FINAL ENVIRONMENTAL IMPACT STATEMENT

408 PERMISSION AND 404 PERMIT TO THREE RIVERS LEVEE IMPROVEMENT AUTHORITY

FOR THE

FEATHER RIVER LEVEE REPAIR PROJECT, CALIFORNIA SEGMENT 2

APPENDIX E – HYDRAULIC AND HYDROLOGIC ANALYSIS OF THE THREE RIVERS LEVEE IMPROVEMENT AUTHORITY'S PHASE IV PROJECT, AND ASSOCIATED TECHNICAL MEMORANDUM ON THE LOCAL AND SYSTEMWIDE HYDRAULIC EFFECTS OF THE SEGMENT 2 SETBACK LEVEE

October 2008

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ERRATA TO APPENDIX E

To further clarify the information included in this appendix, the following additional information is provided.

PROJECT TITLES

Due to the broad scope of the Three Rivers Levee Improvement Authority's (TRLIA's) actions in the Reclamation District (RD) 784 area, there is a refinement in project titles as program level activities focus down to project specific and site specific actions. TRLIA has divided overall improvements to the RD 784 flood protection system into four phases, as described on pages 1-13 and 1-14 of this FEIS. Phase IV Improvements, which are referenced in the title of this Appendix ("Phase IV Project") consist of levee improvements on a focused portion of the upper Yuba River left bank levee and the Feather River Levee Repair Project (FRLRP). The FRLRP consists of three segments (described on pages 1-1, 1-14, and elsewhere in this FEIS). Segments 1 and 3 have received all necessary authorizations and construction was initiated in 2007. Construction will be completed in 2008. Segment 2, the middle segment of the FRLRP, is the subject of this EIS.

RESERVOIRS ADDRESSED IN THE HYDRAULIC AND HYDROLOGIC ANALYSIS

The hydraulic and hydrologic analysis provided in this appendix describes the waterways and tributaries that are included in the model, but does not expressly list the reservoirs that are included in the model. Reservoirs included in the model consist of:

FEATHER RIVER BASIN

- Mountain Meadows on Hamilton Creek
- Almanor on the North Fork of Feather Creek
- Butte Valley on Butte Creek
- Antelope on Indian Creek
- Bucks Lake on Bucks Creek
- Frenchman on Last Chance Creek
- Lake Davis on Big Grizzly Creek
- Little Grass Valley on the South Fork of the Feather River
- Sly Creek on Lost Creek
- Oroville on the Feather River

YUBA RIVER BASIN

- New Bullards Bar on the North Fork of the Yuba River
- Jackson Meadows on the Middle Fort of the Yuba River
- Bowman on Canyon Creek
- Fordyce on Fordyce Creek
- Spaulding on the South Fork of Jackson Creek
- Scotts Flat on Deer Creek
- Merle Collins on Dry Creek

If any reader wishes to obtain additional detail on the hydraulic/hydrologic model used to evaluate the FRLRP Segment 2 project, as well as other projects considered and implemented in the lower Feather River basin, they are referred to the Amended Draft Lower Feather River Floodplain Mapping Study prepared by U.S. Army Corps of Engineers, Sacramento District, Revised February 17, 2005.

Hydraulic and Hydrologic Analysis of the
Three Rivers Levee Improvement Authority's Phase IV Project

Hydraulic and Hydrologic Analysis of the Three Rivers Levee Improvement Authority's Phase IV Project

Feather River Levee Repair Project

July 2006

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1. Background

This document explains the hydraulic analysis of the proposed alternatives for the Reclamation District No. 784 (RD 784) Feather River Levee Repair Project (FRLRP) that is proposed by the Three Rivers Levee Improvement Authority (TRLIA) under the Phase IV program. Included in this document are:

- Background on the hydraulic model used for the analysis.
- A description of the hydrology.
- Description of the existing condition that was modeled.
- Description of the alternatives that were modeled.
- Water surface profiles derived from the modeling analysis.

2. Hydraulic Model

2.1 Description

MBK Engineers was provided a copy of the Feather River HEC-RAS model, dated Jan. 12, 2004 that was developed by the U.S. Army Corps of Engineers, Sacramento District (Corps) for the Lower Feather River Floodplain Mapping Study. This model was the basis for the results displayed in this report. Included with the model were the calibration analysis and synthetic hydrology for the 1-in-2, 1-in-10, 1-in-25, 1-in-50, 1-in-100, 1-in-200, and 1-in-500 annual exceedence probabilities (AEP) for two hydrologic centerings: Feather River at Shanghai with Yuba River emphasis (Shanghai-Yuba) and Bear River.

The model represents the Feather River and its tributaries from the major reservoirs within the basin to its confluence with the Sacramento River. Specifically, the major upstream boundaries of the model are:

- Feather River at Oroville.
- Yuba River about 2 miles upstream of Daguerre Point Dam.
- Bear River at Wheatland Gage.
- Sutter Bypass upstream of Feather River.
- Sacramento River upstream of Fremont Weir.

The model also includes the following minor tributaries:

- Honcut Creek (Feather River) – modeled reach, 0.8 miles long.
- Jack-Simmerly Slough – modeled reach, 6.25 miles long.
- Dry Creek (Yuba River) – lateral inflow.
- Deer Creek (Yuba River) – lateral inflow.
- Yankee Slough (Bear River) – modeled reach, 6.2 miles long.
- Dry Creek (Bear River) – modeled reach, 4.4 miles long.
- WP Interceptor (Bear River) – modeled reach, 4.9 miles long.
- Best Slough (WP Interceptor) – modeled reach, 1 mile long.
- Natomas Cross Canal (Sacramento River) – modeled reach, 6.2 miles long.

The model has two downstream boundaries: Sacramento River at Verona Gage and Yolo Bypass at Woodland Gage. The downstream boundary conditions are represented by rating curves at these locations. The cross-section and reach geometry in this model comes primarily from the Sacramento-San Joaquin Rivers Comprehensive Study (Comp Study) Sacramento Basin UNET model. Figure 1 shows the geographic extent of the model and the waterways contained in the model.

2.2 Corps of Engineers Calibration

The HEC-RAS model was calibrated by the Corps to the January 1997 flood event. For reference, the estimated AEP of the January 1997 flood one-day volume is summarized in Table 1 for locations within the model study area.

Table 1. January 1997 Flood – Annual Exceedence Probabilities, 1-day Duration

Location	Annual Exceedence Probability
Feather River at Oroville	1-in-100
Yuba River at Marysville	1-in-100[1]
Bear River at Wheatland	1-in-33
Latitude of Verona	1-in-91

Source: Sacramento and San Joaquin River Basins Comprehensive Study
[1] Estimated by MBK Engineers

The following is an excerpt from the model description that accompanied the model when provided by the Corps, which explains the Corps' calibration methodology. Additional information on the Corps calibration is documented in *"Lower Feather River Floodplain Mapping Study; Army Corps of Engineers, Sacramento District, February 17, 2005."*

> *Manning's n values, flow roughness factors, and weir coefficients were adjusted to best fit the rising limb of the computed hydrographs with the observed hydrographs at seven stream gage locations. These locations are:*
>
> 1. *Feather River: Yuba City gage.*
> 2. *Feather River: Nicolaus gage.*
> 3. *Yuba River: "Near Marysville" gage.*
> 4. *Bear River: Wheatland gage.*
> 5. *Bear River: Forty Mile Road gage.*
> 6. *Sacramento River: Verona gage.*
> 7. *Sacramento River: Upstream end of Fremont Weir.*
>
> *The model has not been calibrated upstream of the Yuba City gage.*

The gages within the study area for which observed data were available for the calibration event are summarized in Table 2, and a comparison of observed and computed peak stages and flows at the gages for the calibration event is provided in Table 3.

Table 2. Calibration Analysis – Available Data at Gages in Study Area

Gage	Agency	Stage Data (source)	Flow Data (source)
Feather River near Gridley	USGS 11407150	Hourly (CDEC) Peak (USGS)	Hourly (Corps data file) Peak (USGS) Mean Daily (USGS)
Feather River at Yuba City	Ca. DWR	Hourly (CDEC)	N/A
Feather River at Nicolaus	Ca. DWR	Hourly (CDEC)	N/A
Yuba River near Marysville	USGS 11421000	Hourly (Corps data file) Peak (USGS)	Peak (USGS) Mean Daily (USGS
Bear River near Wheatland	USGS 11424000	15 min. (Corps data file) Peak (USGS) Measured (USGS) 12/31/96 15:20 1/1/97 14:55 1/2/97 12:30	15 min. (Corps data file) Peak (USGS) Measured (USGS) 12/31/96 15:20 1/1/97 14:55 1/2/97 12:30 Mean Daily (USGS)
Bear River at Forty Mile Road (Pleasant Grove Road)	Unknown	15 min. (Corps data file)	N/A
Sacramento River at Fremont Weir	Ca. DWR	Hourly (CDEC)	N/A
Sacramento River at Verona	USGS 11425500	Hourly (CDEC) Peak (USGS) Measured (USGS) 1/2/97 11:30	Hourly (CDEC) Peak (USGS) Measured (USGS) 1/2/97 11:30 Mean Daily (USGS)
Yolo Bypass near Woodland	USGS 11453000	10 min. (Corps data file) Peak (USGS) Measured (USGS) 1/3/97 09:30 1/3/97 11:30	Peak (USGS) Measured (USGS) 1/3/97 09:30 1/3/97 11:30 Mean Daily (USGS)

Table 3. Corps of Engineers Calibration Study Results – Peak Stages and Flows at Gages

Gage	Peak Stage (ft.-NGVD)			Peak Flow (cfs)		
	Observed	Computed	Difference (ft.)	Observed	Computed	% Diff
Feather River						
Near Gridley	97.51	99.15	+1.64	163,000	157,740	-3.2%
at Yuba City	75.23	75.51	+0.28	N/A		
at Nicolaus	47.20	47.34	+0.14	N/A		
Yuba River						
Near Marysville	88.69	88.71	+0.02	161,000	172,510	+7.1%
Bear River						
Near Wheatland	95.65	95.68	+0.03	34,900	34,360	-1.5%
at 40 Mile Rd.	70.78	70.99	+0.21	N/A		
Sacramento River						
at Fremont Weir	39.47	38.97	-0.50	N/A		
at Verona	39.09	38.75	-0.34	102,000	101,780	-0.2%
Yolo Bypass						
Near Woodland	31.43	30.81	-0.62	357,000	404,670	+13.4%

2.3 MBK Engineers Re-Calibration for Phase IV Project

MBK Engineers refined and re-calibrated the Corps HEC-RAS model for use in designing the levee improvements under the TRLIA Phase II program. Those levee improvements consisted of work on the Western Pacific Interceptor Canal, Bear River, Yuba River, and Olivehurst Detention Pond. The refinements made to the Corps HEC-RAS model and the re-calibration results are documented in *"Hydraulic and Hydrologic Analysis for Three Rivers Levee Improvement Authority's Phase 2 Project, Basis of Design for the Bear River, Western Pacific Interceptor Canal, Yuba River Levee Improvements and Olivehurst Detention Basin Project (Revision 1); MBK Engineers, March 2006"* (HEC-RAS Phase II model).

Phase IV of the TRLIA project includes levee strengthening on the Feather River and evaluates levee setback alternatives on the Feather River reach river mile (RM) 17 to 24 (Figure 37). It also addresses freeboard issues on the Yuba River levee. The HEC-RAS model developed by the Corps of Engineers and re-calibrated by MBK Engineers for Phase II, included flow roughness factors in the reach of the Feather and Yuba Rivers. These flow roughness factors increased the Manning's n value as the flow increased and were assigned to cross sections on the Feather River from RM 17 to 29.25 and Yuba River from RM 1.6 to 8.34. The TRLIA Phase IV project is evaluating a setback levee which could potentially include habitat enhancement projects along the project reach. Habitat enhancement projects typically consist of re-vegetation which would require simulation of the project condition vegetation types. This is typically done by changing the Manning's n value to represent the change in vegetation type due to the project. The complex nature of the flow roughness factor makes this type of analysis difficult and uncertain; therefore, the HEC-RAS Phase II model was refined and re-calibrated to remove the flow roughness factors. Following are the changes made to the HEC-RAS Phase II model for the current Phase IV analysis:

1. The flow roughness factors in the following reaches were eliminated
    a. Feather River – Yuba River to Bear River, RM 17 to 24.25.
    b. Feather River – Yuba River to Bear River, RM 24.5 to 27.0.
    c. Feather River – Jack Sough. to Yuba River, RM 27.25 to 29.25.
    d. Yuba River (upper) – RM 1.6 to 8.34.

2. For the Feather River reach in item 1.a. above, the Manning's n value from the HEC-RAS Phase II model for the January 1997 calibration, corresponding to the maximum water surface elevation, was used as a single Manning's n value at each of the cross sections in the reach.

3. For the reaches in items 1.b., 1.c. and 1.d., the flow roughness factor in the HEC-RAS Phase II model were converted to a vertical variation of Manning's n value for each cross section. This was done by assigning an elevation to each break point in the flow roughness factor. The Manning's n value at each break point was calculated using the flow roughness factor and the original geometry Manning's n value in the HEC-RAS Phase II model. The output water surface elevations and flows from HEC-RAS Phase II model were then used to assign the elevation at each break point. Minor modifications were made to the Manning's n value to calibrate to the stage gage at Yuba City and Marysville. A vertical variation Manning's n value is needed in these reaches to better match the rising and falling limb of the stage hydrographs at Feather River at Yuba City and Yuba River near Marysville. Using a single Manning's n value for the cross sections matched the peak well at those gage locations but resulted in higher stages on the rising and falling limbs for the January 1997 calibration.

2.4 Results of the Phase IV Re-Calibration

Results of the model re-calibration made by MBK Engineers are presented in Figures 2 through 19. Figures 2 through 5 show the computed maximum water surface profile versus the surveyed high water marks for the Bear, Feather and Yuba Rivers. Figures 6 through 19 show stage and flow hydrographs at available gage locations in the study area. The following descriptions are included to further identify some of the data used to create these figures:

a.) Observed (Corps): from data files compiled by Corps ("1997_event_input.dss" from Lower Feather river HEC-RAS study and "sac97.dss" from Comprehensive Study).

b.) Observed – CDEC (datum adjusted): gage height from CDEC adjusted to NGVD 1929 datum.

c.) Observed (CDEC – adj.): gage height from CDEC adjusted to NGVD 1929 datum.

d.) Observed, est. (Corps): from data files compiled by Corps ("1997_event_input.dss" from Lower Feather river HEC-RAS study and "sac97.dss" from Comprehensive Study).

e.) Observed (Corps data file): from data files compiled by Corps ("1997_event_input.dss" from Lower Feather river HEC-RAS study and "sac97.dss" from Comprehensive Study).

f.) Computed Mean Daily Peak (MBK): mean daily flow from MBK simulated hourly.

Table 4 provides a summary of observed and computed stages and flows at the gage locations in the study area.

Table 4. MBK Engineers Re-Calibration Study Results – Peak Stages and Flows at Gages

Gage	Peak Stage (ft.-NGVD)			Peak Flow (cfs)		
	Observed	Computed	Difference (ft.)	Observed	Computed	% Diff
Feather River						
Near Gridley	97.51	99.14	+1.63	163,000	157,779	-3.2%
at Yuba City	75.23	75.15	-0.08	N/A		
at Nicolaus	47.20	46.6	-0.60	N/A		
Yuba River						
Near Marysville	88.69	87.9	-0.79	161,000	161,655	+0.4%
Bear River						
Near Wheatland	95.65	Boundary Condition		34,900	Boundary Condition	
at 40 Mile Rd.	70.78	70.99	+0.21	N/A		
Sacramento River						
at Fremont Weir	39.47	39.24	-0.23	N/A		
at Verona	39.09	38.92	-0.17	102,000	102,638	+0.6%
Yolo Bypass						
Near Woodland	31.43	31.34	-0.09	357,000	354,755	-0.6%

3. Hydrology

The hydrology used for the analysis of the project alternatives is based on the model inflows developed by the Corps for two storm centerings:

1. Feather River at Shanghai with Yuba River emphasis (SHY).
2. Bear River (BR).

Studies were made for two annual exceedence probabilities: 1-in-100 and 1-in-200 AEP. Table 5 shows the peak flow rate at the upstream boundary of each major reach for each of the combinations of these centerings and frequencies. From Table 5, the SHY centering produces greater flows for all frequencies on the Yuba and Feather Rivers and in the Sutter Bypass. The BR centering has greater flows on the Bear River. The peak flows from the two centerings are comparable on the Sacramento River.

Table 5. Summary of Major River Peak Flow Rates at Upstream Model Boundaries for Feather River at Shanghai with Yuba River Emphasis (SHY) and Bear River (BR) Storm Centerings and Analyzed Frequencies (values are 1,000 cfs).

AEP	Feather River		Yuba River		Bear River		Sutter Bypass		Sacramento R.	
	SHY	BR	SHY	BR	SHY	BR	SHY	BR	SHY	BR
1-in-100	150	150	141	122	41	44	193	173	37	34
1-in-200	174	150	211	135	48	49	232	213	40	38

The study alternatives were simulated with each of the two centerings and two AEP floods. For a given AEP flood, the results presented in this report are for the composite water surface, defined as the maximum of the two water surface elevations for the respective centerings at each model cross-section.

4. Levee Performance Assumptions

An important assumption in performing hydraulic simulations of leveed systems on a regional basis is defining if, when, and how levee failures will occur. The analysis as presented herein assumes that levees would not fail before and after overtopping. Top of levee profiles were compared to 1-in-200 water surface profiles to determine low spots where levee overtopping may occur. The locations were defined in the HEC-RAS model for the without project. Table 6 documents the locations.

Table 6. Potential Levee Overtopping Locations

River	Model River Mile	Side
Bear River	6.49	right
Bear River	5.49	right
Bear River	4.99	left
Bear River	3.855	left
Bear River	3.21	left
Cross Canal	3.99	right
Cross Canal	3.98	left
Dry Creek	2.85	right
Feather River	40.1	right
Feather River	40	left
Feather River	28.9	right
Feather River	24.74	left
Feather River	24.24	right
Feather River	16.49	left
Feather River	14.74	right
Sutter Bypass	66	right

River	Model River Mile	Side
UP Intercept	3.49	left
UP Intercept	1.24	left
Yankee Slough	1.84	right
Yankee Slough	1.81	left
Yuba Overbank	0.42	right
Yuba Overbank	4.57	left
Yuba Overbank	2.82	right
Yuba Overbank	2.487	left
Yuba Overbank	1.787	left

Note: The model also contains potential levee overtopping locations on both banks of the upper Yuba River, Sacramento River, and Sutter Bypass which were not listed individually here due to their volume.

5. Study Alternatives

The following describe each one of the alternatives that were analyzed as part of the work. Three alternatives were analyzed which consisted of levee improvements along the Feather River. For all alternatives, it assumes the existing flood control system with the addition of the Bear River setback as part of TRLIA Phase III program. Also, in a few locations along the Bear River and Yankee Slough in Sutter County where the levees are below the 1957 design criteria, as shown in Figure 20, the existing condition was represented by the 1957 design profile levee elevation (1957 design water surface + 3 feet for freeboard). In other words, top of levee elevations that are below design specifications were elevated to original specified design elevations. This is necessary because the work to raise the low spots in the levee will not be accomplished under the Yuba-Feather Supplemental Flood Control Program (Y-FSFCP) and benefits from such work should not be credited to the Y-FSFCP.

5.1 Alternative 1 – Levee Strengthening Alternative

Under this alternative, levee repair and strengthening activities would be completed along the existing Feather River left bank levee from Project Levee Mile (PLM) 13.3 to PLM 26.1 and along the Yuba River left bank levee from PLM 0.0 to PLM 0.3 (Figure 21). Levee repairs/strengthening would consists of various activities, including installation of cutoff walls and relief wells and placement of buried cobble in areas where erosion of the levee embankment has been identified as a problem.

5.2 Alternative 2 – Levee Strengthening and ASB Setback Levee

Under this alternative, levee repair and strengthening activities would be completed along the existing Feather River left bank levee from PLM 13.3 to PLM 17.1 and PLM 23.6 to PLM 26.1 and along the Yuba River left bank levee from PLM 0.0 to PLM 0.3 (Figure 21). Levee repair and strengthening activities along these segments would be the same as for Alternative 1. From

PLM 17.1 to PLM 23.6 on the Feather River left bank, a setback levee would be constructed roughly following the Above Star Bend (ASB) setback levee alignment identified in the Y-FSFCP EIR. Portions of the existing levee along the setback alignment would be removed to allow water to flow into the new floodway/setback area (i.e., the area between the existing levee and the setback levee) during high river stages.

The setback levee alternative was modeled by modifying the cross sections in the HEC-RAS model to reflect the ASB setback levee alignment and modifying the Manning's roughness value to reflect the land use in the setback area (Figure 22). The land use between the existing levee and new levee was assumed to be habitat restoration. Agricultural operations may occur in this area as the alternative further progresses through planning and design. It is likely that habitat restoration land use would have the higher of the two water surface elevations thus was chosen to be simulated. Habitat restoration land use was simulated using a Manning's roughness value of 0.1. For the area between the riverbank and the existing levee, it was assumed no land use changes thus the Manning's roughness value remained unchanged.

5.3 Alternative 3 – Levee Strengthening and Intermediate Setback Levee

FRLRP Alternative 3 is the same as Alternative 2 except for modifications to a portion of the setback levee alignment. The same levee repair and strengthening activities described previously would be completed along the existing Feather River left bank levee from PLM 13.3 to PLM 17.1 and from PLM 23.6 to PLM 26.1, and along the Yuba River left bank levee from PLM 0.0 to PLM 0.3 (Figure 22). From PLM 17.1 to PLM 23.6 on the Feather River left bank a setback levee would be constructed. The southern one-third of this setback levee alignment would follow the ASB setback levee alignment identified in Alternative 2. However, in the vicinity of Anderson Road, the setback levee alignment would shift west several hundred feet. This westward shift in the intermediate setback levee alignment allows less overall land to be placed in the new floodway and reduces the number of houses, structures, and other facilities that would be affected by levee construction or would need to be removed from the floodway.

The setback levee alternative was modeled by modifying the cross sections in the HEC-RAS model to reflect the intermediate setback levee alignment and modifying the Manning's roughness value to reflect the land use in the setback area (Figure 23). The land use between the existing levee and new levee was assumed to be habitat restoration. Agricultural operations may occur in this area as the alternative further progresses through planning and design. It is likely that habitat restoration land use would have the higher of the two water surface elevations thus was chosen to be simulated. Habitat restoration land use was simulated using a Manning's roughness value of 0.1. For the area between the riverbank and the existing levee, it was assumed no land use changes thus the Manning's roughness value remained unchanged.

6. Results

The hydraulic modeling results of each of the three alternatives are presented in this report in terms of location-stage for each hydrologic frequency analyzed. This data is presented in Tables 7 and 8. Figure 24 shows the location of the index points. Alternative 1 is considered the "Existing Condition" for which impacts will be compared to. Impacts to flows on the Feather River from river mile 9 to 27 are tabulated in Tables 9 and 10 for each of the frequency analyzed.

