FloodSAFE CALIFORNIA

Flood & Hydrodynamic Modeling for LFRCMP

Central Valley Flood Protection Board

June 27, 2014

Presented by:

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Purpose of modeling LFRCMP

- Establish accurate baseline conditions (2011+)
- Compare cumulative effects on 100/200-year floods
- Compare flood stage/velocity @ 2 storm centerings:
  - To top of levee profiles, east and west (N. & S. Bear)
  - To 1957 design water surface profile
- Sediment transport, scour and deposition effects
- Ecosystem benefits of conceptual designs from frequent inundation of floodplains & swales

Sequential modeling process

Models suited to complex floodplains & flow paths

MBK- 100/200-yr flood model: RMA-2D, Vers. 4.5

- Simulated 2 Storm Centerings: Upper and Lower Feather River watersheds

Cbec- hydrodynamic model: MIKE21_C (also 2D)

- 23-day time series hydrographs 2- 10- 100-yr, FAF
- Simulated effects of Shanghai Rapids breach
- Sediment transport simulations (scour/deposit)

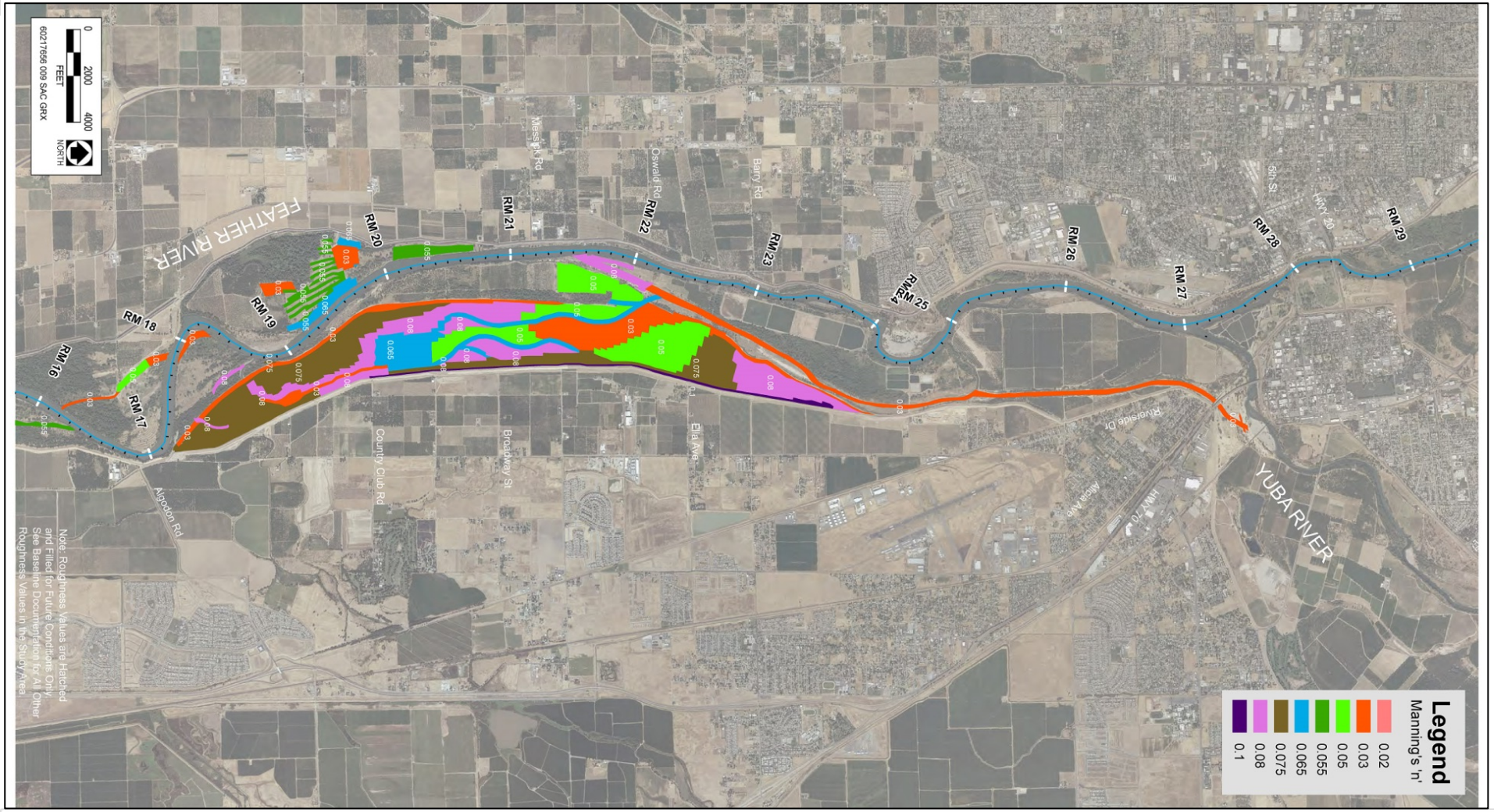
Models developed for optimum accuracy

- Updated USACE/CVFPP base model:
  - As-built topography of levee setback projects
  - Added up-to-date LiDAR topo, new bathymetry
  - More detailed baseline/future vegetation roughness
  - More detailed model “mesh” to improve precision and interpretation of results
- Refinements to assumed inflow hydrology for frequent floods (reduced by reservoir operations)

Future Condition: Conceptual Grading Design

(North Study Area)

Future Condition: Roughness Values

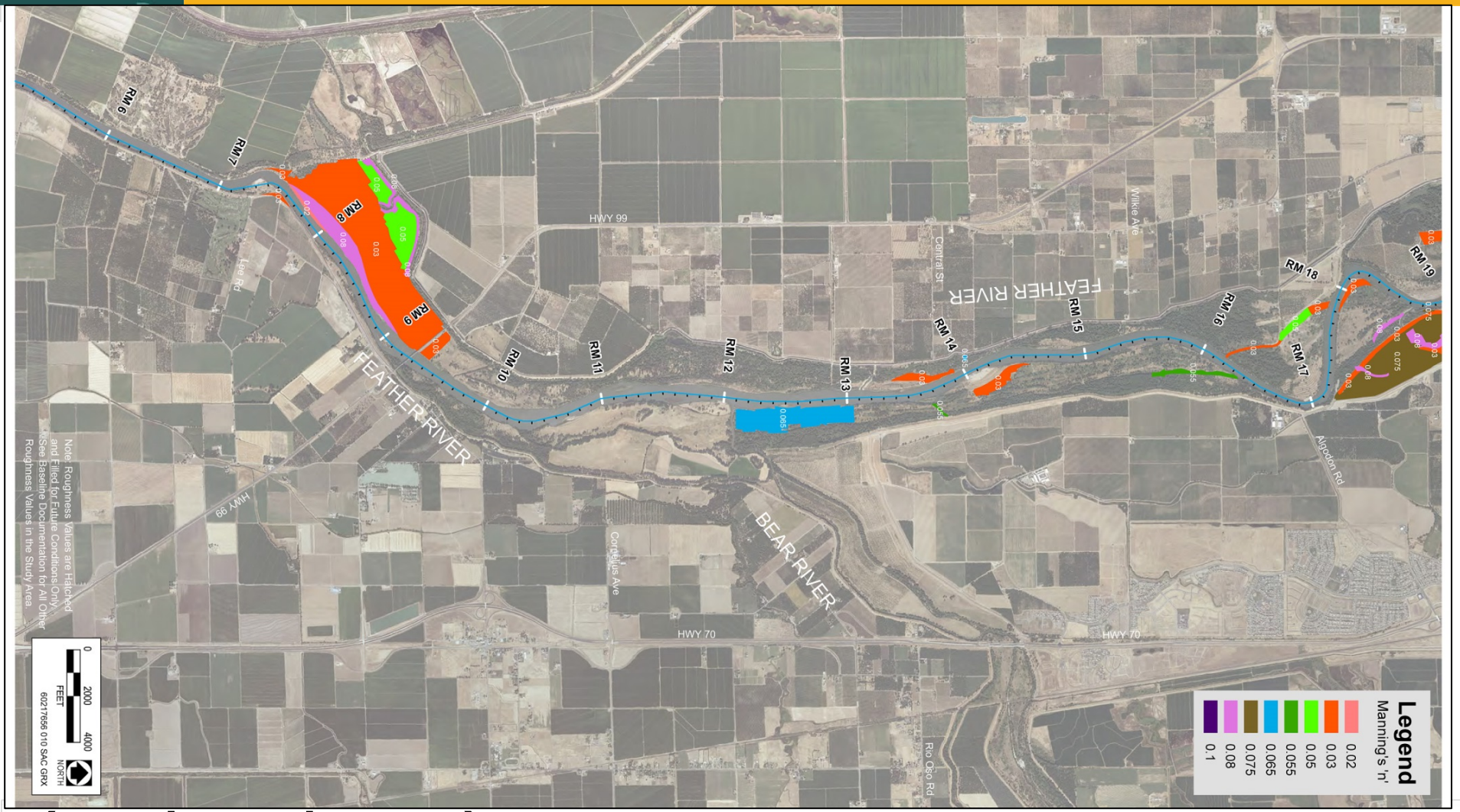


(North Study Area)

Future Condition: Conceptual Grading Design

(South Study Area)

Future Condition: Roughness Values

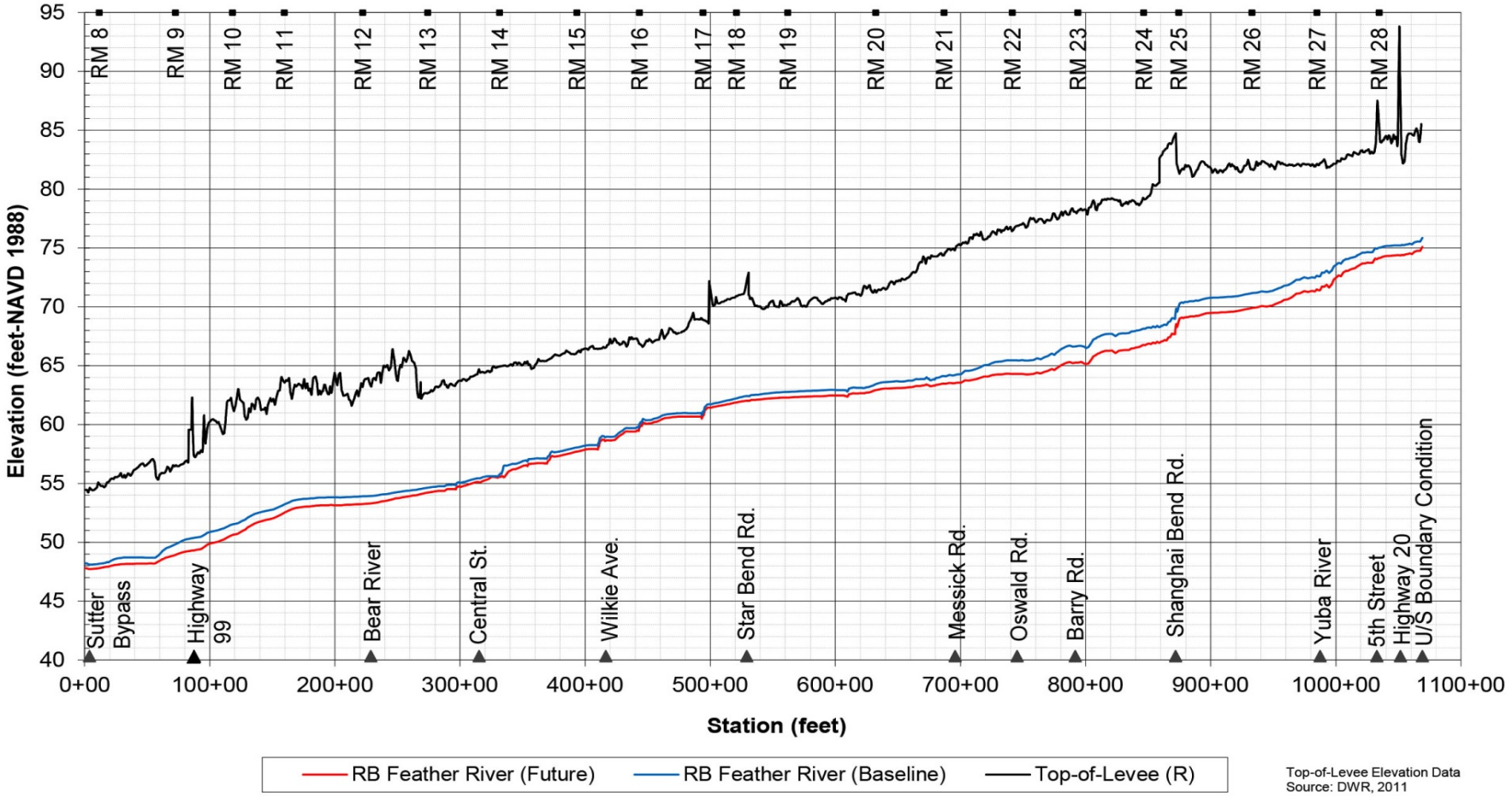


(South Study Area)

