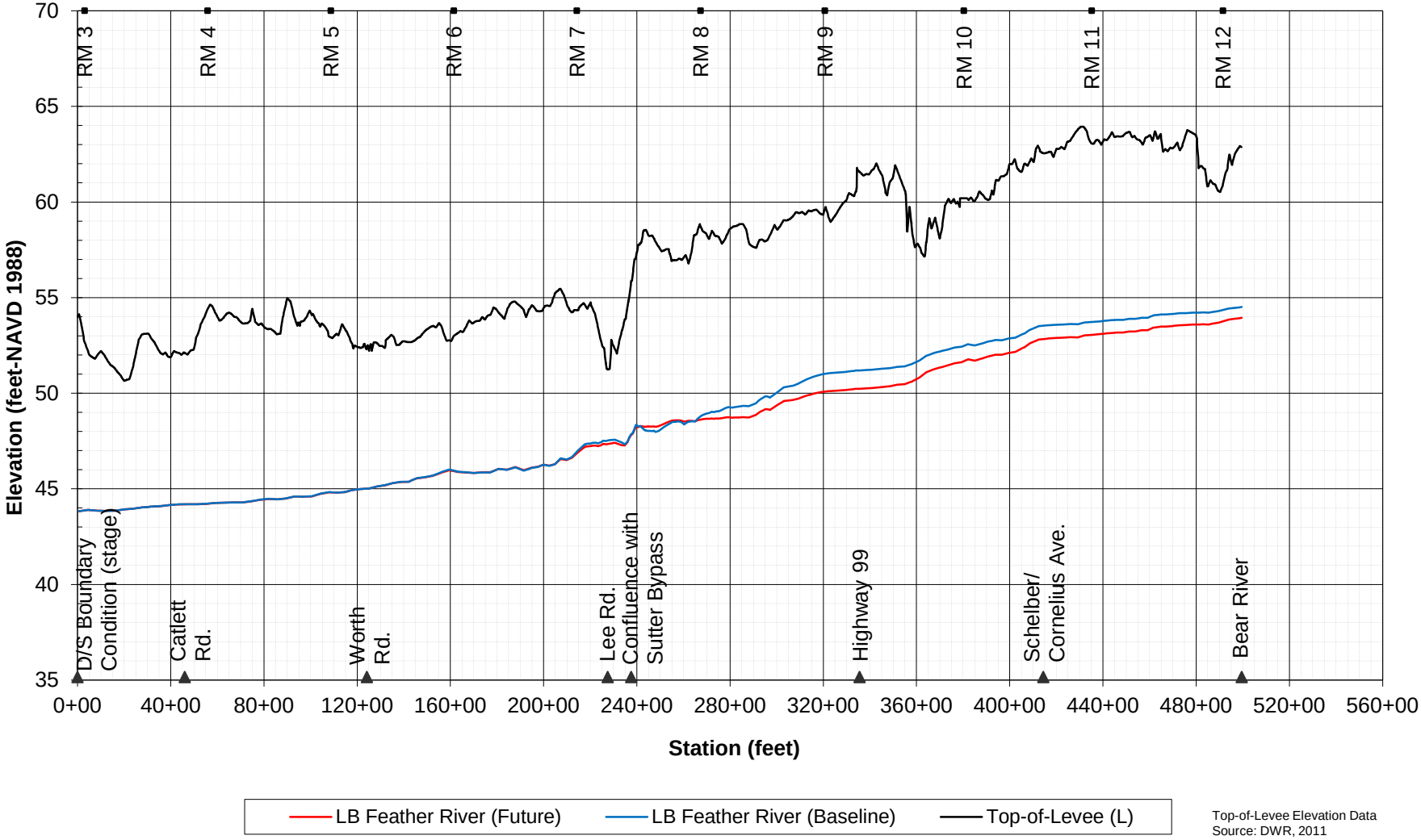
Figure 13
Bear River - Right Bank (RM 0.3 to 4.75)
Maximum Water Surface Profile (2-D Model)-1-in-100 AEP
Upper Feather Centering



Top-of-Levee Elevation Data Source: PSOMAS, 2010 & DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\100yr_Upper_Max_WS_Profile_NAVD

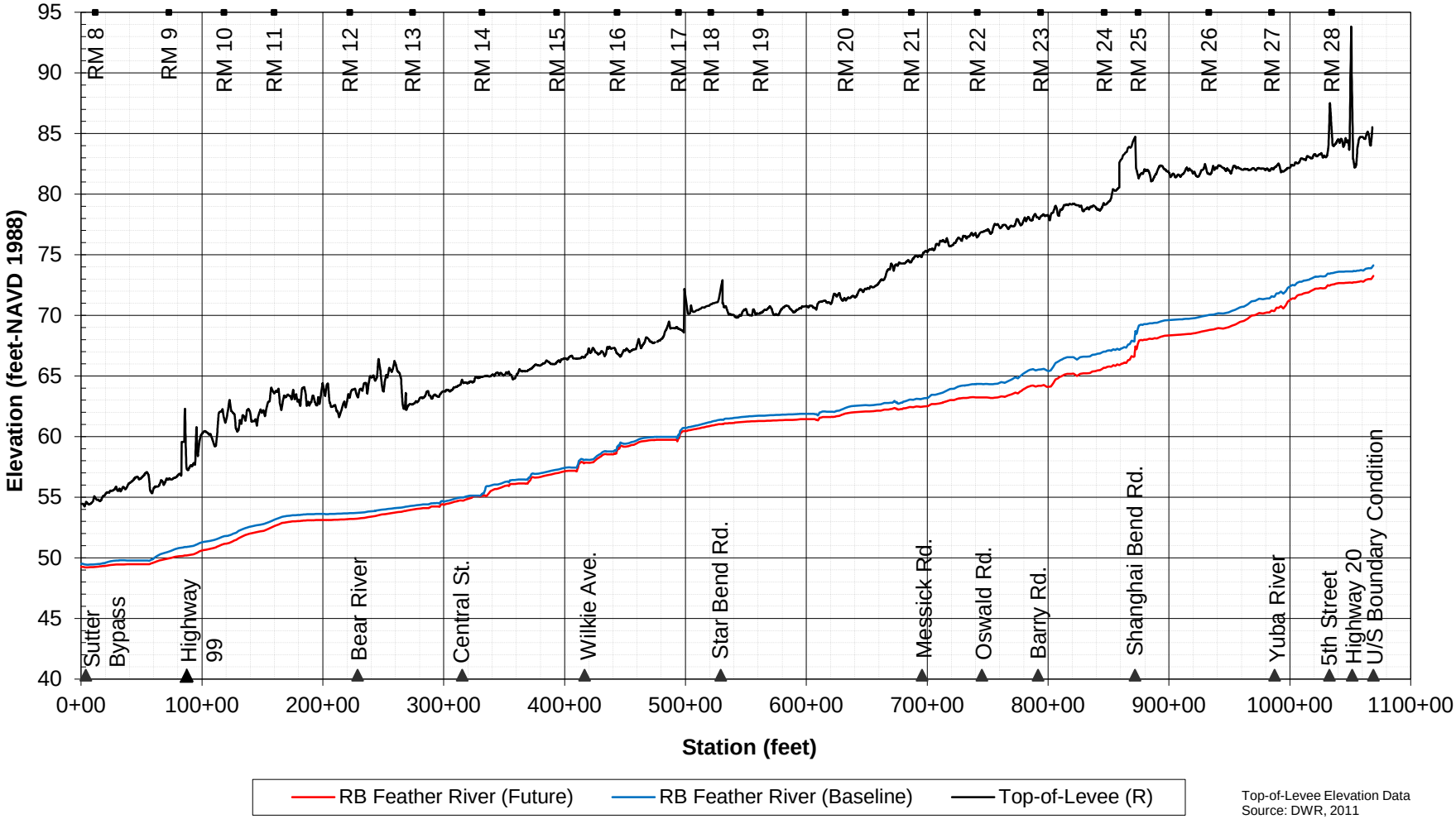
Figure 14
Feather River - Left Bank (RM 2.9 to 12.2)
Maximum Water Surface Profile (2-D Model)-1-in-100 AEP
Upper Feather Centering



Top-of-Levee Elevation Data
Source: DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\100yr_Upper_Max_WS_Profile_NAVD

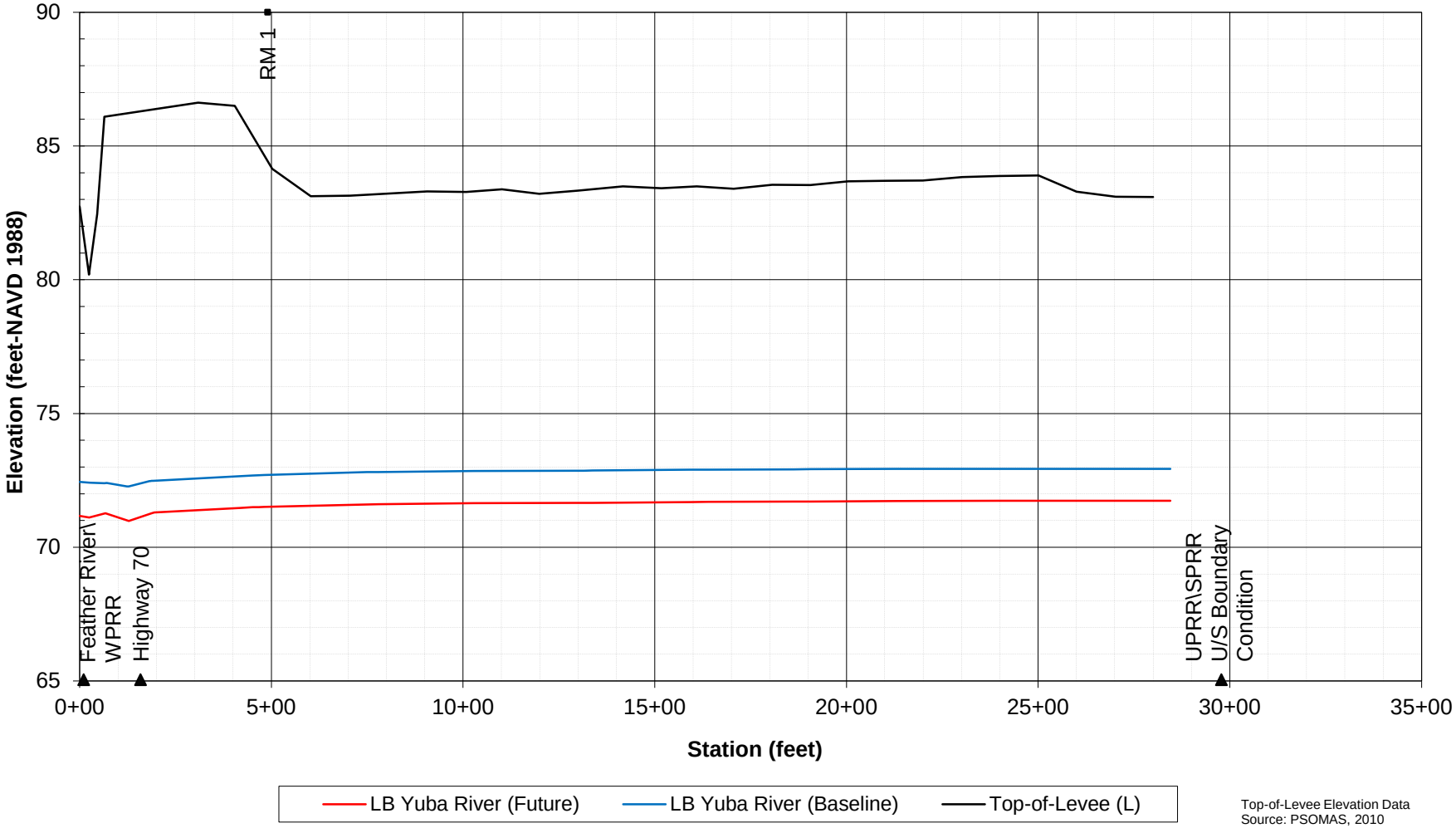
Figure 15
Feather River - Right Bank (RM 7.8 to 28.7)
Maximum Water Surface Profile (2-D Model)-1-in-100 AEP
Lower Feather Centering



Top-of-Levee Elevation Data
Source: DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\100yr_Lower_Max_WS_Profile_NAVD

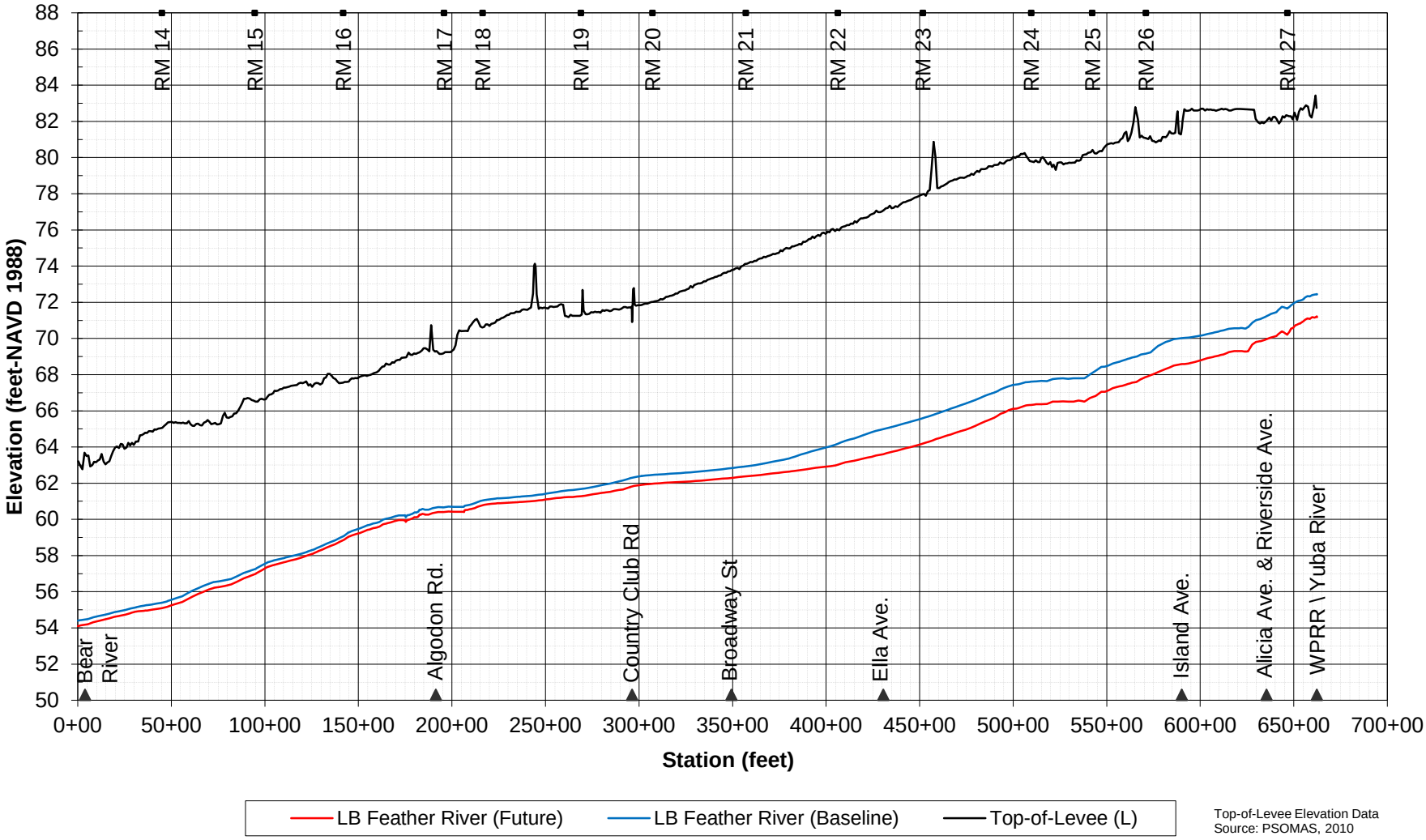
Figure 16
Yuba River - Left Bank (RM 0.3 to 1.2)
Maximum Water Surface Profile (2-D Model)-1-in-100 AEP
Lower Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\100yr_Lower_Max_WS_Profile_NAVD

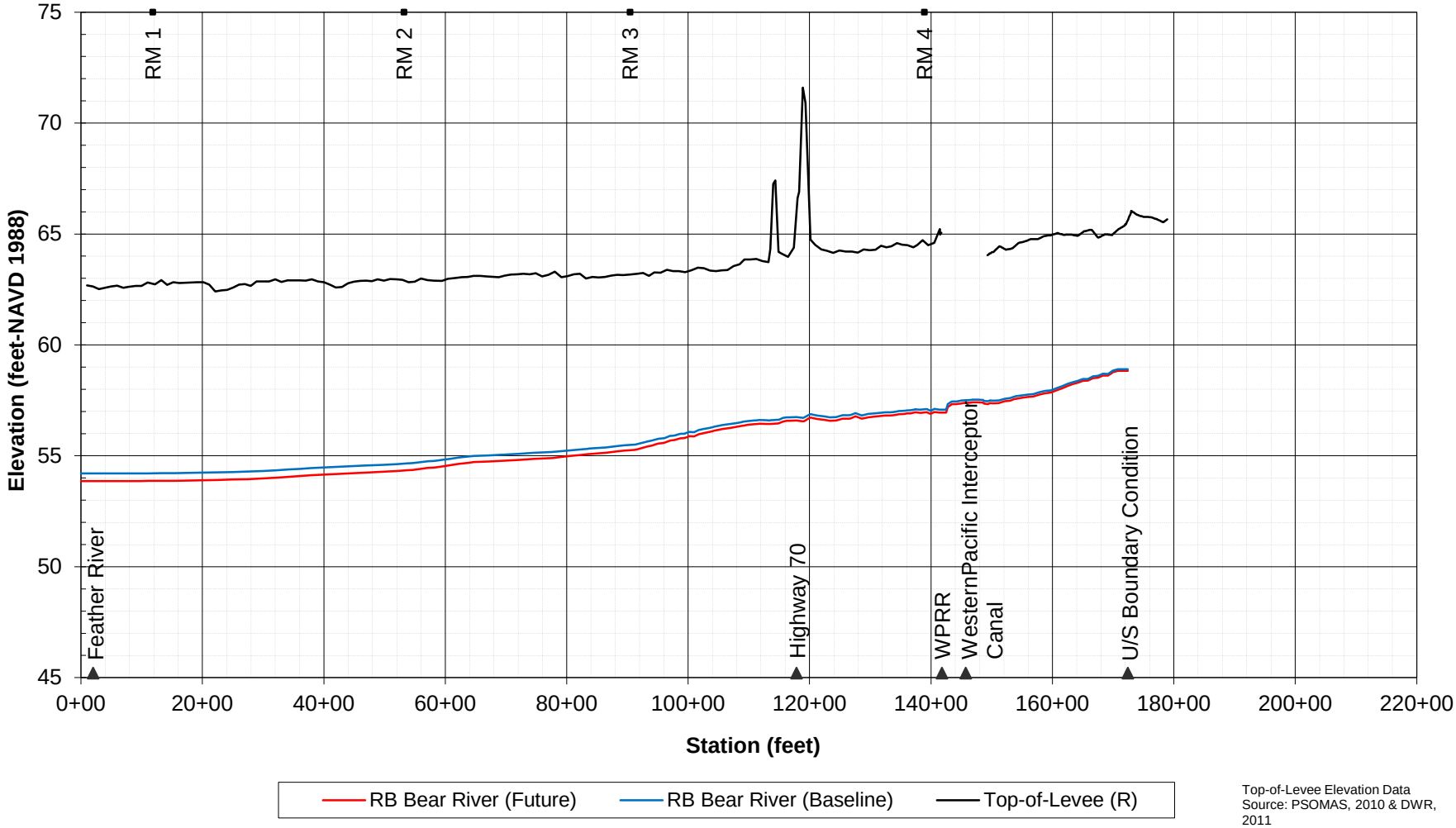
Figure 17
Feather River - Left Bank (RM 13.2 to 27.2)
Maximum Water Surface Profile (2-D Model)-1-in-100 AEP
Lower Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\100yr_Lower_Max_WS_Profile_NAVD

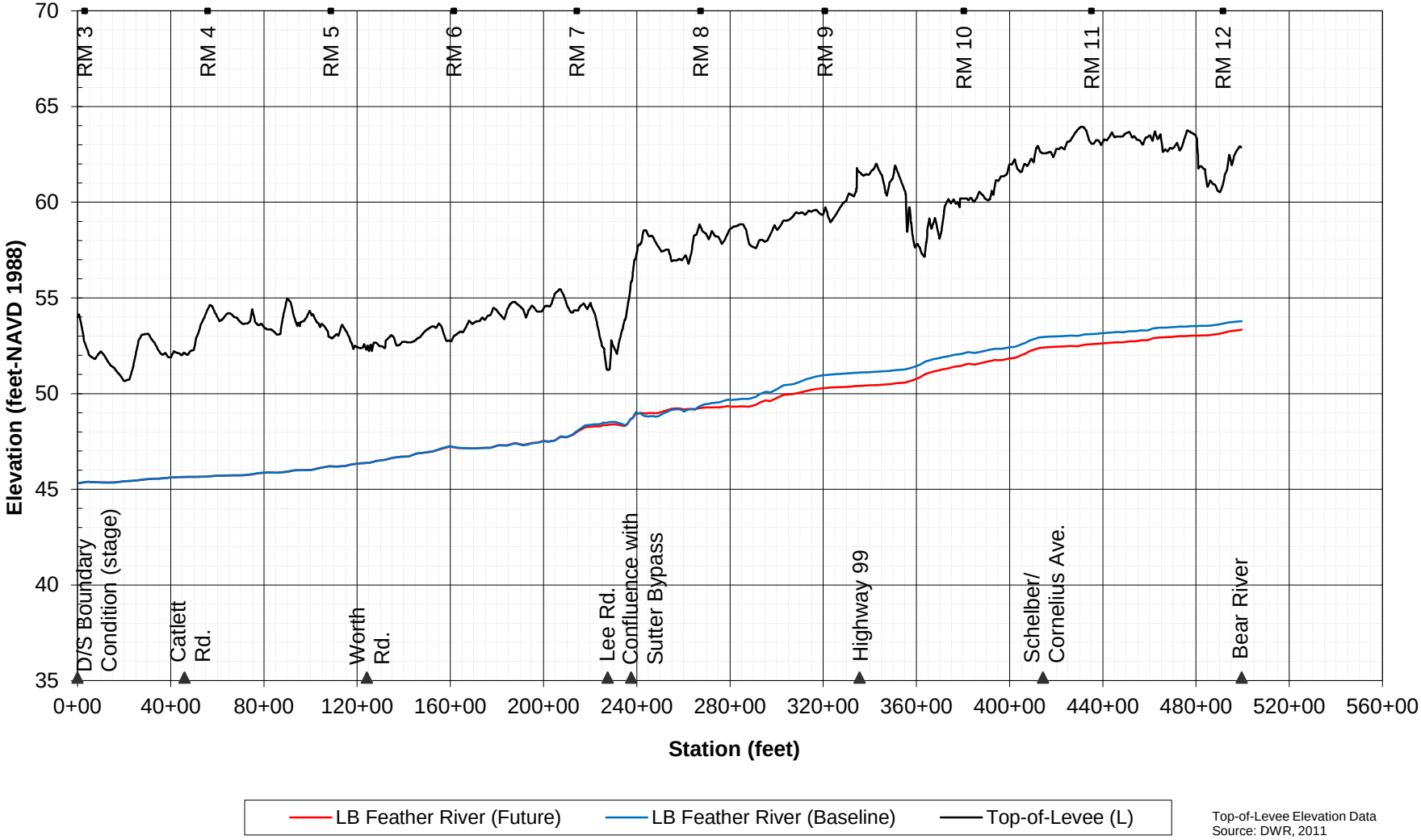
Figure 18
Bear River - Right Bank (RM 0.3 to 4.75)
Maximum Water Surface Profile (2-D Model)-1-in-100 AEP
Lower Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010 & DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\100yr_Lower_Max_WS_Profile_NAVD