Water surface profiles for the 1-in-100 and 1-in-200 AEP water surface profiles are also included in the report for the Feather River (Figure 25 to 36). The figures include the water surface profiles and top of levee.

Table 7, Hydraulic Impacts to Maximum Stage, 1-in-100 AEP

				Alternative 1	**Alternative 2**		**Alternative 3**	
Impact Area	**Description**	**River**	**Model River Mile**	**Maximum Stage (ft-NGVD)**	**Maximum Stage (ft-NGVD)**	**Impact (ft.)**	**Maximum Stage (ft-NGVD)**	**Impact (ft.)**
RD 784	RD 784	Bear	1.75R	53.46	53.47	0.01	53.47	0.01
SAC30	RD 1001	Bear	3.86L	57.07	57.08	0.01	57.08	0.01
SAC30	RD 1001	Feather	7.17L	47.51	47.54	0.03	47.54	0.03
SAC24	LD 1	Feather	9.0R	49.55	49.58	0.03	49.57	0.02
RD 784	RD 784	Feather	19.0L	61.49	60.67	-0.82	60.66	-0.83
RD 784	RD 784	Feather	26.0L	71.02	69.29	-1.73	69.68	-1.34
SAC25	Yuba City	Feather	29.0R	74.48	73.35	-1.13	73.60	-0.88
RD 784	RD 784	Interceptor Canal	2.44R	57.71	57.71	0.00	57.71	0.00
	Verona Gage	Sacramento	78.75R	39.72	39.74	0.02	39.74	0.02
SAC34	RD 1500	Sacramento	86.5L	40.40	40.43	0.03	40.42	0.02
RD 784	RD 784	Yuba	1.14L	73.34	72.24	-1.10	72.48	-0.86
	YR 3	Yuba	1.48L	73.71	72.63	-1.08	72.86	-0.85
Marysville		Yuba	2.6R	74.41	73.64	-0.77	73.80	-0.61

Table 8, Hydraulic Impacts to Maximum Stage, 1-in-200 AEP

				Alternative 1	Alternative 2		Alternative 3	
Impact Area	**Description**	**River**	**Model River Mile**	**Maximum Stage (ft-NGVD)**	**Maximum Stage (ft-NGVD)**	**Impact (ft.)**	**Maximum Stage (ft-NGVD)**	**Impact (ft.)**
RD 784	RD 784	Bear	1.75R	55.95	56.01	0.06	56.00	0.05
SAC30	RD 1001	Bear	3.86L	58.42	58.44	0.02	58.43	0.01
SAC30	RD 1001	Feather	7.17L	49.48	49.52	0.04	49.51	0.03
SAC24	LD 1	Feather	9.0R	51.72	51.77	0.05	51.76	0.04
RD 784	RD 784	Feather	19.0L	64.94	64.11	-0.83	64.11	-0.83
RD 784	RD 784	Feather	26.0L	74.85	72.86	-1.99	73.29	-1.56
SAC25	Yuba City	Feather	29.0R	77.87	76.61	-1.26	76.87	-1.00
RD 784	RD 784	Interceptor Canal	2.44R	58.94	58.96	0.02	58.95	0.01
	Verona Gage	Sacramento	78.75R	40.99	41.02	0.03	41.01	0.02
SAC34	RD 1500	Sacramento	86.5L	41.61	41.63	0.02	41.63	0.02
RD 784	RD 784	Yuba	1.14L	77.41	76.03	-1.38	76.33	-1.08
	YR 3	Yuba	1.48L	78.05	76.70	-1.35	76.99	-1.06
Marysville		Yuba	2.6R	78.42	77.22	-1.20	77.47	-0.95

Table 9: Hydraulic Impacts to Flow, 1-in-100 AEP

			Flow (cfs) [1]		Difference (cfs)		% Difference	
Model River Mile	**Description**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 2**	**Alternative 3**	**Alternative 2**	**Alternative 3**
27	Yuba River	274,480	275,343	275,117	863	637	0.31%	0.23%
26		274,355	275,215	274,993	860	638	0.31%	0.23%
25		274,263	275,098	274,891	835	628	0.30%	0.23%
24		274,177	274,924	274,770	748	594	0.27%	0.22%
23		274,113	274,742	274,628	630	515	0.23%	0.19%
22		274,025	274,471	274,399	446	375	0.16%	0.14%
21		273,857	274,108	274,014	251	157	0.09%	0.06%
20		273,642	273,918	273,806	277	164	0.10%	0.06%
19		273,554	273,781	273,679	226	124	0.08%	0.05%
18	Star Bend	273,391	273,677	273,573	286	182	0.10%	0.07%
17		273,209	273,541	273,434	332	225	0.12%	0.08%
16		273,047	273,385	273,285	338	238	0.12%	0.09%
15		272,735	273,113	272,998	379	264	0.14%	0.10%
14		272,360	272,773	272,652	414	292	0.15%	0.11%
13		271,938	272,406	272,262	468	324	0.17%	0.12%
12	Bear River	319,986	320,209	320,145	224	160	0.07%	0.05%
11		319,210	319,472	319,378	261	168	0.08%	0.05%
10		317,751	317,960	317,893	209	142	0.07%	0.04%
9	Nicolaus	314,018	313,966	314,144	-51	126	-0.02%	0.04%

Note: [1] Flow at maximum water surface.

Table 10: Hydraulic Impacts to Flow, 1-in-200 AEP

			Flow (cfs) [1]		Difference (cfs)		% Difference	
Model River Mile	**Description**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 2**	**Alternative 3**	**Alternative 2**	**Alternative 3**
27	Yuba River	353,413	356,948	356,343	3,535	2,930	1.00%	0.83%
26		353,177	356,451	355,955	3,274	2,778	0.93%	0.79%
25		352,999	355,955	355,600	2,957	2,602	0.84%	0.74%
24		352,805	355,356	355,140	2,552	2,335	0.72%	0.66%
23		352,665	354,870	354,751	2,206	2,086	0.63%	0.59%
22		352,405	354,218	354,151	1,813	1,745	0.51%	0.50%
21		352,010	353,587	353,395	1,577	1,384	0.45%	0.39%
20		351,563	353,160	353,019	1,597	1,456	0.45%	0.41%
19		351,404	352,955	352,764	1,552	1,360	0.44%	0.39%
18	Star Bend	351,070	352,735	352,544	1,665	1,474	0.47%	0.42%
17		350,707	352,445	352,253	1,738	1,546	0.50%	0.44%
16		350,328	352,063	351,868	1,736	1,541	0.50%	0.44%
15		349,473	351,216	351,016	1,743	1,543	0.50%	0.44%
14		348,256	350,207	349,885	1,951	1,629	0.56%	0.47%
13		347,031	348,879	348,624	1,848	1,593	0.53%	0.46%
12	Bear River	399,555	401,246	401,030	1,691	1,475	0.42%	0.37%
11		398,576	400,320	400,032	1,743	1,456	0.44%	0.37%
10		396,429	398,883	398,786	2,454	2,357	0.62%	0.59%
9	Nicolaus	391,598	393,279	393,085	1,680	1,487	0.43%	0.38%

Note: [1] Flow at maximum water surface.

Figures

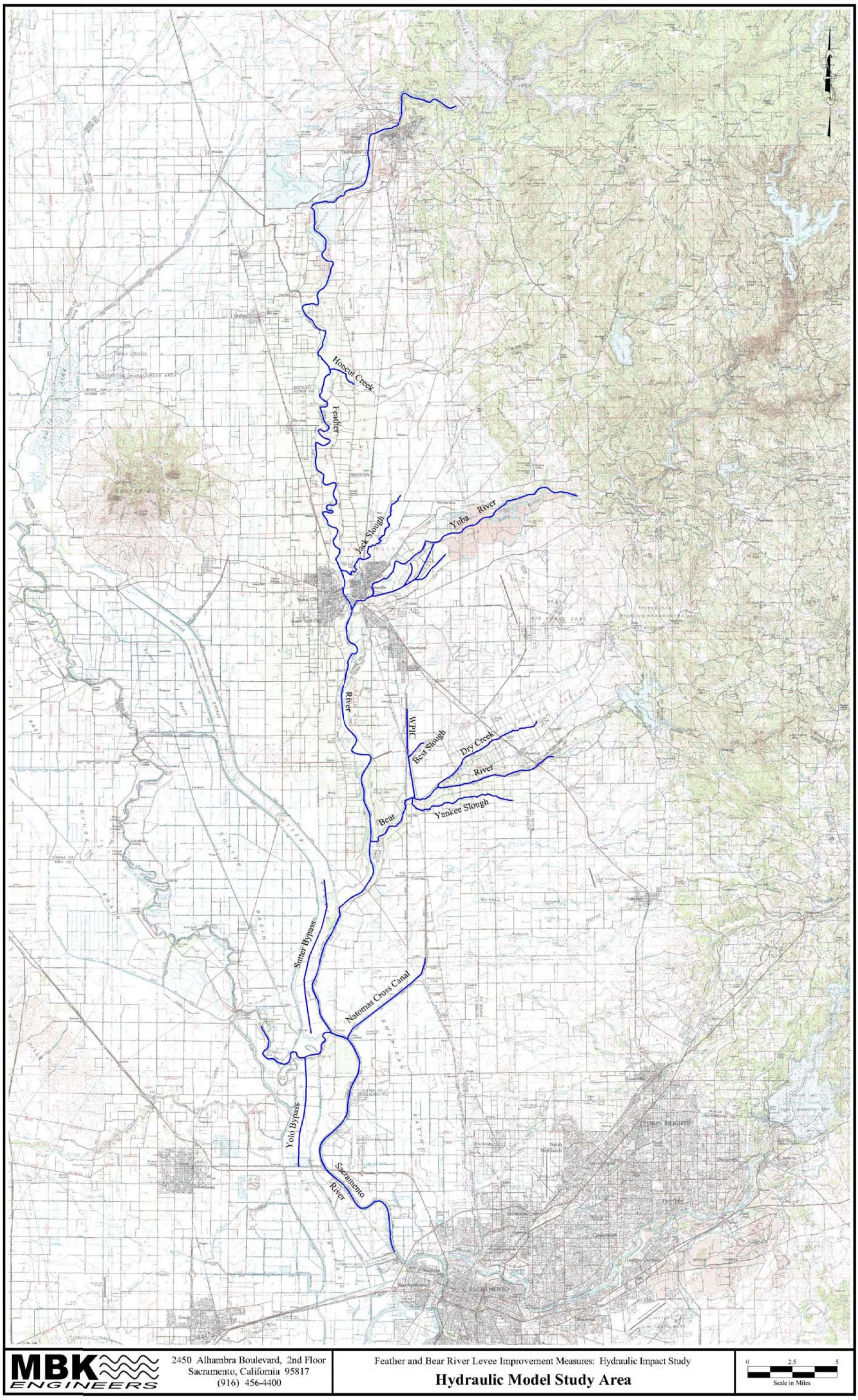

Honcut Creek
Feather
Jack Slough
Yuba River
River
WPIC
Best Slough
Dry Creek
River
Yankee Slough
Bear
Sutter Bypass
Natomas Cross Canal
Yolo Bypass
Sacramento
River
MBK ENGINEERS
2450 Alhambra Boulevard, 2nd Floor
Sacramento, California 95817
(916) 456-4400
Feather and Bear River Levee Improvement Measures: Hydraulic Impact Study
Hydraulic Model Study Area
0 2.5 5
Scale in Miles

FIGURE 1

FIGURE 2

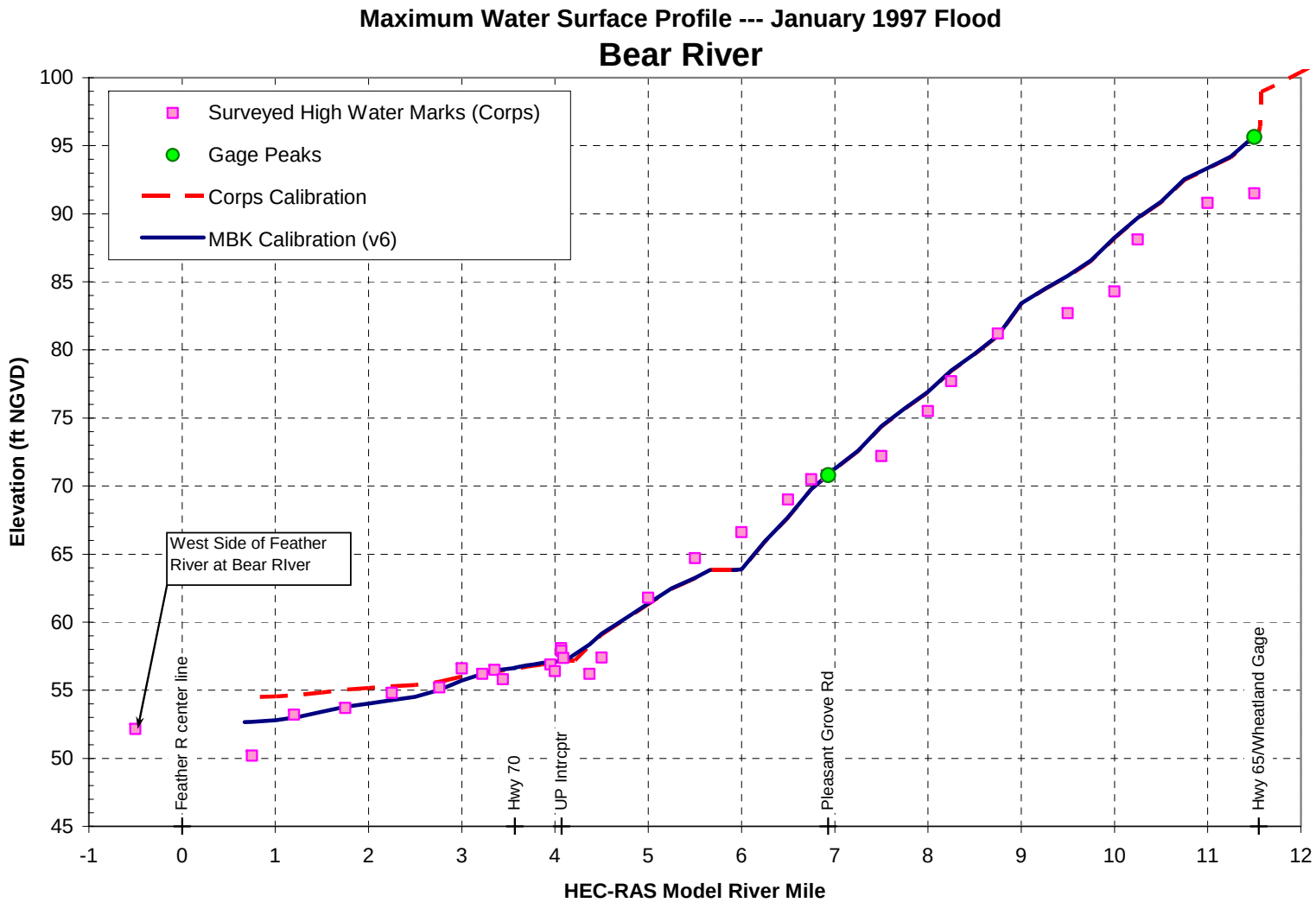

Maximum Water Surface Profile --- January 1997 Flood
Bear River
Surveyed High Water Marks (Corps)
Gage Peaks
Corps Calibration
MBK Calibration (v6)
West Side of Feather River at Bear RIver
Feather R center line
Hwy 70
UP Intrcptr
Pleasant Grove Rd
Hwy 65/Wheatland Gage
Elevation (ft NGVD)
HEC-RAS Model River Mile
100
95
90
85
80
75
70
65
60
55
50
45
-1
0
1
2
3
4
5
6
7
8
9
10
11
12

FIGURE 3

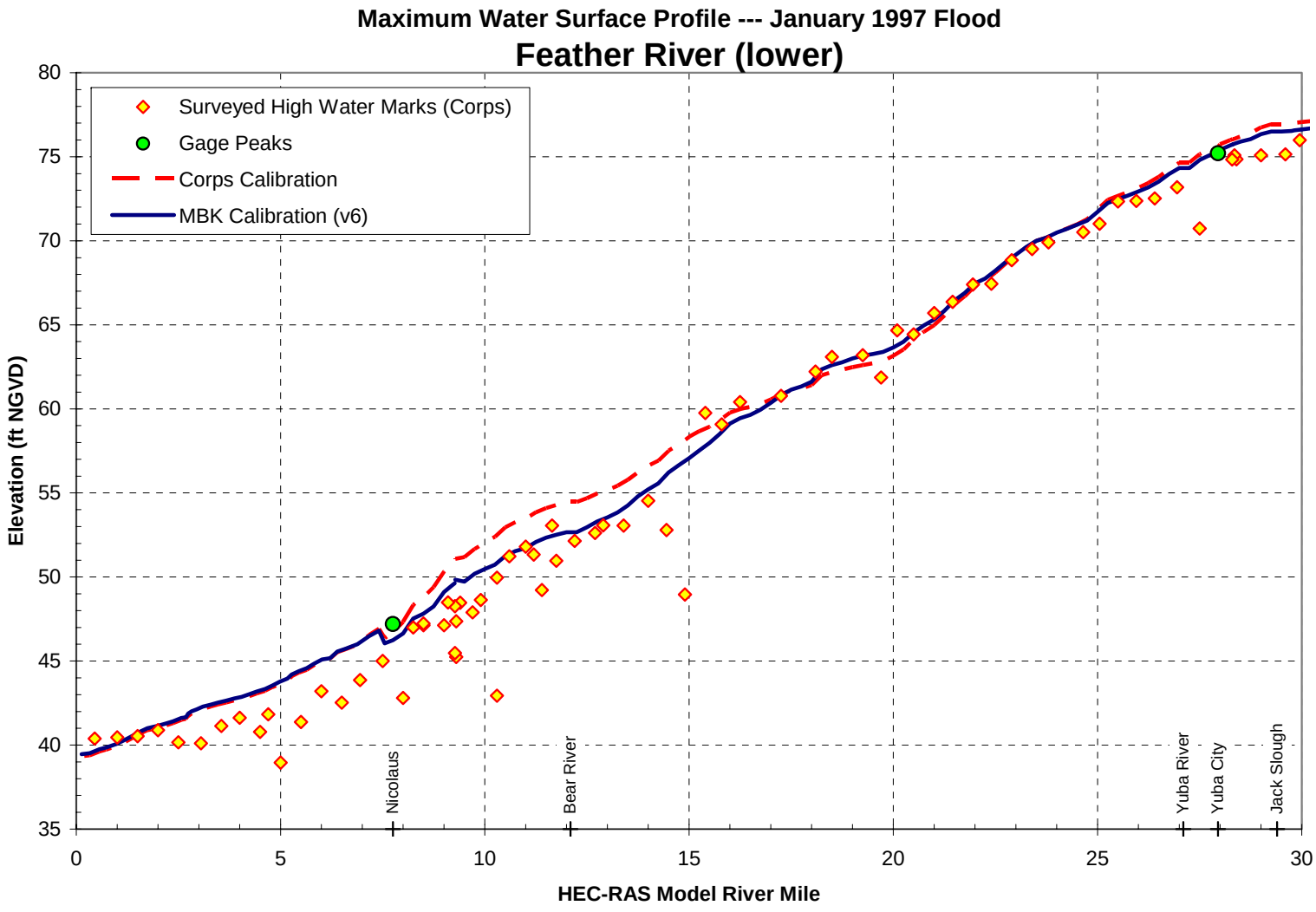

Maximum Water Surface Profile --- January 1997 Flood
Feather River (lower)
Surveyed High Water Marks (Corps)
Gage Peaks
Corps Calibration
MBK Calibration (v6)
Elevation (ft NGVD)
80
75
70
65
60
55
50
45
40
35
0
5
10
15
20
25
30
HEC-RAS Model River Mile
Nicolaus
Bear River
Yuba River
Yuba City
Jack Slough

FIGURE 4

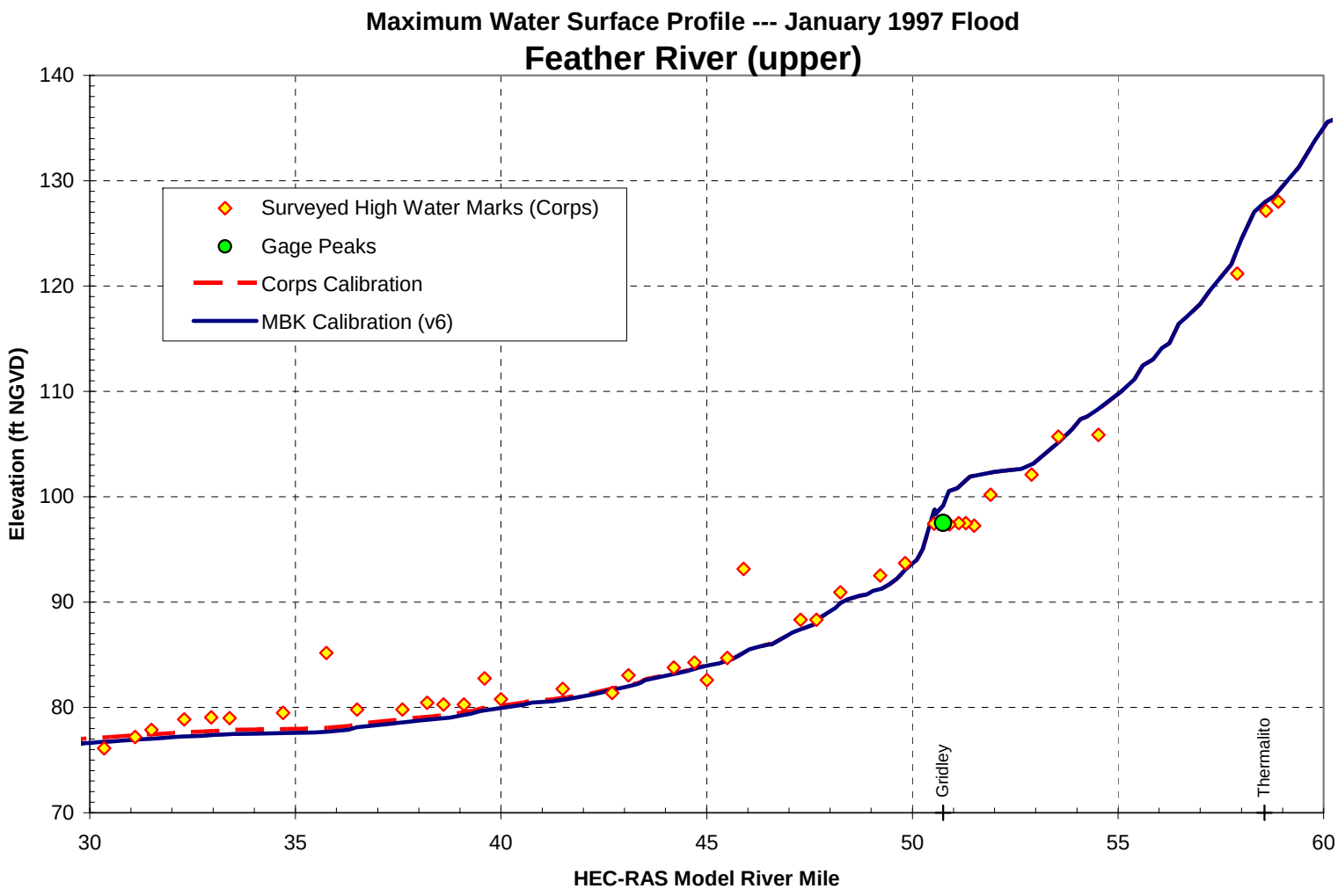

Maximum Water Surface Profile --- January 1997 Flood
Feather River (upper)
Surveyed High Water Marks (Corps)
Gage Peaks
Corps Calibration
MBK Calibration (v6)
Elevation (ft NGVD)
140
130
120
110
100
90
80
70
30
35
40
45
50
55
60
HEC-RAS Model River Mile
Gridley
Thermalito