Example of Water Surface Differences

Water Surface Differences of the 1957 Design Flow Simulation Run (average difference, future minus baseline) for Upper and Lower Feather River Flow Centerings		
Water-Surface Elevation Profile	**Upper Centering (Δ ft)**	**Lower Centering (Δ ft)**
Feather River right bank (RM 7.8 to RM 28.7)	-0.7	-0.7
Feather River left bank (RM 2.9 to RM 12.2)	-0.3	-0.3
Feather River left bank (RM 13.2 to RM 27.2)	-0.8	-0.8
Bear River right bank (RM 0.3 to RM 4.75)	-0.3	-0.2
Yuba River left bank (RM 0.3 to RM 1.2)	-1.2	-1.2
Source: MBK 2012b:Table 10		

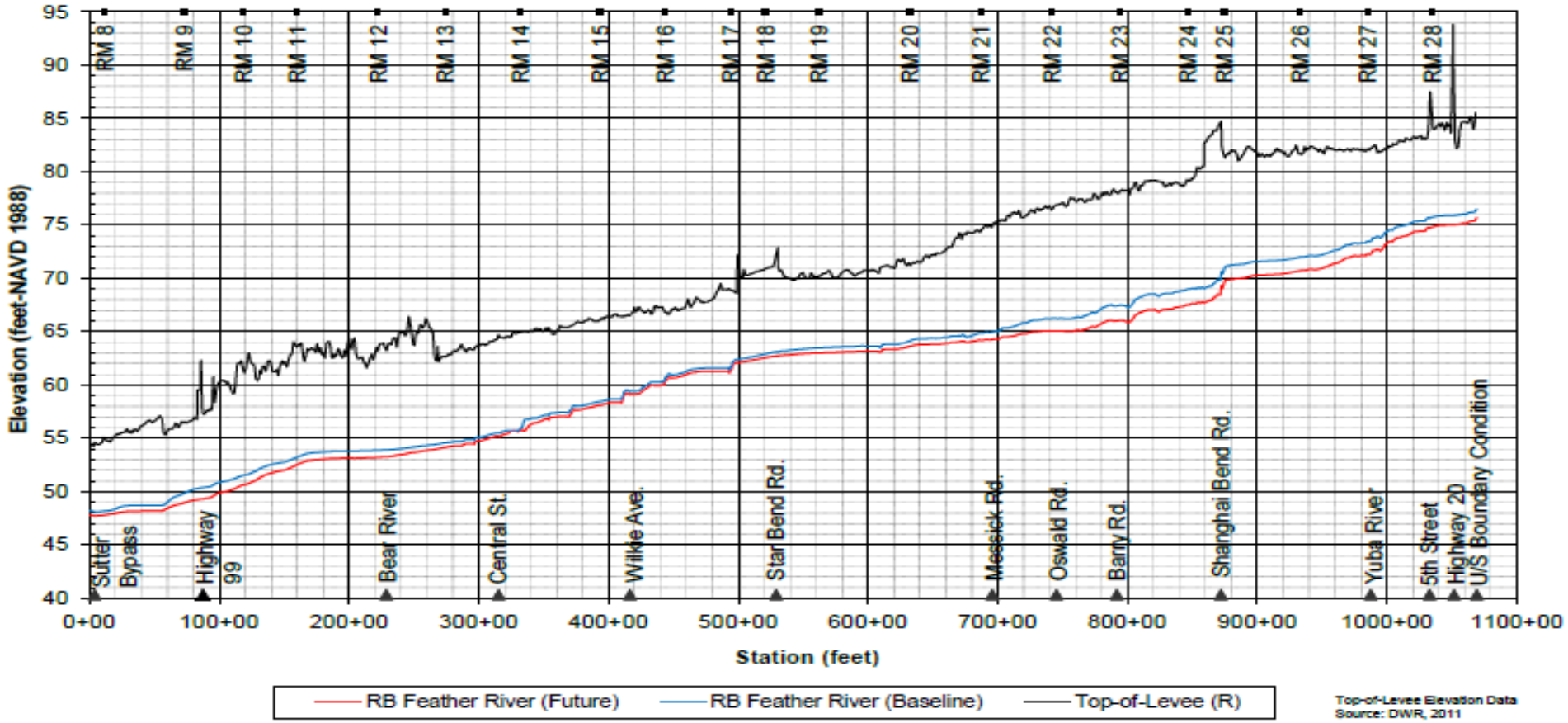
Example: 200-Year Flood Water Surface Profile



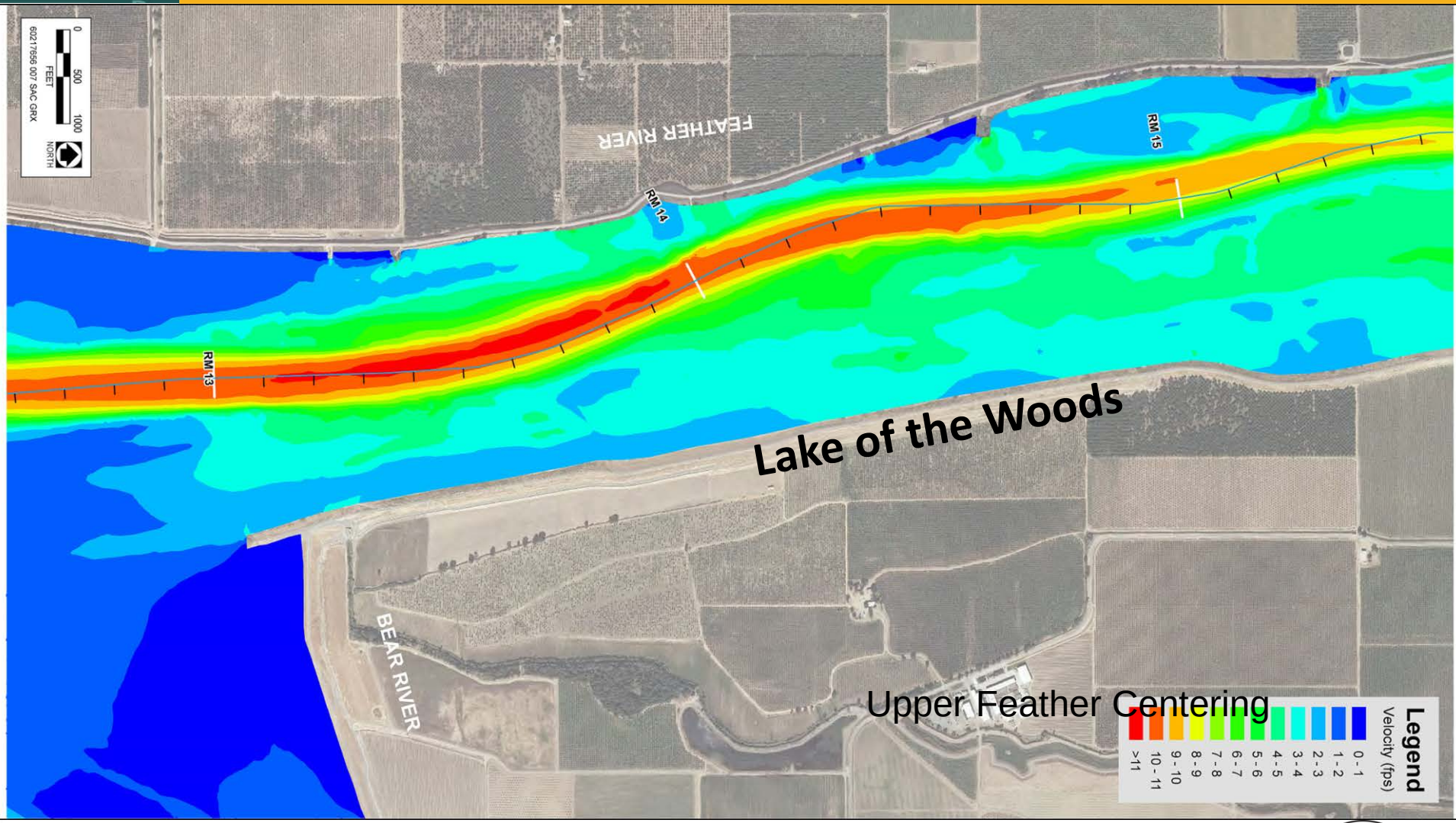
Feather River Right Bank (River Miles 7.8 to 28.7) 1-in-200 Annual Exceedance Probability, Lower Feather Centering

Example: 1957 Design Flow Water Surface

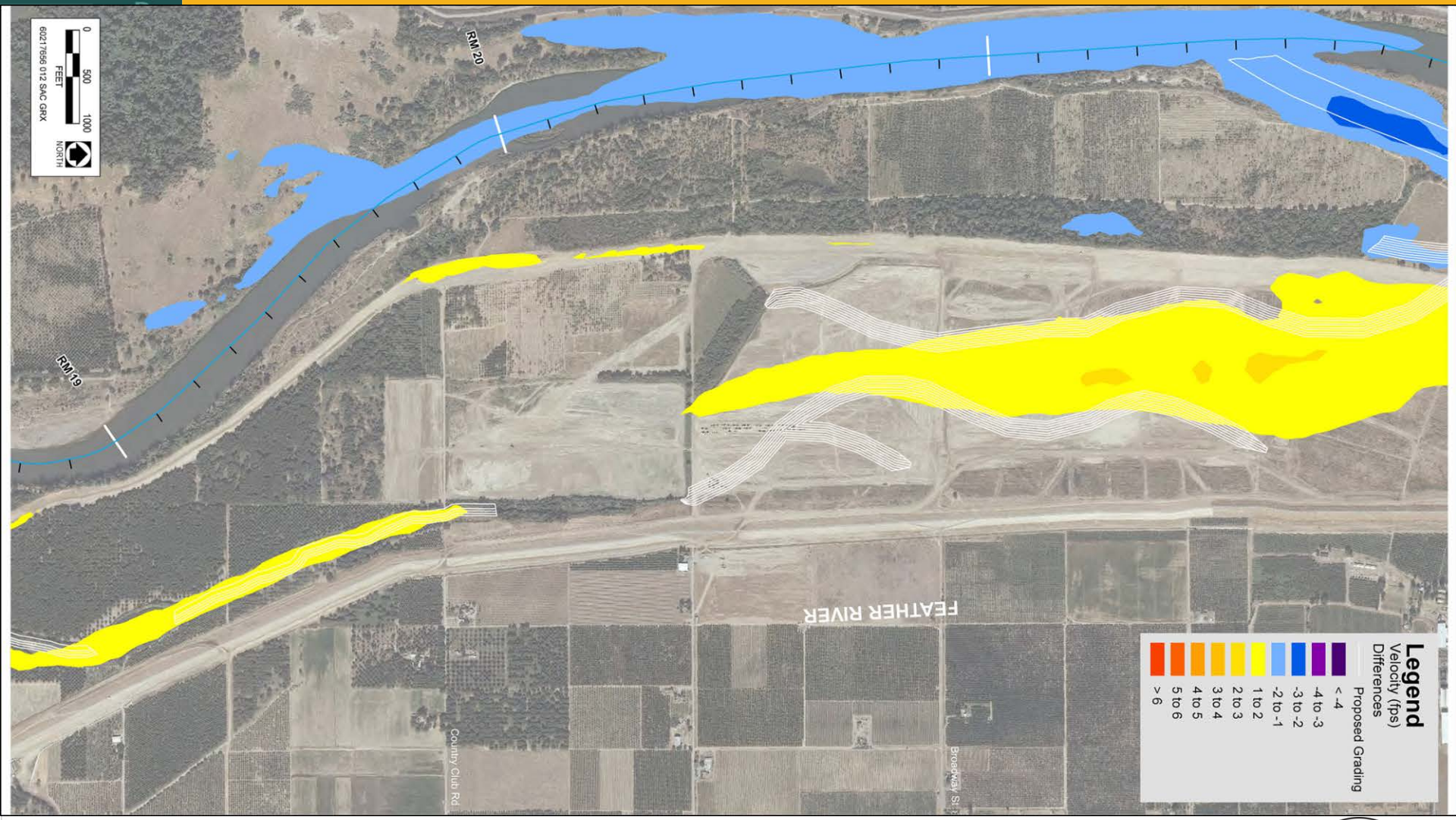
Figure 30
Feather River - Right Bank (RM 7.8 to 28.7)
Maximum Water Surface Profile (2-D Model)-1957 SRFCP Design Flow
Upper Feather Centering