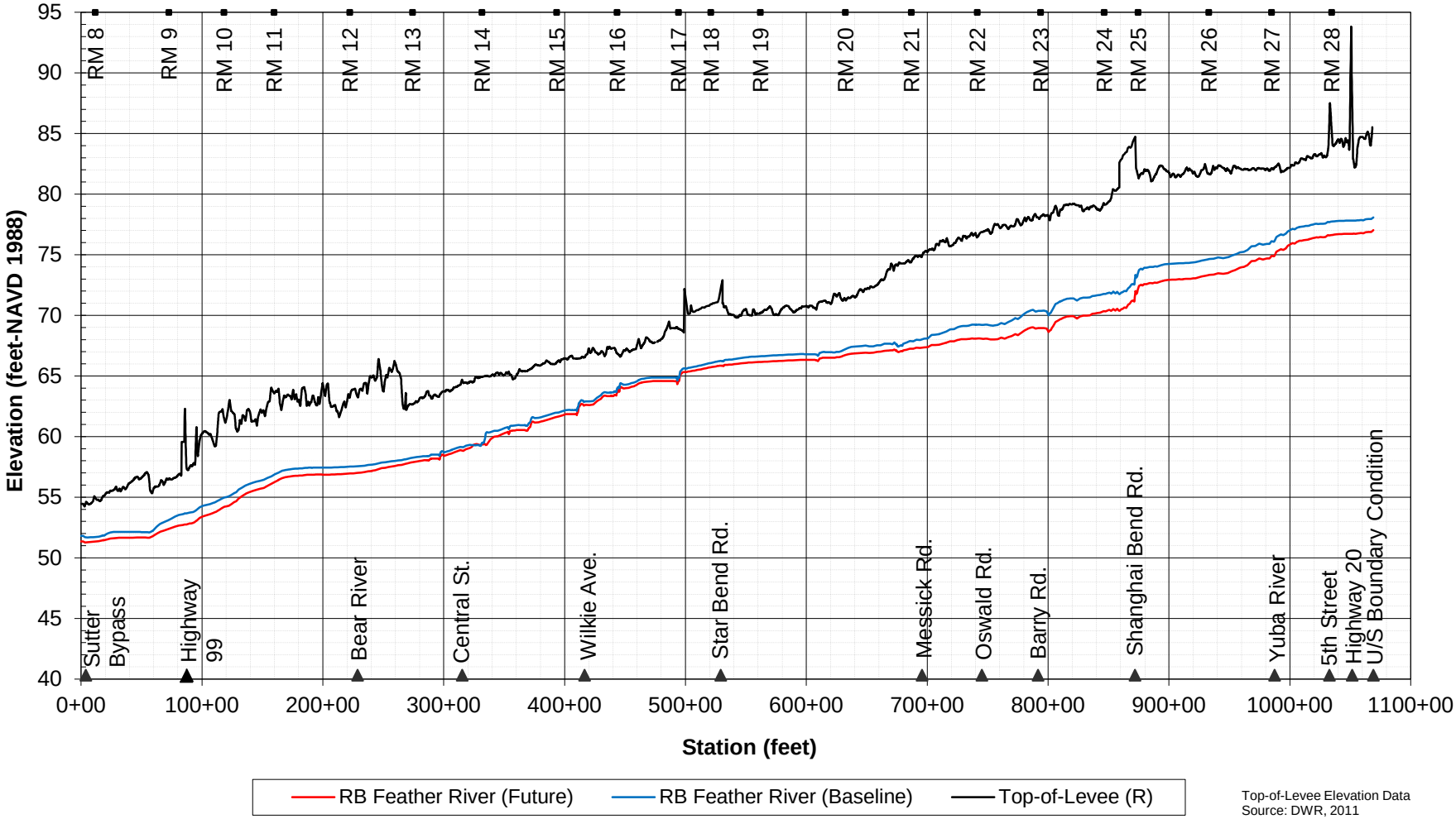
Figure 19
Feather River - Left Bank (RM 2.9 to 12.2)
Maximum Water Surface Profile (2-D Model)-1-in-100 AEP
Lower Feather Centering



Top-of-Levee Elevation Data
Source: DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\100yr_Lower_Max_WS_Profile_NAVD

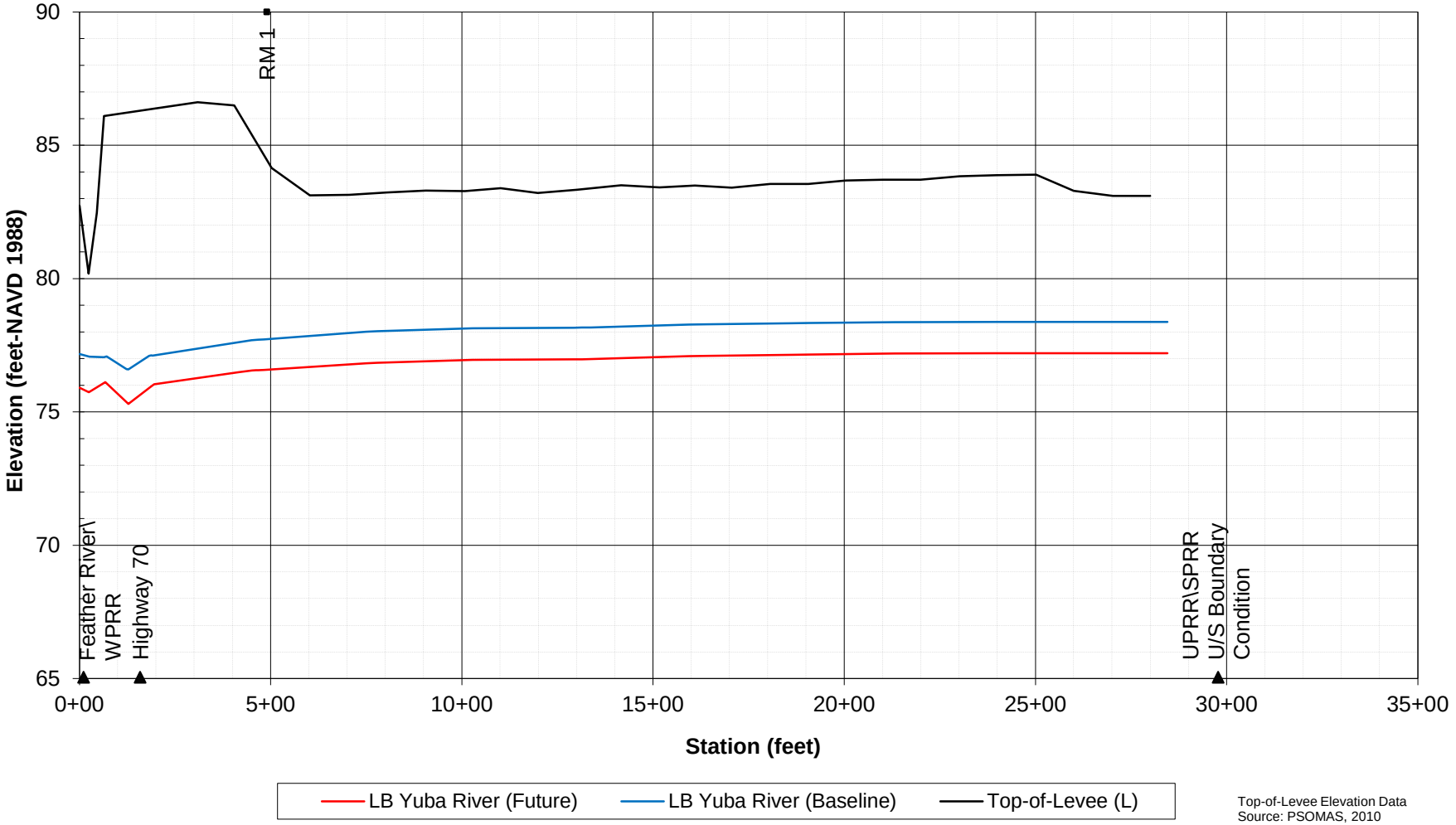
Figure 20
Feather River - Right Bank (RM 7.8 to 28.7)
Maximum Water Surface Profile (2-D Model)-1-in-200 AEP
Upper Feather Centering



Top-of-Levee Elevation Data
Source: DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\200yr_Upper_Max_WS_Profile_NAVD

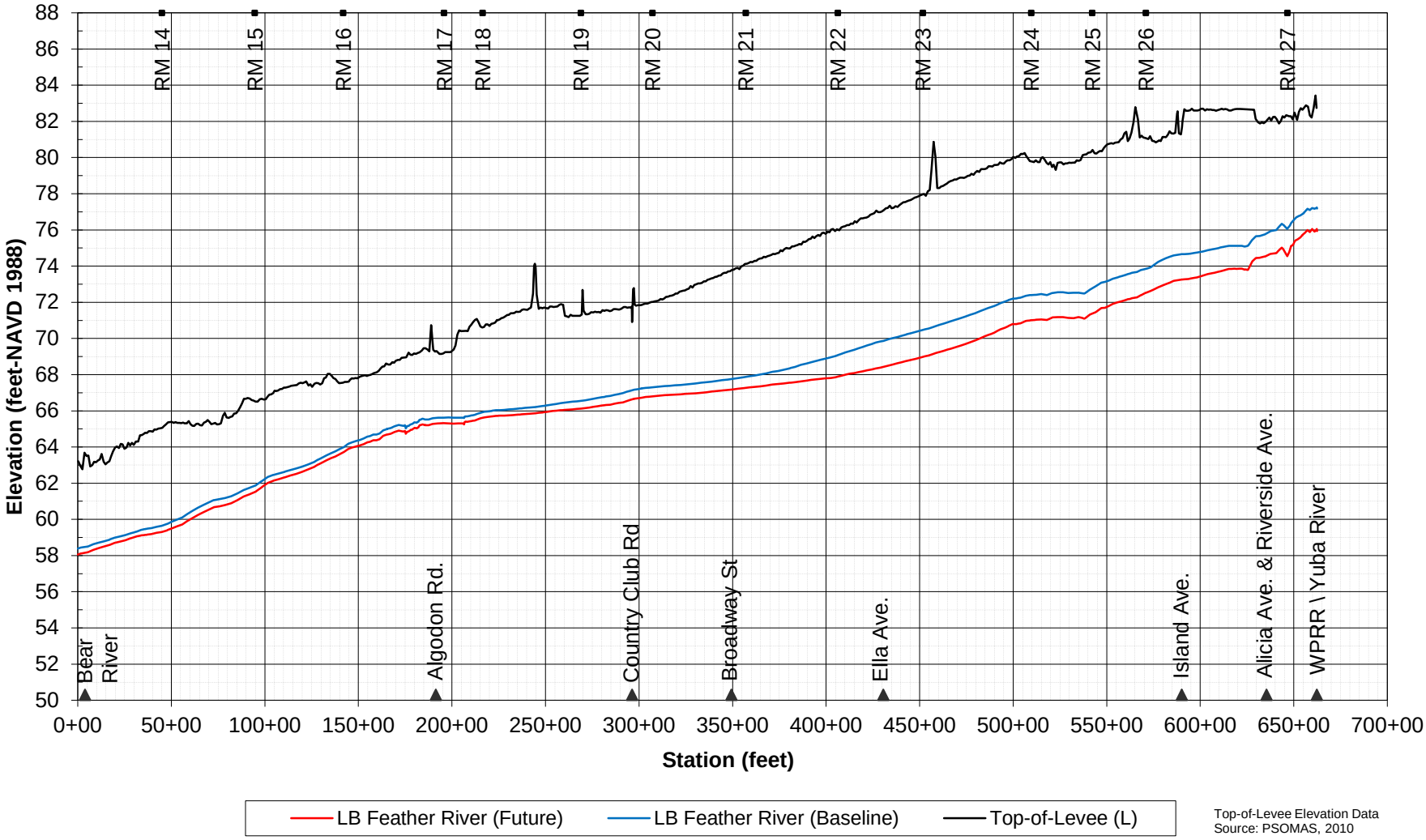
Figure 21
Yuba River - Left Bank (RM 0.3 to 1.2)
Maximum Water Surface Profile (2-D Model)-1-in-200 AEP
Upper Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\200yr_Upper_Max_WS_Profile_NAVD

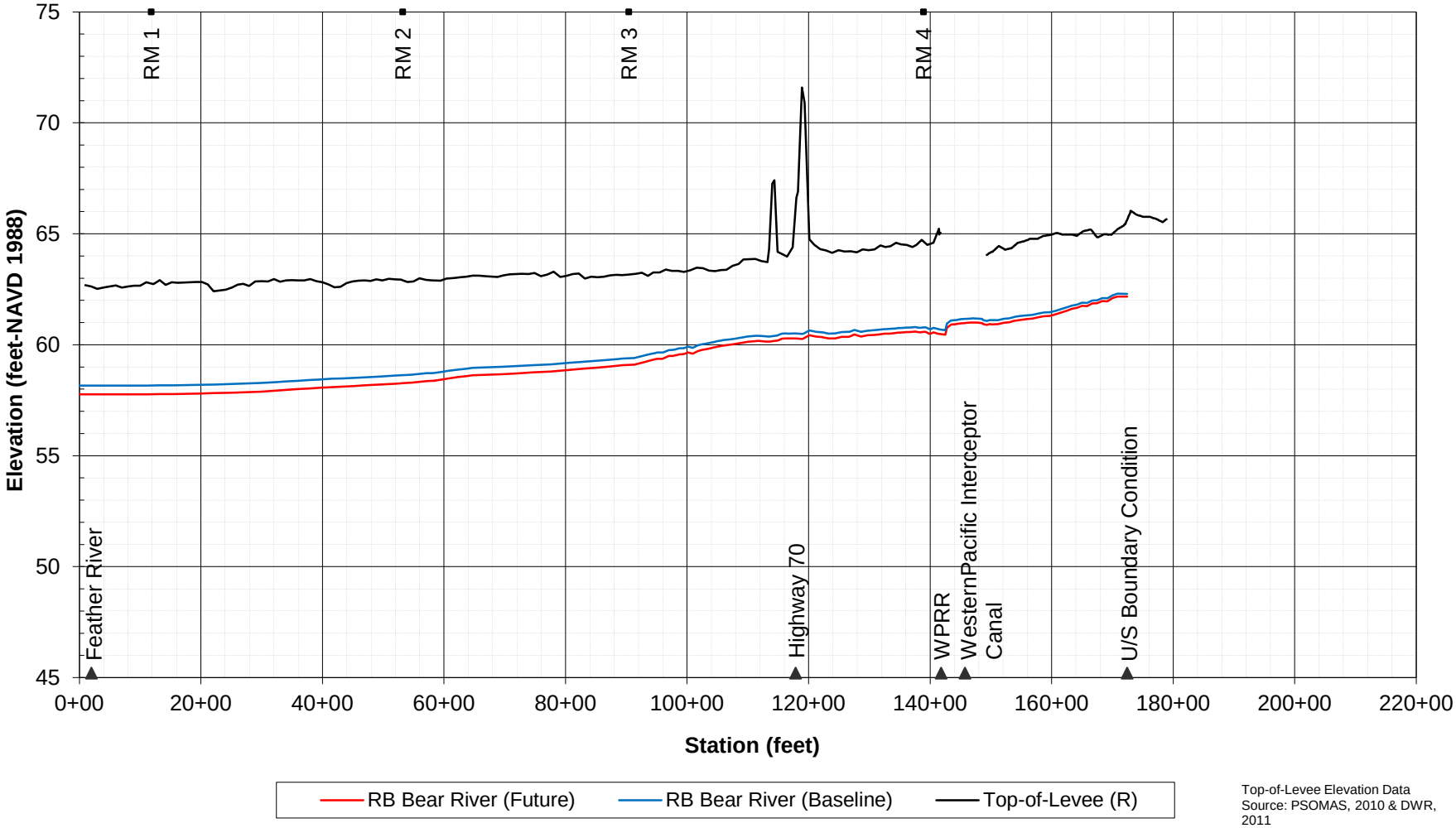
Figure 22
Feather River - Left Bank (RM 13.2 to 27.2)
Maximum Water Surface Profile (2-D Model)-1-in-200 AEP
Upper Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\200yr_Upper_Max_WS_Profile_NAVD

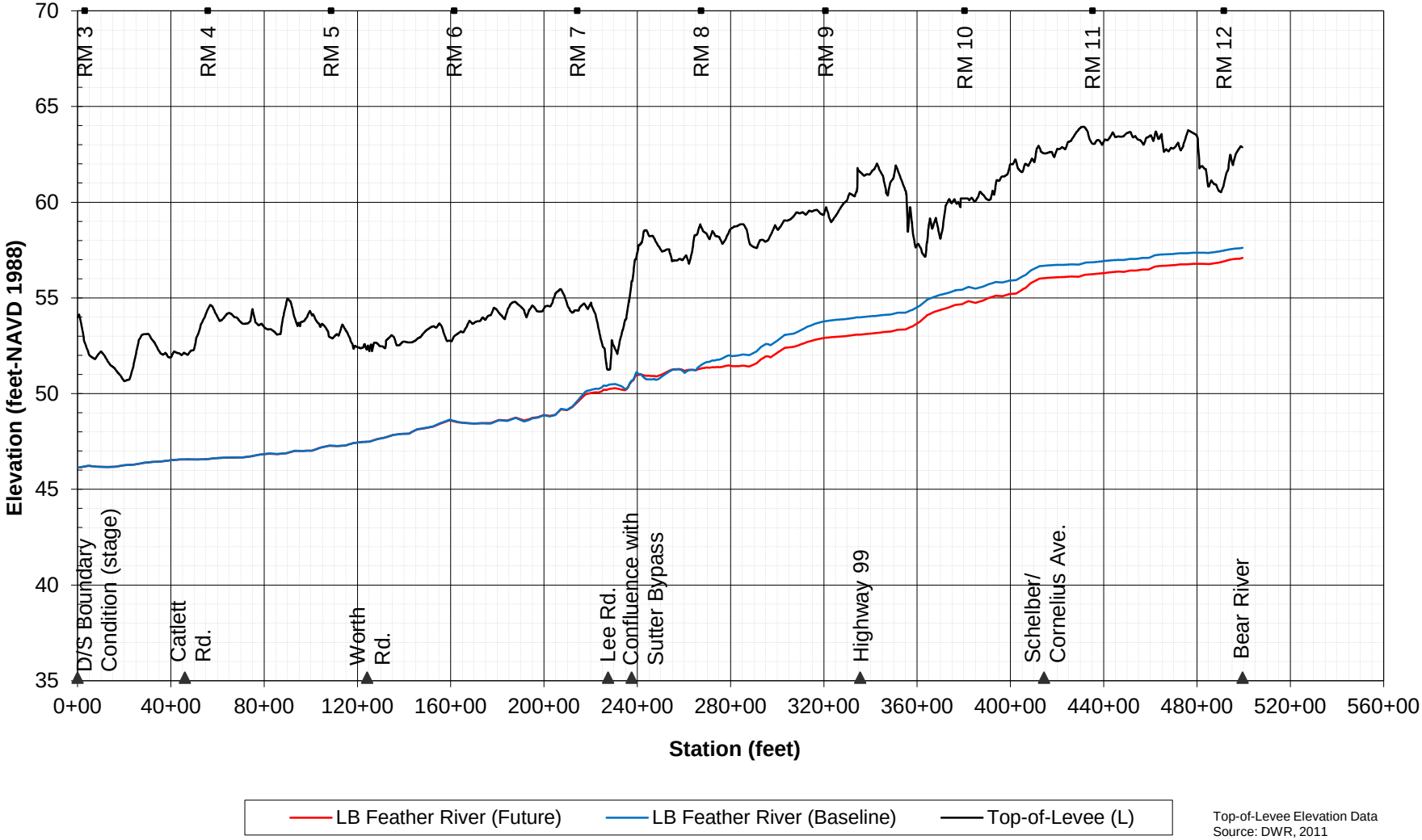
Figure 23
Bear River - Right Bank (RM 0.3 to 4.75)
Maximum Water Surface Profile (2-D Model)-1-in-200 AEP
Upper Feather Centering



Top-of-Levee Elevation Data Source: PSOMAS, 2010 & DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\200yr_Upper_Max_WS_Profile_NAVD

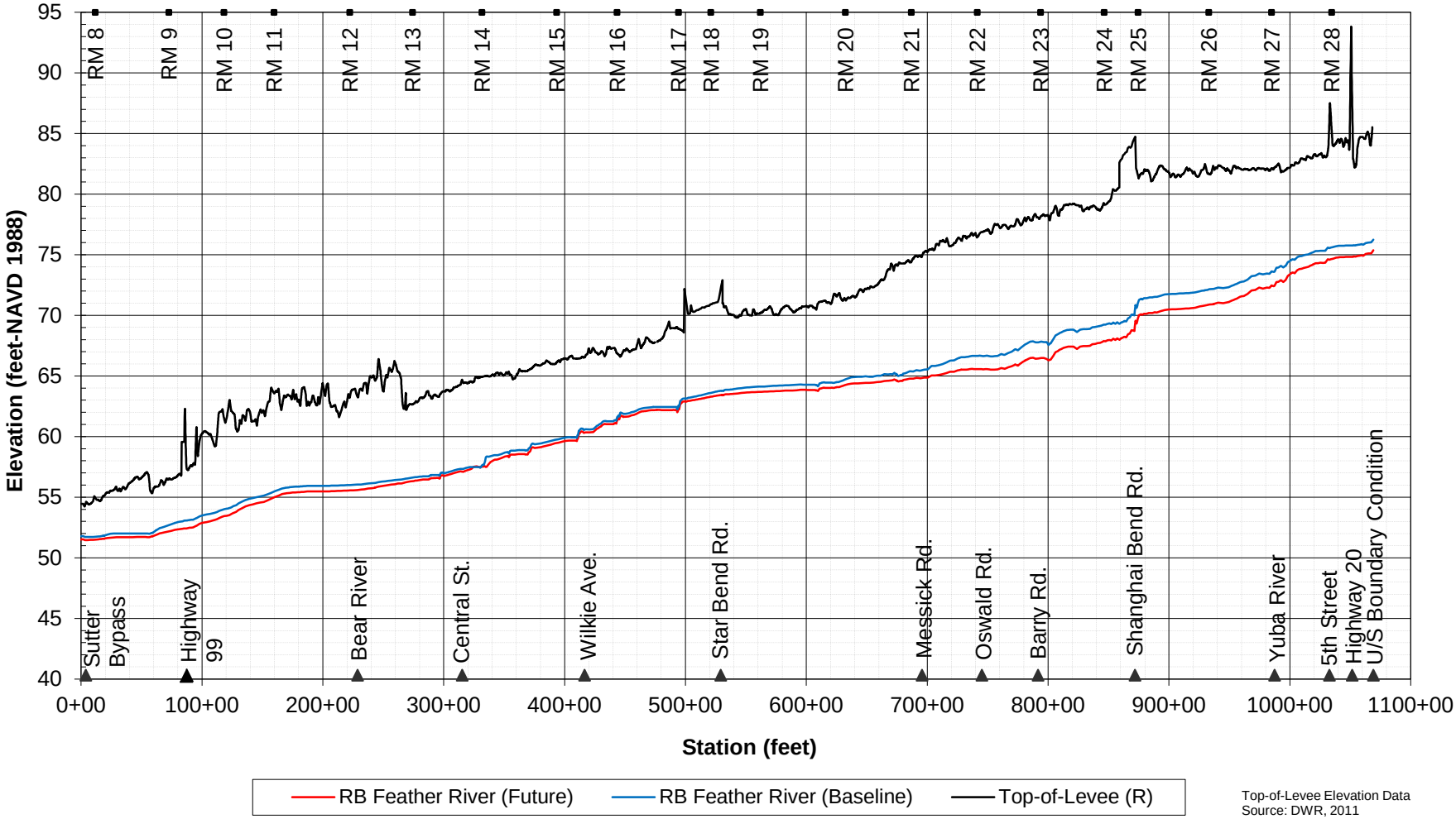
Figure 24
Feather River - Left Bank (RM 2.9 to 12.2)
Maximum Water Surface Profile (2-D Model)-1-in-200 AEP
Upper Feather Centering



Top-of-Levee Elevation Data
Source: DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\200yr_Upper_Max_WS_Profile_NAVD

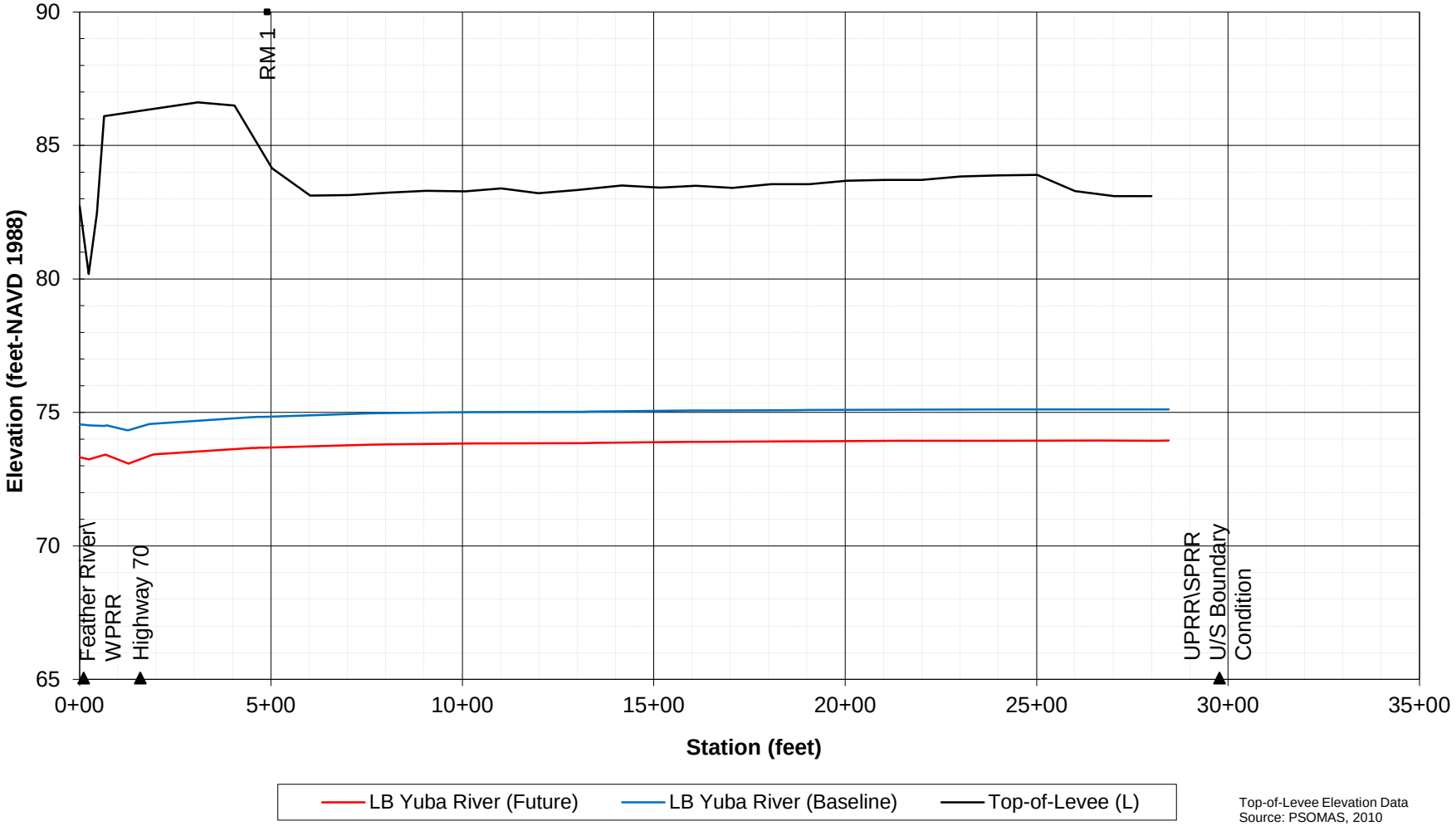
Figure 25
Feather River - Right Bank (RM 7.8 to 28.7)
Maximum Water Surface Profile (2-D Model)-1-in-200 AEP
Lower Feather Centering