FIGURE 5

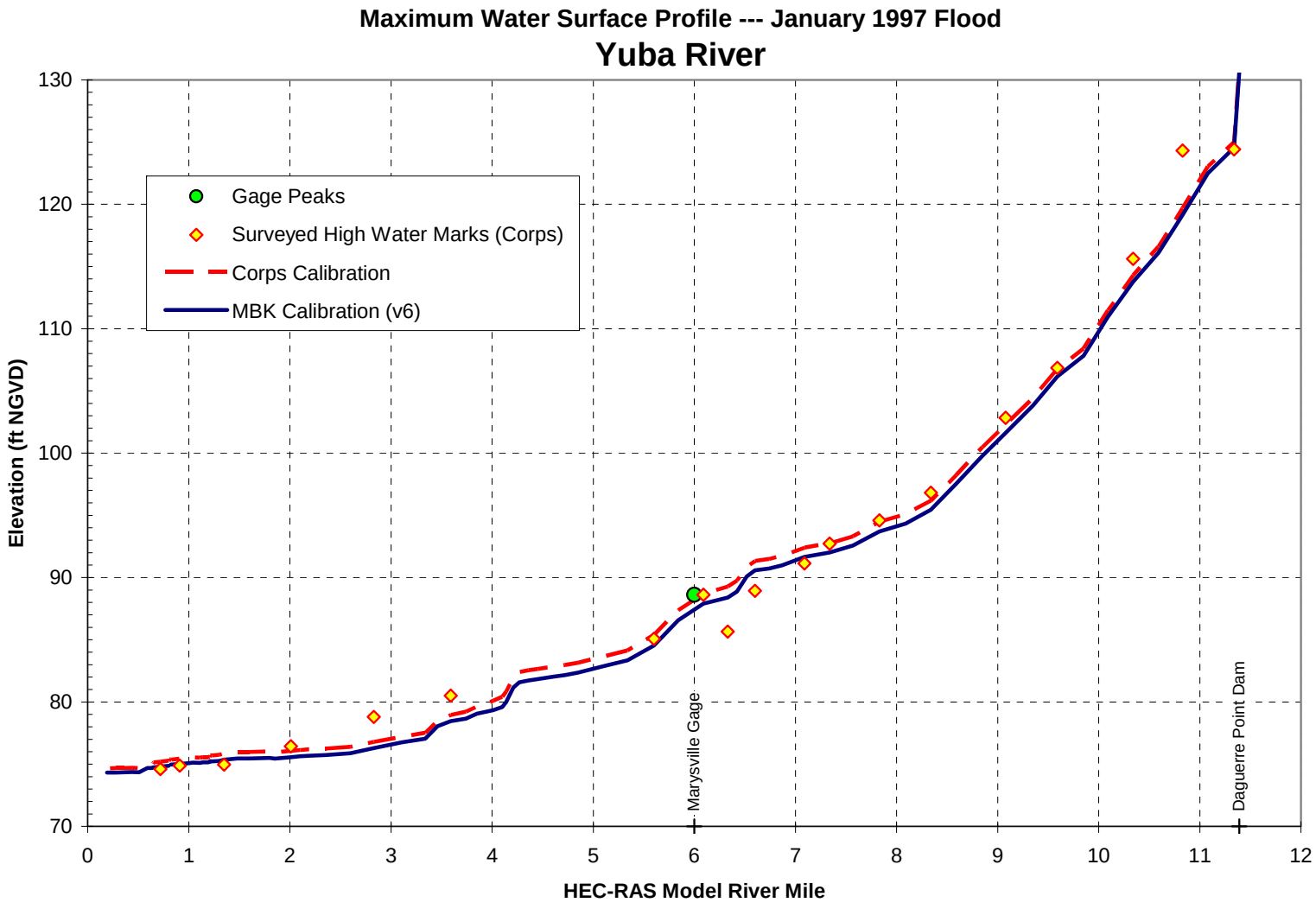
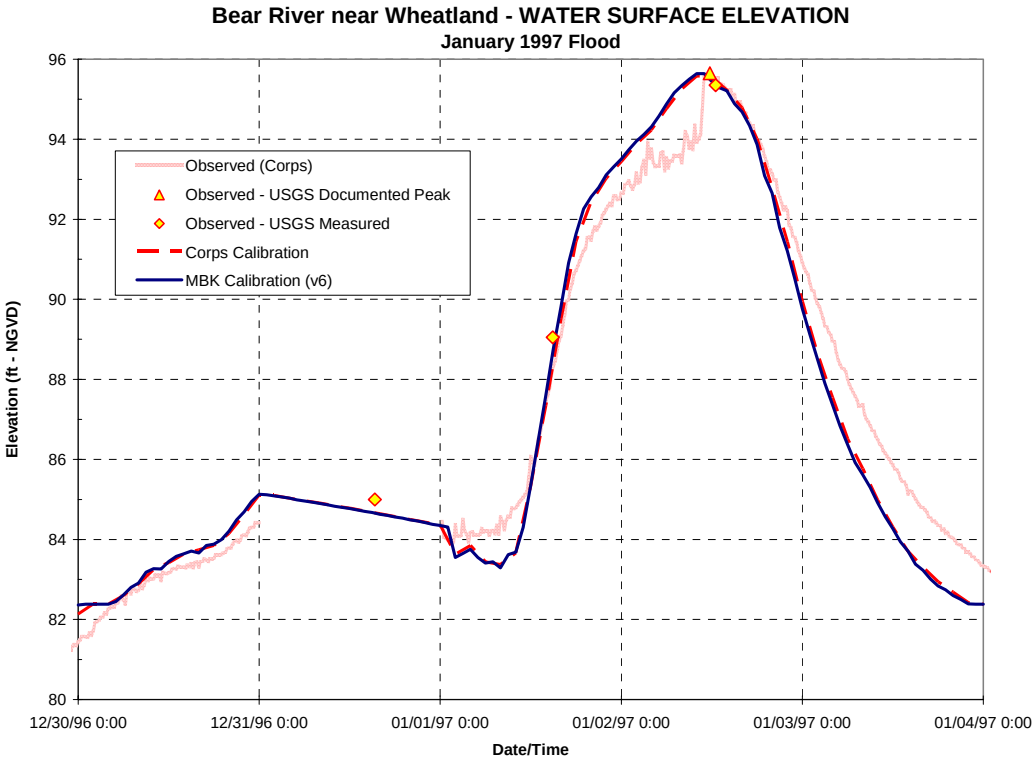

Maximum Water Surface Profile --- January 1997 Flood
Yuba River
Gage Peaks
Surveyed High Water Marks (Corps)
Corps Calibration
MBK Calibration (v6)
Elevation (ft NGVD)
130
120
110
100
90
80
70
0
1
2
3
4
5
6
7
8
9
10
11
12
HEC-RAS Model River Mile
Marysville Gage
Daguerre Point Dam

FIGURE 6



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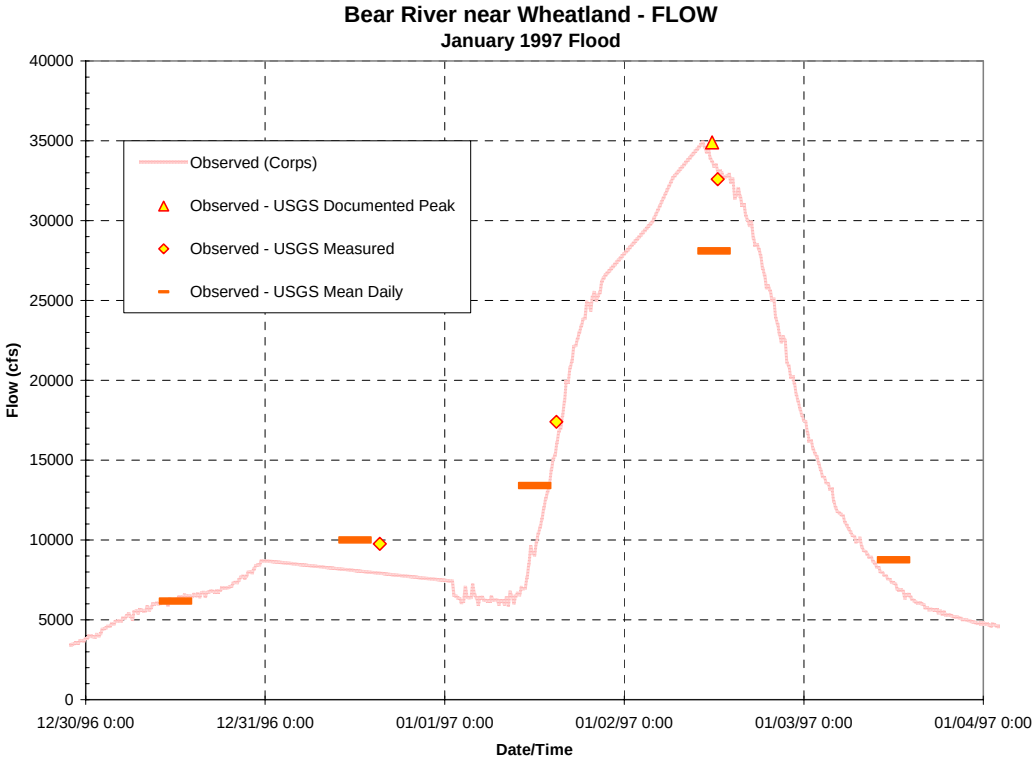