Example: 200-Year Velocity Contours



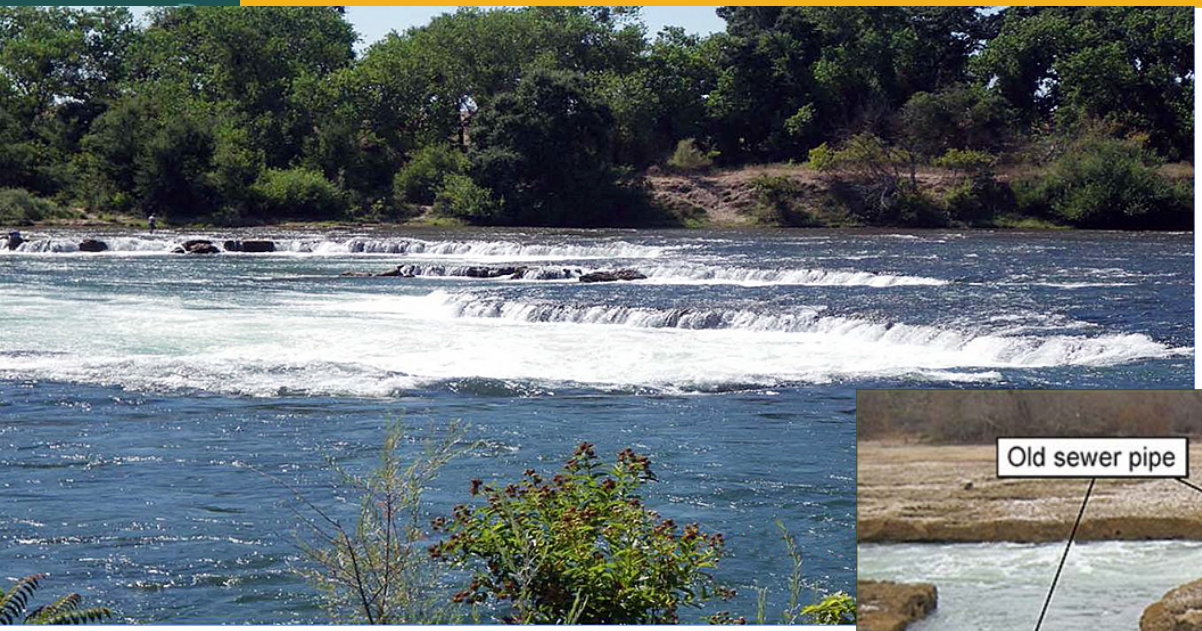
Example: Velocity Change, 200-Year Flood



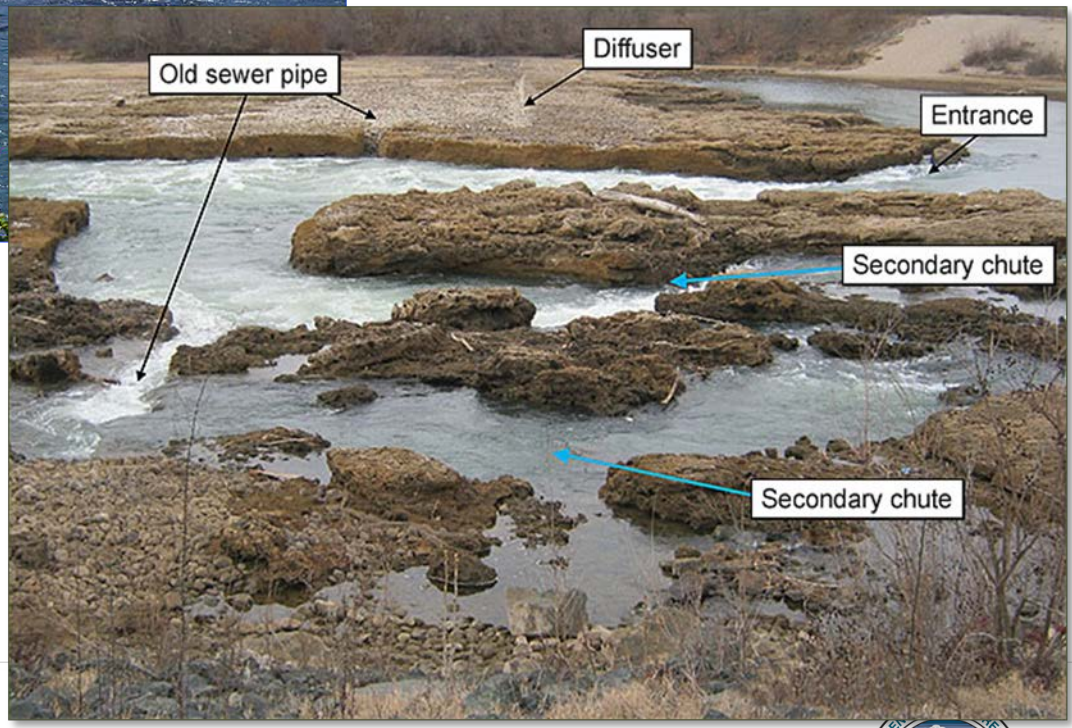
Summary of LFRCMP Flood Model Results

- Net reduction in flood stage for all flow scenarios
- Net increase in levee freeboard:
  - For 200-yr, varies +3'to +6' on Feather R. and Bear R.
  - (baseline slightly <3', RM 16.0-16.8 on west levee)
- Highest velocities within main river channel
- Reduction or no change in channel flow velocities
- Velocity increases on floodplains, away from levees
- Velocity decreases in channel, and near levees