Top-of-Levee Elevation Data
Source: DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\200yr_Lower_Max_WS_Profile_NAVD

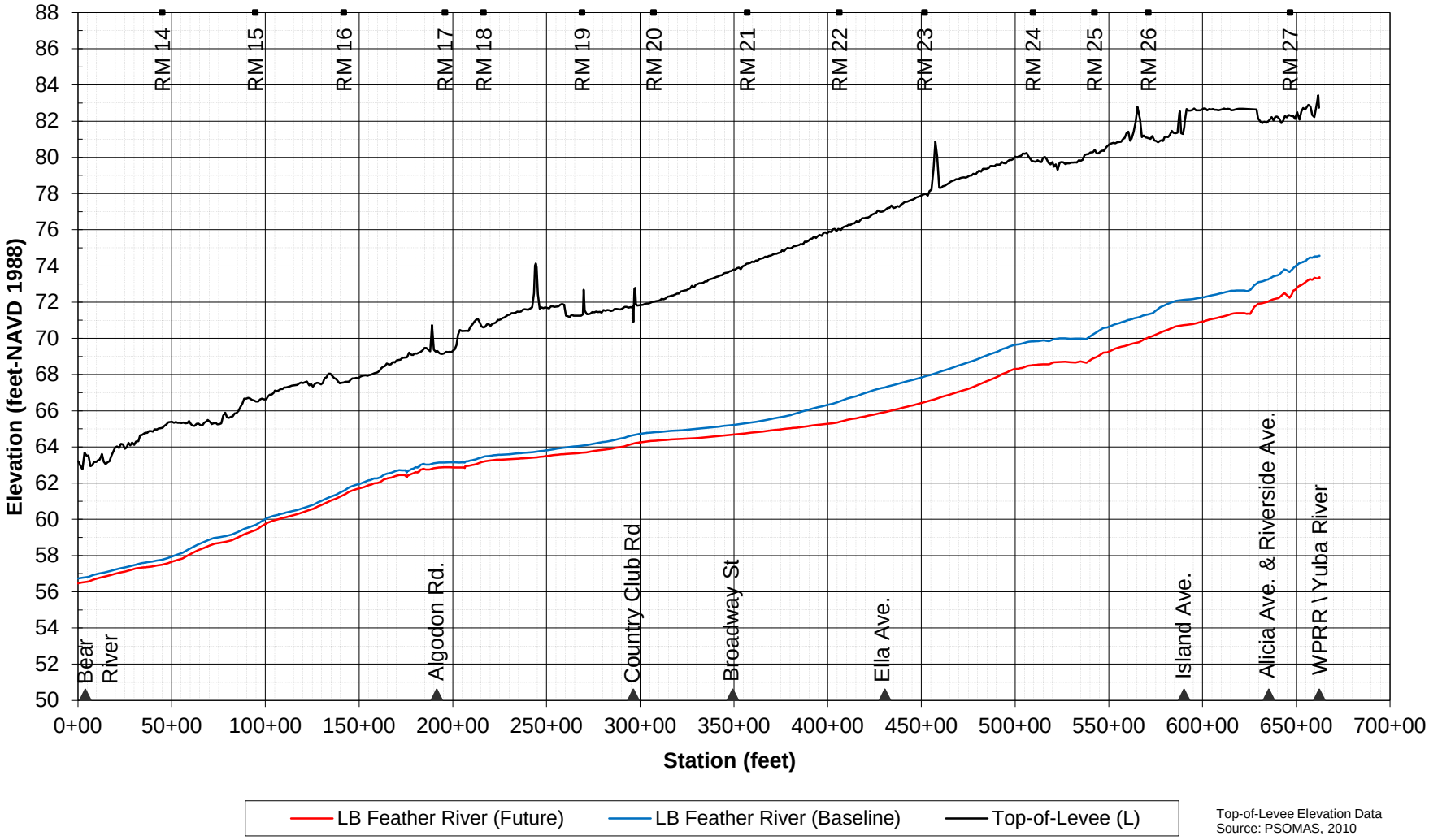
Figure 26
Yuba River - Left Bank (RM 0.3 to 1.2)
Maximum Water Surface Profile (2-D Model)-1-in-200 AEP
Lower Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\200yr_Lower_Max_WS_Profile_NAVD

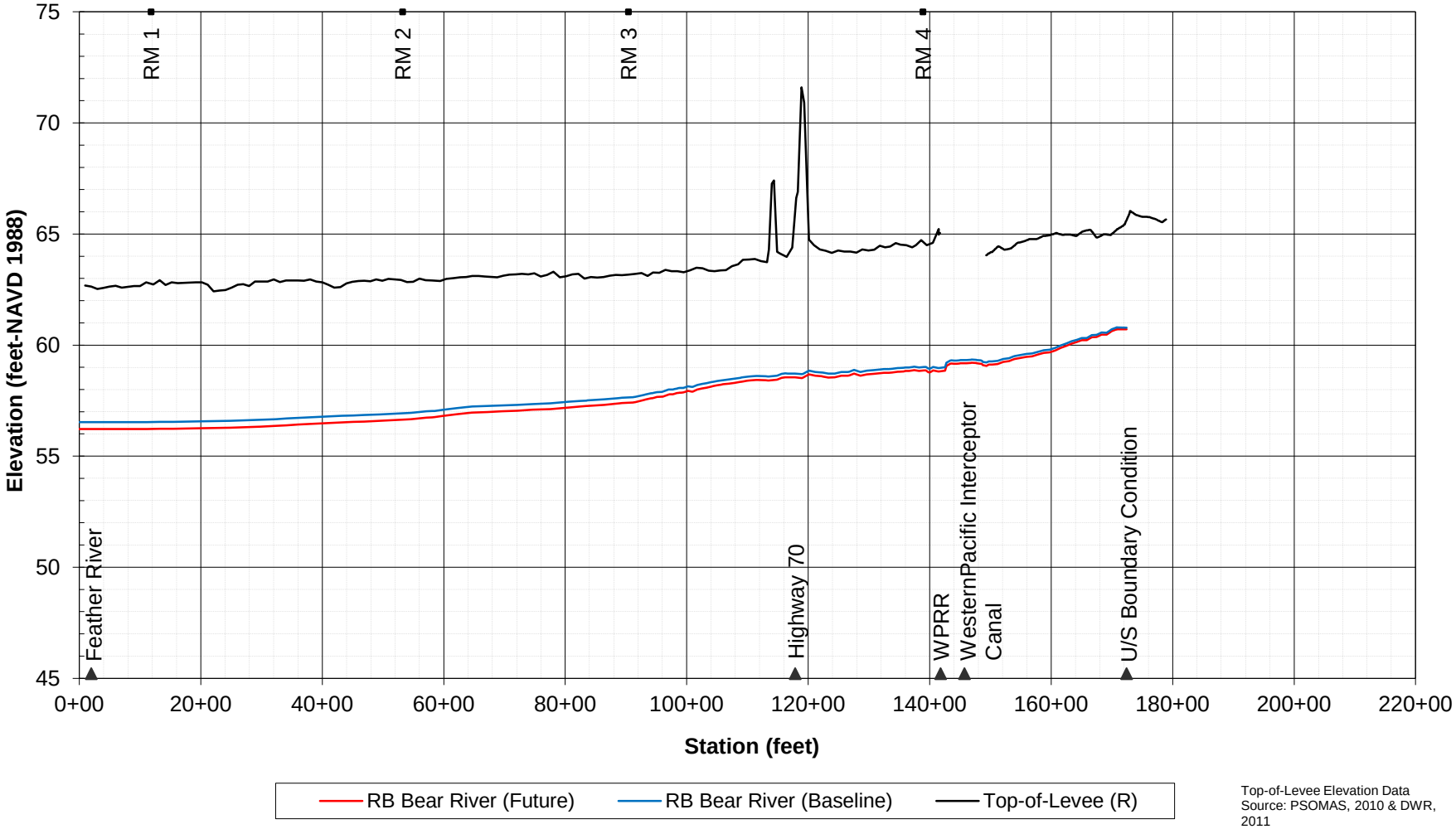
Figure 27
Feather River - Left Bank (RM 13.2 to 27.2)
Maximum Water Surface Profile (2-D Model)-1-in-200 AEP
Lower Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\200yr_Lower_Max_WS_Profile_NAVD

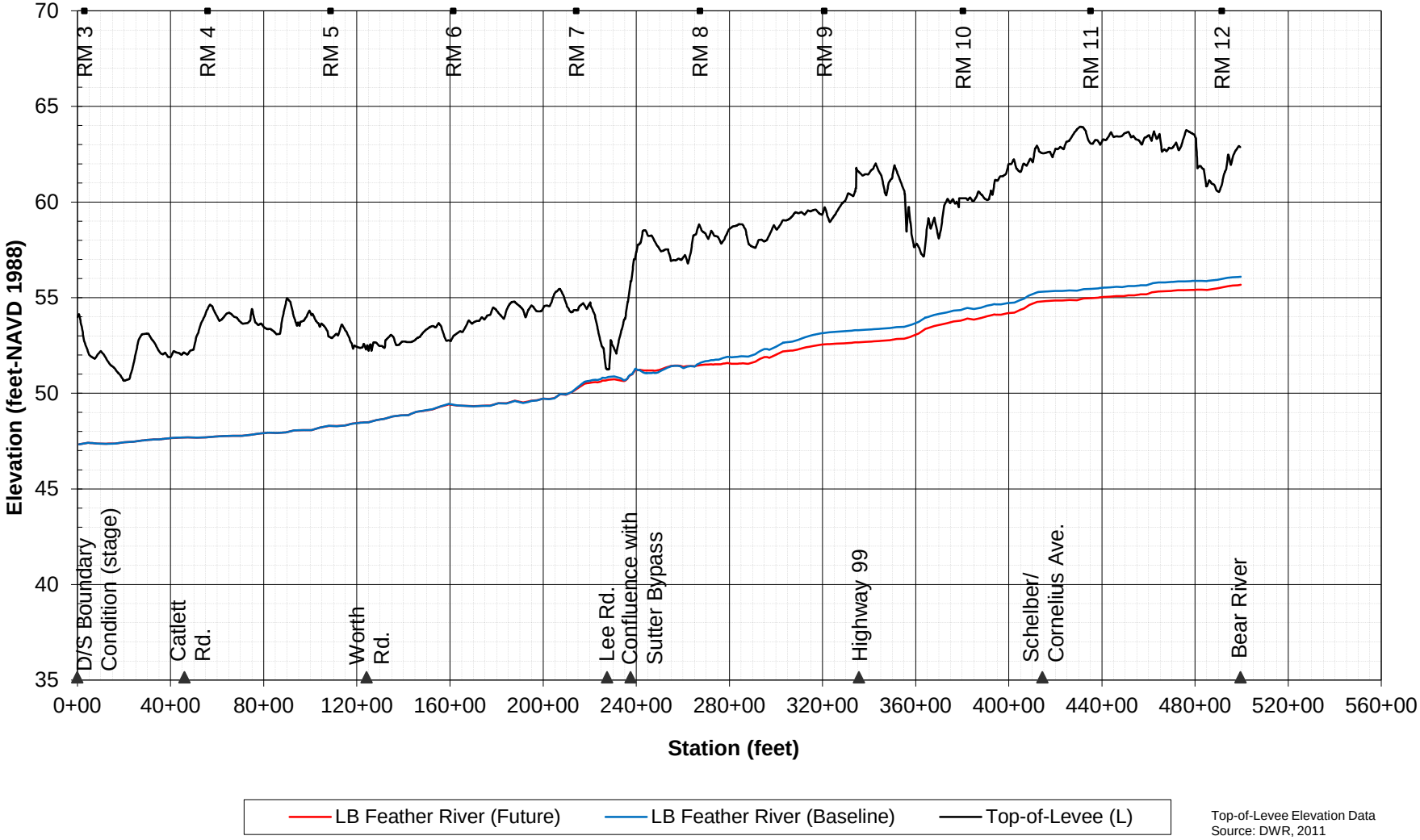
Figure 28
Bear River - Right Bank (RM 0.3 to 4.75)
Maximum Water Surface Profile (2-D Model)-1-in-200 AEP
Lower Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010 & DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\200yr_Lower_Max_WS_Profile_NAVD

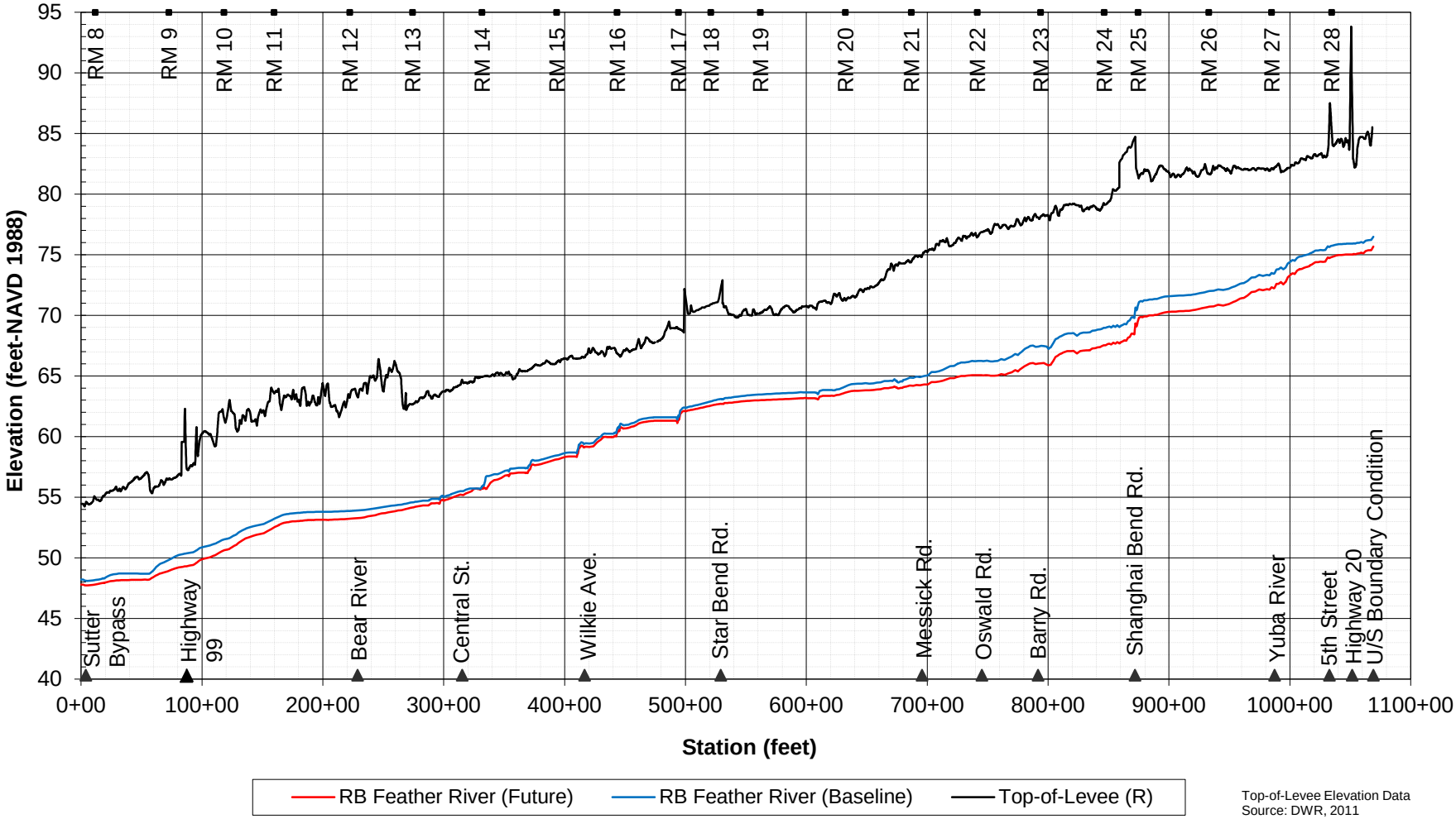
Figure 29
Feather River - Left Bank (RM 2.9 to 12.2)
Maximum Water Surface Profile (2-D Model)-1-in-200 AEP
Lower Feather Centering



Top-of-Levee Elevation Data
Source: DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\200yr_Lower_Max_WS_Profile_NAVD

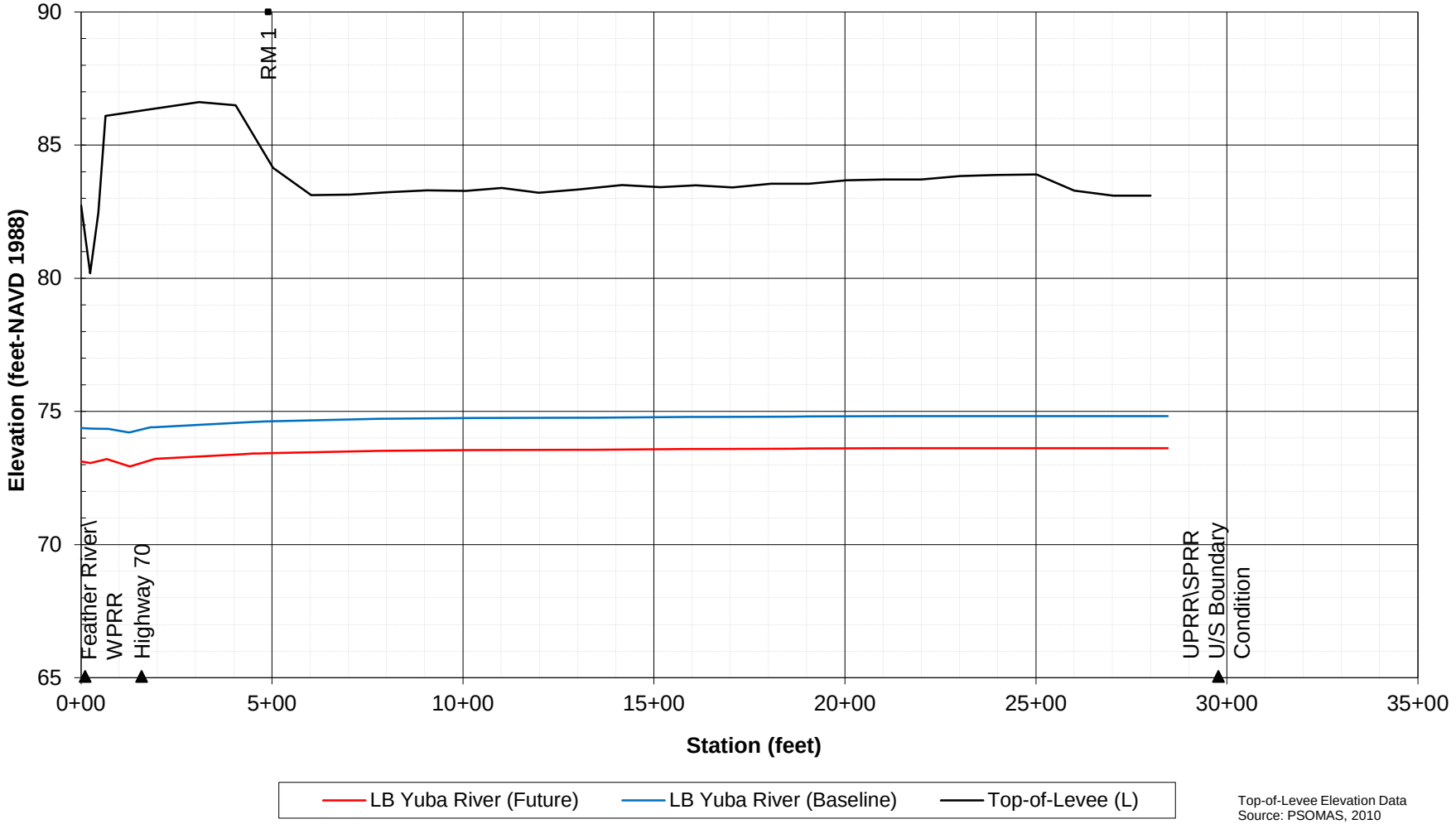
Figure 30
Feather River - Right Bank (RM 7.8 to 28.7)
Maximum Water Surface Profile (2-D Model)-1957 SRFCP Design Flow
Upper Feather Centering



Top-of-Levee Elevation Data
Source: DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\1957Q_Run1_Max_WS_Profile_NAVD

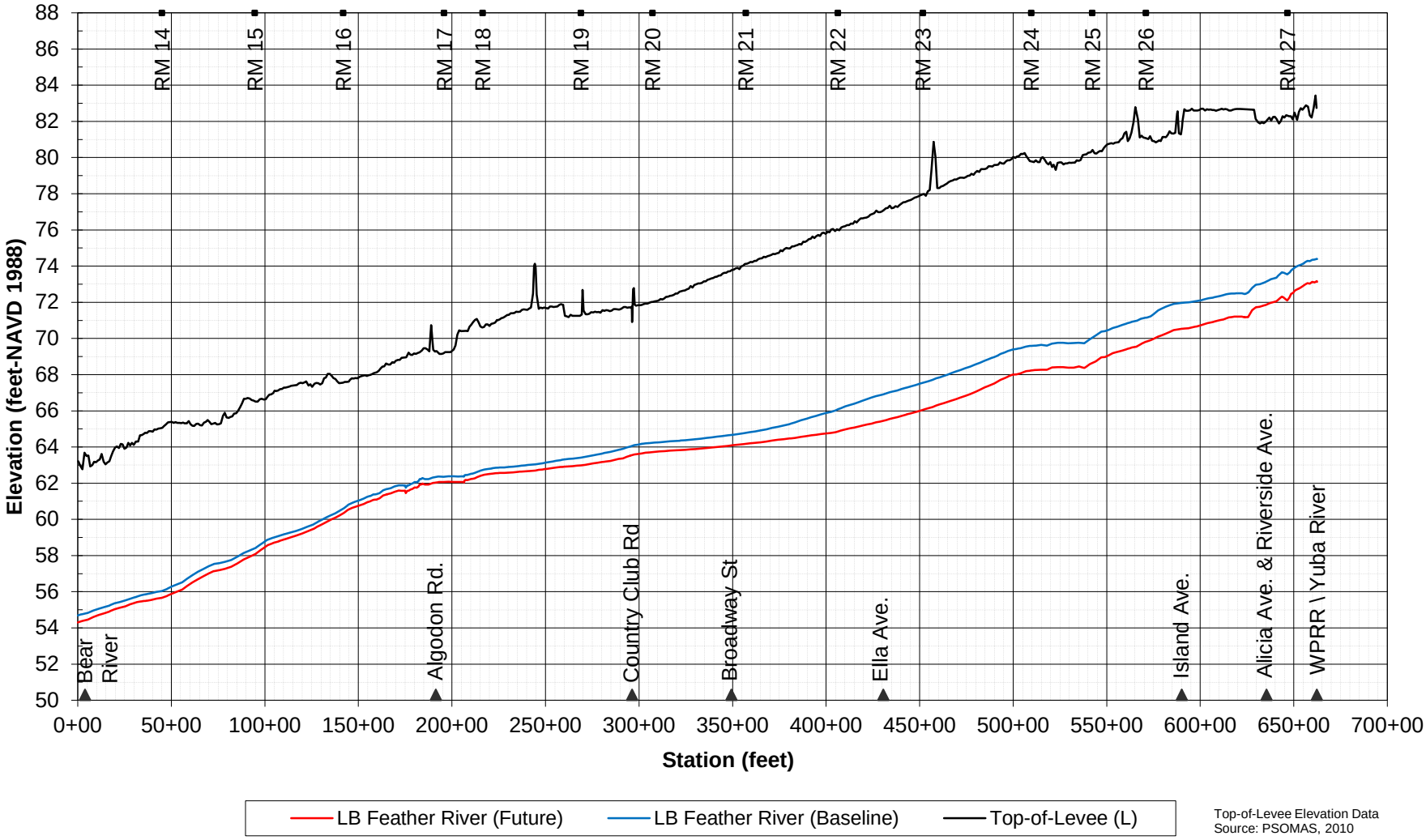
Figure 31
Yuba River - Left Bank (RM 0.3 to 1.2)
Maximum Water Surface Profile (2-D Model)-1957 SRFCP Design Flow
Upper Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\1957Q_Run1_Max_WS_Profile_NAVD