FIGURE 8

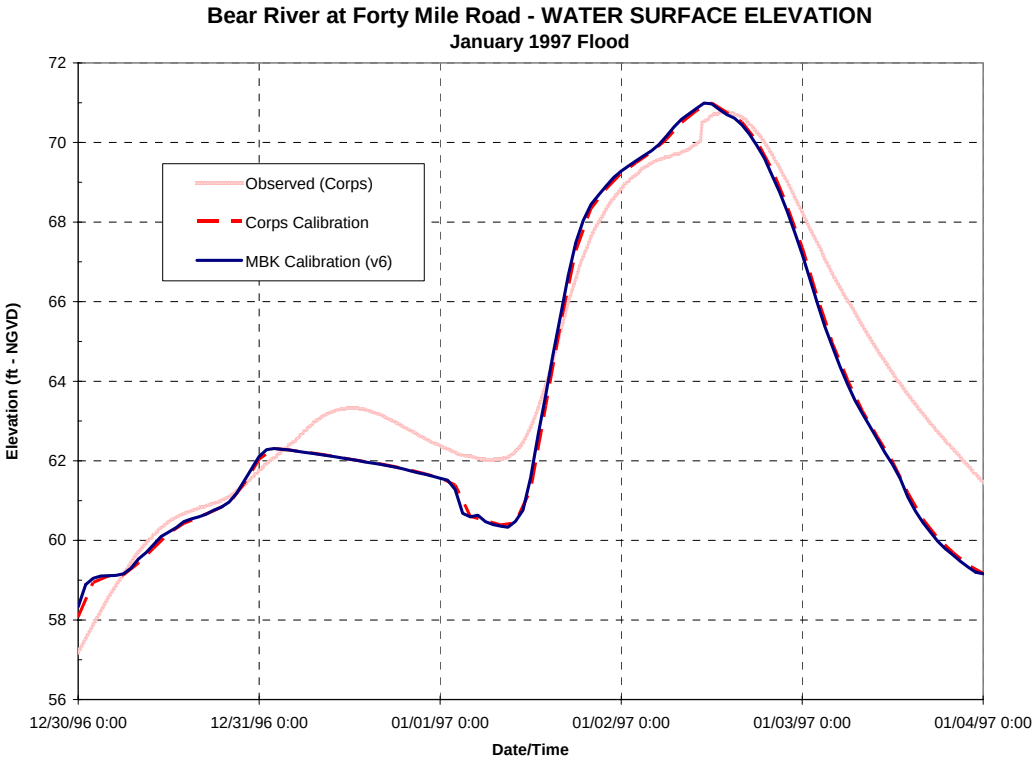


FIGURE 9

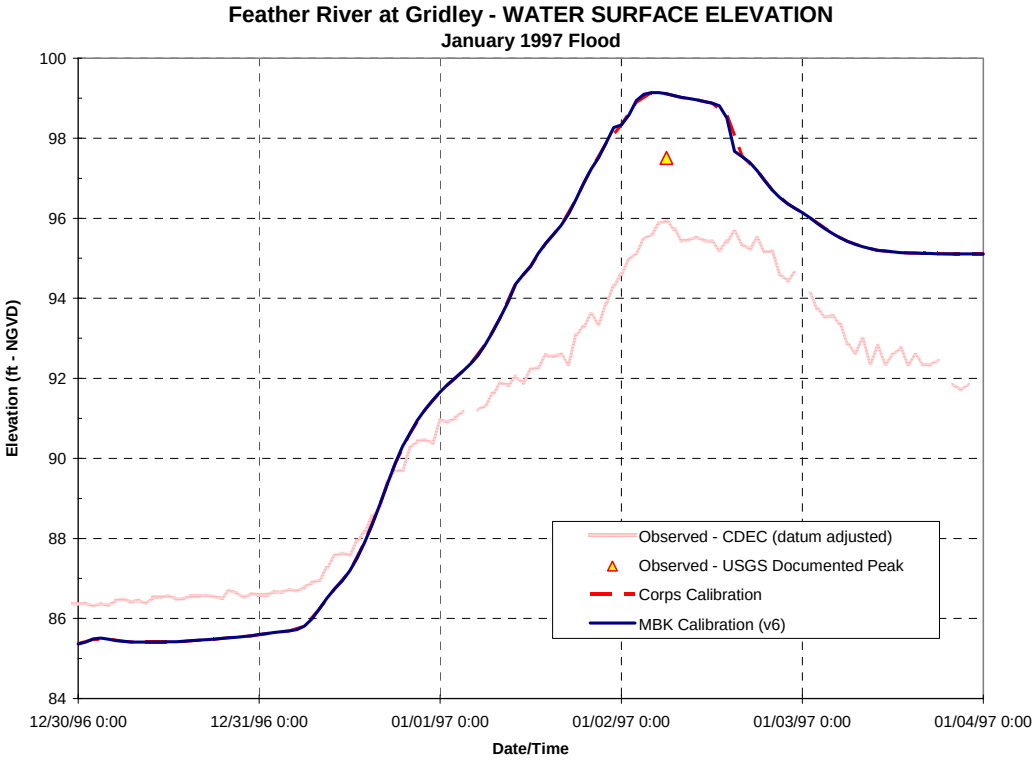


FIGURE 10

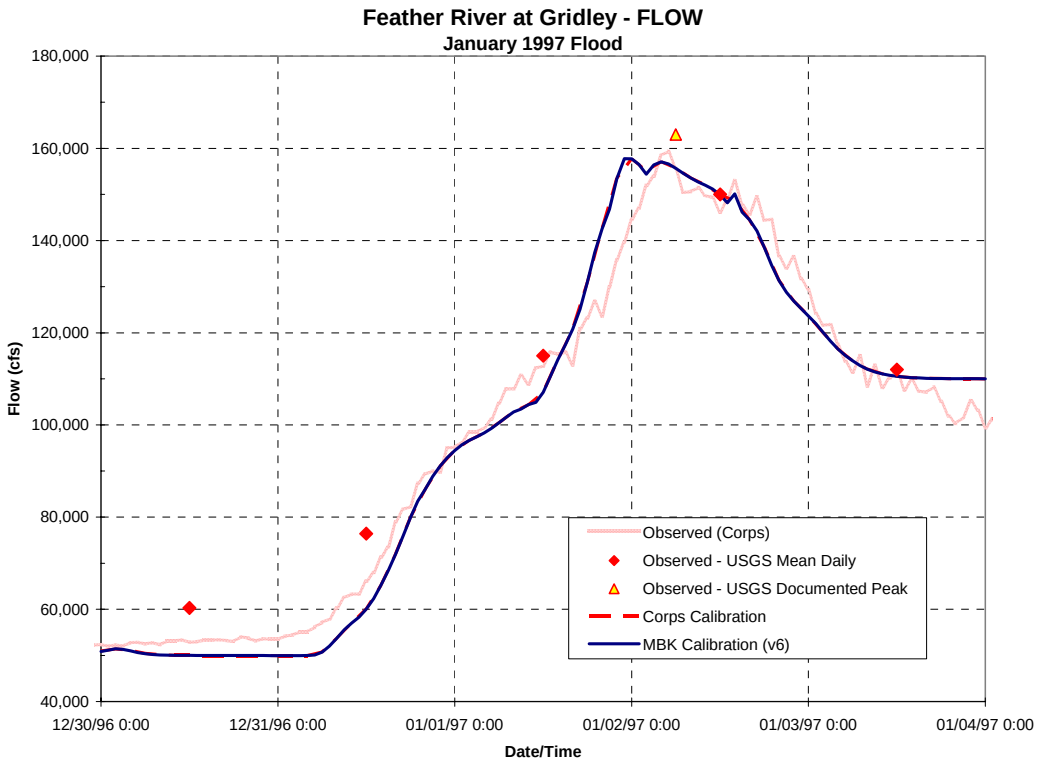


FIGURE 11

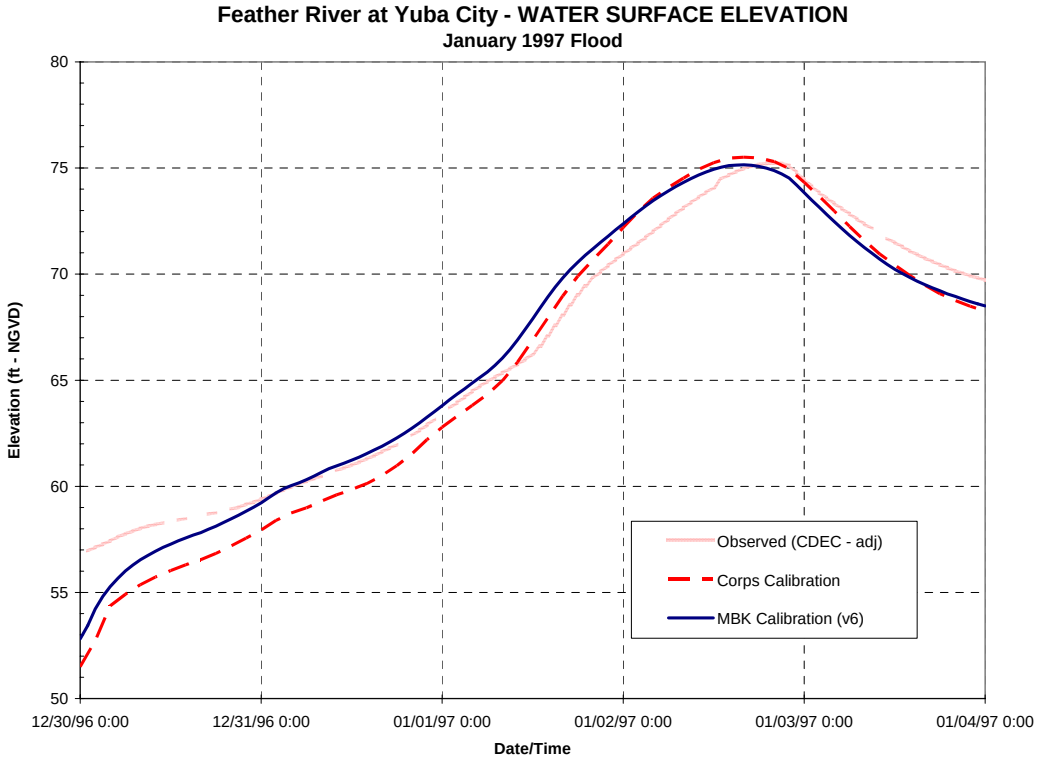


FIGURE 12

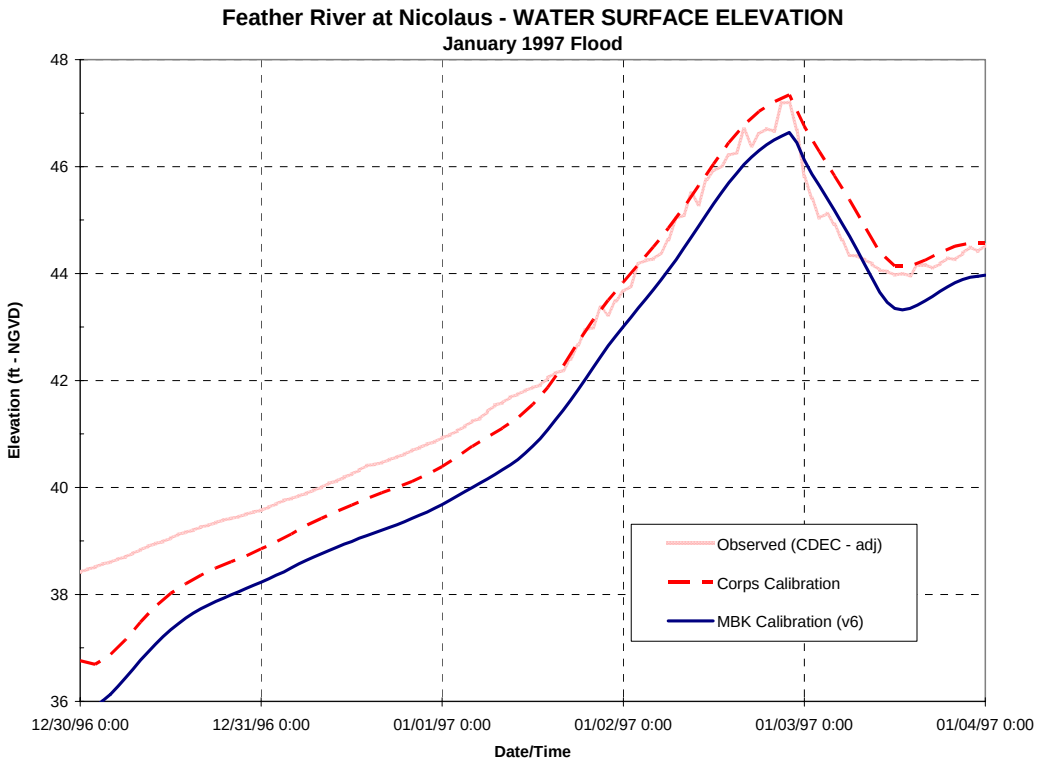


FIGURE 13

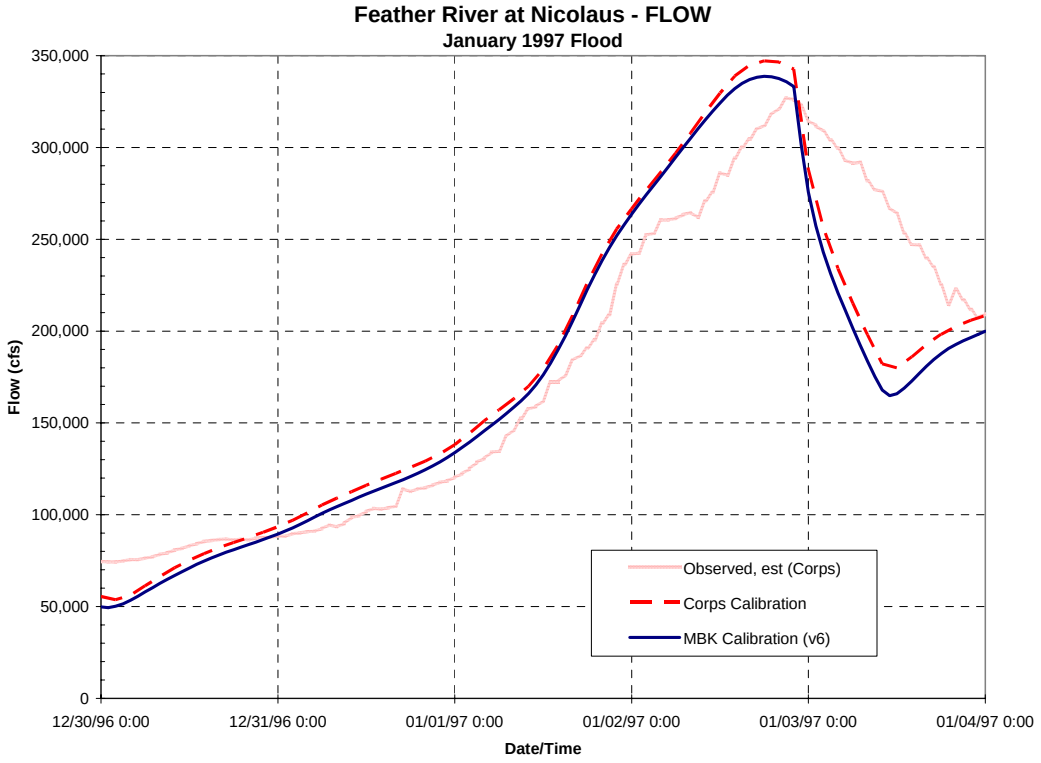


FIGURE 14

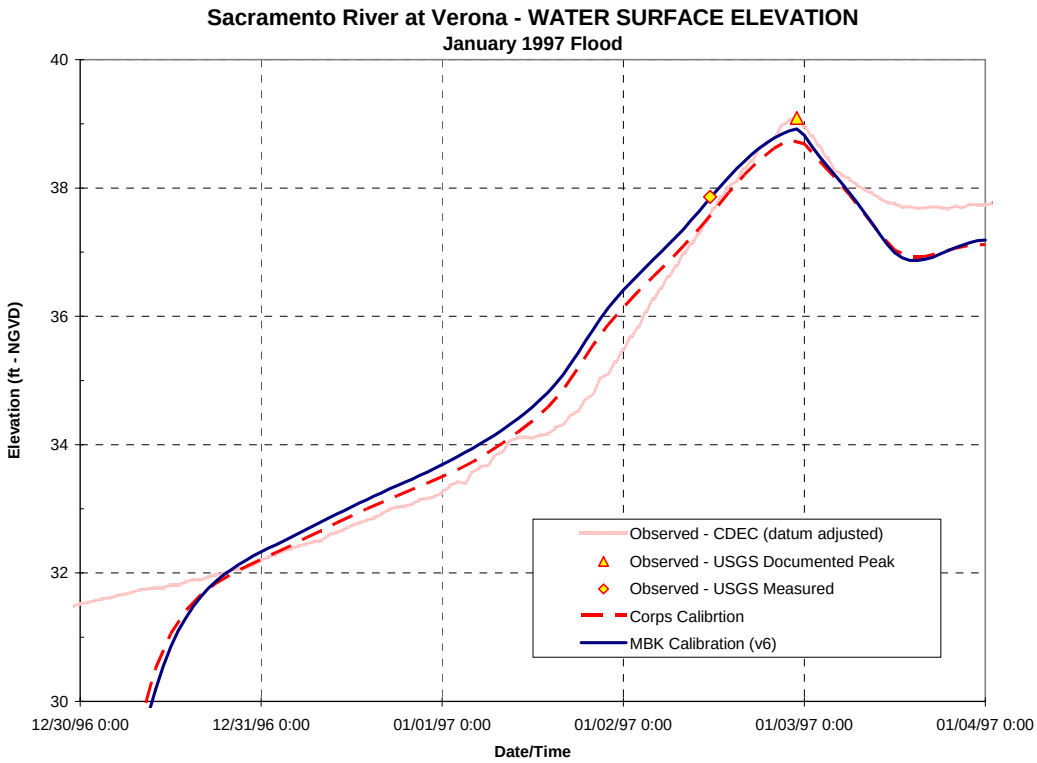


FIGURE 15

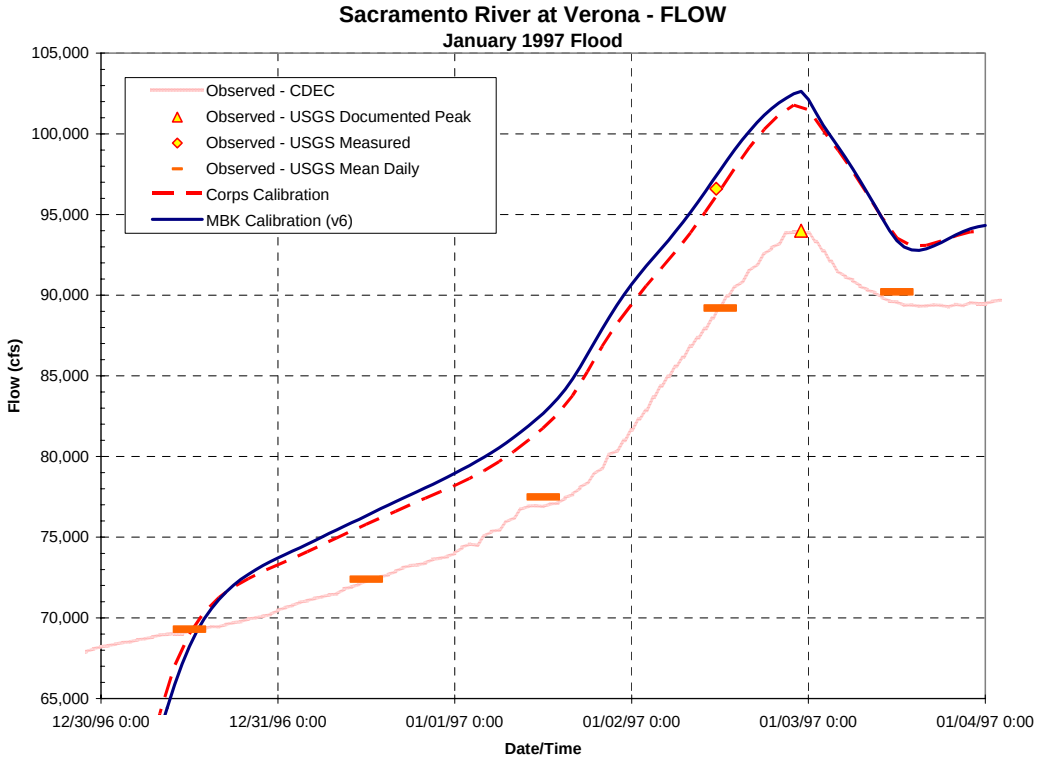


FIGURE 16

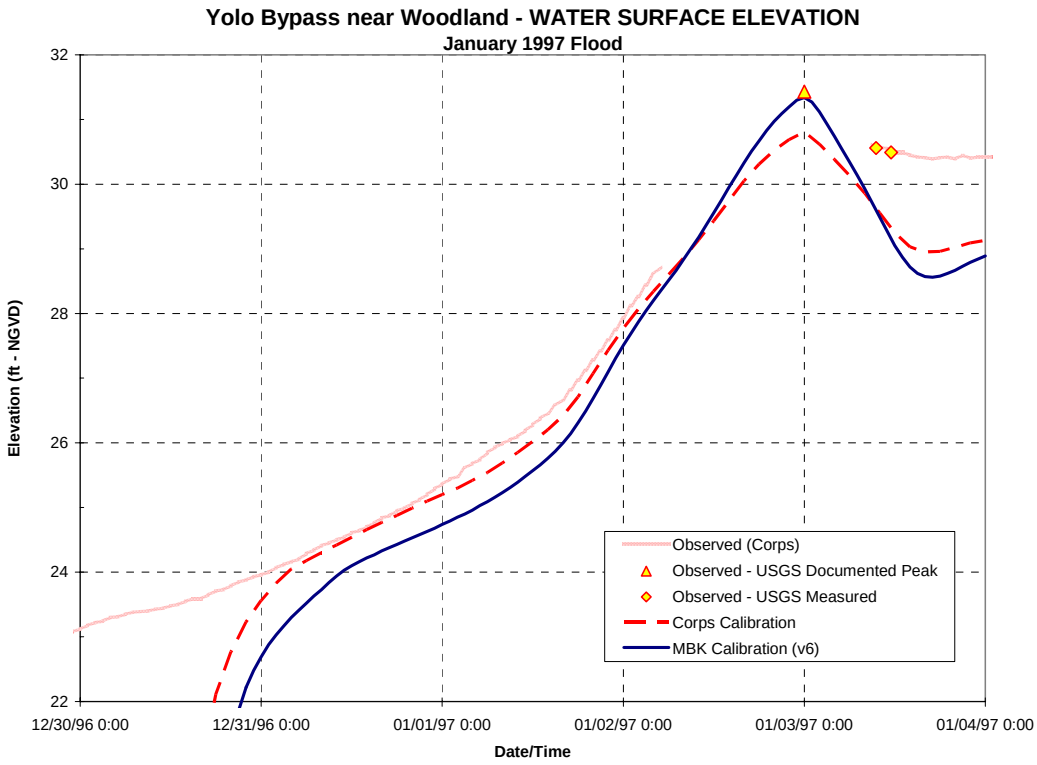


FIGURE 17

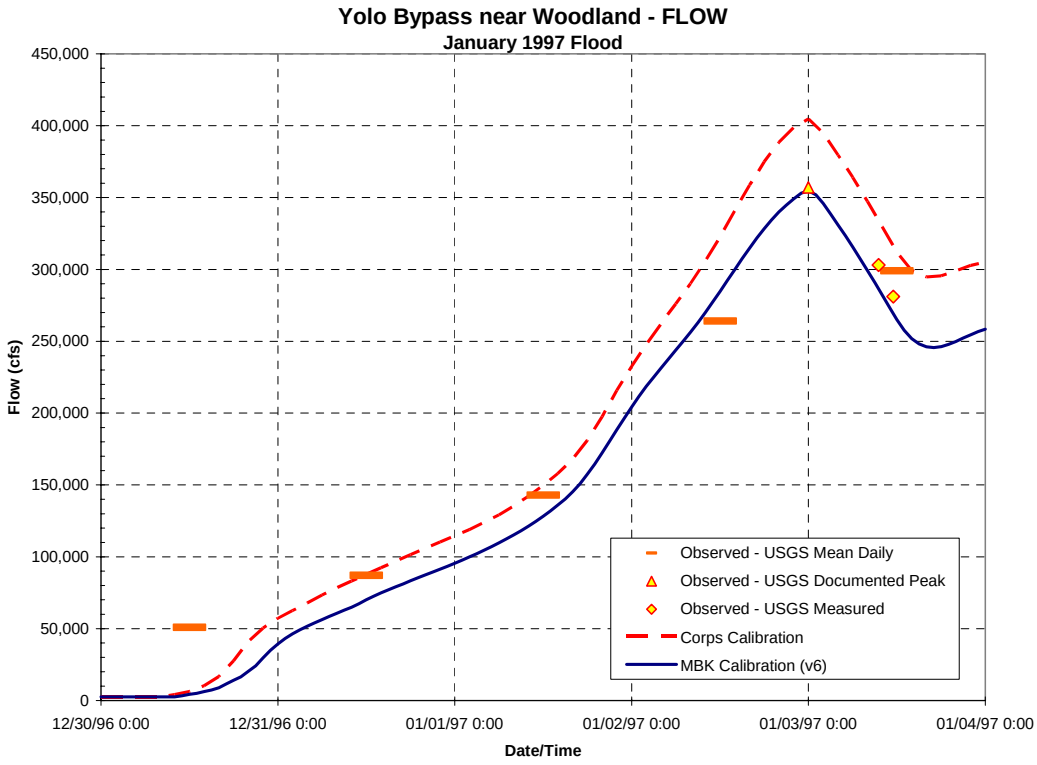


FIGURE 18

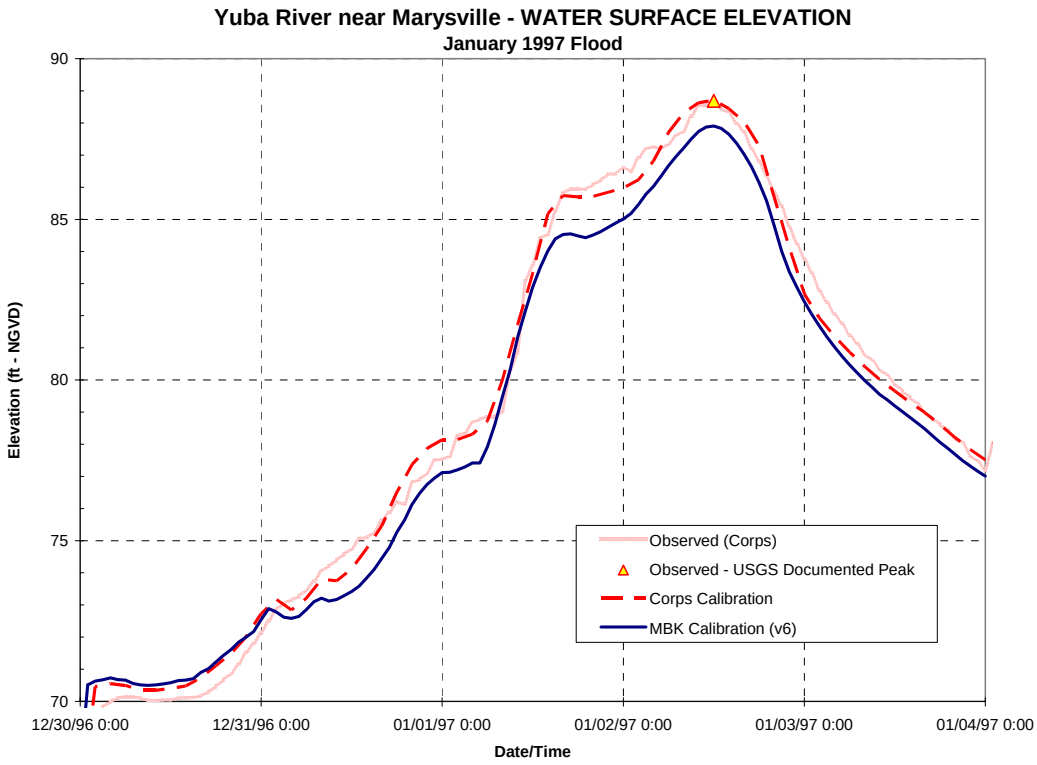


FIGURE 19

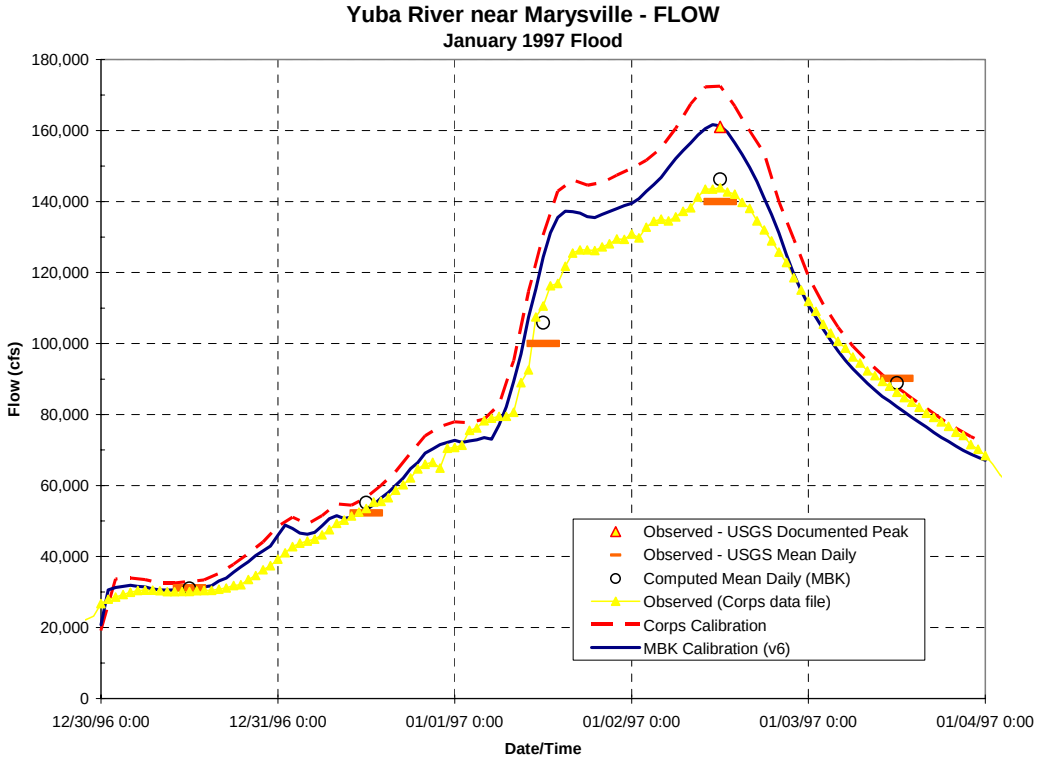
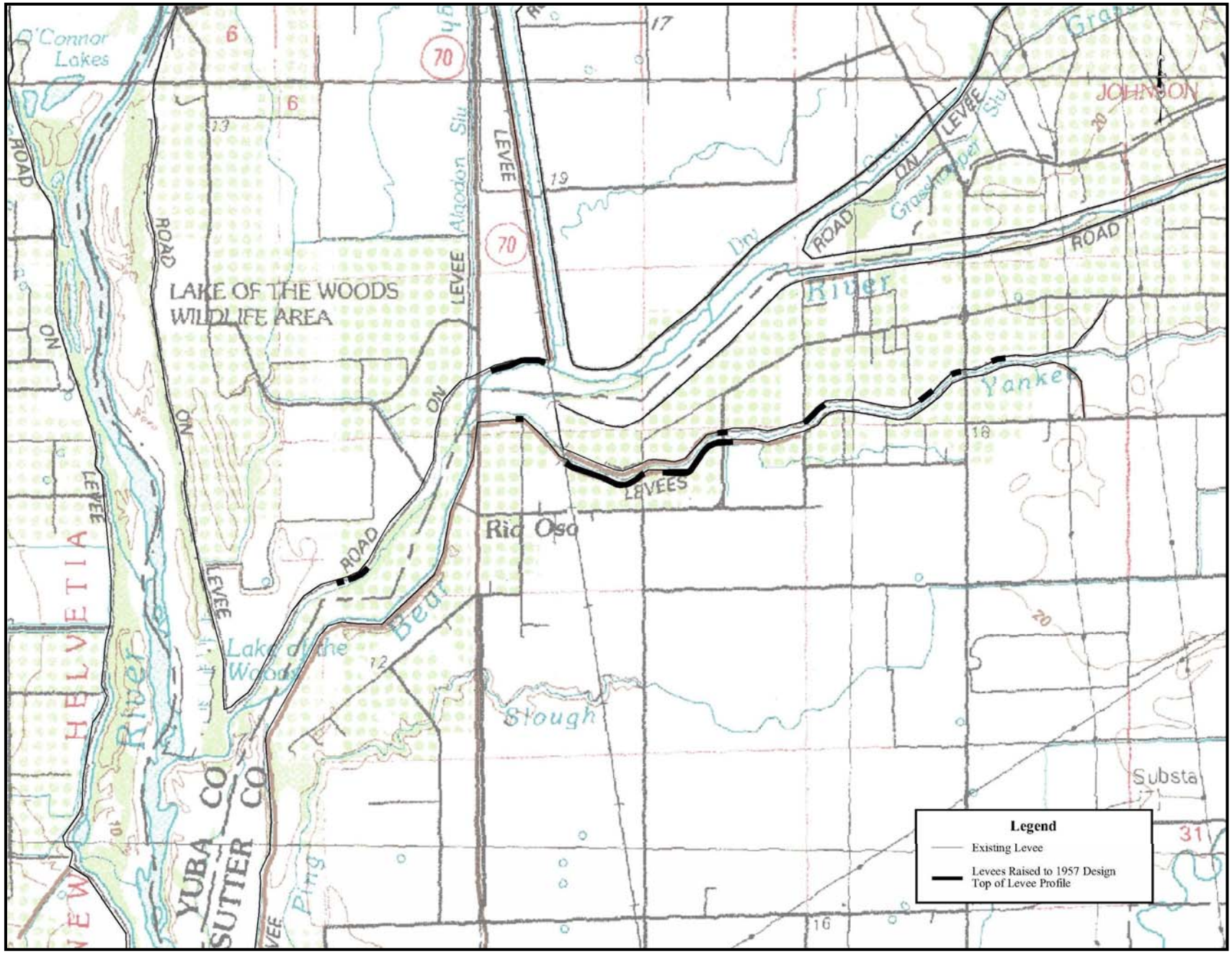
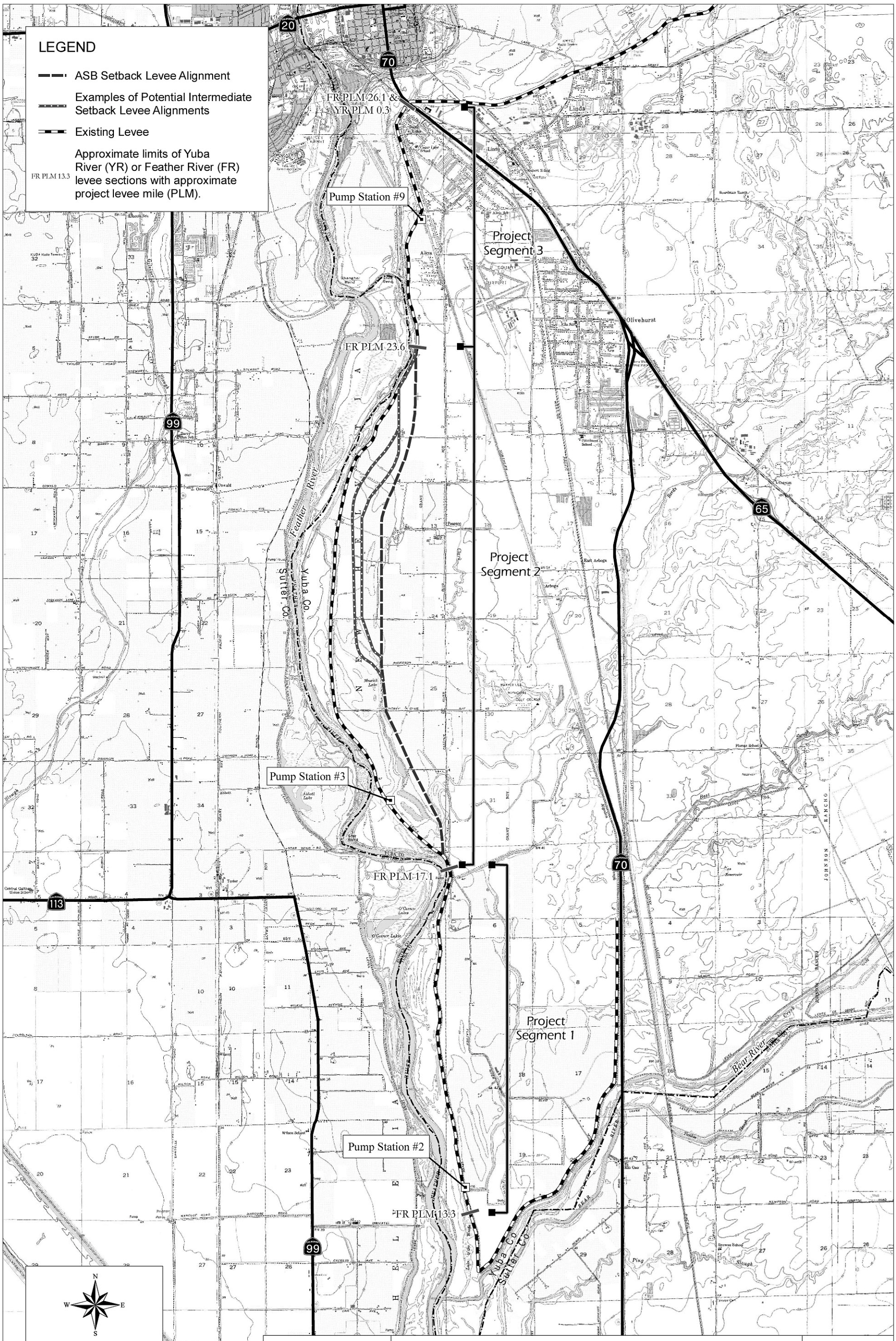