Breach of Modesto Formation at Shanghai Rapids

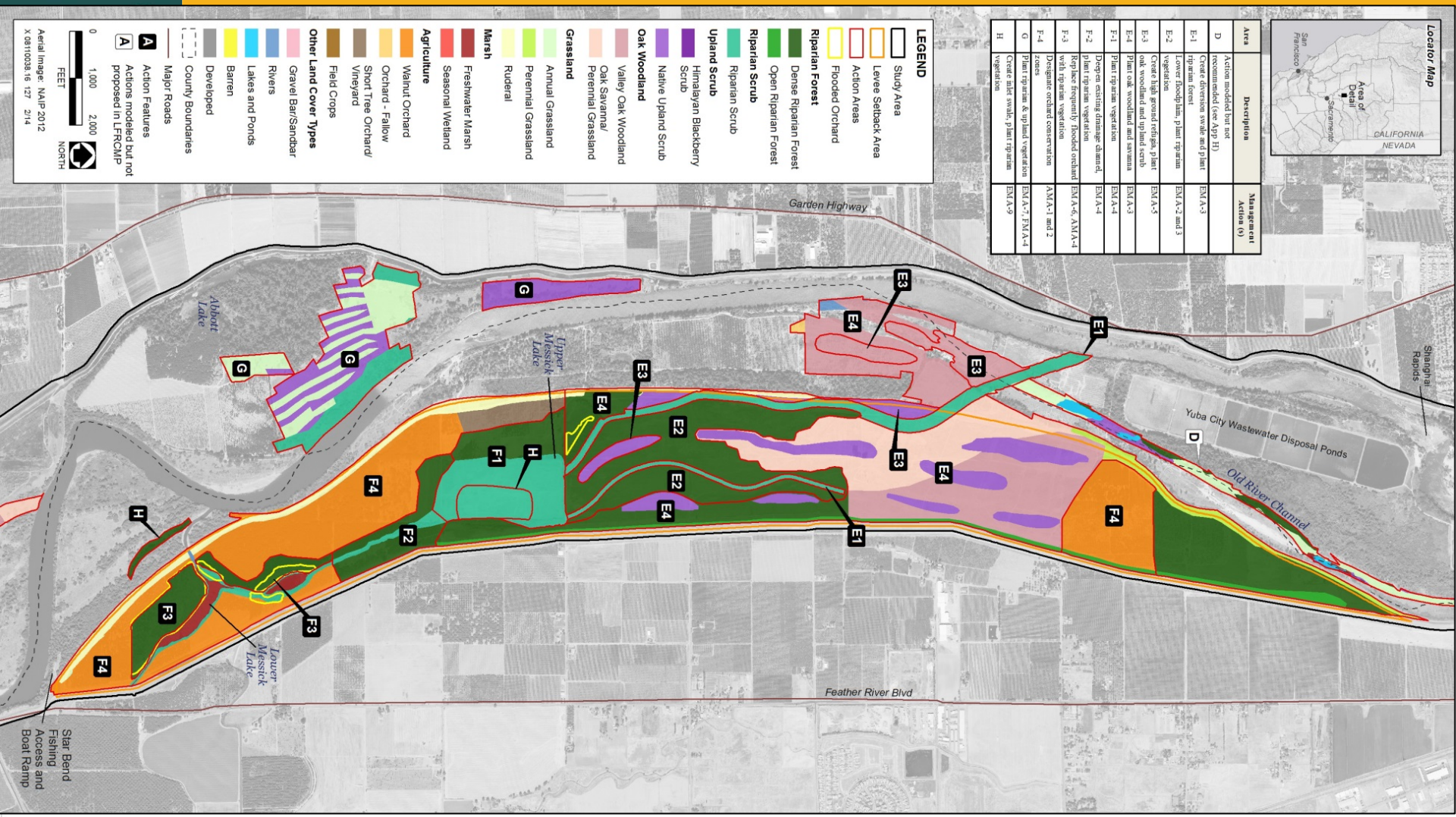


---BEFORE

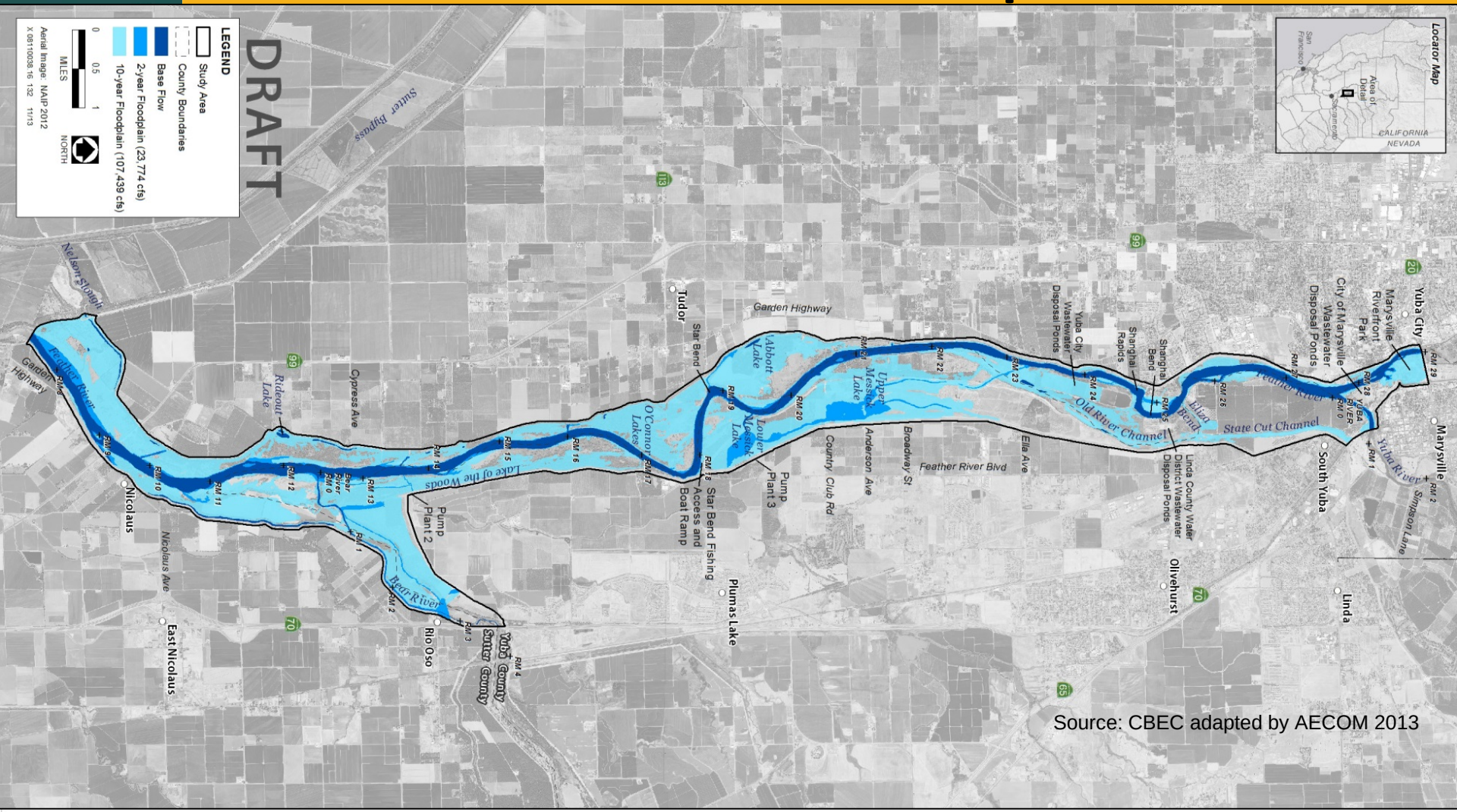


AFTER---

Future Condition: Feather River Setback Area

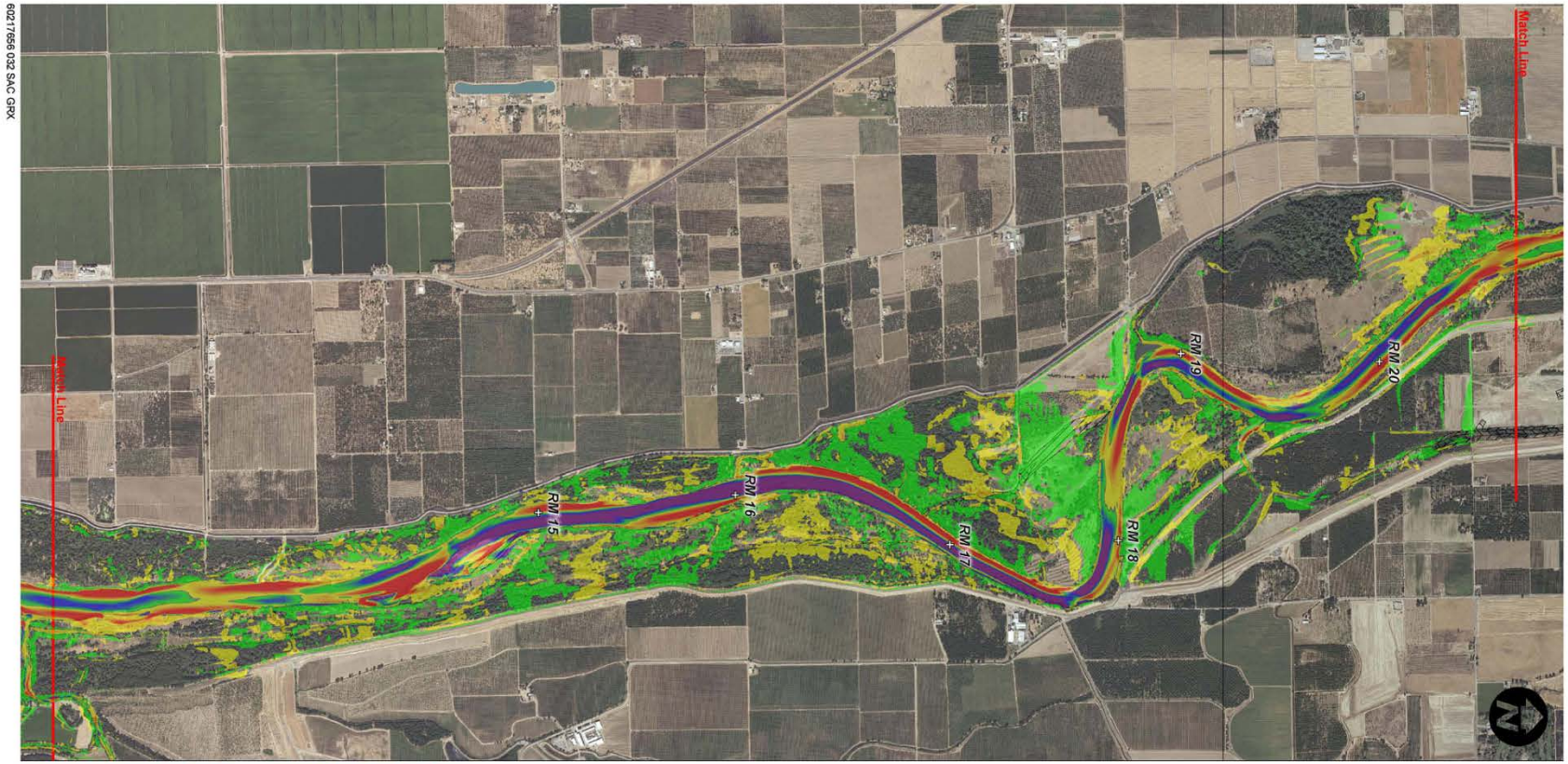


Extent of 2- and 10-Year Floodplains



Source: CBEC adapted by AECOM 2013

100-Year Bed-Level Change Central Study Area



Alternating Sand Bars on LFR, 4/21/2014

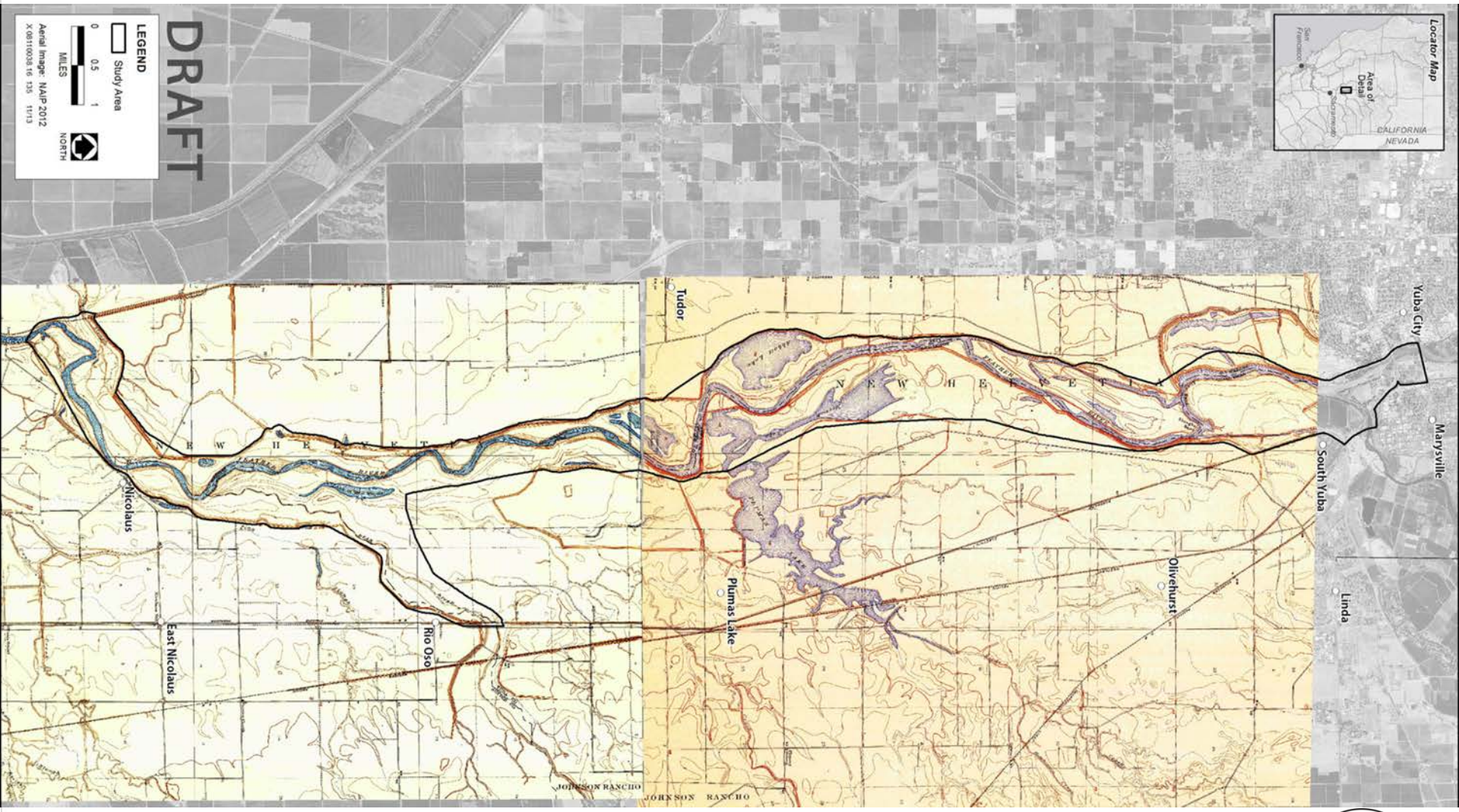
Summary of Hydrodynamic Model Results

- Reduced veg roughness on FRS lowered reach-wide water surface profiles
- 2-, 10-, 100-year water surfaces all lower than under baseline condition
- Effects of 2-year flood across FRS:
  - initiates thru-flow in excavated swales
  - inundates diverse vegetated floodplain
  - enhances natural ecosystem process and benefits
- (Some features in prelim concept plan did not show benefits)

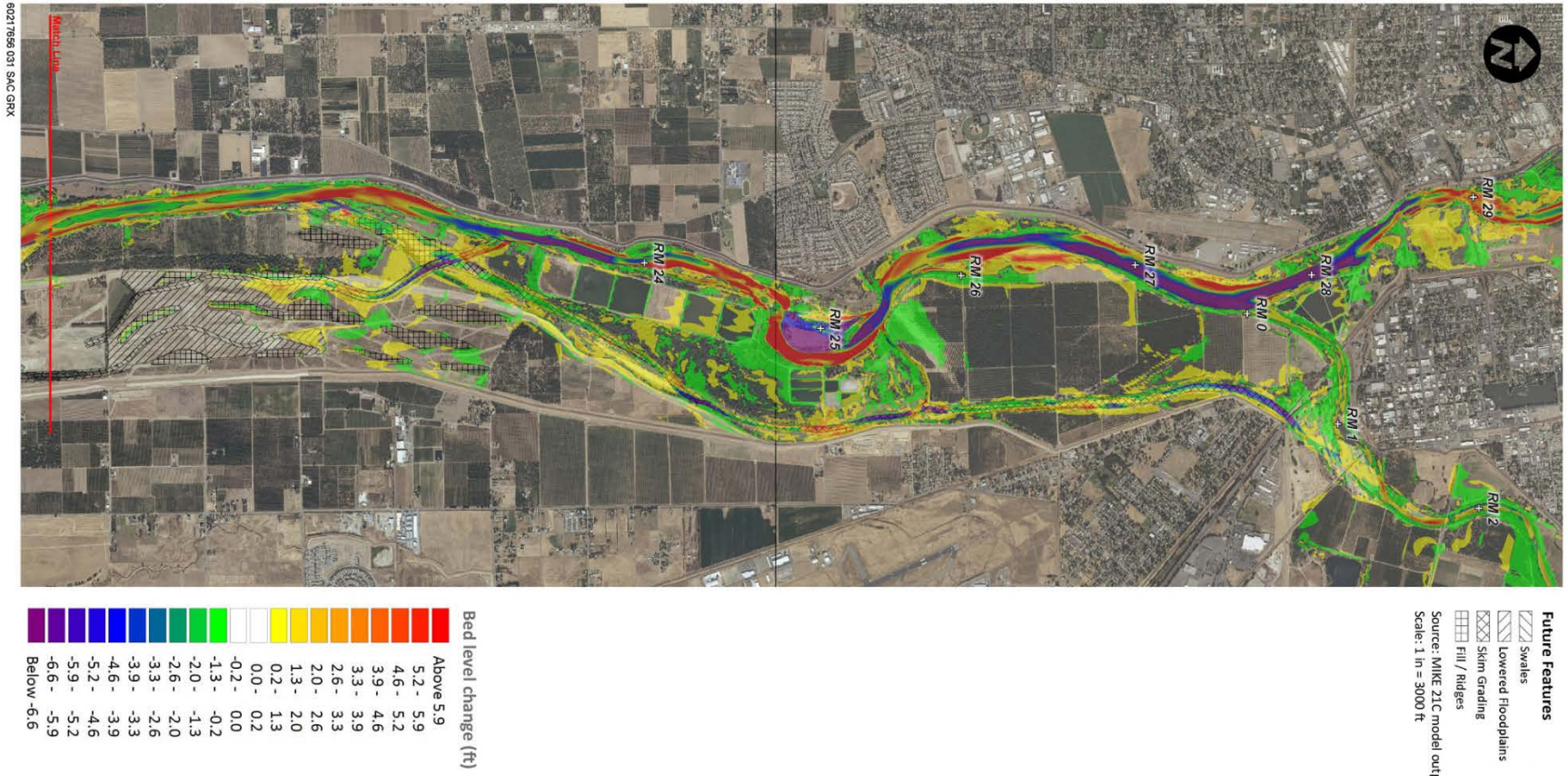
Overall results, both models combined….

- Cumulative future effects of LFRCMP meet all project goals:
  - Reduced flood risk
  - Reduced floodway maintenance burden
  - Substantial increase of diverse habitats
  - Increased frequent inundation of natural vegetation and improved through-flow
  - Accommodated most existing orchards