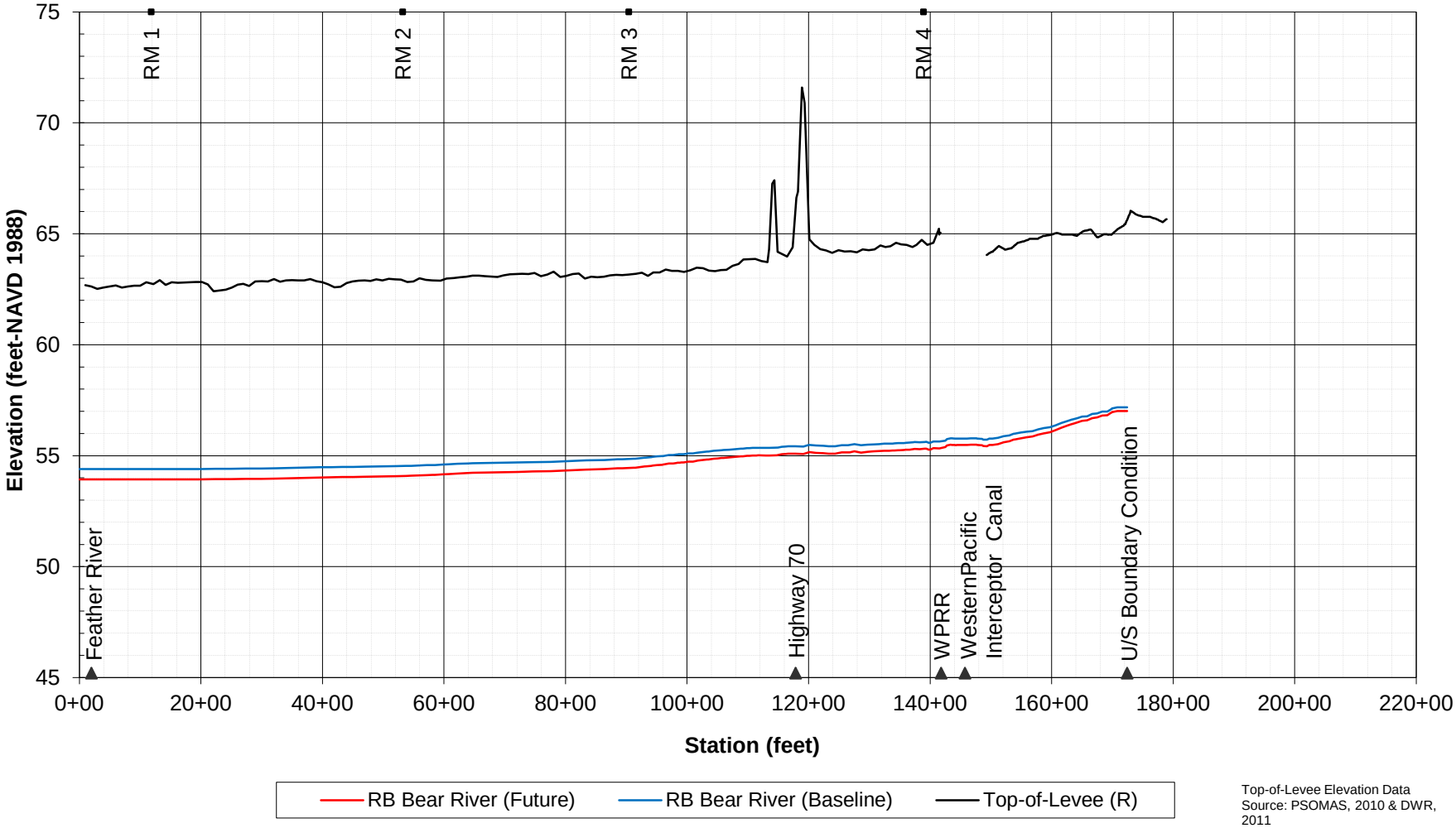
Figure 32
Feather River - Left Bank (RM 13.2 to 27.2)
Maximum Water Surface Profile (2-D Model)-1957 SRFCP Design Flow
Upper Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\1957Q_Run1_Max_WS_Profile_NAVD

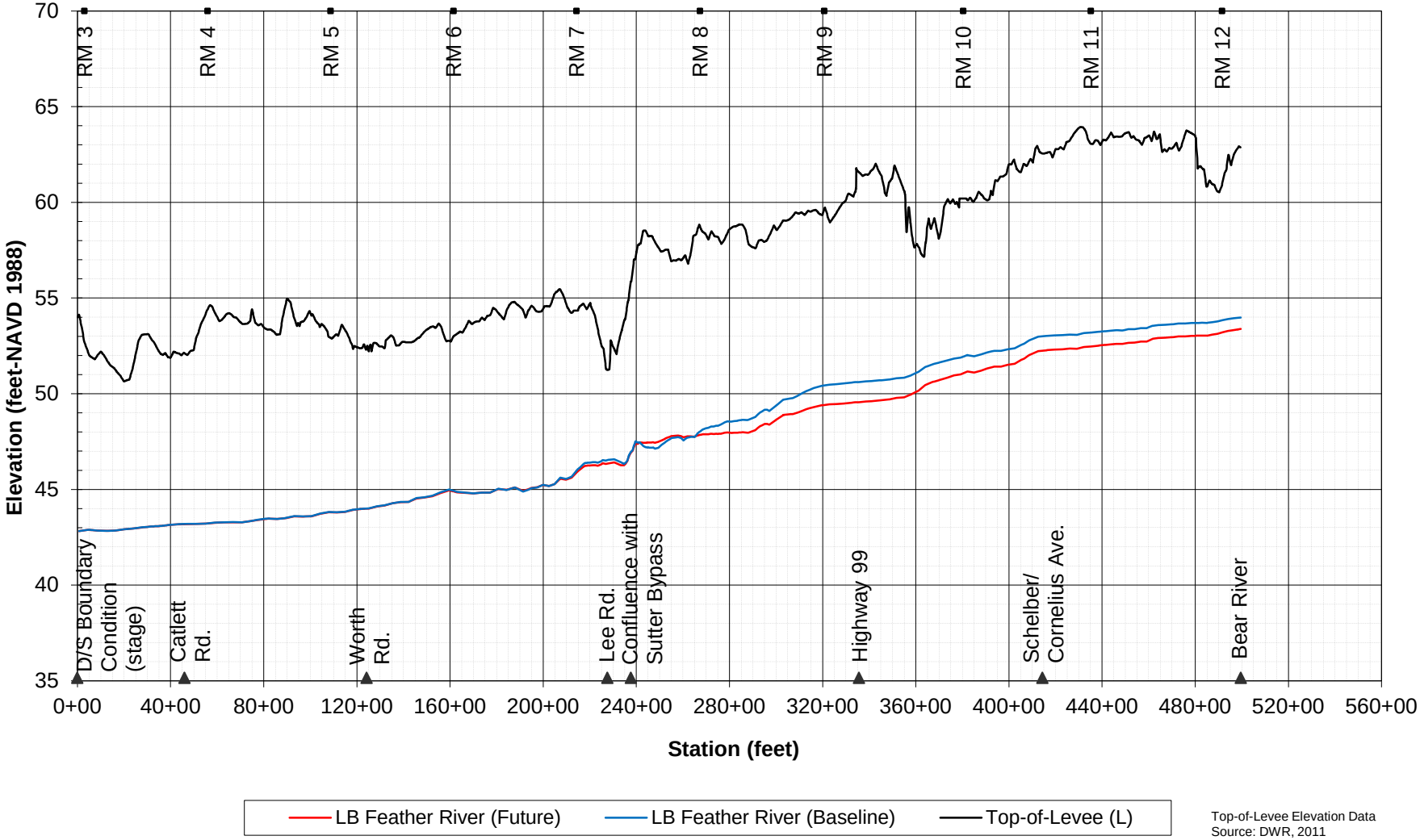
Figure 33
Bear River - Right Bank (RM 0.3 to 4.75)
Maximum Water Surface Profile (2-D Model)-1957 SRFCP Design Flow
Upper Feather Centering



Top-of-Levee Elevation Data Source: PSOMAS, 2010 & DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\1957Q_Run1_Max_WS_Profile_NAVD

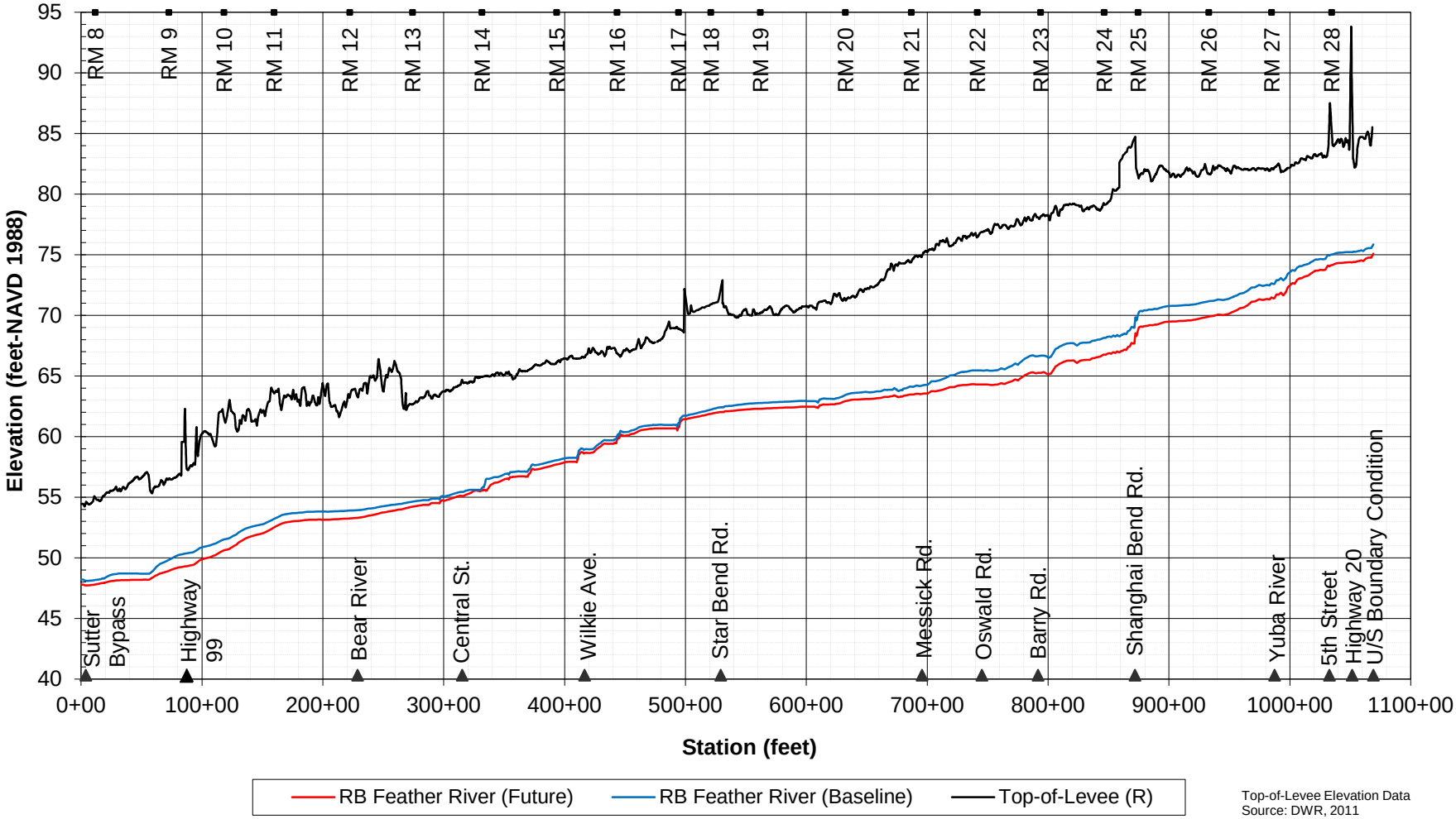
Figure 34
Feather River - Left Bank (RM 2.9 to 12.2)
Maximum Water Surface Profile (2-D Model)-1957 SRFCP Design Flow
Upper Feather Centering



Top-of-Levee Elevation Data
Source: DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\1957Q_Run1_Max_WS_Profile_NAVD

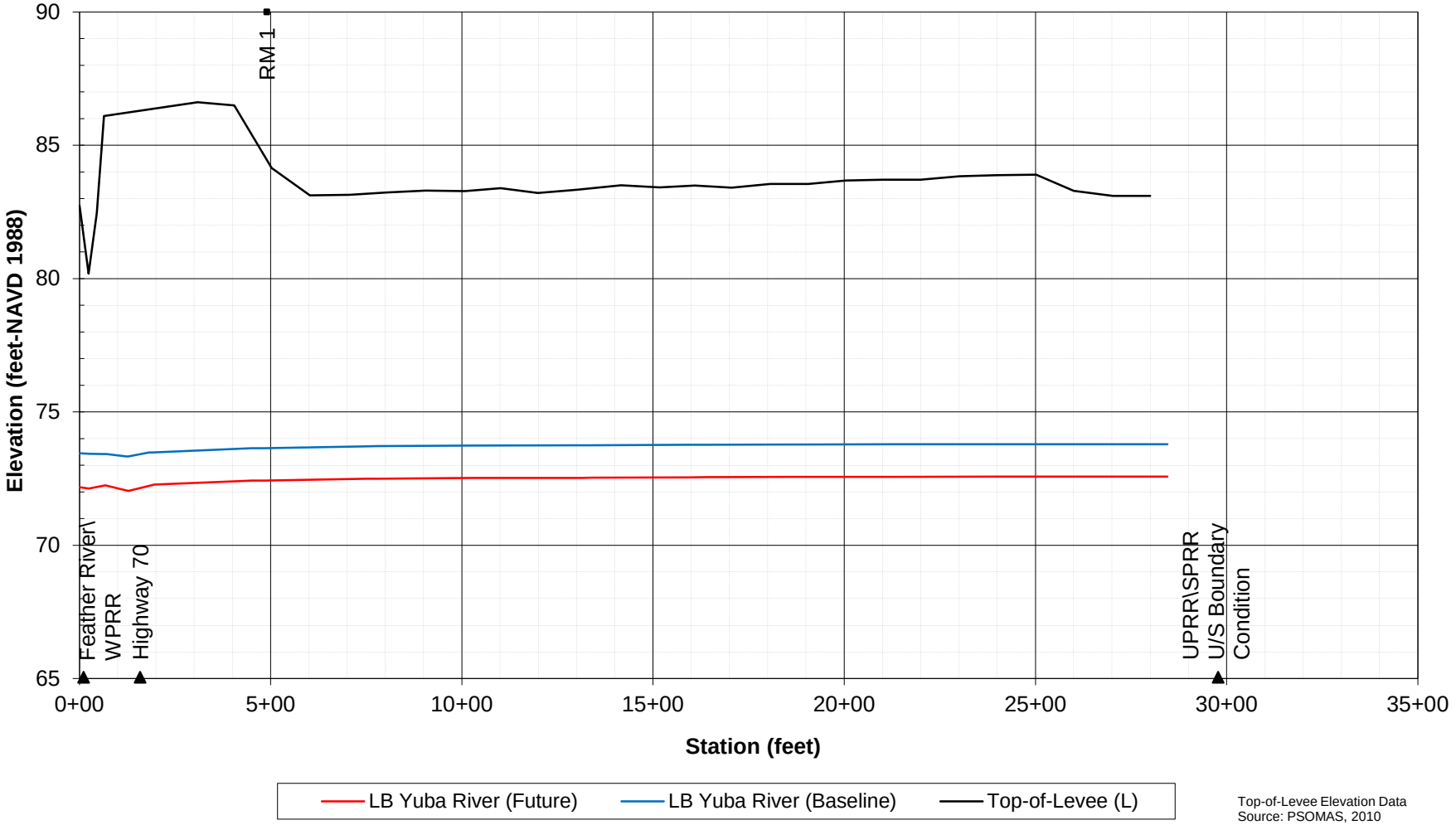
Figure 35
Feather River - Right Bank (RM 7.8 to 28.7)
Maximum Water Surface Profile (2-D Model)-1957 SRFCP Design Flow
Lower Feather Centering



Top-of-Levee Elevation Data
Source: DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\1957Q_Run2_Max_WS_Profile_NAVD

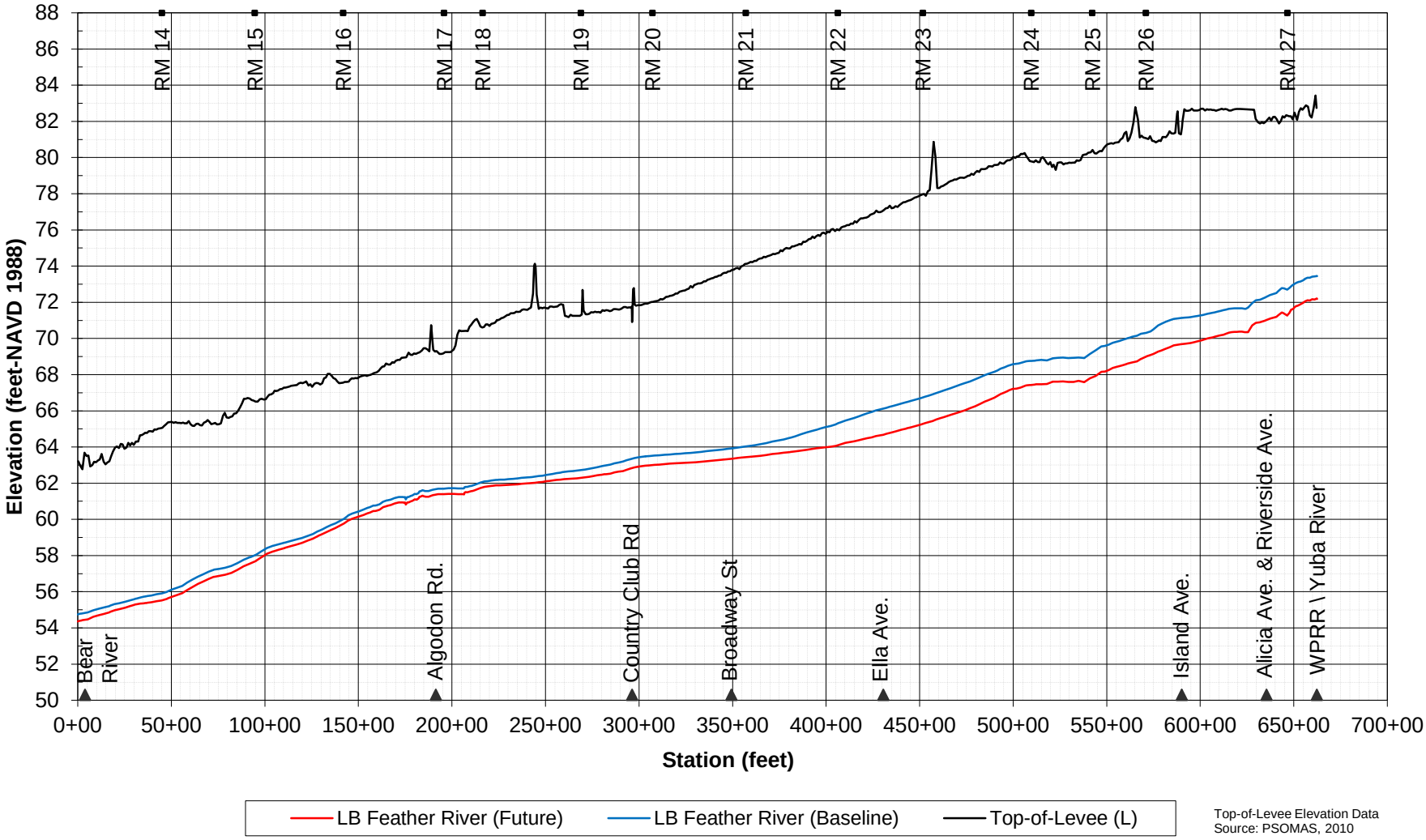
Figure 36
Yuba River - Left Bank (RM 0.3 to 1.2)
Maximum Water Surface Profile (2-D Model)-1957 SRFCP Design Flow
Lower Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\1957Q_Run2_Max_WS_Profile_NAVD

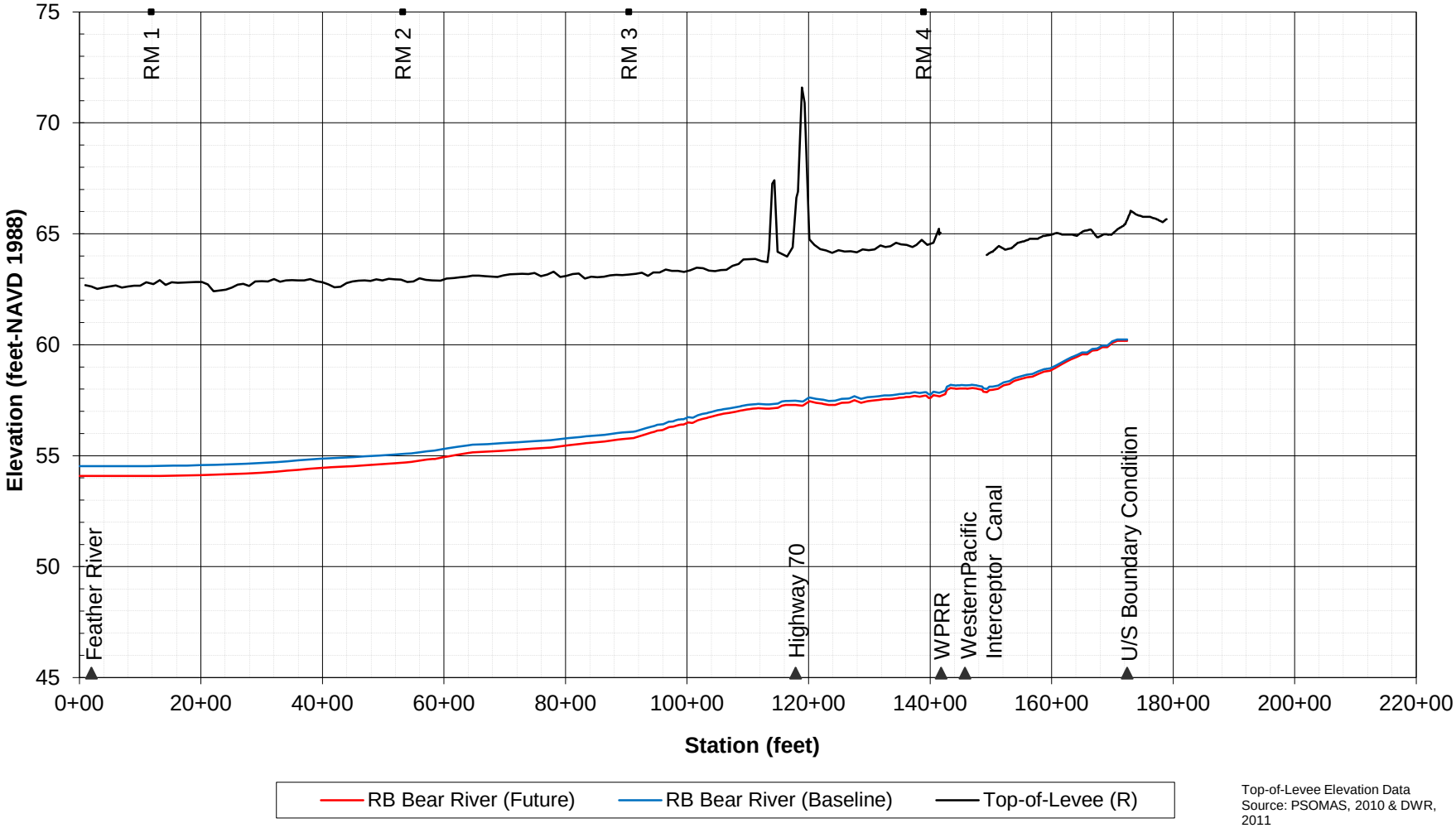
Figure 37
Feather River - Left Bank (RM 13.2 to 27.2)
Maximum Water Surface Profile (2-D Model)-1957 SRFCP Design Flow
Lower Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\1957Q_Run2_Max_WS_Profile_NAVD