FIGURE 20
Levees Reaches Below 1957 Design Elevation





Bookman-Edmonston
A Division of GEI Consultants

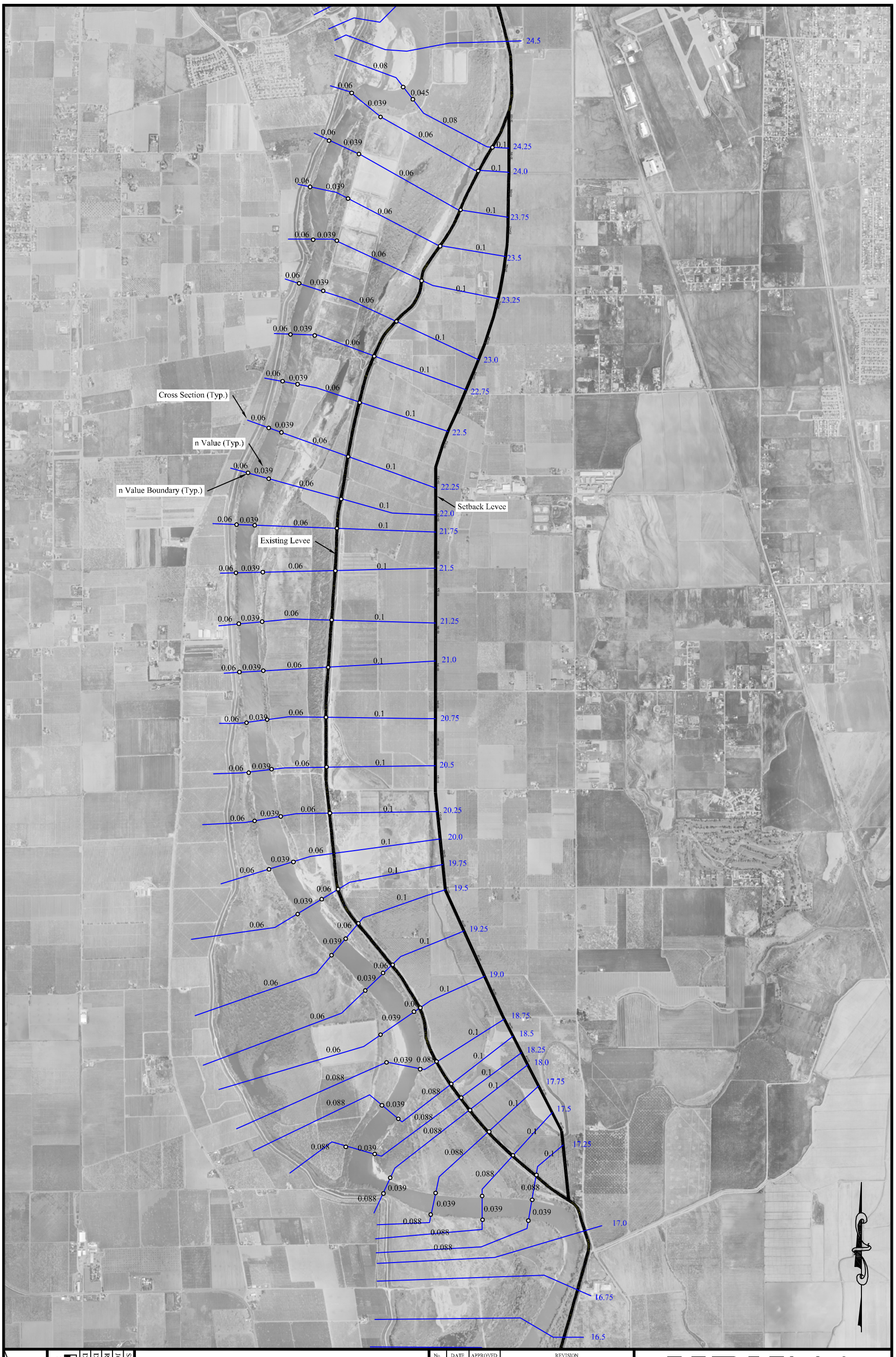
FEATHER RIVER LEVEE REPAIR PROJECT

Project Features

Reclamation District No. 784, Yuba County, California

Sources: EDAW 2004; GEI Consultants, Inc. 2004; Topo baseman provided by GEI Consultants, Inc.

FIGURE 21



Three Rivers Levee Improvement Authority
Phase IV

Alternative 2 Project Features

No.	DATE	APPROVED	REVISION

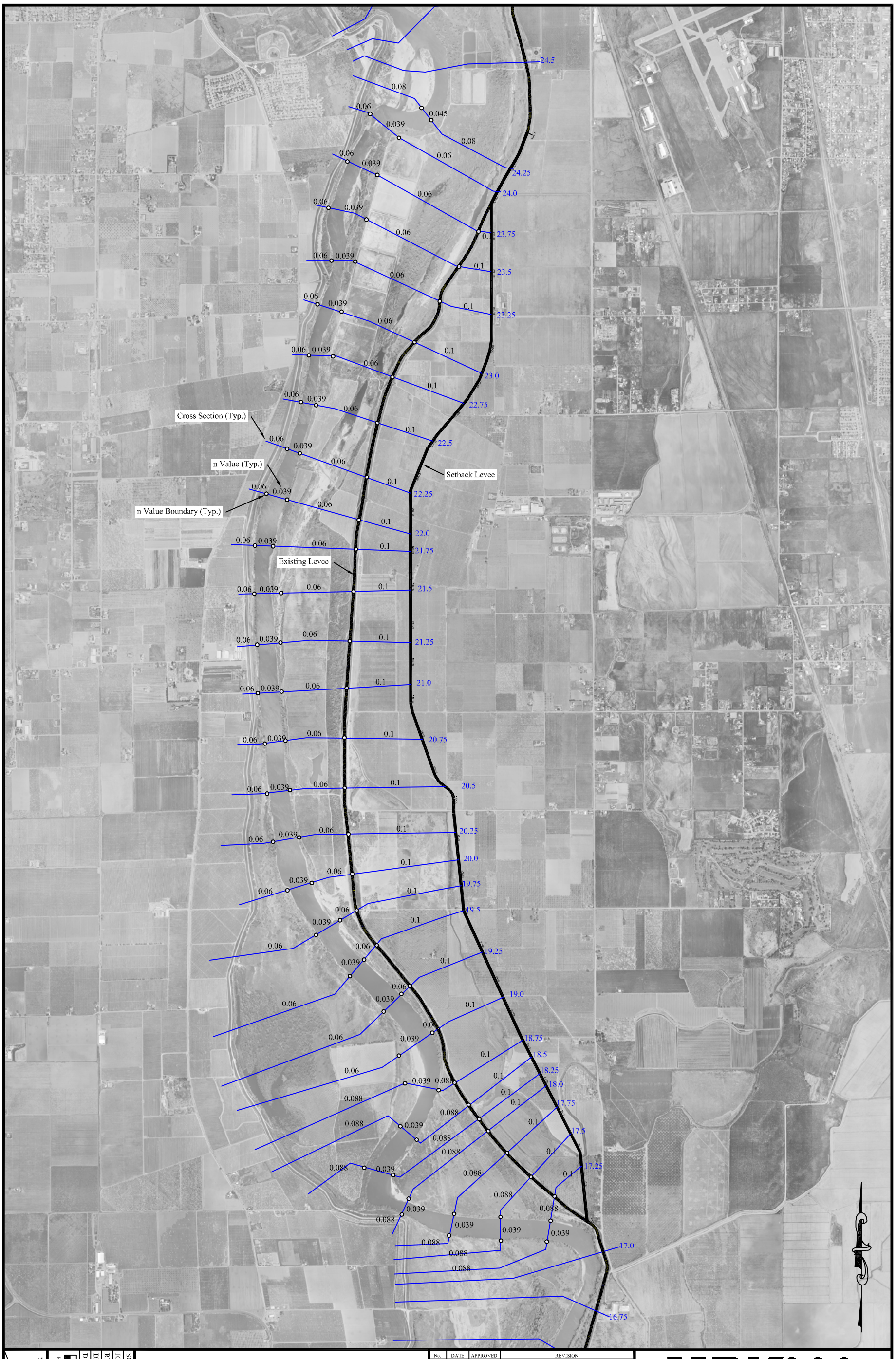
SCALE: 1" = 2500'
JOB NUMBER: 5141
REQUESTED BY: DT
DRAWN BY: DT
DATE: May 2006

Bar Length On Original Drawing Equals One Inch. Adjust Scale Accordingly.

SHEET 1 OF 1 SHEETS

MBK ENGINEERS
2450 Alhambra Boulevard, 2nd Floor
Sacramento, California 95817
Phone: (916) 456-4400 • Fax: (916) 456-0253

FIGURE 22



Three Rivers Levee Improvement Authority
Phase IV

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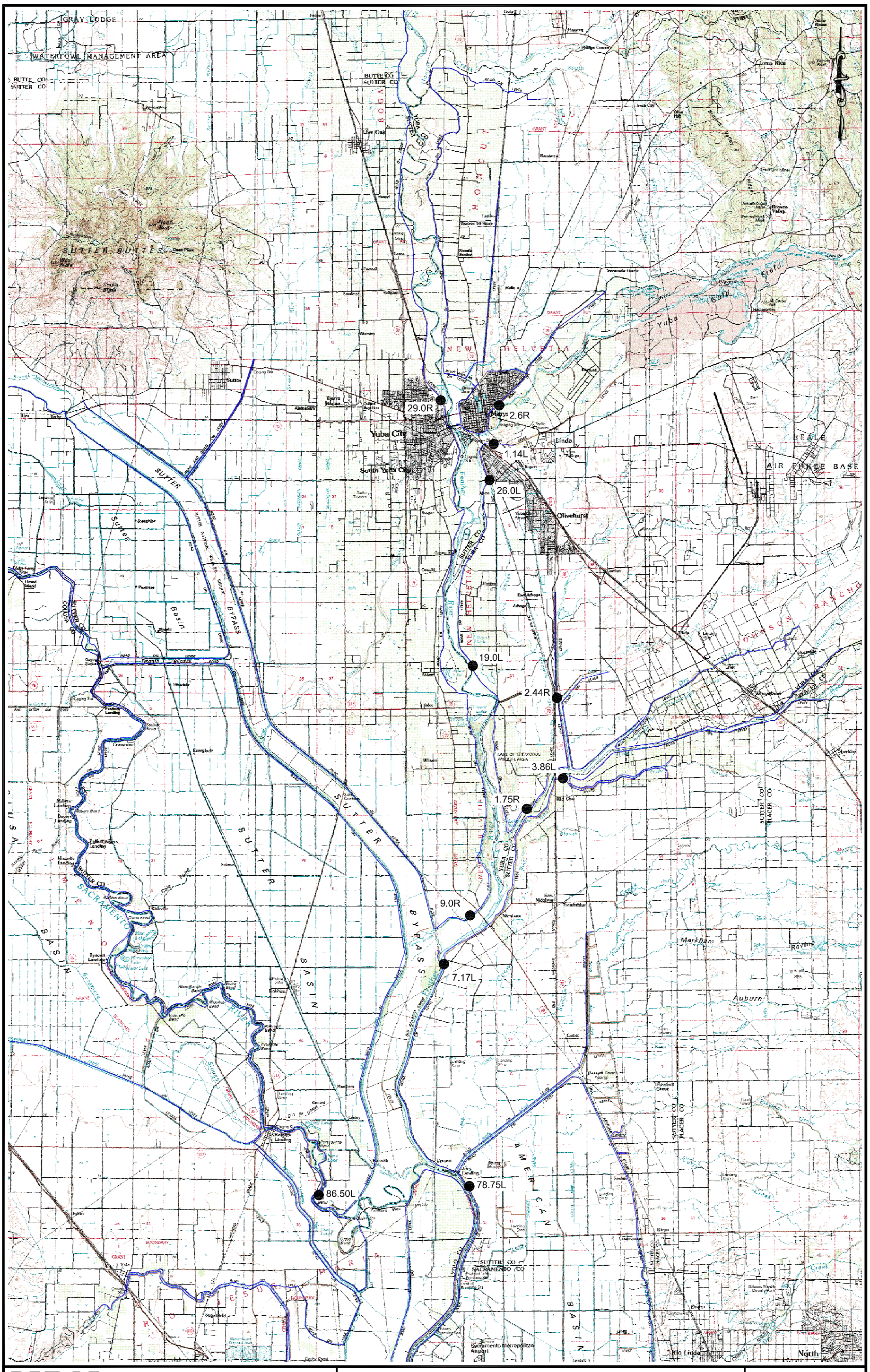
SHEET 1 OF 1 SHEETS

MBK ENGINEERS
2450 Alhambra Boulevard, 2nd Floor
Sacramento, California 95817
Phone: (916) 456-4400 • Fax: (916) 456-0253

FIGURE 23



MBK ENGINEERS
2450 Alhambra Boulevard, 2nd Floor
Sacramento, California 95817
(916) 456-4400