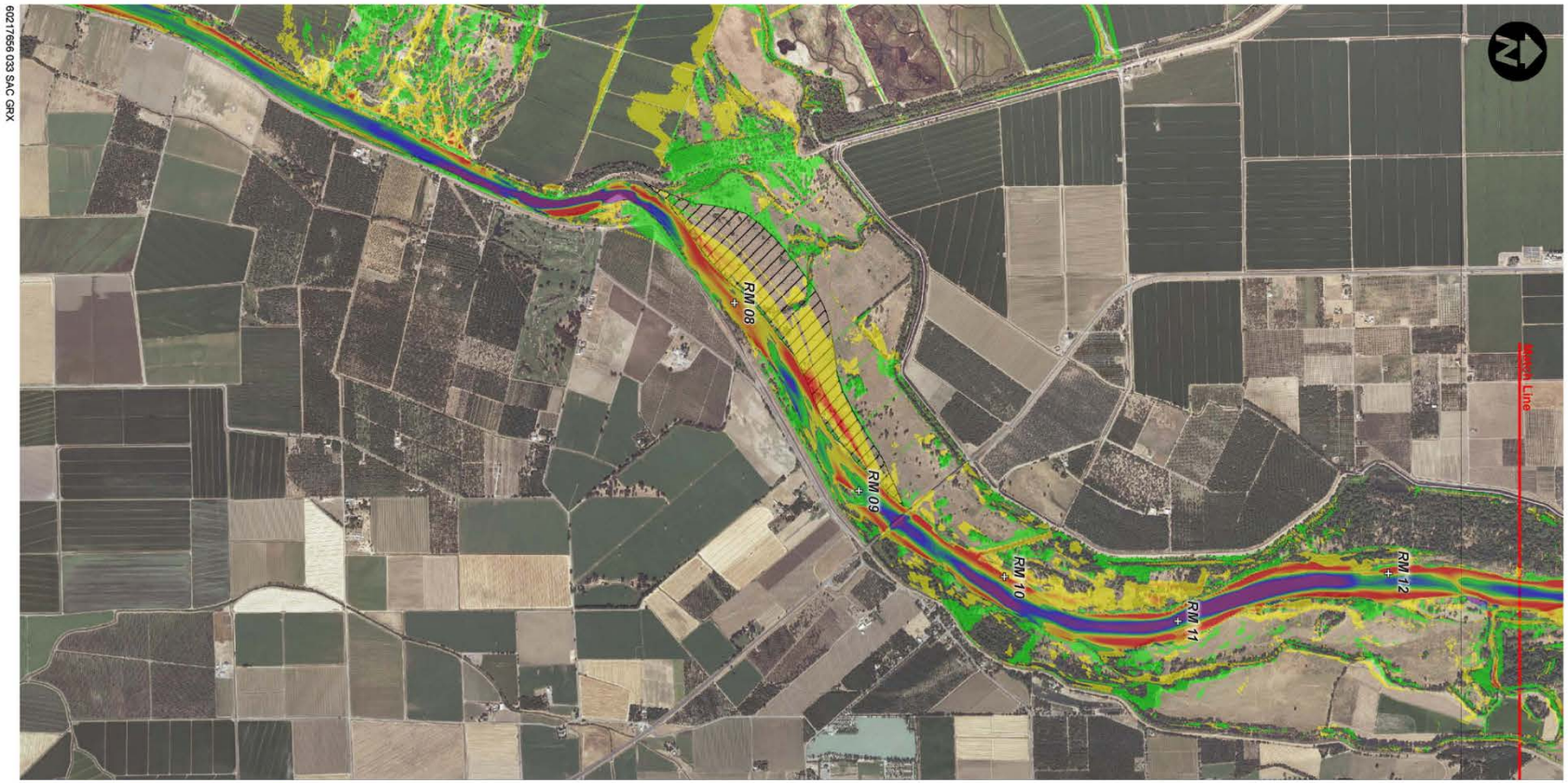
END OF MODELING PRESENTATION



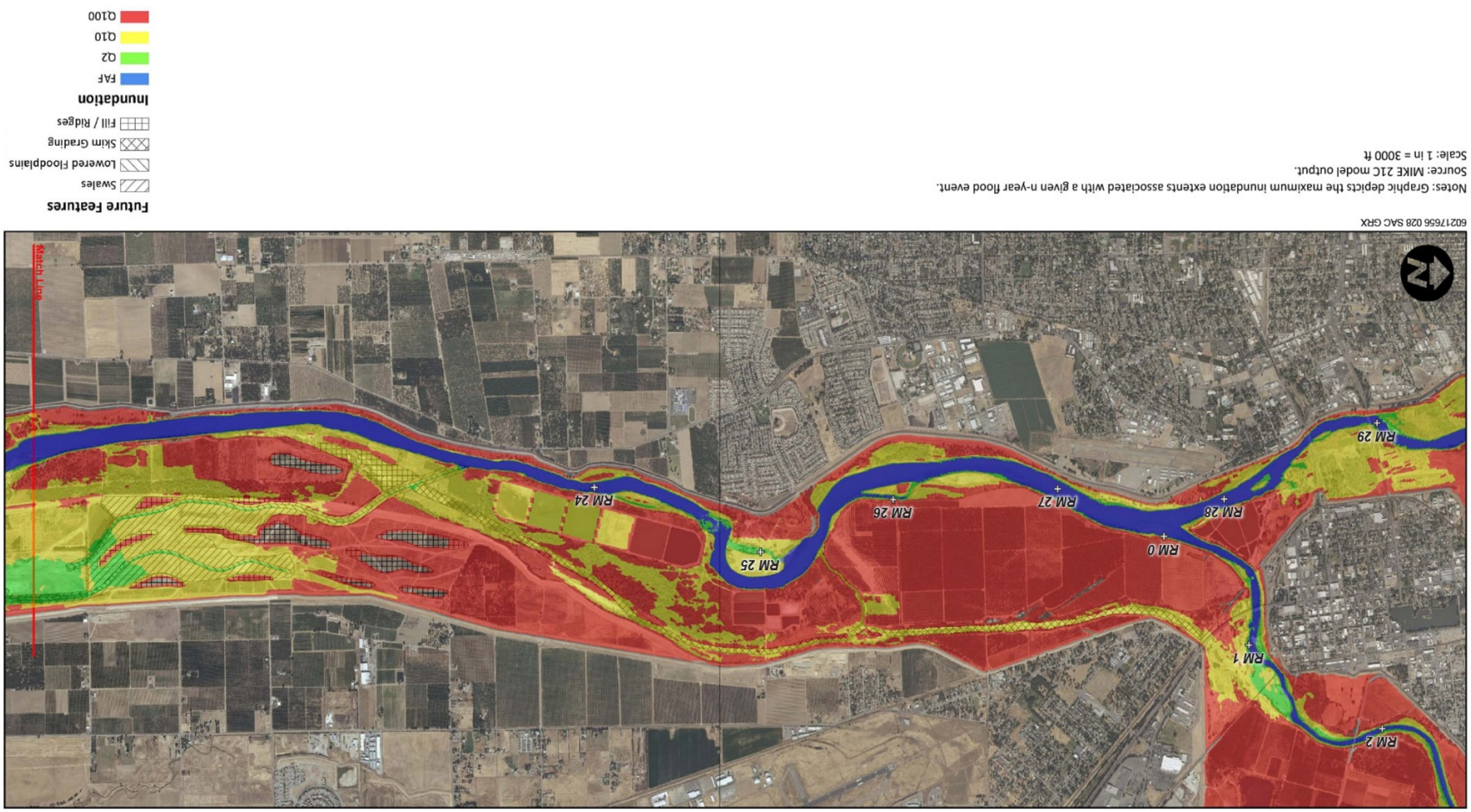
100-Year Bed-Level Change - North Study Area



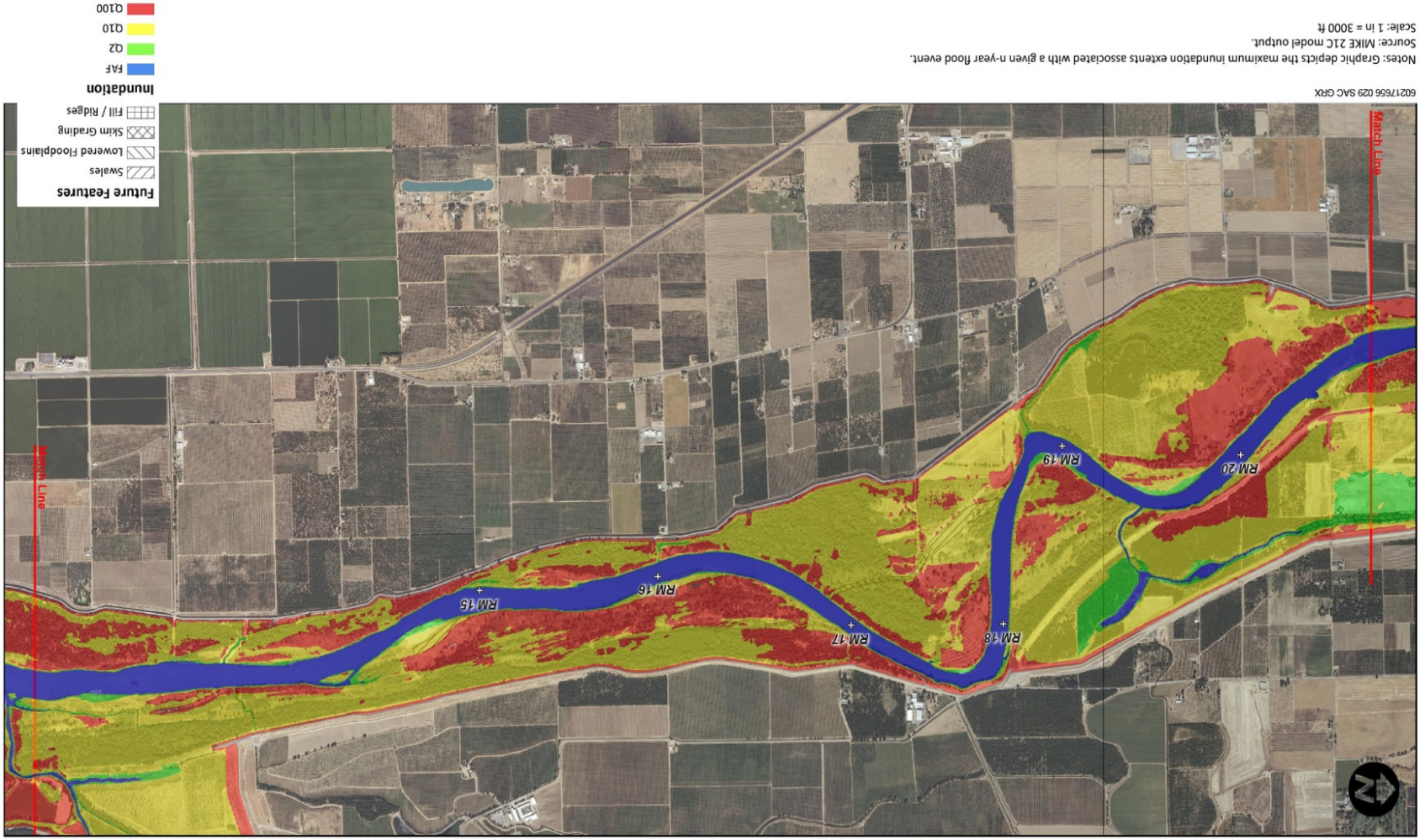
100-Year Bed-Level Change - South Study Area



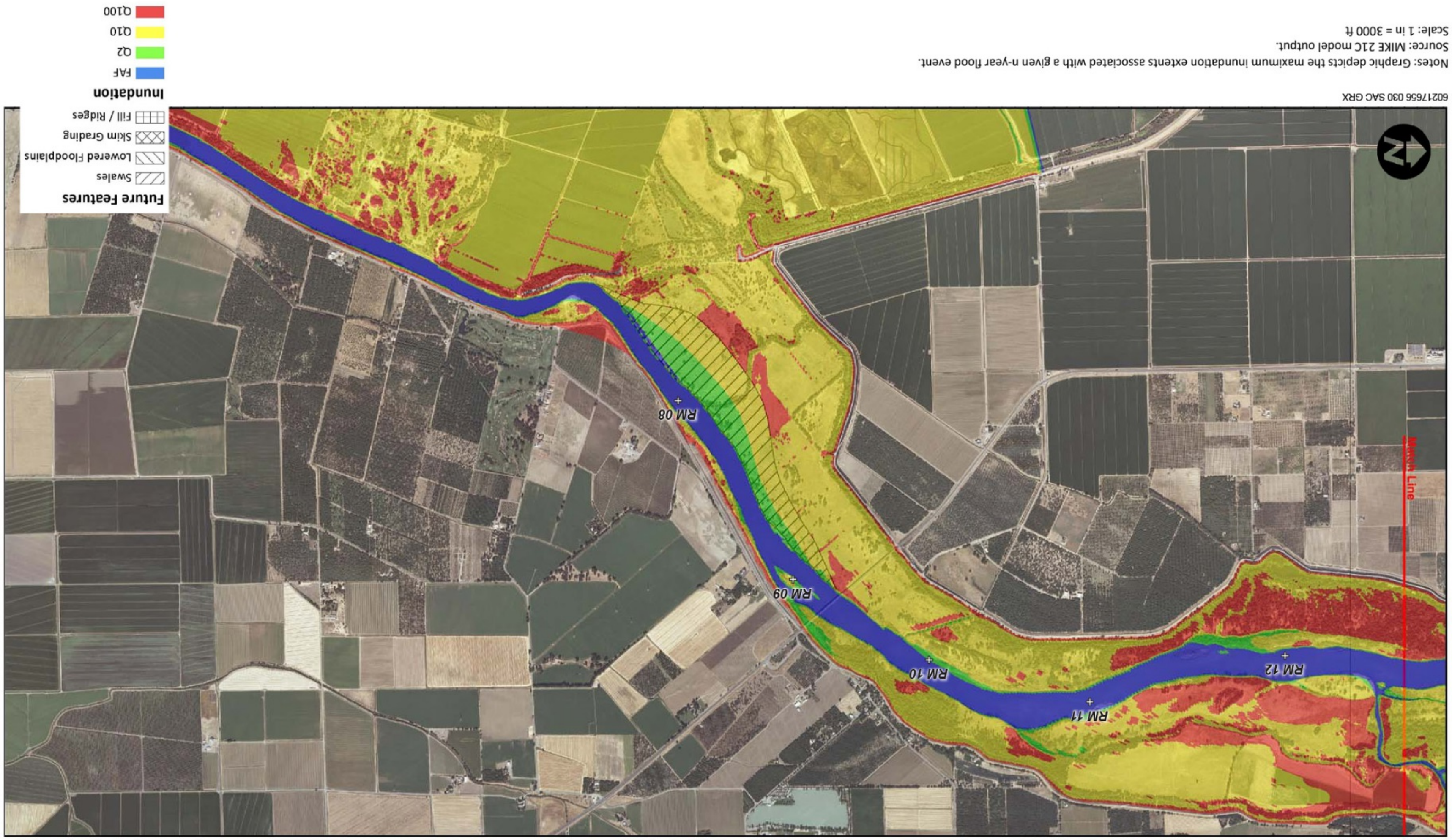
Future Inundation Extents — North Study Area