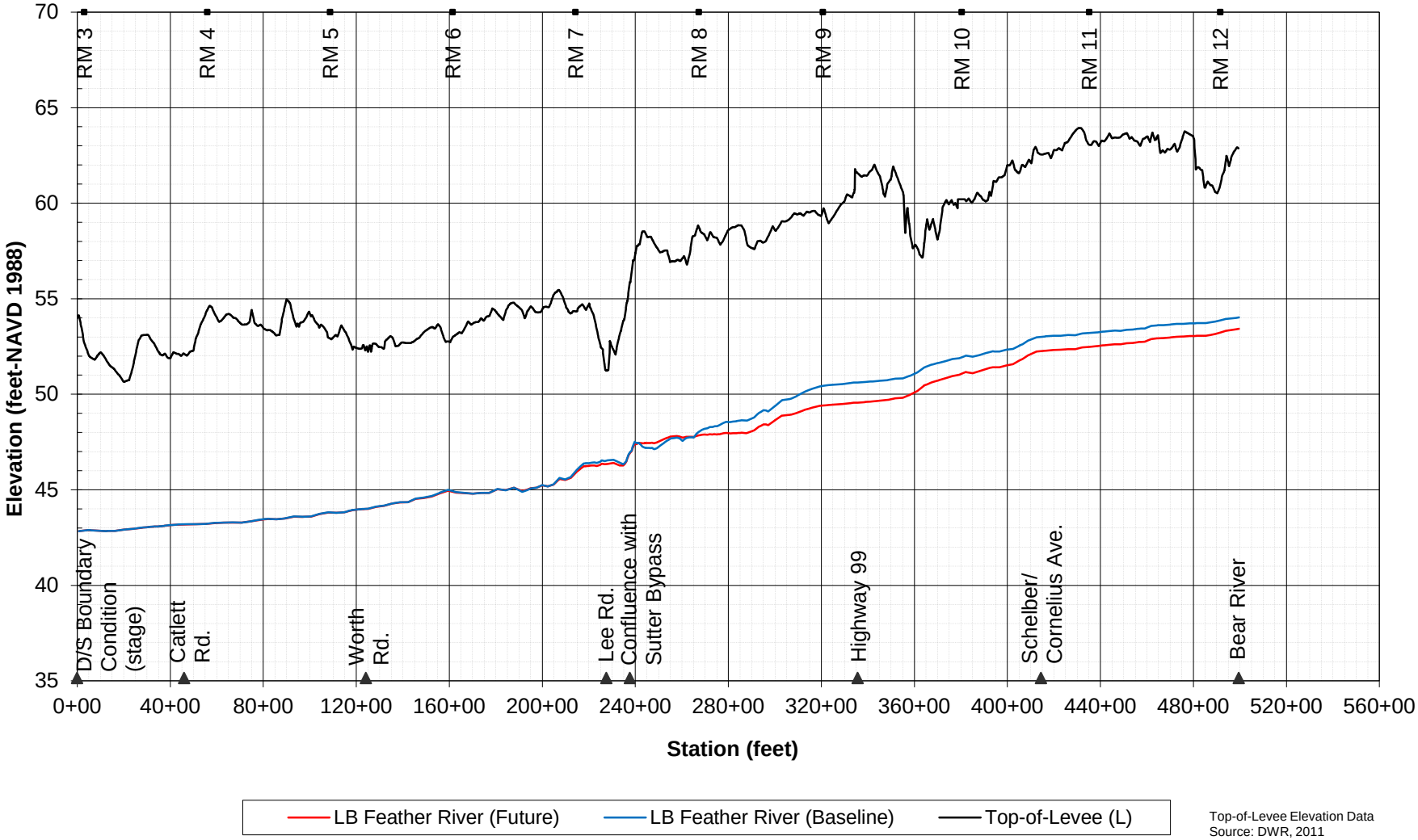
Figure 38
Bear River - Right Bank (RM 0.3 to 4.75)
Maximum Water Surface Profile (2-D Model)-1957 SRFCP Design Flow
Lower Feather Centering



Top-of-Levee Elevation Data
Source: PSOMAS, 2010 & DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\1957Q_Run2_Max_WS_Profile_NAVD

Figure 39
Feather River - Left Bank (RM 2.9 to 12.2)
Maximum Water Surface Profile (2-D Model)-1957 SRFCP Design Flow
Lower Feather Centering



Top-of-Levee Elevation Data
Source: DWR, 2011

R:\1403 AECOM-LFRCMP\SMS\Project Conditions\1957Q_Run2_Max_WS_Profile_NAVD

N

YUBA RIVER

FEATHER RIVER

RM 27

RM 26

RM 25

HWY 70

Riverside Dr

Island Ave

Match Line
(See Figure 41)

Legend

Velocity (fps)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- >11

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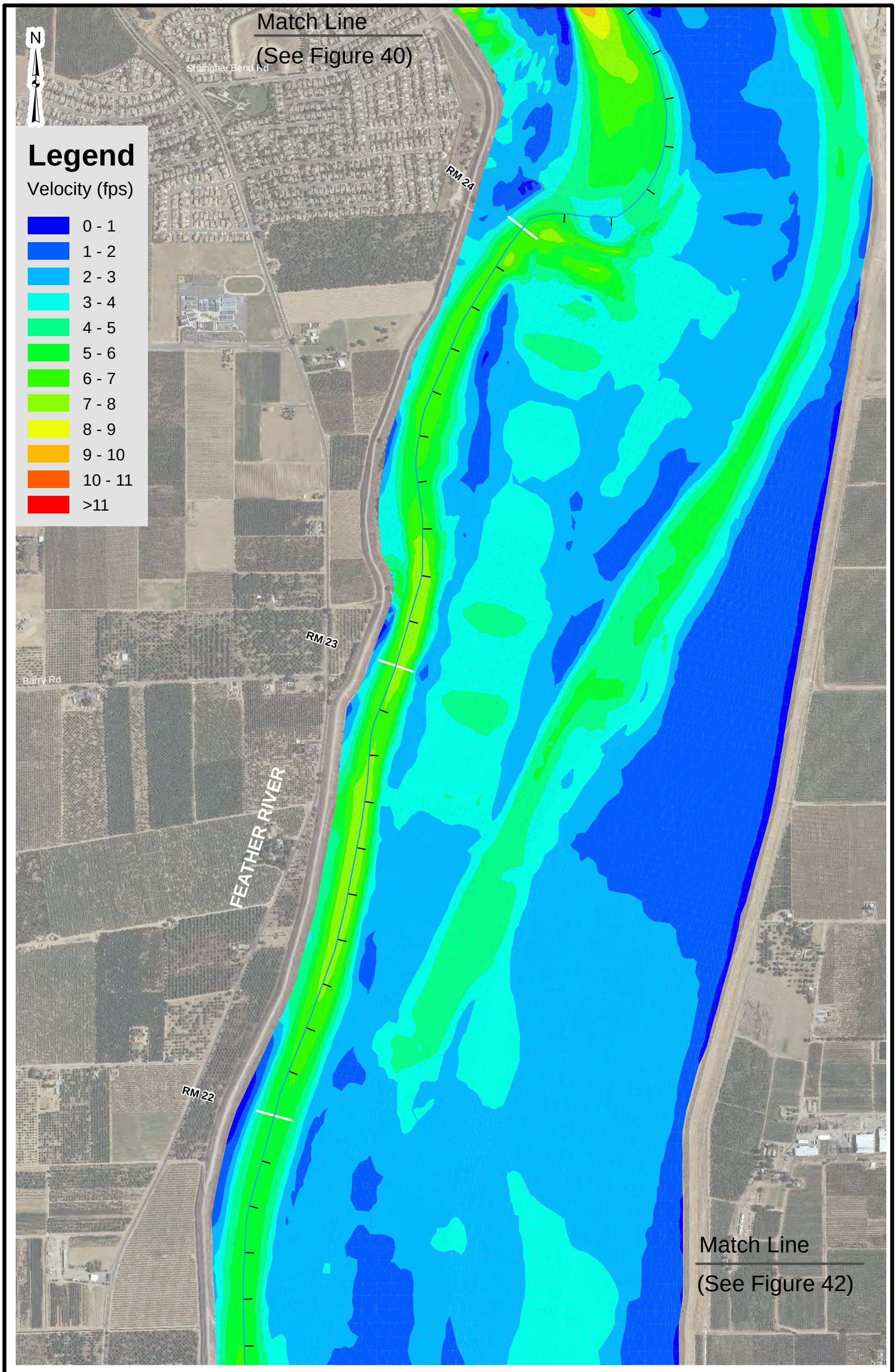
State Cut, Eliza Bend: 1-in-100 AEP
Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 40



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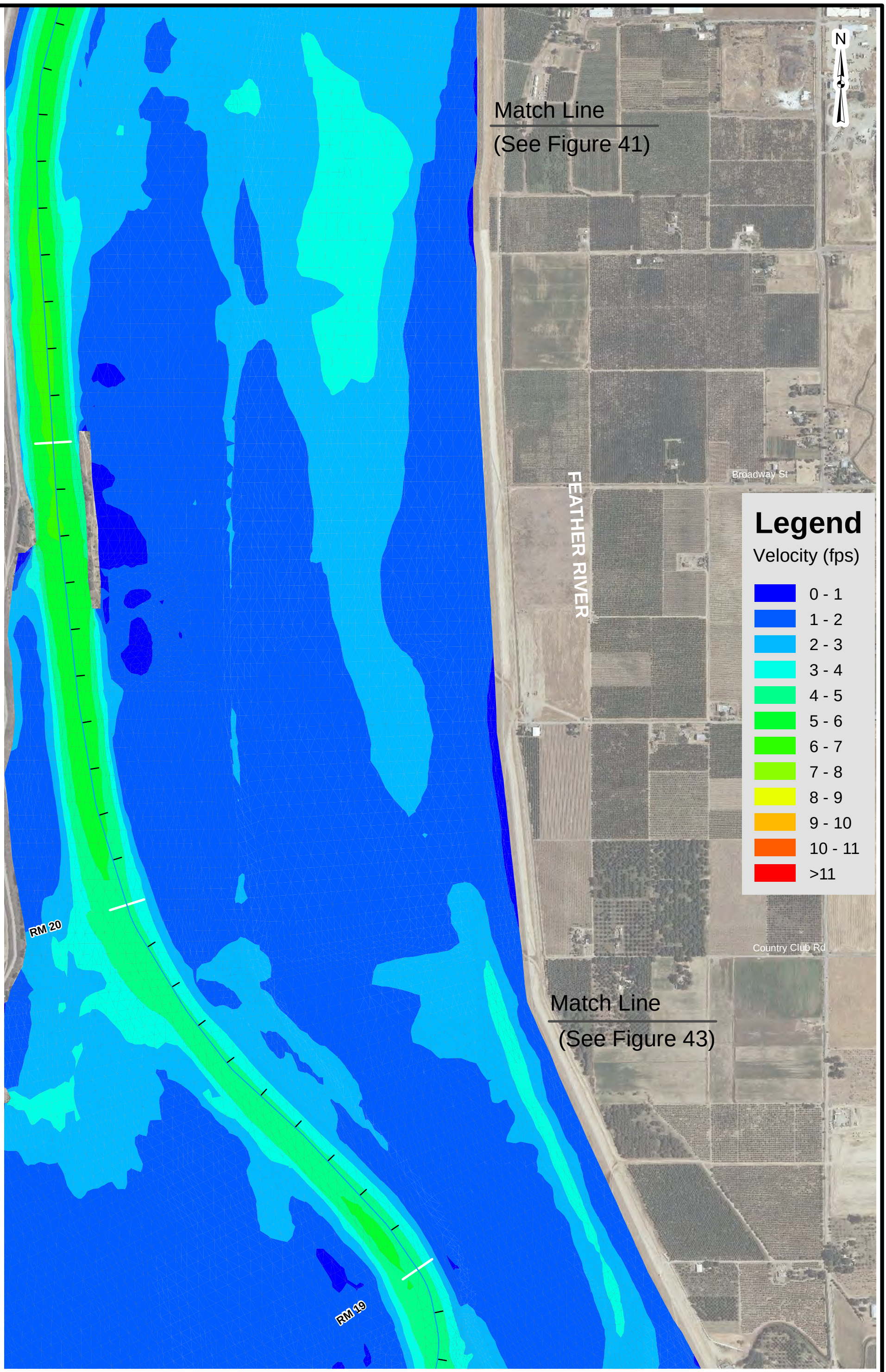
(916) 456-4400

State Cut,Feather River Setback Area: 1-in-100 AEP Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 41



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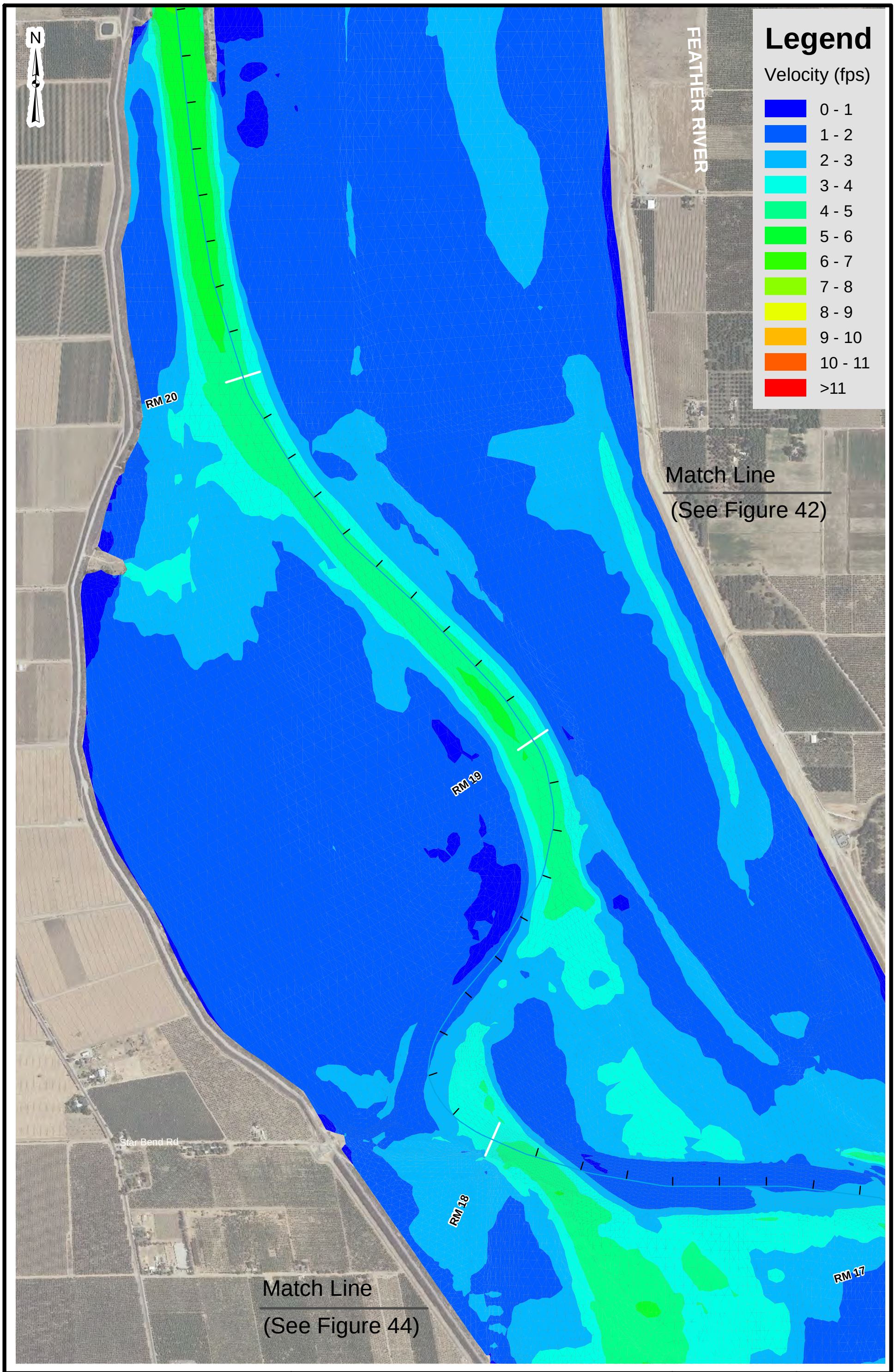
(916) 456-4400

Feather River (FR) Setback Area: 1-in-100 AEP
Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 42



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Abbott Lake: 1-in-100 AEP
Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 43

RM 19

RM 18

RM 17

RM 16

FEATHER RIVER

N

Match Line
(See Figure 43)

Match Line
(See Figure 45)

Legend

Velocity (fps)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- >11

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Star Bend, O' Connor Lake: 1-in-100 AEP
Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 44

N

Match Line
(See Figure 44)

RM 15

RM 14

RM 13

FEATHER RIVER

BEAR RIVER

Legend

Velocity (fps)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- >11

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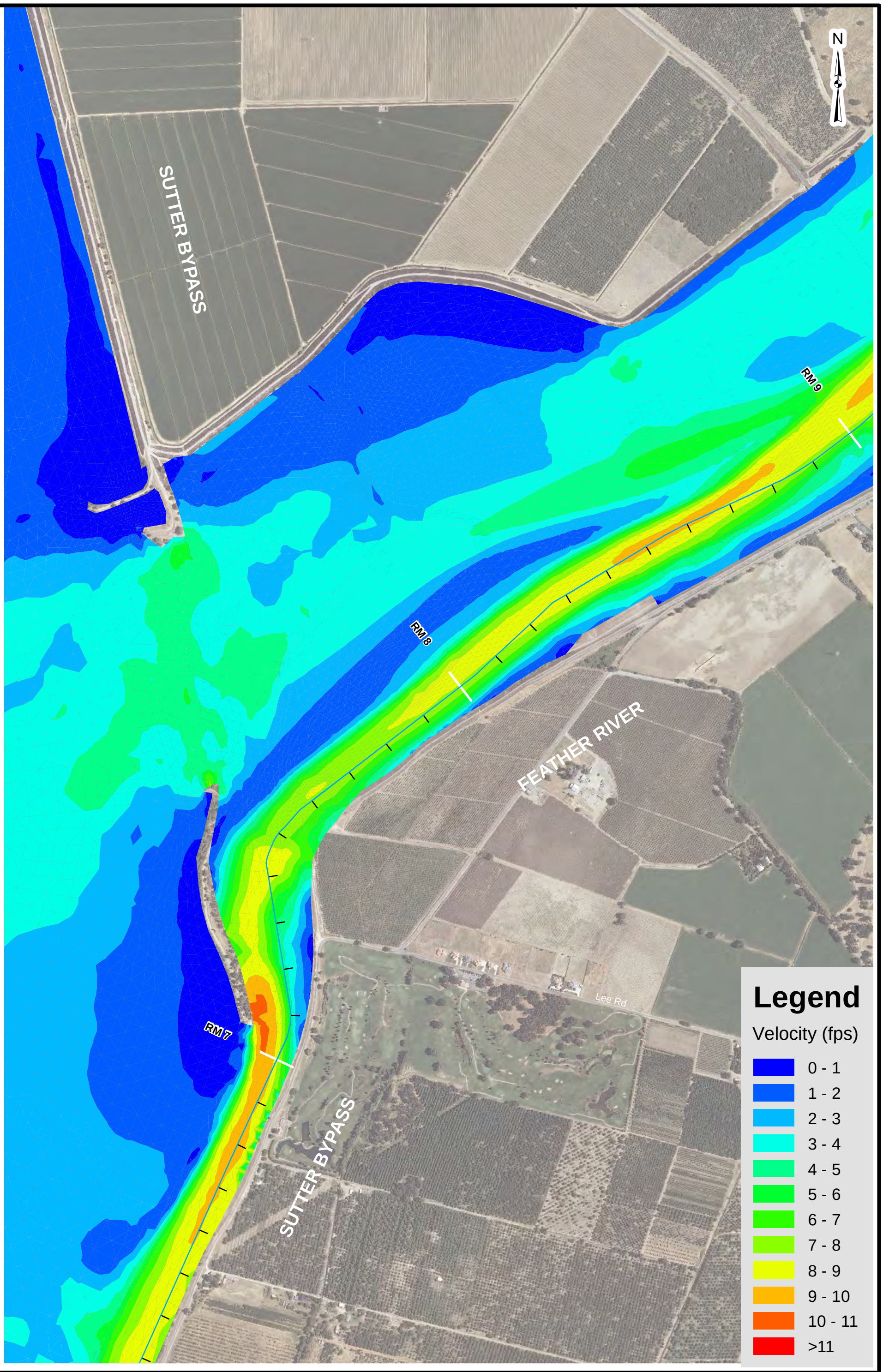
Lake of the Woods: 1-in-100 AEP
Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 45



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Nelson Slough: 1-in-100 AEP
Velocity Contours (Lower Feather Centering)

0 1,000
Scale in Feet

Figure 46

N

YUBA RIVER

FEATHER RIVER

RM 27

RM 26

RM 25

HWY 70

Riverside Dr

Island Ave

Match Line

(See Figure 48)

Legend

Velocity (fps)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- >11

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State Cut, Eliza Bend: 1-in-200 AEP
Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 47

Match Line
(See Figure 47)

N

Shanghai Bend Rd

RM 24

RM 23

Barry Rd

FEATHER RIVER

RM 22

Match Line
(See Figure 49)

Legend

Velocity (fps)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- >11

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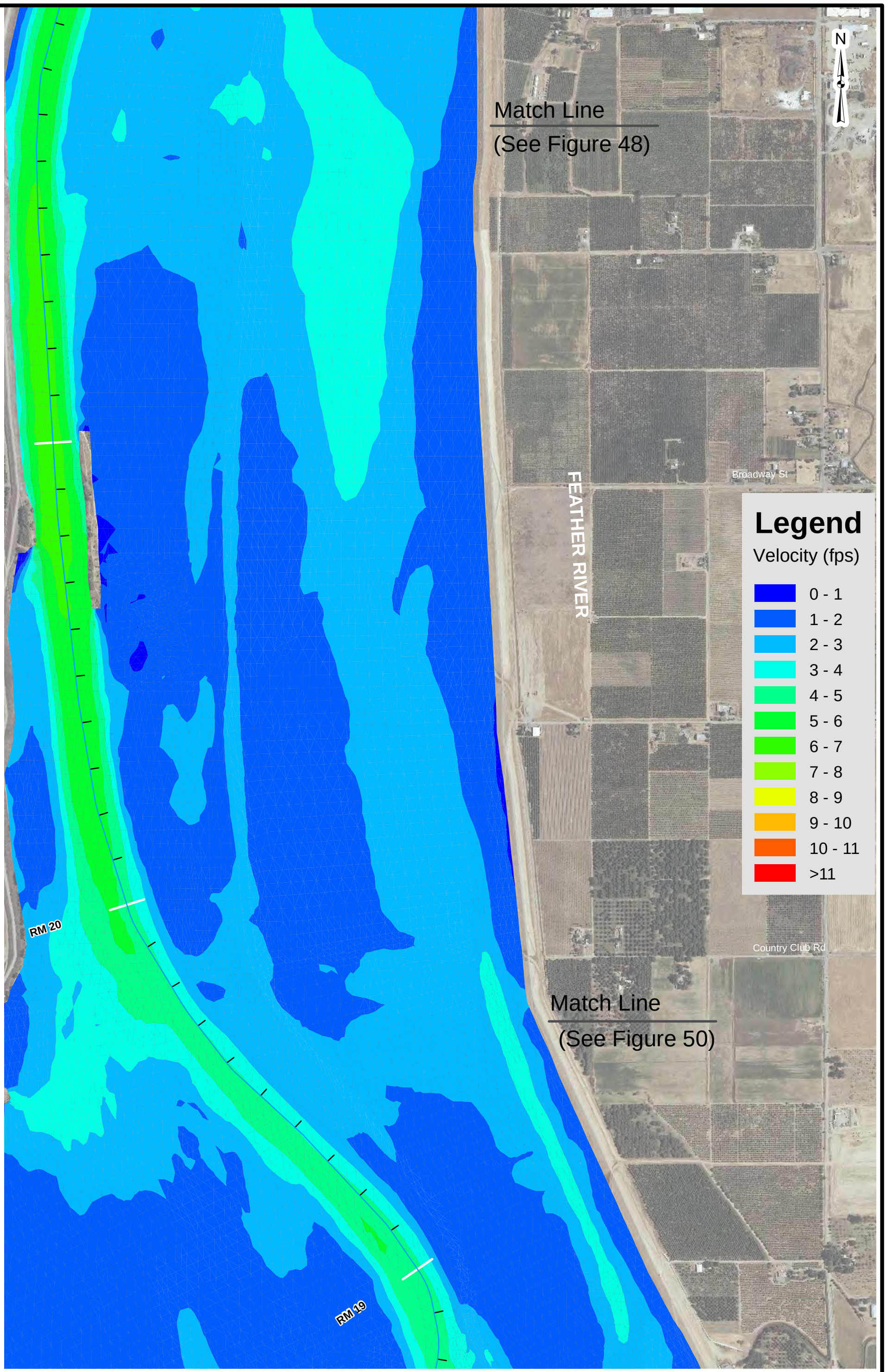
State Cut,Feather River Setback Area: 1-in-200 AEP Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 48



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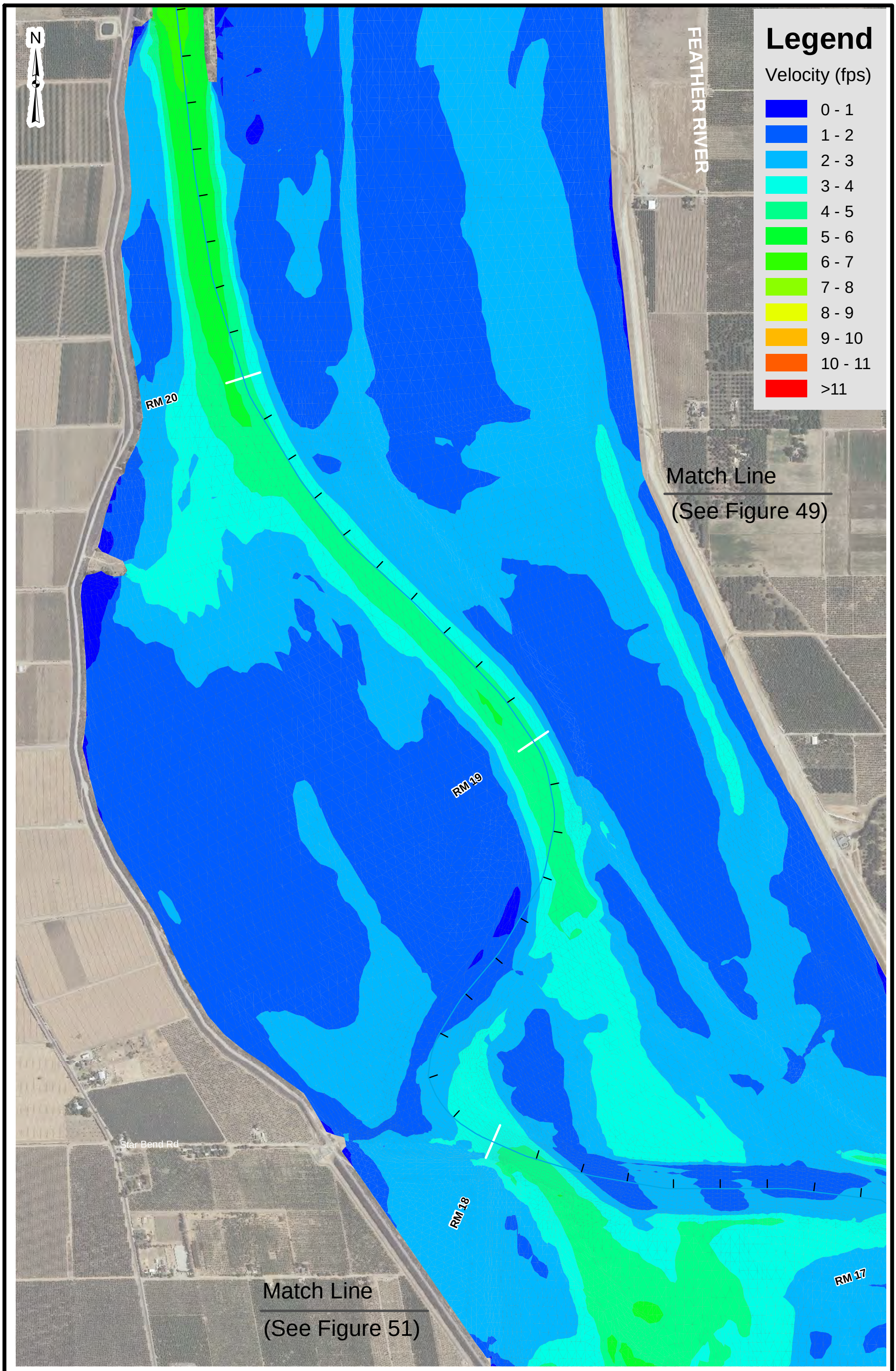
Feather River Setback Area: 1-in-200 AEP
Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 49