Feather River Levee Repair Project

Flood Impact Index Points

0 1.5 3
Scale in Miles

FIGURE 24

FIGURE 25

Feather River (RM 6 to 22)
1-in-100 AEP Water Surface Profile for Alternative 2

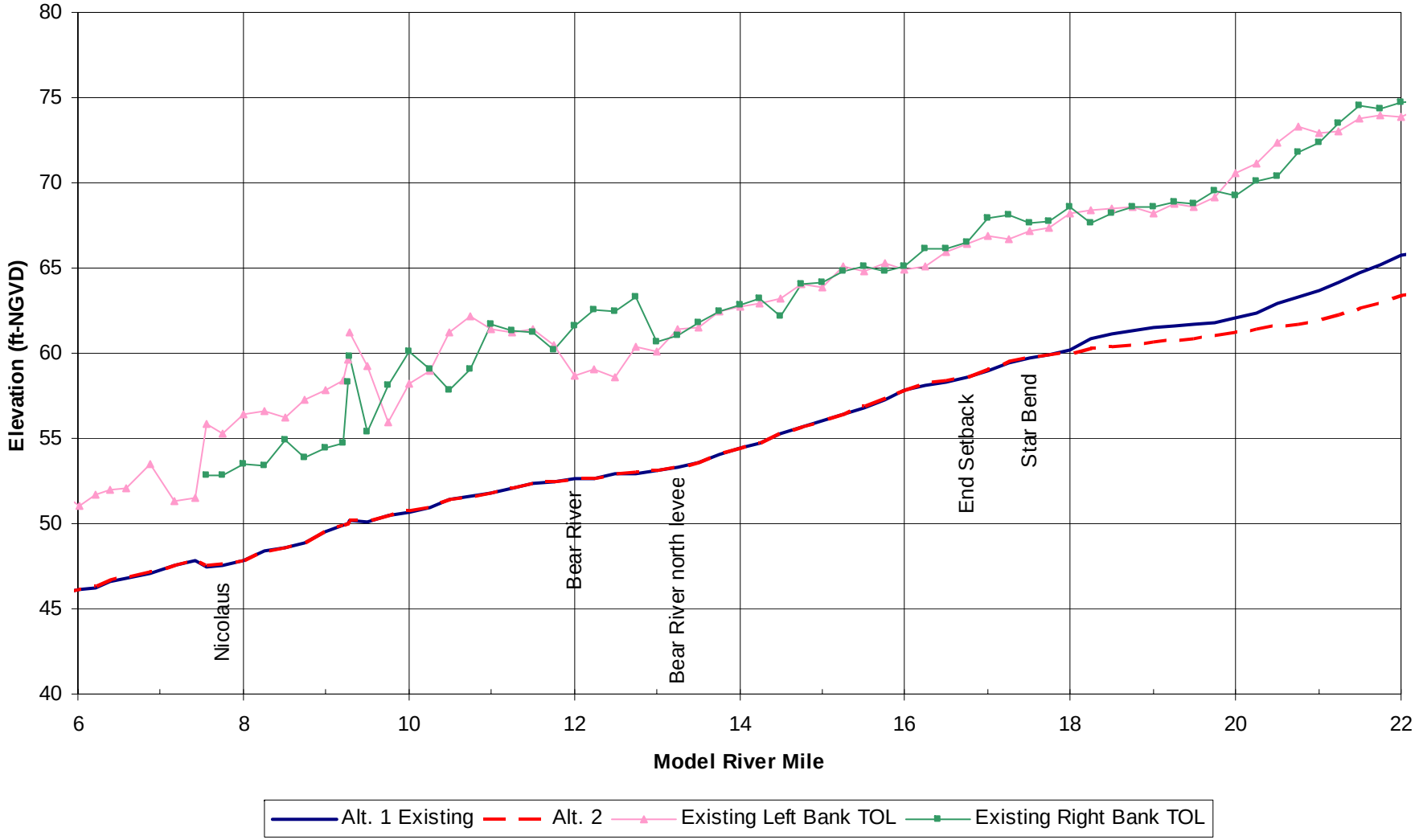


FIGURE 26

Feather River (RM 20 to 36)
1-in-100 AEP Water Surface Profile for Alternative 2

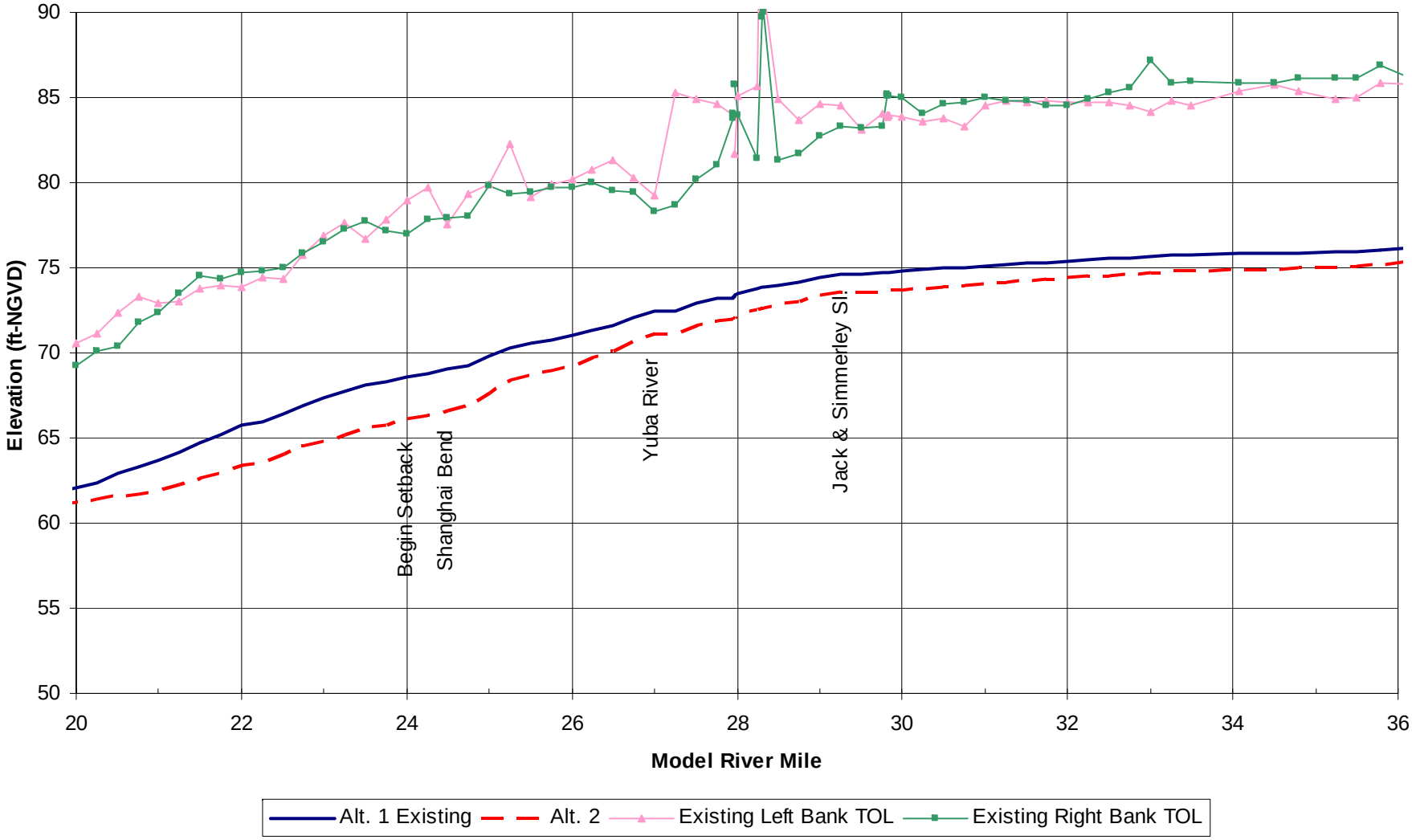


FIGURE 27

Feather River RM (34 to 50)
1-in-100 AEP Water Surface Profile for Alternative 2

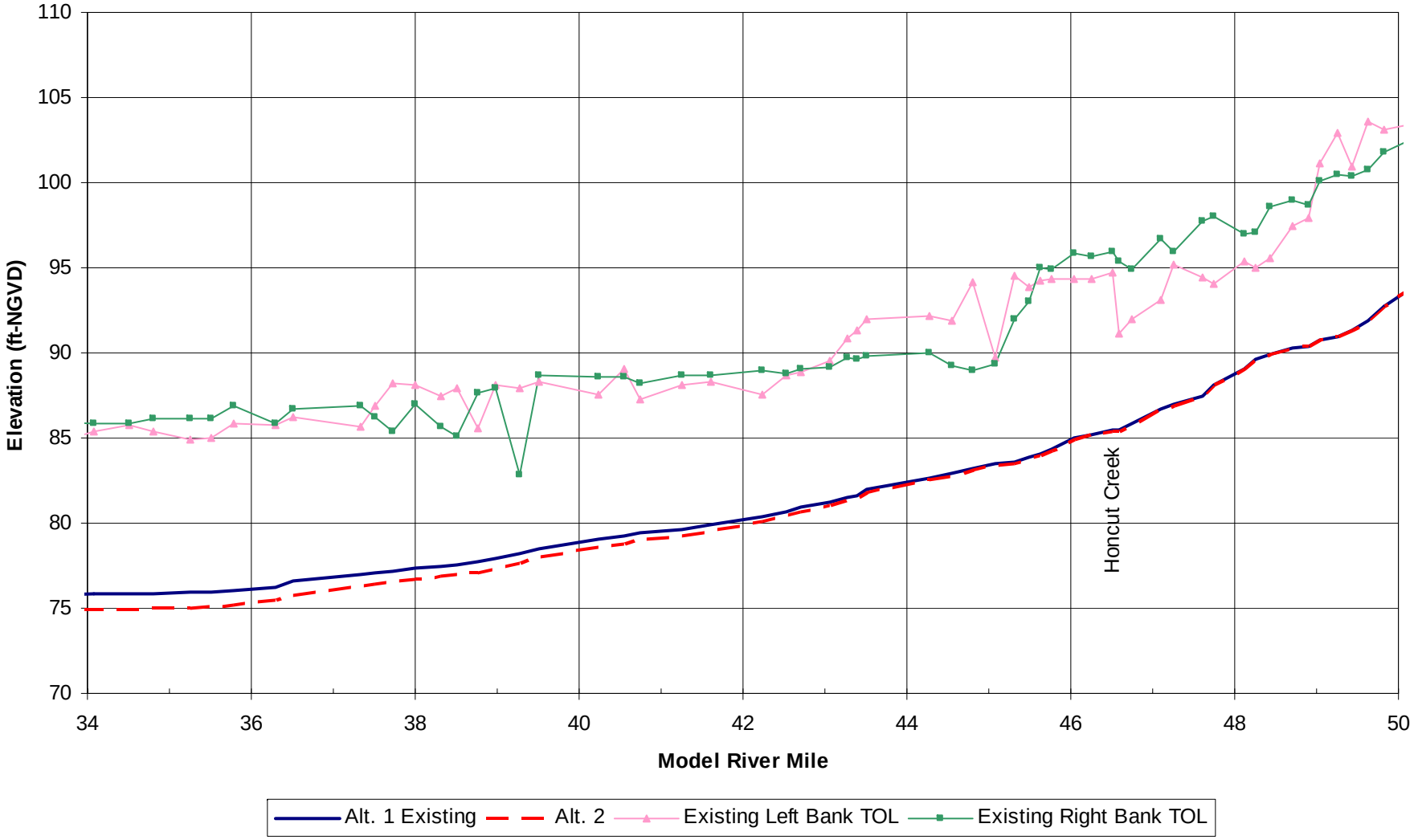


FIGURE 28

Feather River (RM 6 to 22)
1-in-200 AEP Water Surface Profile for Alternative 2

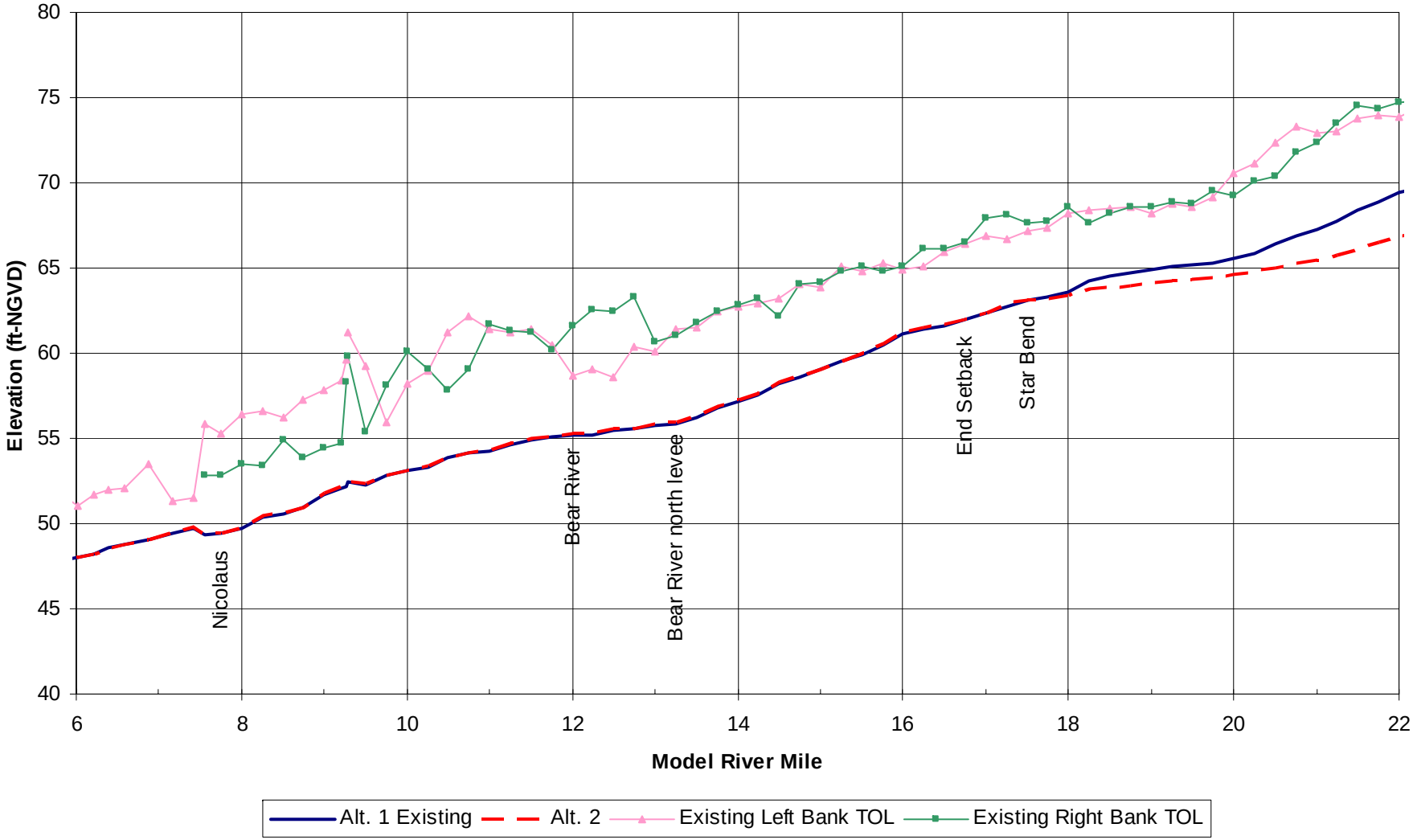


FIGURE 29

Feather River (RM 20 to 36)
1-in-200 AEP Water Surface Profile for Alternative 2

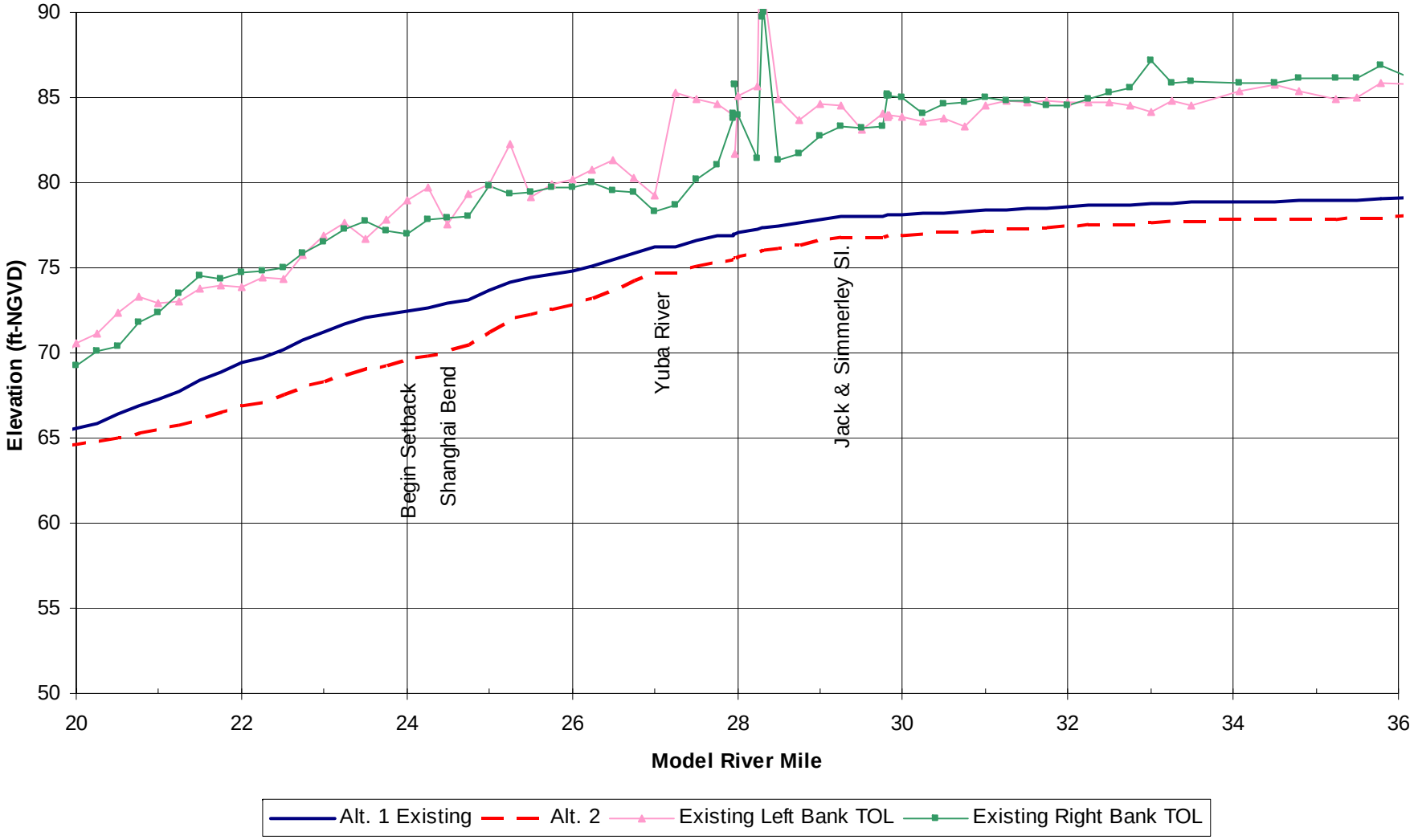


FIGURE 30

Feather River RM (34 to 50)
1-in-200 AEP Water Surface Profile for Alternative 2

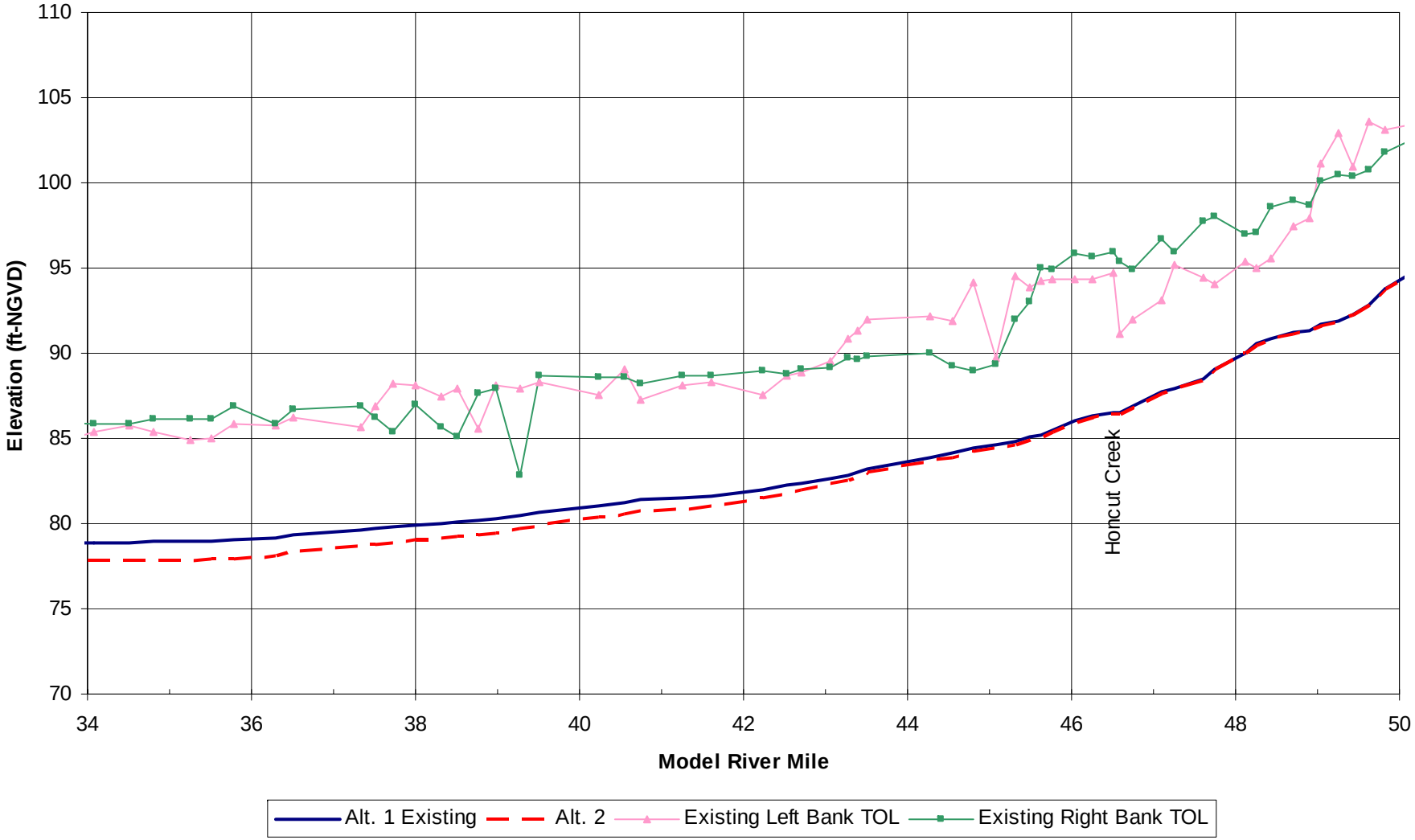


FIGURE 31

Feather River (RM 6 to 22)
1-in-100 AEP Water Surface Profile for Alternative 3

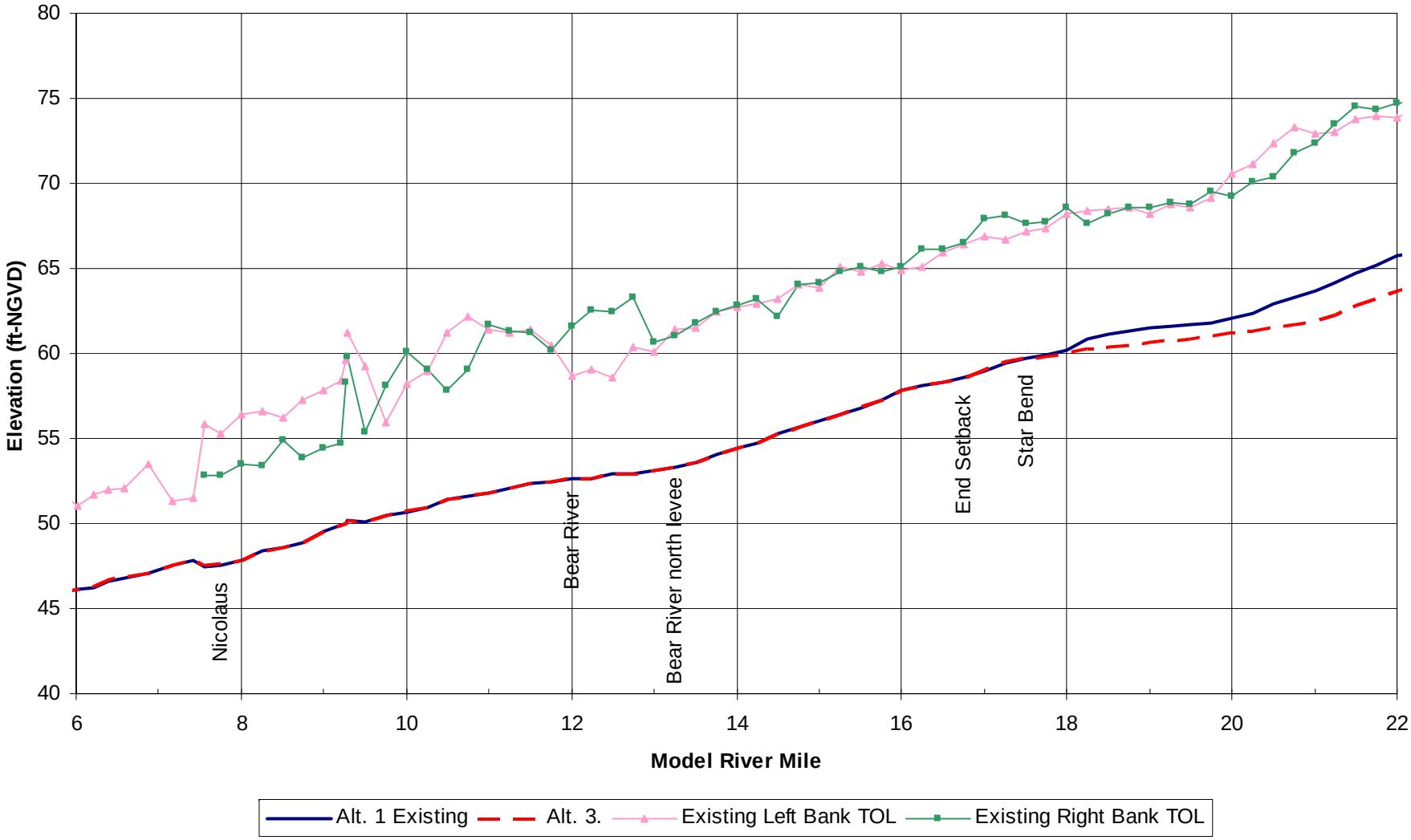


FIGURE 32

Feather River (RM 20 to 36)
1-in-100 AEP Water Surface Profile for Alternative 3

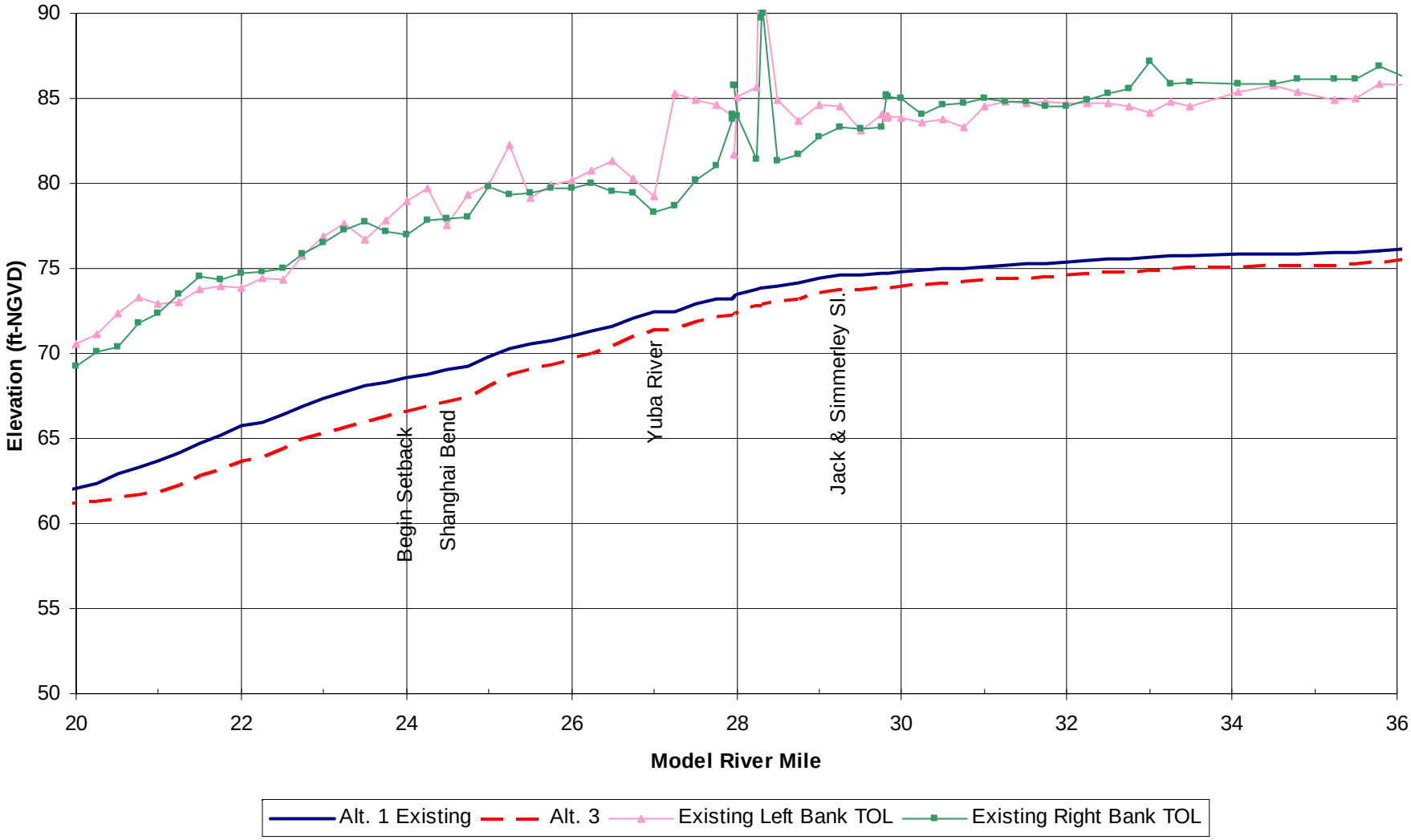


FIGURE 33

Feather River RM (34 to 50)
1-in-100 AEP Water Surface Profile for Alternative 3

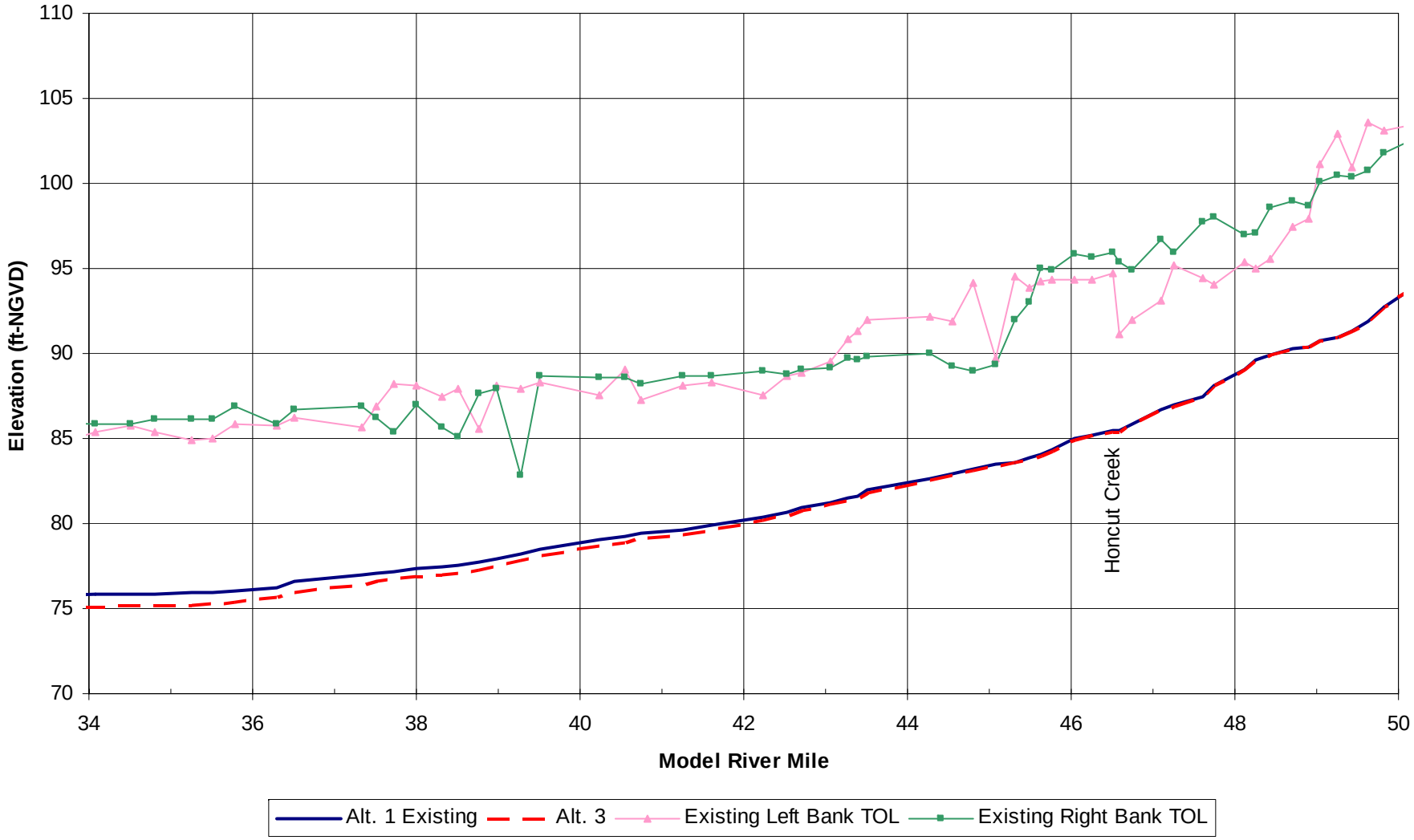


FIGURE 34

Feather River (RM 6 to 22)
1-in-200 AEP Water Surface Profile for Alternative 3

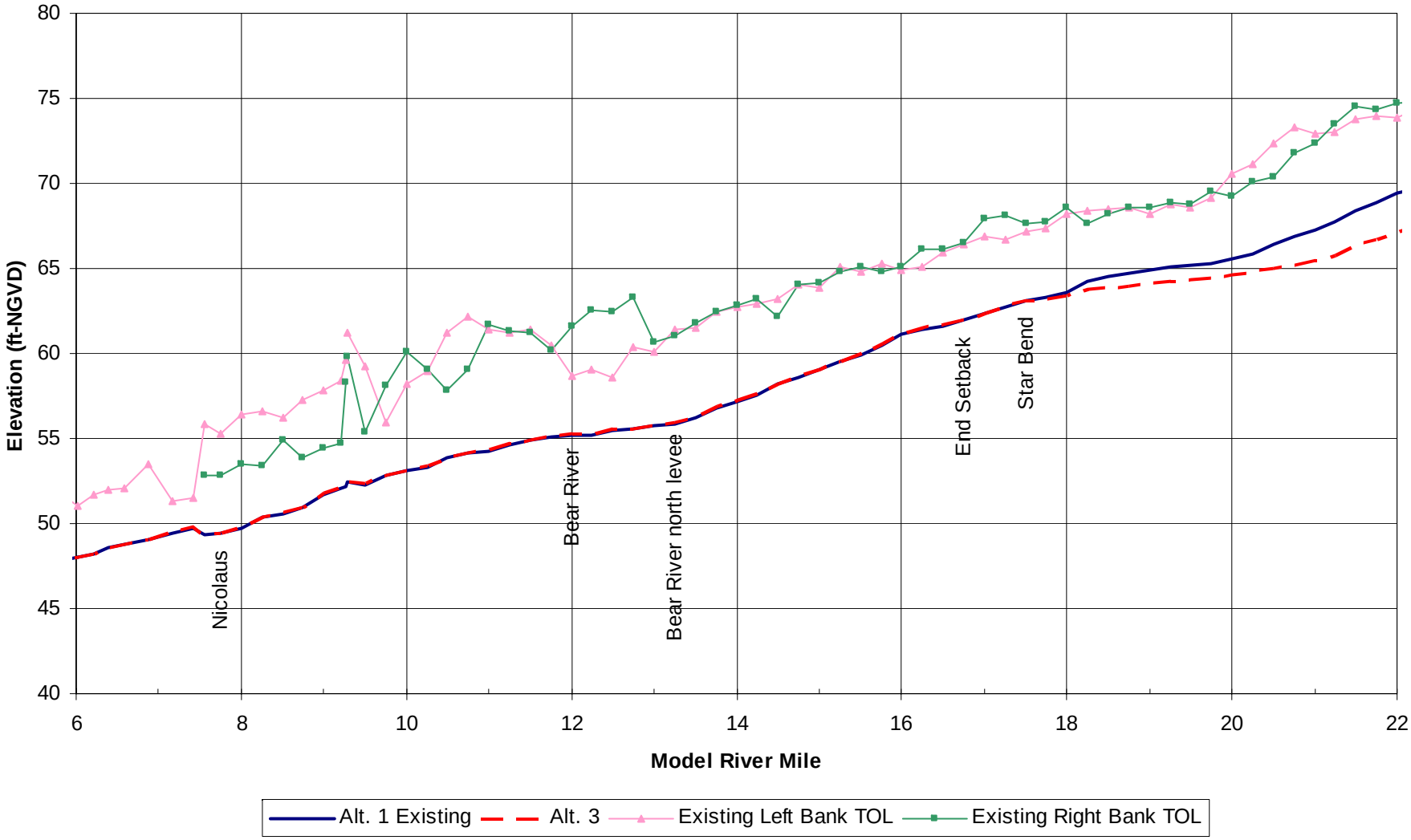


FIGURE 35

Feather River (RM 20 to 36)
1-in-200 AEP Water Surface Profile for Alternative 3

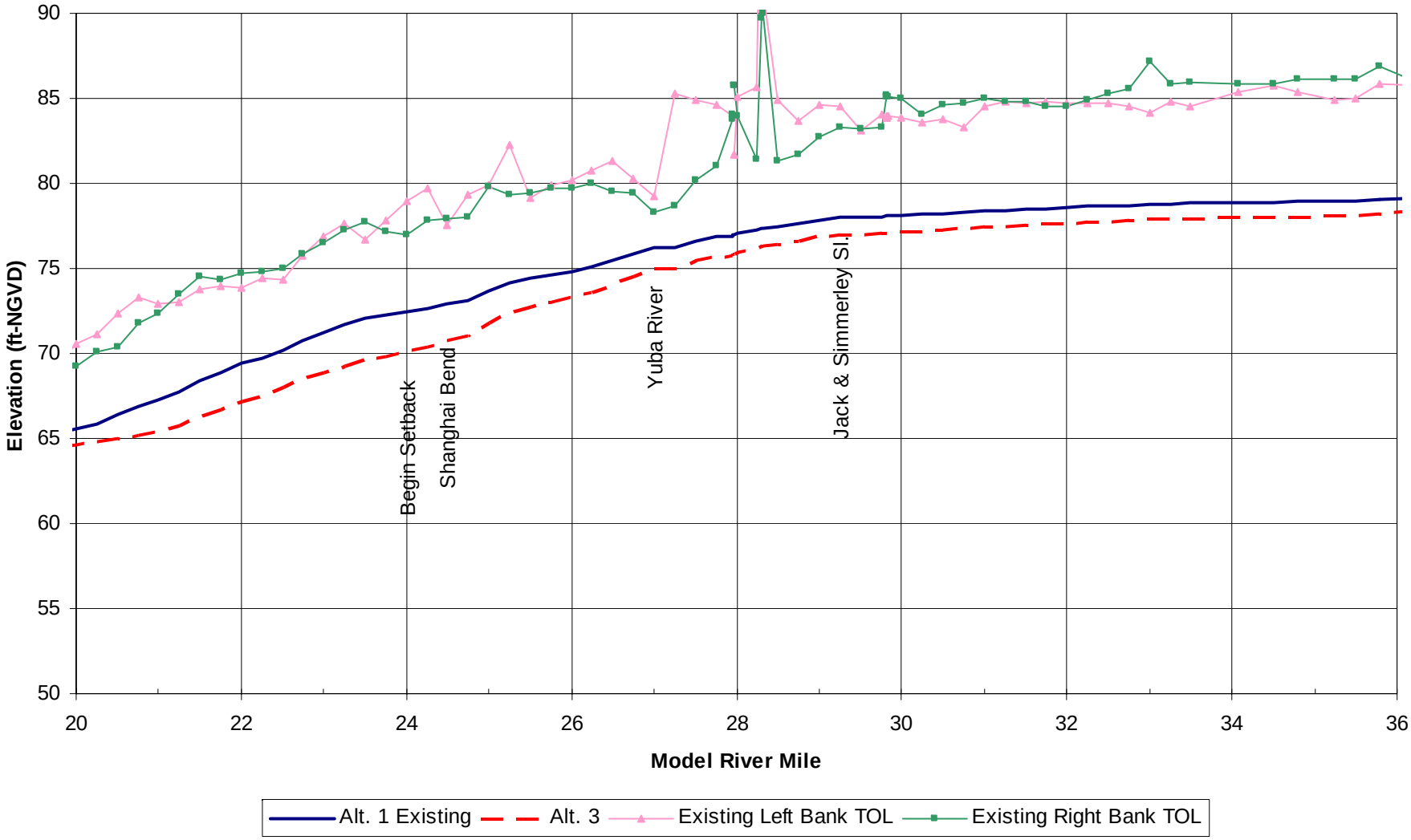
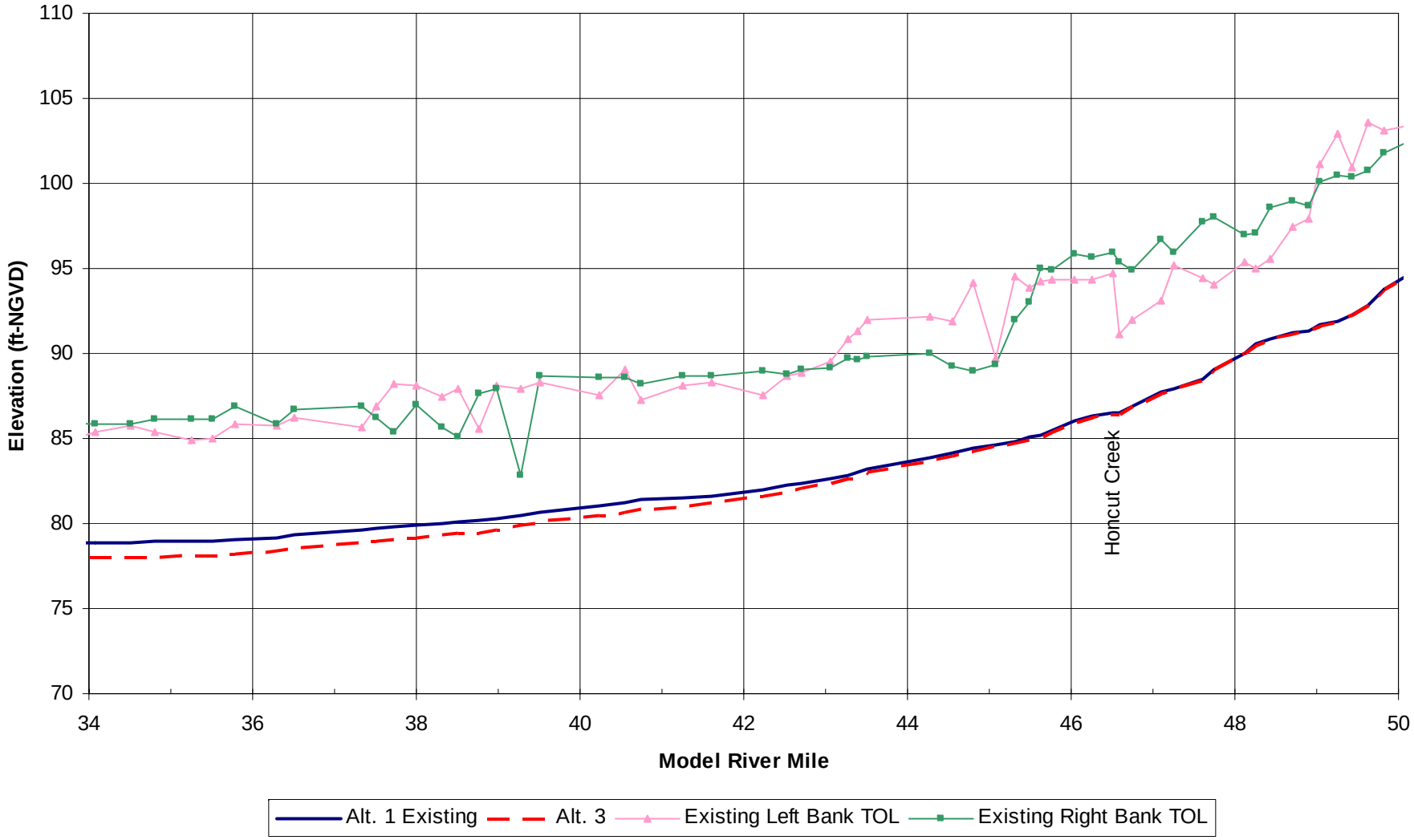
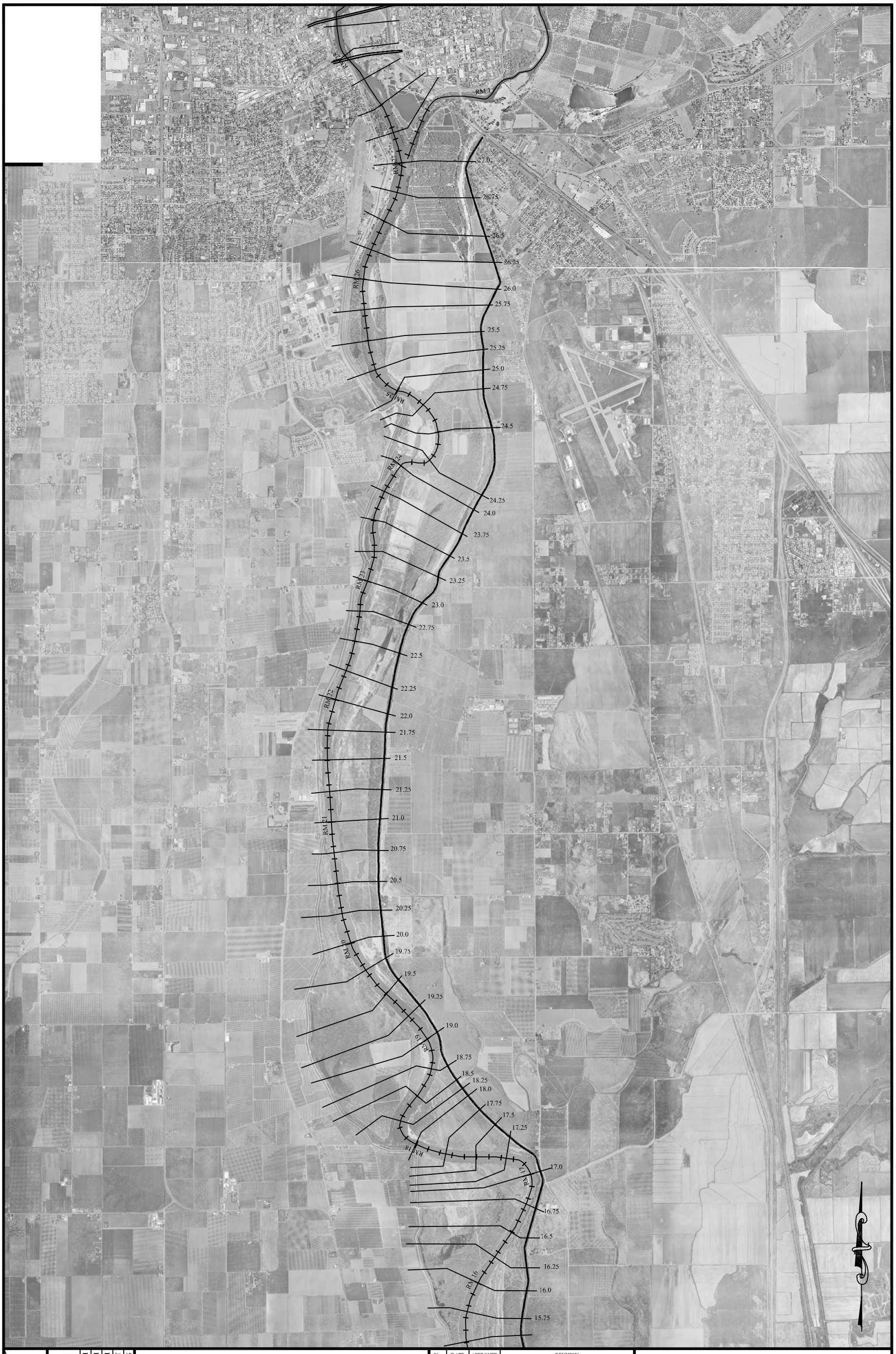


FIGURE 36

Feather River RM (34 to 50)
1-in-200 AEP Water Surface Profile for Alternative 3





Three Rivers Levee Improvement Authority
Phase IV

Feather River Cross Section Locations

No.	DATE	APPROVED	REVISION

MBK ENGINEERS
2450 Alhambra Boulevard, 2nd Floor
Sacramento, California 95817
Phone: (916) 456-4400 • Fax: (916) 456-0253

SCALE: 1" = 4000'
JOB NUMBER: 5141
REQUESTED BY: DT
DRAWN BY: DT
DATE: May 2006

Bar Length On Original Drawing Equals One Inch. Adjust Scale Accordingly.

SHEET 1 OF 1 SHEETS

FIGURE 37

Associated Technical Memorandum on the Local and Systemwide Hydraulic Effects of the Segment 2 Setback Levee

MBK ENGINEERS

Water Resources • Flood Control • Water Rights

TECHNICAL M E M O R A N D U M

October 17, 2007

1. LOCAL AND SYSTEMWIDE HYDRAULIC EFFECTS OF THE FEATHER RIVER SETBACK LEVEE MODIFICATION

Model Development

Potential impacts of the Feather Setback Levee were evaluated using state-of-the-art hydraulic models and hydrology data obtained from the Corps of Engineers. TRLIA obtained a version of the Corps HEC-RAS model of the Feather-Yuba Rivers and refined and recalibrated that model using different and additional data. All refinements made to the model were made 1) to improve the calibration, 2) extend the upstream reach on the Sutter Bypass, and 3) refine the model for the