Future Inundation Extents — Central Study Area



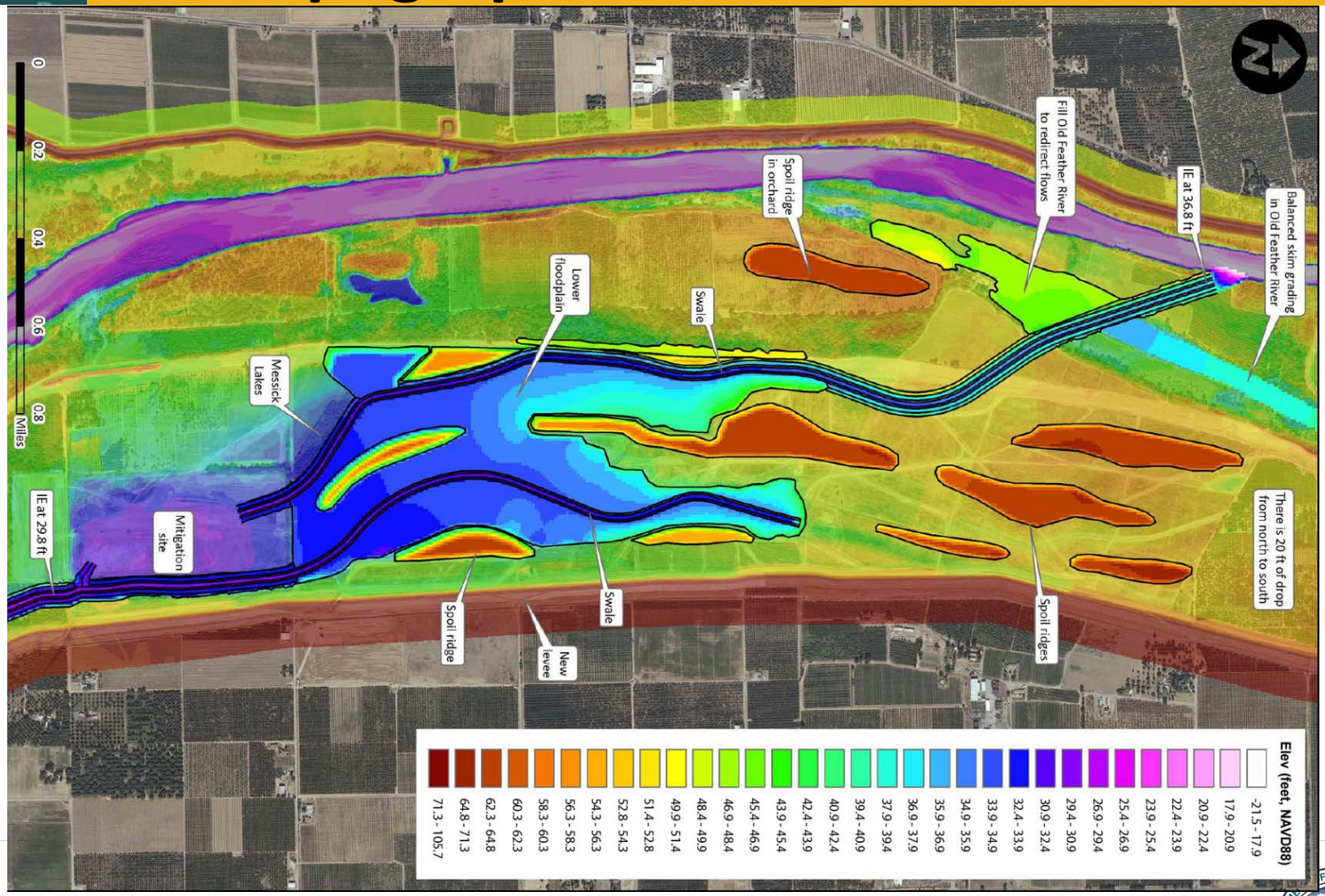
Future Inundation Extents — South Study Area



Additional Hydrodynamic Model Results

- 2-, 10-, 100-year WSPs averaged 0.1, 0.3, and 0.3 foot lower, respectively, than under existing conditions. FAF no change.
- WSPs were up to 0.5 foot, 0.6 foot, and 0.8 foot lower opposite the FRS and Nelson Slough lowered floodplains
- At Shanghai Rapids, decreases in WSEL were 0.6, 0.2, 0.1 foot for 2-, 10-, and 100-year WSPs
- Shanghai Breach reduced FAF- 2-, and 10-year inundation of edge habitats by 10, 40, and 300 acres; 5'6' drop at base flow

FRS Topographic Gradations



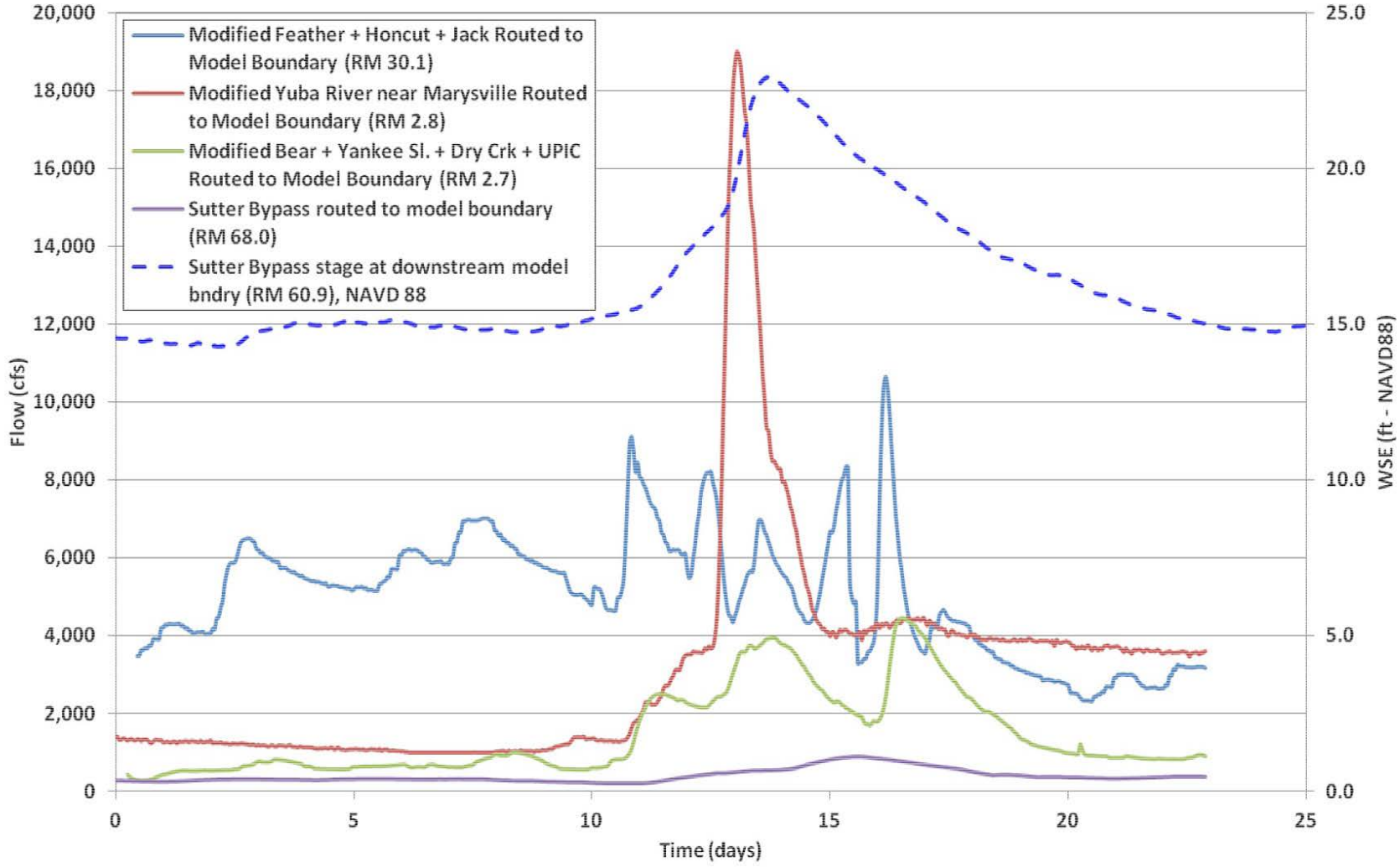
Excavation/Fill Volumes for Future Conditions

Table 5-14
Excavation and Fill Volumes (cubic yards) for Future Conditions on the Lower Feather River

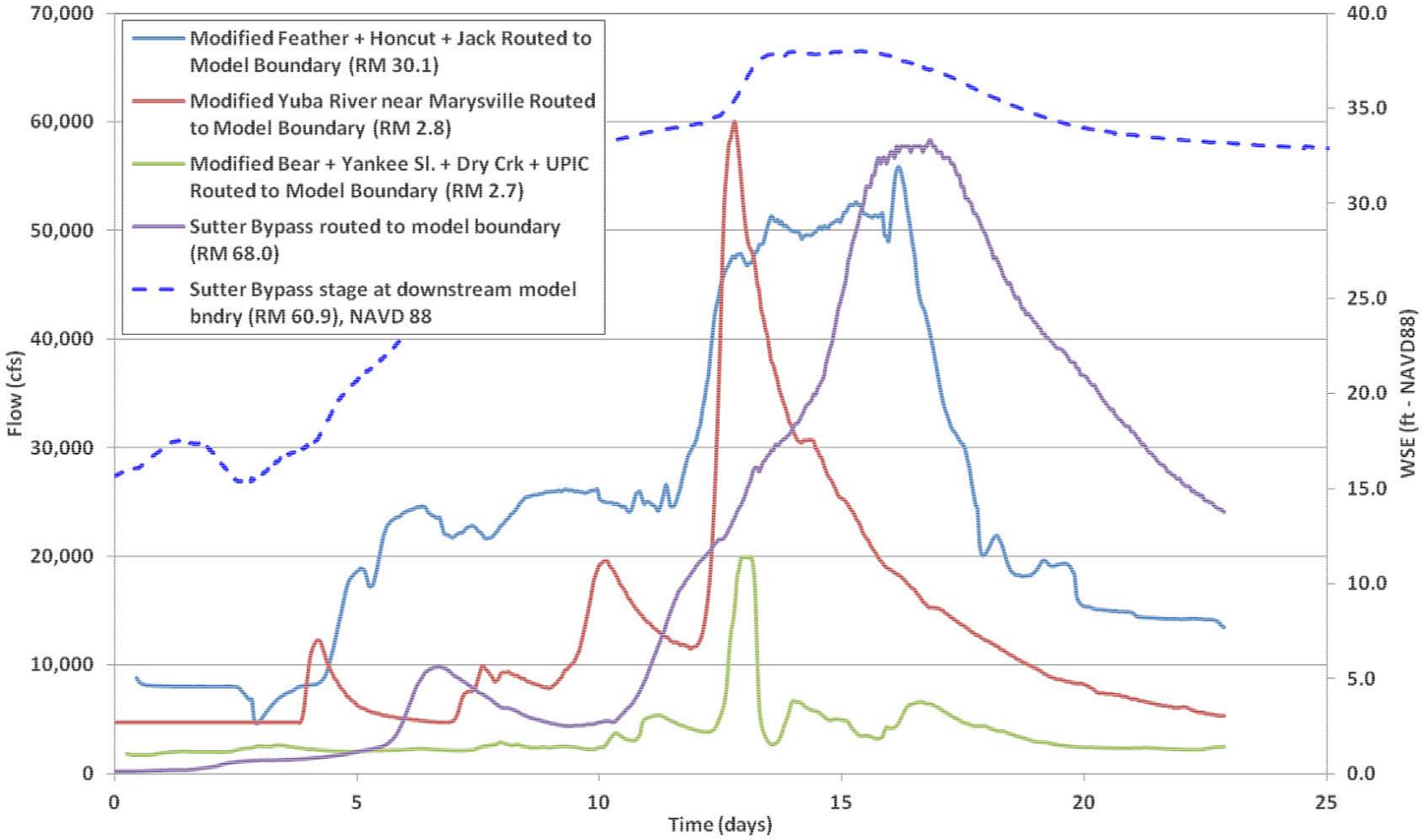
Location	Excavation	Fill	Notes
Eliza Bend channel	5,000		Remove plug at inlet to Old Feather River
Feather River Setback	167,000		East swale, FRS (north end at approximately Anderson Avenue)
Feather River Setback	926,000		West swale and diversion channel from river to FRS
Feather River Setback		1,983,000	Spoils ridges on floodplain
Feather River Setback	1,556,000		Lowered floodplain north of Upper Messick Lake
Feather River Setback	198,000		Widened drainage channel from Upper Messick Lake to Lower Messick Lake
Feather River Setback	30,000		Widened drainage channel between arms of Lower Messick Lake
Feather River Setback		182,000	Plug fill at south terminus of Old Feather River
Lake of Woods, RM 14.5	35,000		Widened floodway, left bank
Lake of Woods, RM 17	28,000		Overbank swale
O'Connor Lakes	193,000		Overbank swale and bench
Star Bend	52,000		Overbank swale
Nelson Slough	588,000		Riparian floodplain bench (assumed 50 feet wide, with 5:1 backslope)
Subtotals	3,778,000	2,165,000	Balance (net off-site use) =+/- 1,613,000 cubic yards