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Abbott Lake: 1-in-200 AEP
Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 50

RM 19

RM 18

RM 17

RM 16

FEATHER RIVER

N

Match Line
(See Figure 50)

Match Line
(See Figure 52)

Legend

Velocity (fps)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- >11

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Star Bend, O' Connor Lake: 1-in-200 AEP
Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 51

N

Match Line
(See Figure 51)

RM 15

RM 14

RM 13

FEATHER RIVER

BEAR RIVER

Legend

Velocity (fps)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- >11

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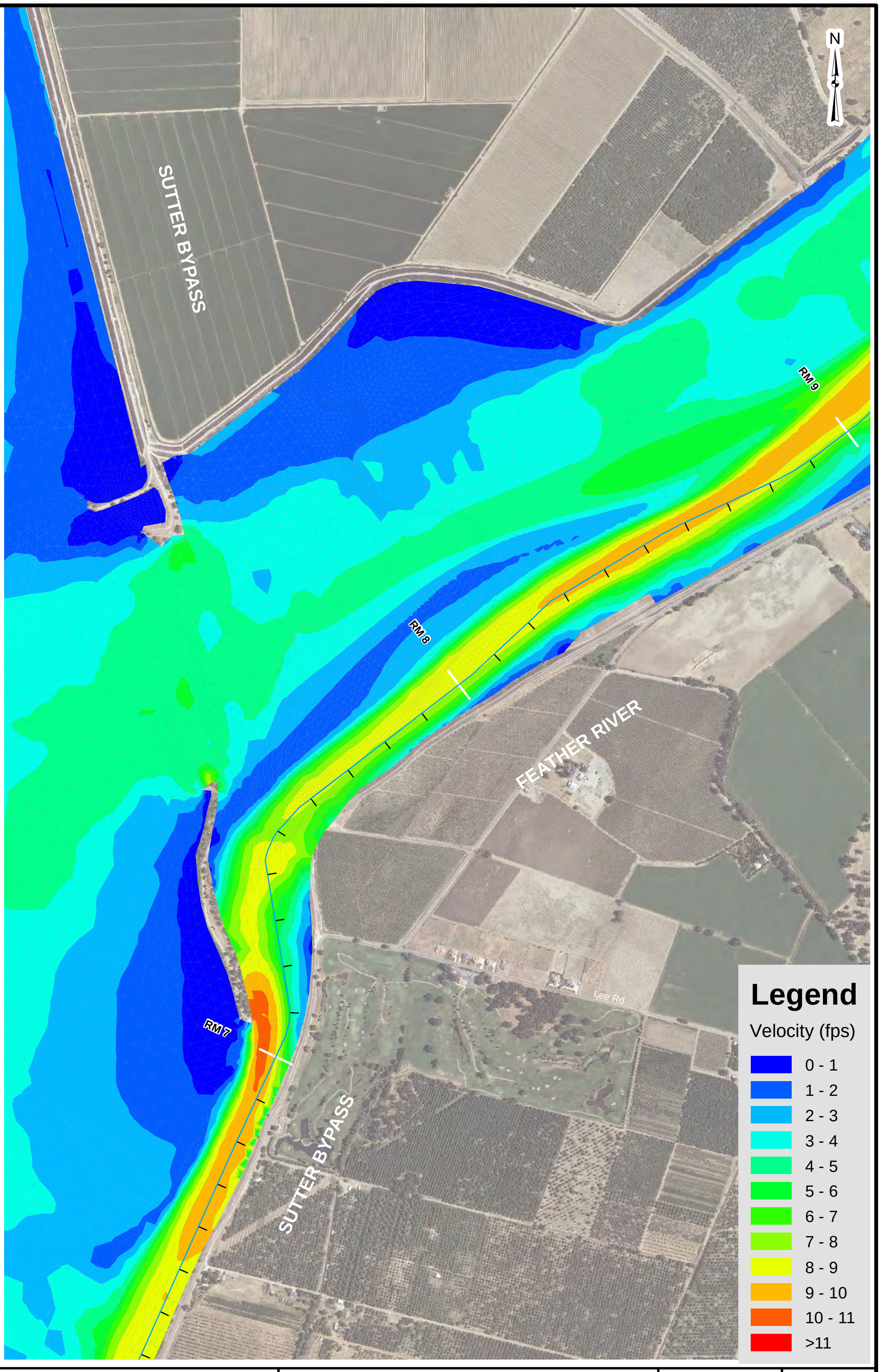
Lake of the Woods: 1-in-200 AEP
Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 52



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Nelson Slough: 1-in-200 AEP
Velocity Contours (Lower Feather Centering)

0 1,000
Scale in Feet

Figure 53

N

YUBA RIVER

FEATHER RIVER

RM 27

RM 26

RM 25

HWY 70

Riverside Dr

Island Ave

Match Line

(See Figure 55)

Legend

Velocity (fps)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- >11

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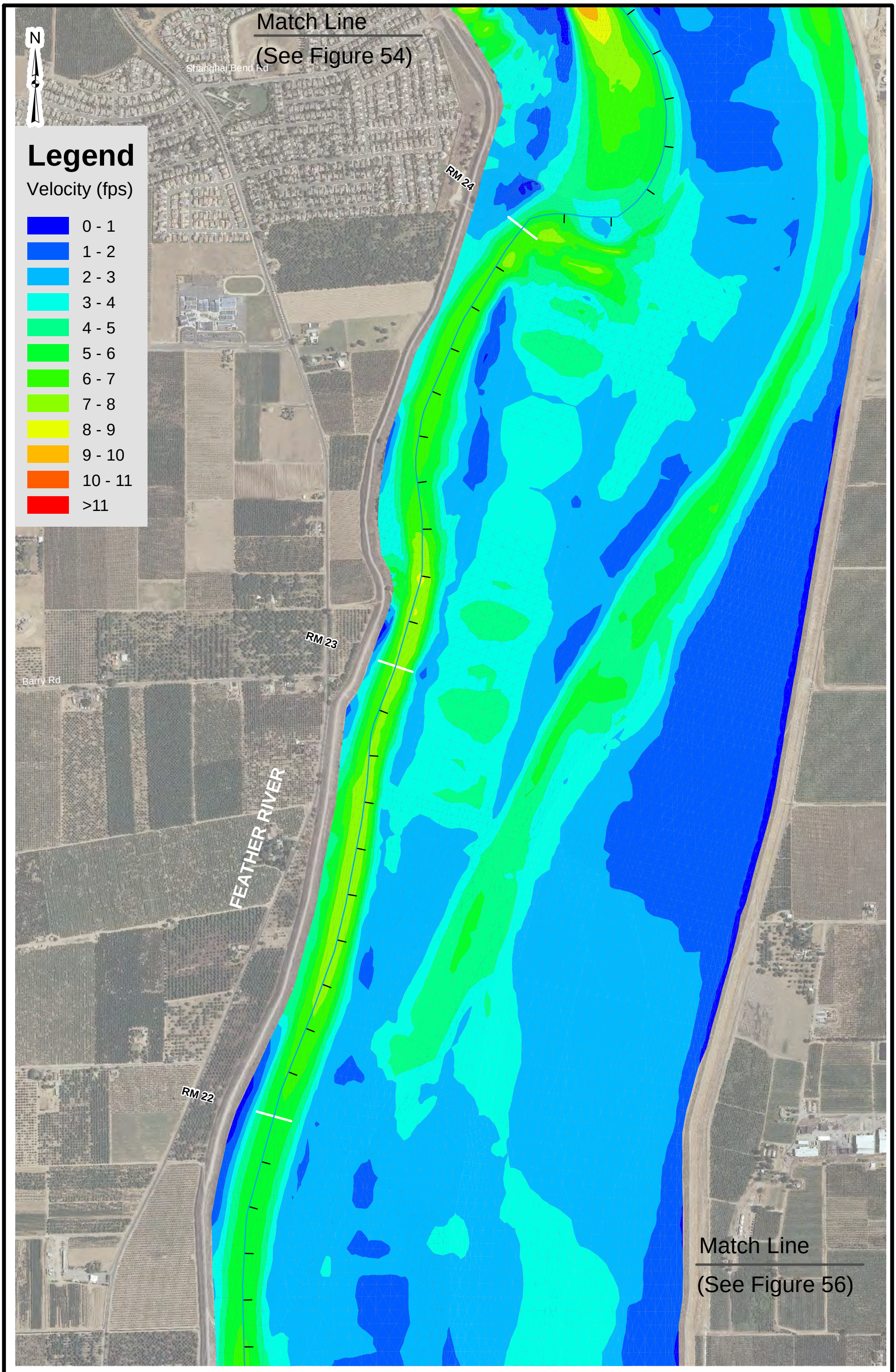
State Cut, Eliza Bend: 1957 SRFCP Design Flow Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 54



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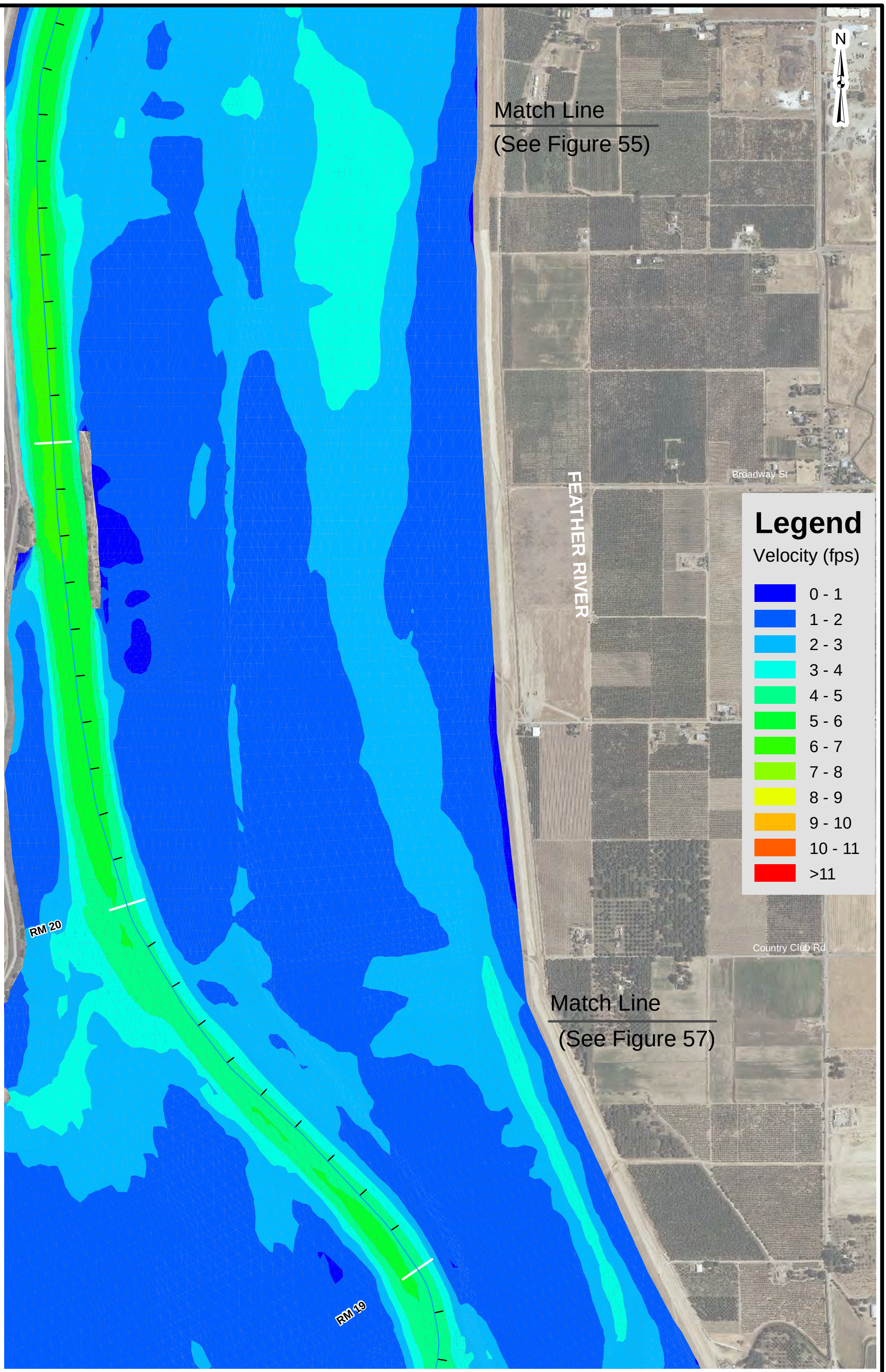
State Cut,FR Setback Area: 1957 Design Flow Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 55



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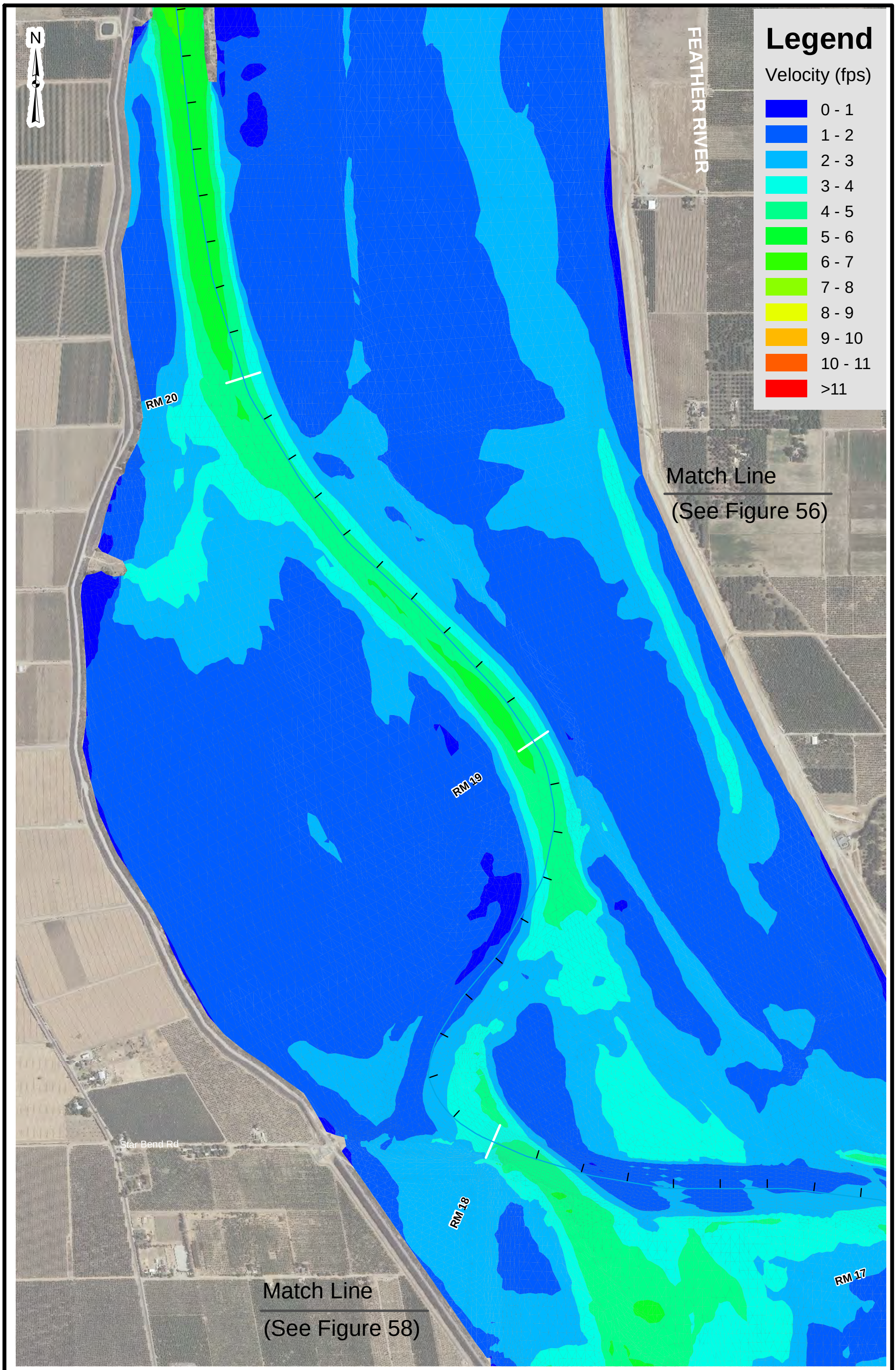
Feather River Setback Area: 1957 SRFCP Design Flow Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 56



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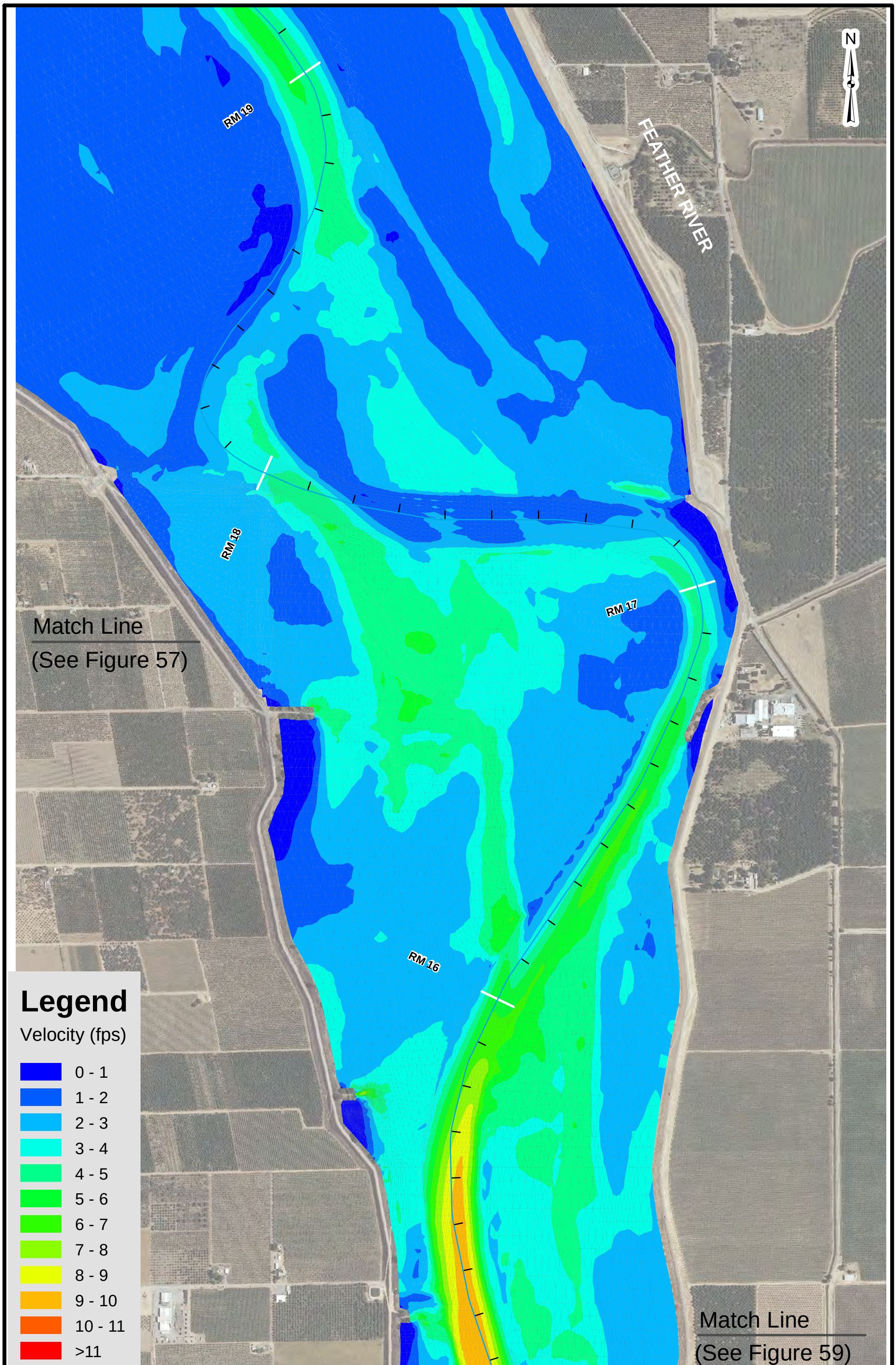
Abbott Lake: 1957 SRFCP Design Flow
Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 57



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Star Bend, O' Connor Lake: 1957 SRFCP Design Flow Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 58

N

Match Line
(See Figure 58)

RM 15

RM 14

RM 13

FEATHER RIVER

BEAR RIVER

Legend

Velocity (fps)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- >11

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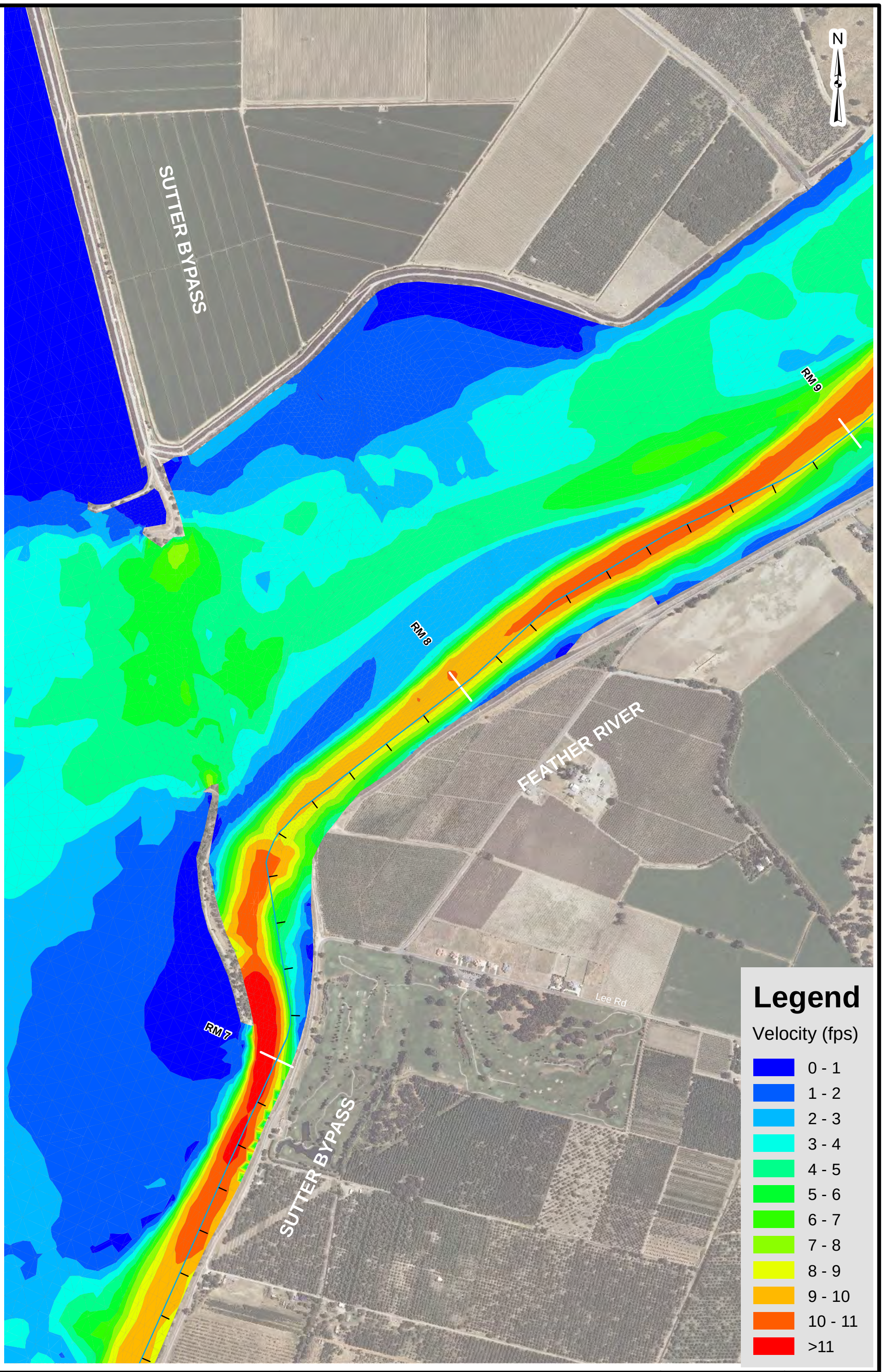
Lake of the Woods: 1957 SRFCP Design Flow Velocity Contours (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 59