economic analysis that was performed on the TRLIA Construction Program. The hydrologic and hydraulic models used for this study are described in the MBK Engineers report titled *Hydraulic and Hydrologic Analysis of the Three River's Levee Improvement Authority's Phase IV Project, Basis of Design for Feather River Setback Levee Project*, dated July 2007. The 1-in-100 and 1-in-200 AEP floods were routed through Lake Oroville and New Bullards Bar Reservoir for hypothetical storms centered over either the Feather River or Yuba River watershed. The resultant flows were routed through the flood system down to the location of Verona, on the Sacramento River immediately downstream of the confluence with the Feather River. Water surface profiles were calculated for each flood event. The Shanghai-Yuba centering (i.e., location in the hydrologic model where a storm is focused) provided the highest water surface elevations along the Feather and Yuba Rivers and also along the lower Bear River. The model extends far enough downstream of the setback levee to demonstrate the without and with modification hydraulic impacts to a point of convergence. The hydraulic impacts of the setback levee were evaluated through modeling of the Sacramento River Flood Protection Project (SRFCP) design discharges, the 100-year discharge, and the 200-year discharge under existing conditions in the project vicinity for without and with proposed modified conditions.

System Levee Performance Assumptions

An important assumption in performing hydraulic simulations of levee systems on a regional basis is defining if, when, and how levee failures will occur. The analysis of the setback levee for impact purposes assumes that levees would not fail before or after overtopping. Top-of-levee profiles were compared to the SRFCP Design Profile plus three feet of freeboard (as defined in the 1953 MOU and as shown on the 1957 Design Profiles) to determine low spots where levee overtopping could occur. These low locations were defined in the HEC-RAS model for the without project condition. At locations, where the top-of-levee elevations were found to be below SRFCP Design Profile plus three feet, the levees were assumed to be restored to the authorized design elevations. TRLIA made these assumptions because it did not want to analyze or design the setback levee in a way that relied on overtopping at low levee locations to achieve the levee performance objectives since it was reasonable to assume

that levees below authorized design conditions might be fixed. The state and local districts are aware of these low reaches and are expected to restore levees to authorized design elevations in the near future. The assumed modifications occur for short reaches on the Bear River and Yankee Slough and are limited in extent and the amount of raising and do not have a significant impact to the flood system. The computed 200-year water surface elevations did not overtop the levee at these assumed modified reaches.