Sources: Data compiled by AECOM in 2013; cbec 2013a

Example: 2-Year Flood Hydrographs, MIKE21



10-Year Flood Hydrographs



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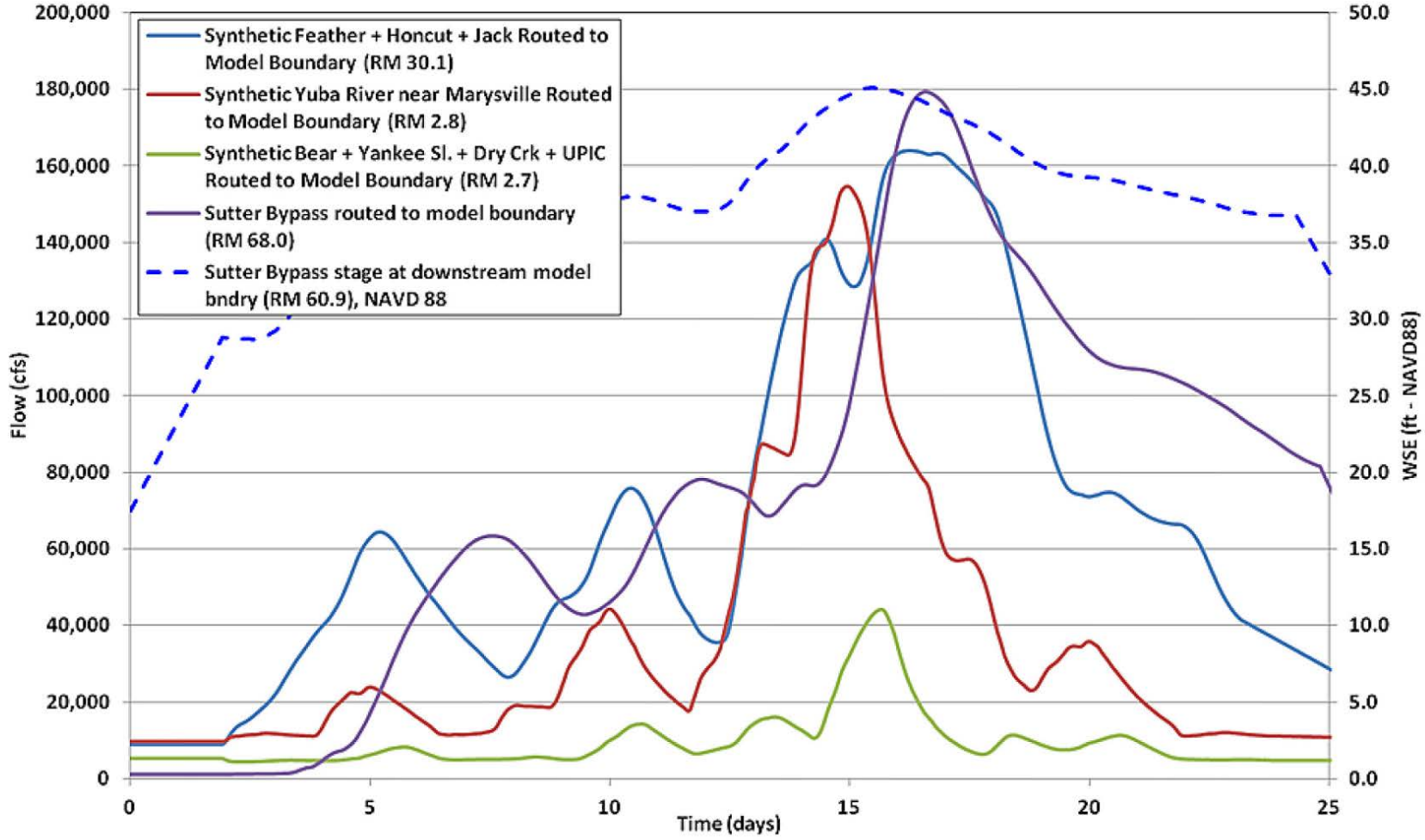
100-Year Flood Hydrographs



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MIKE_21 Model Boundary Conditions

Table 5-11
Boundary Conditions—Peak Flows (cubic feet per second) and Stage Elevations (NAVD88)

Boundary Location	Units	2-year Recurrence		10-year Recurrence		100-year
		Modified[2]	Synthetic[1]	Modified[2]	Synthetic[1]	Synthetic[1]
Feather River RM 30.1	**cfs**	**10,654**	**50,260**	**55,845**	**112,660**	**163,947**
Yuba River RM 2.8	cfs	19,000	27,540	60,000	92,180	154,574
Bear River RM 2.7	cfs	4,447	8,150	19,902	19,340	44,038
Sutter Bypass RM 68.1	cfs	893	55,331	58,300	99,194	179,224
Feather River RM 2.5	ft	22.96	–	38.0	–	45.1

Notes:

[1] Based on the Shanghai Bend—Yuba River Centering flood hydrographs at the modeling boundaries as provided by MBK (2012b).
[2] Based on updated flood frequency analysis and historical flood hydrographs (cbec 2013b).

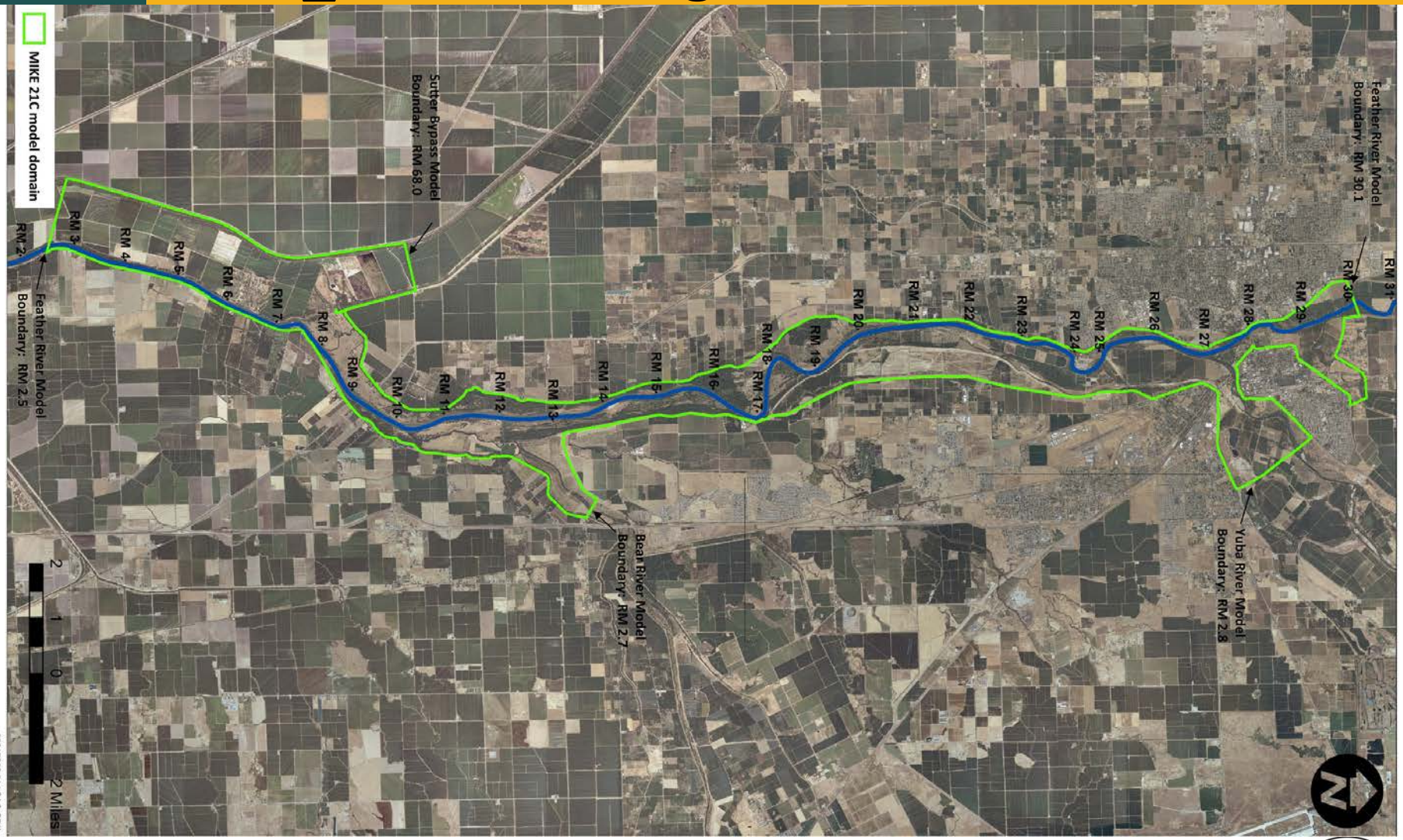
1997 Boundary Conditions (flow & stage)

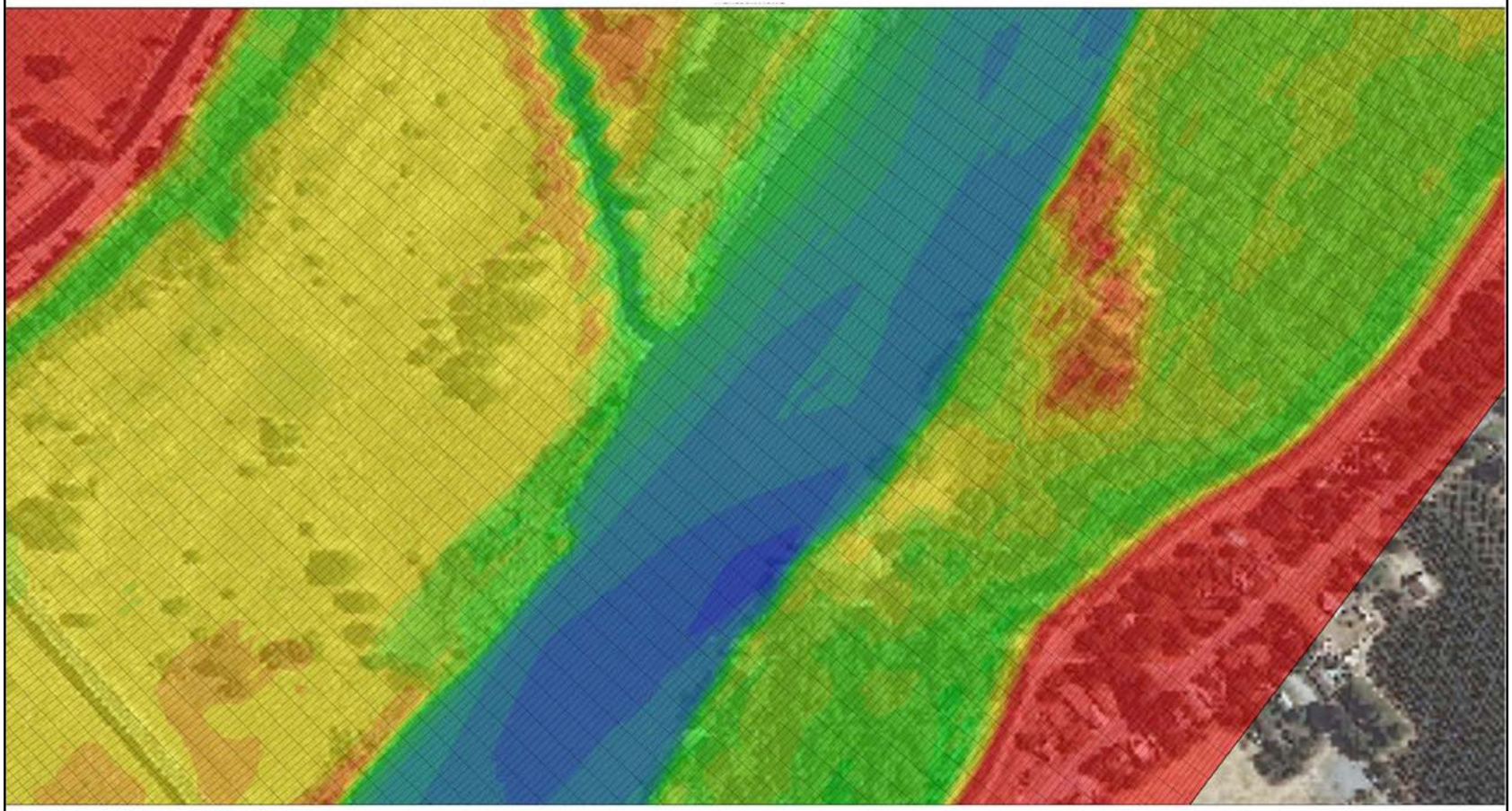
Table 5-2
January 1997 Calibration Boundary Conditions

Boundary Condition	Stage (feet NGVD)	Peak Flow (cfs)
Feather River below Jack Slough, RM 28.75	NA	144,000
Yuba River at WPRR, RM 1.23	NA	167,400
Bear River above WPIC, RM 4.75	NA	37,800
Yankee Slough at Bear River, RM 0.54	NA	400
WPIC at Bear River, RM 0.06	NA	-2,200
Sutter Bypass above Feather River, RM 68.13	NA	95,300
Sutter Bypass above Sacramento River, RM 61.83	41.2	NA

Source: MBK 2012a:Table 1

MIKE_21C Modeling Domain





Notes: Location depicted is downstream of the Bear River and just upstream of Highway 99.