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Nelson Slough: 1957 SRFCP Design Flow Velocity Contours (Lower Feather Centering)

0 1,000
Scale in Feet

Figure 60

N

YUBA RIVER

FEATHER RIVER

RM 27

RM 26

RM 25

HWY 70

Riverside Dr

Island Ave

Match Line

(See Figure 62)

Legend

Velocity (fps)
Differences

- Proposed Grading
- < -4
- -4 to -3
- -3 to -2
- -2 to -1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- 5 to 6
- > 6

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State Cut, Eliza Bend: 1-in-100 AEP
Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 61

Match Line
(See Figure 61)

N

Shanghai Bend Rd

Legend

Velocity (fps)
Differences

- Proposed Grading
- < -4
- -4 to -3
- -3 to -2
- -2 to -1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- 5 to 6
- > 6

RM 24

RM 23

Barry Rd

FEATHER RIVER

RM 22

Match Line
(See Figure 63)

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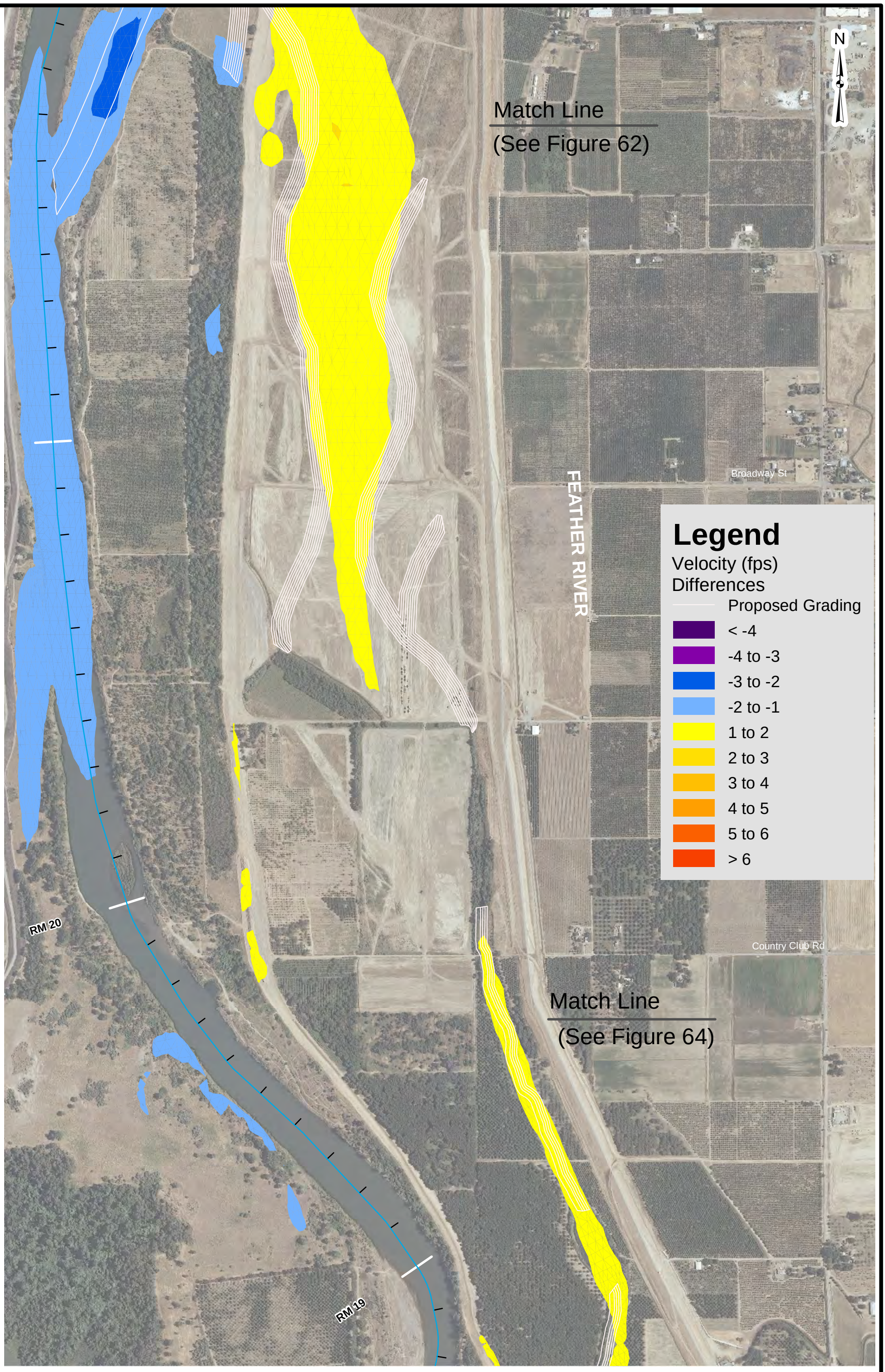
State Cut,Feather River Setback Area: 1-in-100 AEP Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 62



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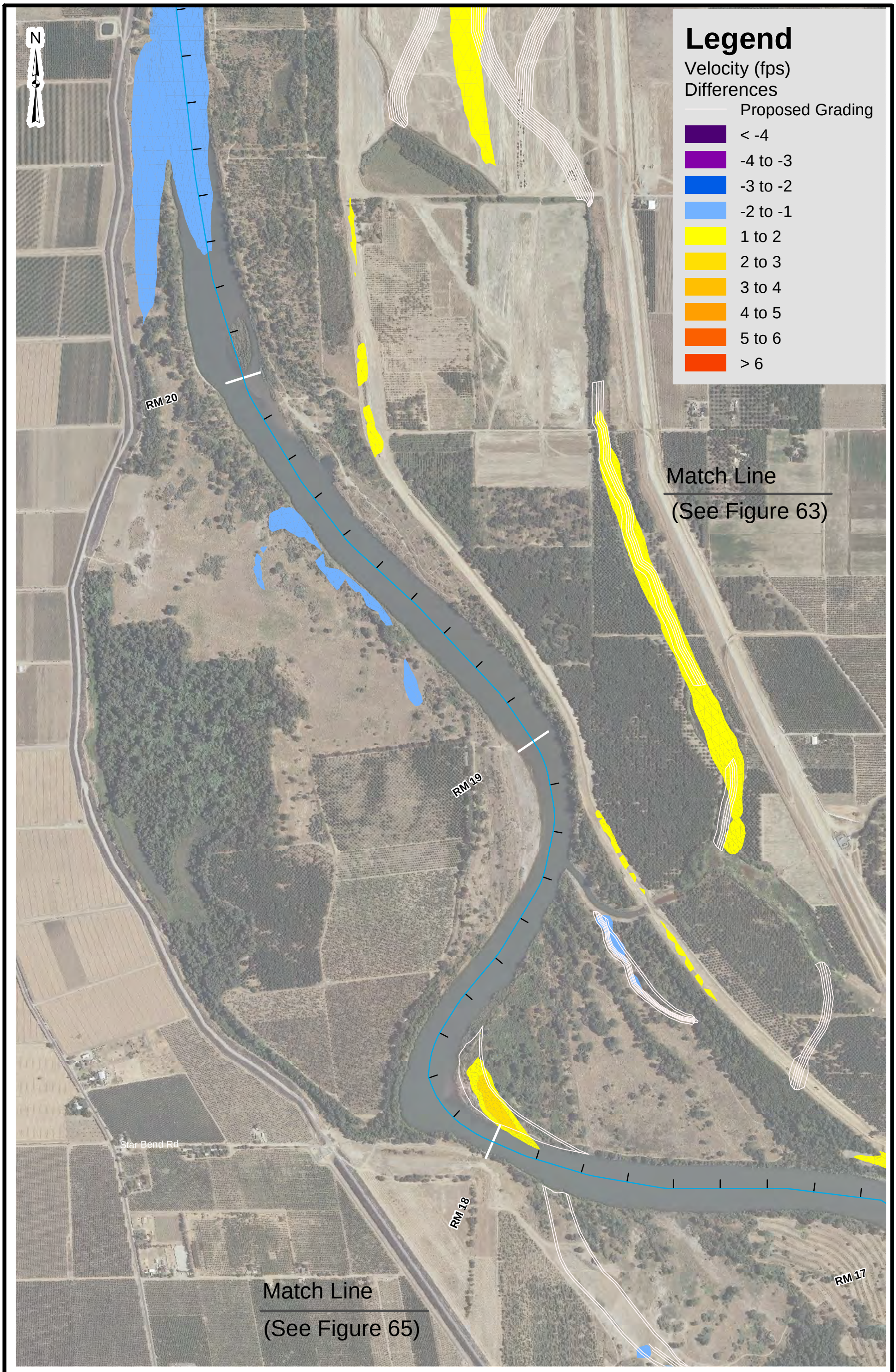
Feather River Setback Area: 1-in-100 AEP
Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 63



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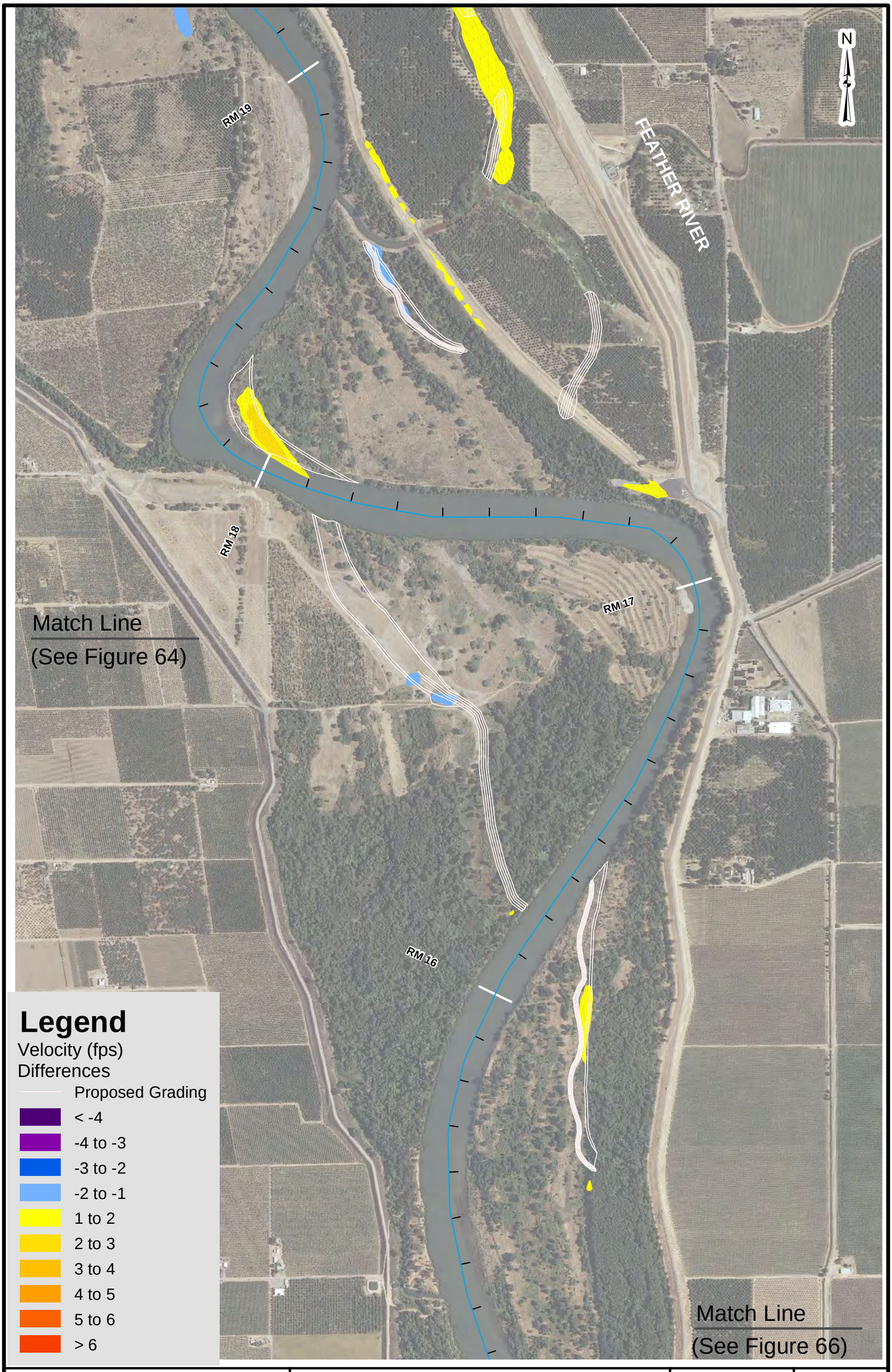
Abbott Lake: 1-in-100 AEP
Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 64



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Star Bend, O' Connor Lake: 1-in-100 AEP
Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 65

N

Match Line
(See Figure 65)

RM 15

RM 14

RM 13

FEATHER RIVER

BEAR RIVER

Legend

Velocity (fps)
Differences

- Proposed Grading
- < -4
- -4 to -3
- -3 to -2
- -2 to -1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- 5 to 6
- > 6

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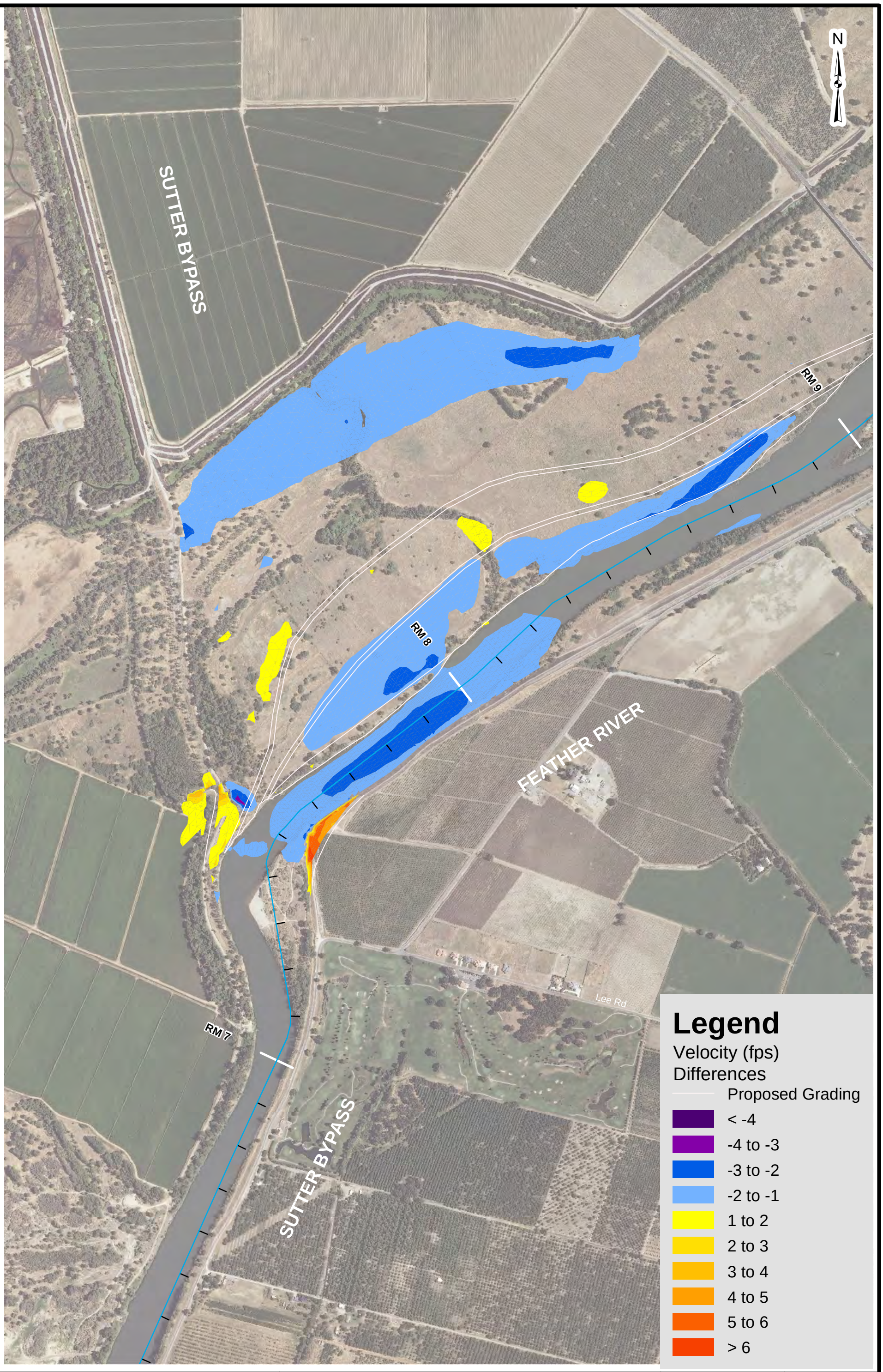
Lake of the Woods: 1-in-100 AEP
Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 66



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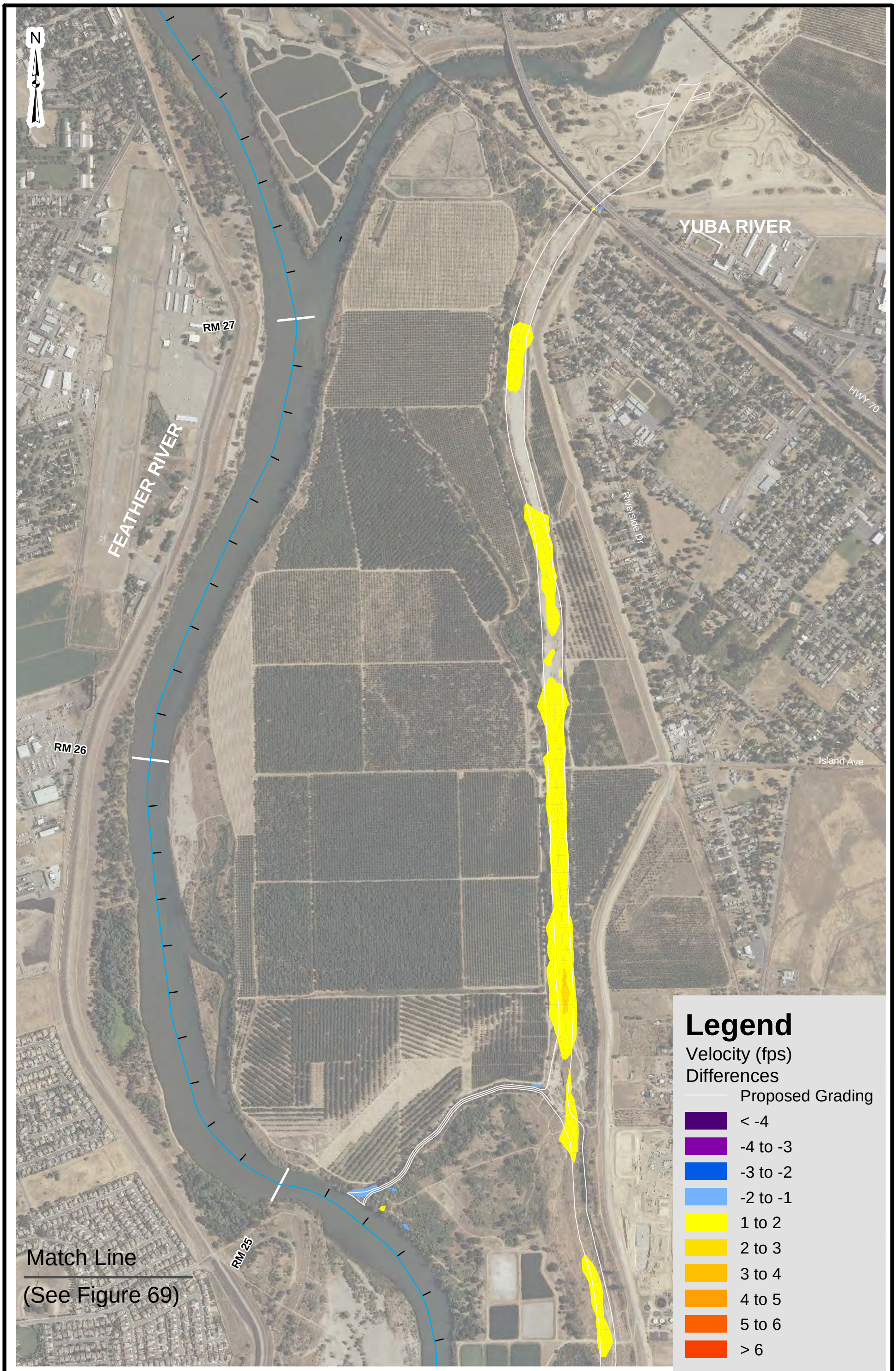
Nelson Slough: 1-in-100 AEP
Velocity Differences (Lower Feather Centering)

0 1,000
Scale in Feet

Figure 67



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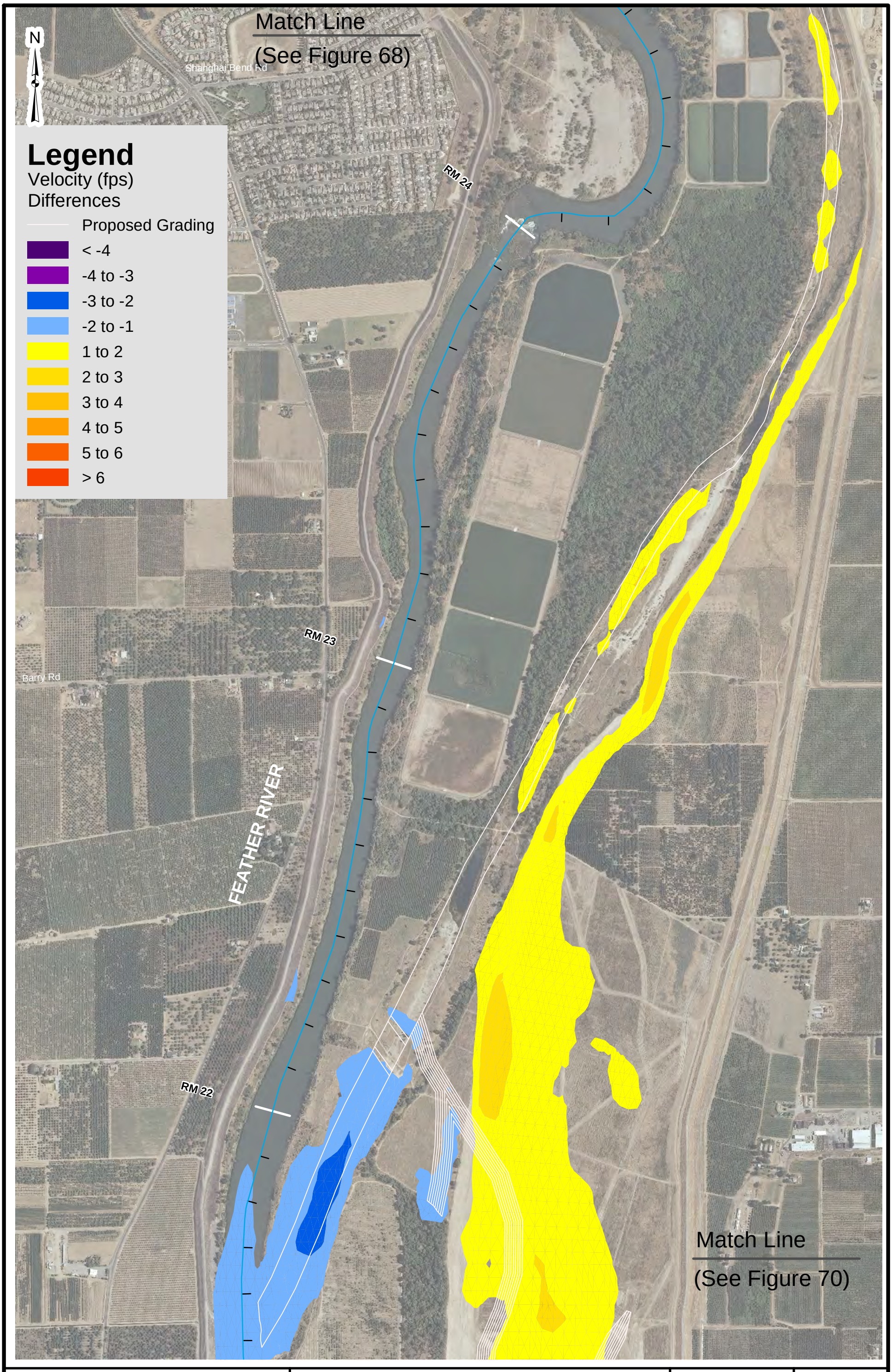
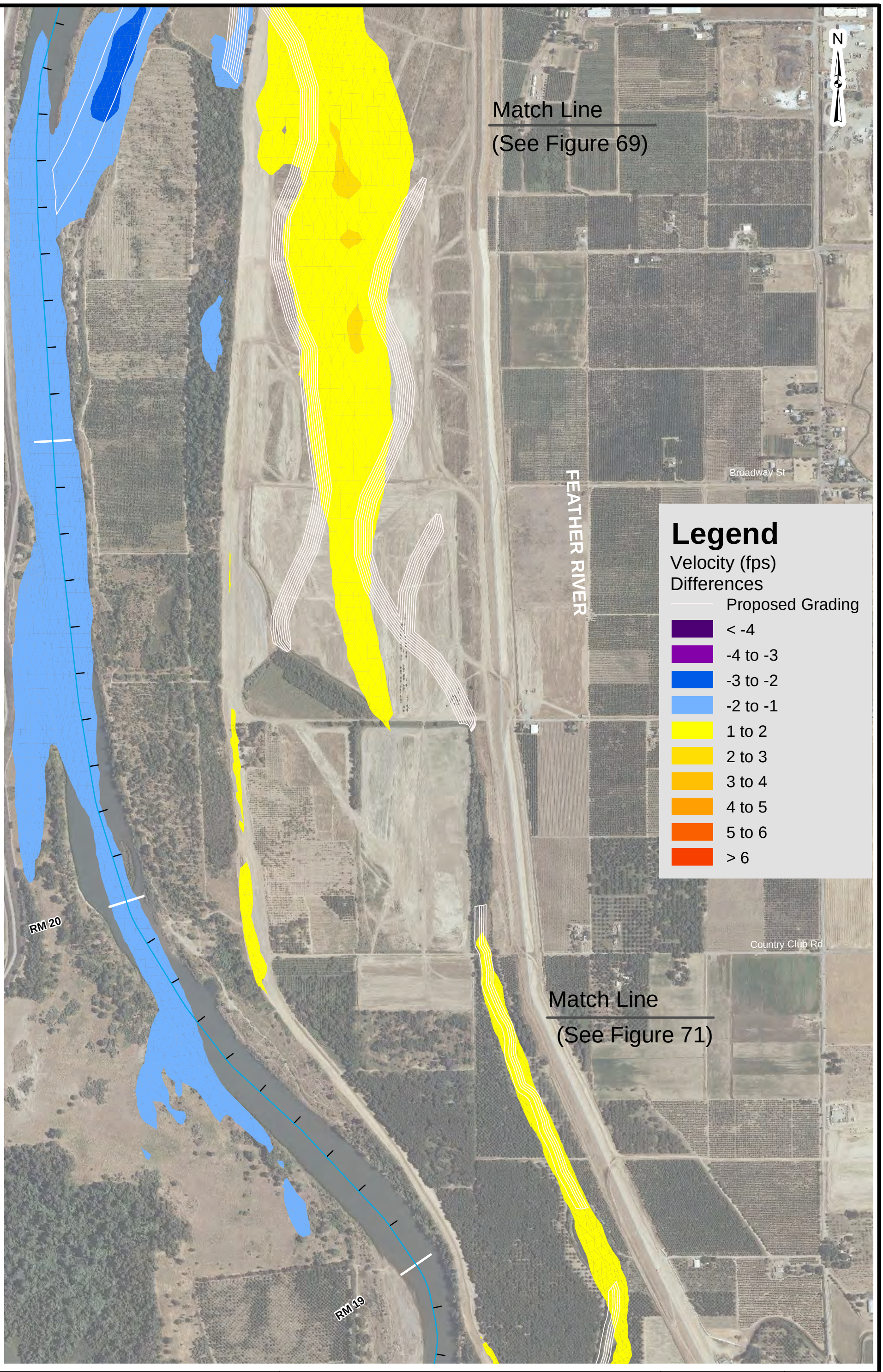
State Cut, Eliza Bend: 1-in-200 AEP
Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 68