For the purposes of the hydraulic impact analyses of the setback levee, an assumption was made that upstream levees do not fail when overtopped. This is a conservative assumption for determining hydraulic impacts that is consistent with standard practice for design of flood control levees by the Corps of Engineers. However, it should be noted that the upstream levees do not overtop under SRFCP Design Conditions or during passage of the 200-year flood event. In fact the existing Feather floodway in the vicinity of the setback levee has 3 feet or more of freeboard over the SRFCP Design Flow as well as the 200-year flow, (see Figure 4). The existing top of levee information was obtained by design surveys along the Feather east levee from the Bear Setback levee to the Yuba South Levee in 2006 and from topography gathered by the Corps and the California Department of Water Resources (DWR) Comprehensive Study in 2000. The 200-year discharge in the Feather River along the setback levee is approximately 350,000 cfs. The 1957 Design Discharge is 300,000. It might seem incongruent for the current existing 200-year profile to be lower than the 1957 Design Profile in some reaches. The 1957 Design Profile associated with the 300,000 cfs 1957 Design Discharge was developed based on topography, vegetation and analytical tools that existed in the 1950's. All have changed in the last 50 years. High water marks and current topography along with more precise analytical tools show that the Feather River can convey a 200-year storm event with 3 foot or more of freeboard in the setback reach. Levee stability however is not reliable at these elevations, which brings about the need to perform levee repairs, which in this case is proposed to be a setback levee.

Modeling of the Setback Levee

From PLM 17.1 (Star Bend) to PLM 23.6 (West of the Yuba County Airport) on the Feather River left bank, it is proposed to modify the SRFCP by constructing a setback levee. After acceptance of the setback levee into the SRFCP, portions of the existing levee would be removed to allow water to flow into the new floodway/setback area (i.e., the area between the existing levee and the setback levee) during high river stages.

The proposed setback levee was modeled by modifying the cross sections in the HEC-RAS model to reflect the setback levee alignment, proposed levee degradation, and the Manning's roughness values to reflect the assumed land use in the setback area. The land use between the existing levee and new levee was assumed to be habitat restoration. It is possible that agricultural operations may remain in portions of this area. Since it is unknown what the final land use will be in the setback area, habitat restoration land use was chosen for the simulation to be conservative since it would result in higher water surface elevations. Habitat restoration land use was simulated using a Manning's roughness value of 0.1 compared to a value of 0.6 to reflect agricultural land use. For the area between the riverbank and the existing levee, it was assumed that there would be no land use changes, and the Manning's roughness value remained unchanged.

Hydraulic Impacts of the Setback Levee

For modeling purposes, the current without modification condition was the benchmark condition by which all hydraulic impacts were measured for the setback levee. The without modification condition was represented in the model by the existing conditions (current channel vegetation, geometry, and top-of-levee elevations) of the flood control system as it exists today, except those few short locations along the Bear River and Yankee Slough where the levees are below the 1957 design criteria and were assumed to be raised to the 57 condition as explained above.

The proposed setback levee is designed to (1) decrease flood stages in the Feather River between Shanghai Bend and Star Bend (i.e., along the setback location) by increasing the channel width and, therefore, channel capacity; and (2) provide a well-designed, well-constructed levee using up-to-date technology. Lowering flood stages along this part of the Feather River channel would provide a hydraulic benefit to the system by reducing the backwater effects on flood stages upstream in both the Feather and Yuba Rivers. Hydraulic simulations indicate that the setback levee would lower water levels in the Feather River upstream of Star Bend. For the 1-in-100 and 1-in-200 AEP events, it was determined that the setback levee would lower the water level at the confluence of the Feather and Yuba Rivers (RM 27.0) by 1.3 feet and 1.6 feet, respectively. It would decrease water surface elevations for the SRFCP Design Discharge by 1.5 feet. Construction of the setback levee and related changes in upstream water levels would not affect the Lake Oroville or New Bullards Bar Reservoir dams or change the operation of the reservoirs. TRLIA does not propose an increase of the objective flow on the Feather River. Lowering flood stages and replacing the existing levee with a well-designed, well-constructed levee using up-to-date construction standards reduces the potential for levee failures in this channel reach that has historically been plagued by levee instability and failures. The effects of the levee setback to local flood protection are beneficial.

The proposed setback levee would increase flood storage capacity along the Feather River channel. Under most conditions, this would help attenuate downstream flows. However, because the levee setback would lower water levels upstream (which reduces the amount of instream transient storage during a flood event), flows in the Feather River just downstream of the setback levee increase slightly. The hydraulic simulations indicate that the Feather River peak flow just downstream of the setback levee during a 1.0% (or 1:100) annual chance of exceedence flood event would increase from 271,938 cfs to 272,406 cfs, an increase of 468 cfs which is less than 0.2%. The slight increase in flows would result in a negligible increase in the water surface elevation (calculated as 0.02 foot) in the Feather River from the southern end of the setback levee to the confluence with the Bear River. There would be no measurable increase in flood stage elevations downstream of the Bear River. For the 0.5% (1:200) annual chance of exceedence flood event, the flows would increase from 347,031 cfs to 348,879 cfs, an increase of 1,848 cfs (less than 0.6%). The water surface elevation in the Feather River from the southern end of the setback levee to the confluence with the Bear River would increase by less than 0.1 foot (calculated as 0.08) foot as a result of the increased flow. Again, there would be no measurable increase in flood stage elevations downstream of the Bear River.

Tables 1 and 2 show the hydraulic impacts of the proposed setback levee in the Feather-Yuba system. The without project condition for these tables includes the construction of all TRLIA Levee Repair Phases

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Table 1. Hydraulic Impacts to Maximum Stage, 1-in-100 AEP Without Project Condition Includes Construction of All TRLIA Repair Phases

		Without Project	Proposed Setback Levee	
River	Model River Mile	Maximum Stage (ft-NGVD)	Maximum Stage (ft-NGVD)	Impact (ft.)
Bear	3.44	55.8	55.8	0
Feather	9.0	49.5	49.6	0.1
Feather	19.0	61.7	60.9	-0.8
Feather	26.0	71.4	69.6	-1.8
Feather	29.0	75.1	74.2	-0.9
Yuba	1.14	73.7	72.6	-1.1
Yuba	2.6	74.7	73.9	-0.8

Table 2. Hydraulic Impacts to Maximum Stage, 1-in-200 AEP Without Project Condition Includes Construction of All TRLIA Repair Phases

		Without Project	Proposed Setback Levee	
River	Model River Mile	Maximum Stage (ft-NGVD)	Maximum Stage (ft-NGVD)	Impact (ft.)
Bear	3.44	57.7	57.7	0
Feather	9.0	51.7	51.7	0
Feather	19.0	64.9	64.1	-0.8
Feather	26.0	74.8	72.8	-2
Feather	29.0	78.2	77.1	-1.1
Yuba	1.14	77.3	75.9	-1.4
Yuba	2.6	78.4	77.2	-1.2

It should be noted that the hydraulic model used for this analysis does not take into account the Forecast-Coordinated Operations (F-CO) of Lake Oroville and New Bullards Bar Reservoir completing implementation this year. The F-CO is a cooperative planning and model development process that is directed toward strengthening flood control operations for the Yuba and Feather Rivers by improving flood forecasts, closely coordinating the flood operations of Lake Oroville and New Bullards Bar Reservoir, improving operational procedures, and providing for improved communication and real-time forecast information to reservoir operators and downstream emergency managers. With implementation of the F-CO,

any increases in downstream discharges associated with modification of the SRFCP by the setback levee would be eliminated. Specifically, any discharge increase would be mitigated as part of the operation of Lake Oroville and New Bullards Bar Reservoir. Operating rules and objective releases for these two reservoirs will not be changed by the FCO or construction of the setback levee. The operating rules for the reservoirs will still require that adjustments in reservoir outflows be made to control flows to the objective releases given in Table 3. The FCO will increase the reliability and effectiveness of reservoir operations to meet the objective discharges in the system. The coordinated operation of the reservoirs and the improved forecasting that are part of the F-CO will mitigate the slight increase in flows due to the improved hydraulics of the Feather River. A small adjustment (perhaps as much as 2,000 cfs for the 200-year event) in the reservoir operation (a normal occurrence under existing operation criteria) might be made to maintain flows in the Feather River at or below the prescribed objective flows.

The SRFCP, based on the 1953 Corps/State Memorandum of Understanding (1953 MOU), called for the levees to contain the flows shown in Table 3 with at least 3 feet of freeboard. The authorization of Oroville and New Bullards Bar Dams included objective flows for flood control at certain locations below the reservoirs. These are also shown in Table 3.

Table 3. 1957 Design Flows and Current Objective Flows

Location	Design Flow 1957 MOU	Objective Flows Established by Oroville / New Bullards Bar Authorization[1/]
Feather R. Upstream from Yuba R.	210,000 cfs	180,000 cfs
Feather R. Downstream from Yuba R.	300,000 cfs	300,000 cfs
Feather R. Downstream from Bear R.	320,000 cfs	320,000 cfs
Yuba R. above confluence with Feather R.	120,000 cfs	120,000 cfs to 180,000 cfs depending on Feather River flow
Bear R. above confluence with Feather R.	40,000 cfs	40,000 cfs

1/ Objective flows were adopted in federal regulation (see Title 33, Chapt. II, part 208). These reservoir operation rules are governed by federal regulation and have the force of law.

It is estimated that the objective flows can be maintained up to an approximate recurrence interval of once every 125-years. With the F-CO in place, there will not be any impact to the system design flows due to the proposed modification because objective flows will not change and operating rules will not change. The most significant impact of the proposed setback levee is to provide additional freeboard for the levees upstream of Star Bend on the Feather River. Operation at the downstream Fremont Weir will not change as a result of the Feather River setback levee and no measurable changes to water surface elevations will occur.

The SRFCP 1957 Design Profile was based on a “Steady State” analysis using the design discharges. That is; hydrographs were not routed through the system using a hydraulic model.

Instead, hydrologic routings were performed that made certain assumptions as to timing of the flood waves (based on historical flood experience). The maximum flows were then analyzed with a hydraulic model assuming constant (steady state) flows. It is unknown at this time all of the assumptions that were made to calculate the 1957 Design Profile as to timing, etc. To determine the impacts of the proposed setback levee on the SRFCP Design Flows, TRLIA performed a simulation with the current HEC-RAS model in the "Steady State" mode using the 1957 Design Discharges from Table 3 for the without and with modified conditions. Figure 5 compares the steady state water surface profiles for without and with modified conditions. It also shows the 1957 Design Profile for the Feather River. Table 4 lists the water surface elevation differences for the SRFCP Design Discharges.

Table 4. Hydraulic Impacts to Maximum Stage, SRFCP Design Discharge
Without Project Condition Includes Construction of All TRLIA Repair Phases

		Without Project	Proposed Setback Levee	
River	Model River Mile	Maximum Stage (ft-NGVD)	Maximum Stage (ft-NGVD)	Impact (ft.)
Feather	9.0	48.9	48.9	0
Feather	19.0	63.0	62.0	-1.0
Feather	26.0	72.7	70.8	-1.9
Feather	29.0	77.6	76.6	-1.0

Figure 5 indicates that the 1957 Design Discharge has different elevations for today's existing conditions than what were computed in the 1950's. At the lower end of the Feather River, current computations show that the 57 Design Discharge would have a higher elevation than originally computed. This is caused by changes in the channel topography and a better understanding/analysis of the backwater impacts that occur at the Sacramento/Feather/ Sutter Bypass/Fremont Weir confluence. It is likely the assumed timing of coincident peak flows used in the development of the 1957 Design Profile is substantially different than the timing that is currently indicated and being used. This cannot be explored further because there is no information on this timing in the Corps historic documents. None of the differences shown between the historic design elevations and the current computed elevations for the Design Discharge from Feather RM 0 to 12 are caused by construction of the setback levee and thus do not require mitigation by TRLIA. Figure 5 does show a significant reduction in water surface elevation for the Design Discharge upstream from Star Bend due to construction of the proposed setback levee. As explained earlier, the use of recent topographic information, incorporation of large event calibration information, and the use of more sophisticated analysis tools are thought to give a more accurate determination of existing elevations for the 57 Design Discharge than the elevations developed in the early 1950's and reported on the 1957 Design Profiles. Impacts of the proposed setback levee are best depicted by comparing the without t and with modification project water surface elevations for the 57 Design Discharge using the most recently developed hydraulic model.

Minor modifications to the most recent hydraulic model were necessary to provide consistent results because of evident timing issues of coincident peak flows. The discharges used in the "Steady State" hydraulic model were 180,000 cfs in the Feather River above the Yuba River,

300,000 cfs in the Feather River between the Yuba and Bear Rivers, 320,000 cfs in the Feather River between the Bear River and the Sutter Bypass, and 380,000 cfs in the Feather River below the Sutter Bypass. TRLIA does not believe an "Unsteady Flow" analysis of the 1957 Design Discharges is relevant or advisory at this time because of the complexity involved in establishing a consistent data set.

Water velocities in the floodway are changed by construction of the setback levee. These changes occur in the reach where the setback levee is constructed and upstream of this reach. Velocities downstream of the setback levee remain essentially the same. In general, the following impacts are identified. There is a reduction in velocity across the setback area floodway which should decrease the potential for setback levee erosion. Under the modified condition, the setback floodplain and areas near the proposed setback levee have velocities on the average of 1 foot per second. All maximum velocities near the proposed levee are less than 2 feet per second which should not produce erosion on the vegetated slopes of the proposed levee. Velocities along the channel banks upstream of the setback reach are slightly elevated due to the reduced downstream water surface elevations, which result in increased water slope. These increases could slightly accelerate the rate of existing channel bank erosion in some locations upstream of the setback levee reach unless these areas have sufficient vegetation cover or rock protection. There is potential for the proposed modification to slightly accelerate the headward migration of the existing knick zone, contributing to channel bank erosion in the bend downstream of Shanghai Bend (east bank). Compared with existing conditions, the increases in velocity on the west bank and within the channel (less than one foot per second) are small in the context of natural variations in erosion forces, and the impacts on the west levee and the channel banks are less than significant. An assessment of modeled flow vectors relative to former channel locations does not indicate a strong inclination for the river to immediately avulse and re-occupy historic eastern channel areas. The potential geomorphic effects, which include velocity changes and impacts, are described in more detail in the Phillip Williams & Associates document *The Feather River levee Setback: Preliminary Assessment of Potential Geomorphic Effects*, dated 25 July 2007 and which accompanies the design package for the setback levee.

Conclusions

The proposed setback levee will provide regional flood protection benefits by reducing water surface elevations above Star Bend on the Feather and Yuba Rivers. These reduced upstream water surface elevations also reduce transient storage in the river system which could slightly increase flow downstream of the setback levee and produce insignificant water surface increases in large flow events. However, these potential increases will be mitigated by completion of implementation of the Flood Forecast-Coordinated Operations of Lake Oroville and New Bullards Bar Reservoir. While velocities in some areas upstream will slightly increase, these changes are small compared to the natural variation that occurs in erosive forces in a system. These velocity increases are not expected to significantly change the erosion locations or rates that already occur. Hydraulic impacts on the Sacramento River Flood Control Project caused by the proposed modification are generally beneficial with any adverse impacts being mitigated by the Flood Forecast-Coordinated Operations.

FIGURE 4
Feather River
1-in-200 AEP Maximum Water Surface Profile - Alternative 2 vs. Without Project

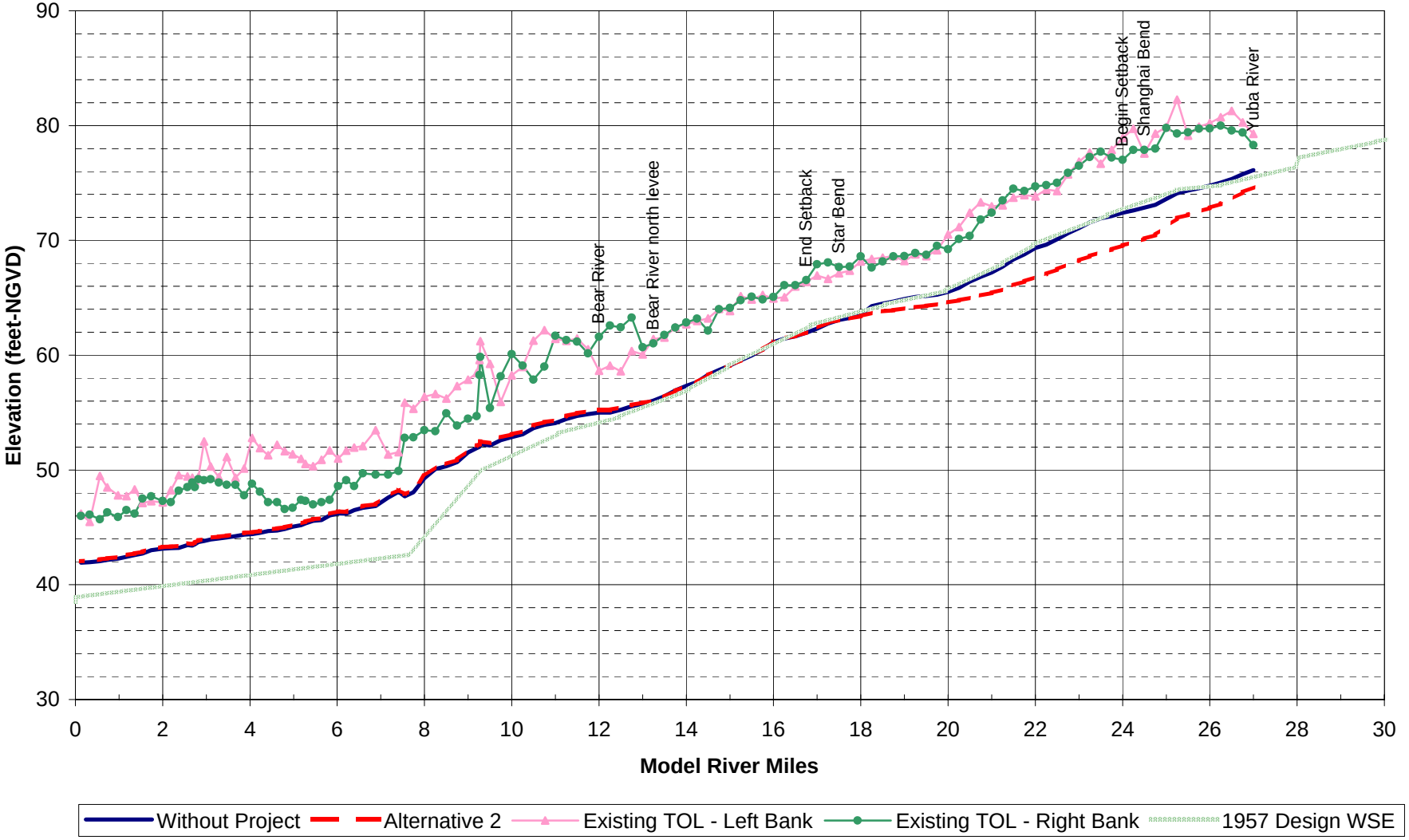
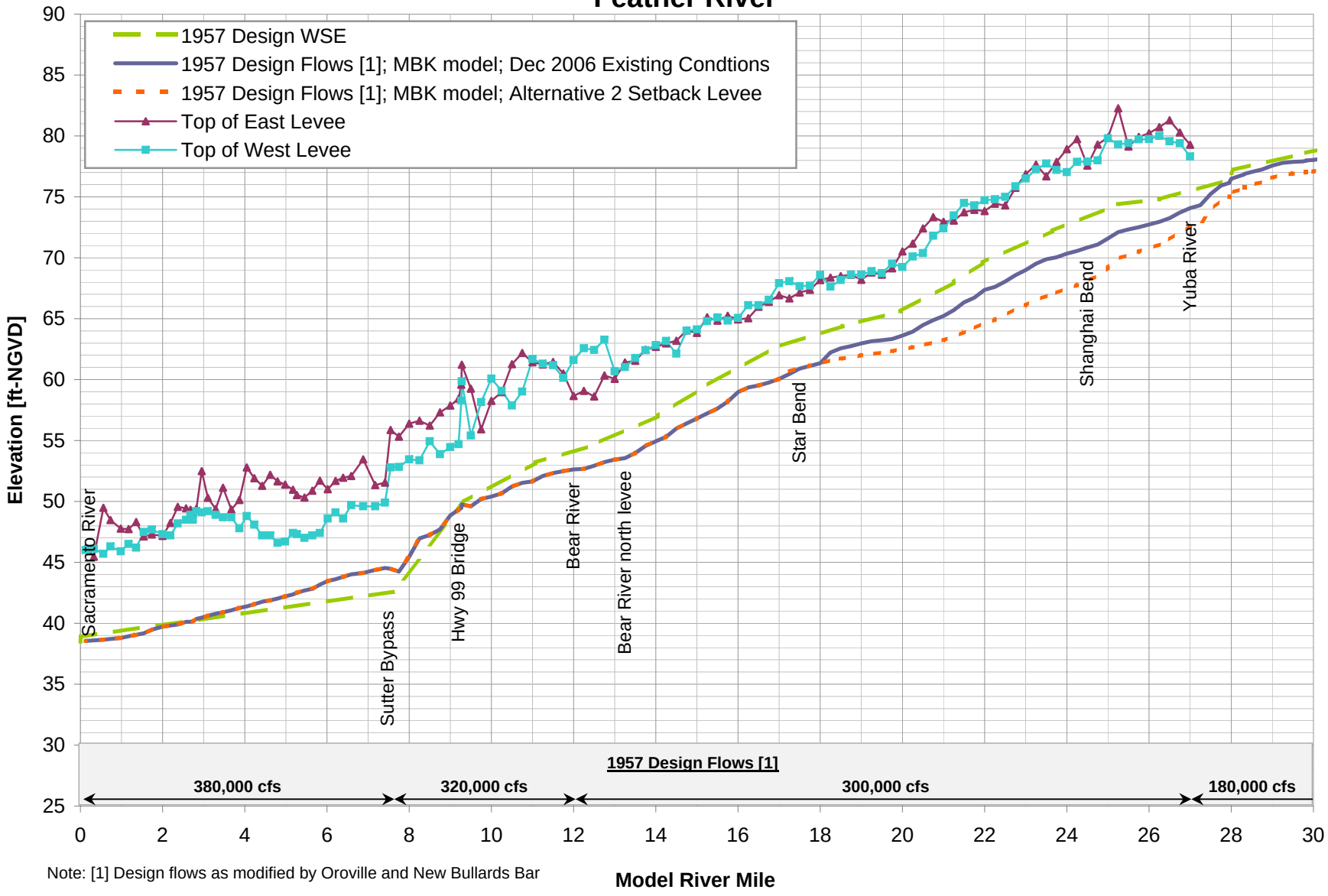


FIGURE 5
Comparison of 1957 Design Water Surface Profiles
Feather River



Note: [1] Design flows as modified by Oroville and New Bullards Bar