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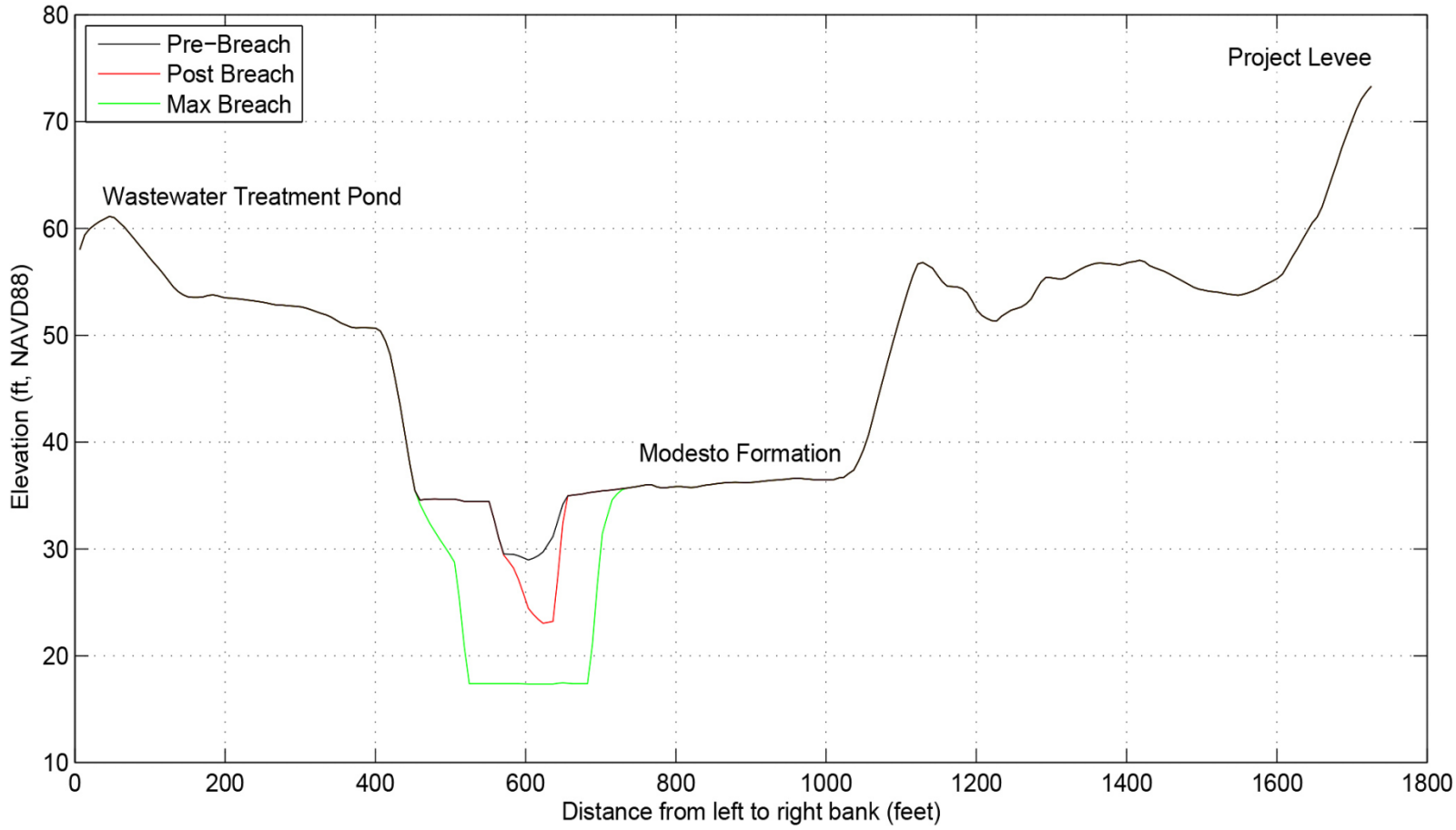
MIKE_21C Modeling Run Catalog

Table 5-17 MIKE_21C Modeling Run Catalog				
Hydrology	Topography & Bathymetry	Shanghai Rapids Breach Condit'n	Hydrodynamic Simulations	Sediment Transport
Calibration	Existing	Post	X	
Validation	Existing	Post	X	
Revised FAF 1.1-year	Existing	Pre	X	
		Post	X	
		Max	X	
	Future	Pre	X	
Modified 2-year	Existing	Pre	X	X
		Post	X	X
		Max	X	X
	Future	Pre	X	X
		Post	X	X
Modified 10-year	Existing	Pre	X	X
		Post	X	X
		Max	X	X
	Future	Pre	X	X
Synthetic 100-year	Existing	Pre	X	X
		Post	X	X
		Max	X	X
	Future	Pre	X	X

Shanghai Rapids Breach Scenarios



Note: shown as implemented in the MIKE 21C model; post breach condition surveyed on June 29, 2012

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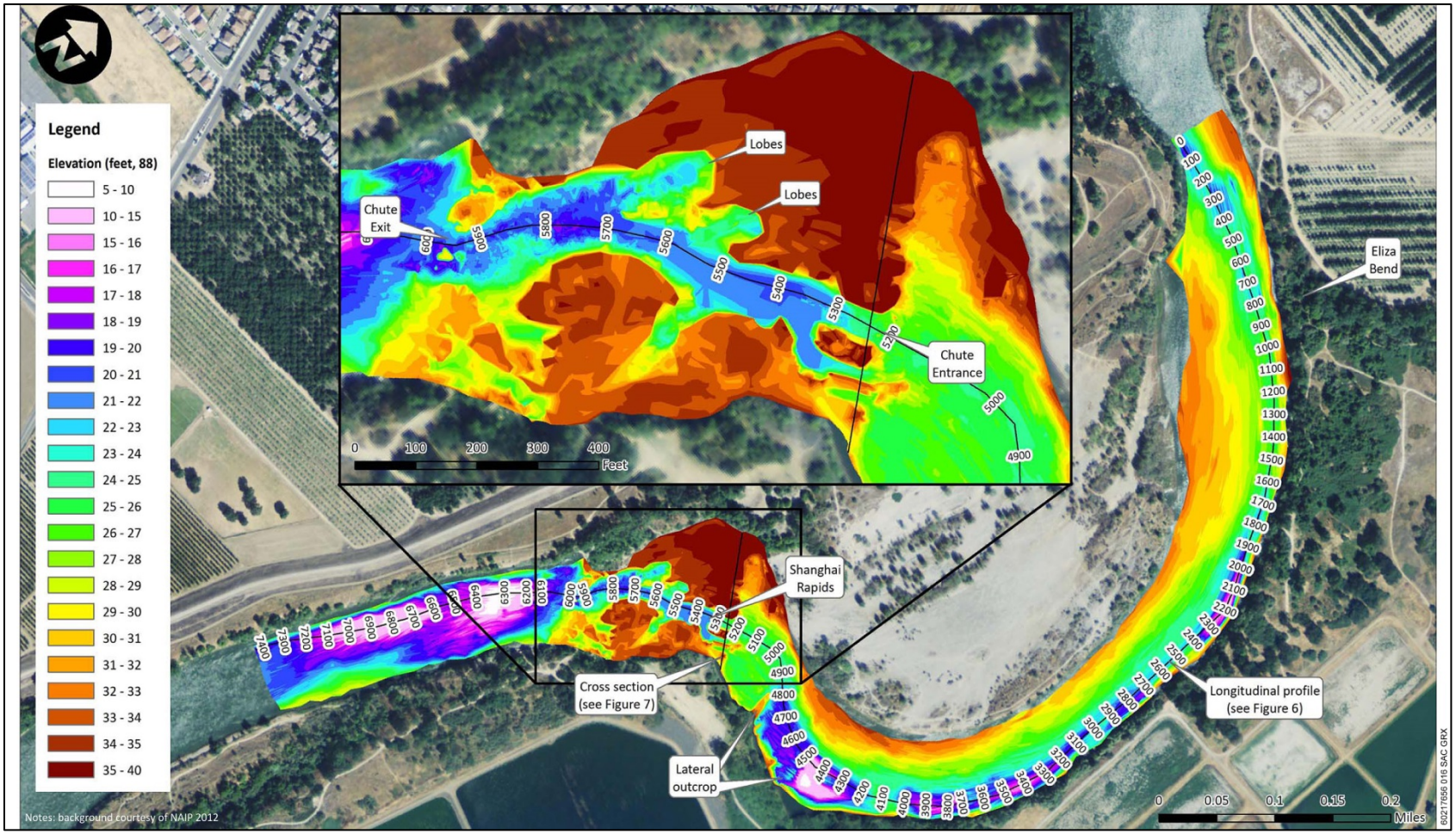
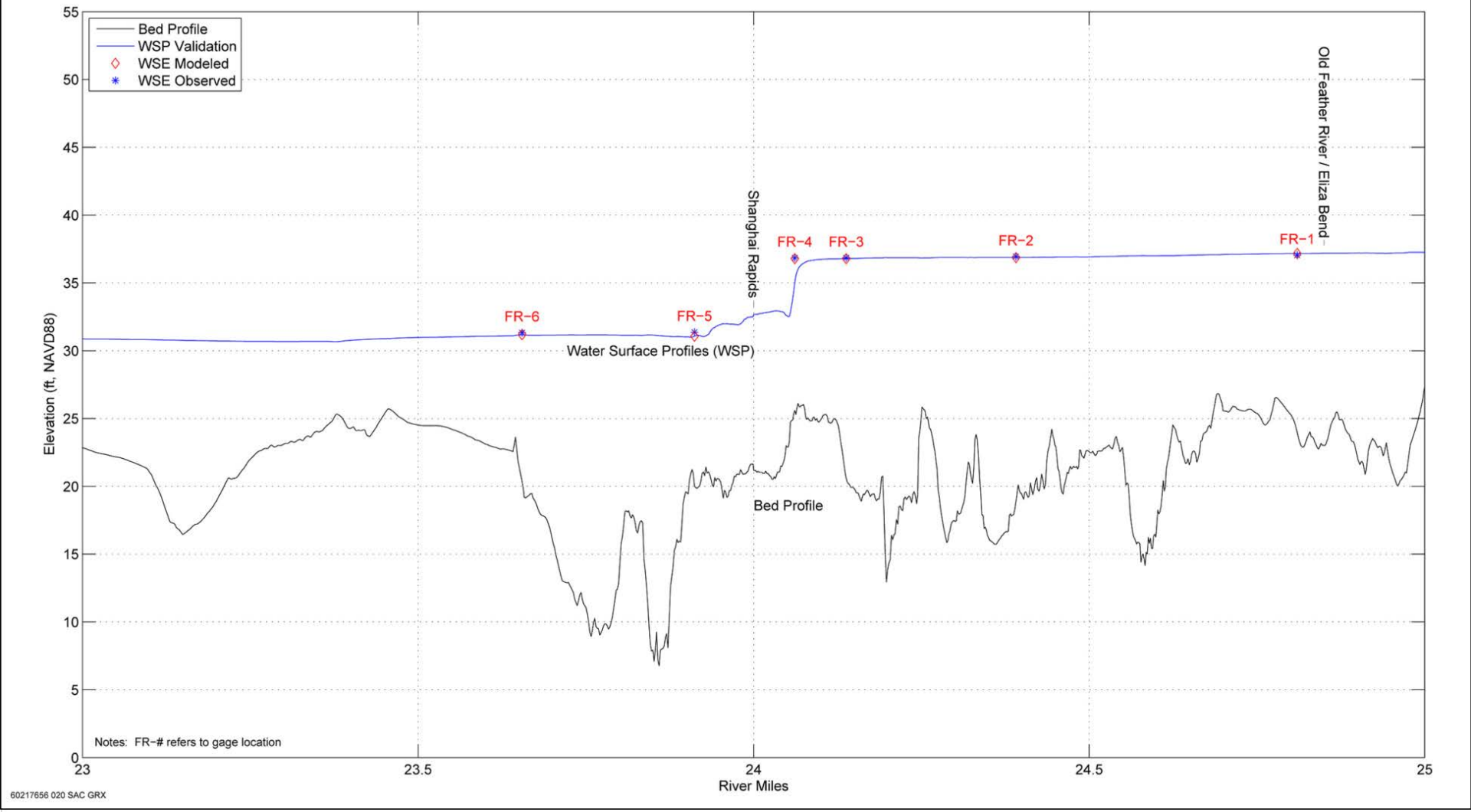
MIKE_21C Shanghai Rapids Surface Model



Shanghai Rapids Base Flow Calibration



100/200-Year Boundary Conditions

Table 5-3
1-in-100 AEP Flood, Lower Feather Centering Boundary Conditions

Boundary Condition[1]	Stage (feet-NAVD88)	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	45.3 ft elev.	N/A

Note:
1 Naming convention is in reference to the cross-section location in the PBI Model and is named as 'River Reach Station'

Table 5-4
1-in-200 AEP Flood, Lower Feather Centering Boundary Conditions

Boundary Condition[1]	Stage (feet-NAVD88)	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	47.3 ft elev.	N/A

Note:
1 Naming convention is in reference to the cross-section location in the PBI Model and is named as 'River Reach Station'

1957 Design Flow Boundary Conditions

Table 5-5
1957 SRFCP Design Flow, Lower Feather Centering Boundary Conditions

Boundary Condition[1]	Stage (feet-NAVD88)	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	42.8 ft elev.	N/A

Note:
1 Naming convention is in reference to the cross-section location in the PBI Model and is named as 'River Reach Station'