MBK ENGINEERS 1771 Tribute Road, Suite A Sacramento, California 95815-4401 (916) 456-4400	**State Cut,Feather River Setback Area: 1-in-200 AEP Velocity Differences (Upper Feather Centering)**	0 1,000 Scale in Feet	**Figure 69**



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Feather River Setback Area: 1-in-200 AEP
Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 70

N

Legend

Velocity (fps)
Differences

Proposed Grading

- < -4
- -4 to -3
- -3 to -2
- -2 to -1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- 5 to 6
- > 6

RM 20

RM 19

RM 18

RM 17

Star Bend Rd

Match Line
(See Figure 70)

Match Line
(See Figure 72)

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Abbott Lake: 1-in-200 AEP
Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 71

RM 19

RM 18

RM 17

RM 16

FEATHER RIVER

N

Match Line
(See Figure 71)

Match Line
(See Figure 73)

Legend

Velocity (fps)
Differences

- Proposed Grading
- < -4
- -4 to -3
- -3 to -2
- -2 to -1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- 5 to 6
- > 6

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Star Bend, O' Connor Lake: 1-in-200 AEP
Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 72

N

Match Line
(See Figure 72)

RM 15

RM 14

RM 13

FEATHER RIVER

BEAR RIVER

Legend

Velocity (fps)
Differences

- Proposed Grading
- < -4
- -4 to -3
- -3 to -2
- -2 to -1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- 5 to 6
- > 6

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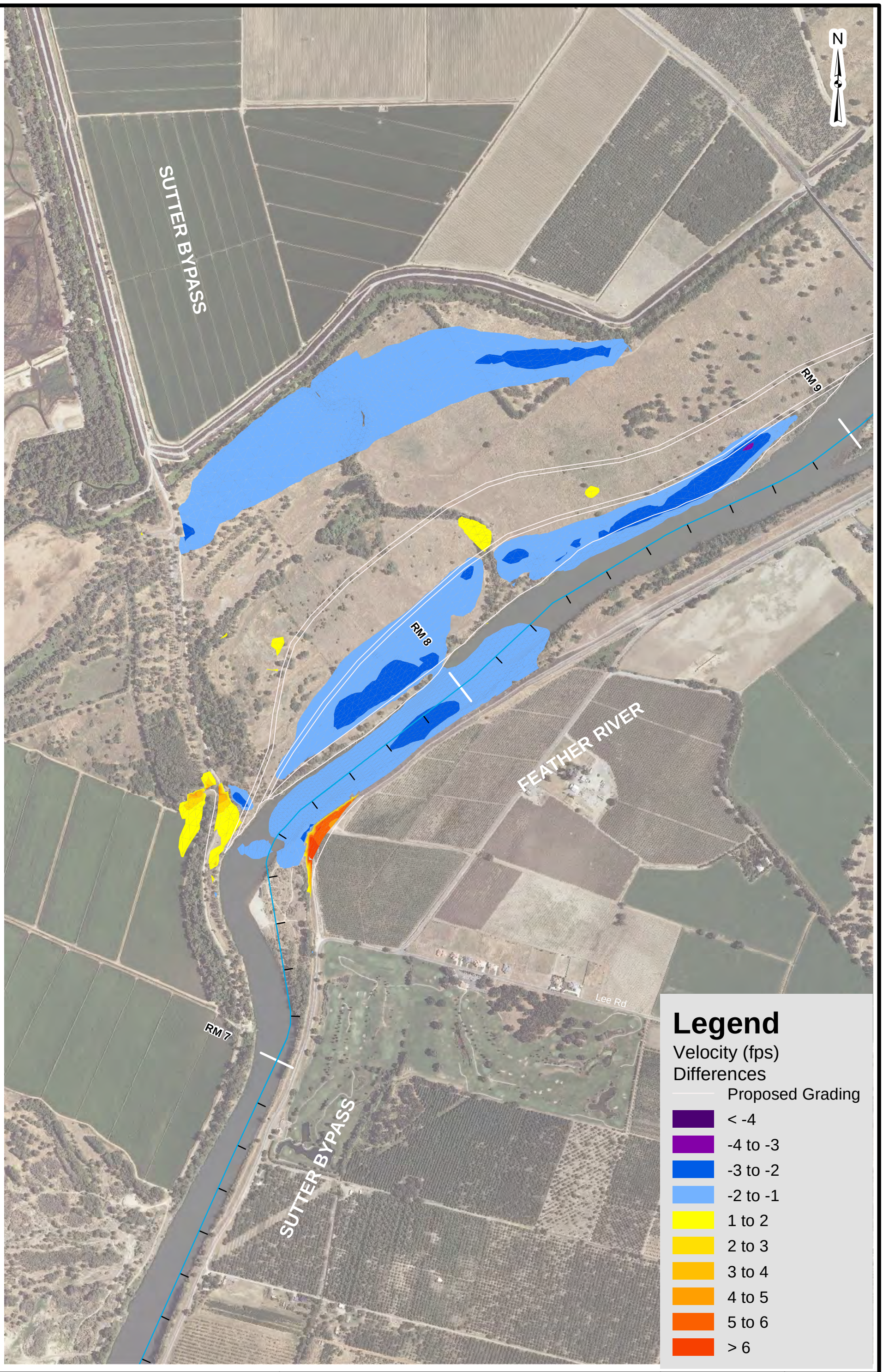
Lake of the Woods: 1-in-200 AEP
Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 73



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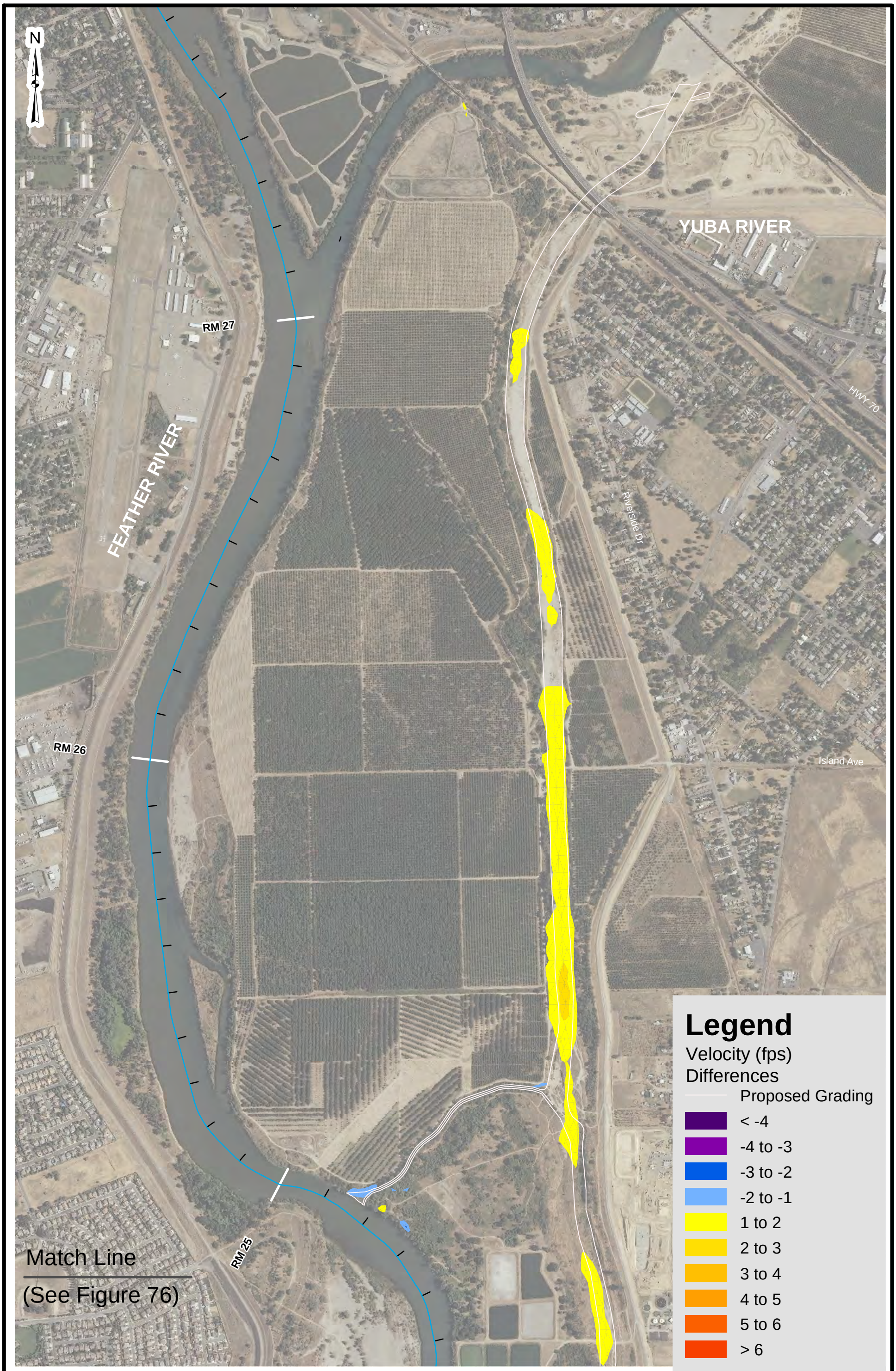
Nelson Slough: 1-in-200 AEP
Velocity Differences (Lower Feather Centering)

0 1,000
Scale in Feet

Figure 74



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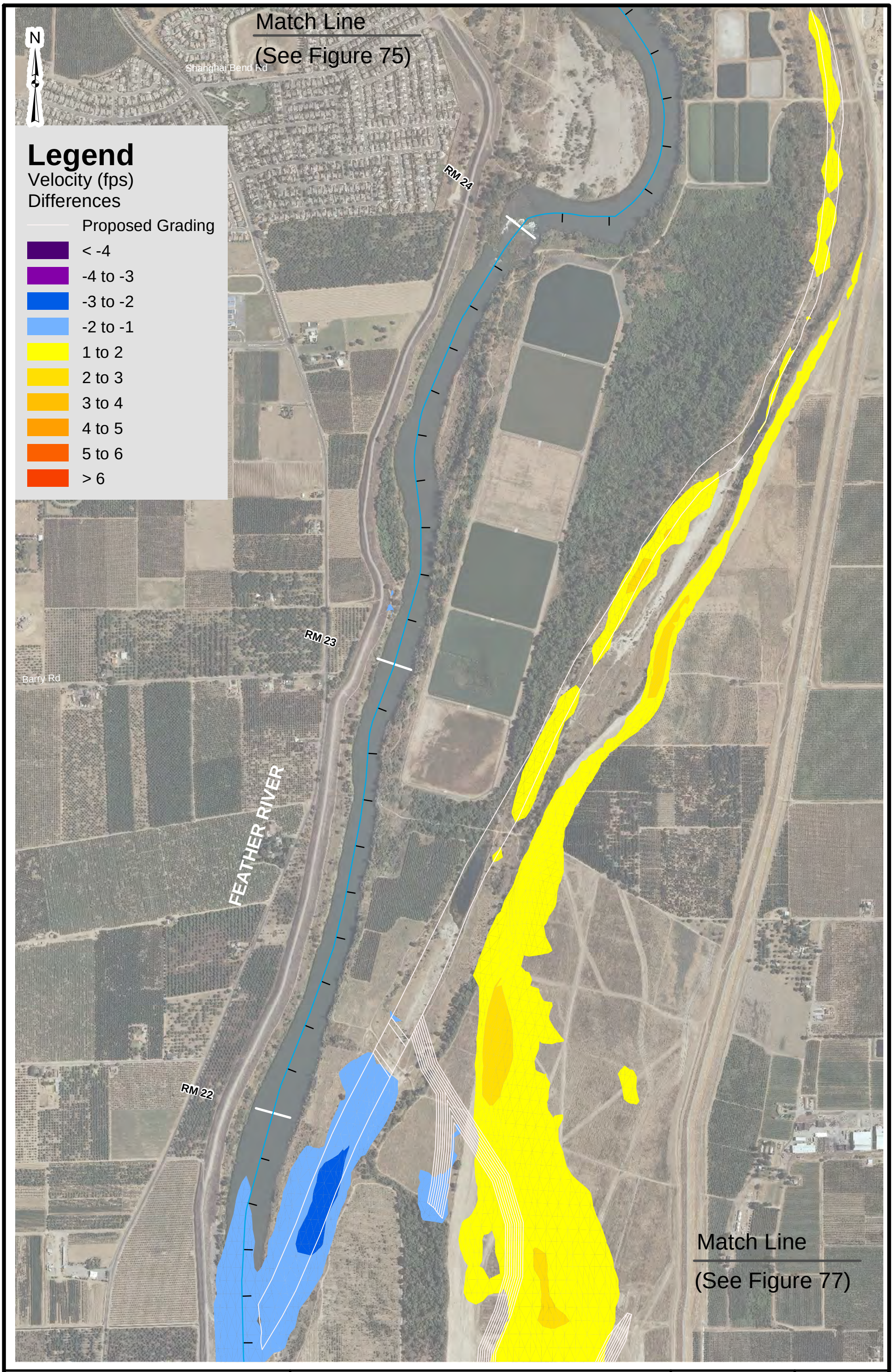
State Cut, Eliza Bend: 1957 SRFCP Design Flow Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 75



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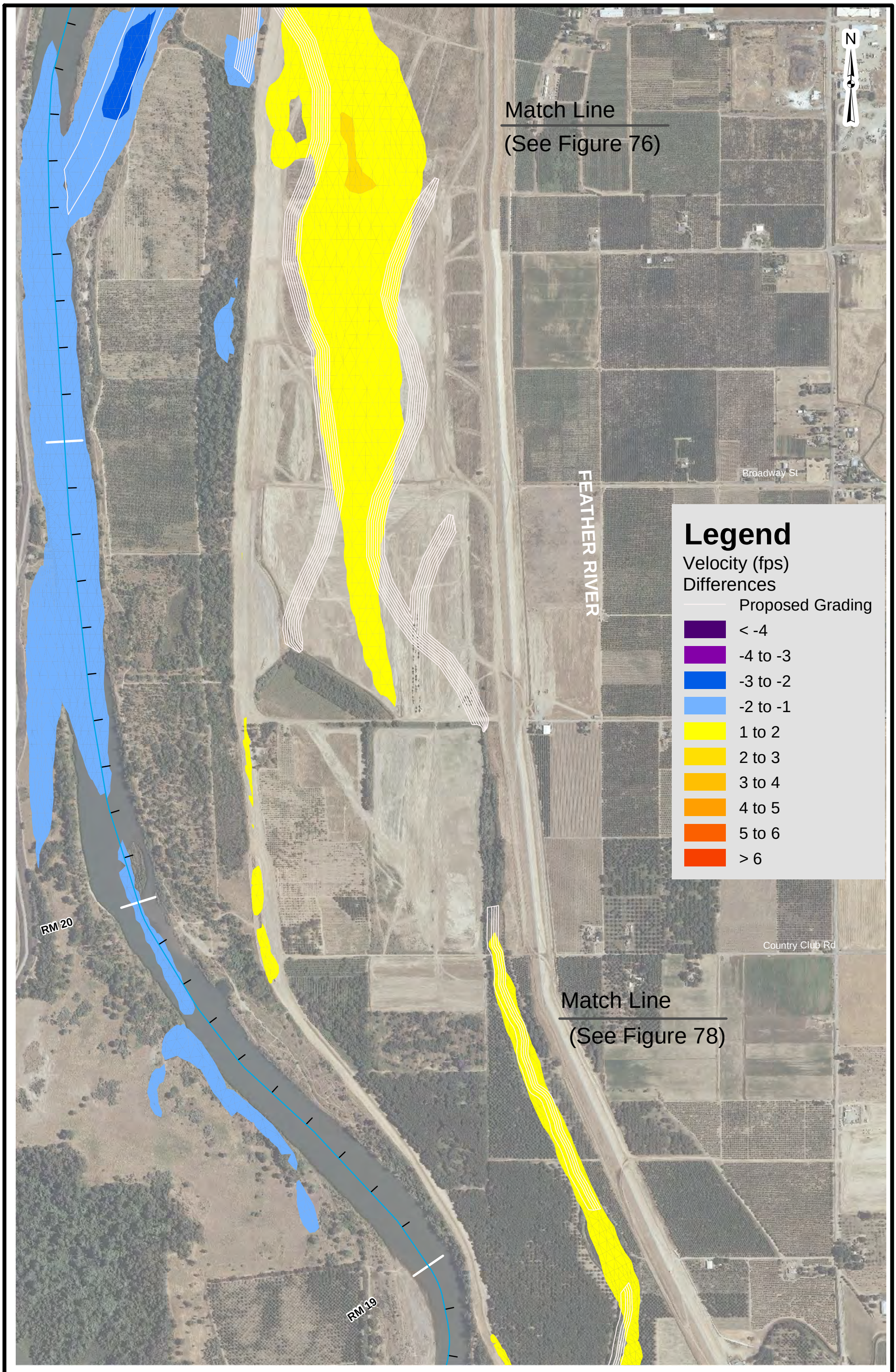
State Cut,FR Setback Area: 1957 Design Flow Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 76



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Feather River Setback Area: 1957 SRFCP Design Flow Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 77

N

RM 20

RM 19

RM 18

RM 17

Star Bend Rd

Legend

Velocity (fps)
Differences

- Proposed Grading
- < -4
- -4 to -3
- -3 to -2
- -2 to -1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- 5 to 6
- > 6

Match Line
(See Figure 77)

Match Line
(See Figure 79)

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Abbott Lake: 1957 SRFCP Design Flow
Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 78

N

RM 19

FEATHER RIVER

RM 18

RM 17

RM 16

Match Line
(See Figure 78)

Match Line
(See Figure 80)

Legend

Velocity (fps)
Differences

- Proposed Grading
- < -4
- -4 to -3
- -3 to -2
- -2 to -1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- 5 to 6
- > 6

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Star Bend, O' Connor Lake: 1957 SRFCP Design Flow Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 79

N

Match Line
(See Figure 79)

RM 15

RM 14

RM 13

FEATHER RIVER

BEAR RIVER

Legend

Velocity (fps)
Differences

- Proposed Grading
- < -4
- -4 to -3
- -3 to -2
- -2 to -1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- 5 to 6
- > 6

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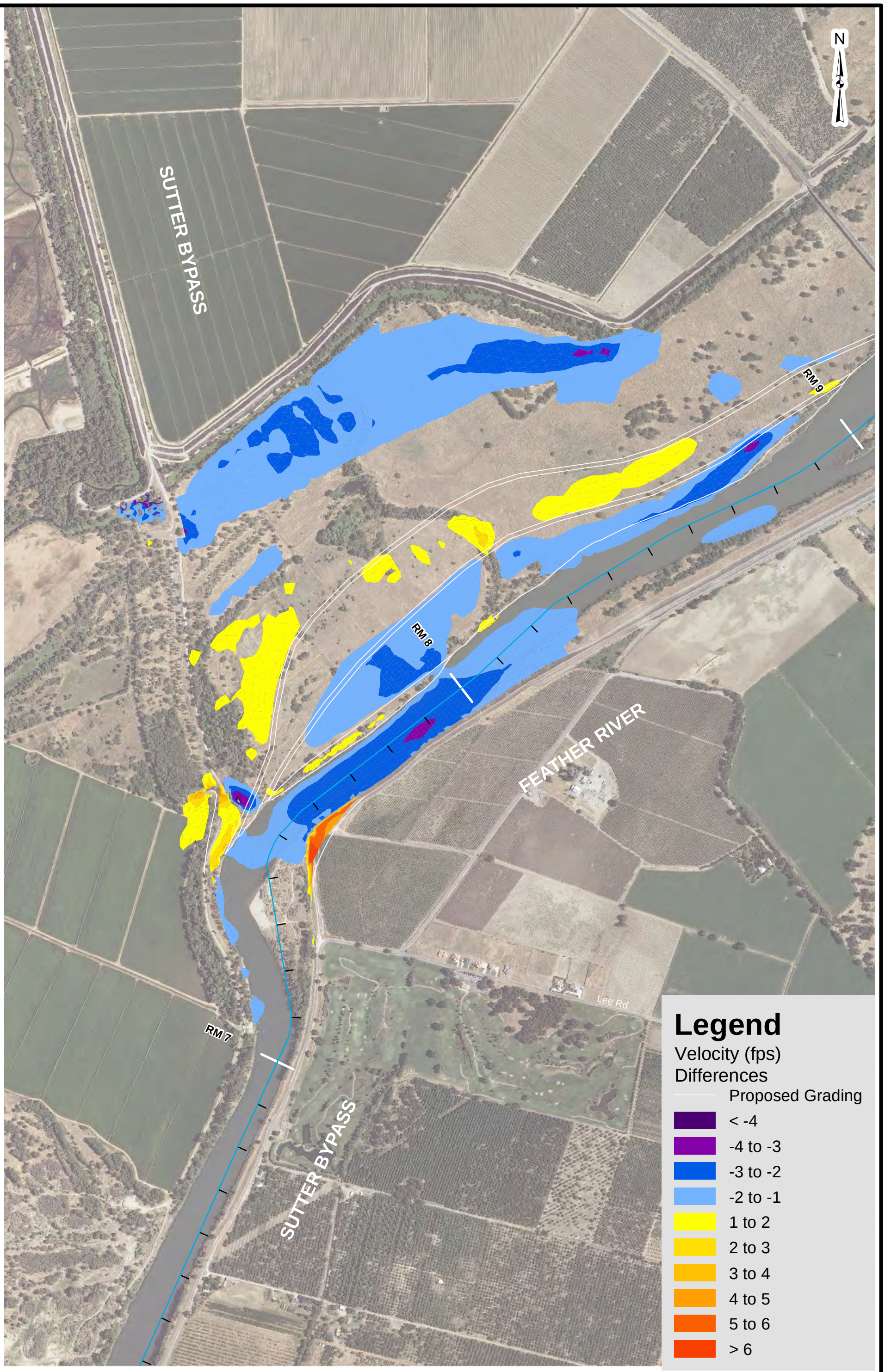
Lake of the Woods: 1957 SRFCP Design Flow Velocity Differences (Upper Feather Centering)

0 1,000
Scale in Feet

Figure 80



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Nelson Slough: 1957 SRFCP Design Flow Velocity Differences (Lower Feather Centering)

0 1,000
Scale in Feet

Figure 81